MATHEMATICS-I

COURSE FILE

I B.TECH I SEMISTER

2022-2023

Prepared by

R.NAGA SAI LAKSHMI

Assistant Professor

Department of Science and Humanities

Malineni Lakshmaiah Women's Engineering College

Guntur

MALINENI LAKSHMAIAH WOMEN'S ENGINEERING COLLEGE
(Approved by AICTE, Affiliated to JNTUK)
Pulladigunta (Village), Vatticherukuru (Mandal),
Guntur-522017, Andhra Pradesh, India

ESTD : 2008

Department of Computer Science and Engineering

CONTENTS OF COURSE FILE

S.NO	CONTENTS	AVAILABLE/ NOT AVAILABLE
1	V/M/PEO/PO/PSO	Yes
2	Course syllabus including course structure	Yes
3	Course outcomes	Yes
4	Mapping co with po/pso	Yes
5	Academic calender	Yes
6	Timetable	Yes
7	Lesson plan	Yes
8	Lecture notes	Yes
9	End exam question papers	Yes
10	Internal question paper with key	Yes
11	Assignment question papers	Yes
12	Scheme of evaluation (university, mid, assignment)	Yes
13	Tutorial topics with evidence	Yes
14	Result analysis to identify weak & advanced learners	Yes
15	Result analysis at the end of course	Yes
16	Remedial class schedule & evidences	Yes
17	Bright student engagement documentation	Yes
18	Course assessment	Yes
19	CO PO attainment	Yes
20	Observation for not attaining co or for improvement	Yes
21	Plan of action for improve co attainment	Yes
22	Attendance register	Yes
23	Course file digital form	Yes

PRINCIPAL
MALINENI LAKSHMAIAH
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PULLADIGUNTA, GUNTUR-17.

FACULTY INCHARGE

MALINENI LAKSHMAIAH
WOMEN'S ENGINEERING COLLEGE
PULLADIGUNTA, GUNTUR-17.

Malineni Lakshmaiah Women's Engineering College , Guntur

Department of Science and Humanities

VISION

To be a pioneer institute in engineering education, fostering academic excellence, and producing empowered women engineers, blended with ethics and values, to serve the society.

MISSION

- To achieve academic excellence through innovative teaching-learning practices
- To inculcate self-discipline, ethics and values amongst the learners
- To bridge the gap between industry and academia through industry institute interface
- To promote higher education, research and inculcate entrepreneurial attitude amongst the learners.

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PROGRAM OUTCOMES

PO1	**Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2	**Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5	**Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.
PO6	**The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO7	**Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development
PO8	**Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO9	**Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO10	**Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO11	**Project management and finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary
PO12	**Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological

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JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY KAKINADA
KAKINADA – 533 003, Andhra Pradesh, India
DEPARTMENT OF CSE - ARTIFICIAL INTELLIGENCE & DATA SCIENCE

COURSE STRUCTURE

I Year – I SEMESTER

S. No	Course Code	Courses	L	T	P	Credits
1	HS1101	Communicative English	3	0	0	3
2	BS1101	Mathematics – I	3	0	0	3
3	BS1102	Applied Chemistry	3	0	0	3
4	ES1101	Programming for Problem Solving using C	3	0	0	3
5	ES1102	Computer Engineering Workshop	1	0	4	3
6	HS1102	English Communication Skills Laboratory	0	0	3	1.5
7	BS1103	Applied Chemistry Lab	0	0	3	1.5
8	ES1103	Programming for Problem Solving using C Lab	0	0	3	1.5
9	MC1101	Environmental Science*	2	0	0	0
		Total Credits				**19.5**

I Year – II SEMESTER

S. No	Course Code	Courses	L	T	P	Credits
1	BS1201	Mathematics – II	3	0	0	3
2	BS1202	Applied Physics	3	0	0	3
3	ES1201	Digital Logic Design	3	0	0	3
4	ES1202	Python Programming	3	0	0	3
5	CS1201	Data Structures	3	0	0	3
6	BS1203	Applied Physics Lab	0	0	3	1.5
7	ES1203	Python Programming Lab	0	0	3	1.5
8	CS1202	Data Structures Lab	0	0	3	1.5
9	MC1201	Constitution of India *	2	0	0	0
		Total Credits				**19.5**

*Internal Evaluation

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KAKINADA – 533 003, Andhra Pradesh, India

DEPARTMENT OF CSE - ARTIFICIAL INTELLIGENCE & DATA SCIENCE

I Year - I Semester		L	T	P	C
		3	0	0	3

MATHEMATICS-I (BS1101)
(Common to all Branch's for I Year B. Tech)

Course Objectives:

- To familiarize a variety of well-known sequences and series, with a developing intuition about the behaviour of new ones.
- To enlighten the learners in the concept of differential equations and multivariable calculus.
- To equip the students with standard concepts and tools at an intermediate to advanced level mathematics to develop the confidence and ability among the students to handle various real world problems and their applications.

Course Outcomes: At the end of the course, the student will be able to

- utilize mean value theorems to real life problems (L3)
- solve the differential equations related to various engineering fields (L3)
- familiarize with functions of several variables which is useful in optimization (L3)
- apply double integration techniques in evaluating areas bounded by region (L3)
- students will also learn important tools of calculus in higher dimensions. Students will become familiar with 2- dimensional and 3-dimensional coordinate systems(L5)

UNIT – I: Sequences, Series and Mean value theorems: **(10hrs)**

Sequences and Series: Convergences and divergence – Ratio test – Comparison tests – Integral test – Cauchy's root test – Alternate series– Leibnitz's rule.

Mean Value Theorems (without proofs): Rolle's Theorem – Lagrange's mean value theorem – Cauchy's mean value theorem – Taylor's and Maclaurin's theorems with remainders, Problems and applications on the above theorem.

UNIT – II: Differential equations of first order and first degree: **(10hrs)**

Linear differential equations– Bernoulli's equations –Exact equations and equations reducible to exact form.

Applications: Newton's Law of cooling– Law of natural growth and decay– Orthogonal trajectories– Electrical circuits.

UNIT – III: Linear differential equations of higher order: **(10hrs)**

Homogeneous and Non-homogeneousdifferential equations of higher order with constant coefficients – with non-homogeneous term of the type e^{ax}, sin ax, cos ax, polynomials in x^n, $e^{ax}V(x)$ and $x^nV(x)$ – Method of Variation of parameters, Cauchy and Legendre's linear equations.

Applications: LCR circuit, Simple Harmonic motion.

UNIT – IV: Partial differentiation: **(10hrs)**

Introduction – Homogeneous function – Euler's theorem– Total derivative– Chain rule– Jacobian – Functional dependence –Taylor's and MacLaurin's series expansion of functions of two variables.

Applications: Maxima and Minima of functions of two variables without constraints and Lagrange's method.

UNIT – V: Multiple integrals: **(8 hrs)**

Double and Triple integrals – Change of order of integration in double integrals – Change of variables to polar, cylindrical and spherical coordinates.

Applications: Finding Areas and Volumes.

Text Books:

1. B. S. Grewal, Higher Engineering Mathematics, 44th Edition, Khanna Publishers.
2. B. V. Ramana,Higher Engineering Mathematics, 2007 Edition, Tata Mc. Graw Hill Education.

Reference Books:

1. Erwin Kreyszig,Advanced Engineering Mathematics, 10th Edition, Wiley-India.
2. Joel Hass, Christopher Heil and Maurice D. Weir, Thomas calculus, 14thEdition, Pearson.
3. Lawrence Turyn,Advanced Engineering Mathematics, CRC Press, 2013.
4. Srimantha Pal, S C Bhunia, Engineering Mathematics, Oxford University Press.

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Department of Science And Humanities

COURSE OBJECTIVES & OUTCOMES

COURSE :**MATHEMATICS-1**	DEGREE/BRANCH: **B.Tech**
COURSE CODE: **C102**	YEAR: **I** SEMESTER: **I**
REGULATION: **R20**	COURSE TYPE: **REGULAR**
ACADEMIC YEAR : **2022-2023**	CREDITS: **3**

COURSE OBJECTIVES:

1	To familiarize a variety of well-known sequences and series, with a developingintuitionabout the behaviour ofnew ones.
2	To enlighten the learners in the concept of differential equations and multivariablecalculus.
3	To equip the students with standard concepts and tools at an intermediate to advancedlevel mathematics to develop the confidence and ability among the students to handlevariousreal world problems and their applications.

COURSE OUTCOMES:

Students will be able to:

CO. NO	COURSE OUT COME	RBTL
C102.1	Study various types of Convergence and Mean value Theorems	Understand(L2)
C102.2	Solve first order differential equations and applications of first order differential equations	Apply(L3)
C102.3	Solve linear differential equations of higher order and Applications	Apply(L3)
C102.4	Find the total derivative and Jacobian .Determine the maximum and minimum values of functions of two variables.	Apply(L3)
C102.5	Apply double and triple integration techniques in evaluating areas and volumes covered by region.	Apply(L3)

R.N.S.Lavanya
Faculty Incharge

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DEPARTMENT OF SCIENCE AND HUMANITIES
COURSE OUTCOME WITH PO S

NAME OF THE PROGRAM	: B.Tech
SUBJECT NAME	: MATHEMATICS-1
SUBJECT CODE	: C102
REGULATION	: R20
ACADEMIC YEAR	: 2022-23
SEMESTER	: I/I

After the completion of the course the student will able to learn

CO. NO	COURSE OUT COME	RBTL
C102.1	Study various types of Convergence and Mean value Theorems	Understand(L2)
C102.2	Solve first order differential equations and applications of first order differential equations	Apply(L3)
C102.3	Solve linear differential equations of higher order and Applications	Apply(L3)
C102.4	Find the total derivative and Jacobian .Determine the maximum and minimum values of functions of two variables.	Apply(L3)
C102.5	Apply double and triple integration techniques in evaluating areas and volumes covered by region.	Apply(L3)

Remember- L 1 **Understand - L 2** **Apply - L 3**

Mapping of course outcomes with program outcomes:

CO&PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
C102.1	2	2												
C102.2	2	2												
C102.3	2	2												
C102.4	2	2												
C102.5	3	2												
TOTAL	11	10												
No of Co's Mapping With Po/Pso	5	5												
Average	2.2	2												

* Low: 1 *Medium: 2 *High: 3

R.N.Slaufl
Faculty in-charge

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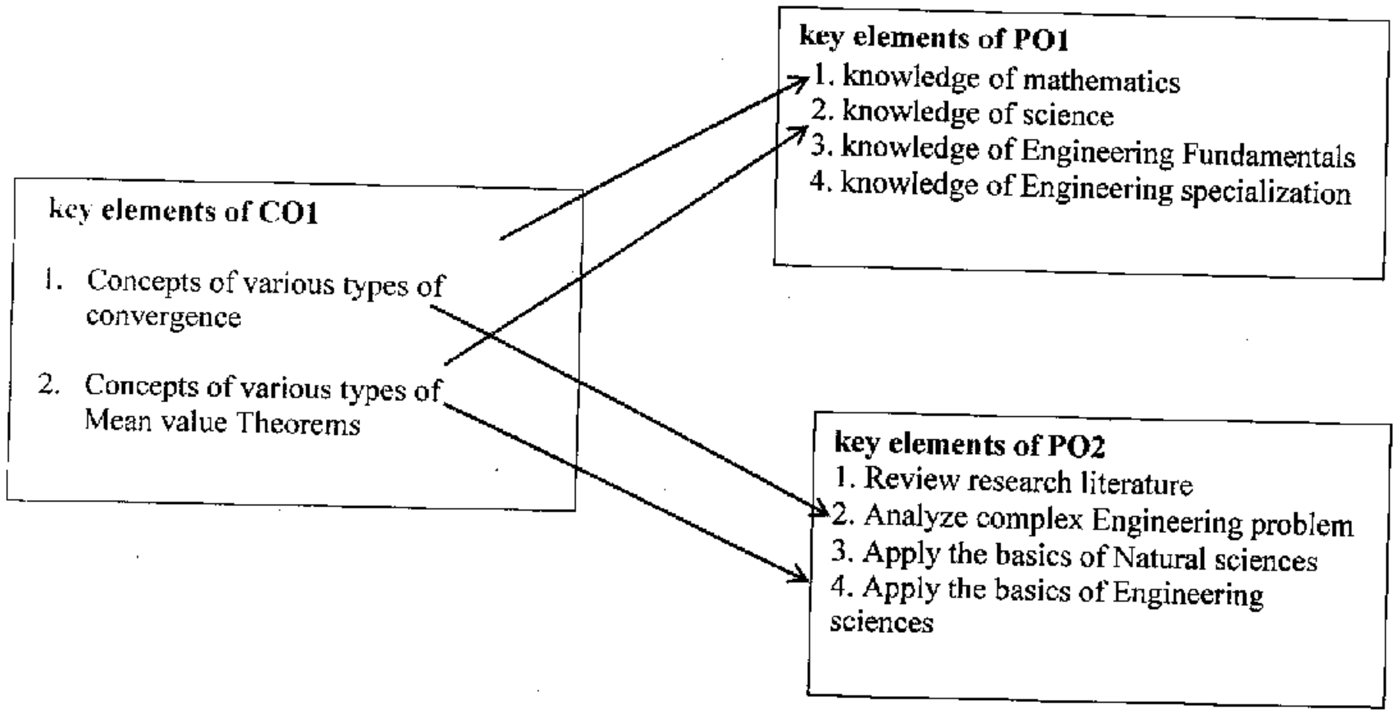
CO1: Study various types of Convergence and Mean value Theorems



No .of Key elements in PO1=n = 4

No. of key elements of CO1 mapping with key elements of PO1=m=2

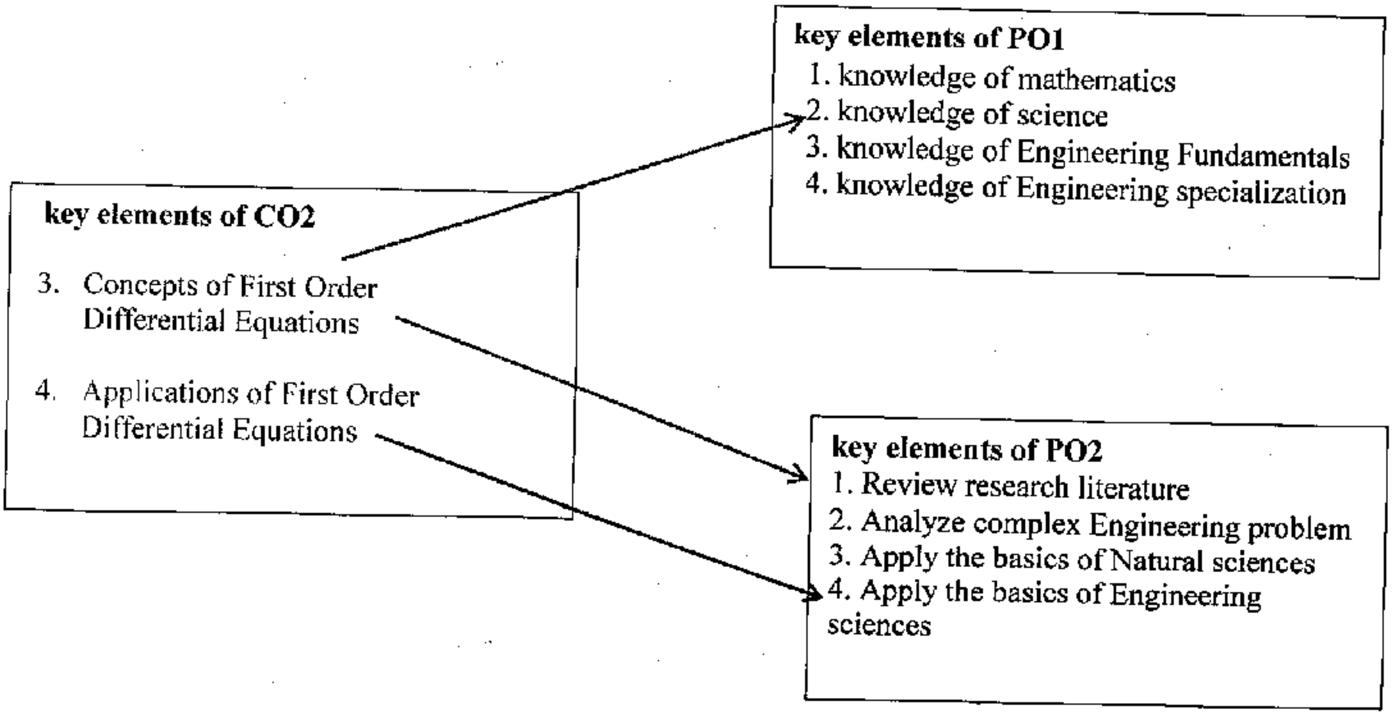
(m/n)*100=(2/4)*100=50%=2

No .of Key elements in PO2=n = 4

No. of key elements of CO1 is mapping with key elements of PO2= m=2

(m/n)*100=(2/4)*100=50%=2

CO2: Solve first order differential equations and applications of first order differential equations



No .of Key elements in PO1=n = 4

No. of key elements of CO2 mapping with key elements of PO1=m=2

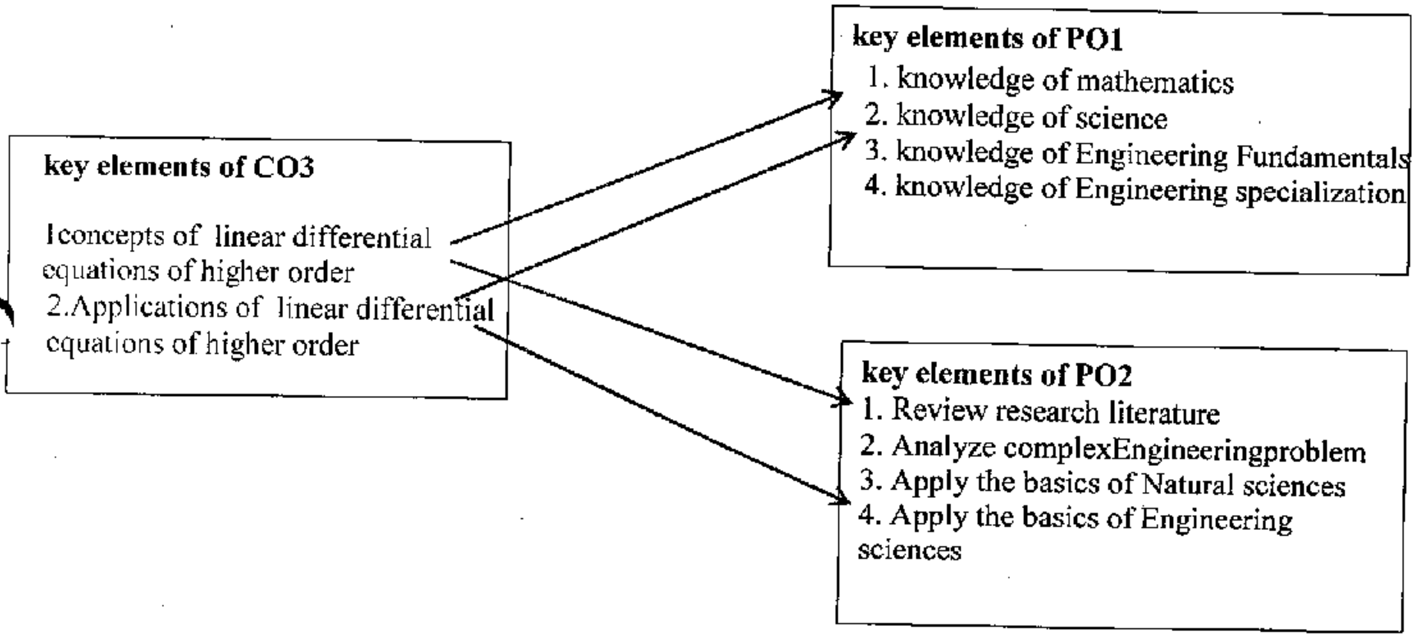
(m/n)*100=(2/4)*100=50%=2

No .of Key elements in PO2=n = 4

No. of key elements of CO2 is mapping with key elements of PO2= m=2

(m/n)*100=(2/4)*100=50%=2

CO3: Solve linear differential equations of higher order and Applications



No .of Key elements in PO1=n = 4

No. of key elements of CO3 mapping with key elements of PO1=m=2

(m/n)*100=(2/4)*100=50%=2

No .of Key elements in PO2=n = 4

No. of key elements of CO3 is mapping with key elements of PO2= m=2

(m/n)*100=(2/4)*100=50%=2

CO4: Find the total derivative and Jacobian .Determine the maximum and minimum values of functions of two variables..

key elements of PO1

1. knowledge of mathematics

4. knowledge of Engineering specialization

key elements of CO4

1. concepts of Total Derivative and Jacobian.
2. Determination of maximum and minimum values of functions of two variables.

key elements of PO2

1. Review research literature
2. Analyze complex Engineering problem
3. Apply the basics of Natural sciences
4. Apply the basics of Engineering sciences

No .of Key elements in PO1=n = 4

No. of key elements of CO4 mapping with key elements of PO1=m=2

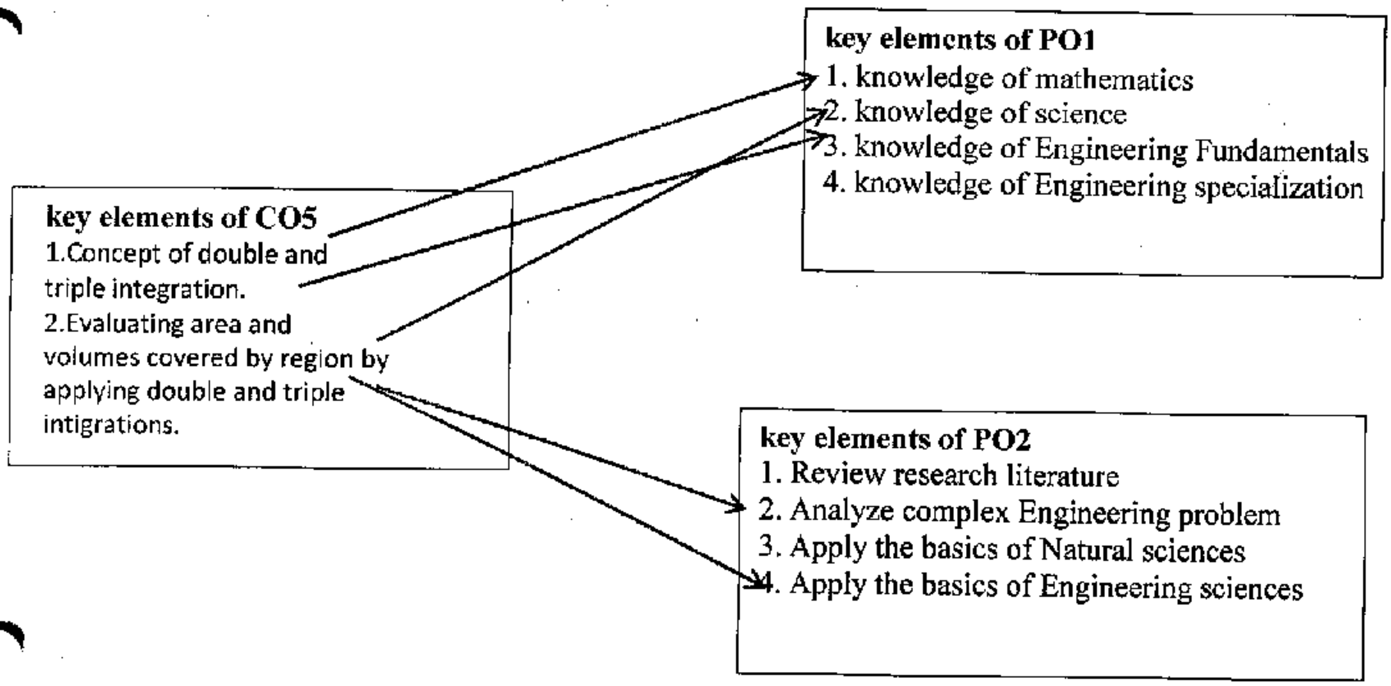
(m/n)*100=(2/4)*100=50%=2

No .of Key elements in PO2=n = 4

No. of key elements of CO4 is mapping with key elements of PO2= m=2

(m/n)*100=(2/4)*100=50%=2

CO5: Apply double and triple integration techniques in evaluating areas and volumes covered by region.



No .of Key elements in PO1=n = 4

No. of key elements of CO5 mapping with key elements of PO1=m=3

(m/n)*100=(3/4)*100=75%=3

No .of Key elements in PO2=n = 4

No. of key elements of CO5 is mapping with key elements of PO2= m=2

(m/n)*100=(2/4)*100=50%=2

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Directorate of Academic Planning

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY KAKINADA
KAKINADA-533003, Andhra Pradesh, INDIA
(Established by AP Government Act No. 30 of 2008)

Lr. No. DAP/AC/I Year /B. Tech/2022 *Date 23.09.2022*

Dr. KVSG Murali Krishna,
M.E. Ph.D.,
Director, Academic Planning
JNTUK, Kakinada

To
All the Principals of Affiliated Colleges,
JNTUK, Kakinada.

Academic Calendar for I Year - B. Tech for the AY 2022-23

I SEMESTER			
Description	**From**	**To**	**Weeks**
Commencement of Class Work	**26.09.2022**		
Induction Classes	26.09.2022	15.10.2022	3W
I Unit of Instruction	17.10.2022	10.12.2022	8W
I Mid Examinations	05.12.2022	10.12.2022	
II Unit of Instructions	12.12.2022	04.02.2023	8W
II Mid Examinations	30.01.2023	04.02.2023	
Preparation & Practicals	06.02.2023	11.02.2023	1W
End Examinations	13.02.2023	25.02.2023	2W
Commencement of II Semester Class Work	**27.02.2023**		
II SEMESTER			
I Unit of Instructions	**27.02.2023**	22.04.2023	8W
I Mid Examinations	17.04.2023	22.04.2023	
II Unit of Instructions	24.04.2023	17.06.2023	8W
II Mid Examinations	12.06.2023	17.06.2023	
Preparation & Practicals	19.06.2023	24.06.2023	1W
End Examinations	26.06.2023	08.07.2023	2W

KVSG 23/9/22

Director,
Academic Planning,
JNTUK Kakinada

Copy to the Secretary to the Hon'ble Vice Chancellor, JNTUK
Copy to the PA to the Rector, JNTUK
Copy to the PA to Registrar, JNTUK.
Copy to Director Academic Audit, JNTUK
Copy to Director of Evaluation, JNTUK

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DEPARTMENT OF SCIENCE AND HUMANITIES

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Department Academic Calendar (AY: 2022-23, ODD SEMESTER)

Date: 24-09-2022

S. No	Academic Schedule	Date
1	Commencement of class work	26-09-2022
2	I phase of instructions	17-10-2022 To 07-12-2022
3	Revision classes	08-12-2022 To 10-12-2022
4	I mid examinations	12-12-2022 To 17-12-2022
7	II mid examinations	30-01-2023 To 03-02-2023
8	Preparation & Practical Examinations	06-02-2023 To 11-02-2023
9	End examinations	**13-02-2023 To 25-02-2023**
S. No	**Department Events**	**Tentative Month & Date**
1	Staff meeting & Class allotment	II week of Oct'2022
2	Fresher's Day celebrations	24-11-2022 To 26-11-2022
3	Sankranthi sambaralu	07-01-2023
4	Republic Day celebrations	26-01-2023
5	Staff meeting & Subject syllabus completion status	03-12-2022
6	Staff meeting & Subject syllabus completion status	IV week of JAN '2023

Department Academic Calendar (AY: 2022-23, Sem-I)

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DEPARTMENT OF SCIENCE AND HUMANITIES
ACADEMIC YEAR 2022-2023

CLASS TIME TABLE

MLWEC/DS/ TIMETABLES /22-23/CT/01

Class: I B.Tech DS **Semester: I** **Section: A** **W.E.F :17-10-2022**

DAY	I	II	III	IV		V	VI	VII
	9.00-9.50	9.50-10.40	10.40-11.30	11.30-12.20	12.20-1.10	1.10-2.00	2.10-3.00	3.00-3.50
MON	ENG	CHE	M1	ENG	L	M1	ES	SPORTS
TUE	M1	CHE LAB/TUTORIAL			U	ENG LAB		
WED	CHE	ENG	M1	PPC	N C	CEW LAB		
THU	PPC	TUTORIAL/ CHE LAB			H	CHE	PPC	LIB
FRI	CHE	M1	PPC	ENG		PPC LAB		
SAT	PPC	ES	M1	PPC		ENG	SEMINAR	SPORTS

* Tutorials will be handled by the respective course faculty

Course	Course Name (Code)	Name of the Faculty	Course	Course Name	Name of the Faculty
ENG	ENGLISH(R201102)	J.SRI LAKSHMI	SPORTS	SPORTS	SAMBASIVA RAO
MI	MATHEMATICS- I (R20II01)	R.NAGA SAI LAKSHMI	LIBRARY	LIBRARY	KALYANI
CHE	APPLIED CHEMISTRY(R201115)	P.ARUN KUMAR	MENT	MENTORING	LAVANYA
PPC	PROGRAMMING FOR PROBLEM SOLVING USING C LAB (R201110)	G.VASANTHA LAKSHMI	INTERNET	INTERNET	K.SIREESHA
CEW	COMPUTER ENGINEERING WORKSHOP	T. MADHAVI			
ES	ENVIRONMENTAL STUDIES	V.SREEKANTH			
ENG LAB	ENGLISH LAB(R201106)	J.SRI LAKSHMI L.NAGESWARA RAO			
APP LAB	APPLIED CHEMISTRY LAB(R201116)	P.ARUN KUMAR M.SWARAJYAM			
PPC LAB	PROGRAMMING FOR PROBLEM SOLVING USING C LAB(R201113)	G.VASANTHA LAKSHMI			

Class In-Charge **Time Table In-charge** **Head of the Department**

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DEPARTMENT OF SCIENCE AND HUMANITIES

ACADEMIC YEAR 2022-2023

CLASS TIME TABLE

MLWEC/DS/ TIMETABLES /22-23/CT/01

Class: I B.Tech DS **Semester: I** **Section: B** **W.E.F:17-10-2022**

DAY	I	II	III	IV		V	VI	VII
	9.00-9.50	9.50-10.40	10.40-11.30	11.30-12.20	12.20-1.10	1.10-2.00	2.10-3.00	3.00-3.50
MON	M1	CEW LAB			L	PPC LAB		
TUE	ENG	M1	PPC	LIB	U	M1	CHE	SPORTS
WED	PPC	M1	CHE	ENG	N C	PPC	ES	SEMINAR
THU	CHE	ENG	PPC	ES	H	PPC	ENG	SPORTS
FRI	M1	CHE LAB/TUTORIAL				ENG LAB		
SAT	CHE	M1	PPC	ENG		TUTORIAL/ CHE LAB		

* Tutorials will be handled by the respective course faculty

Course	Course Name (Code)	Name of the Faculty	Course	Course Name	Name of the Faculty
ENG	ENGLISH(R201102)	J.SRI LAKSHMI	SPORTS	SPORTS	SAMBASIVA RAO
MI	MATHEMATICS-1(R20II01)	R.NAGA SAI LAKSHMI	LIBRARY	LIBRARY	SK.BAJI
CHE	APPLIED CHEMISTRY(R201115)	P.ARUN KUMAR	MENT	MENTORING	M.SWARAJYAM
PPC	PROGRAMMING FOR PROBLEM SOLVING USING C LAB (R201110)	G.VASANTHA LAKSHMI	INTERNET	INTERNET	K.SIREESHA
CEW	COMPUTER ENGINEERING WORKSHOP	T. MADHAVI			
ES	ENVIRONMENTAL STUDIES	V.SREEKANTH			
ENG LAB	ENGLISH LAB(R201106)	J.SRI LAKSHMI L.NAGESWARA RAO			
APP LAB	APPLIED CHEMISTRY LAB(R201116)	P.ARUN KUMAR T.VELANGINI			
PPC LAB	PROGRAMMING FOR PROBLEM SOLVING USING C LAB(R201113)	G.VASANTHA LAKSHMI			

Class In-Charge **Time Table In-Charge** **Head of the Department**

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DEPARTMENT OF SCIENCE AND HUMANITIES

INDIVIDUAL TIME TABLE

MLWEC/DS-A/DS-B/ TIME TABLES /22-23/01

DATE:**17-10-2022**

SEMESTER: I / I

NAME OF THE FACULTY: R.NAGA SAI LAKSHMI
NAME OF THE SUBJECT: MATHEMATICS-I

DAY	I	II	III	IV		V	VI	VII
	9.00-9.50	9.50-10.40	10.40-11.30	11.30-12.20	12.20-1.10	1.10-2.00	2.10-3.00	3.00-3.50
MON	DS-B		DS-A		L	DS-A		
TUE	DS-A		DS-B		U	DS-B		
WED		DS-B	DS-A		N			
THU					C			
FRI	DS-B	DS-A			H			
SAT		DS-B	DS-A					

R. N. Sai Lakshmi

Time Table In-Charge

Head of the Department

HOD
Dept. of Science & Humanities
Malineni Lakshmaiah Women's Engineering College
Pulladigunta, GUNTUR-522017

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MALINENI LAKSHMAIAH
WOMEN'S ENGINEERING COLLEGE
PULLADIGUNTA, GUNTUR-17.

MALINENI LAKSHMAIAH WOMEN'S ENGINEERING COLLEGE

(Approved by AICTE, Affiliated to JNTUK)
(An ISO9001:2008 Certified Institution)
Pulladigunta (Village), Vatticherukuru (Mandal),
Guntur-522017, Andhra Pradesh, India
Department of Science and Humanities

LESSON PLAN

Academic Year: **2022-23** | Regulation: **R20**

Year / Semester: **I** | Branch: **DS**

Faculty name: R.NAGA SAI LAKSHMI | Period (Hours): **(3+1T)**

COURSE : **MATHEMATICS-I** | **Credits:** 3

L.NO	NAME OF THE TOPIC	TYPE OF CLASS	TEACHING AID	TEXT/REFERENCE BOOK
	UNIT-1: SEQUENCES,SERIES AND MEAN VALUE THEOREMS			
1	Introduction and definitions	L	Chalk & Talk	T1
2	Convergence and divergence	L	Chalk & Talk	T1
3	Ratio test	L	Chalk & Talk	T1
4	Comparision test	L	Chalk & Talk	T1
5	Integral test	L	Chalk & Talk	T1
6	Cauchy's root test	L	Chalk & Talk	T1
7	Alternate series	T	Chalk & Talk	T1
8	Leibnitz's rule	L	Chalk & Talk	T1
9	Mean value theorems.Roll's theorem	L	Chalk & Talk	T1
10	Lagrange's mean value theorem	L	Chalk & Talk	T1
11	Cauchy's mean value theorem	L	Chalk & Talk	T1
12	Newton's Law of cooling	L	Chalk & Talk	T1
13	Taylor,s and Maclaurin,s theorems with remainders	L	Chalk & Talk	T1
14	Problems	L		T1
	UNIT-11:DIFFERENTIAL EQUATIONS OF FIRST ORDER AND FIRST DEGREE			
15	General Introduction to the differentiation	L	Chalk & Talk	T1
16	Definition of D.E,P.D.E, It's Order, Degree with examples	L	Chalk & Talk	T1
17	Formation of Differential Equations	L	Chalk & Talk	T1

18	Variable Separable &Homogenous Differential Equations.	L	Chalk & Talk	T1
19	Linear Differential Equations	L	Chalk & Talk	T1
20	Bernoulli's Differential Equations	L	Chalk & Talk	T1
21	Exact Differential Equations	T	Chalk & Talk	T1
22	Reducible to exact Differential Equations	L	Chalk & Talk	T1
23	Orthogonal Trajectories in Cartesian form	L	Chalk & Talk	T1
24	Orthogonal Trajectories in polar form	L	Chalk & Talk	T1
25	Electrical circuits	L	Chalk & Talk	T1
26	Newton's Law of cooling	L	Chalk & Talk	T1
27	Law of natural growth, decay	L	Chalk & Talk	T1
28	Chemical reactions	L		T1
29	Problems			
	UNIT-III: DIFFERENTIAL EQUATIONS OF SECOND AND HIGHER ORDER			
30	Definition of Non-Homogenous L.D.E with constant coefficients, General Solution	L	Chalk & Talk	T1
31	To Find the complementary Solution	L	Chalk & Talk	T1
32	To find y_p,=If Q(x)= e^{ax},	L	Chalk & Talk	T1
33	To find y_p,=If Q(x)=Sin(ax+b) (or)Cos(ax+b)	L	Chalk & Talk	T1
34	To find y_p,=If Q(x)= x^n	T	Chalk & Talk	T1
35	To find y_p= If Q(x)= e^{ax} v(x)	T	Chalk & Talk	T1
36	To find y_p,=If Q(x)=XV(x)	L	Chalk & Talk	T1
37	To find y_p,=If Q(x)= x^n V(x)	L	Chalk & Talk	T1
	LCR circuit	L	Chalk & Talk	T1
38	Problems			
39	Simple Harmonic Motion	L	Chalk & Talk	T1
40	Problems			
	UNIT-IV PARTIAL DIFFERENTIATION			
41	Total Derivatives and Chain	L	Chalk & Talk	T1

	Rule			
42	Taylor's series for single & two variables	L	Chalk & Talk	T1
43	Mc Laurent's series for single & two variables	L	Chalk & Talk	T1
44	Functional Dependence	L	Chalk & Talk	T1
45	Jacobian	L	Chalk & Talk	T1
46	Maxima and minima of functions of two variables with constant	L	Chalk & Talk	T1
47	Maxima and minima of functions of two variables without constant coefficients	L	Chalk & Talk	T1
48	Lagrange's method of undetermined multipliers	L	Chalk & Talk	T1
49	Problems	L	Chalk & Talk	T1
50	Problems	L	Chalk & Talk	T1
	UNIT-V: MULTIPLE INTEGRALS			
51	Introduction	L	Chalk & Talk	T1
52	Double Integration in cartisian form	L	Chalk & Talk,	T1
53	Double Integration in polar form	L	Chalk & Talk	T1
54	Triple Integrals	L	Chalk & Talk	T1
55	Areas	L	Chalk & Talk	T1
56	Volumes	L	Chalk & Talk	T1
57	Integration Changing cartisian into polar	L	Chalk & Talk	T1
58	Changing the order of Integration	L	Chalk & Talk	T1
59	Problems of volume as double integral	L	Chalk & Talk	T1
60	Change of varialbles in atriple integral	L	Chalk & Talk	T1

61	Problems	L	Chalk & Talk	T1

Text Books:

1. **B.S.Grewal,** Higher Engineering Mathematics, 43rd Edition, Khanna Publishers.
2. **N.P.Bali**, Engineering Mathematics, Lakshmi Publications.

Reference Books:

1. **Erwin Kreyszig,** Advanced Engineering Mathematics, 10th Edition, Wiley-India
2. **Micheael Greenberg,** Advanced Engineering Mathematics, 9th edition, Pearson edn
3. **Dean G. Duffy,** Advanced engineering mathematics with MATLAB, CRC Press
4. **Peter O'neil,**Advanced Engineering Mathematics, Cengage Learning.
5. **Srimanta Pal, SubodhC.Bhunia,** Engineering Mathematics, Oxford University Press.
6. **Dass H.K., RajnishVerma. Er.,**Higher Engineering Mathematics, S. Chand Co. Pvt. Ltd, Delhi.

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Department of Science and Humanities

UNIT WISE QUESTION COURSE CODE : C112 SUBJECT:MATHEMATICS-I

S.NO	QUESTIONS	TAXONOMY
	UNIT-I	
1	Obtain the Taylor's expansion of sinx in powers of $\left(x-\frac{\pi}{2}\right)$	Understand
2	Verify Rolle's theorem of $f(x)=e^{x}[\sin x-\cos x]$ in $\left(\frac{\pi}{4},\frac{5\pi}{4}\right)$	Understand
3	Show that $\log(1+e^{x})=\log 2+\frac{x}{2}+\frac{x^2}{8}-\frac{x^4}{192}+\ldots$	Understand
4	Verify Rolle's theorem of $f(x)=x^2$ in $(-1\ ,1)$	Understand
[illegible]	Obtain the Taylor's expansion of cosx about $x=\frac{\pi}{3}$	Understand
6	Show that $e^{x}=1+x+\frac{x^2}{2!}+\ldots$	Understand
7	Test the convergence of $\sum\left[\sqrt{n^3+1}-\sqrt{n^3}\right]$	Understand
8	Examine the convergence of $\sum\frac{(n^3-5n^2+7)}{(n^5+5n^4+n)}$	Understand
9	Test the convergence of $1+\frac{x}{2}+\frac{x^2}{5}+\frac{x^3}{10}+\ldots(x>0)$	Understand
10	Test the convergence of $2+\frac{2.5.8}{1.5.9}+\frac{2.5.8.11}{1.5.9.13}+\ldots$	Understand
11	Test the convergence of $\frac{3x}{4}+\left(\frac{5}{6}\right)^2x^2+\left(\frac{7}{8}\right)^3x^3+\ldots$	Understand
12	Show that the harmonic series of order p, $\sum_{n=1}^{\infty}\frac{1}{n^p}$ converges for p>1 and diverges for $p\le 1$	Understand
13	Discuss the convergence of the series $\sum_{n=1}^{\infty}\frac{\cos n\pi}{n^2+1}$	Understand
14	Examine the convergence and absolute convergence of the series $\sum_{n=1}^{\infty}(-1)^{n-1}\frac{n}{n^2+1}$	Understand

UNIT-II		
1	a) Solve $2xy\,dy = (x^2 + y^2 + 1)dx$	Application
2	b) The temperature of the body drops from $100^{o}C$ to $75^{O}C$ in ten minutes when the surrounding air is at $20^{O}C$ What will be its temperature after half an hour	Application
3	Solve $(x+1)\frac{dy}{dx} - y = e^{3x}(x+1)^2$	Application
4	A bacterial culture growing exponentially increases from 100 to 400 grams in 10 hours . How much was present after 3 hours from intial instant	Application
5	Solve $(3xy^2 - y^3)\,dx = (2x^2y - xy^2)\,dy$	Application
6	Find the O.T of family of curves $r = 2a(\cos\theta + \sin\theta)$	Application
7	Solve $2\frac{dy}{dx} - y\sec x = y^3\tan x$	Application
8	A body kept in air with temperature $25^{0}C$ cools from $140^{0}C$ to $80^{0}C$ in 20 minutes . Find when the body cools down to $35^{0}C$	Application
9	Solve $(3y^2 + 4xy - x)\ dx + x(x + 2y)dy = 0$	Application
10	Bactria in a culture grows exponentially so that the initial number has doubled in three hours .How many times initial number will be present after 9 hours	Application
11	Uranium disintegrates at a rate proportional to the amount present at any instant. If M_1 and $M_{1/2}$ grams of uranium that are present at times T_1 and T_2 respectively. Show that the half life of uranium is T_1-T_2	Application
12	A pot of boiling water at 100^{o} C is removed from the fire and allowed to cool at $30^{o}C$ room temperature .Two minutes later , the temperature of water in the pot is $90^{o}C$. What will be the temperature of the water after 5min	Application
13	Show that the system of confocal conics $\frac{x^2}{a^2+\lambda} + \frac{y^2}{b^2+\lambda} = 1$, where λ is Parameter is self Orthogonal	Application
14	Solve $(1 + y\cos x)\ dx + \sin x\ dy = 0$	Application

	UNIT-III	
1	Solve $\left(D^2-2D+1\right)y=e^x+\sin x+e^x\cos 2x+x\sin x$	Application
2	Solve the differential equation $\left(D^2-2D+2\right)y=e^x\tan x$ by using method of variation of Parameter	Application
3	Determine the charge on the capacitor at any time $t>0$ in a series RLC circuit having E.M.F $E(t)=100\sin 60t$ a resistor of 2 ohms, an inductor of 0.1 henries and capacitor of $\frac{1}{260}$ farads . If the initial current in the inductor and charge on the capacitor are both zero	Application
4	Solve $\left(D^2-4D+1\right)y=e^x+\cos x\cos 2x$	Application
5	Solve $\left(D^2-4\right)y=x\sinh x+54x$	Application
6	Solve $\left(D^2+4D+3\right)y=e^x+\cos x\cos 2x+x$	
7	Determine the charge on the capacitor at any time $t>0$ in a series RLC circuit having E.M.F $E(t)=17\sin 2t$ a resistor of 120 ohms , an inductor of 10 henries and capacitor of $\frac{1}{1000}$ farads . If the initial current in the inductor and charge on the capacitor are both zero	Application
8	Solve $\left(D^2-D+1\right)y=\cos 2x$	Application
9	Solve $\left(D^2-4D+4\right)y=x^3e^{2x}$	Application
10	Solve $\left(D^2-4D+3\right)y=2xe^{3x}+3e^x\cos x\cos 2x$	Application
11	Solve the differential equation $\left(D^2+1\right)y=\operatorname{cosec}x$ by using method of variation of Parameter	Application
12	Solve $(D^2-4)y=2\cos^2x+\sin x\cos 2x+e^{2x}$	Application
13	Solve $(D^2-1)y=\frac{2}{1+e^x}$ by the method of variation of parameters	Application
14	Solve $(D^3+2D^2+D)y=x^2+x+e^{2x}$	Application

UNIT-IV

1	If $u=\frac{yz}{x}$, $v=\frac{xz}{y}$, $w=\frac{yx}{z}$ show that $\frac{\partial(u,v,w)}{\partial(x,y,z)}=4$	Application
2	Find the maxima and minima values of $x^3+3xy^2-15x^2-15y^2+72x$	Application
3	If $x=e^r\cos\theta,\ y=e^r\sin\theta$ then Prove that $\frac{\partial(x,y)}{\partial(r,\theta)}\times\frac{\partial(r,\theta)}{\partial(x,y)}=1$	Application
4	Find the dimensions of rectangular box requiring least material for its construction whose top is open is to have volume 32 c.ft.	Application
5	If $x=e^r\sec\theta,\ y=e^r\tan\theta$ then Prove that $\frac{\partial(x,y)}{\partial(r,\theta)}\times\frac{\partial(r,\theta)}{\partial(x,y)}=1$	Application
6	Find the maxima and minima values of $x^3+3xy^2-3x^2-3y^2+4$	Application
7	Find extreme values of $x^3+3xy^2-3x^2-3y^2+4$	Application
8	Find $x^2\frac{\partial^2u}{\partial x^2}+2xy\frac{\partial^2u}{\partial x\partial y}+y^2\frac{\partial^2u}{\partial y^2}$ if $u=\tan^{-1}\left(\frac{x^3+y^3}{x-y}\right)$	Application
9	Expand $f(x,y)=e^y\log(1+x)$ in powers of "x" and "y"	Application
10	Show that the rectangular solid of maximum volume that can be inscribed in the sphere is a cube	Application
11	Find $x^2\frac{\partial^2u}{\partial x^2}+2xy\frac{\partial^2u}{\partial x\partial y}+y^2\frac{\partial^2u}{\partial y^2}$ if $u=\mathrm{cosce}^{-1}\left(\frac{\sqrt{x}+\sqrt{y}}{x^{1/3}+y^{1/3}}\right)$	Application
12	If $u=\frac{x+y}{1-xy}$ and $v=\tan^{-1}x+\tan^{-1}y$ find $\frac{\partial(u,v)}{\partial(x,y)}$	Application
13	In a plane triangle ΔABC find the maximum values of $\cos A\cos B\cos C$	Application
14	If $u=x\log xy$ where $x^3+y^3+3xy=1$ then find $\frac{du}{dx}$	Application

UNIT-V		
1	Evaluate $\iint_R (x+y)^2\, dxdy$ where R is the Parallelogram in the xy-plane with the vertices (1,0), (3,1), (2,2) and (0,1) by using the transformations u = x+y & v = x-2y .	Evaluation
2	Evaluate $\iiint_R (x+y+z)dxdydz$ where R is the region bounded by the planes x=0 ,x=1 , y=0, y=1 , z=0 & z=1	Evaluation
3	Evaluate $\iint ydxdy$ Where R is the region bounded by the parabolas $y^2=4x$ & $x^2=4y$	Evaluation
4	Find the area which is inside the cardioid $r=a(1+\cos\theta)$ and out side the circle $r=a$	Evaluation
5	Evaluate $\iint ydxdy$ Where R is the region bounded by the parabolas $y^2=4x$ & $x^2=4y$	Evaluation
6	Change the order of the integration and evaluate $\int_0^a \int_{x/a}^{\sqrt{x/a}} \left(x^2+y^2\right) dx\, dy$	Evaluation
7	Find the area of the cardioids $r=a\,(1-\cos\theta)$	Evaluation
8	By changing the order of integration evaluate $\int_0^{12-x} \int_1 xy\, dx\, dy$	Evaluation
9	By changing the order of integration evaluate $\int_0^{4a} \int_{x^2/4a}^{2\sqrt{ax}} dy\, dx$	Evaluatior
10	Evaluate $\iint \left(x^2+y^2\right) dxdy$ over the area bounded by the ellipse $\frac{x^2}{a^2}+\frac{y^2}{b^2}=1$	Evaluatioi
11	Evaluate $\int_0^1 \int_x^{\sqrt{x}} x^2y^2(x+y)\, dy\, dx$	Evaluatioi
12	Evaluate $\iint \left(x^2+y^2\right) dxdy$ over the area bounded by the ellipse $\frac{x^2}{a^2}+\frac{y^2}{b^2}=1$	Evaluatio
13	Evaluate $\iint r^3\, dr\, d\theta$ over the area included between the circles $r=2\sin\theta$ and $r=4\sin\theta$	Evaluatio
14	Show that $\iint_R r^2\sin\theta\, dr\, d\theta$ Where R is the semi circle $r=2a\cos\theta$ above the initial line	Evaluatic

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I B.TECH, I SEM I INTERNAL EXAMINATIOS, March: 2021(R20) Branches:DS

Max. Marks: 15COURSE: MATHEMATICS- I(UNIVERSITY CODE: R20101)Time: 90 min Date : 13/12/2022
(COURSE CODE: C102)

Answer all the questions REGD NO:

Q.NO		QUESTIONS	CO	RBTL	Marks
1	a)	Examine the convergence of $1-\frac{1}{2^2}+\frac{1}{3^2}-\frac{1}{4^2}+\cdots$	C112.1	L3 (APPLY)	2.5
	b)	Find Taylor's series expansion of the $f(x)=\cos x$ about $x=\frac{\pi}{3}$.	C112.1	L3 (APPLY)	2.5
2	a)	Solve $\cosh x\frac{dy}{dx}+y\sinh x=2\,cosh^2 x\sinh x$.	C112.2	L3 (APPLY)	2.5
	b)	Find the orthogonal trajectories of the family of curves : $r^n=a^n\sin n\theta$.	C112.2	L3 (APPLY)	2.5
3	a)	Slove $(D^2-4D+3)Y=\sin 3x\cos 2x$	C112.3	L3 (APPLY)	5

***Level 1(Remember): * Level 2 (Understand): * Level 3 (Apply):**

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1) a) Examine the convergence of $1-\frac{1}{2^2}+\frac{1}{3^2}-\frac{1}{4^2}+\cdots$

A:- The given series is $1-\frac{1}{2^2}+\frac{1}{3^2}-\frac{1}{4^2}+\cdots$.

$\Sigma u_n = \Sigma (-1)^{n-1}\frac{1}{n^2}$

It is an alternating series

Here $u_n = \frac{1}{n^2} > 0$

$u_{n+1} = \frac{1}{(n+1)^2}$

since $u_n \geq u_{n+1}$

Now $\lim\limits_{n\to\infty} u_n$

$\lim\limits_{n\to\infty} \frac{1}{n^2} = \frac{1}{\infty^2} = 0$

$\therefore$ By leibnitz's test, the given series is convergent.

b) Find Taylor's series expansion of the $f(x)=\cos x$ about $x=\frac{\pi}{3}$.

A:- The Taylor's series expansion of $f(x)$ in powers of $x-a$ is given by

$f(x) = f(a)+(x-a)f'(a)+\frac{(x-a)^2}{2!}f''(a)+\frac{(x-a)^3}{3!}f'''(a)+\cdots$

$f(x) = \cos x \;;\; a=\frac{\pi}{3}$

$f(x) = f(\frac{\pi}{3})+(x-\frac{\pi}{3})f'(\frac{\pi}{3})+\frac{(x-\frac{\pi}{3})^2}{2!}f''(\frac{\pi}{3})+\frac{(x-\frac{\pi}{3})^3}{3!}f'''(\frac{\pi}{3})+\cdots$

$f(x) = \cos x \Rightarrow f(\frac{\pi}{3}) = \cos\frac{\pi}{3} = \frac{1}{2}$

$f'(x) = -\sin x \Rightarrow f'(\frac{\pi}{3}) = -\sin(\frac{\pi}{3}) = -\frac{\sqrt{3}}{2}$

$f''(x) = -\cos x \Rightarrow f''(\frac{\pi}{3}) = -\cos(\frac{\pi}{3}) = -\frac{1}{2}$

$f'''(x) = \sin x \Rightarrow f'''\left(\frac{\pi}{3}\right) = \sin\left(\frac{\pi}{3}\right) = \frac{\sqrt{3}}{2}$

Hence

$$\cos x = \frac{1}{2} + \left(x-\frac{\pi}{3}\right)\left(-\frac{\sqrt{3}}{2}\right) + \frac{\left(x-\frac{\pi}{3}\right)^2}{2!}\left(-\frac{1}{2}\right) + \frac{\left(x-\frac{\pi}{3}\right)^3}{3!}\left(\frac{\sqrt{3}}{2}\right) + \cdots$$

2) a) solve $\cosh x \frac{dy}{dx} + y\sinh x = 2\cosh^2 x \sinh x$.

A:- Given that $\cosh x \frac{dy}{dx} + y\sinh x = 2\cosh^2 x \sinh x$

$$\frac{dy}{dx} + y\frac{\sinh x}{\cosh x} = \frac{2\cosh^{\cancel{2}} x \sinh x}{\cancel{\cosh x}}$$

$$\frac{dy}{dx} + y\tanh x = 2\cosh x \sinh x \quad — ①$$

Which is linear equation in y.

Here $P = \tanh x$, $Q = 2\cosh x \cdot \sinh x$

Now Integrating factor $(I.F) = e^{\int P\,dx}$

$= e^{\int \tanh x\, dx}$

$= e^{\log|\cosh x|}$

$= \cosh x$.

$\therefore$ The general solution of ① is

$y \cdot I.F = \int Q \times (I.F) \cdot dx + c$

$y \cdot \cosh x = \int 2\cosh^2 x \sinh x\, dx + c$

$y \cdot \cosh x = 2\frac{\cosh^3 x}{3} + c \quad \left[\because \int f(x)^n \cdot f'(x) = \frac{f(x)^{n+1}}{n+1}\right]$.

b) Find the orthogonal trajectories of the family of curves: $r^n = a^n \sin n\theta$.

A:- Given the equation of the family of curves

$r^n = a^n \sin n\theta \quad — ①$

Differentiate with respect to θ on both sides

$\cancel{n} r^{n-1}\frac{dr}{d\theta} = a^n \cos n\theta \cdot \cancel{n}$

$$a^n = \frac{r^{n-1}}{\cos n\theta}\frac{dr}{d\theta}$$

By eliminating 'an' substitute 'an' value in equation ①

$$r^n = \frac{r^{n-1}}{\cos n\theta}\frac{dr}{d\theta}(\sin n\theta)$$

$$\cancel{r^n} = \cancel{r^n}\cdot r^{-1}\frac{\sin n\theta}{\cos n\theta}\frac{dr}{d\theta}$$

$$1 = \frac{1}{r}\tan n\theta\frac{dr}{d\theta}$$

$$r = \tan n\theta\frac{dr}{d\theta}$$

Replace $\frac{dr}{d\theta}$ by $-r^2\frac{d\theta}{dr}$

$$\cancel{r} = \tan n\theta - r^2\frac{d\theta}{dr}$$

$$1 = \tan n\theta(-r)\frac{d\theta}{dr}$$

$\frac{1}{r}dr = -\tan n\theta\, d\theta$ (By seperation)

Take Integrating on both sides

$$\int\frac{1}{r}dr = -\int\tan n\theta\, d\theta$$

$$\log r = -\left(-\log\frac{(\cos n\theta)}{n}\right) + \log c$$

$$\log r = \log\frac{(\cos n\theta)}{n} + \log c$$

$$\log r = \frac{\log\cos n\theta + n\log c}{n}$$

$$n\log r = \log\cos n\theta + n\log c$$

$$\log r^n = \log\cos n\theta + \log c^n$$

$$\cancel{\log} r^n = \cancel{\log}\cos n\theta . c^n$$

$$r^n = c^n\cos n\theta$$

Hence solved.

3) a) solve $(D^2-4D+3)y = \sin 3x \cdot \cos 2x$.

A:- Given $(D^2-4D+3)y = \sin 3x \cdot \cos 2x$

To find complementary function :-

The auxilary equation is $f(m)=0$

$$m^2-4m+3=0$$
$$m^2-3m-m+3=0$$
$$m(m-3)-(m-3)=0$$
$$m-1=0,\ m-3=0$$
$$m=1,\quad m=3.$$

The roots are real and distinct

$$y_c = c_1e^x + c_2e^{3x}$$

To find particular integral :-

$$y_p = \frac{1}{f(D)} Q(x)$$

$$f(D) = D^2-4D+3$$

$$Q(x) = \sin 3x \cos 2x$$

$$Q(x) = \frac{1}{2}[\sin(3x+2x) + \sin(3x-2x)]$$

$$Q(x) = \frac{1}{2}[\sin 5x + \sin x]$$

$$y_p = \frac{1}{D^2-4D+3}\left[\frac{1}{2}(\sin 5x + \sin x)\right]$$

$$y_p = \frac{1}{2}\frac{1}{D^2-4D+3}(\sin 5x) + \frac{1}{2}\frac{1}{D^2-4D+3}(\sin x)$$

Replace $D^2 \to -b^2$ Replace $D^2 \to -b^2$

$$y_p = \frac{1}{2}\left[\frac{1}{-5^2-4D+3}\sin 5x\right] + \frac{1}{2}\frac{1}{-1^2-4D+3}(\sin x)]$$

$$y_p = \frac{1}{2}\left[\frac{1}{-25+3-4D}\sin 5x\right] + \frac{1}{2}\left[\frac{1}{-1-4D+3}\sin x\right]$$

$$y_p = \frac{1}{2}\left[\frac{1}{-22-4D}\sin 5x\right] + \frac{1}{2}\left[\frac{1}{-4D+2}\sin x\right]$$

$$y_p = \frac{1}{2}\left[\left(\frac{1}{-22-4D}\times\frac{-22+4D}{-22+4D}\right)\sin 5x + \left(\frac{1}{-4D+2}\times\frac{-4D-2}{-4D-2}\right)\sin x\right]$$

$$y_p = \frac{1}{2}\left[\frac{-22+4D}{(-22)^2-(4D)^2}\sin 5x + \frac{-4D-2}{(-4D)^2-2^2}\sin x\right]$$

$$y_p = \frac{1}{2}\left[\frac{-22+4D}{484-16D^2}\sin 5x + \frac{-4D-2}{16D^2-4}\sin x\right]$$

Replace $D^2 \to -b^2$ Replace $D^2 \to -b^2$

$$y_p = \frac{1}{2}\left[\frac{(-22+4D)}{484-16(-5^2)}\sin 5x + \frac{(-4D-2)}{16(-1^2)-4}\sin x\right]$$

$$y_p = \frac{1}{2}\left[\frac{(-22+4D)}{484-16(-25)}\sin 5x + \frac{(-4D-2)}{-16-4}\sin x\right]$$

$$y_p = \frac{1}{2}\left[\frac{(-22+4D)}{484+400}\sin 5x + \frac{(-4D-2)}{-20}\sin x\right]$$

$$y_p = \frac{1}{2}\left[\frac{-22\sin 5x + 20\cos 5x}{884} + \frac{-4\cos x - 2\sin x}{-20}\right]$$

$$y_p = \frac{1}{2}\left[\frac{-22\sin 5x + 20\cos 5x}{884} + \frac{\cancel{-}(4\cos x + 2\sin x)}{\cancel{-}20}\right]$$

$$y_p = \frac{1}{\cancel{2}}\cancel{2}\left[\frac{-11\sin 5x + 10\cos 5x}{884}\right] + \frac{1}{\cancel{2}}\cancel{2}\left(\frac{2\cos x + \sin x}{20}\right)$$

$$y_p = \frac{-11\sin 5x + 10\cos 5x}{884} + \frac{2\cos x + \sin x}{20}$$

$\therefore$ The general solution is

$$y = y_c + y_p$$

$$y = c_1 e^{x} + c_2 e^{3x} - \frac{11\sin 5x + 10\cos 5x}{884} + \frac{2\cos x + \sin x}{20}$$

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Department of Science and Humanities

SCHEME OF EVALUATION – MID 1 EXAMINATION

COURSE : **MATHEMATICS-I**	DEGREE/ BRANCH: **B.Tech/**
COURSE CODE: **C102**	YEAR: **I** SEMESTER: **I**
REGULATION: **R20**	COURSE TYPE: **REGULAR**
ACADEMIC YEAR : **2022-23**	CREDITS: **3**

Date:13/12/2022

Max Marks:15

Q.NO.	QUESTION	MARKS ALLOTTED	COURSE OUTCOME MAPPING	BLOOM'S TAXONOMY LEVEL
1.	a)Examine the convergence of $1-\frac{1}{2^2}+\frac{1}{3^2}-\frac{1}{4^2}+\cdots$.	2.5M	C102.1	Apply
	b)Find Taylor's series expansion of the $f(x)=\cos x$ about $x=\frac{\pi}{3}$	2.5M	C102.1	Apply
2.	a) Solve $\cosh x\frac{dy}{dx}+y\sinh x = 2\cosh^2 x\sinh x$. b) Find the orthogonal trajectories of the family of curves : $r^n=a^n\sin n\theta$.	5M	C102.2	Apply
3.	Slove $(D^2-4D+3)Y = \sin 3x\cos 2x$	5M	C102.3	Apply

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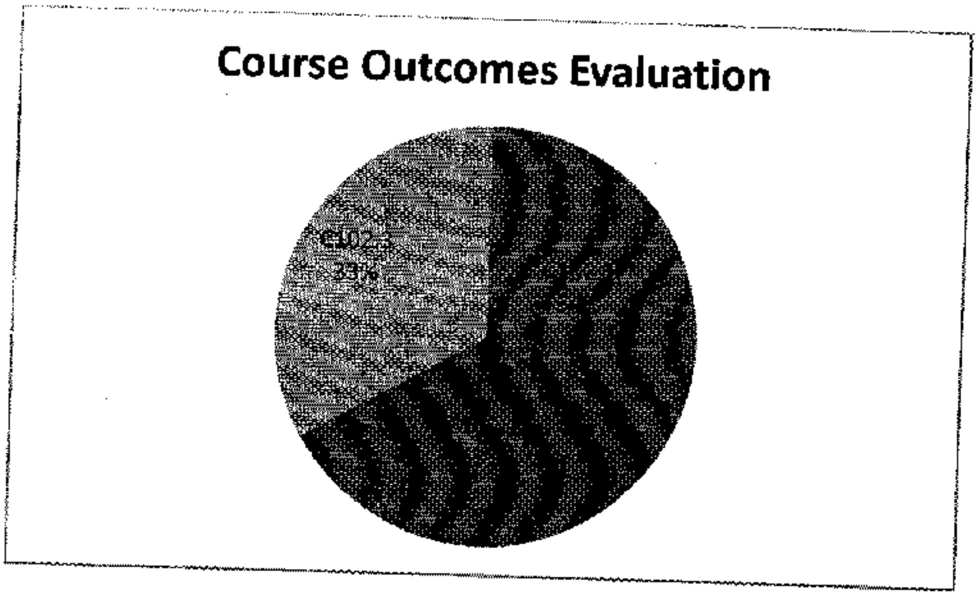
Course Outcome Number	Marks Allotted	Percentage of Marks		Taxonomy level	Marks Allotted	Percentage of Marks
C101.1	5	34		Remember		
C101.2	5	33		Understand		
C101.3	5	33		Apply	15	100
Total Marks	15	100		Analyze		
				Evaluate		
				Create		
				Total Marks	15	100



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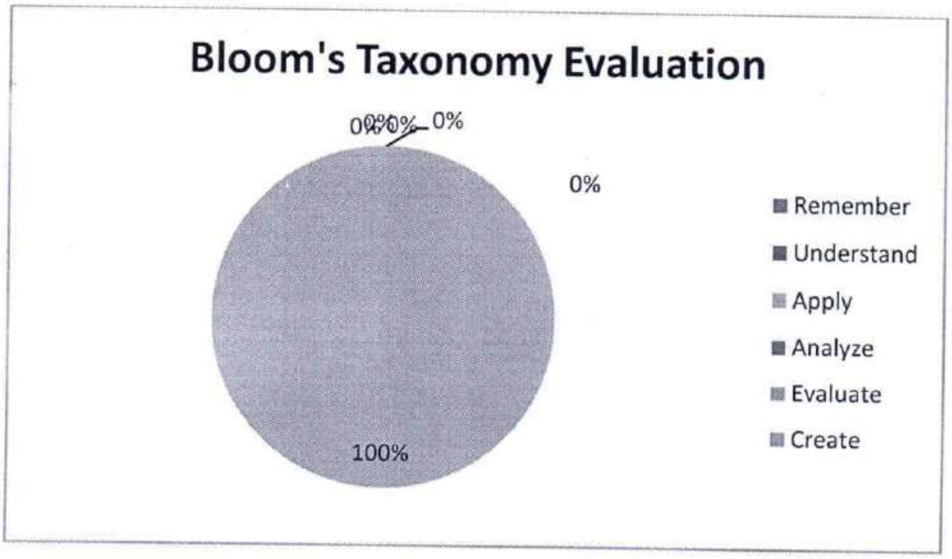
CSE & ECE - 2022-2025

Department of Science and Humanities



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ESTD : 2008

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ASSAIGNMENT-I

COURSE:**MATHEMATICS-I**	DEGREE: **B.Tech**
COURSE CODE: C102	YEAR: **I** SEMESTER: **I**
REGULATION: **R20**	COURSE TYPE: **REGULAR**
ACADEMIC YEAR: **2022-23**	CREDITS: **3**

Name of the Course Coordinator/Advisor: **Max Marks: 5**

Q.No.	Solution	Marks Allotted	Course Outcome mapping	Taxonomy level
1	Solve $\frac{dy}{dx}+\frac{y}{x\,logx}=\frac{sin2x}{logx}$.	1	CO2	Apply
2	Solve that the system of confocal conics $\frac{x^2}{a^2+\lambda}+\frac{y^2}{b^2+\lambda}=1$, Where □ is a parameter is self orthogonal.	1	CO2	Apply
4	Verify Rolle's Theorem for the function $\log\left(\frac{x^2+ab}{x(a+b)}\right)$ in (a,b),b>0 ?	1	CO1	Apply
5	If a <b , Prove that $\frac{b-a}{1+b^2}<\tan^{-1}a<\frac{b-a}{1+a^2}$ using Lagrange's mean value Theorem . Deduce the following (i) $\frac{\pi}{4}+\frac{3}{25}<\tan^{-1}\frac{4}{3}<\frac{\pi}{4}+\frac{1}{6}$. (ii) $\frac{5\pi+4}{20}<\tan^{-1}2<\frac{\pi+2}{4}$.	1	CO1	Apply
6	A body kept in air with temperature 25^0C cool from 140^0C to 80^0C in 20 minutes . Find when the body cools down to 35^0C	1	CO2	Remember

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SCHEME OF EVALUATION – ASSAIGNMENT-I

COURSE:**MATHEMATICS-I**	DEGREE: **B.Tech**
COURSE CODE: C102	YEAR: **I** SEMESTER: **I**
REGULATION: **R20**	COURSE TYPE: **REGULAR**
ACADEMIC YEAR: **2022-23**	CREDITS: **3**

Name of the Course Coordinator/Advisor: **Max Marks: 5**

Q.No.	Solution	Marks Allotted	Course Outcome mapping	Taxonomy level
1	Solve $\frac{dy}{dx} + \frac{y}{x\,logx} = \frac{sin2x}{logx}$.	1	CO2	Apply
2	Solve that the system of confocal conics $\frac{x^2}{a^2+\lambda} + \frac{y^2}{b^2+\lambda} = 1$, Where □ is a parameter is self orthogonal.	1	CO2	Apply
4	Verify Rolle's Theorem for the function $\log\left(\frac{x^2+ab}{x(a+b)}\right)$ in (a, b),b>0 ?	1	CO1	Apply
5	If a <b , Prove that $\frac{b-a}{1+b^2}<\tan^{-1} a<\frac{b-a}{1+a^2}$ using Lagrange's mean value Theorem . Deduce the following (i) $\frac{\pi}{4} + \frac{3}{25} < \tan^{-1}\frac{4}{3} < \frac{\pi}{4} + \frac{1}{6}$. (ii) $\frac{5\pi+4}{20} < \tan^{-1} 2 < \frac{\pi+2}{4}$.	1	CO1	Apply
6	A body kept in air with temperature 25^0C cool from 140^0C to 80^0C in 20 minutes . Find when the body cools down to 35^0C	1	CO2	Remember

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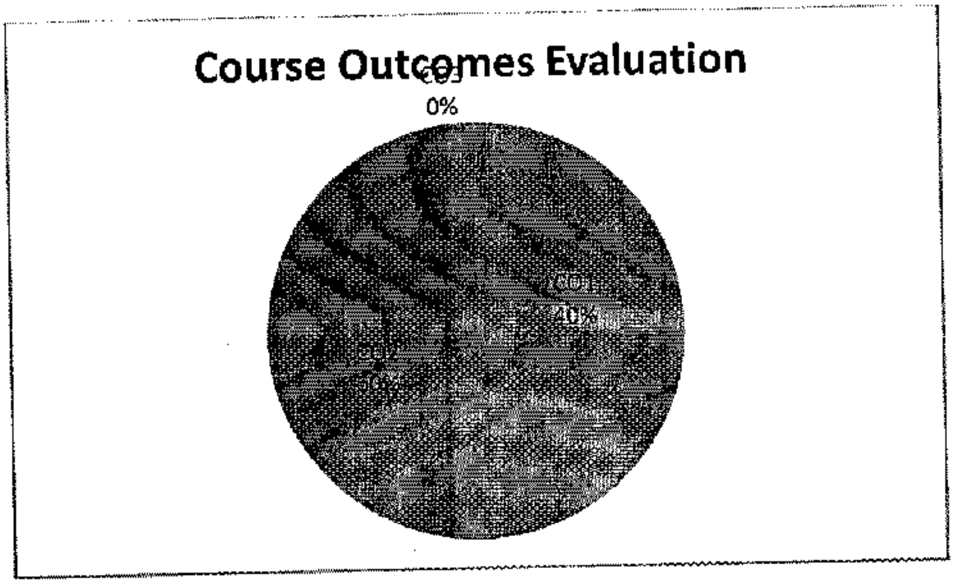
Course Outcome Number	Marks Allotted	Percentage of Marks	Taxonomy level	Marks Allotted	Percentage of Marks
CO1	2	40	Remember	1	20
CO2	3	60	Understand		
CO3			Apply	4	80
			Analyze		
			Evaluate		
			Create		
Total Marks	5	100	Total Marks	5	100



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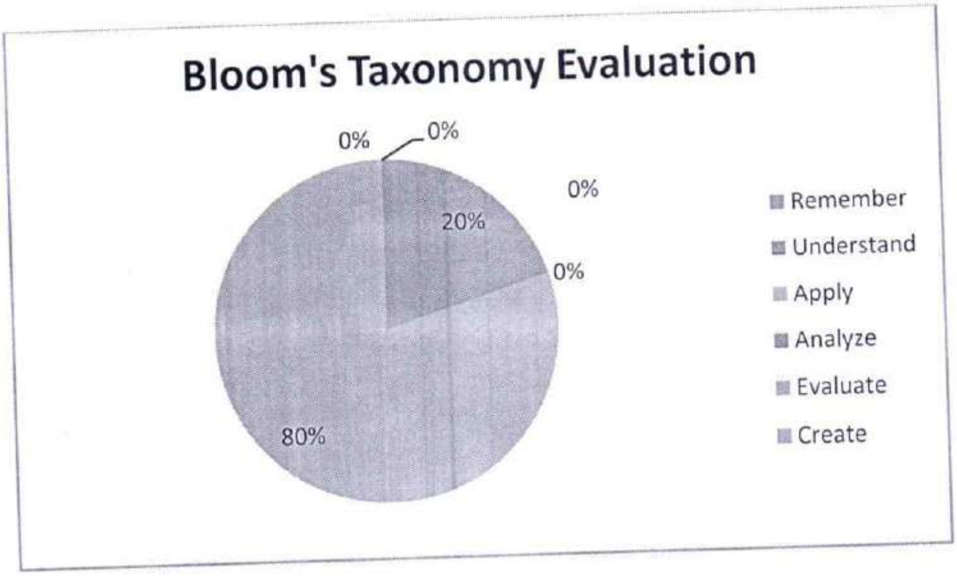

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NAME :- K.vani Akshitha

BRANCH :- CSE (DS)

CLASS :- DS

YEAR :- 1^{st} year

ROLL NUMBER :- 22KE1A4448

COLLAGE :- Malineni Lakshmaia women's Engineering collage.

SUBJECT :- Math - 1

ASSIGNMENT NO :- 1

1. Solve $\frac{dy}{dx} + \frac{y}{\log x} = \frac{\sin 2x}{\log x}$

Sol:- Given

$$\frac{dy}{dx} + \frac{y}{\log x} = \frac{\sin 2x}{\log x} \quad \text{——①}$$

which is in the linear D.E $\frac{dy}{dx} + P(x)y = Q(x)$

were $P = \frac{1}{x\log x}$ $\quad Q = \frac{\sin 2x}{\log x}$

$$I.F = e^{\int P dx} = e^{\int \frac{dx}{x\log x}}$$

$$= e^{\int \frac{\frac{1}{x}}{\log x} dx}$$

$$= e^{\log|\log x|}$$

$$= \log x$$

the general solution is

$$y(I.F) = \int Q(I.F)\,dx + c$$

$$y(I.F) = \int \frac{\sin 2x}{\cancel{\log x}} (\cancel{\log x})\,dx + c$$

$$y\log x = \frac{-\cos x}{2} + c$$

$$\log x = -\frac{\cos 2x}{2} + c$$

2. Show that the system of confocal conics $\frac{x^2}{a^2+\lambda} + \frac{y^2}{b^2+\lambda} = 1$, where λ is a parameter, is self orthogonal.

Sol:- Given,

The equation of confocal concis is

$$\frac{x^2}{a^2+\lambda} + \frac{y^2}{b^2+\lambda} = 1 \quad \text{--- (1)}$$

differentiate w.r.to x

$$\frac{2x}{a^2+\lambda} + \frac{2y}{b^2+\lambda}\frac{dy}{dx} = 0$$

Put $\frac{dy}{dx} = p$

$$\frac{x}{a^2+\lambda} + \frac{yp}{b^2+\lambda} = 0$$

$$\frac{x(b^2+\lambda)+yp(a^2+\lambda)}{(a^2+\lambda)(b^2+\lambda)} = 0$$

$$xb^2 + x\lambda + ypa^2 + yp\lambda = 0$$

$$\lambda(x+yp) + xb^2 + ypa^2 = 0$$

$$\lambda(x+yp) = -(xb^2 + yp^2)$$

$$\lambda = -\frac{(xb^2+ypa^2)}{(x+yp)}$$

By eliminating λ, where to substitute 'λ' values in eq (1)

$$\frac{x^2}{a^2-\left[\frac{xb^2+ypa^2}{x+yp}\right]} + \frac{y^2}{b^2-\left[\frac{xb^2+ypa^2}{x+yp}\right]} = 1$$

$$\frac{x^2}{\frac{a^2(x+yp)-xb^2-ypa^2}{x+yp}} + \frac{y^2}{\frac{b^2(x+yp)-xb^2-ypa}{x+yp}} = 1$$

$$\frac{x^2(x+yp)}{a^2x+a^2yp-xb^2-ypa^2} + \frac{y^2(x+yp)}{b^2x+b^2yp-xb^2-ypa^2} = 1$$

$$\frac{x^2(x+yp)}{a^2x+a^2yp-xb^2-ypa^2} + \frac{y^2(x+yp)}{b^2x+b^2yp-xb^2-ypa^2} = 1$$

$$\frac{x^2(x+yp)}{a^2x-xb^2} + \frac{y^2(x+yp)}{b^2yp-ypa^2} = 1$$

$$\frac{x(x+yp)}{a^2-b^2} + \frac{y(x+yp)}{p(b^2-a^2)} = 1$$

$$\frac{x(x+yp)}{a^2-b^2} - \frac{(x+yp)y}{(a^2-b^2)p} = 1$$

$$\frac{x+yp}{a^2-b^2}\left[x-\frac{y}{p}\right] = 1 \quad \text{——} ②$$

Replace 'p' by $-1/p$

$$\frac{x+y(-1/p)}{a^2-b^2}\left[x-\frac{y}{(-1/p)}\right] = 1$$

$$\frac{x-y/p}{a^2-b^2}(x+yp) = 1$$

$$\frac{x+yp}{a^2-b^2}\left(x-\frac{y}{p}\right) = 1 \quad \text{—} ③$$

Equation ③ is the system of confocal conics and 2 & 3 are same D.E of confocal conics & the given equation is self ortho gonal.

3. Test for convergence of the series $\frac{1}{2\sqrt{1}}+\frac{x^2}{3\sqrt{2}}+\frac{x^4}{4\sqrt{3}}+\cdots$

Sol:- Given, the series is $\sum \frac{x^{2n-2}}{\sqrt{n}(n+1)}$

Consider, $u_n = \frac{x^{2n-2}}{\sqrt{n}(n+1)} > 0$

since $u_n > 0$ the series is +ve terms

$$u_n = \frac{x^{2n-2}}{\sqrt{n}(n+1)}$$

$$u_{n+1} \; \frac{x^{2(n+1)-2}}{\sqrt{n+1}(n+2)}$$

$$u_{n+1} = \frac{x^{2n}}{\sqrt{n+1}(n+2)}$$

Now, $\lim\limits_{n\to\infty} \frac{u_n}{u_{n+1}} = \lim\limits_{n\to a} \frac{x^{2n-2}}{\sqrt{n}(n+1)} \times \frac{\sqrt{n+1}(n+2)}{x^{2n}}$

$$= \lim_{n\to\infty} \frac{\sqrt{n+1}(n+2)}{\sqrt{n}(n+1)} \; 1/x^2$$

$$= \lim_{n\to\infty} \frac{\cancel{\sqrt{n}}(\sqrt{1+1/n})\,\cancel{n}\,(1+2/n)}{\cancel{\sqrt{n}}\,\cancel{n}\,(1+1/n)\,x^2}$$

$$= \lim_{n\to\infty} \frac{\sqrt{1+1/n}\;(1+2/n)}{1+1/n}\;\frac{1}{x^2}$$

$$= \lim_{n\to\infty} \frac{u_n}{u_{n+1}} = \frac{1}{x^2}$$

$\therefore \sum u_n$ is converges, it $\frac{1}{x^2} > 1$ i.e, $x^2 < 1$

$\sum u_n$ is diverges $\frac{1}{x^2} < 1$ i.e; $x^2 > 1$

Now, test fails, if $\frac{1}{x^2} = 1$ i.e, $x^2 = 1$

when $x^2 = 1$

By $u_n = \dfrac{x^{2n-2}}{\sqrt{n}\,(n+1)}$

$$u_n = \frac{1}{\sqrt{n}\,(n+1)} = \frac{1}{\sqrt{n}\,n\left(1+\frac{1}{n}\right)} = \frac{1}{n^{3/2}\left(1+1/n\right)}$$

Select $v_n = \dfrac{1}{n^{3/2}}$ $\quad \Sigma v_n = \Sigma \dfrac{1}{n^{3/2}}$

By P- series $\Sigma \dfrac{1}{n^p}$ $P = \dfrac{3}{2} > 1$

$\therefore \Sigma v_n$ is converges

Now $\displaystyle\lim_{n\to\infty} \frac{u_n}{v_n} = \lim_{n\to\infty} \frac{\frac{1}{\cancel{n^{3/2}}\left(1+\frac{1}{n}\right)}}{\cancel{1/n^{3/2}}}$

$$\Rightarrow \lim_{n\to\infty} \frac{1}{1+\frac{1}{n}} = \frac{1}{1} \neq 0$$

$\therefore \Sigma v_n$ is converages, By comparsion test.

Σu_n also converges.

4. verify rolle's theorem for $f(x) = \log\left[\frac{x^2+ab}{x(a+b)}\right]$ in (a,b), $a>0$, $b>0$.

Sol:- Given, $f(x) = \log\left[\frac{x^2+ab}{x(a+b)}\right]$ in (a,b)

$$f(x) = \log(x^2+ab) - \log(x(a+b))$$

$$= \log(x^2+ab) - (\log x + \log(a+b))$$

$$= \log(x^2+ab) - \log x - \log(a+b)$$

The given function is composite function

Thus $f(x)$ is continuous in (a,b)

$$f(x) = \log(x^2+ab) - \log x - \log(a+b)$$

$$f'(x) = \frac{1}{x^2+ab}(2x) - \frac{1}{x}$$

$$= \frac{2x}{x^2+ab} - \frac{1}{x}$$

$$= \frac{2x^2-x^2-ab}{x(x^2+ab)}$$

$$= \frac{x^2-ab}{x(x^2+ab)}$$

Thus $f'(x)$ exists (a,b)

$$f(x) = \log\left[\frac{x^2+ab}{x(a+b)}\right]$$

$$f(a) = \log\left[\frac{a^2+ab}{a(a+b)}\right]$$

$$= \log\left[\frac{a^2+ab}{a^2+ab}\right]$$

$$f(a) = 1$$

$$f(b) = \log\left[\frac{b^2+ab}{b(a+b)}\right]$$

$$= \log\left[\frac{ab+b^2}{ab+b^2}\right]$$

$$= \log 1$$

$$f(b) = 0$$

$$f(a) = f(b)$$

Thus, By Rolle's theorem,

the three condition are satisfied

$\exists$ c in (a,b) $\ni$ $f'(c)=0$

$$f'(x) = \frac{x^2-ab}{x(x^2+ab)}$$

$$f'(c) = \frac{c^2-ab}{c(c^2+ab)}$$

$$0 = \frac{c^2-ab}{c^3+abc}$$

$$c^2-ab=0$$

$$c = \pm\sqrt{ab}$$

$$c \in (a,b)$$

Rolle's theorm is verified.

5. If $a<b$, prove that $\frac{b-a}{1+b^2} < \tan^{-1}b - \tan^{-1}a < \frac{b-a}{1+a^2}$ using languages mean value theorem, Deduce the folling.

i) $\frac{\pi}{4}+\frac{3}{25} < \tan^{-1}\frac{4}{3} < \frac{\pi}{4}+\frac{1}{6}$

ii) $\frac{5\pi+4}{20} < \tan^{-1}2 < \frac{\pi+2}{4}$

Sol:- Let $f(x) = \tan^{-1}x$

(i) clearly the given function $\tan^{-1}x$ continuous $[a,b]$

(ii) $f(x) = \tan^{-1}x$

$$f'(x) = \frac{1}{1+x^2}$$

$\therefore$ By L.M.V.T two conditions are satisfied the $\exists$ a c in $[a,b]$ $\exists$ $f'(c) = \frac{f(b)-f(a)}{b-a}$ — ①

$$a<c<b$$

S.O.B.S

$$a^2<c^2<b^2$$

Adding '1' on the both sides

$$1+a^2<1+c^2<1+b^2$$

Doing Reciprocal on b.s

$$\frac{1}{1+a^2} > \frac{1}{1+c^2} > \frac{1}{1+b^2} \quad \text{— ③}$$

from ①&②; $f'(c) = \frac{1}{1+c^2}$

$$f(b) = \tan^{-1}b$$

$$f(a) = \tan^{-1}a$$

$$f'(c) = \frac{\tan^{-1}b - \tan^{-1}a}{b-a} \quad \text{— ③}$$

from ② & ③, we have

$$\frac{1}{1+a^2} > \frac{Tan^{-1}b - Tan^{-1}a}{b-a} > \frac{1}{1+b^2}$$

$$\frac{b-a}{1+b^2} < Tan^{-1}b - Tan^{-1}a < \frac{b-a}{1+a^2}$$

Hence solved//

(i) Taking $a=1$; $b=4/3$

we have

$$\frac{b-a}{1+b^2} < Tan^{-1}b - Tan^{-1}a < \frac{b-a}{1+a^2} \quad - ①$$

substitute a, b values in ①

$$\frac{\frac{4}{3}-1}{1+16/9} < Tan^{-1}\frac{4}{3} - Tan^{-1}(1) < \frac{\frac{4}{3}-1}{1+1}$$

$$\Rightarrow \frac{\frac{1}{3}}{\frac{25}{9}} < Tan^{-1}\frac{4}{3} - \frac{\pi}{4} < \frac{\frac{1}{3}}{2}.$$

$$\Rightarrow \frac{3}{25} < Tan^{-1}\frac{4}{3} \text{ on b.s}$$

$$\frac{3}{25} + \frac{\pi}{4} < Tan^{-1}\frac{4}{3} < \frac{1}{6} + \frac{\pi}{4}$$

Hence solved//

(ii) $\frac{5\pi+4}{20} < \tan^{-1} 2 = \frac{\pi+2}{4}$

Taking $a=1$; $b=2$.

we have

$$\frac{b-a}{1+b^2} < \operatorname{Tan}^{-1} b - \operatorname{Tan}^{-1} a < \frac{b-a}{1+a^2} \quad \text{—} \ (1)$$

substitute a, b values in (1)

$$\frac{2-1}{1+4} < \operatorname{Tan}^{-1}(2) - \operatorname{Tan}^{-1}(1) < \frac{2-1}{1+1}$$

$$\Rightarrow \frac{1}{5} < \operatorname{Tan}^{-1} 2 - \operatorname{Tan}^{-1} \pi/4 < \frac{1}{2}$$

Adding $\pi/4$ on both sides

$$\frac{1}{5} + \frac{\pi}{4} < \operatorname{Tan}^{-1} 2 < \frac{1}{2} + \frac{\pi}{4}$$

Hence solved.

6. A body kept in air with temperature 25°c cools from 140°c to 80°c in 20min. Find (i) when the body cools down to 35°c
(ii) when will be temperature 60°c.

Given ;

$\theta_0 = 25°c$

$\theta = 140°c$

$t = 0$

By Newton's law

$\theta = \theta_0 + ce^{-kt}$ — ①

$140 = 25 + ce^{-0}$

$c = 115$

Given , $\theta_0 = 25°c$, $\theta = 80°c$ $t = 20$ $c = 115$

from ① $\theta = \theta_0 + ce^{-kt}$

$80 = 25 + 115\, e^{-20k}$

$e^{-20k} = \frac{55}{115}$

(i) Given , $\theta_0 = 25°c$ $\theta = 35°c$ $t = ?$

$\theta = \theta_0 + ce^{-kt}$

$35 = 25 + 115\, e^{-kt}$

$10 = 115 e^{-kt}$

$\frac{10}{45} = (e^{-20k})^{t/20}$

$\frac{10}{15} = \left(\frac{55}{115}\right)^{t/20}$

Apply log on b.s

$\log\left(\frac{10}{15}\right) = \log\left(\frac{55}{115}\right)^{t/2}$ 0

$$\log 10 - \log 115 = \frac{t}{20}(\log 55 - \log 115)$$

$$\frac{t}{20} = \frac{\log 10 - \log 115}{\log 55 - \log 115}$$

$$t = 20 \times \frac{\log 10 - \log 115}{\log 55 - \log 115}$$

$$t = 66.25$$

(ii) Given,

$$\theta_0 = 25^0 c, \theta = 60^e c \quad t = 2 \quad C = 115 \quad e^{-20k} = \frac{55}{115}$$

$$\theta = \theta_0 + ce^{-kt}$$

$$60 = 25 + 115e^{-kt}$$

$$35 = 115 (e^{-20k})^{t/20}$$

$$\frac{35}{115} = \left(\frac{55}{115}\right)^{t/20}$$

Apply 'log' on both sides

$$\log\left(\frac{35}{115}\right) = \frac{t}{20} \log\left(\frac{55}{115}\right)$$

$$\frac{t}{20} = \frac{\log 35 - \log 115}{\log 55 - \log 115}$$

$$t = 20 \times \frac{\log 35 - \log 115}{\log 55 - \log 115}$$

$$t = 32.25$$

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STUDENT RESULT ANALYSIS FOR MID-I

COURSE:MATHEMATICS-I	DEGREE: B.Tech(CSE-DS)
COURSE CODE: C 102	YEAR: I SEMESTER: I
REGULATION: R20	COURSE TYPE: REGULAR
ACADEMIC YEAR: 2022-23	CREDITS: 3

S.NO	ROLL.NO	NAME OF THE STUDENT	1(a)	1(b)	2(a)	2(b)	3	DESCRIPTIVE	OBJECTIVE	ASSIGNMENT	TOTAL
1	22KE1A4401	ALLAKUNTA NAGA PALLAVI	2.5	2.5	2.5	2.5	3	13	2	5	20
2	22KE1A4402	ALOKAM SAHITHI PRIYA	2.5	2.5	2.5	2.5	5	15	3	5	23
3	22KE1A4403	AMARA SREEJA	2	2.5	2.5	2	5	14	6	5	25
4	22KE1A4404	ANNAVARAPU HARITHA	2.5	2.5	2.5	2.5	5	15	3	5	23
5	22KE1A4405	ARE NAVYA	2.5	2.5	2.5	2.5	5	15	4	5	24
6	22KE1A4406	BELLAMKONDA ANN MARY	2.5	2.5	2.5	2.5	5	15	4	5	24
7	22KE1A4407	BANDI MOUNIKA	2.5	2.5	2.5	2.5	5	15	4	5	24
8	22KE1A4408	BANDARUPALLI POOJITHA	1.5	0	1.5	2	4	9	2	5	16
9	22KE1A4409	AVULA NAGA SRI	2.5	2.5	2.5	2.5	5	15	4	5	24
10	22KE1A4410	BANGARU LAKSHMI TIRUPATHAMMA	1.5	2.5	2	1	4	11	2	5	18
11	22KE1A4411	BATTULA ANUSHA	2.5	2.5	2.5	2.5	5	15	2	5	22
12	22KE1A4412	BATTULA LAKSHMI JYOTHIKA	2	2.5	2.5	2	5	14	2	5	21
13	22KE1A4413	A DEEPTHI VENKATA SOWMYA	1.5	2	2.5	2	4	12	3	5	20
14	22KE1A4414	BIKKI INDHU	0.5	2.5	2.5	2.5	5	13	4	5	22

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15	22KE1A4415	BOTLA KALYANI	1	0	2	0	2	5	3	5	13
16	22KE1A4416	CHAGANTI PRASANNA	1	2.5	2.5	2	5	13	3	5	21
17	22KE1A4417	GOTTIPATI SRAVANA SANDHYA	2.5	2	2.5	2	5	14	5	5	24
18	22KE1A4418	CHANDOLU SRAVANI	2	2	2.5	2.5	5	14	4	5	23
19	22KE1A4419	CHEBROLU SOWMYA	1	2.5	2.5	2	5	13	4	5	22
20	22KE1A4420	KOTHAMASU VYSHNAVI	2.5	2.5	2.5	2.5	5	15	3	5	23
21	22KE1A4421	KOVI CHETANA	2.5	2.5	2.5	2.5	5	15	3	5	23
22	22KE1A4422	CHINTHALA BHAGYALAKSHMI	2.5	2.5	2.5	2.5	4	14	5	5	24
23	22KE1A4423	ELASAGAR TRIVENI	1	1.5	1.5	1	3	8	4	5	17
24	22KE1A4424	MUPPARAJU ANUSHA	2.5	2.5	2.5	2.5	5	15	3	5	23
25	22KE1A4425	MANDALAPU LOKA PUJITHA	2.5	2.5	2.5	2.5	5	15	4	5	24
26	22KE1A4426	GALLA VIJAYALAKSHMI	1.5	2.5	2.5	2.5	5	14	5	5	24
27	22KE1A4427	GORANTLA RAMYA	2.5	2.5	2.5	2.5	5	15	3	5	23
28	22KE1A4428	GORANTLA SRAVANTHI	2.5	2.5	2.5	2.5	5	15	6	5	26
29	22KE1A4429	NARIPEDDI UMAMAHESWARI	2.5	2.5	2.5	2.5	5	15	2	5	22
30	22KE1A4430	GRANDHI THRIVENI	1.5	2.5	2.5	2.5	4	13	2	5	20
31	22KE1A4431	POPURI VENU SRI	2.5	2.5	2.5	2.5	5	15	2	5	22
32	22KE1A4432	PAVULURI MEGHANA	2.5	2.5	2.5	2.5	5	15	6	5	26
33	22KE1A4433	PARUCHURI MANEESHA	2.5	2.5	2.5	2.5	5	15	4	5	24
34	22KE1A4434	KAKUMANU SRI VIDYA	2.5	2.5	2.5	2.5	5	15	3	5	23
35	22KE1A4435	RUDRAPATI MEGHANA	2	2.5	2.5	1.5	5	13	2	5	20
36	22KE1A4436	SHAIK NAZMA BEGUM	1	2.5	2.5	2.5	5	13	3	5	21
37	22KE1A4437	SHAIK GULLAPALLI SAHIRA BANU	2	2.5	2.5	2	5	14	3	5	22

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38	22KE1A4438	SHAIK SOFIYA YASMEEN	2.5	2.5	2.5	2.5	4	14	4	5	23
39	22KE1A4439	SHAIK HAPSA	2	2	2.5	0.5	5	12	3	5	20
40	22KE1A4440	SHAIK SHAMEERA	0.5	1	1.5	1	3	7	4	5	16
41	22KE1A4441	SHAIK KARISHMA	1	1.5	2.5	2.5	5	12	4	5	21
42	22KE1A4442	KAMINENI SRAVYA VYSHNAVI	1.5	2.5	2.5	2.5	5	14	3	5	22
43	22KE1A4443	SHAIK FARHANA	0	2.5	2.5	1	3	9	3	5	17
44	22KE1A4444	KILARI RAMYA	1	1	2.5	2.5	3	10	1	5	16
45	22KE1A4445	KOLA SNEHA LATHA	2.5	0	2.5	2.5	4	11	3	5	19
46	22KE1A4446	KONDRU DEEPIKA	2.5	2.5	2.5	2.5	5	15	4	5	24
47	22KE1A4447	KOTA BHAVYA	0	1	2.5	2.5	3	9	3	5	17
48	22KE1A4448	KOTHA VANI AKSHITHA	0.5	2.5	2.5	2.5	5	13	3	5	21
49	22KE1A4449	CHINNABOYINA LATHA	1	0.5	2.5	0	3	7	3	5	15
50	22KE1A4450	MAKKENA BHARGAVI	0.5	2	2	2.5	4	11	3	5	19
51	22KE1A4451	KOYA DEVIKA CHOWDARY	0	1.5	1	2.5	4	9	5	5	19
52	22KE1A4452	KUPPALA POOJITHA	2.5	2.5	2.5	2.5	5	15	3	5	23
53	22KE1A4453	KURIYALA ABHINAYA	2.5	2.5	2.5	2.5	5	15	3	5	23
54	22KE1A4454	GADDE SAI SREE	1.5	2.5	2	2	3	11	3	5	19
55	22KE1A4455	MADDELA VENKATA KARISHMA	0	2	2.5	2.5	5	12	3	5	20
56	22KE1A4456	MAGULURI PADMAVATHI	2.5	2.5	2.5	2.5	5	15	4	5	24
57	22KE1A4457	YARLAGADDA PUSHYA	1.5	2.5	2.5	2.5	5	14	5	5	24
58	22KE1A4458	MANTRI BABY SRI VALLI	2.5	2.5	2.5	2.5	5	15	3	5	23
59	22KE1A4459	MULLA KHADAR AFISA EFAATH	2	2.5	2.5	2	4	13	4	5	22
60	22KE1A4460	ELURI SAI DHATRI	0	2	2.5	2.5	5	12	2	5	19
61	22KE1A4461	MUTHINENI HARIKA	1	2	2.5	1.5	4	11	8	5	24
62	22KE1A4462	NAGASURI DIVYA SREE	1.5	2.5	2.5	2.5	5	14	3	5	22

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63	22KE1A4463	NALABOTHU VIJAYALAKSHMI	2	2.5	2.5	2	5	14	3	5	22
64	22KE1A4464	NAMBURI MONAPRIYANJALI	2	2	2.5	0.5	3	10	2	5	17
65	22KE1A4465	NANDIPATI VENKATA LAKSHMI PRASANTHI	2.5	2.5	2.5	1.5	4	13	2	5	20
66	22KE1A4466	CHALLAGUNDLA AMRUTHA NAGA PAVANI	1.5	2.5	2.5	2.5	5	14	4	5	23
67	22KE1A4467	NISSANKARARAO SANGEETHA	1.5	2.5	2.5	1.5	5	13	4	5	22
68	22KE1A4468	OGETI TRIVENI	2	2	2.5	2.5	4	13	3	5	21
69	22KE1A4469	PADMAVATHI PADHI	1	2.5	2.5	2	4	12	4	5	21
70	22KE1A4470	PAINEDI LAHARI	2.5	2.5	2.5	2.5	5	15	3	5	23
71	22KE1A4471	PALAKEETI SRILAKSHMI	2	2	1.5	2.5	5	13	3	5	21
72	22KE1A4472	PALLAPU AKHILA	2	1.5	2	2.5	5	13	2	5	20
73	22KE1A4473	JALE BANGARU	1.5	1	2	2.5	5	11	3	5	19
74	22KE1A4474	PASUPULETI USHA RANI	2.5	2.5	2.5	2.5	4	14	3	5	22
75	22KE1A4475	GUTTA SRILAKSHMI	2.5	2.5	2.5	2.5	5	15	3	5	23
76	22KE1A4476	GUNTUPALLI DHANALAKSHMI	2.5	2.5	2.5	2.5	5	15	3	5	23
77	22KE1A4477	PUTTA BHARGAVI	1.5	2	2	0	3	8	4	5	17
78	22KE1A4478	RAMISETTI PUJITHA	0.5	1	2.5	2	5	11	3	5	19
79	22KE1A4479	RANGINENI POOJITHA	2.5	0	0	1.5	5	9	2	5	16
80	22KE1A4480	RAYIDI NAVYA SRI	2.5	2.5	2.5	2.5	5	15	3	5	23
81	22KE1A4481	REDDY SANDYA RANI	2	1.5	2.5	2	5	13	1	5	19
82	22KE1A4482	REVU ALEKHYA	1	2	2.5	2.5	5	13	3	5	21
83	22KE1A4483	KAMBHAMPATI ANURADHA	1.5	2	2	1.5	3	10	2	5	17
84	22KE1A4484	SAGAMREDDY THEERDHA PRASANNA LAKSHMI	1	1	2	1	4	9	3	5	17
85	22KE1A4485	SANDU SNEHA SUMA	1	1	2	2	2	8	3	5	16

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86	22KE1A4486	SARVANI SIMHADRI	1.5	1	2.5	0	3	8	2	5	15
87	22KE1A4487	KESARI NAVYA SIRISHA	1.5	2.5	2.5	2.5	5	14	3	5	22
88	22KE1A4488	KATTA ABHINAYA	2	2	2.5	2.5	4	13	4	5	22
89	22KE1A4489	KANUGULA ISWARYA	1	1.5	2.5	2	5	12	2	5	19
90	22KE1A4490	KASARAPU HARITHA	2.5	2	2.5	2.5	5	14	3	5	22
91	22KE1A4491	SHAIK MASTHANBI	2	2	2.5	0	5	11	4	5	20
92	22KE1A4492	KAMBHAMPATI VANAJA	2.5	2.5	0.5	2	5	12	2	5	19
93	22KE1A4493	KARNA VENKATA SAI ELESWARI REDDY	2.5	2.5	2.5	2.5	5	15	3	5	23
94	22KE1A4494	KANDLAKUNTA ASWINI	2	1.5	2.5	1	4	11	3	5	19
95	22KE1A4495	SHANKARSETTI SAI SREEJA	2	1.5	2.5	1	5	12	3	5	20
96	22KE1A4496	SUNKARA SAI NAMITHA	2	2.5	2.5	2.5	5	14	3	5	22
97	22KE1A4497	SUREPALLI HEMALATHA	2.5	2.5	2.5	1.5	5	14	3	5	22
98	22KE1A4498	THATIKONDA MOUNIKA	1.5	0	2.5	0	5	9	3	5	17
99	22KE1A4499	THIPPIREDDY GAYATHRI	2.5	1.5	2.5	2	5	13	2	5	20
100	22KE1A44A0	THOTA SRAVANI	2.5	2.5	2.5	1.5	5	14	4	5	23
101	22KE1A44A1	THUMU DEVIKA LAKSHMI	2	2.5	2.5	2.5	5	14	3	5	12
102	22KE1A44A2	UPPALAPATI PAVANI	2.5	1.5	2.5	2.5	3	12	3	5	20
103	22KE1A44A3	VADDEMGUNTA POOJA DEVI	2	2	2.5	2.5	4	13	6	5	24
104	22KE1A44A4	VALETI HARSHINI	2.5	2.5	2.5	2.5	5	15	2	5	22
105	22KE1A44A5	VEERAMREDDY KEERTHIREDDY	1.5	2.5	1.5	2.5	3	11	2	5	18
106	22KE1A44A6	VUTUKURI VENKATA SATYA SAI ROSHNI	2.5	2.5	2.5	2.5	5	15	3	5	23
107	22KE1A44A7	YARRAGOPU KESIYANJALI	2	1	2.5	1	4	10	3	5	18
108	22KE1A44A8	YAMPARALA RAJYALAKSHMI	1	2.5	2	1.5	4	11	4	5	20
109	22KE1A44A9		2.5	2.5	2.5	2.5	5	15	4	5	24

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		MAMILLAPALLI LALITHA									
110	22KE1A44B0	YARRA ANUSHA	2.5	2.5	2.5	2.5	4	14	2	5	21
111	22KE1A44B1	YERRIBOINA VAISHNAVI	1.5	2	2.5	1	3	10	3	5	18
112	22KE1A44B2	YERRIBOYINA JAHNAVI	2.5	2.5	2.5	2.5	3	13	3	5	21
113	22KE1A44B3	SOMAROUTHU LIKHITA	2.5	2.5	2.5	2.5	5	15	4	5	24
114	22KE1A44B4	TIRUVEEDHI NAVYA	2.5	2.5	2.5	2.5	5	15	4	5	24
115	22KE1A44B5	DEVINENI VENKATA TRIVENI	2	2.5	2.5	2	5	14	3	5	22

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COURSE:MATHEMATICS-I	DEGREE: B.Tech(CSE-DS)
COURSE CODE: C102	YEAR: I SEMESTER: I
REGULATION: R20	COURSE TYPE: REGULAR
ACADEMIC YEAR: 2022-23	CREDITS: 3

ADVANCED LEARNERS FOR MID-I EXAMINATION

S.NO	ROLL.NO	NAME OF THE STUDENT	MARKS	GRADE
1	22KE1A4401	ALLAKUNTA NAGA PALLAVI	20	AL
2	22KE1A4402	ALOKAM SAHITHI PRIYA	23	AL
3	22KE1A4403	AMARA SREEJA	25	AL
4	22KE1A4404	ANNAVARAPU HARITHA	23	AL
5	22KE1A4405	ARE NAVYA	24	AL
6	22KE1A4406	BELLAMKONDA ANN MARY	24	AL
7	22KE1A4407	BANDI MOUNIKA	24	AL
8	22KE1A4409	AVULA NAGA SRI	24	AL
9	22KE1A4410	BANGARU LAKSHMI TIRUPATHAMMA	18	AL
10	22KE1A4411	BATTULA ANUSHA	22	AL
11	22KE1A4412	BATTULA LAKSHMI JYOTHIKA	21	AL
12	22KE1A4413	ATHMAKURI DEEPTHI VENKATA SOWMYA	20	AL
13	22KE1A4414	BIKKI INDHU	22	AL
14	22KE1A4416	CHAGANTI PRASANNA	21	AL
15	22KE1A4417	GOTTIPATI SRAVANA SANDHYA	24	AL
16	22KE1A4418	CHANDOLU SRAVANI	23	AL
17	22KE1A4419	CHEBROLU SOWMYA	22	AL
18	22KE1A4420	KOTHAMASU VYSHNAVI	23	AL
19	22KE1A4421	KOVI CHETANA	23	AL
20	22KE1A4422	CHINTHALA BHAGYALAKSHMI	24	AL
21	22KE1A4424	MUPPARAJU ANUSHA	23	AL
22	22KE1A4425	MANDALAPU LOKA PUJITHA	24	AL

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23	22KE1A4426	GALLA VIJAYALAKSHMI	24	AL
24	22KE1A4427	GORANTLA RAMYA	23	AL
25	22KE1A4428	GORANTLA SRAVANTHI	26	AL
26	22KE1A4429	NARIPEDDI UMAMAHESWARI	22	AL
27	22KE1A4430	GRANDHI THRIVENI	20	AL
28	22KE1A4431	POPURI VENU SRI	22	AL
29	22KE1A4432	PAVULURI MEGHANA	26	AL
30	22KE1A4433	PARUCHURI MANEESHA	24	AL
31	22KE1A4434	KAKUMANU SRI VIDYA	23	AL
32	22KE1A4435	RUDRAPATI MEGHANA	20	AL
33	22KE1A4436	SHAIK NAZMA BEGUM	21	AL
34	22KE1A4437	SHAIK GULLAPALLI SAHIRA BANU	22	AL
35	22KE1A4438	SHAIK SOFIYA YASMEEN	23	AL
36	22KE1A4439	SHAIK HAPSA	20	AL
37	22KE1A4441	SHAIK KARISHMA	21	AL
38	22KE1A4442	KAMINENI SRAVYA VYSHNAVI	22	AL
39	22KE1A4445	KOLA SNEHA LATHA	19	AL
40	22KE1A4446	KONDRU DEEPIKA	24	AL
41	22KE1A4448	KOTHA VANI AKSHITHA	21	AL
42	22KE1A4450	MAKKENA BHARGAVI	19	AL
43	22KE1A4451	KOYA DEVIKA CHOWDARY	19	AL
44	22KE1A4452	KUPPALA POOJITHA	23	AL
45	22KE1A4453	KURIYALA ABHINAYA	23	AL
46	22KE1A4454	GADDE SAI SREE	19	AL
47	22KE1A4455	MADDELA VENKATA KARISHMA	20	AL
48	22KE1A4456	MAGULURI PADMAVATHI	24	AL
49	22KE1A4457	YARLAGADDA PUSHYA	24	AL
50	22KE1A4458	MANTRI BABY SRI VALLI	23	AL
51	22KE1A4459	MULLA KHADAR AFISA EFAATH	22	AL
52	22KE1A4460	ELURI SAI DHATRI	19	AL
53	22KE1A4461	MUTHINENI HARIKA	24	AL
54	22KE1A4462	NAGASURI DIVYA SREE	22	AL
55	22KE1A4463	NALABOTHU VIJAYALAKSHMI	22	AL
56	22KE1A4465	NANDIPATI VENKATA LAKSHMI	20	AL

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		PRASANTHI		
57	22KE1A4466	CHALLAGUNDLA AMRUTHA NAGA PAVANI	23	AL
58	22KE1A4467	NISSANKARARAO SANGEETHA	22	AL
59	22KE1A4468	OGETI TRIVENI	21	AL
60	22KE1A4469	PADMAVATHI PADHI	21	AL
61	22KE1A4470	PAINEDI LAHARI	23	AL
62	22KE1A4471	PALAKEETI SRILAKSHMI	21	AL
63	22KE1A4472	PALLAPU AKHILA	20	AL
64	22KE1A4473	JALE BANGARU	19	AL
65	22KE1A4474	PASUPULETI USHA RANI	22	AL
66	22KE1A4475	GUTTA SRILAKSHMI	23	AL
67	22KE1A4476	GUNTUPALLI DHANALAKSHMI	23	AL
68	22KE1A4478	RAMISETTI PUJITHA	19	AL
69	22KE1A4480	RAYIDI NAVYA SRI	23	AL
70	22KE1A4481	REDDY SANDYA RANI	19	AL
71	22KE1A4482	REVU ALEKHYA	21	AL
72	22KE1A4487	KESARI NAVYA SIRISHA	22	AL
73	22KE1A4488	KATTA ABHINAYA	22	AL
74	22KE1A4489	KANUGULA ISWARYA	19	AL
75	22KE1A4490	KASARAPU HARITHA	22	AL
76	22KE1A4491	SHAIK MASTHANBI	20	AL
77	22KE1A4492	KAMBHAMPATI VANAJA	19	AL
78	22KE1A4493	KARNA VENKATA SAI ELESWARI REDDY	23	AL
79	22KE1A4494	KANDLAKUNTA ASWINI	19	AL
80	22KE1A4495	SHANKARSETTI SAI SREEJA	20	AL
81	22KE1A4496	SUNKARA SAI NAMITHA	22	AL
82	22KE1A4497	SUREPALLI HEMALATHA	22	AL
83	22KE1A4499	THIPPIREDDY GAYATHRI	20	AL
84	22KE1A44A0	THOTA SRAVANI	23	AL
85	22KE1A44A1	THUMU DEVIKA LAKSHMI	22	AL
86	22KE1A44A2	UPPALAPATI PAVANI	20	AL
87	22KE1A44A3	VADDEMGUNTA POOJA DEVI	24	AL
88	22KE1A44A4	VALETI HARSHINI	22	AL

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89	22KE1A44A5	VEERAMREDDY KEERTHIREDDY	18	AL
90	22KE1A44A6	VUTUKURI VENKATA SATYA SAI ROSHNI	23	AL
91	22KE1A44A7	YARRAGOPU KESIYANJALI	18	AL
92	22KE1A44A8	YAMPARALA RAJYALAKSHMI	20	AL
93	22KE1A44A9	MAMILLAPALLI LALITHA	24	AL
94	22KE1A44B0	YARRA ANUSHA	21	AL
95	22KE1A44B1	YERRIBOINA VAISHNAVI	18	AL
96	22KE1A44B2	YERRIBOYINA JAHNAVI	21	AL
97	22KE1A44B3	SOMAROUTHU LIKHITA	24	AL
98	22KE1A44B4	TIRUVEEDHI NAVYA	24	AL
99	22KE1A44B5	DEVINENI VENKATA TRIVENI	22	AL

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COURSE:MATHEMATICS-I	DEGREE: **B.Tech(CSE-DS)**
COURSE CODE: C102	YEAR: I SEMESTER: I
REGULATION: R20	COURSE TYPE: **REGULAR**
ACADEMIC YEAR: 2022-23	CREDITS: **3**

SLOW LEARNERS FOR MID-I EXAMINATION

S.NO	ROLL.NO	NAME OF THE STUDENT	MARKS	GRADE
1	22KE1A4408	BANDARUPALLI POOJITHA	16	SL
2	22KE1A4415	BOTLA KALYANI	14	SL
3	22KE1A4423	ELASAGAR TRIVENI	17	SL
4	22KE1A4440	SHAIK SHAMEERA	16	SL
5	22KE1A4443	SHAIK FARHANA	17	SL
6	22KE1A4444	KILARI RAMYA	16	SL
7	22KE1A4447	KOTA BHAVYA	17	SL
8	22KE1A4449	CHINNABOYINA LATHA	15	SL
9	22KE1A4464	NAMBURI MONAPRIYANJALI	17	SL
10	22KE1A4477	PUTTA BHARGAVI	17	SL
11	22KE1A4479	RANGINENI POOJITHA	16	SL
12	22KE1A4483	KAMBHAMPATI ANURADHA	17	SL
13	22KE1A4484	SAGAMREDDY THEERDHA PRASANNA LAKSHMI	17	SL
14	22KE1A4485	SANDU SNEHA SUMA	16	SL
15	22KE1A4486	SARVANI SIMHADRI	15	SL
16	22KE1A4498	THATIKONDA MOUNIKA	17	SL

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Date: 20-12-2022

From
R.NAGA SAI LAKSHMI
Asst.Professor,
Department of S and H
MLWEC

To,
The Head of the Department,
SCIENCE AND HUMANITIES
MLWEC.

Sub: Permission to conduct remedial classes to I –DS(I-SEM) students.

Respected Sir,

I have identified following students as slow learners for **MATHEMATICS-I**course based on the slip test conducted for I-DS(1-SEM) students. In this regard I request you to grant permission to conduct **REMEDIAL CLASSES** for the enclosed list of students as per the schedule given below.

S.No	Day	Time
1	Monday	3.00 pm to 3.50 pm
2	Tuesday	3.00 pm to 3.50 pm
3	Wednesday	3.00 pm to 3.50 pm
4	Thursday	3.00 pm to 3.50 pm
5	Friday	3.00 pm to 3.50 pm

Thanking you sir,

Yours Sincerely,
R.NAGA SAI LAKSHMI

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List of Slow Learners for MATHEMATICS-I in I B.Tech (DS)

S.NO	ROLL.NO	NAME OF THE STUDENT	MARKS	GRADE
1	22KE1A4408	BANDARUPALLI POOJITHA	16	SL
2	22KE1A4415	BOTLA KALYANI	14	SL
3	22KE1A4423	ELASAGAR TRIVENI	17	SL
4	22KE1A4440	SHAIK SHAMEERA	16	SL
5	22KE1A4443	SHAIK FARHANA	17	SL
6	22KE1A4444	KILARI RAMYA	16	SL
7	22KE1A4447	KOTA BHAVYA	17	SL
8	22KE1A4449	CHINNABOYINA LATHA	15	SL
9	22KE1A4464	NAMBURI MONAPRIYANJALI	17	SL
10	22KE1A4477	PUTTA BHARGAVI	17	SL
11	22KE1A4479	RANGINENI POOJITHA	16	SL
12	22KE1A4483	KAMBHAMPATI ANURADHA	17	SL
13	22KE1A4484	SAGAMREDDY THEERDHA PRASANNA LAKSHMI	17	SL
14	22KE1A4485	SANDU SNEHA SUMA	16	SL
15	22KE1A4486	SARVANI SIMHADRI	15	SL
16	22KE1A4498	THATIKONDA MOUNIKA	17	SL

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Date: 23-12-2022

CIRCULAR

It is observed that the following are the slow learners in I-DS (I-Sem) in**M-I**Remedial classes are scheduled for the weak learners from 26-12-2022 - 30-12-2022.(3.00 to 3.50) Hence the following students should attend the remedial classes regularly.

S.NO	ROLL.NO	NAME OF THE STUDENT	MARKS	GRADE
1	22KE1A4408	BANDARUPALLI POOJITHA	16	SL
2	22KE1A4415	BOTLA KALYANI	14	SL
3	22KE1A4423	ELASAGAR TRIVENI	17	SL
4	22KE1A4440	SHAIK SHAMEERA	16	SL
5	22KE1A4443	SHAIK FARHANA	17	SL
6	22KE1A4444	KILARI RAMYA	16	SL
7	22KE1A4447	KOTA BHAVYA	17	SL
8	22KE1A4449	CHINNABOYINA LATHA	15	SL
9	22KE1A4464	NAMBURI MONAPRIYANJALI	17	SL
10	22KE1A4477	PUTTA BHARGAVI	17	SL
11	22KE1A4479	RANGINENI POOJITHA	16	SL
12	22KE1A4483	KAMBHAMPATI ANURADHA	17	SL
13	22KE1A4484	SAGAMREDDY THEERDHA PRASANNA LAKSHMI	17	SL
14	22KE1A4485	SANDU SNEHA SUMA	16	SL
15	22KE1A4486	SARVANI SIMHADRI	15	SL
16	22KE1A4498	THATIKONDA MOUNIKA	17	SL

R.N. [signature]
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REMEDIAL CLASS ATTENDANCE

STUDENTS DETAILS:

S.NO	ROLL.NO	NAME OF THE STUDENT	DATE 26-12-22	DATE 27-12-22	DATE 28-12-22	DATE 29-12-22	DATE 30-12-22
1	22KE1A4408	BANDARUPALLI POOJITHA	B.poojitha	B.poojitha	B.poojitha	B.poojitha	B.poojitha.
2	22KE1A4415	BOTLA KALYANI	B.Kalyani	A	B.Kalyani	B.Kalyani	B.Kalyani
3	22KE1A4423	ELASAGAR TRIVENI	E.Triveni	E.Triveni	E.Triveni	E.Triveni	A
4	22KE1A4440	SHAIK SHAMEERA	S	S	S	A	S
5	22KE1A4443	SHAIK FARHANA	Fa	Fa	Fa	Fa	Fa
6	22KE1A4444	KILARI RAMYA	P	A	P	P	P
7	22KE1A4447	KOTA BHAVYA	K.Bhavya	K.Bhavya	K.Bhavya	K.Bhavya	K.Bhavya
8	22KE1A4449	CHINNABOYINA LATHA	Ch.Latha	Ch.Latha	A	Ch.Latha	Ch.Latha
9	22KE1A4464	NAMBURI MONAPRIYANJALI	N.Mona	N.Mona	N.Mona	N.Mona	N.Mona
10	22KE1A4477	PUTTA BHARGAVI	P.Bha	P.Bha	P.Bha	P.Bha	P.Bha
11	22KE1A4479	RANGINENI POOJITHA	Pooji	Pooji	Pooji	Pooji	Pooji
12	22KE1A4483	KAMBHAMPATI ANURADHA	K.An	K.An	K.An	A	K.An
13	22KE1A4484	SAGAMREDDY THEERDHA PRASANNA LAKSHMI	A	P	P	P	P
14	22KE1A4485	SANDU SNEHA SUMA	SS	SS	SS	SS	SS
15	22KE1A4486	SARVANI SIMHADRI	S.Simhadri	S.Simhadri	S.Simhadri	A	S.Simhadri
16	22KE1A4498	THATIKONDA MOUNIKA	Mavk	M	M	M	M

R.N.Sankar

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Subject Name : MATHEMATICS-I
Faculty Name : R.NAGA SAI LAKSHMI
Academic Year : 2022-23& I- Semester

S.No.	Name of the Subject	Topics Covered	Name of the Faculty	Date	No. of Students attended
1	Mathematics I	1. Mean value theorems	R.NAGA SAI LAKSHMI	26-12-22	15
		2. linear differential eqns		27-12-22	13
		3. Bernaulli's eqn & newton's law of cooling		28-12-22	15
		4. Exact eqns & non exact		29-12-22	12
		5. Homogeneous and non-homogeneous eqns of higher order		30-12-22	15

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R.NS Lakshmi
Faculty In-Charge

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ASSAIGNMENT-II

COURSE: **MATHEMATICS-I**	DEGREE: **B.Tech**
COURSE CODE: C102	YEAR: I SEMESTER: I
REGULATION: **R20**	COURSE TYPE: **REGULAR**
ACADEMIC YEAR: **2022-23**	CREDITS: **3**

Name of the Course Coordinator/Advisor: **Max Marks: 5**

Q.No.	Solution	Marks Allotted	Course Outcome mapping	Taxonomy level
1	Determine wether the functions U $=\frac{X}{Y-Z}$, V $=\frac{Y}{Z-X}$, W $=\frac{Z}{X-Y}$ are dependent. If Dependent find the relation between them	1	CO2	Apply
2	Find the extreme values of $f(x,y)=x^3+3xy^2-15x^2+72x-15y^2$	1	CO2	Apply
43	Evaluate $\int_0^1\int_x^{\sqrt{x}} x^2\, y^2(x+y)\,dy\,dx$	1	CO1	Apply
64	Evaluate $\int_0^1\int_0^{1-x}\int_0^{1-x-y} dx\,dy\,dz$	1	CO2	Remember

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SCHEMEOFEVALUATION–ASSAIGNMENT-II

COURSE:**MATHEMATICS-I**	DEGREE:**B.Tech**
COURSECODE:**C112**	YEAR:I SEMESTER:I
REGULATION:**R20**	COURSETYPE:**REGULAR**
ACADEMICYEAR:2022-23	CREDITS:3

Name oftheCourseCoordinator/Advisor:DrP.Srilakshmi **MaxMarks:5**

Q.No.	Solution	Marks Allotted	Course Outcome mapping	Taxonomy level
1	DeterminewetherthefunctionsU=$\frac{x}{y-z}$, V=$\frac{y}{z-x}$,W=$\frac{z}{x-y}$ aredependent.If Dependentfindtherelationbetweenthem	1.5	C112.4	Apply
2	Findtheextremevaluesof $f(x,y)=x^3+3xy^2-15x^2+72x-15y^2$	1.5	C112.4	Apply
3	Evaluate$\int_0^1\int_x^{\sqrt{x}} x^2y^2(x+y)\,dydx$	1	C112.5	Evaluate
4	Evaluate$\int_0^1\int_0^{1-x}\int_0^{1-x-y} dxdydz$	1	C112.5	Evaluate

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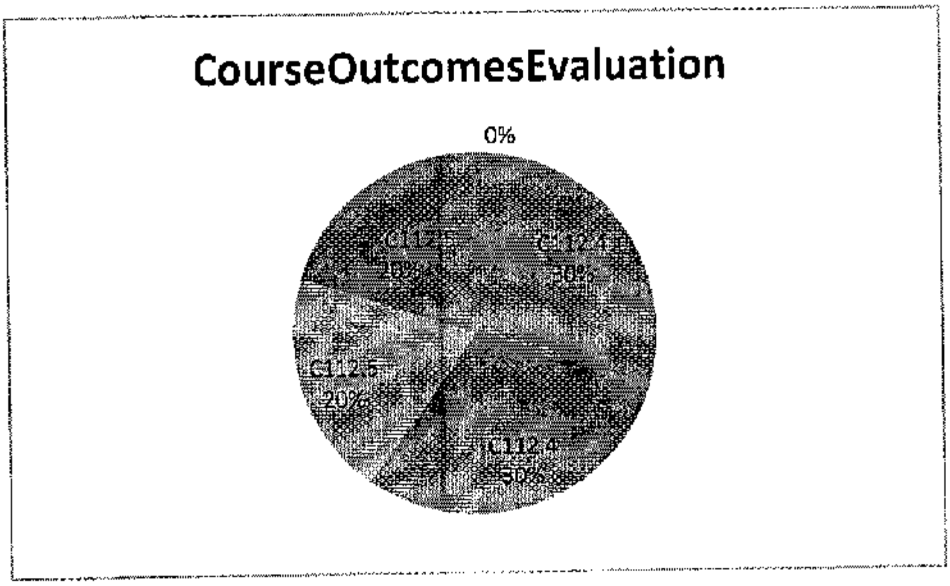
Course Outcome Number	Marks Allotted	Percentage of Marks	Taxonomy level	Marks Allotted	Percentageof Marks
C112.4	1.5	30	Remember		
C112.4	1.5	30	Understand		
C112.5	1	20	Apply	3	60
C112.5	1	20			
			Analyze		
			Evaluate	2	40
			Create		
Total Marks	5	100	TotalMarks	5	100



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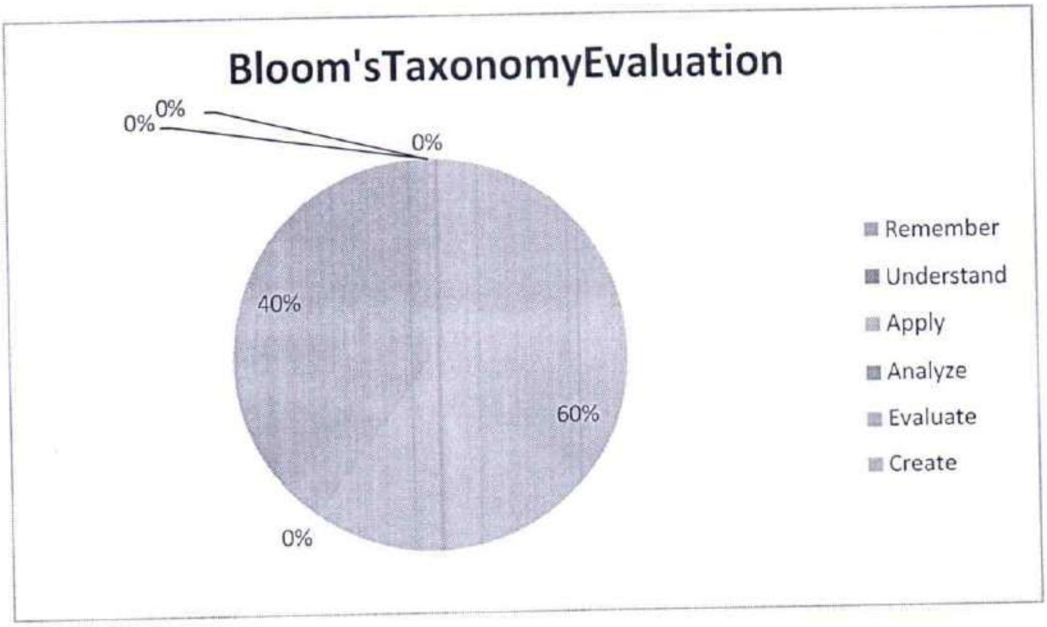

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MATHS ASSIGNMENT-2

NAME : SHAIK·NAZMA BEGUM

BRANCH : CSD

ROLL NO : 22KE1A4436

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1) Evaluate $\int_0^1 \int_x^{\sqrt{x}} x^2 y^2 (x+y)\, dy\, dx$

Sol:

Given, $\int_0^1 \int_x^{\sqrt{x}} x^2 y^2 (x+y)\, dy\, dx$

$= \int_0^1 x^2 \int_x^{\sqrt{x}} (xy^2 + y^3)\, dy\, dx$

$= \int_0^1 x^2 \left[\frac{xy^3}{3} + \frac{y^4}{4} \right]_x^{\sqrt{x}} dx$

$= \int_0^1 x^2 \left[\frac{x(\sqrt{x})^3}{3} + \frac{(\sqrt{x})^4}{4} - \frac{x(x)^3}{3} + \frac{(x)^4}{4} \right] dx$

$= \int_0^1 x^2 \left[\frac{x(x^{1/2})^3}{3} + \frac{(x^{1/2})^{4/2}}{4} - \frac{x^4}{3} + \frac{x^4}{4} \right] dx$

$= \int_0^1 x^2 \left[\frac{x^{5/2}}{3} + \frac{x^2}{4} - \frac{x^4}{3} + \frac{x^4}{4} \right] dx$

$= \int_0^1 x^2 \left[\frac{1}{3} x^{5/2} + \frac{1}{4} x^2 - \frac{1}{3} x^4 + \frac{1}{4} x^4 \right] dx$

$= \int_0^1 \left[\frac{1}{3} x^{9/2} + \frac{1}{4} x^4 - x^6 \left(\frac{1}{3} + \frac{1}{4} \right) \right] dx$

$= \int_0^1 \left[\frac{1}{3} x^{9/2} + \frac{1}{4} x^4 - \frac{7}{12} x^6 \right] dx$

$= \int_0^1 \left[\frac{1}{3} x^{9/2} + \frac{1}{4} x^4 - \frac{7}{12} x^6 \right] dx$

$= \left. \frac{1}{3} \times \frac{2}{11} x^{11/2} + \frac{1}{5} \times \frac{1}{4} x^5 - \frac{\cancel{7}}{12} \times \frac{1}{\cancel{7}} x^7 \right]_0^1$

$= \left. \frac{2}{33} x^{11/2} + \frac{1}{20} x^5 - \frac{1}{12} x^7 \right]_0^1$

$= \frac{2}{33} + \frac{1}{20} - \frac{1}{12} = \frac{18}{660}$

2) Determine whether the functions $u = \frac{x}{y-z}$, $v = \frac{y}{z-x}$, $w = \frac{z}{x-y}$ are dependent. If dependent find the relationship between them.

Sol:- $u = \frac{x}{y-z}$; $v = \frac{y}{z-x}$; $w = \frac{z}{x-y}$.

$u_x = \frac{1}{y-z}$; $v_x = \frac{y}{(z-x)^2}$; $w_x = \frac{-z}{(x-y)^2}$

$u_y = \frac{-x}{(y-z)^2}$; $v_y = \frac{1}{z-x}$; $w_y = \frac{z}{(x-y)^2}$

$u_z = \frac{x}{(y-z)^2}$; $v_z = \frac{-y}{(z-x)^2}$; $w_z = \frac{1}{x-y}$

By Jacobian's series, the expansion of

$$\frac{\partial(u,v,w)}{\partial(x,y,z)} = \begin{vmatrix} u_x & u_y & u_z \\ v_x & v_y & v_z \\ w_x & w_y & w_z \end{vmatrix} = \begin{vmatrix} \frac{1}{y-z} & \frac{-x}{(y-z)^2} & \frac{x}{(y-z)^2} \\ \frac{y}{(z-x)^2} & \frac{1}{z-x} & \frac{-y}{(z-x)^2} \\ \frac{-z}{(x-y)^2} & \frac{z}{(x-y)^2} & \frac{1}{x-y} \end{vmatrix}$$

$$= \frac{1}{y-z}\left[\frac{1}{z-x}\left(\frac{1}{x-y}\right) + \frac{y}{(z-x)^2}\left(\frac{z}{(x-y)^2}\right)\right] + \frac{x}{(y-z)^2}\left[\frac{y}{(z-x)^2}\left(\frac{1}{x-y}\right) - \frac{y}{(z-x)^2}\left(\frac{z}{(x-y)^2}\right)\right] + \frac{x}{(y-z)^2}\left[\frac{y}{(z-x)^2}\left(\frac{z}{(x-y)^2}\right) + \frac{1}{z-x}\left(\frac{z}{(x-y)^2}\right)\right]$$

$$= \frac{1}{y-z}\left[\frac{1}{(z-x)(x-y)} + \frac{yz}{(z-x)^2(x-y)^2}\right] + \frac{x}{(y-z)^2}\left[\frac{y}{(z-x)^2(x-y)} - \frac{yz}{(z-x)^2(x-y)^2}\right] + \frac{x}{(y-z)^2}\left[\frac{yz}{(z-x)^2(x-y)^2} + \frac{z}{(z-x)(x-y)}\right]$$

$$= \frac{1}{(x-y)(y-z)(z-x)} + \frac{yz}{(x-y)^2(y-z)(z-x)^2} + \frac{xy}{(x-y)(y-z)^2(z-x)^2} - \frac{xyz}{(x-y)^2(y-z)^2(z-x)^2} + \frac{xyz}{(y-z)^2(z-x)^2(x-y)^2} + \frac{xz}{(x-y)^2(y-z)^2(z-x)}$$

(2) $= \dfrac{1}{(x-y)^2(y-z)^2(z-x)^2}\left[(x-y)(y-z)(z-x) + yz(y-z) + xy(x-y) - x\cancel{y}z + x\cancel{y}z + xz(z-x)\right]$

$= \dfrac{1}{(x-y)^2(y-z)^2(z-x)^2}\left[xy - zx - y^2 + yz(z-x) + y^2z - yz^2 + x^2y - xy^2 + xz^2 - x^2z\right]$

$= \dfrac{1}{(x-y)^2(y-z)^2(z-x)^2}\left[\cancel{xyz} - \cancel{xz^2} - \cancel{y^2z} - \cancel{xyz} + \cancel{y^2z} - \cancel{yz^2} + \cancel{x^2y} - \cancel{xy^2} + \cancel{xz^2} - \cancel{x^2z}\right]$

$= \dfrac{1}{(x-y)^2(y-z)^2(z-x)^2}(0)$

$= 0$

$\therefore$ The relationship between them is $uv + vw + wu = 0$

$= uv + vw + wu$

$= \dfrac{x}{y-z}\left(\dfrac{y}{z-x}\right) + \dfrac{y}{z-x}\left(\dfrac{z}{x-y}\right) + \dfrac{z}{x-y}\left(\dfrac{x}{y-z}\right)$

$= \dfrac{xy}{(y-z)(z-x)} + \dfrac{yz}{(z-x)(x-y)} + \dfrac{zx}{(x-y)(y-z)}$

$= \dfrac{xyz}{(x-y)(y-z)(z-x)}\left[z(x-y) + x(y-z) + y(z-x)\right]$

$= \dfrac{xyz}{(x-y)(y-z)(z-x)}\left[\cancel{zx} - \cancel{yz} + \cancel{xy} - \cancel{xz} + \cancel{yz} - \cancel{xy}\right]$

$= \dfrac{xyz}{(x-y)(y-z)(z-x)}(0)$

$= 0$

3) Find the extreme values of the function $f(x,y) = x^3+3xy^2-15x^2+72x-15y^2$

Sol: Given, $f(x,y) = x^3+3xy^2-15x^2+72x-15y^2$

Evaluate, $p = \frac{\partial f}{\partial x}$, $q = \frac{\partial f}{\partial x}$, $r = \frac{\partial^2 f}{\partial x^2}$, $s = \frac{\partial^2 f}{\partial x \partial y}$, $t = \frac{\partial^2 f}{\partial y^2}$

$p = \frac{\partial f}{\partial x} = 3x^2+3y^2-30x+72$

$q = \frac{\partial f}{\partial y} = 6xy-30y$

$r = \frac{\partial^2 f}{\partial x^2} = 6x-30$

$s = \frac{\partial^2 f}{\partial x \partial y} = 6y$

$t = \frac{\partial^2 f}{\partial y^2} = 6x-30$

To find stationary points

Evaluate $p=0$ & $q=0$

$p = 3x^2+3y^2-30x+72 = 0$

$3(x^2+y^2-10x+24) = 0$

$x^2+y^2-10x+24 = 0$ — ②

$q = 6xy-30y = 0$

$6y(x-5) = 0$

$\boxed{y=0}$ $\boxed{x=5}$

From ②

$x=5$, $x^2+y^2-10x+24=0$

$25+y^2-10(5)+24=0$

$y^2-1=0$

$\boxed{y=\pm 1}$

; $y=0$ $x^2+y^2-10x+24=0$

$x^2+0-10x+24=0$

$x^2-10x+24=0$

$x^2-4x-6x+24=0$

$x(x-4)-6(x-4)=0$

$(x-4)(x-6)=0$

$\boxed{x=4}$ $\boxed{x=6}$

A(5,1) B(6,−1) C(4,0) D(6,0)

A(5,1)

$r = 6x-30 = 6(x-5) = 0$

$s = 6y = 6(1) = 6$

$t = 6x-30 = 0$

B(5,−1)

$r = 6x-30 = 0$

$s = 6y = -6$

$t = 6x-30 = 0$

C(4,0)

$r = 6x-30 = -6$

$s = 6y = 0$

$t = 6x-30 = -6$

D(6,0)

$r = 6x-30 = 6$

$s = 6y = 0$

$t = 6x-30 = 6$

To find maximum & minimum value of $f(x,y)$

At A(5,1)

If $rt-s^2 = 0-6^2 = -36 < 0$ & $r=0$

If $rt-s^2 < 0$ and $r=0$ then it is

$f(x,y)$ is saddle point at A(5,1)

	A(5,1)	B(6,−1)	C(4,0)	D(6,0)
r	0	0	−6	6
s	6	−6	0	0
t	0	0	−6	6

(3) At $B(5,-1)$

If $rt-s^2 = 0-(-6)^2 = -36 < 0$ & $r=0$

$f(x,y)$ is saddle point at $B(5,-1)$

At $C(4,0)$

If $rt-s^2 = 36-0 = 36 > 0$ & $r = -6 < 0$

$f(x,y)$ has maximum value at $C(4,0)$

from ①

$f(x,y) = x^3+3xy^2-15x^2-15y^2+72x$

$f(4,0) = 4^3+3(4)(0)-15(4)^2-15(0)+72(4)$

$= 64+288-240$

$= 112$

At $D(6,0)$

If $rt-s^2 = 36-0 = 36 > 0$ & $r = 6 > 0$

$f(x,y)$ has minimum value at $D(6,0)$

from ①

$f(x,y) = x^3+3xy^2-15x^2-15y^2+72x$

$f(6,0) = (6)^3+3(6)(0)-15(6)^2-15(0)+72(6)$

$= 108$

4) Evaluate $\int_0^1 \int_0^{1-x} \int_0^{1-x-y} dx\,dy\,dz$

Sol:- Given, $\int_0^1 \int_0^{1-x} \int_0^{1-x-y} dx\,dy\,dz$

$= \int_0^1 \int_0^{1-x} \int_0^{1-x-y} dz\,dy\,dx$

$= \int_0^1 \int_0^{1-x} (1-x-y)\,dy\,dx$

$= \int_0^1 \left[y - xy - \frac{y^2}{2} \right]_0^{1-x} dx$

$$= \int_0^1 (1-x) - x(1-x) - \frac{(1-x)^2}{2}\,dx$$

$$= \int_0^1 (1-x-x+x^2) - \frac{(1-x)^2}{2}\,dx$$

$$= \int_0^1 (1-2x+x^2) - \frac{(1-x)^2}{2}\,dx$$

$$= \int_0^1 (1-x)^2 - \frac{(1-x)^2}{2}\,dx$$

$$= \frac{1}{2}\int_0^1 (1-x)^2\,dx$$

$$= \frac{1}{2} \left.\frac{(1-x)^3}{-3}\right]_0^1$$

$$= \frac{-1}{6}\left[(1-x)^3\right]_0^1$$

$$= \frac{-1}{6}\left[(1-1)-(1-0)\right]$$

$$= \frac{-1}{6}\left[0-1\right]$$

$$= \frac{-1}{6}(-1)$$

$$= 1/6$$

MALINENI LAKSHMAIAH WOMEN'S ENGINEERING COLLEGE

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(An ISO9001:2008 Certified Institution)

Pulladigunta (Village), Vatticherukuru (Mandal),

Guntur-522017, Andhra Pradesh, India

Department of Science and Humanities

SCHEME OF EVALUATION – MID II EXAMINATION

COURSE : **MATHEMATICS-I**	DEGREE/ BRANCH : **B.Tech/DS**
COURSE CODE: **C102**	YEAR: **I** SEMESTER: **I**
REGULATION: **R20**	COURSE TYPE: **REGULAR**
ACADEMIC YEAR : **2022-23**	CREDITS: **3**

Date: 03/02/23 **Max Marks:15**

Q.NO.	QUESTION	MARKS ALLOTTED	COURSE OUTCOME MAPPING	BLOOM'S TAXONOMY LEVEL
1.	a) Solve $(D^2+4)y = \tan 2x$, by the method of variation of parameters b) Solve $(x+1)^2 \frac{d^2y}{dx^2} + (x+1)\frac{dy}{dx} + y = \sin(2\log(1+x))$	2.5M 2.5M	C102.3 C102.3	Apply Apply
2.	a) Expand $e^x \cos y$ by Taylor's theorem about the point $\left(1, \frac{\pi}{4}\right)$ up to the second degree terms. b) Find the extreme values of the function $f(x,y) = x^3 + 3xy^2 - 15x^2 + 72x - 15y^2$	2.5M 2.5M	C102.4 C102.4	remember apply
3.	By transforming into polar coordinates, evaluate $\iint \frac{x^2y^2}{x^2+y^2} dxdy$ over the annular region between the circles $x^2+y^2=a^2$ and $x^2+y^2=b^2$,with b>a	5M	C102.5	evaluate

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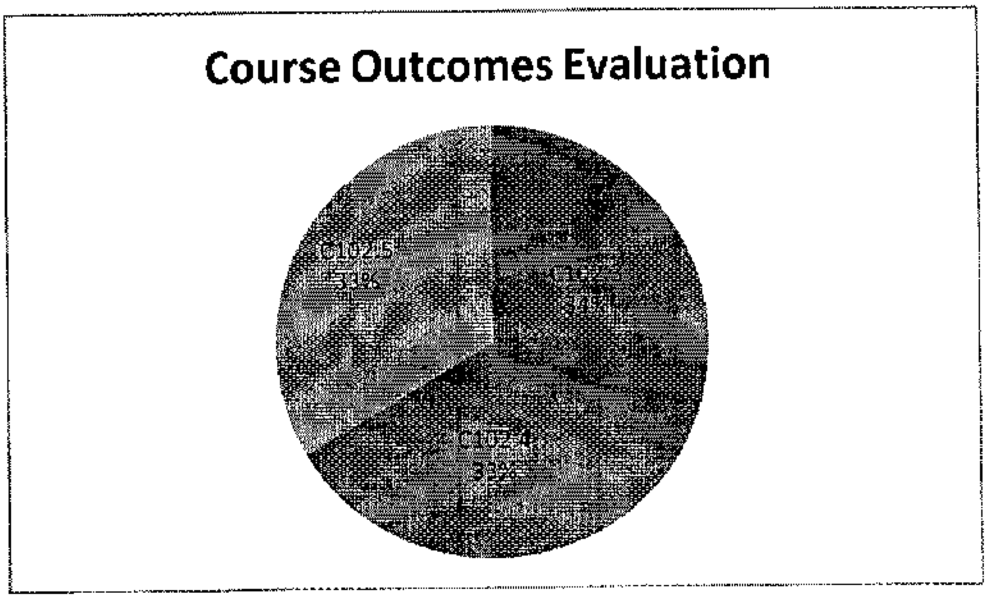
Department of Science and Humanities

Course Outcome Number	Marks Allotted	Percentage of Marks
C102.3	5	34
C102.4	5	33
C102.5	5	33
Total Marks	15	100

Taxonomy level	Marks Allotted	Percentage of Marks
Remember	2.5	17
Understand		
Apply	7.5	50
Analyze		
Evaluate	5	33
Create		
Total Marks	15	100



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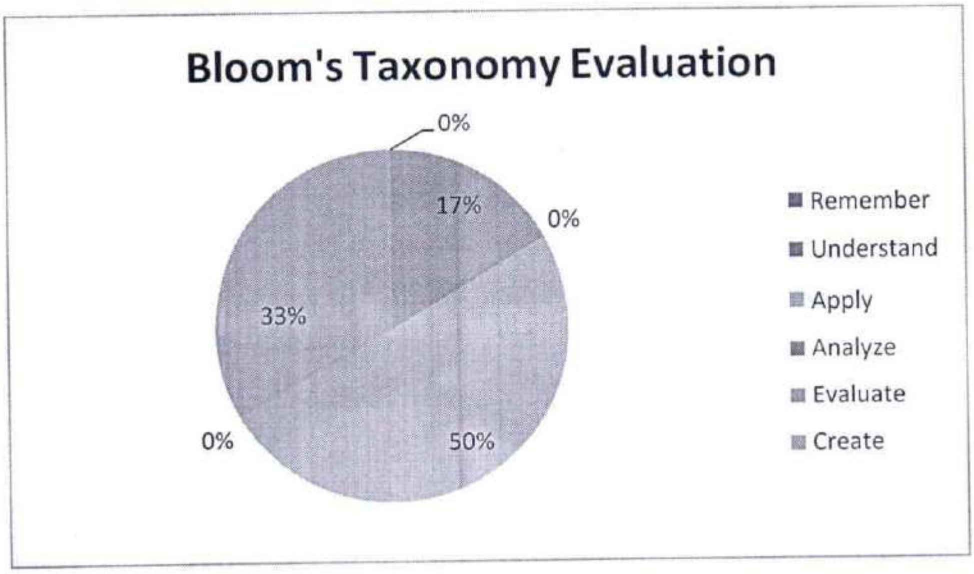

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MID-II - Key

1a) solve $(D^2+4)y = \tan 2x$, by the method of variation of Parameters

Given

$$(D^2+4)y = \tan 2x$$

To find complementary function:

The Auxillary eqn is $f(m)=0$

$$m^2+4=0$$

$$m^2=-4$$

$$m=\pm 2i$$

$$y_c = e^{0x}(c_1\cos 2x + c_2 \sin 2x)$$

$$y_c = c_1\cos 2x + c_2\sin 2x$$

$u=\cos 2x \quad v=\sin 2x \quad R=\tan 2x$

To find P.I:

$$y_p = Au+Bv$$

where $A = -\int \frac{vR}{u\frac{dv}{dx}-v\frac{du}{dx}}$, $B = \int \frac{uR}{u\frac{dv}{dx}-v\frac{du}{dx}}$

$$u\frac{dv}{dx} - v\frac{du}{dx} = \cos 2x(2\cos 2x) - \sin 2x(-2\sin 2x)$$

$$= 2\cos^2 2x + 2\sin^2 2x$$

$$= 2(\cos^2 2x + \sin^2 2x)$$

$$= 2(1)$$

$$= 2$$

$$A = -\int \frac{\sin 2x \tan 2x}{2} dx$$

$$= \frac{-1}{2}\int \sin 2x \cdot \frac{\sin 2x}{\cos 2x} dx$$

$$= \frac{-1}{2} \int \frac{\sin^2 2x}{\cos 2x} dx$$

$$= \frac{-1}{2} \int \left(\frac{1-\cos^2 2x}{\cos 2x}\right) dx$$

$$= \frac{-1}{2} \int (\sec 2x - \cos 2x) dx$$

$$= \frac{-1}{2} \left[\frac{\log(\sec 2x + \cos 2x)}{2} - \frac{\sin 2x}{2} \right]$$

$$= \frac{-1}{4} \left[\log|\sec 2x + \cos 2x| - \sin 2x \right]$$

$$A = \frac{-1}{4} \left[\log|\sec 2x + \cos 2x| - \sin 2x \right]$$

$$B = \int \frac{\cos 2x \tan 2x}{2} dx$$

$$= \frac{1}{2} \int \cos 2x \frac{\sin 2x}{\cos 2x} dx$$

$$= \frac{1}{2} \int \sin 2x dx$$

$$= \frac{1}{2} \left(-\frac{\cos 2x}{2}\right)$$

$$B = \frac{-1}{4} \cos 2x$$

$$y_p = Au + Bv$$

$$= -\frac{\cos 2x}{4} \left[\log|\sec 2x + \cos 2x| - \sin 2x \right] - \frac{\sin 2x \cos 2x}{4}$$

$$y_p = \frac{-\cos 2x}{4} \log|\sec 2x + \cos 2x| + \frac{\sin 2x \cos 2x}{4} - \frac{\sin 2x \cos 2x}{4}$$

The General sol $y = y_c + y_p$

$$y = c_1 \cos 2x + c_2 \sin 2x - \frac{\cos 2x}{4} \cdot \log|\sec 2x + \cos 2x| + \cancel{\frac{\sin 2x \cos 2x}{4}} - \cancel{\frac{\sin 2x \cos 2x}{4}}$$

$$y = c_1 \cos 2x + c_2 \sin 2x - \frac{\cos 2x}{4} \cdot \log|\sec 2x + \cos 2x|$$

1b) Solve $(x+1)^2 \frac{d^2y}{dx^2} + (x+1)\frac{dy}{dx} + y = \sin(2\log(1+x))$

Given

$$(x+1)^2 \frac{d^2y}{dx^2} + (x+1)\frac{dy}{dx} + y = \sin(2(\log(1+x))$$

$$\left[(x+1)^2 D^2 + (x+1) D + 1\right] y = \sin(2(\log(1+x))$$

put $x+1 = e^z$ $\quad \log(x+1) = z$

$(1+x^2) D^2 = \theta(\theta-1)$ $\quad (x+1)D = \theta$

$\Rightarrow (\theta(\theta-1) + \theta + 1) y = \sin(2\log(1+x))$

$\Rightarrow (\theta^2 - \theta + \theta + 1) y = \sin(2\log(1+x))$

$\Rightarrow (\theta^2+1) y = \sin(2\log(1+x))$

$\Rightarrow (\theta^2+1) y = 2\sin z$

To find CF: $f(m) = 0$

$m^2+1 = 0$ $\quad m^2 = -1$

$m = \pm i$

$y_c = (c_1 \cos z + c_2 \sin z)$

To find PI:

$$y_p = \frac{1}{f(D)} G(z)$$

$$= \frac{1}{\theta^2+1} \sin 2z$$

$$y_p = \frac{z}{2\theta} 2\sin z$$

$$= z(-\cos z)$$

$$y_p = -z\cos z$$

$y = y_c + y_p$

$y = c_1 \cos z + c_2 \sin z - z \cos z$

$y = c_1 \cos \log(1+x) + c_2 \sin \log(1+x) - z \cos \log(1+x)$

$y = c_1 \cos \log(1+x) + c_2 \sin \log(1+x) - \log(1+x) \cos \log(1+x)$

2a) Expand $e^x \cos y$ by Taylor's theorem about the point $(1, \frac{\pi}{4})$ upto the second degree terms.

Let $f(x,y) = e^x \cos y$ near $(1, \frac{\pi}{4})$

$a = 1 \quad b = \pi/4$

By Taylor's theorem

$f(x,y) = f(a,b) + \frac{1}{1!}\left[(x-a) f_x(a,b) + (y-b) f_y(a-b)\right] + \frac{1}{2!}\left[(x-a)^2 f_{xx}(a,b)\right.$

$\left. + 2(x-a)(y-b) f_{xy}(a,b) + (y-b)^2 f_{yy}(a,b) + \cdots\right]$ —— (1)

$f(x,y) = e^x \cos y$

$\Rightarrow f(1, \frac{\pi}{4}) = e^1 \cos(\frac{\pi}{4})$

$= e \cdot \frac{1}{\sqrt{2}}$

$f(1, \frac{\pi}{4}) = \frac{e}{\sqrt{2}}$

$f_x = e^x \cos y$

$\Rightarrow f_x(1, \frac{\pi}{4}) = \frac{e}{\sqrt{2}}$

$f_y = -e^x \sin y$

$\Rightarrow f_y(1, \frac{\pi}{4}) = \frac{-e}{\sqrt{2}}$

$f_{xx} = e^x \cos y$

$\Rightarrow f_{xx}\left(1,\frac{\pi}{4}\right) = \frac{e}{\sqrt{2}}$

$f_{yy} = -e^x \cos y$

$\Rightarrow f_{yy}\left(1,\frac{\pi}{4}\right) = \frac{-e}{\sqrt{2}}$

$f_{xy} = -e^x \sin y$

$\Rightarrow f_{xy}\left(1,\frac{\pi}{4}\right) = \frac{-e}{\sqrt{2}}$

From eqn (1)

$$f(x,y) = f\left(1,\frac{\pi}{4}\right) = \frac{e}{\sqrt{2}} + \frac{1}{1!}\left[(x-1)\frac{e}{\sqrt{2}} + \left(y-\frac{\pi}{4}\right)\left(\frac{-e}{\sqrt{2}}\right)\right] + \frac{1}{2!}\left[(x-1)^2\left(\frac{e}{\sqrt{2}}\right) + 2(x-1)\left(y-\frac{\pi}{4}\right)\left(\frac{-e}{\sqrt{2}}\right) + \left(y-\frac{\pi}{4}\right)^2\left(\frac{-e}{\sqrt{2}}\right)\right] + \cdots$$

$$= \frac{e}{\sqrt{2}}\left[1+(x-1) - \cancel{y}\left(y-\frac{\pi}{4}\right) + \frac{1}{2!}\left[(x-1)^2 - 2\left(y-\frac{\pi}{4}\right)(x-1) - \left(y-\frac{\pi}{4}\right)^2\right] + \cdots\right.$$

$$e^x \cos y = \frac{e}{\sqrt{2}}\left[1+(x-1) - (y-\pi/4) + \frac{1}{2}\left[(x-1)^2 - 2(x-1)\left(y-\frac{\pi}{4}\right) - \left(y-\frac{\pi}{4}\right)^2\right] + \cdots\right.$$

This is the expansion of Taylor's series of given function

2b) Find the extreme value of the function $f(x,y) = x^3 + 3xy^2 - 15x^2 + 72x - 15y^2$

Given $f(x,y) = x^3 + 3xy^2 - 15x^2 + 72x - 15y^2$

$\Rightarrow f(x,y) = x^3 + 3xy^2 - 15x^2 - 15y^2 + 72x$ —(1)

Evaluate $p = \frac{\partial f}{\partial x}$ $q = \frac{\partial f}{\partial y}$ $r = \frac{\partial^2 f}{\partial x^2}$ $s = \frac{\partial^2 f}{\partial x \partial y}$ $t = \frac{\partial^2 f}{\partial y^2}$

$\frac{\partial f}{\partial x} = x^3 + 3xy^2 - 15x^2 - 15y^2 + 72x$

$\frac{\partial f}{\partial x} = 3x^2 + 3y^2 - 30x + 72$

$$\frac{\partial f}{\partial y} = 6xy - 30y$$

$$\frac{\partial f}{\partial y} = 6x - 30$$

$$\frac{\partial^2 f}{\partial x^2} = 6x - 30$$

$$\frac{\partial^2 f}{\partial y^2} = 6x - 30$$

$$\frac{\partial^2 f}{\partial x \partial y} = 6y$$

To find stationary points equate $p=0, q=0$

$3x^2+3y^2-30x+72=0$

$\Rightarrow x^2+y^2-10x+24=0 \quad -(2)$

$6xy-30y=0$

$y(x-5)=0$

$y=0, x=5$

From (2) $x=5$

$25+y^2-10(5)+24=0$

$\Rightarrow y^2-1=0$

$\boxed{y=\pm 1}$

$y=0$, from $eq^n(2)$

$x^2+y^2-10x+24=0$

$\Rightarrow x^2-10x+24=0$

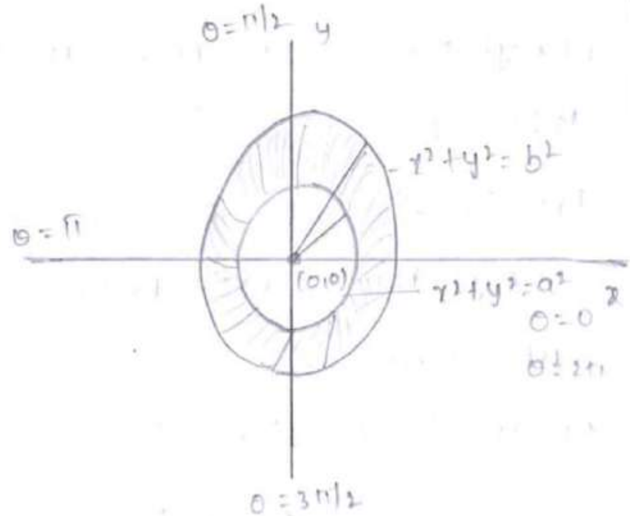
$\Rightarrow x^2-6x-4x+24=0$

$\Rightarrow x(x-6)-4(x-6)=0$

$\Rightarrow (x-6)(x-4)=0$

$x=4,6$

3a) By transforming into polar coordinates, evaluate $\iint \frac{x^2y^2}{x^2+y^2}\,dx\,dy$ over the annular region b/w the circles $x^2+y^2=a^2$ and $x^2+y^2=b^2$ with $b>a$



$x^2+y^2=a^2 \quad , \quad x^2+y^2=b^2$

$r=a \qquad\qquad r=b$

$\theta : 0 \text{ to } 2\pi \qquad r : a \text{ to } b$

$x=r\cos\theta \quad y=r\sin\theta \quad dx\,dy=r\,dr\,d\theta$

$$\iint \frac{x^2y^2}{x^2+y^2}\,dx\,dy$$

$$= \int_{\theta=0}^{2\pi}\int_{r=a}^{b} \frac{r^4(\cos^2\theta\sin^2\theta)}{r^{\cancel{2}}(\cos^2\theta+\sin^2\theta)}\,r\,dr\,d\theta$$

$$= \int_{\theta=0}^{2\pi}\int_{r=a}^{b} \frac{r^3(\cos^2\theta\sin^2\theta)}{1}\,dr\,d\theta$$

$$= \int_0^{2\pi} \cos^2\theta\sin^2\theta\left(\frac{r^4}{4}\right)_a^b d\theta$$

$$= \int_0^{2\pi} \cos^2\theta\sin^2\theta\left(\frac{b^4-a^4}{4}\right)d\theta$$

$$= \frac{b^4-a^4}{4}\int_0^{2\pi}\cos^2\theta\sin^2\theta\,d\theta$$

$$= \frac{b^4-a^4}{4\times 4}\int_0^{2\pi}(2\cos\theta\sin\theta)^2 d\theta$$

$$= \frac{b^4-a^4}{16}\int_0^{2\pi}(\sin 2\theta)^2 d\theta$$

$$= \frac{b^4-a^4}{16}\int_0^{2\pi}\sin^2 2\theta\,d\theta$$

$A=(5,1)$ $B=(5,-1)$ $C=(4,0)$ $D=(6,0)$

	A(5,1)	B(5,-1)	C(4,0)	D(6,0)
r	0	0	-6	6
s	6	-6	0	0
t	0	0	-6	6

To find max & min value of $f(x,y)$ is $A(5,1)$

If $rt-s^2 = 0-6^2 = -36<0$ & $r=0$

$f(x,y)$ has saddle point at $(5,1)$

$B(5,-1)$

If $rt-s^2 = 0-(-6)^2 = -36<0$, $r=0$

$f(x,y)$ has saddle point

At $C(4,0)$

If $rt-s^2 = (-6)(-6)-0$

$= 36>0$ & $r=-6<0$

$f(x,y)$ has max. value at $C(4,0)$

From (1)

$f(x,y) = x^3+3xy^2-15x^2-15y^2+72x$

$f(x,y) = 4^3+3(4)(0)-15(4^2)-15(0)+72(4)$

$= 64+288-240$

$= 112$

At $D(6,0)$

If $rt-s^2 = 6(6)-0$

$= 36>0$ & $r=6>0$

$f(x,y)$ has min. value at $D(6,0)$

From (1)

$f(x,y) = x^3+3xy^2-15x^2-15y^2+72x$

$= 6^3+3(6)(0)-15(6)^2-15(0)+72(6)$

$= 108$

$$= \frac{b^4 - a^4}{16} \int_0^{2\pi} \frac{(1-\cos 4\theta)}{2} \, d\theta$$

$$= \frac{b^4 - a^4}{32} \int_0^{2\pi} (1-\cos 4\theta) \, d\theta$$

$$= \frac{b^4 - a^4}{32} \left[\theta - \frac{\sin 4\theta}{4} \right]_0^{2\pi}$$

$$= \frac{b^4 - a^4}{32} \left[2\pi - 0 \right]$$

$$= \frac{\pi}{16} (b^4 - a^4)$$

MALINENI LAKSHMAIAH WOMEN'S ENGINEERING COLLEGE

(Approved by AICTE, Affiliated to JNTUK)

(An ISO9001:2008 Certified Institution)

Pulladigunta (Village), Vatticherukuru (Mandal),

Guntur-522017, Andhra Pradesh, India

Department of Science and Humanities

RESULT ANALYSIS FOR MID-II

BRANCH: DATA SCIENCE MID-II M-I I-B.Tech/I -sem

S.NO	ROLL-NO	1(a)	1(b)	2(a)	2(b)	3	DESCRIPTIVE	OBJECTIVE	ASSIGNMENT	TOTAL
1	22KE1A4401	2	2	2.5	2.5	5	14	3	5	22
2	22KE1A4402	2	2	2.5	1.5	5	13	3	5	21
3	22KE1A4403	2.5	2	2.5	2.5	4.5	14	3	5	22
4	22KE1A4404	1.5	1.5	2.5	2.5	2	10	2	5	17
5	22KE1A4405	2.5	1.5	2.5	2.5	5	14	5	5	24
6	22KE1A4406	2.5	2.5	2.5	2.5	3	13	4	5	22
7	22KE1A4407	2.5	1.5	2.5	2.5	4	13	4	5	22
8	22KE1A4408	1.5	0.5	2.5	0	4.5	9	1	5	15
9	22KE1A4409	2	2	2.5	2.5	5	14	5	5	24
10	22KE1A4410	1.5	2	2	2	2.5	11	5	5	21
11	22KE1A4411	2.5	2.5	2.5	2.5	5	15	5	5	25
12	22KE1A4412	2.5	1.5	0.5	1.5	0	8	2	5	15
13	22KE1A4413	2.5	25	2.5	2.5	5	15	7	5	27
14	22KE1A4414	2	0	1.5	1.5	4	9	4	5	18
15	22KE1A4415	1.5	2	1	1.5	3	9	3	5	17
16	22KE1A4416	2.5	1.5	2.5	2.5	4	13	2	5	20
17	22KE1A4417	2.5	1.5	2.5	2.5	3	12	4	5	21
18	22KE1A4418	2.5	1.5	2.5	2.5	5	14	7	5	26
19	22KE1A4419	2	2.5	2.5	1	4	12	2	5	19
20	22KE1A4420	2.5	2.5	2.5	2.5	4	14	9	5	28
21	22KE1A4421	2.5	2.5	2.5	2.5	5	15	8	5	28
22	22KE1A4422	2.5	2.5	2.5	2.5	5	15	3	5	23
23	22KE1A4423	2	1.5	1	1.5	3	9	3	5	17
24	22KE1A4424	2.5	2.5	2.5	2.5	5	15	6	5	26
25	22KE1A4425	2.5	2.5	2.5	2.5	5	15	6	5	26
26	22KE1A4426	2	2	2.5	2.5	5	14	3	5	22
27	22KE1A4427	2.5	2.5	2.5	2.5	5	15	4	5	24
28	22KE1A4428	2.5	2.5	2.5	2.5	5	15	6	5	26
29	22KE1A4429	2.5	2.5	2.5	2.5	5	15	3	5	23
30	22KE1A4430	2	2	1	2	4	11	1	5	17
31	22KE1A4431	2.5	2.5	2.5	2.5	5	15	6	5	26
32	22KE1A4432	2.5	2.5	2.5	2.5	5	15	8	5	28

33	22KE1A4433	2.5	2.5	2.5	2.5	5	15	6	5	26
34	22KE1A4434	1.5	1	2.5	2	3	10	4	5	19
35	22KE1A4435	2	1	2	1	5	11	2	5	18
36	22KE1A4436	2.5	1.5	2.5	2.5	5	14	5	5	24
37	22KE1A4437	0	1	2.5	1.5	5	10	4	5	19
38	22KE1A4438	2	2	1.5	2.5	5	13	4	5	22
39	22KE1A4439	0	2	0	2	3	8	4	5	17
40	22KE1A4440	2.5	2.5	0	1	1	8	2	5	15
41	22KE1A4441	1.5	1	1.5	2	3	9	3	5	17
42	22KE1A4442	2.5	2.5	2.5	2.5	5	15	4	5	24
43	22KE1A4443	2	0	0	2.5	4.5	9	4	5	18
44	22KE1A4444	2.5	2.5	2	2	4	13	4	5	22
45	22KE1A4445	1.5	1	1	1.5	3	8	2	5	15
46	22KE1A4446	2.5	0	2.5	2	4	11	2	5	18
47	22KE1A4447	1	0	2	2	4	9	2	5	16
48	22KE1A4448	2	2	2	0	3	9	0	5	14
49	22KE1A4449	2	1	2.5	1.5	3	10	2	5	17
50	22KE1A4450	2	0	2.5	2.5	5	11	4	5	20
51	22KE1A4451	2	1	1	2.5	1.5	8	3	5	16
52	22KE1A4452	2.5	2.5	2.5	2.5	4	14	3	5	22
53	22KE1A4453	0	0	2.5	2.5	4	9	2	5	16
54	22KE1A4454	1	2	2	2.5	4.5	12	3	5	20
55	22KE1A4455	1.5	1	2.5	2.5	4.5	12	2	5	19
56	22KE1A4456	2.5	2	2.5	2	5	14	5	5	24
57	22KE1A4457	2.5	2.5	2.5	2.5	5	15	4	5	24
58	22KE1A4458	2.5	2.5	2.5	1	5	13	1	5	19
59	22KE1A4459	0	1	2	0	5	8	2	5	15
60	22KE1A4460	2.5	2	2	2.5	2	11	2	5	18
61	22KE1A4461	1.5	1.5	2.5	15	2	9	3	5	17
62	22KE1A4462	2.5	2	2	2.5	4	13	4	5	22
63	22KE1A4463	2	1.5	2.5	1	4	11	4	5	20
64	22KE1A4464	2	2	0	2	4	10	2	5	17
65	22KE1A4465	2.5	2.5	2.5	2.5	4	14	3	5	22
66	22KE1A4466	1.5	1	2.5	2.5	3.5	11	8	5	24
67	22KE1A4467	1.5	1.5	2.5	2.5	3	11	4	5	20
68	22KE1A4468	2.5	2	0.5	1	5	11	4	5	20
69	22KE1A4469	1	2	1.5	1.5	4	10	5	5	20
70	22KE1A4470	2.5	2.5	2.5	2.5	5	15	3	5	23
71	22KE1A4471	2.5	1.5	2.5	2.5	4	13	4	5	22
72	22KE1A4472	2	2.5	2.5	2	0	9	4	5	18
73	22KE1A4473	2	2	1.5	2.5	3	11	5	5	21
74	22KE1A4474	2	0	0	2.5	4.5	9	4	5	18

75	22KE1A4475	2.5	2	2.5	2.5	4.5	14	3	5	22
76	22KE1A4476	0.5	2	2.5	2	5	12	4	5	21
77	22KE1A4477	1.5	0	1.5	2	3	8	6	5	19
78	22KE1A4478	2.5	2.5	1.5	2.5	0	9	2	5	16
79	22KE1A4479	2	2	1	2	1	8	4	5	17
80	22KE1A4480	2.5	2.5	2.5	2.5	5	15	4	5	24
81	22KE1A4481	2.5	1.5	1.5	2.5	4	12	2	5	19
82	22KE1A4482	2.5	2	2.5	2	1	10	0	5	15
83	22KE1A4483	2	1.5	1	0.5	3	8	2	5	15
84	22KE1A4484	1	1.5	0	2.5	4	9	4	5	18
85	22KE1A4485	2	1	1.5	1.5	3	9	2	5	16
86	22KE1A4486	1.5	1	2	2	2.5	9	2	5	16
87	22KE1A4487	2.5	1.5	2.5	2.5	5	14	3	5	22
88	22KE1A4488	2.5	2	2.5	1	4	12	3	5	20
89	22KE1A4489	2	2	2.5	1.5	5	13	4	5	22
90	22KE1A4490	2	1.5	2.5	2.5	4.5	13	5	5	23
91	22KE1A4491	2	1.5	1.5	2	4	11	2	5	18
92	22KE1A4492	2	1	2	2	2	9	3	5	17
93	22KE1A4493	2.5	2	2.5	2.5	4.5	14	2	5	21
94	22KE1A4494	2.5	2.5	1.5	1.5	3	11	6	5	22
95	22KE1A4495	2	1.5	2.5	1	2	9	4	5	18
96	22KE1A4496	2	0	2.5	2.5	2	9	3	5	17
97	22KE1A4497	2.5	0	2.5	2	4	11	3	5	19
98	22KE1A4498	2	1.5	2.5	1.5	2.5	10	5	5	20
99	22KE1A4499	2	1	2	2	2	9	2	5	16
100	22KE1A44A0	1.5	2	2	2.5	2	10	3	5	18
101	22KE1A44A1	2.5	2.5	0	2	3	10	1	5	16
102	22KE1A44A2	2	0	2	2	4	10	3	5	18
103	22KE1A44A3	2.5	2.5	2.5	2.5	5	15	4	5	24
104	22KE1A44A4	2	2	2.5	2.5	5	14	3	5	22
105	22KE1A44A5	2.5	0.5	1	2	3	9	3	5	17
106	22KE1A44A6	2.5	2.5	2.5	2.5	5	15	5	5	25
107	22KE1A44A7	2.5	2	0	2	3.5	10	2	5	17
108	22KE1A44A8	2.5	2	0	2.5	1	8	3	5	16
109	22KE1A44A9	0	2.5	1	2.5	1	8	4	5	17
110	22KE1A44B0	1.5	2.5	2.5	2.5	5	14	3	5	22
111	22KE1A44B1	2	2.5	2.5	2	4	13	6	5	24
112	22KE1A44B2	1.5	2	2.5	2	4	12	4	5	21
113	22KE1A44B3	2.5	2.5	2.5	2.5	5	15	4	5	24
114	22KE1A44B4	2	2	2.5	2.5	4	13	3	5	21
115	22KE1A44B5	1.5	1.5	2.5	1.5	2	9	4	5	18

HOD
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PRINCIPAL
MALINENI LAKSHMAIAH
WOMEN'S ENGINEERING COLLEGE
PULLADIGUNTA, GUNTUR-17.

Code No: **R201101** **R20** **SET - 1**

I B. Tech I Semester Regular/Supplementary Examinations, February - 2023

MATHEMATICS-I

(Common to all Branches)

Time: 3 hours Max. Marks: 70

Answer any FIVE Questions ONE Question from Each Unit
All Questions Carry Equal Marks

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UNIT - I

1. a) Examine the convergence of $\frac{2^{n+1}-2}{3^{n+1}+1}x^n$ for $x > 0$. [7M]

   b) Fine the Maclaurin series expansion of $f(x) = coshx$. [7M]

(OR)

2. a) Show that $\log(1+x)=\frac{x}{(1+\theta x)}$ where $0<\theta<1$. and hence deduce that $\frac{x}{1-x} <$ $\ln(1+x) < x$ if $x > a$. [7M]

   b) Examine the convergence of $\sum_{n=0}^{\infty}(-1)^n(n+1)x^n$ with $x > \frac{1}{2}$. [7M]

UNIT - II

3. a) Solve $3y' + xy = xy^{-2}$. [7M]

   b) If a substance cools from 370k to330k in 10minutes, when the temperature of the surrounding air is 290k, find the temperature of the substance after 40 minutes. [7M]

(OR)

4. a) Show that the family of parabolas $y^2 = 4cx + 4c^2$ is "self-orthogonal". (Where c is a parameter). [7M]

   b) Solve $(2y^2 + 4x^2y)dx + (4xy + 3x^3)dy = 0$. [7M]

UNIT - III

5. a) Solve $(D^3 - 2D + 4)y = x^4 + 3x^2 - 5x + 2$. [7M]

   b) Determine the current $I(t)$ in an RLC circuit with *emf* $E(t) = E_0 cos\ \omega t$. [7M]

(OR)

6. a) Solve $(D^2 + 1)y = xcos2x$ by the method of variation of parameters. [7M]

   b) Solve $x^2\frac{d^2y}{dx^2} - 3x\frac{dy}{dx} + 5y = x^2sin(log\ x)$. [7M]

UNIT - IV

7. a) If $w = x^2y + y^2z + z^2x$, then prove that $w_x + w_y + w_z = (x + y + z)^2$. [7M]

   b) Investigate the maxima and minima, if any, of the function $f(x,y) = x^4 + y^4 - x^2 - y^2 + 1$. [7M]

(OR)

8. a) Determine whether the following functions are functionally dependent or not? Find a functional relation between them in case they are functionally dependent. $u = \frac{x+y}{x-y}, v = \frac{xy}{(x-y)^2}$. [7M]

   b) Expand $f(x,y) = e^y\ ln(1 + x)$ in powers if x and y. [7M]
~~~~~~

UNIT - V

9. a) Evaluate $\iint_D (1+x+y)dxdy$ where D is the region bounded by $y=x, x=\sqrt{y}$, y=1 and y=0. [7M]

b) Change the order of integration and thenevaluate$\int_0^1 \int_{x^2}^{2-x} xy\, dy\, dx$. [7M]

(OR)

10 a) Evaluate$\int_0^2 \int_1^z \int_0^{yz} xyz\, dx\, dy\, dz.$ [7M]

b) Evaluate $\int_0^{2a} \int_0^{\sqrt{2a-x^2}} dydx$ by changing into polar coordinates. [7M]

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Code No: **R201101** **R20** **SET - 2**

I B. Tech I Semester Regular/Supplementary Examinations, February - 2023

MATHEMATICS-I

(Common to All Branches)

Time: 3 hours Max. Marks: 70

Answer any FIVE Questions ONE Question from Each Unit
All Questions Carry Equal Marks

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UNIT - I

1. a) Examine the convergence of $\left[\frac{n}{n^2+1}x^{2n}\right]^{\frac{1}{2}}$. [7M]

 b) State Maclaurin's theorem with Lagrange's form of remainder for $f(x) = Cos\ x$. [7M]

(OR)

2. a) Using Lagrange's Mean Value theorem prove that $\frac{\pi}{3} - \frac{1}{5\sqrt{3}} > cos^{-1}\frac{3}{5} > \frac{\pi}{3} - \frac{1}{8}$. [7M]

 b) Examine the convergence of $\sum_{n=2}^{\infty}\frac{(-1)^{n-1}x^n}{n(n-1)}$ with $0 < x < 1$. [7M]

UNIT - II

3. a) Solve $2xyy' = y^2 - 2x^3$. [7M]

 b) Water at temperature 100^0C cools in 10 min to 80^0C in a room of temperature 25^0C. (i) Find the temperature of water after 20 min. [7M]
 (ii) When will the temperature be 40^0C.

(OR)

4. a) Show that the family of confocal conics $\frac{x^2}{a^2+c} + \frac{y^2}{b^2+c} = 1$ is "self-orthogonal". Here a and b are given constants. [7M]

 b) Solve $(xy^3 + y)dx + 2(x^2y^2 + x + y^4)dy = 0$. [7M]

UNIT - III

5. a) Solve $(D^4 + D^3 + D^2)y = 5x^2 + sin2x + 4e^{-3x}$ [7M]

 b) Determine the current $I(t)$ in an RLC circuit with *emf* $E(t) = E_0 sin\ \omega t$. [7M]

(OR)

6. a) Solve $(D^2 + 4)y = 4sec2x$ by the method of variation of parameters. [7M]

 b) Solve $x^3y''' + 2x^2y'' = x + sin(ln\ x)$. [7M]

UNIT - IV

7. a) Prove that $\left(\frac{\partial}{\partial x} + \frac{\partial}{\partial y} + \frac{\partial}{\partial z}\right)^2 u = \frac{-9}{(x+y+z)^2}$ if $u = ln(x^3 + y^3 + z^3 - 3xyz)$. [7M]

 b) Investigate the maxima and minima, if any, of the function $f(x,y) = x^3 + 3xy^2 - 15x^2 - 15y^2 + 72x$. [7M]

|''|'|''|'''||'|
~~~~~~

(OR)

8\. a) Determine whether the following functions are functionally dependent or not? Find a functional relation between them in case they are functionally dependent. $u = \frac{x-y}{x+a}$, $v = \frac{x+a}{y+a}$ where a is constant. [7M]

b) Find Taylor's expansion of $f(x, y) = cot^{-1}xy$ in powers of $(x + 0.5)$ and $(y - 2)$ up to second degree terms. [7M]

UNIT - V

9\. a) Evaluate $\iint_D (x^2 + y^2)dxdy$ where D is the region bounded by $y = x, y^2 = x$ and x=1 in the first quadrant. [7M]

b) Change the order of integration and then evaluate $\int_0^2 \int_{y^3}^{4\sqrt{2y}} y^2 \, dx \, dy$. [7M]

(OR)

10 a) Evaluate $\int_0^a \int_0^x \int_0^{y+x} e^{x+y+z} \, dz \, dy \, dx$. [7M]

b) Evaluate $\int_0^a \int_0^{\sqrt{a^2-y^2}} (x^2 + y^2)dxdy$ by changing into polar coordinates. [7M]

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Code No: **R201101** **R20** **SET - 3**

I B. Tech I Semester Regular/Supplementary Examinations, February - 2023

MATHEMATICS-I

(Common to All Branches)

Time: 3 hours Max. Marks: 70

Answer any FIVE Questions ONE Question from Each Unit
All Questions Carry Equal Marks

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UNIT - I

1. a) Examine the convergence of $\frac{1.3.5......(2n-1)}{2.4.6.....2n}x^{n-1}$ with $x > 0$. [7M]

   b) Verify Taylor's theorem for $f(x) = x^3 - 3x^2 + 2x$ in $\left[0, \frac{1}{2}\right]$ with Lagrange's remainder up to 2 terms. [7M]

(OR)

2. a) Show that $0 < \sin b - \sin a < b - a$ if $0 < a < b < \frac{\pi}{2}$. [7M]

   b) Examine the convergence of $\sum_{n=1}^{\infty} \frac{(-1)^{n-1}}{(x+n)}$. [7M]

UNIT - II

3. a) Solve $(xy^5 + y)dx - dy = 0$. [7M]

   b) Water at temperature 10^0C takes 5 min to warm up to 20^0C in a room at temperature 40^0C. Find the temperature after 20 min and after ½ hr. [7M]

(OR)

4. a) Show that the family of parabolas $y^2 = 2cx + c^2$ is "self-orthogonal". (where c is a parameter). [7M]

   b) Solve$(y^4 + 2y)dx + (xy^3 + 2y^4 - 4x)dy = 0$. [7M]

UNIT - III

5. a) Solve $(D^4 + 2D^3 - 3D^2)y = 5x^2 + 7e^{2x} + 4cosx$. [7M]

   b) A circuit consists of inductance of 0.05 *henrys*, a resistance of 5 *ohms* and a condenser of capacitance 4×10^{-4} *farad*. If $Q = I = 0$ when $t = 0$, find $Q(t)$ and $I(t)$ when there is a constant *emf* of 110 *volts*. [7M]

(OR)

6. a) Solve $(D^2 + a^2)y = xcosax$ by the method of variation of parameters. [7M]

   b) Solve $x^2y'' + 5xy' + 4y = x^2 + 16\,(ln\,x)^2$. [7M]

UNIT - IV

7. a) Show that $yz_x + xz_y = x^2 - y^2$ if $e^{-\frac{z}{(x^2-y^2)}} = (x - y)$. [7M]

   b) If the total surface area of a closed rectangular box is 108 *sq. cm*, find the dimensions of the box having maximum volume. [7M]

(OR)

8. a) If $x = e^u \sec v, y = e^u \cos v$, find $J = \frac{\partial(x,y)}{\partial(u,v)}$ and $J' = \frac{\partial(u,v)}{\partial(x,y)}$. Also show that $JJ' = 1$. [7M]

   b) Expand $\cos x \cos y$ in powers of x and y up to third degree terms. [7M]
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UNIT - V

9. a) Evaluate $\iint_D xydxdy$ where D is the domain bounded by the parabola $x^2 = 4ay$, the ordinates x=a and x-axis. [7M]

b) Change the order of integration and thene valuate$\int_0^a \int_{\frac{y^2}{a}}^{2a-y} xy\,dx\,dy$. [7M]

(OR)

10 a) Evaluate$\int_0^{\frac{\pi}{2}} \int_x^{\frac{\pi}{2}} \int_0^{xy} cos\frac{z}{x}\;dz\;dy\;dx$. [7M]

b) Evaluate $\int_{-a}^{a} \int_0^{\sqrt{a^2-x^2}} xy\;dxdy$ by changing into polar coordinates. [7M]

*****

Code No: **R201101** **R20** **SET - 4**

I B. Tech I Semester Regular/Supplementary Examinations, February - 2023
MATHEMATICS-I
(Common to All Branches)

Time: 3 hours Max. Marks: 70

Answer any FIVE Questions ONE Question from Each Unit
All Questions Carry Equal Marks

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UNIT - I

1. a) Examine the convergence of $\left(\sqrt{n^2+1}-n\right)x^{2n}$. [7M]

   b) Fine the Maclaurin's series expansion of $f(x) = sinhx$. [7M]

(OR)

2. a) If $0 \le a < b < \frac{\pi}{2}$ then show that $0 < \cos a - \cos b < b - a$. [7M]

   b) Examine the convergence of $\sum_{n=0}^{\infty} \frac{(-1)^n}{1+n^2}$. [7M]

UNIT - II

3. a) Solve $y' - \cot y + x\cot y = 0$. [7M]

   b) A body is heated to 110^0C and placed in air at 10^0C. After 1 hour its temperature is 60^0C. How much additional time is required for it to cool to 30^0C? [7M]

(OR)

4. a) Show that the family of confocal conics $\frac{x^2}{a} + \frac{y^2}{a-b} = 1$ is "self-orthogonal". Here a is an arbitrary constant. [7M]

   b) Solve $y(xy + 2x^2y^2)dx + x(xy - x^2y^2)dy = 0$. [7M]

UNIT - III

5. a) Solve $(D^4 + 2D^3 - 3D^2)y = x^2 + 3e^{2x} + 4sinx$. [7M]

   b) A circuit consists of an inductance of 0.05 *henrys*, a resistance of 5 *ohms* and a condenser of capacitance 4×10^{-4} *farad*. If $Q = I = 0$ when $t = 0$, find $Q(t)$ and $I(t)$ when there is an alternating *emf* 200 *cos* 100*t*. [7M]

(OR)

6. a) Solve $(D^2 + 1)y = log\ cos\ x$ by the method of variation of parameters. [7M]

   b) Solve $x^3y''' - 8x^2y'' + 28xy' - 40y = -\frac{9}{x}$. [7M]

UNIT - IV

7. a) If $u = (x^2 + y^2 + z^2)^{-\frac{1}{2}}$ then show that $(u_x)^2 + (u_y)^2 + (u_z)^2 = u^4$. [7M]

   b) An aquarium with rectangular sides and bottom (and no top) is to hold 32 *liters*. Find its dimensions so that it will use the least amount of material. [7M]
~~~~~~

(OR)

8. a) Determine whether the following functions are functionally dependent or not? Find a functional relation between them in case they are functionally dependent. [7M]

$u = \frac{x}{y}, v = \frac{x+y}{x-y}$.

b) Obtain the expansion of e^{xy} in powers of $(x-1)$and $(y-1)$. [7M]

UNIT - V

9. a) Evaluate $\iint_D x^3 y dx dy$ where D is the region enclosed by the ellipse $\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$ in the first quadrant. [7M]

b) Change the order of integration and then evaluate $\int_0^1 \int_{y^2}^{y^{1/3}} xy\, dx\, dy$. [7M]

(OR)

10 a) Evaluate $\int_0^1 \int_0^{1-x} \int_0^{1-x-y} \frac{dx\, dy\, dz}{(x+y+z+1)^3}$. [7M]

b) Evaluate $\int_0^\infty \int_0^\infty e^{-(x^2+y^2)} dx dy$ by changing into polar coordinates. [7M]

******

Code No: **R19BS1101** **R19** **SET - 1**

I B. Tech I Semester Supplementary Examinations, February - 2023
MATHEMATICS-I
(Common to CE, EEE, ME, ECE, CSE, Chem E, EIE, IT, Auto E, Min E, Pet E, Agri E)

Time: 3 hours Max. Marks: 75

Answer any FIVE Questions ONE Question from Each Unit
All Questions Carry Equal Marks

~~~~~~

UNIT-I

1. a) Test for convergence of the series $\frac{1}{4.7.10}+\frac{4}{7.10.13}+\frac{9}{10.13.16}+......\infty$. [8M]

   b) If $f(x)=\sin^{-1}x, 0<a<b<1$, use mean value theorem to prove that $\frac{b-a}{\sqrt{1-a^2}}<\sin^{-1}b-\sin^{-1}a<\frac{b-a}{\sqrt{1-b^2}}$. [7M]

(OR)

2. a) Test for convergence of the series (*i*). $\sum_{n=1}^{\infty}\frac{n!3^n}{n^n}$, (*ii*). $\sum_{n=1}^{\infty}\left(\frac{n+2}{n+3}\right)^n x^n$. [8M]

   b) Verify Rolle's theorem for $f(x)=(x-a)^m(x-b)^n$, where m, n are positive integers in $[a,b]$. [7M]

UNIT-II

3. a) Solve $\frac{dy}{dx}+x\sin 2y=x^3\cos^2 y$. [8M]

   b) A copper ball is heated to a temperature of $100°\,C$. Then at time $t=0$ it is placed in water which is maintained at a temperature of $30°\,C$. At the end of 3 minutes the temperature of the ball is reduced to $70°\,C$. Find the time at which the temperature of the ball drops to $31°\,C$. [7M]

(OR)

4. a) Solve $\left(y^2e^{xy^2}+4x^3\right)dx+\left(2xy\,e^{xy^2}-3y^2\right)dy=0$. [8M]

   b) Show that the family of parabolas $y^2=4a(x+a)$ is "self-orthogonal". [7M]

UNIT-III

5. a) Solve $\frac{d^4y}{dx^4}-y=e^x\cos x$. [8M]

   b) An uncharged condenser of capacity C is charged by applying and e.m.f $E\sin\left(\frac{t}{\sqrt{LC}}\right)$, through leads of self-inductance L and negligible resistance. Prove that at any time t, the charge on one of the plates is $\frac{EC}{2}\left\{\sin\left(\frac{t}{\sqrt{LC}}\right)-\frac{t}{\sqrt{LC}}\cos\left(\frac{t}{\sqrt{LC}}\right)\right\}$. Assume initially q = 0 and i = 0. [7M]
~~~~~~

(OR)

6. a) Solve $\frac{d^3y}{dx^3}-3\frac{d^2y}{dx^2}+4\frac{dy}{dx}-2y=e^x+\cos x$. [8M]

b) Solve by method of variation of parameters $\frac{d^2y}{dx^2}+4y=\tan 2x$. [7M]

UNIT-IV

7. a) If $x=r\cos\theta, y=r\sin\theta$ then prove that $\frac{\partial(x,y)}{\partial(r,\theta)}\times\frac{\partial(r,\theta)}{\partial(x,y)}=1$. [8M]

b) If $u=x^2+y^2+z^2$ and $x=e^t$; $y=\sin t$; $z=\log t$ [7M]

Find $\frac{du}{dt}$ using chain rule and verify the result by direct substitution.

(OR)

8. a) If $u(x,y)=\cos^{-1}\left(\frac{x+y}{\sqrt{x}+\sqrt{y}}\right)$, $0<x$, $y<1$, prove that $x\frac{\partial u}{\partial x}+y\frac{\partial u}{\partial y}=-\frac{1}{2}\cot u$. [8M]

b) Discuss the maxima and minima of $f(x,y)=x^4+y^4-2x^2+4xy-2y^2$. [7M]

UNIT-V

9. a) Evaluate $\int_0^a\int_0^{\sqrt{a^2-y^2}}\sqrt{a^2-x^2-y^2}\,dxdy$ [8M]

b) By changing the order of integration, evaluate $\int_0^\infty\int_x^\infty\frac{e^{-y}}{y}\,dy\,dx$. [7M]

(OR)

10 a) Evaluate $\int_0^1\int_0^{\sqrt{1-x^2}}\int_0^{\sqrt{1-x^2-y^2}} xyz \quad dxdydz$. [8M]

b) By changing into polar coordinates, evaluate $\int_0^\infty\int_0^\infty e^{-(x^2+y^2)}dxdy$. [7M]

*****

Code No: **R161102** **R16** **SET - 1**

I B. Tech I Semester Supplementary Examinations, February - 2023
MATHEMATICS-I

Time: 3 hours Max. Marks: 70

*Note: 1. Question paper consists of two parts (**Part-A and Part-B**)*
*2. All the questions in **Part-A** is Compulsory*
*3. Answer any **FOUR** Questions from **Part-B***

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PART –A (14 Marks)

1. a) Write the RL circuit [2M]
   b) Find the P.I of $(D^2+1)y = sinx$ [2M]
   c) Find the $L(2e^{4t})$ [2M]
   d) Find the inverse LaPlace transform of $\frac{1}{s^3}$ [2M]
   e) Find $\frac{\partial f}{\partial x}, \frac{\partial f}{\partial y}$ for $f(x,y) = cos(2x-3y)$ [2M]
   f) Solve the PDE $pq = 1$ [2M]
   g) Classify the nature of the partial differential equation $4\frac{\partial u}{\partial t} - 2\frac{\partial^2 u}{\partial y^2} = 0$ [2M]

PART –B (56 Marks)

2. a) Solve the D.E $y\,dx - x\,dy = 3x^2 e^{x^3} y^2\,dx$ [7M]
   b) Solve the D.E $x\,.\frac{dy}{dx} + y = \log x$ [7M]

3. a) Solve the D.E $\frac{d^2y}{dx^2} + 9y = \tan 3x$ by the method of variation of parameters [7M]
   b) Solve the D.E $\left(D^2-4D+3\right)y = e^x \cos 2x$ [7M]

4. a) Find $L\left\{e^{-t}\int_0^t cost\,dt\right\}$ [7M]
   b) Find $L^{-1}\left\{\frac{s+3}{s^2-10s+29}\right\}$ [7M]

5. a) Expand the f(x,y) = e^xcos y about $(1,\frac{\pi}{4})$ using Taylor's series [7M]
   b) Find $x\frac{\partial u}{\partial x} + y\frac{\partial u}{\partial y}$ using Euler's theorem for $u = \frac{x^2+y^2}{\sqrt{x}+\sqrt{y}}$ [7M]

6. a) Form the differential equation by elimination arbitrary function from the $\phi(x+y+z, x^2+y^2+z^2) = 0$ [7M]
   b) Solve the PDE $x(y-z)p + y(z-x)q = z(x-y)$. [7M]

7. a) Solve the PDE $\left(D^2+2DD^1+D^{1^2}\right)z = e^{2x+3y}$ [7M]
   b) Solve the PDE $\left(D^2+DD^1-6D^{1^2}\right)z = \cos(3x+y)$ [7M]

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Code No: **R13102** **R13** **SET - 1**

I B. Tech I Semester Supplementary Examinations, February - 2023
MATHEMATICS-I
(Common to all Branches)

Time: 3 hours Max. Marks: 70

*Note: 1. Question Paper consists of two parts (**Part-A** and **Part-B**)*
*2. Answer **ALL** the question in **Part-A***
*3. Answer any **THREE** Questions from **Part-B***

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PART –A (22 Marks)

1. a) Find the general solution of the differential equation $x\,dy - y\,dx = xy^2\,dx$. [4M]
   b) Find the general solution of $\frac{d^3y}{dx^3} - 3\frac{dy}{dx} + 2y = 0$. [3M]
   c) Find the Laplace transform of $\frac{\sin 2t}{t}$. [4M]
   d) If $u = x^2 - y^2$, $v = 2xy$, find $\frac{\partial(u,v)}{\partial(x,y)}$. [3M]
   e) Form the partial differential equation by eliminating the arbitrary constants a and b from $2z = \frac{x^2}{a^2} + \frac{y^2}{b^2}$. [4M]
   f) State all possible solutions of Laplace's equation. [4M]

PART –B (48 Marks)

2. a) Solve the differential equation $\frac{dy}{dx} + y\cos x = y^3 \sin 2x$. [8M]
   b) If the temperature of the air is $20\,^oC$ and the temperature of the body drops from $100\,^oC$ to $80\,^oC$ in 10 minutes. What will be its temperature after 20 minutes? [8M]
3. a) Solve $\frac{d^2y}{dx^2} - 7\frac{dy}{dx} + 6y = e^{2x}$. [8M]
   b) Solve $(D^2 - 4)y = x\,sin\,2x$. [8M]
4. a) Use Laplace transform method to solve $y'' + 4y' + 3y = e^{-t}$, $y(0) = y'(0) = 1$. [8M]
   b) Find the Laplace transform of $\frac{\cos at - \cos bt}{t} + t\sin at$. [8M]
5. a) If $U = \log\left(x^3 + y^3 + z^3 - 3xyz\right)$, prove that $\left(\frac{\partial}{\partial x} + \frac{\partial}{\partial y} + \frac{\partial}{\partial z}\right)^2 U = \frac{-9}{(x+y+z)^2}$. [8M]
   b) Discuss the maxima and minima of the function $x^2 + y^2 + 6x + 12$. [8M]
6. a) Solve $\left(x^2 - y^2 - z^2\right)p + 2xyq = 2xz$. [8M]
   b) Solve $p(1+q) = qz$. [8M]
7. An infinitely long plane uniform plate is bounded by two parallel edges and an end at right angles to them. The breadth is π; this end is maintained at a temperature u_0 at all points and other edges are at zero temperature. Determine the temperature at any point of the plate in the steady-state. [16M]

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Pulladigunta, GUNTUR-522017

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PULLADIGUNTA, GUNTUR-17.
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MALINENI LAKSHMAIAH WOMEN'S ENGINEERING COLLEGE

(Approved by AICTE, Affiliated to JNTUK)
(An ISO9001:2008 Certified Institution)
Pulladigunta (Village), Vatticherukuru (Mandal),
Guntur-522017, Andhra Pradesh, India

Department of science and Humanities

SCHEME OF EVALUATION – UNIVERSITY EXAMINATION

COURSE:MATHEMATICS-I	DEGREE: **B.Tech**
COURSE CODE: **C102**	YEAR: **I** SEMESTER: **I**
REGULATION: **R20**	COURSE TYPE: **REGULAR**
ACADEMIC YEAR : **2022-23**	CREDITS: **3**

Date:

Q.No.	Question	Marks Allotted	Course Outcome mapping	Blooms Taxonomy level
1.	a) Examine the convergence of $\frac{2^{n+1}-2}{3^{n+1}+1}x^n$ for $x>0$	7	C102.1	Analyze
	b) Find the Maclaurin series expansion of $f(x)$ = coshx.	7	C102.1	Apply
2.	a) Show that $\log(1+x)=x/(1+\theta x)$ where $0<\theta<1$. and hence deduce that $\frac{x}{1-x}<\ln(1+x)<x$ if $x>a$.	7	C102.1	Understand
	b) Examine the convergence of $\sum_{n=0}^{\infty}(-1)^n(n+1)x^n$ with $x>\frac{1}{2}$	7	C102.1	Analyze
3.	a) Solve $3y' + xy = xy^{-2}$	7	C102.2	Apply
	b) If a substance cools from 370k to330k in 10minutes, when the temperature of thesurrounding air	7	C102.2	Apply

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	is 290k, find the temperature of the substance after 40 minutes			
4	a) Show that the family of parabolas $y^2 = 4cx + 4c^2$ is "self-orthogonal". (Where *c* is a parameter).	7	C102.2	Understand
	b Solve $(2y^2+4x^2y)dx+(4xy\ 3x^3)dy=0$	7	C102.2	Apply
5	a)Solve $(D^3-2D+4)y = x^4+3x^2-5x+2.$	7	C102.3	Apply
	b) Determine the current $i(t)$ in an *RLC* circuit with *emf* $E(t)=E_0 \cos \omega t$.	7	C102.3	Understand
6	a) Solve $(D^2+1)y = x\cos 2x$ by the method of Variation of parameters	7	C102.3	Apply
	b) solve $x^2\frac{d^2y}{dx^2} - 3x\frac{dy}{dx}+5y = x^2 \sin(\log x)$.	7	C102.3	Apply
	a) If $w = x^2y + y^2z + z^2x$, then prove that $w_x+w_y+w_z=(x+y+z)^2$.	7	C102.4	Understand
7	b)Investigate the maxima and minima, if any, of the function$f(x, y)=x^4+y^4-x^2-y^2+1$.	7	C102.4	Understand
8	a) Determine whether the following functions are functionally dependent or not?Find a functional	7	C102.4	Understand

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	relation between them in case they are functionally dependent. $u=\frac{x+y}{x-y}$, $v=\frac{xy}{(x-y)^2}$.			
	b)Expand $f(x, y) = e^y \ln(1 + x)$ in powers if x and y.	7	C102.4	Remember
9	a)Evaluate $\iint (1 + x + y)dxdy$ where D is the region bounded by $y = x, x = \sqrt{y}, y=1$ and $y=0$.	7	C102.5	Evaluate
	b) Change the order of integration and then evaluate $\int_0^1 \int_{X^2}^{2-X} xy \, dxdy$	7	C102.5	Evaluate
10	a) Evaluate $\int_0^2 \int_1^z \int_0^{yz} xyz\,dxdydz$	7	C102.5	Evaluate
	b) Evaluate $\int_0^{2a} \int_0^{\sqrt{2a-x^2}} dydx$ by changing into polar coordinates.	7	C102.5	Evaluate

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Guntur-522017, Andhra Pradesh, India

ESTD : 2008

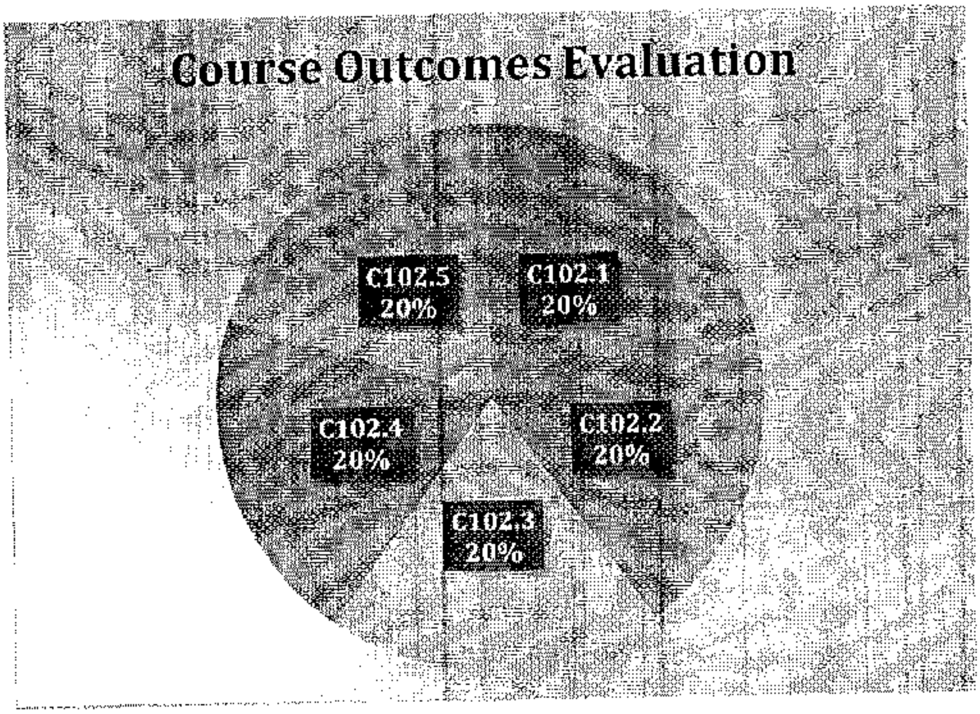
Department of science and Humanities

Subject Name: MATHEMATICS-I

Course Outcomes& Bloom's Taxonomy Evaluation:

Course Outcome Number	Marks Allotted	Percentage of Marks
C102.1	28	20
C102.2	28	20
C102.3	28	20
C102.4	28	20
C102.5	28	20
Total Marks	140	100

Taxonomy level	Marks Allotted	Percentage of Marks
Remember	7	5
Understand	42	30
Apply	49	35
Analyze	14	10
Evaluate	28	20
Create		
Total Marks	140	100



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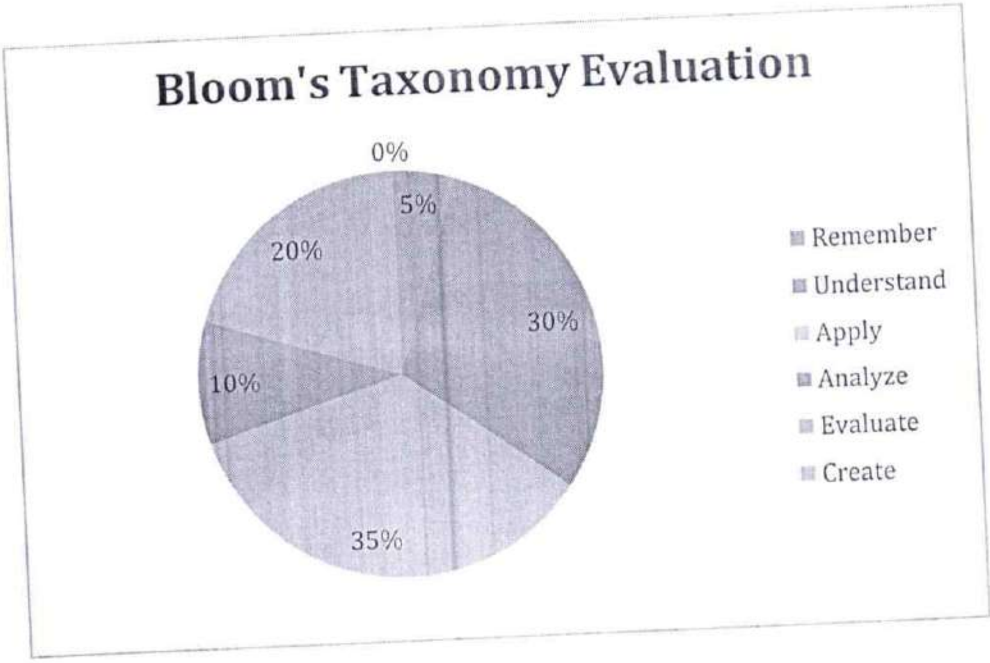

Faculty in-charge:

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Approved by AICTE, New Delhi, Affiliated to JNTUK
ESTD: 2008

DEPARTMENT OF SCIENCE AND HUMANITIES

Course Code	:	C102
Course Name	:	MATHEMATICS-I
Academic Year	:	2022-2023
Semester	:	IYear ISemester
Regulation	:	R20
Name of the Faculty	:	R.NAGA SAI LAKSHMI

COURSE ASSESSMENT TOOLS AND WEIGHTAGES

Direct Assessment (DA)			Indirect Assessment (IA)	
Assessment Tool		Weightage	Assessment Tool	Weightage
Continuous Internal Evaluation (CIE)	MID-I	30%	Course End Survey - CES (Feedback on course outcomes collected from students)	100%
	Objective-I			
	Assignment-I			
	MID-II			
	Objective-II			
	Assignment-II			
Semester End Examination (SEE)		70%	Total (CES)	100%
Total (CIE + SEE)		100%		
Weightage of Direct Assessment(DA) is 80%			Weightage of Indirect Assessment(IA) is 20%	
TOTAL = DA + IA = 100%				

COURSE OUTCOMES

#	STATEMENT
C102.1	study and apply various types of convergence
C102.2	solve first order differential equations and applications of first order differential equations.
C102.3	solve linear differential equations of heigher order
C102.4	find the maximum and minimum values of functions of two variables

C102.5	apply double and triple integral techniques in evaluating areas and volumes covered by integration

Course Articulation Matrix: Mapping Course Outcomes (COs) with Program Outcomes (POs)

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
C102.1	2	2												
C102.2	2	2												
C102.3	2	2												
C102.4	2	2												
C102.5	3	2												

Program Outcomes & Program Specific Outcomes

PO1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems
PO2	**Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

Questions fall under corresponding CO in each Assessment Tool:

CO#	CIE						SEE
	MID 1	MID 2	QUIZ1	(ASSN1)	QUIZ2	(ASSN2)	
C102.1	Q1		Applicable	Applicable			Applicable
C102.2	Q2A.2B		Applicable	Applicable			Applicable
C102.3	Q3	Q1	Applicable	Applicable	Applicable	Applicable	Applicable

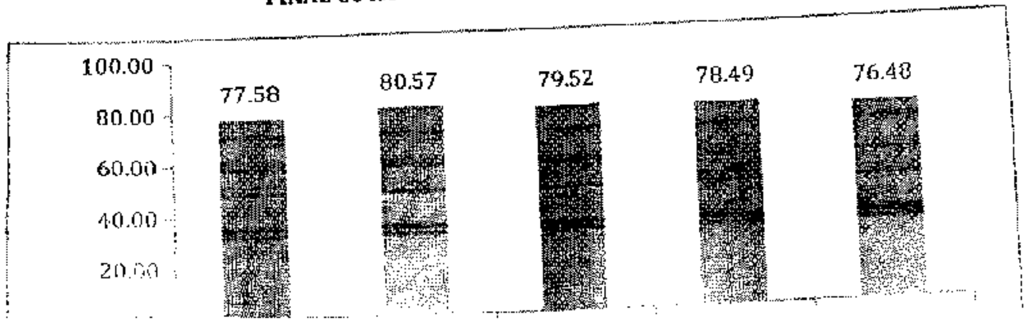
C102.4		Q2A,2B			Applicable	Applicable	Applicable
C102.5		Q3			Applicable	Applicable	Applicable

ATTAINMENT LEVEL	1	55 - 65% students scoring more than set target
	2	65 - 75 % students scoring more than set target
	3	>=75 % students scoring more than set target

OVERALL ATTAINMENT OF COURSE OUTCOMES (CO) THROUGH DIRECT AND INDIRECT ASSESSMENT TOOLS

CO No	DIRECT ASSESSMENT					INDIRECT ASSESSMENT	TOTAL AT% THROUGH (80% DA + 20% IDA)	TARGET	AT LEVEL	YES/NO
	CIE (100 %)	SEE (100 %)	30% of CIE	70% of SEE	TOTAl (30% CIE +70% SEE)					
C102.1	81	78	24.26	54.78	79.04	71.73	77.58	60.00	3	YES
C102.2	90	78	27.13	54.78	81.91	75.20	80.57	60.00	3	YES
C102.3	88	78	26.35	54.78	81.13	73.07	79.52	60.00	3	YES
C102.4	82	78	24.60	54.78	79.38	74.93	78.49	60.00	3	YES
C102.5	77	78	23.22	54.78	78.00	70.40	76.48	60.00	3	YES

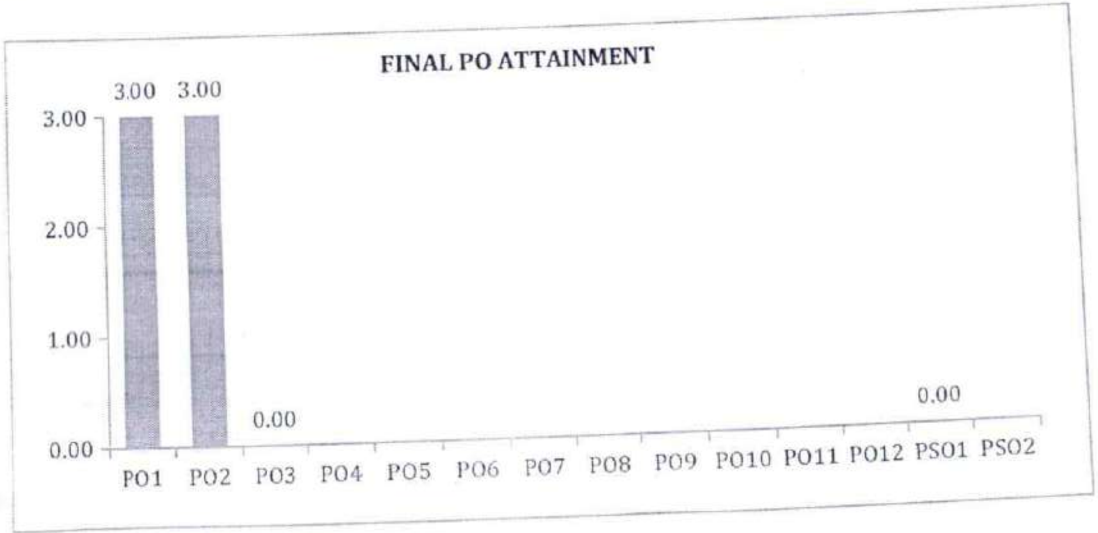
FINAL CO ATTAINMENT



C102.1	C102.2	C102.3	C102.4	C102.5

OVERALL ATTAINMENT OF PO&PSO THROUGH DIRECT ASSESSMENT TOOL

CO #	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
C102.1	0.55	0.60												
C102.2	0.55	0.60												
C102.3	0.55	0.60												
C102.4	0.55	0.60												
C102.5	0.82	0.60												
PO AT	3.00	3.00												



COMMENTS:

PO	ATTAINMENT LEVEL	TARGET	STATUS
PO1	3	1.95	YES
PO2	3	1.95	YES
PO3			
PO4			

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UNIT – I

SEQUENCES AND SERIES

***SEQUENCE :**

→ A Sequence of real numbers is a set of numbers arranged in a well-defined order. Thus for each +ve integer there is associated number of the sequence.

→ A function $S : Z^+ \to R$ is called a sequence of real numbers

→ A Sequence is defined from set of Natural numbers (N) to real numbers (R) i.e., $S : N \to R$

Ex:- (1) $1, 3, 5, 7, ----$

(2) $1+2+3+4+ ---$

(3) $1 - \frac{1}{2} + \frac{1}{3} - \frac{1}{4} + \frac{1}{5} + ----$

→ Sequence is denoted by $\{S_n\}$ (or) $\langle S_n \rangle$

***Constant Sequence:**

The sequence $\{S_n\}$ denoted by $S_n = K (\in R)$ is called a constant sequence

Ex:- $2, 2, 2, 2, ----$ is a constant sequence

*** Operations on Sequences:**

1. If $\{S_n\}, \{t_n\}$ are sequences then their sum of the sequence is defined by $\{S_n + t_n\} = \{S_n\} + \{t_n\}$ and product sequence is defined as $\{S_n t_n\} = \{S_n\}\{t_n\}$

Ex:- If $\{S_n\} = 1, 2, 3, ----$ and $\{t_n\} = 3, 4, 5 ----$ then

(i) $\{S_n + t_n\} = 4, 6, 8, ----$

(ii) $\{S_n t_n\} = 3, 8, 15, ---$

2. If $c \in R$ and $\{S_n\}$ is a Sequence then $c\{S_n\} = \{cS_n\}$

Note:- $(-1)\{S_n\} = \{-S_n\}$ is called negative of the Sequence $\{S_n\}$

3. $\left\{\frac{1}{S_n}\right\}$ is called the Reciprocal of the sequence $\{S_n\}$, $\left(\begin{array}{c} n \in Z^+, \\ S_n \neq 0 \end{array}\right)$

4. $\left\{\frac{S_n}{t_n}\right\}$ is defined as the quotient of the sequences $\{S_n\}$ and $\{t_n\}$ where $t_n \neq 0, n \in Z^+$

* Bounded of a Sequence

1) Def:- A Sequence $\{S_n\}$ is said to be bounded below if there Exist $K_1 \in R \ni K_1 \leq S_n, \forall n \in Z^+$.

→ K_1 is called a lower bound of the sequence $\{S_n\}$

→ If $\{S_n\}$ has no lower bound, then $\{S_n\}$ is said to be Unbounded below.

→ If $\{S_n\}$ is bounded below, the greatest among the lowerbounds of $\{S_n\}$ is called the greatest lowerbound (g.l.b) of S_n

2) Def:- A Sequence $\{S_n\}$ is said to be bounded above if $\exists$ $K_2 \in R$ Suchthat $S_n \leq K_2$, $\forall n \in Z^+$.

→ The number K_2 is called an upper bound of the Sequence $\{S_n\}$.

→ If $\{S_n\}$ has no upper bound, then $\{S_n\}$ is said to be unbounded above.

→ If $\{S_n\}$ is bounded above, the lowest among the upperbounds of $\{S_n\}$ is called the least upper bound (l.u.b) of $\{S_n\}$.

3) Def:- A Sequence $\{S_n\}$ is said to be <u>bounded</u> if it is bounded below as well as bounded above

→ If $\{S_n\}$ is not bounded, it is said to be <u>unbounded</u>.

4) <u>Monotonic Sequence</u>: A sequence $\{S_n\}$ is said to be

(i) <u>Monotonically increasing</u> if $S_{n+1} \geq S_n$ for Every n.

i.e., $S_1 \leq S_2 \leq S_3 \leq \cdots \leq S_n \leq S_{n+1} \leq \cdots$

(ii) <u>Monotonically decreasing</u> if $S_{n+1} \leq S_n$ for Every n.

i.e., $S_1 \geq S_2 \geq S_3 \geq \cdots \geq S_n \geq S_{n+1} \geq \cdots$

(iii) <u>Monotonic</u> if it is Either monotonically increasing or monotonically decreasing.

<u>Oscillatory sequence</u>: If $\lim_{n\to\infty} S_n$ is not unique

i) <u>Oscillating finitely</u>:- A sequence $\{S_n\}$ is said to be oscillate finitely if $\{S_n\}$ is bounded and not convergent

ii) <u>Oscillates infinitely</u>:- $\{S_n\}$ is said to be oscillate infinitely if $\{S_n\}$ is neither bounded nor divergent.

Ex:- $$\underset{n\to\infty}{Lt}\ n(-1)^n = \begin{cases} +\infty, & \text{if } n \text{ is +ve} \\ -\infty, & \text{if } n \text{ is -ve} \end{cases}$$

* Every Convergent Sequence is bounded.

Convergent Sequence

→ If $\lim_{n\to\infty} S_n = l$ then we say that the sequence $\{S_n\}$ converges to l. (or) $\{S_n\}$ is convergent to limit l

If $\lim_{n\to\infty} S_n = l$, where l is finite and unique, then the sequence $\{S_n\}$ is said to be "convergent", otherwise sequence $\{S_n\}$ is said to be divergent

→ Divergent sequences can be classified as

1) Divergent $\rightarrow +\infty$
2) Divergent $\rightarrow -\infty$
3) Oscillating finitely, means sequence S_n is bounded but not convergent
4) Oscillating infinitely, means sequence is neither bounded nor divergent

Series:-

An Expression of the form $u_1+u_2+u_3+u_4+\cdots+u_n+\cdots$ where $\{u_n\}$ is a sequence is called a series

→ If the series is like $u_1+u_2+u_3+\cdots+u_n$, it is called a finite series, otherwise it is said to be an infinite series.

The number U_n is called n^{th} term of the series

i.e., $\sum_{n=1}^{\infty} U_n$

→ If the sequence U_n converges then the series $\sum_{n=1}^{\infty} U_n$ converges.

→ If the sequence U_n is diverges then the series $\sum_{n=1}^{\infty} u_n$ is diverges.

p - seri

→ $\lim_{n\to\infty} \frac{1}{n} = 0$, $\lim_{n\to\infty} \frac{1}{n^2} = 0$, $\lim_{n\to\infty} \frac{1}{\sqrt{n}} = 0$,

$$\lim_{n\to\infty} \left(1+\frac{1}{n}\right)^n = e$$

Comparision test :- If $\sum u_n$ and $\sum v_n$ are two series of positive terms and $\lim_{n\to\infty} \frac{U_n}{V_n} = l \neq 0$, then the series $\sum U_n$ and $\sum V_n$ both converge or both diverge

Auxiliary series (P-series test)

The series $\sum \frac{1}{n^P} = \frac{1}{1^P} + \frac{1}{2^P} + \frac{1}{3^P} + \cdots$, $P \in R$

(a) converges if $P > 1$

(b) diverges if $P \leq 1$

Problems

1. Test for convergence: $\sum_{n=1}^{\infty} \frac{2n-1}{n(n+1)(n+2)}$

Sol: let $u_n = \frac{2n-1}{n(n+1)(n+2)} > 0, \forall n$

This is a series of positive terms

Take $U_n = \frac{n\left(2-\frac{1}{n}\right)}{n^3\left(1+\frac{1}{n}\right)\left(1+\frac{2}{n}\right)} = \frac{1}{n^2}\left[\frac{2-\frac{1}{n}}{\left(1+\frac{1}{n}\right)\left(1+\frac{2}{n}\right)}\right]$

Let $V_n = \frac{1}{n^2}$

$\sum V_n = \sum \frac{1}{n^2}$

Here $p>1$, So the series is Convergent.
By Comparision test.

$\therefore \lim_{n\to\infty} \frac{u_n}{V_n} = \lim_{n\to\infty} \frac{2-\frac{1}{n}}{\left(1+\frac{1}{n}\right)\left(1+\frac{2}{n}\right)} = \frac{2}{(1)(1)} = 2 \neq 0$

$\therefore$ By Comparision test, $\sum u_n$ is Convergent.

2. Test the Convergence of the series

(i) $\sum_{n=1}^{\infty} \left\{ \sqrt[3]{(n^3+1)} - n \right\}$

(ii) $\sum_{n=1}^{\infty} \left[(n^4+1)^{1/4} - n \right]$

Soln let $u_n = \sqrt[3]{n^3+1} - n \Rightarrow u_n = (n^3+1)^{1/3} - n$

$u_n = \left[n^3\left[1+\frac{1}{n^3}\right]\right]^{1/3} - n$

$u_n = n\left[1+\frac{1}{n^3}\right]^{1/3} - n$

Since $u_n > 0$, $\forall n$ this is a series of positive terms

$$(1+a^n)^{1/n} = 1 + \frac{1}{n}a^n + \frac{\frac{1}{n}\left(\frac{1}{n}-1\right)}{2}\left(a^{\frac{1}{n}}\right)^2 + \frac{\frac{1}{n}\left(\frac{1}{n}-1\right)\left(\frac{1}{n}-2\right)}{3}\left(a^{\frac{1}{n}}\right)^3 + \cdots$$

(or)

$$(1+a^x)^y = 1 + y a^x + \frac{y(y-1)}{2}(a^x)^2 + \frac{y(y-1)(y-2)}{3}(a^x)^3 + \cdots$$

$$\left(1+\frac{1}{n^3}\right)^{\frac{1}{3}} = 1 + \frac{1}{3}\,\frac{1}{n^3} + \frac{\frac{1}{3}\left(\frac{1}{3}-1\right)}{2}\,\frac{1}{n^6} + \cdots$$

$$u_n = \frac{2}{n^2\left[\sqrt{1+\frac{1}{n^4}} + \sqrt{1-1/n^4}\right]}$$

Select $v_n = \frac{1}{n^2} \Rightarrow \Sigma v_n = \Sigma \frac{1}{n^2}$, $p = 2 > 1$

By p-series test Σv_n is convergent.

Now by comparision test

$$\lim_{n\to\infty} \frac{u_n}{v_n} = \lim_{n\to\infty} \frac{\frac{2}{\cancel{n^2}\left[\sqrt{1+\frac{1}{n^4}} + \sqrt{1-\frac{1}{n^4}}\right]}}{\frac{1}{\cancel{n^2}}} = \lim_{n\to\infty} \frac{2}{\sqrt{1+\frac{1}{n^4}} + \sqrt{1-\frac{1}{n^4}}}$$

$$= \frac{2}{1+1} = \frac{2}{2} = 1 \neq 0.$$

$\therefore$ By comparision test $\Sigma u_n, \Sigma v_n$ are both behave in same way. $\therefore$ Σv_n also convergent Σu_n is convergent,

(7) Test for convergence (or) divergence:

$$\frac{1}{1\cdot 3} + \frac{2}{3\cdot 5} + \frac{3}{5\cdot 7} + \cdots + \infty$$

Sol:

$1, 2, 3 \cdots = a+(n-1)d = 1+(n-1)1 = n$

$1, 3, 5 \cdots = a+(n-1)d = 1+(n-1)2 = 2n-1$

$3, 5, 7 \cdots = (a+(n-1)d = 3+(n-1)2 = 2n+1$

$$u_n = \frac{n}{(2n-1)(2n+1)}$$

$$u_n = \frac{n}{n\left(2-\frac{1}{n}\right) n\left(2+\frac{1}{n}\right)} = \frac{\cancel{n}}{n^{\cancel{2}}\left(2-\frac{1}{n}\right)\left(2+\frac{1}{n}\right)}$$

$$u_n = \frac{1}{n} \cdot \frac{1}{\left(2-\frac{1}{n}\right)\left(2+\frac{1}{n}\right)}$$

Select $v_n = \frac{1}{n} \Rightarrow \Sigma v_n = \Sigma \frac{1}{n}$

By p-series test $\Sigma \frac{1}{n^p}$, $p = 1 \leq 1$

Σu_n is divergent

(5) Test for convergence or divergence of the following series

$$\sum_{n=1}^{\infty} \frac{\sqrt{n}}{n^2+1}$$

Sol: Given $\sum_{n=1}^{\infty} \frac{\sqrt{n}}{n^2+1}$

let $u_n = \frac{\sqrt{n}}{n^2+1} > 0$

Since $u_n > 0$, the given series is positive

$$u_n = \frac{\sqrt{n}}{n^2(1+\frac{1}{n^2})} = \frac{\sqrt{n}}{n^2} \cdot \frac{1}{1+\frac{1}{n^2}}$$

Select $v_n = \frac{\sqrt{n}}{n^2} = \frac{(n)^{1/2}}{n^2} = \frac{1}{n^2 \cdot n^{-\frac{1}{2}}} = \frac{1}{n^{2-\frac{1}{2}}} = \frac{1}{n^{3/2}}$

$$v_n = \frac{1}{n^{3/2}} \Rightarrow \sum v_n = \sum \frac{1}{n^{3/2}}$$

By p-series test, $p = \frac{3}{2} > 1$

$\therefore \sum v_n$ is converges.

By comparision test, $\lim_{n\to\infty} \frac{u_n}{v_n} = \dfrac{\frac{\cancel{\sqrt{n}}}{\cancel{n^2}} \cdot \frac{1}{1+\frac{1}{n^2}}}{\frac{\cancel{\sqrt{n}}}{\cancel{n^2}}} = \lim_{n\to\infty} \frac{1}{1+\frac{1}{n^2}}$

$$= \frac{1}{1+\frac{1}{\infty}} = \frac{1}{1} = 1 \neq 0$$

$\therefore \sum u_n$ is converges., By comparision test, both $\sum u_n$ and $\sum v_n$ converges.

(6) Test the convergence or divergence of the following series. $\sum_{n=1}^{\infty} \left(\sqrt{n^4+1} - \sqrt{n^4-1}\right)$

Sol: Given $\sum_{n=1}^{\infty} \left(\sqrt{n^4+1} - \sqrt{n^4-1}\right)$

let $u_n = \sqrt{n^4+1} - \sqrt{n^4-1}$

Rationalize u_n, we get

$$u_n = \sqrt{n^4+1} - \sqrt{n^4-1} \times \frac{\sqrt{n^4+1} + \sqrt{n^4-1}}{\sqrt{n^4+1} + \sqrt{n^4-1}}$$

$$u_n = \frac{\cancel{n^4}+1 - \cancel{n^4}+1}{\sqrt{n^4+1} + \sqrt{n^4-1}} = \frac{2}{n^2\left[\sqrt{1+\frac{1}{n^4}} + \sqrt{1-\frac{1}{n^4}}\right]}$$

Let $v_n = \frac{1}{3^n}$ [If the series is of the form $1 + r + r^2 + r^3 + \cdots$ then (1) converges if $-1 < r < 1$ (2) diverges if $r \geq 1$ (3) Test fails if $r = -1$

$\Sigma v_n = \Sigma \left(\frac{1}{3}\right)^n$ is a geometric series $r = \frac{1}{3} \in (0,1)$

$\therefore$ Σv_n is convergent by G-test

$r^n = \frac{1}{3} < 1$

$$\lim_{n\to\infty} \frac{u_n}{v_n} = \lim_{n\to\infty} \frac{\frac{1}{2^n+3^n}}{\frac{1}{3^n}} = \lim_{n\to\infty} \frac{\frac{1}{3^n\left(1+\frac{2^n}{3^n}\right)}}{\frac{1}{3^n}}$$

$$= \lim_{n\to\infty} \frac{1}{1+\left(\frac{2}{3}\right)^n}$$

$$= 1 \neq 0.$$

$\therefore$ Σu_n is convergent by comparison test.

(4) Show that $\frac{2}{1^p} + \frac{3}{2^p} + \frac{4}{3^p} + \cdots$ is convergent for $p > 2$ and divergent for $p \leq 2$

(or)

Examine the convergence of $\Sigma \frac{n+1}{n^p}$

Sol: we have $u_n = \frac{n+1}{n^p} = \frac{n\left(1+\frac{1}{n}\right)}{n^p} = \frac{1+\frac{1}{n}}{n^p \cdot n^{-1}} = \frac{1+\frac{1}{n}}{n^{p-1}}$

Take $v_n = \frac{1}{n^{p-1}} \Rightarrow \Sigma v_n = \Sigma \frac{1}{n^{p-1}}$

By p-series $p = p-1$

$$U_n = n\left[1+\frac{1}{n^3}\right]^{1/3} - n$$

$$= n\left[1+\frac{1}{3}\cdot\frac{1}{n^3} + \frac{\frac{1}{3}\left(\frac{1}{3}-1\right)}{2}\cdot\frac{1}{n^6}+\cdots\right] - n$$

$$= \left[\frac{\cancel{n}}{3n^3} - \frac{\cancel{2}\cancel{n}}{9n^6}\times\frac{1}{\cancel{2}} + \cdots\right] - n$$

$$= \frac{1}{3n^2} - \frac{1}{9n^5} + \cdots$$

$$= \frac{1}{n^2}\left[\frac{1}{3} - \frac{1}{9n^3} + \cdots\right.$$

let $V_n = \frac{1}{n^2}$

$\therefore \Sigma V_n = \Sigma \frac{1}{n^2}$ and ΣV_n is convergent

Now $\lim_{n\to\infty} \frac{u_n}{V_n} = \dfrac{\cancel{\frac{1}{n^2}}\left[\frac{1}{3} - \frac{1}{9n^3} + \cdots\right]}{\cancel{\frac{1}{n^2}}}$

$\Rightarrow \lim_{n\to\infty} \frac{u_n}{V_n} = \frac{1}{3} - \frac{1}{\infty} = \frac{1}{3} \neq 0.$

$\therefore$ By Comparison test Σu_n and ΣV_n behaves in same way. But $\Sigma V_n = \Sigma \frac{1}{n^2}$ is convergent

$\therefore$ By Comparison test ΣU_n is also convergent.

(3) Test for convergence of $\sum_{n=1}^{\infty} \frac{1}{2^n+3^n}$

Sol: let $U_n = \frac{1}{2^n+3^n}$

Since $U_n > 0, \forall n$ this is a series of positive terms. let $U_n = \frac{1}{2^n+3^n}$

$$= \frac{1}{3^n\left[\frac{2^n}{3^n}+1\right]} = \frac{1}{3^n\left[1+\left(\frac{2}{3}\right)^n\right]}$$

By Comparission test

$$\lt_{n\to\infty} \frac{u_n}{v_n} = \lt_{n\to\infty} \frac{\cancel{\frac{1}{n}}\left(\frac{1}{(2-\frac{1}{n})(2+\frac{1}{n})}\right)}{\cancel{\frac{1}{n}}}$$

$$= \lt_{n\to\infty} \frac{1}{(2-\frac{1}{n})(2+\frac{1}{n})}$$

$$= \frac{1}{(2-0)(2+0)} = \frac{1}{4} \neq 0.$$

$\therefore$ Σu_n is divergent.
By comparission test Σv_n is divergent and Σu_n also divergent.

(8) Test for Convergence

$$\frac{1\cdot 2}{3\cdot 4\cdot 5} + \frac{2\cdot 3}{4\cdot 5\cdot 6} + \frac{3\cdot 4}{5\cdot 6\cdot 7} + \cdots$$

sol: Given $\frac{1\cdot 2}{3\cdot 4\cdot 5} + \frac{2\cdot 3}{4\cdot 5\cdot 6} + \frac{3\cdot 4}{5\cdot 6\cdot 7} + \cdots$

now $1, 2, 3, \cdots = [a+(n-1)d = 1+(n-1)1 = n$

Similar $2, 3, 4, \cdots = (n+1)$

$3, 4, 5, \cdots = (n+2)$

$4, 5, 6 \cdots = (n+3)$

$5, 6, 7 \cdots = (n+4).$

$$\therefore u_n = \frac{n(n+1)}{(n+2)(n+3)(n+4)}$$

$\therefore$ Σu_n is a series of +ve terms

$$u_n = \frac{\cancel{n^2}(1+\frac{1}{n})}{n^3(1+\frac{2}{n})(1+\frac{3}{n})(1+\frac{4}{n})} = \frac{1}{n} \cdot \frac{(1+\frac{1}{n})}{(1+\frac{2}{n})(1+\frac{3}{n})(1+\frac{4}{n})}$$

Select $v_n = \frac{1}{n} \Rightarrow \Sigma v_n = \Sigma \frac{1}{n}$

By p-series test $\Sigma \frac{1}{n^p}$, $p = 1$

$\therefore \Sigma v_n$ is divergent

$$\therefore \lim_{n\to\infty} \frac{u_n}{v_n} = \lim_{n\to\infty} \frac{\dfrac{1+\frac{1}{n}}{\cancel{n^2}\left(1+\frac{2}{n}\right)\left(1+\frac{3}{n}\right)\left(1+\frac{4}{n}\right)}}{\frac{1}{\cancel{n^2}}}$$

$$= \lim_{n\to\infty} \frac{1+\frac{1}{n}}{\left(1+\frac{2}{n}\right)\left(1+\frac{3}{n}\right)\left(1+\frac{4}{n}\right)}$$

$$= \frac{1}{1} = 1 \neq 0$$

$\therefore$ By comparision test Σu_n, Σv_n are both behaves in a sameway.

$\therefore \Sigma v_n$ is divergent, Σu_n is also divergent

(9) Test for Convergence : $\Sigma \frac{1}{n} \sin\frac{1}{n}$

Sol: Given $\Sigma \frac{1}{n}\sin\frac{1}{n}$

let $u_n = \frac{1}{n}\sin\frac{1}{n} > 0, \forall n$

Σu_n is a series of +ve terms

$$u_n = \frac{1}{n^2} \frac{\sin\frac{1}{n}}{\frac{1}{n}}$$

Select $v_n = \frac{1}{n^2}$ i.e., $\Sigma \frac{1}{n^p}, p = 2$

$\Sigma v_n = \Sigma \frac{1}{n^2}$

$\therefore \Sigma v_n$ is Convergent.

$\left[\because \lim_{t\to 0} \frac{\sin t}{t} = 1\right]$

$\therefore$ By Comparision test

$$\lim_{n\to\infty} \frac{u_n}{v_n} = \lim_{n\to\infty} \frac{\cancel{\frac{1}{n^2}} \cdot \frac{\sin\frac{1}{n}}{\frac{1}{n}}}{\cancel{\frac{1}{n^2}}} = \lim_{n\to\infty} \frac{\sin 1/n}{\frac{1}{n}} = 1 \neq 0.$$

$\therefore$ By Comparision test $\Sigma u_n, \Sigma v_n$ both behave in same way.

$\therefore \Sigma v_n$ is convergent, Σu_n is also convergent.

(10) Test for Convergence: $\sum_{n=1}^{\infty} \frac{1}{n^3}\left(\frac{n+2}{n+3}\right)^n$

Sol: Given $\sum_{n=1}^{\infty} \frac{1}{n^3}\left(\frac{n+2}{n+3}\right)^n > 0, \forall n$

$\therefore \Sigma u_n$ is a series of +ve terms

Hence $v_n = \frac{1}{n^3}$

i.e., $\Sigma v_n = \Sigma \frac{1}{n^3}$ i.e., $\frac{1}{n^p}, p = 3 > 1$

$\therefore \Sigma v_n$ is convergent.

$$\lim_{n\to\infty} \frac{u_n}{v_n} = \lim_{n\to\infty} \frac{\cancel{\frac{1}{n^3}}\left[\frac{n+2}{n+3}\right]^n}{\cancel{\frac{1}{n^3}}}$$

$$= \lim_{n\to\infty} \left[\frac{n+2}{n+3}\right]^n = \lim_{n\to\infty} \frac{n^n\left[1+\frac{2}{n}\right]^n}{n^n\left[1+\frac{3}{n}\right]^n}$$

$$= \lim_{n\to\infty} \frac{\left(1+\frac{2}{n}\right)^n}{\left(1+\frac{3}{n}\right)^n}$$

$$\left[\because \lim_{n\to\infty}\left(1+\frac{1}{n}\right)^n = e\right]$$

$$= \lim_{n\to\infty} \frac{e^2}{e^3} = \frac{1}{e} \neq 0$$

$\therefore$ By comparision test, Σu_n and Σv_n behave in the Same way.

$\therefore$ Both Σu_n and Σv_n are Convergent

(11) Test for Convergence : $\sum_{n=1}^{\infty} \frac{1}{\sqrt{n}+\sqrt{n+1}}$

Sol: Given $\sum_{n=1}^{\infty} \frac{1}{\sqrt{n}+\sqrt{n+1}} > 0$. , u_n is a +ve series.

let $u_n = \frac{1}{\sqrt{n}+\sqrt{n+1}}$

$$u_n = \frac{1}{\sqrt{n}\left(1+\sqrt{1+\frac{1}{n}}\right)}$$

Select $v_n = \frac{1}{\sqrt{n}} = \frac{1}{n^{1/2}}$

By p-series , $\sum \frac{1}{n^p}$, $p = \frac{1}{2} < 1$

$\therefore \sum v_n$ is divergent.

Now $\lim_{n\to\infty} \frac{u_n}{v_n} = \lim_{n\to\infty} \frac{\frac{1}{\cancel{\sqrt{n}}\left(1+\sqrt{1+\frac{1}{n}}\right)}}{\frac{1}{\cancel{\sqrt{n}}}} = \lim_{n\to\infty} \frac{1}{1+\sqrt{1+\frac{1}{n}}}$

$= \frac{1}{2} \neq 0$

$\therefore$ By Comparison test $\sum u_n$ and $\sum v_n$ will have same property.

Hence $\sum u_n$ also divergent.

(12) Test for Convergence $\sum \frac{\sqrt{2n^2-5n+1}}{4n^3-7n^2+2}$

Sol: Given $\sum \frac{\sqrt{2n^2-5n+1}}{4n^3-7n^2+2} > 0, \forall n$

$\sum u_n$ is a series of +ve terms

let $u_n = \frac{\cancel{n}\sqrt{2-\frac{5}{n}+\frac{1}{n^2}}}{n^{\cancel{3}}\left(4-\frac{7}{n}+\frac{2}{n^3}\right)} = \frac{\sqrt{2-\frac{5}{n}-\frac{1}{n^2}}}{n^2\left(4-\frac{7}{n}+\frac{2}{n^3}\right)}$

Select $v_n = \frac{1}{n^2} \Rightarrow \sum v_n = \sum \frac{1}{n^2}$

By p-series test , $\sum \frac{1}{n^p}$, ie, $p = 2 > 1$

$\therefore \sum v_n$ is Convergent

$$\therefore \lim_{n\to\infty} \frac{u_n}{v_n} = \lim_{n\to\infty} \frac{\dfrac{\sqrt{2-\frac{5}{n}+\frac{1}{n^2}}}{\cancel{n^2}\left(4-\frac{7}{n}+\frac{2}{n^3}\right)}}{\cancel{\frac{1}{n^2}}}$$

$$= \lim_{n\to\infty} \frac{\sqrt{2-\frac{5}{n}+\frac{7}{n^2}}}{4-\frac{7}{n}+\frac{2}{n^3}} = \frac{\sqrt{2}}{4} \neq 0$$

By comparision test,

$\therefore$ Σu_n also Convergent.

(13) Test for convergence: $\sqrt{n^3+1} - \sqrt{n^3}$

Sol Given $u_n = \sqrt{n^3+1} - \sqrt{n^3} > 0, \forall n$

$\therefore \Sigma u_n$ is a series of +ve terms

$$u_n = \sqrt{n^3+1} - \sqrt{n^3} \times \frac{\sqrt{n^3+1} + \sqrt{n^3}}{\sqrt{n^3+1} + \sqrt{n^3}}$$

$$= \frac{(\cancel{n^3}+1-\cancel{n^3})}{\sqrt{n^3+1}+\sqrt{n^3}} = \frac{1}{\sqrt{n^3}\left(\sqrt{1+\frac{1}{n^3}}+1\right)}$$

$$u_n = \frac{1}{\sqrt{n^3}\left(\sqrt{1+\frac{1}{n^3}}+1\right)}$$

Select $v_n = \frac{1}{\sqrt{n^3}} = \frac{1}{n^{3/2}} \Rightarrow \Sigma v_n = \Sigma \frac{1}{n^{3/2}}$

By p-series, $\Sigma \frac{1}{n^p}$, $p = \frac{3}{2} > 1$

$\therefore \Sigma v_n$ is Convergent

$$\lim_{n\to\infty} \frac{u_n}{v_n} = \lim_{n\to\infty} \frac{\dfrac{1}{\cancel{\sqrt{n^3}}\left(\sqrt{1+\frac{1}{n^3}}+1\right)}}{\dfrac{1}{\cancel{\sqrt{n^3}}}} = \lim_{n\to\infty} \frac{1}{\sqrt{1+\frac{1}{n^3}}+1}$$

$$= \frac{1}{1+1} = \frac{1}{2} \neq 0$$

$\therefore$ By comparision test Σu_n and Σv_n are Convergent

(14) Test for Convergence : $\frac{\sqrt{2}-1}{3^2-1} + \frac{\sqrt{3}-1}{4^2-1} + \frac{\sqrt{4}-1}{5^2-1} + \cdots$

Sol: Given $\frac{\sqrt{2}-1}{3^2-1} + \frac{\sqrt{3}-1}{4^2-1} + \frac{\sqrt{4}-1}{5^2-1} + \cdots$

Here $U_n = \frac{\sqrt{n+1}-1}{(n+2)^2-1}$

$\therefore \Sigma u_n$ is Series of +ve terms

$$u_n = \frac{\sqrt{n+1}-1}{(n+2)^2-1} = \frac{\sqrt{n}\left(\sqrt{1+\frac{1}{n}}-\frac{1}{\sqrt{n}}\right)}{n^2\left[\left(1+\frac{2}{n}\right)^2-\frac{1}{n^2}\right]}$$

$$= \frac{\sqrt{1+\frac{1}{n}}-\frac{1}{\sqrt{n}}}{n^{3/2}\left[\left(1+\frac{2}{n}\right)^2-\frac{1}{n^2}\right]}$$

$$u_n = \frac{1}{n^{3/2}} \cdot \frac{\sqrt{1+\frac{1}{n}}-\frac{1}{\sqrt{n}}}{\left(1+\frac{2}{n}\right)^2-\frac{1}{n^2}}$$

Select $v_n = \frac{1}{n^{3/2}} \Rightarrow \Sigma v_n = \Sigma \frac{1}{n^{3/2}}$

i.e., $\Sigma \frac{1}{n^p}$, $p = 3/2 > 1$

$\therefore \Sigma v_n$ is Convergent

$$\therefore \lim_{n\to\infty} \frac{u_n}{v_n} = \lim_{n\to\infty} \frac{\frac{1}{\cancel{n^{3/2}}} \cdot \frac{\sqrt{1+\frac{1}{n}}-\frac{1}{\sqrt{n}}}{\left(1+\frac{2}{n}\right)^2+\frac{1}{n^2}}}{\frac{1}{\cancel{n^{3/2}}}}$$

$$= \lim_{n\to\infty} \frac{\sqrt{1+\frac{1}{n}}-\frac{1}{\sqrt{n}}}{\left(1+\frac{2}{n}\right)^2+\frac{1}{n^2}} = \frac{1}{1} = 1 \neq 0.$$

$\therefore$ By comparison test both Σu_n and Σv_n are Convergent.

(15) Test for Convergence of $1+\frac{1}{2^2}+\frac{2^2}{3^3}+\frac{3^3}{4^4}+\cdots$

Sol: Given $1+\frac{1}{2^2}+\frac{2^2}{3^3}+\frac{3^3}{4^4}+\cdots$

By omitting first term,

consider $u_n=\frac{n^n}{(n+1)^{n+1}}$

$$u_n=\frac{n^n}{(n+1)^{n+1}}=\frac{n^n}{n^{n+1}\left[\frac{1}{n}+1\right]^{n+1}}$$

$$=\frac{n^n}{n^n\cdot n^1\left[1+\frac{1}{n}\right]^{n+1}}$$

$$u_n=\frac{1}{n\left[1+\frac{1}{n}\right]^{n+1}}$$

Select $v_n=\frac{1}{n} \Rightarrow \Sigma v_n=\Sigma\frac{1}{n}$ i.e., $\Sigma\frac{1}{n^p}$, $p=1$

$\therefore \Sigma v_n$ is divergent

$$\therefore \lim_{n\to\infty}\frac{u_n}{v_n}=\lim_{n\to\infty}\frac{\frac{1}{\cancel{n}\left[1+\frac{1}{n}\right]^{n+1}}}{\frac{1}{\cancel{n}}}=\lim_{n\to\infty}\frac{1}{\left[1+\frac{1}{n}\right]^{n+1}}$$

$$=\lim_{n\to\infty}\frac{1}{\left(1+\frac{1}{n}\right)^n}\times\frac{1}{1+\frac{1}{n}}$$

$$=\frac{1}{e}\neq 0.$$

$\therefore$ By comparision test Σu_n, Σv_n are both behaves in the Sameway.

$\therefore$ Both Σv_n, Σu_n are divergent.

* D'ALEMBERT'S RATIO TEST

If $\sum u_n$ is a series of positive terms such that $\lim_{n\to\infty} \frac{u_n}{u_{n+1}} = l$ then

(a) $\sum u_n$ is convergent, if $l>1$

(b) $\sum u_n$ is divergent, if $l<1$

(c) Then test fails to decide the nature of the series, if $l=1$

① Test for converges $\sum_{n=1}^{\infty} \frac{n}{n^n}$

Sol: let $u_n = \frac{n}{n^n} > 0, \forall n$

and $\sum u_n$ is a series of +ve terms

$$U_{n+1} = \frac{n+1}{(n+1)^{n+1}}$$

$$\lim_{n\to\infty} \frac{u_n}{U_{n+1}} = \lim_{n\to\infty} \frac{\frac{n}{n^n}}{\frac{(n+1)}{(n+1)^{n+1}}} = \lim_{n\to\infty} \frac{n}{n^n} \times \frac{(n+1)^{n+1}}{n+1}$$

$$= \lim_{n\to\infty} \frac{\cancel{n}}{n^n} \times \frac{n^{n+1}\left(1+\frac{1}{n}\right)^{n+1}}{\cancel{n}\left(1+\frac{1}{n}\right)}$$

$$= \lim_{n\to\infty} \frac{\cancel{n^n}.n}{\cancel{n^n}} \cdot \frac{\left(1+\frac{1}{n}\right)^{n+1}}{1+\frac{1}{n}}$$

$$= \infty . e$$

$$= \infty > 1$$

∴ By ratio test, $\sum u_n$ converges

② $\sum_{n=1}^{\infty} \frac{n^4}{n!}$

Sol: let $u_n = \frac{n^4}{n!} > 0, \forall n$

and $\sum U_n$ is a series of +ve terms

$$u_{n+1} = \frac{(n+1)^4}{(n+1)!}$$

$$\boxed{\begin{aligned} n! &= n(n-1)! \\ (n+1)! &= n!\,(n+1) \end{aligned}}$$

$$\lim_{n\to\infty} \frac{u_n}{u_{n+1}} = \lim_{n\to\infty} \frac{\frac{n^4}{n!}}{\frac{(n+1)^4}{(n+1)!}} = \lim_{n\to\infty} \frac{n^4}{n!} \times \frac{(n+1)!}{(n+1)^4}$$

$$= \lim_{n\to\infty} \frac{\cancel{n^4}}{\cancel{n!}} \times \frac{\cancel{n!}\,(n+1)}{\cancel{n^4}\left(1+\frac{1}{n}\right)^4}$$

$$= \lim_{n\to\infty} \frac{n+1}{\left(1+\frac{1}{n}\right)^4} = \frac{\infty}{1} = \infty > 1$$

$\therefore$ By ratio test, $\sum u_n$ Converges.

(3) Test for Convergence: $\sum_{n=1}^{\infty} \frac{3n-1}{2^n}$

Sol: Let $u_n = \frac{3n-1}{2^n} > 0, \forall n$

and $\sum u_n$ is a series of +ve terms

$$u_{n+1} = \frac{3(n+1)-1}{2^{n+1}}$$

$$\lim_{n\to\infty} \frac{u_n}{u_{n+1}} = \lim_{n\to\infty} \frac{\frac{3n-1}{2^n}}{\frac{3(n+1)-1}{2^{n+1}}} = \lim_{n\to\infty} \frac{3n-1}{\cancel{2^n}} \times \frac{\cancel{2^n}\cdot 2}{3n+2}$$

$$= \lim_{n\to\infty} \frac{2\cancel{n}\left(3-\frac{1}{n}\right)}{\cancel{n}\left(3+\frac{2}{n}\right)} = \lim_{n\to\infty} \frac{2\left(3-\frac{1}{n}\right)}{3+\frac{2}{n}}$$

$$= \frac{2(3-0)}{3+0} = \frac{6}{3} = 2 > 1$$

$\therefore$ By ratio test, $\sum u_n$ Converges.

(4) Test for Convergence: $\sum \frac{n^2}{2^n}$

Sol: Let $u_n = \frac{n^2}{2^n} > 0, \forall n$

and $\sum u_n$ is a series of +ve terms

$$u_{n+1} = \frac{(n+1)^2}{2^{(n+1)}}$$

$$\lim_{n\to\infty} \frac{u_n}{u_{n+1}} = \lim_{n\to\infty} \frac{\frac{n^2}{2^n}}{\frac{(n+1)^2}{2^{n+1}}}$$

$$= \lim_{n\to\infty} \frac{n^2}{2^n} \times \frac{2^{n+1}}{(n+1)^2}$$

$$= \lim_{n\to\infty} \frac{n^2}{\cancel{2^n}} \times \frac{\cancel{2^n}\cdot 2}{(n+1)^2}$$

$$= \lim_{n\to\infty} \frac{2\cancel{n^2}}{\cancel{n^2}(1+\frac{1}{n})^2} = \lim_{n\to\infty} \frac{2}{(1+\frac{1}{n})^2} = 2 > 1$$

$\therefore$ By ratio test, Σu_n converges.

(5) Test for Convergence : $\sum \frac{2^n n!}{n^n}$.

Sol: Let $u_n = \frac{2^n n!}{n^n} > 0, \forall n$

and Σu_n is a series of +ve terms

$$u_{n+1} = \frac{2^{n+1}(n+1)!}{(n+1)^{n+1}}$$

$$\lim_{n\to\infty} \frac{u_n}{u_{n+1}} = \lim_{n\to\infty} \frac{\frac{2^n n!}{n^n}}{\frac{2^{n+1}(n+1)!}{(n+1)^{n+1}}} = \lim_{n\to\infty} \frac{2^n n!}{n^n} \times \frac{(n+1)^{n+1}}{2^{n+1}(n+1)!}$$

$$= \lim_{n\to\infty} \frac{\cancel{2^n}\cdot \cancel{n!}}{n^n} : \frac{n^{(n+1)}\left[1+\frac{1}{n}\right]^{n+1}}{\cancel{2^n}\cdot 2 \cdot \cancel{n!}(n+1)}$$

$$= \lim_{n\to\infty} \frac{\cancel{n^n}\cancel{n}}{\cancel{n^n}} \frac{\left[1+\frac{1}{n}\right]^{n+1}}{2\cancel{n}\left[1+\frac{1}{n}\right]}$$

$$= \lim_{n\to\infty} \frac{1}{2}\left[1+\frac{1}{n}\right]^n$$

$$= \frac{e}{2} > 1$$

$\therefore$ By ratio test Σu_n is Converges.

(6) Test for Convergence of $\sum \frac{1.2.3.\cdots n}{3.5.7.\cdots(2n+1)}$

Sol: let $u_n = \frac{1.2.3.\cdots n}{3.5.7.\cdots(2n+1)} > 0, \forall n$

$\sum u_n$ is a series of the terms

$$u_{n+1} = \frac{1.2.3\cdots n(n+1)}{3.5.7\cdots(2n+1)(2n+3)}$$

$$\lim_{n\to\infty} \frac{u_n}{u_{n+1}} = \lim_{n\to\infty} \frac{\cancel{1.2.3.\cdots n}}{\cancel{3.5.7.\cdots(2n+1)}} \times \frac{\cancel{3.5.7\cdots(2n+1)}(2n+3)}{\cancel{1.2.3\cdots n}(n+1)}$$

$$= \lim_{n\to\infty} \frac{2n+3}{n+1}$$

$$= \lim_{n\to\infty} \frac{\cancel{n}\left(2+\frac{3}{n}\right)}{\cancel{n}\left(1+\frac{1}{n}\right)} = \lim_{n\to\infty} \frac{2+\frac{3}{n}}{1+\frac{1}{n}}$$

$$= 2 > 1$$

$\therefore$ By ratio test $\sum u_n$ converges.

(7) Test for Convergence $\sum \frac{1}{2\sqrt{1}} + \frac{x^2}{3\sqrt{2}} + \frac{x^4}{4\sqrt{3}} + \cdots + \infty$

Sol: Here $u_n = \frac{x^{2n-2}}{\sqrt{n}(n+1)} > 0, \forall n$

$\sum U_n$ is a series at the terms

$$U_{n+1} = \frac{x^{2(n+1)-2}}{\sqrt{n+1}\,(n+1+1)} = \frac{x^{2n}}{\sqrt{n+1}\,(n+2)}$$

$$\lim_{n\to\infty} \frac{u_n}{u_{n+1}} = \lim_{n\to\infty} \frac{x^{2n-2}}{(n+1)\sqrt{n}} \times \frac{(\sqrt{n+1})(n+2)}{x^{2n}}$$

$$= \lim_{n\to\infty} \frac{x^{2n-2}}{\sqrt{n}\,(n+1)} \times \frac{n^{1/2}.n\left(\cancel{\frac{n+1}{\sqrt{n}}}\right)\left(1+\frac{2}{n}\right)}{x^{2n}}$$

$$= \frac{\cancel{x^{2n}} \cdot x^{-2}}{\cancel{n^{1/2}} \cdot \cancel{n}\left[1+\frac{1}{n}\right]} \times \frac{\cancel{n^{1/2}} \cdot \cancel{n} \left[\sqrt{1+\frac{1}{n}}\right]\left[1+\frac{2}{n}\right]}{\cancel{x^{2n}}}$$

$$= \frac{1}{x^2} \lim_{n\to\infty} \frac{\sqrt{1+\frac{1}{n}}\,(1+2/n)}{1+1/n}$$

$$= \frac{1}{x^2} \frac{(\sqrt{1+0})(1+0)}{1+0} = \frac{1}{x^2}\frac{1}{1} = \frac{1}{x^2} \neq 0$$

if $\frac{1}{x^2} > 1$, Σu_n Converges.

i.e, $x^2 < 1$

if $\frac{1}{x^2} < 1$, Σu_n diverges.

i.e., $x^2 > 1$, if $\frac{1}{x^2} = 1$, Test fails.

put $x^2 = 1$, in U_n

$$u_n = \frac{1}{\sqrt{n}(n+1)} = \frac{1}{n^{1/2} \cdot n\left[1+\frac{1}{n}\right]}$$

$$\Sigma v_n = \Sigma \frac{1}{n^{3/2}}, \; p = \frac{3}{2} > 1$$

Σv_n is Converges.

$$\lim_{n\to\infty} \frac{U_n}{V_n} = \lim_{n\to\infty} \frac{\frac{1}{\cancel{n^{3/2}}\left[1+\frac{1}{n}\right]}}{\cancel{1/n^{3/2}}} = \lim_{n\to\infty} \frac{1}{1+\frac{1}{n}} = \frac{1}{1} = 1 \neq 0$$

$\therefore$ By Comparison test

Σu_n & Σv_n Converges.

$\therefore \Sigma u_n$ converges if $x^2 \leq 1$

Σv_n diverges if $x^2 > 1$

(8) Test for Convergence: $\sum \frac{x^1}{1\cdot 2} + \frac{x^2}{2\cdot 3} + \frac{x^3}{3\cdot 4} + \cdots$

Sol: Here $u_n = \frac{x^n}{n(n+1)} > 0, \forall n$

$\sum u_n$ is a series of +ve terms

$$u_{n+1} = \frac{x^{n+1}}{(n+1)(n+2)}$$

$$\therefore \lim_{n\to\infty} \frac{u_n}{u_{n+1}} = \lim_{n\to\infty} \frac{x^n}{n(n+1)} \times \frac{(n+1)(n+2)}{x^{n+1}}$$

$$= \lim_{n\to\infty} \frac{x^n}{n} \cdot \frac{n+2}{x^n \cdot x}$$

$$= \lim_{n\to\infty} \frac{n\left(1+\frac{2}{n}\right)}{n \cdot x}$$

$$= \lim_{n\to\infty} \frac{1+\frac{2}{n}}{x}$$

$$= \frac{1}{x} \cdot \lim_{n\to\infty} 1 + \frac{2}{n}$$

$$= \frac{1}{x} \cdot (1) = \frac{1}{x} \ (l)$$

if $\frac{1}{x} > 1$, $\sum u_n$ converges, i.e., $x < 1$

if $\frac{1}{x} < 1$, $\sum u_n$ converges i.e., $x > 1$

if $\frac{1}{x} = 1$, test fails i.e., $x = 1$

put $x = 1$

$$u_{n+1} = \frac{1}{(n+1)(n+2)}$$

$$u_n = \frac{1}{n(n+1)} = \frac{1}{n \cdot n(1+\frac{1}{n})} = \frac{1}{n^2} \cdot \frac{1}{1+\frac{1}{n}}$$

Consider the auxiliary series, $v_n = \frac{1}{n^2} \Rightarrow \sum v_n = \sum \frac{1}{n^2}$, $p = 2 > 1$

$\therefore \sum v_n$ is converges.

now $\frac{u_n}{v_n} = \frac{n^2}{n(n+1)}$

$$\therefore \lim_{n\to\infty} \frac{u_n}{v_n} = \lim_{n\to\infty} \frac{n}{n+1} = 1 \neq 0$$

By Comparision test $\Sigma U_n, \Sigma V_n$. behave in same way.

But ΣV_n converges, Thus ΣU_n also converges.

(9) Show that $1+\frac{2^P}{2!}+\frac{3^P}{3!}+\frac{4^P}{4!}+\cdots$ is convergent for all values of P (or)

Test for Convergence of $\Sigma \frac{n^P}{n!}$

Soln Consider $U_n = \frac{n^P}{n!}$

and $U_{n+1} = \frac{(n+1)^P}{(n+1)!}$

$n! = n(n-1)!$
$(n+1)! = n!(n+1)$

now $\lim_{n\to\infty} \frac{U_n}{U_{n+1}} = \lim_{n\to\infty} \frac{n^P}{n!} \times \frac{(n+1)!}{(n+1)^P}$

$= \lim_{n\to\infty} \frac{n^P (n+1)!}{n!(n+1)(n+1)^{P-1}} = \lim_{n\to\infty} \frac{n^P \cancel{(n+1)!}}{\cancel{(n+1)!}(n+1)^{P-1}}$

$= \lim_{n\to\infty} \frac{n^P}{(n^P+1)^{P-1}}$

$= \lim_{n\to\infty} \frac{n^P}{(n+1)^{P-1}}$

$= \lim_{n\to\infty} \frac{n^P}{n^{P-1}\left(1+\frac{1}{n}\right)^{P-1}}$

$= \lim_{n\to\infty} \frac{n^P}{n^P . n^{-1}\left(1+\frac{1}{n}\right)^{P-1}}$

$\therefore \lim_{n\to\infty} \frac{U_n}{U_{n+1}} = \infty > 1 \ \forall P$.

$\therefore$ By D'Alembert's ratio test the series is convergent for all values of P.

(10) Test for convergence of the series

$$\frac{1}{2\sqrt{1}} + \frac{x^2}{3\sqrt{2}} + \frac{x^4}{4\sqrt{3}} + \frac{x^6}{5\sqrt{4}} + \cdots \infty$$

(or)

Test for convergence of the series: $\sum_{n=1}^{\infty} \frac{x^{2n-2}}{\sqrt{n}(n+1)}$

Sol: Given series is $\sum_{n=1}^{\infty} \frac{x^{2n-2}}{\sqrt{n}(n+1)}$

consider $U_n = \frac{x^{2n-2}}{\sqrt{n}(n+1)} > 0$

Since $U_n > 0$, the given series is in the terms

$$U_{n+1} = \frac{x^{2n}}{\sqrt{n+1}(n+2)}$$

now $\lim_{n\to\infty} \frac{U_n}{U_{n+1}} = \lim_{n\to\infty} \frac{x^{2n-2}}{\sqrt{n}(n+1)} \times \frac{\sqrt{n+1}\,(n+2)}{x^{2n}}$

$$= \lim_{n\to\infty} \frac{\cancel{x^{2n}} \cdot x^{-2}}{\sqrt{n}(n+1)} \times \frac{\sqrt{n+1}\,(n+2)}{\cancel{x^{2n}}}$$

$$= \lim_{n\to\infty} \frac{\sqrt{n+1}\,(n+2)}{\sqrt{n}(n+1)} \cdot \frac{1}{x^2}$$

$$= \lim_{n\to\infty} \frac{\cancel{\sqrt{n}}\left(\sqrt{1+\frac{1}{n}}\right) \cdot \cancel{n}\left(1+\frac{2}{n}\right)}{\cancel{\sqrt{n}} \cdot \cancel{n}\left(1+\frac{1}{n}\right)} \cdot \frac{1}{x^2}$$

$$= \lim_{n\to\infty} \frac{\left(\sqrt{1+\frac{1}{n}}\right)\left(1+\frac{2}{n}\right)}{1+\frac{1}{n}} \cdot \frac{1}{x^2}$$

$$= 1 \cdot \frac{1}{x^2}$$

$$\lim_{n\to\infty} \frac{U_n}{U_{n+1}} = \frac{1}{x^2}$$

$\therefore$ $\sum U_n$ is converges, if $\frac{1}{x^2} > 1$ i.e., $x^2 < 1$

$\sum U_n$ is diverges, if $\frac{1}{x^2} < 1$ i.e., $x^2 > 1$

Test fails, if $\frac{1}{x^2} = 1$ i.e., $x^2 = 1$

when $x=1$, the given series

$$U_n = \frac{x^{2n-2}}{\sqrt{n}(n+1)}$$

$$u_n = \frac{1}{\sqrt{n}(n+1)} \Rightarrow u_n = \frac{1}{\sqrt{n}.n(1+\frac{1}{n})}$$

$$\Rightarrow u_n = \frac{1}{n^{3/2}(1+\frac{1}{n})}$$

Select $v_n = \frac{1}{n^{3/2}} \Rightarrow \sum \frac{1}{n^{3/2}} = \sum v_n$

i.e, $\sum \frac{1}{n^p}$; $p = \frac{3}{2} > 1$

$\therefore \sum v_n$ is converges, by p-series test

now $\lim_{n\to\infty} \frac{u_n}{v_n} = \lim_{n\to\infty} \frac{1}{\sqrt{n}.n(1+\frac{1}{n})} \times n^{3/2}(1+\frac{1}{n})$

$$= \lim_{n\to\infty} \frac{n^{3/2}}{n^{3/2}(1+\frac{1}{n})} = \lim_{n\to\infty} \frac{1}{1+\frac{1}{n}} = 1 \neq 0.$$

$\therefore$ By Comparision test both $\sum u_n$ and $\sum v_n$ are converges

) Examine the convergence of $\sum \frac{[(n+1)!]^2 x^{n-1}}{n}$, $(x>0)$

Test the convergence of the series:

$$\sum_{n=1}^{\infty} \frac{1 \cdot 3 \cdot 5 \cdots (2n+1)}{2 \cdot 5 \cdot 8 \cdots (3n+2)}$$

Test for convergence of the series

$$\frac{2}{1} + \frac{2 \cdot 5 \cdot 8}{1 \cdot 5 \cdot 9} + \frac{2 \cdot 5 \cdot 8 \cdot 11}{1 \cdot 5 \cdot 9 \cdot 13} + \cdots \infty$$

* RAABE'S TEST

Theorem stmt:- Let $\sum u_n$ be a series of positive terms and let $\lim_{n\to\infty} n\left[\frac{u_n}{u_{n+1}} - 1\right] = l$ Then

(a) if $l>1$ the series converges

(b) if $l \nless 1$ the series diverges

(c) the test fails when $l=1$

Problems:

1. Test for Convergence of the series:

$$\sum \frac{4.7 \cdots (3n+1)}{1.2.3 \cdots n} x^n$$

Sol: Given $\sum \frac{4.7 \cdots (3n+1)}{1.2.3 \cdots n} x^n$

consider $u_n = \frac{4.7 \cdots (3n+1)}{1.2.3 \cdots n} x^n$

$u_{n+1} = \frac{4.7 \cdots (3n+1)(3n+4)}{1.2.3 \cdots n(n+1)} x^{n+1}$

Now $\frac{u_n}{u_{n+1}} = \frac{n+1}{3n+4} \cdot \frac{1}{x}$

$$\lim_{n\to\infty} \frac{u_n}{u_{n+1}} = \lim_{n\to\infty} \frac{n+1}{3n+4} \cdot \frac{1}{x} = \lim_{n\to\infty} \frac{\cancel{n}(1+\frac{1}{n})}{\cancel{n}(3+\frac{4}{n})x}$$

$$= \frac{1}{3x}$$

$\therefore \lim_{n\to\infty} \frac{u_n}{u_{n+1}} = \frac{1}{3x}$.

$\therefore$ By Ratio test, the series is convergent if $\frac{1}{3x}>1$ or if $x<\frac{1}{3}$ and divergent if $\frac{1}{3x}<1$ or if $x>\frac{1}{3}$

The test fails when $x = \frac{1}{3}$

when $x = \frac{1}{3}$

$$\frac{u_n}{u_{n+1}} = \frac{(n+1)3}{3n+4} = \frac{3n+3}{3n+4}$$

By Rabees test,

$$\lim_{n\to\infty} n\left[\frac{u_n}{u_{n+1}} - 1\right] = \lim_{n\to\infty} n\left[\frac{3n+3}{3n+4} - 1\right]$$

$$= \lim_{n\to\infty} n\left[\frac{\cancel{3n}+3-\cancel{3n}-4}{3n+4}\right]$$

$$= \lim_{n\to\infty} \frac{-\cancel{n}}{\cancel{n}(3+\frac{4}{n})}$$

$$= \frac{-1}{3} < 1$$

Hence by Rabeels test, the series is divergent if $x < \frac{1}{3}$

$\therefore$ The given series is convergent

and divergent $x \geq \frac{1}{3}$.

(2) Examine the convergence of $\sum \left[\frac{1.4.7 \cdots (3n-2)}{3.6.9 \cdots 3n}\right]^2$

Sol: Given $\sum \left[\frac{1.4.7 \cdots (3n-2)}{3.6.9 \cdots 3n}\right]^2$

Consider $u_n = \left[\frac{1.4.7 \cdots (3n-2)}{3.6.9 \cdots 3n}\right]^2 > 0$

$$u_{n+1} = \left[\frac{1.4.7 \cdots (3n-2)(3n+1)}{3.6.9 \cdots 3n(3n+3)}\right]^2$$

Now $$\frac{u_n}{u_{n+1}} = \left[\frac{3n+3}{3n+1}\right]^2 = \left[\frac{\cancel{3n}(1+\frac{3}{3n})}{\cancel{3n}(1+\frac{1}{3n})}\right]^2$$

$$\frac{u_n}{u_{n+1}} = \left[\frac{1+\frac{3}{3n}}{1+\frac{1}{3n}}\right]^2$$

$$\lim_{n\to\infty} \frac{u_n}{u_{n+1}} = 1$$

Hence D'Alemberts ratio test fails

So we will consider Raabe's test

Consider $\lim_{n\to\infty} n\left[\frac{u_n}{u_{n+1}} - 1\right] = \lim_{n\to\infty} n\left[\left(\frac{3n+3}{3n+1}\right)^2 - 1\right]$

$$= \lim_{n\to\infty} n\left[\frac{(3n+3)^2 - (3n+1)^2}{(3n+1)^2}\right]$$

$$= \lim_{n\to\infty} n\left[\frac{\cancel{9n^2} + 9 + 18n - \cancel{9n^2} - 1 - 6n}{(3n+1)^2}\right]$$

$$= \lim_{n\to\infty} n\left[\frac{9+12n}{9n^2\left[1+\frac{1}{3n}\right]^2}\right]$$

$$= \lim_{n\to\infty} \frac{9n+12n^2}{9n^2\left[1+\frac{1}{3n}\right]^2}$$

$$= \lim_{n\to\infty} \frac{\cancel{n^2}}{\cancel{n^2}}\left[\frac{12+\frac{9}{n}}{9\left(1+\frac{1}{3n}\right)^2}\right]$$

$$= \lim_{n\to\infty} \frac{12+\frac{9}{n}}{9+\left(1+\frac{1}{3n}\right)^2}$$

$$= \frac{12}{9} = \frac{4}{3} > 1$$

$\therefore$ By Raabe's test, the series converges.

(3) Examine the Convergence of $\sum \frac{2^2 \cdot 4^2 \cdot 6^2 \cdots (2n)^2}{3^2 \cdot 4^2 \cdot 5^2 \cdots (2n+2)^2}$

Sol: Given series is $\sum \frac{2^2 \cdot 4^2 \cdot 6^2 \cdots (2n)^2}{3^2 \cdot 4^2 \cdot 5^2 \cdots (2n+2)^2}$

Consider $u_n = \frac{2^2 \cdot 4^2 \cdot 6^2 \cdots (2n)^2}{3^2 \cdot 4^2 \cdot 5^2 \cdots (2n+2)^2}$

$$U_{n+1} = \frac{2^2 \cdot 4^2 \cdot 6^2 \cdots (2n)^2 (2n+2)^2}{3^2 \cdot 4^2 \cdot 5^2 \cdots (2n+2)^2 (2n+4)^2}$$

now

$$\frac{U_n}{U_{n+1}} = \frac{(2n+4)^2}{(2n+2)^2}$$

$$\lim_{n\to\infty} \frac{U_n}{U_{n+1}} = \lim_{n\to\infty} \frac{(2n+4)^2}{(2n+2)^2}$$

$$= \lim_{n\to\infty} \frac{\cancel{4n^2}\left[1+\frac{4}{2n}\right]^2}{\cancel{4n^2}\left[1+\frac{2}{2n}\right]^2}$$

$$= \lim_{n\to\infty} \frac{\left(1+\frac{4}{2n}\right)^2}{\left(1+\frac{2}{2n}\right)^2} = 1$$

$$\therefore \lim_{n\to\infty} \frac{U_n}{U_{n+1}} = 1$$

$\therefore$ The Ratio test fails. we will use Raabe's test

now $\frac{U_n}{U_{n+1}} = \frac{(2n+4)^2}{(2n+2)^2}$

$$n\left[\frac{U_n}{U_{n+1}}\right]-1 = n\left[\frac{(2n+4)^2}{(2n+2)^2} - 1\right]$$

$$= n\left[\frac{(2n+4)^2 - (2n+2)^2}{(2n+2)^2}\right]$$

$$= n\left[\frac{\cancel{4n^2}+16+16n-\cancel{4n^2}-4-8n}{(2n+2)^2}\right]$$

$$= n\left[\frac{8n+12}{(2n+2)^2}\right]$$

$$= \frac{8n^2+12n}{(2n+2)^2}$$

$$\lim_{n\to\infty} n\left[\frac{U_n}{U_{n+1}}-1\right] = \lim_{n\to\infty} \frac{8n^2+12n}{(2n+2)^2}$$

$$= \lim_{n\to\infty} \frac{n^2\left[8+\frac{12}{n}\right]}{4n^2\left[1+\frac{2}{2n}\right]^2}$$

$$= \frac{8}{4} = 2 > 1$$

$\therefore \lim_{n\to\infty} n\left[\frac{u_n}{u_{n+1}} - 1\right] = 2 > 1$

$\therefore$ By Raabe's test, the series Σu_n converges.

(4) Test for convergence of the series

$$\frac{1}{3} + \frac{1\cdot4}{3\cdot6} + \frac{1\cdot4\cdot7}{3\cdot6\cdot9} + \frac{1\cdot4\cdot7\cdot10}{3\cdot6\cdot9\cdot12} + \cdots$$

Sol: Σu_n is divergent

(5) Test for convergence of the series

$$1 + \frac{3}{7}x + \frac{3\cdot6}{7\cdot10}x^2 + \frac{3\cdot6\cdot9}{7\cdot10\cdot13}x^3 + \cdots, \; x>0$$

Sol: By Raabe's test ΣU_n is convergent for $x=1$

(6) Test for convergence of the series

$$\frac{3^2}{6^2} + \frac{3^2\cdot5^2}{6^2\cdot8^2} + \frac{3^2\cdot5^2\cdot7^2}{6^2\cdot8^2\cdot10^2} + \cdots$$

Sol: By Raabe's test, the series Σu_n is convergent.

* CAUCHY's n^{th} ROOT TEST:

If Σu_n is a series of positive terms suchthat $\lim_{n\to\infty} u_n^{1/n} = l$, then

(a) Σu_n Converges if $l<1$

(b) Σu_n diverges if $l>1$ and

(c) Test fails if $l=1$

<u>Problems:</u>

1. Test for Convergence of $\Sigma\left[1+\frac{1}{n}\right]^{-n^2}$

Sol: Given $\Sigma\left[1+\frac{1}{n}\right]^{-n^2}$

This series is in positive terms

let $u_n = \left[1+\frac{1}{n}\right]^{-n^2}$

now $\lim_{n\to\infty} u_n^{1/n} = \lim_{n\to\infty}\left[\left[1+\frac{1}{n}\right]^{-n^2}\right]^{1/n}$

$$= \lim_{n\to\infty}\left[1+\frac{1}{n}\right]^{-n}$$

$$= \lim_{n\to\infty}\frac{1}{\left[1+\frac{1}{n}\right]^{n}}$$

$\therefore \lim_{n\to\infty} u_n^{1/n} = \frac{1}{e} < 1$

$\therefore$ By cauchy's n^{th} root test, Σu_n Converges.

2. Test for convergence of the series:

$$\frac{2}{1^2}x + \frac{3^2}{2^3}x^2 + \cdots + \frac{(n+1)^n}{n^{n+1}}x^n + \cdots \quad (x>0)$$

Sol: The given series is in positive terms

$$U_n = \frac{(n+1)^n}{n^{n+1}} x^n$$

$$u_n^{1/n} = \frac{((n+1)^n)^{1/n} \cdot (x^n)^{1/n}}{(n^{n+1})^{1/n}}$$

$$= \frac{n+1}{(n^n)^{1/n} \cdot n^{1/n}} \cdot x$$

$$= \frac{n+1}{n \cdot n^{1/n}} \cdot x \qquad \left[\because \lim_{n\to\infty} n^{1/n} = 1\right]$$

$$\lim_{n\to\infty} u_n^{1/n} = \lim_{n\to\infty} \frac{\cancel{n}\left(1+\frac{1}{n}\right)}{\cancel{n} \cdot n^{1/n}} \cdot x$$

$$\therefore \lim_{n\to\infty} u_n^{1/n} = x.$$

$\therefore$ By cauchy's nth root test,

Σu_n converges if $x<1$ and Σu_n is divergent if $x>1$, when $x=1$, the root test fails.

when $x=1$

$$u_n = \frac{(n+1)^n}{n^{n+1}} = \frac{\cancel{n^n}\left[1+\frac{1}{n}\right]^n}{\cancel{n^n} \cdot n} = \frac{\left[1+\frac{1}{n}\right]^n}{n}$$

Take $V_n = \frac{1}{n} \Rightarrow \Sigma V_n = \Sigma \frac{1}{n}$

i.e., $\Sigma \frac{1}{n^p}$, $p=1$

By p-series ΣV_n is divergent.

now $\lim_{n\to\infty} \frac{u_n}{V_n} = \lim_{n\to\infty} \left[1+\frac{1}{n}\right]^n = e \neq 0$

$\therefore$ By Comparision test, Σu_n and ΣV_n behave in the same way.

But ΣV_n is divergent so ΣU_n is also divergent

Hence the given series is Convergent when $x<1$ and divergent when $x \geq 1$

(3) Show that the series

$$\left[\frac{2^2}{1^2}-\frac{2}{1}\right]^{-1}+\left[\frac{3^3}{2^3}-\frac{3}{2}\right]^{-2}+\left[\frac{4^4}{3^4}-\frac{4}{3}\right]^{-3}+\cdots$$ is convergent.

Soln The given series is in positive terms.

Here $$u_n=\left[\frac{(n+1)^{n+1}}{n^{n+1}}-\frac{n+1}{n}\right]^{-n}$$

$$\therefore u_n^{1/n}=\left[\left[\frac{(n+1)^{n+1}}{n^{n+1}}-\frac{n+1}{n}\right]^{-n}\right]^{1/n}$$

$$=\left[\frac{(n+1)^{n+1}}{n^{n+1}}-\frac{n+1}{n}\right]^{-1}$$

$$=\left[\frac{n+1}{n}\right]^{-1}\left[\frac{(n+1)^n}{n^n}-1\right]^{-1}$$

$$=\left[\frac{\cancel{n}(1+\frac{1}{n})}{\cancel{n}}\right]^{-1}\left[\frac{\cancel{n^n}(1+\frac{1}{n})^n}{\cancel{n^n}}-1\right]^{-1}$$

$$u_n^{1/n}=\left[1+\frac{1}{n}\right]^{-1}\left[\left(1+\frac{1}{n}\right)^n-1\right]^{-1}$$

Now

$$\lim_{n\to\infty} u_n^{1/n}=\lim_{n\to\infty}\frac{1}{1+\frac{1}{n}}\left[\frac{1}{(1+\frac{1}{n})^n-1}\right]$$

$$=1\cdot\frac{1}{e-1}<1$$

$$=\frac{1}{e-1}<1$$

$\therefore$ The series is Convergent.

(4) Test the convergence of the series: $\sum \frac{1}{\log(\log n)^n}$

Sol: Given series is

$$\sum u_n = \sum \frac{1}{\log(\log n)^n}$$

consider $u_n = \frac{1}{\log(\log n)^n}$

Now

$$\lim_{n\to\infty} u_n^{1/n} = \lim_{n\to\infty} \frac{1}{\log(\log n)}$$

$$\lim_{n\to\infty} u_n^{1/n} = 0 < 1$$

∴ By cauchy's n^{th} root test, the series is convergent.

(5) Test the convergence: $\frac{3x}{4} + \left(\frac{5}{6}\right)^2 x^2 + \left(\frac{7}{8}\right)x^3 + \cdots$

Sol: $\sum u_n$ is divergent

(6) Test the convergence: $\sum \left[1+\frac{1}{\sqrt{n}}\right]^{-n^2}$

Sol: By cauchy's root test, $\sum u_n$ converges.

(7) Test the convergence: $\sum \left[\frac{nx}{1+n}\right]^n \ (x>0)$

Sol: The given series is diverges.

CAUCHY'S INTEGRAL TEST:

let $\sum u_n = u_1 + u_2 + u_3 + \cdots + u_n + \cdots$ be series with positive and non-increasing terms i.e., $u_1 \geq u_2 \geq u_3 \geq \cdots$

let $f(x)$ be a non-negative decreasing function suchthat $f(1) = u_1$, $f(2) = u_2$, ---- $f(n) = u_n$ on $[1, \infty)$. Then the series $\sum_{n=1}^{\infty} f(n)$ converges or diverges according to the improper integral $\int^{\infty} f(x)\,dx$ is finite or infinite. we must understand $\int_1^{\infty} f(x)\,dx$ as $\underset{t \to \infty}{Lt} \int_1^t f(x)\,dx$

Problems:

1) prove that $\sum_{n=1}^{\infty} \frac{1}{n^2+1}$ converges.

Sol: let $f(x) = \frac{1}{x^2+1}$ for $x \in [1, \infty)$

Then $\sum_{n=1}^{\infty} f(n) = \sum_{n=1}^{\infty} \frac{1}{n^2+1}$.

we have $f(x) > 0$ and $f(x)$ is decreasing on $[1, \infty)$

$$F(t) = \int_1^t f(x)\,dx = \int_1^t \frac{1}{x^2+1}\,dx = \left[\operatorname{Tan}^{-1} x\right]_1^t$$

$$= \operatorname{Tan}^{-1}(t) - \operatorname{Tan}^{-1}(1)$$

$$= \operatorname{Tan}^{-1}(t) - \frac{\pi}{4}.$$

$$\therefore \lim_{n \to \infty} F(t) = \underset{n \to \infty}{Lt} \left[\operatorname{Tan}^{-1}(t) - \frac{\pi}{4}\right]$$

$$= \operatorname{Tan}^{-1}(\infty) - \frac{\pi}{4}$$

$$= \frac{\pi}{2} - \frac{\pi}{4}$$

$$\therefore \lim_{n \to \infty} F(t) = \frac{\pi}{4}$$

Thus $\int_1^{\infty} f(x)dx$ converges to $\frac{\pi}{4}$

Hence, by integral test $\Sigma f(n)$ also converges.

(2) Using integral test determine the convergence of the series- $\sin\pi + \frac{1}{4}\sin\frac{\pi}{2} + \frac{1}{9}\sin\frac{\pi}{3} + \cdots$

Sol: let $f(x) = \frac{\sin(\pi/x)}{x^2}$; $f(x) = \frac{\sin \pi/x}{x^2}$

Then $\sum_{n=1}^{\infty} f(n) = \frac{\sin \pi/n}{n^2}$

we have $f(x)>0$ and decreasing in $[1,\infty)$

$$F(t) = \int_1^t f(x)\,dx = \int_1^t \frac{\sin(\pi/x)}{x^2}\,dx$$

put $\pi/x = u \Rightarrow \frac{-\pi}{x^2}dx = du$

Also when $x=1, \Rightarrow u=\pi$

when $x=t$, $u=\frac{\pi}{t}$.

$$\therefore F(t) = \frac{-1}{\pi}\int_{\pi}^{\pi/t} \sin u\,du = -\frac{1}{\pi}(-\cos u)_{\pi}^{\pi/t}$$

$$= \frac{1}{\pi}\left(\cos\frac{\pi}{t}+1\right)$$

$$F(t) = \frac{1}{\pi}\left[\cos\frac{\pi}{t}+1\right]$$

$$\lim_{t\to\infty} F(t) = \lim_{t\to\infty}\frac{1}{\pi}\left[\cos\frac{\pi}{t}+1\right]$$

$$= \frac{1}{\pi}\left[\cos\frac{\pi}{\infty}+1\right]$$

$$= \frac{1}{\pi}\left[\cos(0)+1\right]$$

$$= \frac{1}{\pi}[1+1] = \frac{2}{\pi}$$

Hence $\int_1^{\infty} f(x)\,dx$ is Convergent

$\therefore$ By Integral test, $\sum f(n)$ is also convergent

* ALTERNATING SERIES

A series whose terms are alternatively positive and negative is called an alternating series.

An alternating series may be written as

$$u_1 - u_2 + u_3 - u_4 + \cdots + (-1)^{n-1} u_n + \cdots$$

where each u_n is positive.

It is denoted by $\sum_{n=1}^{\infty} (-1)^{n-1} u_n$

* LEIBNITZ'S TEST

If $\{u_n\}$ is a sequence of positive terms such that

(a) $u_1 \geq u_2 \geq u_3 \geq \cdots \geq u_n \geq u_{n+1} \cdots$

(b) $\lim_{n\to\infty} u_n = 0$.

then the alternating series $\sum_{n=1}^{\infty} (-1)^n$ is Convergent

Problems:- (i) Test for convergence $\sum \frac{(-1)^{n-1}}{2n-1}$

Soln: The given series $\frac{1}{1} - \frac{1}{3} + \frac{1}{5} - \frac{1}{7} + \cdots$ which is an alternating series

Here $u_n = \frac{1}{2n-1} > 0$ and $u_{n+1} < u_n$ for all n

$\therefore \lim_{n\to\infty} u_n = \lim_{n\to\infty} \frac{1}{2n-1} = 0$

$\therefore$ By Leibnitz's test the series is Convergent.

Mean Values Theorems

→ Rolle's Theorem

→ Lagrange's Theorem

→ Cauchy's Mean value Theorem

→ Taylor's Theorem

→ Maclaurin's theorem.

Rolle's Theorem: let $f(x)$ be a function ∋

i) If $f(x)$ is continuous $[a,b]$

ii) $f(x)$ is derivable in (a,b) and

iii) $f(a)=f(b)$

then ∃ at least one point c in open (a,b) ∋ $f'(c)=0$

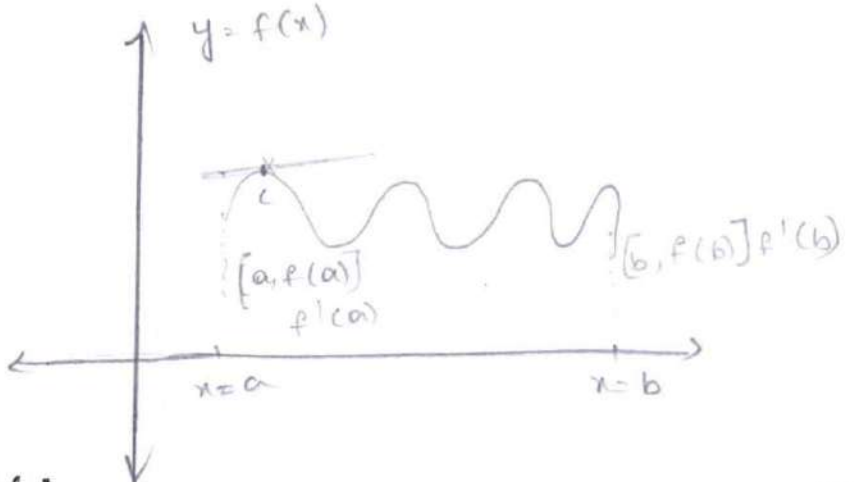
Instructions:

* Every polynomial, $\sin x$, $\cos x$ and e^x all are continuous Everywhere
* $\log x$ is continuous in $(0,\infty)$ or positive values
* e^x will never be zero
* If $f(x)$ and $g(x)$ are continuous functions then their difference $f(x)-g(x)$ the sum $f(x)+g(x)$, their product $f(x).g(x)$, their Quotient $\frac{f(x)}{g(x)}$ are also continuous. where $(g(x)\neq 0)$

Geometrical Interpretation of Rolle's theorem:

let us consider a continuous function $y=f(x)$ in $[a,b]$ and derivable at (a,b), and $f(a)=f(b)$ then ∃ a tangent line at c which is parallel to x-axis i.e., Tangent slope $(m)=0$

$f'(c)=0$



Problems:

(1) verify Rolle's Theorem for $f(x) = 2x^3+x^2-4x-2$ in $[-\sqrt{3}, \sqrt{3}]$

Sol: Given $f(x) = 2x^3+x^2-4x-2$ in $[-\sqrt{3}, \sqrt{3}]$

Here $a=-\sqrt{3}$, $b=\sqrt{3}$

i) clearly $f(x)$ is polynomial function so it is continuous in $[-\sqrt{3}, \sqrt{3}]$

ii) $f'(x) = 6x^2+2x-4$

Exist for every $x \in (-\sqrt{3}, \sqrt{3})$

$\Rightarrow f(x)$ is differentiable in $(-\sqrt{3}, \sqrt{3})$

iii) $f(-\sqrt{3}) = 2(-\sqrt{3})^3+(-\sqrt{3})^2-4(-\sqrt{3})-2$

$= -6\sqrt{3}+3+4\sqrt{3}-2$

$= 1-2\sqrt{3}$

and $f(\sqrt{3}) = 2(\sqrt{3})^3+(\sqrt{3})^2-4(\sqrt{3})-2$

$= 6\sqrt{3}+3-4\sqrt{3}-2$

$= 1+2\sqrt{3}$

Since $f(-\sqrt{3}) \neq f(\sqrt{3})$, therefore Rolle's theorem is not applicable for $f(x)$ in $[-\sqrt{3}, \sqrt{3}]$

(2) Verify Rolle's theorem for the function

$f(x) = (x-a)^m (x-b)^m$ where m, n are the integers in $[a,b]$

Sol Given $f(x) = (x-a)^m (x-b)^n$

(i) Since Every polynomial function is continuous for all values, $f(x)$ is also continuous in $[a,b]$

(ii) $f(x) = (x-a)^m (x-b)^n$

$\therefore f'(x) = m(x-a)^{m-1}(x-b)^n + (x-a)^m n.(x-b)^{n-1}$ (using product rule)

$= (x-a)^{m-1}(x-b)^{n-1}\{m(x-b) + n(x-a)\}$

$f'(x) = (x-a)^{m-1}(x-b)^{n-1}[(m+n)x - [mb+na]]$

which Exists in (a,b)

Thus $f(x)$ is derivable in (a,b)

(iii) $f(a) = 0$

$f(b) = 0$

$\therefore f(a) = f(b)$

Thus three Conditions of Rolle's theorem are Satisfied.

$\therefore$ There Exists $c \in (a,b)$ Such that $f'(c) = 0$

$f'(x) = (x-a)^{m-1}(x-b)^{n-1}[(m+n)x - [mb+na]]$

$f'(c) = (c-a)^{m-1}(c-b)^{n-1}[(m+n)c - [mb+na]]$

$0 = (c-a)^{m-1}(c-b)^{n-1}[(m+n)c - (mb+na)]$

$(m+n)c - mb+na = 0$

$(m+n)c = mb+na \Rightarrow c = \dfrac{mb+na}{m+n}$

$$c = \frac{mb+na}{m+n} \in (a,b)$$

Since the point $c \in (a,b)$ divides a and b internally in the ratio $m:n$

$\therefore$ Rolle's theorem is verified.

(3) verify Rolle's theorem for the function

$$f(x) = \frac{\sin x}{e^x} \text{ (or) } e^{-x}\sin x \text{ in } [0,\pi]$$

Sol: (i) Given $f(x) = \frac{\sin x}{e^x}$

Since $\sin x$ and e^x both are continuous functions in $[0,\pi]$, therefore, $\frac{\sin x}{e^x}$ is also continuous in $[0,\pi]$

(ii) Since $f(x) = \frac{\sin x}{e^x}$ $\quad \boxed{\because \frac{u}{v} = \frac{vu' - uv'}{v^2}}$

$$f'(x) = \frac{e^x \cos x - \sin x\, e^x}{(e^x)^2} = \frac{e^x(\cos x - \sin x)}{(e^x)^2}$$

$$f'(x) = \frac{\cos x - \sin x}{e^x}$$

Thus $f'(x)$ is derivable in (a,b)

(iii) $f(0) = \frac{\sin(0)}{0} = 0$

$$f(\pi) = \frac{\sin\pi}{e^\pi} = 0$$

$$\therefore f(0) = f(\pi)$$

$$\therefore f(a) = f(b)$$

By Rolles theorem $\exists\, c \in (a,b) \ni f'(c) = 0$

$$f'(x) = \frac{\cos x - \sin x}{e^x} = 0$$

$$f'(c) = \frac{\cos c - \sin c}{e^c} = 0$$

$$\cos c - \sin c = 0 \qquad (e^c \neq 0)$$

$$\cos c = \sin c$$

$$1 = \frac{\sin c}{\cos c} \Rightarrow 1 = \tan c$$

$$\Rightarrow c = \tan^{-1}(1)$$

$$\Rightarrow c = \pi/4 \in (0, \pi)$$

Hence Rolle's theorem is verified.

(4) Verify Rolle's theorem for the function

$\log\left[\frac{x^2+ab}{x(a+b)}\right]$ in $[a,b]$, $a>0, b>0$

Sol: let $f(x) = \log\left[\frac{x^2+ab}{x(a+b)}\right]$

$$f(x) = \log(x^2+ab) - \log(x(a+b))$$

$$f(x) = \log(x^2+ab) - \log x - \log(a+b)$$

(i) Since $f(x)$ is a composite function of continuous function in $[a,b]$, it is continuous in $[a,b]$

ii) $f'(x) = \frac{1}{x^2+ab} 2x - \frac{1}{x}$

$$f'(x) = \frac{x^2 - ab}{x(x^2+ab)}$$

$\therefore f'(x)$ Exists $\forall\ x \in (a,b)$

(iii) $f(a) = \log\left[\frac{a^2+ab}{a^2+ab}\right] = \log 1 = 0$

$$f(b) = \log\left[\frac{b^2+ab}{b^2+ab}\right] = \log 1 = 0$$

$\therefore f(a) = f(b)$

Thus $f(x)$ satisfies all the three conditions of Rolle's theorem

$\therefore$ There Exists $c \in (a,b)$ Suchthat $f'(c)=0$

$$\Rightarrow \frac{c^2-ab}{c(c^2+ab)} = 0 \Rightarrow c^2-ab=0$$
$$\Rightarrow c^2 = ab$$
$$c = \pm\sqrt{ab}$$

$$\therefore c = \sqrt{ab} \in (a,b)$$

Hence Rolle's theorem is verified.

(5) Verify whether Rolle's theorem can be applied to the following functions in the intervals cited.

i) $f(x) = \tan x$ in $[0,\pi]$

ii) $f(x) = \frac{1}{x^2}$ in $[-1,1]$

iii) $f(x) = x^3$ in $[1,3]$

Sol: i) Given $f(x) = \tan x$ in $[0,\pi]$

$f(x)$ is discontinuous at $x=\pi/2$ as it is not defined there. Thus Condition (i) of Rolle's theorem is not satisfied.

Hence we can't apply Rolle's theorem.

$\therefore$ Rolle's Theorem is not applicable to $f(x)=\tan x$ in $[0,\pi]$

ii) $f(x)=\frac{1}{x^2}$ in $[-1,1]$, Here $f(x)$ is discontinuous at $x=0$.

Hence Rolle's theorem cannot be applied

iii) $f(x)=x^3$ in $[1,3]$.

a) $f(x)$ is continuous at $[1,3]$

b) $f(x)=x^3 \Rightarrow f'(x)=3x^2$

$\therefore f(x)$ is derivable at $(1,3)$

c) $f(1) = 1^3 = 1$

$f(3) = 3^3 = 27$

$\therefore f(1) \neq f(3)$

The Conditions of the Rolle's theorem are not satisfied by $f(x)$.

Hence Rolle's theorem is not applicable to $f(x) = x^3$ in $[1,3]$.

6) using Rolle's theorem, Show that

$\cdot g(x) = 8x^3 - 6x^2 - 2x + 1$ has a zero between 0 & 1.

Sol $c = 0.63$ lies in $(0,1)$

7) verify Rolle's theorem for $f(x) = x^2 - 2x - 3$ in the interval $(1,-3)$

Sol $c = 1 \in (-1,3)$

Hence Rolle's theorem is verified.

8) verify Rolle's theorem for $f(x) = e^x \sin x$ in $[0,\pi]$

Sol $C = \frac{3\pi}{4} \in (0,\pi)$

Hence Rolle's theorem is verified.

9) verify Rolles theorem for $f(x) = e^x(\sin x - \cos x)$ in $\left[\frac{\pi}{4}, \frac{5\pi}{4}\right]$

Sol $\pi \in \left[\frac{\pi}{4}, \frac{5\pi}{4}\right]$

Hence Rolle's theorem is verified.

* LAGRANGE'S MEAN VALUE THEOREM

Theorem:- Let $f(x)$ be a function such that

(i) It is continuous in closed interval $[a,b]$ and

(ii) Differentiable in open interval (a,b)

Then there Exist atleast one point c in open interval (a,b) suchthat

$$f'(c) = \frac{f(b)-f(a)}{b-a}$$

Problems:-

1. Verify Lagrange's mean value theorem for $f(x) = x^3-x^2-5x+3$ in $[0,4]$

$f(x) = x^3-x^2-5x+3$ in $[0,4]$.

Sol: Given $f(x) = x^3-x^2-5x+3$ is polynomial in x.

Given function $f(x)$ is continuous and derivable for Every value of x

$\therefore$ It is continuous and derivable for every value of x

In particular, $f(x)$ is continuous in closed interval $[0,4]$ and derivable in open interval $(0,4)$

Hence by Lagrange's Mean value theorem, $\exists$ a point c in open interval $(0,4)$ suchthat

$$f'(c) = \frac{f(b)-f(a)}{b-a} \quad \text{— (1)}$$

$$f'(c) = \frac{f(4)-f(0)}{4}$$

$$f'(x) = 3x^2-2x-5$$

$$f'(c) = 3c^2-2c-5$$

Now

$$\therefore f'(c) = \frac{f(4)-f(0)}{4}$$

$$f(4) = 4^3 - 4^2 - 5(4) + 3$$
$$= 64 - 16 - 20 + 3$$
$$= 67 - 36 = 31 \quad \text{and}$$

$$f(0) = 3.$$
$$\therefore \frac{f(4) - f(0)}{4} = \frac{31-3}{4} = \frac{28}{4} = 7.$$

from (i).
$$f'(c) = \frac{f(b) - f(a)}{b-a}$$

$$3c^2 - 2c - 5 = 7.$$
$$3c^2 - 2c = 12$$
$$3c^2 - 2c - 12 = 0$$
which is quadratic Equation in c.
$$c = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} = \frac{2 \pm \sqrt{4+144}}{6} = \frac{2 \pm \sqrt{148}}{6}$$
$$\therefore \quad = \frac{1 \pm \sqrt{37}}{3}$$
$c = \frac{1 \pm \sqrt{37}}{3}$ lies in open interval $(0, 4)$
and thus Lagrange's mean value theorem verified

(2) verify Lagrange's Mean value theorem for $f(x) = \log_e x$ in $[1, e]$

Sol: Given $f(x) = \log_e x$
This function is continuous in closed interval $[1, e]$
and derivable in open interval $(1, e)$
Hence Lagrange's mean value theorem is applicable
here, By this theorem, there Exists a point c in open
interval $(1, e)$ Such that
$$f'(c) = \frac{f(e) - f(1)}{e-1} = \frac{1-0}{e-1} = \frac{1}{e-1}$$

But $f'(c) = \frac{1}{c} \Rightarrow \frac{1}{c} = \frac{1}{e-1}$

$\therefore c = e-1$

Note that $(e-1)$ lies in the interval $(1,e)$

Hence Lagrange's mean value theorem is verified

(8) If $a<b$, prove that

$\frac{b-a}{(1+b^2)} < \tan^{-1}b - \tan^{-1}a < \frac{b-a}{(1+a^2)}$ using Lagrange's Mean value theorem. Deduce the following:

i) $\frac{\pi}{4} + \frac{3}{25} < \tan^{-1}\frac{4}{3} < \frac{\pi}{4} + \frac{1}{6}$

(ii) $\frac{5\pi+4}{20} < \tan^{-1}2 < \frac{\pi+2}{4}$

Sol: let $f(x) = \tan^{-1}x$ in $[a,b]$ is continuous

$f'(x) = \frac{1}{1+x^2}$ exists in (a,b)

By Lagrange's mean value theorem, $f'(c) = \frac{f(b)-f(a)}{b-a}$

$c \in (a,b), f'(c) = \frac{1}{1+c^2}$

$\Rightarrow \frac{1}{1+c^2} = \frac{\tan^{-1}b - \tan^{-1}a}{b-a}$

$a < c < b$ squaring on both sides

$a^2 < c^2 < b^2$ Adding 1 on both sides

$1+a^2 < 1+c^2 < 1+b^2$ Doing reciprocal

$\frac{1}{1+a^2} > \frac{1}{1+c^2} > \frac{1}{1+b^2}$

$\frac{1}{1+a^2} > \frac{\tan^{-1}b - \tan^{-1}a}{b-a} > \frac{1}{1+b^2}$

$$\therefore \frac{b-a}{1+a^2} > \tan^{-1} b - \tan^{-1} a > \frac{b-a}{1+b^2}$$

Hence proved.

i) we have $\frac{b-a}{1+b^2} < \tan^{-1} b - \tan^{-1} a < \frac{b-a}{1+a^2}$ — ①

Taking $b = \frac{4}{3}$, $a = 1$, we get

from — ①

$$\frac{\frac{4}{3}-1}{1+\frac{16}{9}} < \tan^{-1}\frac{4}{3} - \tan^{-1}(1) < \frac{\frac{4}{3}-1}{1+1^2}$$

$$\Rightarrow \frac{\frac{4-3}{3}}{\frac{25}{9}} < \tan^{-1}\frac{4}{3} - \frac{\pi}{4} < \frac{\frac{4-3}{3}}{2}$$

$$\Rightarrow \frac{3}{25} + \frac{\pi}{4} < \tan^{-1}\frac{4}{3} < \frac{\pi}{4} + \frac{1}{6}$$

ii) Taking $b = 2$ and $a = 1$, we get

$$\frac{2-1}{1+2^2} < \tan^{-1} 2 - \tan^{-1}(1) < \frac{2-1}{1+1^2}$$

i.e., $\frac{1}{5} < \tan^{-1} 2 - \tan^{-1}(1) < \frac{1}{2}$

$$\frac{1}{5} < \tan^{-1} 2 - \frac{\pi}{4} < \frac{1}{2}$$

$$\frac{1}{5} + \frac{\pi}{4} < \tan^{-1} 2 < \frac{1}{2} + \frac{\pi}{4}$$

$$\therefore \frac{4+5\pi}{20} < \tan^{-1} 2 < \frac{2+\pi}{4}$$

Hence proved.

(4) find 5^{th} root of 245 (or) calculate approximately $\sqrt[5]{245}$ by using Lagrange's mean value theorem.

Sol: Given $f(x) = \sqrt[5]{245}$

$f(x) = (245)^{1/5}$ in $[243, 245]$

consider $f'(x)$ let it be $f(x) = \sqrt[5]{x}$

$= x^{1/5}$

now $f'(x) = \frac{1}{5} x^{\frac{1}{5}-1}$

$= \frac{1}{5} x^{-4/5}$ in $[243, 245]$

$f'(x)$ Exists in $(243, 245]$

$f'(c) = \frac{f(b)-f(a)}{b-a}$ $c \in (243, 245)$

$\frac{1}{5} c^{\frac{1}{5}-1} = \frac{f(245)-f(243)}{245-243}$

$\frac{1}{5} c^{-4/5} = \frac{(245)^{1/5} - (243)^{1/5}}{2}$

$\frac{2}{5} c^{-4/5} = (245)^{1/5} - (243)^{1/5}$

$\frac{2}{5} c^{-4/5} + (243)^{1/5} = (245)^{1/5}$

$(245)^{1/5} = \frac{2}{5} c^{-4/5} + (243)^{1/5}$

Take $c = 244$

$(245)^{1/5} = \frac{2}{5} (244)^{-4/5} + (243)^{1/5}$

$(245)^{1/5} \approx 3.0049$

(5) Using Lagrange's mean value theorem, prove that
$|\sin u - \sin v| \le |u-v|$

Sol: If $u=v$ there is nothing to prove

If $u>v$, then consider the function

$f(u) = \sin u$ on $[v,u]$

Clearly, f is continuous on $[v,u]$ and derivable on (v,u) i.e., $f'(u) = \cos u$.

$\therefore$ By Lagrange's mean value theorem, $\exists\, c \in (v,u)$

Such that $\dfrac{f(u)-f(v)}{u-v} = f'(c)$

$$\Rightarrow \frac{\sin u - \sin v}{u-v} = \cos c$$

But $|\cos c| \le 1$

$$\therefore \left|\frac{\sin u - \sin v}{u-v}\right| \le 1$$

$$\Rightarrow |\sin u - \sin v| \le |u-v|$$

If $v>u$, then in similar manner, we have

$\therefore |\sin v - \sin u| \le |v-u|$

$\Rightarrow |\sin u - \sin v| \le |u-v| \quad [\because |-x| = |x|]$

Hence for all $u, v \in R$

$|\sin u - \sin v| \le |u-v|$

UNIT - II

DIFFERENTIAL EQUATIONS OF FIRST ORDER AND FIRST DEGREE

Def:- An Equation involving derivative of the dependent variable with respect to independent variable is called a Differential Equation.

Ex:- 1) $x\frac{dy}{dx} + y = 0$

2) $2\frac{d^2y}{dx^2} + \left[\frac{dy}{dx}\right]^3 = 0$

3) $2\frac{d^2y}{dx^2} - 3\frac{dy}{dx} + 2y = 0$

Order:- The heighest derivative involve in the given differential Equation is called Order of the Differential Equation

Ex: 1) $\left(\frac{d^2y}{dx^2}\right)^3 - 2\left(\frac{dy}{dx}\right)^4 - 4y = e^x$

Order - 2

Degree:- The power of the term of the heighest Order of given Differential equation is called Degree of Differential Equation.

Ex:- 1) $\left(\frac{d^2y}{dx^2}\right)^3 - 2\left(\frac{dy}{dx}\right)^4 - 4y = e^x$

Degree - 3

2) $2\frac{d^2y}{dx^2} - 3\frac{dy}{dx} - 3x = \sin x$

Degree = 1

General form:- The general notation of first order first degree is $\frac{dy}{dx} = f(x,y)$

Exact Differential Equation: An Equation which is in the form of $Mdx+Ndy=0$ is said to be an Exact differential equation, if it satisfies the Condition $\boxed{\frac{\partial M}{\partial y} = \frac{\partial N}{\partial x}}$

The general solution of Exact Differential Equation is $\int\limits_{(y\,const)} M dx + \int N(\text{terms of } N \text{ without } x)\, dy = c$

Problems:-

(1) Solve $(x^2+y^2)dx + 2xy\,dy = 0$

Sol: Given $(x^2+y^2)dx + 2xy\,dy = 0$ — (1)

The given Differential Equation is in the form of $Mdx+Ndy=0$

where $M = x^2+y^2 \Rightarrow \frac{\partial M}{\partial y} = 2y$

$N = 2xy \Rightarrow \frac{\partial N}{\partial x} = 2y$

$\therefore \frac{\partial M}{\partial y} = \frac{\partial N}{\partial x}$

$\therefore$ The given Differential Equation is in Exact form

$\therefore$ The general solution of Equation (1) is

$\int\limits_{(y\,const)} M dx + \int N(\text{terms of } N \text{ without } 'x')\, dy = c$

$\Rightarrow \int (x^2+y^2)dx + \int 0\,dy = c$

$\Rightarrow \int x^2 dx + \int y^2 dx = c$ $\quad \left[\because \int x^n dx = \frac{x^{n+1}}{n+1}\right]$

$\Rightarrow \frac{x^3}{3} + y^2 x = c$ $\quad \left[\because \int 1\,dx = x+c\right]$

$\Rightarrow x^3 + 3xy^2 = c$

Hence solved

(2) Solve $(e^y+1)\cos x\,dx + e^y \sin x\,dy = 0$

Sol: Given $(e^y+1)\cos x\,dx + e^y \sin x\,dy = 0$ —(1)

The given equation is in the form is $Mdx+Ndy=0$

Here $M = (e^y+1)\cos x \Rightarrow M = e^y\cos x + \cos x$

$\Rightarrow \frac{\partial M}{\partial y} = e^y \cos x$

$N = e^y \sin x \Rightarrow \frac{\partial N}{\partial x} = e^y \cos x$

$\therefore \frac{\partial M}{\partial y} = \frac{\partial N}{\partial x}$

$\therefore$ Equation (1) is an Exact Differential Eq^n

So, The general solution of Equation (1) is

$\int\limits_{y\ \text{constant}} M dx + \int N (\text{terms without } x)\, dy = c$

$\int (e^y+1)\cos x + \int 0\,dy = c$

$\therefore (e^y+1)\sin x = c$ is the general solution of Equation (1).

Hence solved

(3) Solve $\left[1+e^{x/y}\right]dx + e^{x/y}\left[1-\frac{x}{y}\right]dy = 0$

Sol: Given $\left[1+e^{x/y}\right]dx + e^{x/y}\left[1-\frac{x}{y}\right]dy = 0$ —(1)

Equation (i) is in the form of $Mdx+Ndy=0$

Here $M = 1+e^{x/y} \Rightarrow \frac{\partial M}{\partial y} = e^{x/y}\left[-\frac{x}{y^2}\right]$

$N = e^{x/y}\left[1-\frac{x}{y}\right] \Rightarrow N = e^{x/y} - e^{x/y}\cdot\frac{x}{y}$

$$\frac{\partial N}{\partial x} = e^{x/y}\left(-\frac{1}{y}\right) + \left[1-\frac{x}{y}\right]e^{x/y}\left[\frac{1}{y}\right]$$

$$= e^{x/y}\left[-\cancel{\frac{1}{y}} + \cancel{\frac{1}{y}} - \frac{x}{y^2}\right] \quad \left[\because \frac{d}{dx}(uv) = u'v+vu'\right]$$

$$\frac{\partial N}{\partial x} = \frac{-x}{y^2}e^{x/y}$$

$$\therefore \frac{\partial M}{\partial y} = \frac{\partial N}{\partial x}$$

$\therefore$ The given D.E is in Exact form

The general soln of Equation (i) is

$\int M\,dx + \int N$ (without x terms) $dy = c$

(y constant)

$\Rightarrow \int (1+e^{x/y})\,dx + \int 0\,dy = c$

$\Rightarrow x + \frac{e^{x/y}}{1/y} = c \Rightarrow x + ye^{x/y} = c$ is the general soln of Eqn (i).

1) Solve $(xe^{xy}+2y)\frac{dy}{dx} + ye^{xy} = 0$

Sol: Given $(xe^{xy}+2y)\frac{dy}{dx} + ye^{xy} = 0$

$$(xe^{xy}+2y)\,dy + ye^{xy}\,dx = 0 \quad \text{— (i)}$$

It is in the form of $Mdx+Ndy=0$

Here $M = ye^{xy} \Rightarrow \frac{\partial M}{\partial y} = ye^{xy}\cdot x + e^{xy}(1)$

$$= e^{xy}(xy+1)$$

$$N = xe^{xy}+2y \Rightarrow \frac{\partial N}{\partial x} = xe^{xy}\cdot y + e^{xy}(1)$$

$$= e^{xy}(xy+1$$

$$\therefore \frac{\partial M}{\partial y} = \frac{\partial N}{\partial x}$$

$\therefore$ The Eq^n is in Exact form

$\therefore$ The general sol^n of Eq^n (1) is

$$\underset{y\,constant}{\int M dx} + \int N (\text{terms without } x)\, dy = c$$

$$\Rightarrow \int ye^{xy}\, dx + \int 2y\, dy = c$$

$$\Rightarrow y\frac{e^{xy}}{y} + y^2 = c$$

$\Rightarrow e^{xy} + y^2 = c$ is the general sol^n of Eq^n (1)

Hence solved.

(5) Solve $(r + \sin\theta - \cos\theta)dr + r(\sin\theta + \cos\theta)d\theta = 0$ — (1)

sol: Given Eq^n is $(r + \sin\theta - \cos\theta)dr + r(\sin\theta + \cos\theta)d\theta = 0$

This is in the form of $Md\theta + Ndr = 0$

where $M = r(\sin\theta + \cos\theta) \Rightarrow \frac{\partial M}{\partial r} = \sin\theta + \cos\theta$

$N = r + \sin\theta - \cos\theta \Rightarrow \frac{\partial N}{\partial \theta} = \sin\theta + \cos\theta$

$$\therefore \frac{\partial M}{\partial r} = \frac{\partial N}{\partial \theta}$$

The given equation is Exact

Thus the general sol^n of Eq^n (1) is

$$\underset{(r\,constant)}{\int M d\theta} + \int N (\text{term without } \theta)\, dr = c$$

$$\int r(\sin\theta + \cos\theta)\, d\theta + \int r\, dr = c$$

$$r(\sin\theta - \cos\theta) + \frac{r^2}{2} = c$$

Hence the general sol^n is

$$r^2 + 2r(\sin\theta - \cos\theta) = c$$

Hence Solved

6) solve $x^3 \sec^2 y \frac{dy}{dx} + 3x^2 \tan y = \cos x$

Sol: Given eqn can be written as

$(3x^2 \tan y - \cos x)dx + (x^3 \sec^2 y)dy = 0$ — (1)

Here $M = 3x^2 \tan y - \cos t \Rightarrow \frac{\partial M}{\partial y} = 3x^2 \sec^2 y$

$N = x^3 \sec^2 y \Rightarrow \frac{\partial N}{\partial x} = 3x^2 \sec^2 y$

$\therefore \frac{\partial M}{\partial y} = \frac{\partial N}{\partial x}$

$\therefore$ The given eqn is Exact

$\therefore$ The general soln of eqn (1) is

$\int M dx + \int N(\text{~~terms~~ w.o.t } x) dy = c$

$\int (3x^2 \tan y - \cos x) dx + \int 0 dy = c$

$3\frac{x^3}{3} \tan y - \sin x = c$ (or) $x^3 \tan y - \sin x = c$

Hence solved.

7) solve $(2x - y + 1)dx + (2y - x - 1)dy = 0$

Ans: $x^2 + y^2 + x - y - xy = c$

) solve $(y^2 - 2xy)dx = (x^2 - 2xy)dy$

Ans: $xy(y - x) = c$

) solve $\frac{dy}{dx} + \frac{y\cos x + \sin y + y}{\sin x + x\cos y + x} = 0$

Ans: $y\sin x + (\sin y + y)x = c$

) solve $(2y\sin x + \cos y)dx = (x\sin y + 2\cos x + \tan y)dy$

Ans: $2y\cos x - x\cos y + \log\sec y = c$

) solve $[\cos x \tan y + \cos(x+y)]dx + [\sin x \sec^2 y + \cos(x+y)]dy = 0$

Ans: $\sin x \tan y + \sin(x+y) = c$

EQUATIONS REDUCIBLE TO EXACT EQUATIONS

Def:- Let $M(x,y)dx + N(x,y)dy = 0$ be not an Exact D.Eqⁿ.
If $Mdx + Ndy = 0$ can be made Exact by multiplying it with a suitable function $u(x,y) \neq 0$

Method-1 :- Inspection Method:

Exact differentials:-

1) $d(xy) = xdy + ydx$

2) $d(x/y) = \dfrac{ydx + xdy}{y^2}$

3) $d(y/x) = \dfrac{xdy - ydx}{x^2}$

4) $d\left[\dfrac{x^2+y^2}{2}\right] = xdx + ydy$

5) $d\left[\log(y/x)\right] = \dfrac{xdy - ydx}{xy}$

6) $d\left[\log(x/y)\right] = \dfrac{ydx - xdy}{xy}$

7) $d\left[\mathrm{Tan}^{-1}\left(\frac{x}{y}\right)\right] = \dfrac{ydx - xdy}{x^2+y^2}$

8) $d\left[\mathrm{Tan}^{-1}(y/x)\right] = \dfrac{xdy - ydx}{x^2+y^2}$

9) $d\left[\log(xy)\right] = \dfrac{ydx + xdy}{xy}$

10) $d\left[\log(x^2+y^2)\right] = \dfrac{2(xdx + ydy)}{x^2+y^2}$

11) $d\left[\dfrac{e^x}{y}\right] = \dfrac{ye^x dx - e^x dy}{y^2}$

① Solve $(1+xy)xdy + (1-\cancel{y}x)ydx = 0$

Sol: Given $(1+xy)xdy + (1-yx)ydx = 0$

$$xdy + ydx + (xy)(xdy - ydx) = 0$$

Divide with x^2y^2, we get

$$\frac{xdy + ydx}{x^2y^2} + \frac{xdy - ydx}{xy} = 0$$

$$\cancel{\left[\frac{d(xy)}{(x^2y)^2} - d\left[\log(y/x)\right]\right]}$$

$$\frac{d(xy)}{(xy)^2} + \frac{xdy}{xy} - \frac{ydx}{xy} = 0$$

$$\frac{d(xy)}{(xy)^2} + \frac{1}{y}dy - \frac{1}{x}dx = 0$$

On Integrating, we get

$$\frac{-1}{xy} - \log x + \log y = \log c$$

which is required solⁿ

(2) Solve $xdx + ydy = \frac{xdy - ydx}{x^2+y^2}$

Sol: Given $xdx + ydy = \frac{xdy - ydx}{x^2+y^2}$

$$d\left[\frac{x^2+y^2}{2}\right] = d\left[\tan^{-1}(y/x)\right]$$

On Integrating we get

$$\frac{x^2+y^2}{2} = \tan^{-1} y/x + C$$

which is required solⁿ.

(3) Solve $y(2x^2y + e^x)dx = (e^x + y^3)dy$

Sol: Given $y(2x^2y + e^x)dx = (e^x + y^3)dy$

$$2x^2y^2dx + ye^xdx = e^xdy + y^3dy$$

$$ye^xdx - e^xdy + 2x^2y^2dx - y^3dy$$

Divide with y^2, we get

$$\frac{ye^xdx - e^xdy}{y^2} + 2x^2dx - ydy$$

On Integrating, we get

$$d\left[\frac{e^x}{y}\right] + 2\frac{x^3}{3} - \frac{y^2}{2} = C$$

we $\frac{e^x}{y} + 2\frac{x^3}{3} - \frac{y^2}{2} = c$ which is the required solution.

(4) Solve $ydx - xdy = a(x^2+y^2)dx$

Sol: $\tan^{-1}(x/y) = ax + C$

(5) Solve $xdx + ydy = \frac{a^2(xdy - ydx)}{x^2+y^2}$

Sol: $\frac{x^2}{2} + \frac{y^2}{2} = a^2 \tan^{-1}\frac{y}{x} + C$

(6) $(x^3y^2+x)dy + (x^2y^3-y)dx = 0$

Sol: $\log(y/x) + \frac{x^2y^2}{2} = C$

(7) $(y-xy^2)dx - (x+x^2y)dy = 0$

Sol: $cx + y + 1 + \log x = 0$

Method-2 :- To find an integrating factor of $Mdx+Ndy=0$

If $M(x,y)dx + N(x,y)dy = 0$ is a homogeneous D.Eq^n and $Mx+Ny \neq 0$ then $\frac{1}{Mx+Ny}$ is an integrating factor of

$Mdx+Ndy=0$

(1) Solve $y^2dx + (x^2-xy-y^2)dy = 0$

Soln: Given D.Eq^n is $y^2dx + (x^2-xy-y^2)dy = 0$ — (1)

It is in the form of $Mdx+Ndy=0$

Here $M = y^2 \Rightarrow \frac{\partial M}{\partial y} = 2y$

$N = (x^2-xy-y^2) \Rightarrow \frac{\partial N}{\partial x} = 2x-y.$

$\therefore \frac{\partial M}{\partial y} \neq \frac{\partial N}{\partial x}.$

So, the given D.Eq^n is non-Exact. But (1) is homogeneous D.Eq^n.

Now $Mx+Ny = xy^2 + \cancel{x^2y} - \cancel{xy^2} - xy^2 =$

$= y^2x + yx^2 - xy^2 - y^3 = y(x^2-y^2)$

$I.F = \frac{1}{Mx+Ny} = \frac{1}{y(x^2-y^2)}$

Multiplying (1) with $\frac{1}{y(x^2-y^2)}$, we get

$$\frac{y}{x^2-y^2}\,dx + \frac{x^2-xy-y^2}{y(x^2-y^2)}\,dy = 0 \quad (2)$$

$$\boxed{\left(\frac{u}{v}\right)' = \frac{v'u-uv'}{v^2}}$$

It is in the form of $M_1dx+N_1dy=0$

$$M_1 = \frac{y}{x^2-y^2} \Rightarrow \frac{\partial M_1}{\partial y} = \frac{x^2-y^2(1)-y(-2y)}{(x^2-y^2)^2} = \frac{x^2-y^2+2y^2}{(x^2-y^2)^2}$$

$$= \frac{x^2+y^2}{(x^2-y^2)^2}$$

$$N_1 = \frac{x^2-xy-y^2}{y(x^2-y^2)} \Rightarrow \frac{\partial N}{\partial x} = \frac{1}{y}\left[\frac{(x^2-y^2)(2x-y)-[(x^2-xy-y^2)(2x)]}{(x^2-y^2)^2}\right]$$

$$= \frac{1}{y}\left[\frac{\cancel{2x^3}-x^2y-\cancel{2xy^2}+y^3-\cancel{2x^3}+2x^2y+\cancel{2xy^2}}{(x^2-y^2)^2}\right]$$

$$= \frac{1}{y}\left[\frac{x^2y+y^3}{(x^2-y^2)^2}\right] = \frac{1}{\cancel{y}}\left[\frac{\cancel{y}(x^2+y^2)}{(x^2-y^2)^2}\right]$$

$$\frac{\partial N_1}{\partial x} = \frac{x^2+y^2}{(x^2-y^2)^2}$$

$$\therefore \frac{\partial M_1}{\partial y} = \frac{\partial N_1}{\partial x}.$$

The Eqn (2) is Exact.

The General soln of Eqn (2) is

$\int M_1 dx + \int N_1$ (terms of N_1 without x) $dy = c$
(y const)

$$\int \frac{y}{x^2-y^2}dx + \int \frac{1}{y}dy = c \Rightarrow y\int \frac{1}{x^2-y^2}dx + \int \frac{1}{y}dy = c$$

$$\int \frac{1}{x^2-a^2}dx = \frac{1}{2a}\log\left|\frac{x-a}{x+a}\right| + c$$

$$\Rightarrow \cancel{y}\cdot\frac{1}{2\cancel{y}}\log\left|\frac{x-y}{x+y}\right| + \log y = \log c$$

$$\Rightarrow \frac{1}{2}\log\left|\frac{x-y}{x+y}\right| + \log y = \log c$$

$$\log\left(\frac{x-y}{x+y}\right)^{1/2} = \log c - \log y$$

$$\log\left(\frac{x-y}{x+y}\right)^{1/2} = \log c/y$$

$$\left(\frac{x-y}{x+y}\right)^{1/2} = c/y$$

$$y\left[\frac{x-y}{x+y}\right]^{1/2} = c$$ is the General solⁿ of

Eqⁿ ② of ①.

② Solve $y(y^2-2x^2)dx + x(2y^2-x^2)dy = 0$ — ①

Solⁿ Given $(y^3-2x^2y)dx + (2xy^2-x^3)dy = 0$

It is in the form of $Mdx+Ndy=0$

where $M = y^3-2x^2y \Rightarrow \frac{\partial M}{\partial y} = 3y^2-2x^2$

$N = 2xy^2-x^3 \Rightarrow \frac{\partial N}{\partial x} = 2y^2-3x^2$

$\therefore \frac{\partial M}{\partial y} \neq \frac{\partial N}{\partial x}$

The Eqⁿ ①. is non-Exact.

we have $Mx+Ny = (y^3-2x^2y)x + (2xy^2-x^3)y$

$= xy^3 - 2x^3y + 2xy^3 - x^3y$

$= 3xy^3 - 3x^3y$

$= 3xy^3 - 3x^3y$

$$I.F = \frac{1}{Mx+Ny} = \frac{1}{3xy^3 - 3x^3y} = \frac{1}{3xy(y^2-x^2)}$$

Multiplying $\frac{1}{3xy(y^2-x^2)}$ with Eq^n (1).

$$\frac{y(y^2-2x^2)}{3xy(y^2-x^2)}\,dx + \frac{x(2y^2-x^2)}{3xy(y^2-x^2)}\,dy = 0$$

$$\frac{y^2-2x^2}{3x(y^2-x^2)}\,dx + \frac{2y^2-x^2}{3y(y^2-x^2)}\,dy = 0$$

$$\frac{y^2-2x^2}{x(y^2-x^2)}\,dx + \frac{2y^2-x^2}{y(y^2-x^2)}\,dy = 0$$

$$\frac{(y^2-x^2)-x^2}{x(y^2-x^2)}\,dx + \frac{y^2+(y^2-x^2)}{y(y^2-x^2)}\,dy = 0$$

$$\left[\frac{1}{x} - \frac{x}{y^2-x^2}\right]dx + \left[\frac{y}{y^2-x^2} + \frac{1}{y}\right]dy = 0$$

$$\frac{1}{x}\,dx - \frac{x}{y^2-x^2}\,dx + \frac{y}{y^2-x^2}\,dy + \frac{1}{y}\,dy = 0$$

$$\frac{1}{x}\,dx + \frac{1}{y}\,dy + \frac{y}{y^2-x^2}\,dy - \frac{x}{y^2-x^2}\,dx = 0$$

$$\frac{y\,dx + x\,dy}{xy} + \frac{1}{2}\left[\frac{2y\,dy - 2x\,dx}{y^2-x^2}\right] = 0$$

$$\frac{d(xy)}{xy} + \frac{1}{2}\,\frac{d(y^2-x^2)}{y^2-x^2} = 0$$

On Integrating b.s. we get

$$\log(xy) + \frac{1}{2}\log(y^2-x^2) = c_1$$

$\Rightarrow 2\log(xy) + \log(y^2 - x^2) = c_1$

$\Rightarrow \log(xy)^2 + \log(y^2 - x^2) = c_1$

$\Rightarrow \log x^2y^2(y^2 - x^2) = c_1 \Rightarrow x^2y^2(y^2 - x^2) = c$

which is required solⁿ.

(3) Solve $x^2y\,dx - (x^3+y^3)dy = 0$

Sol: $\dfrac{-x^3}{3y^3} + \log|y| = c$

(4) $(3xy^2 - y^3)dx - (2x^2y - xy^2)dy = 0$

Sol: $3\log|x| - 2\log|y| + \frac{y}{x} = c$

(5) Solve $(x^2y - 2xy^2)\,dx - (x^3 - 3x^2y)dy = 0$

Sol: $\frac{x}{y} + \log\left(\frac{y^3}{x^2}\right) = c$

Method-3:- To find an integrating factor of $Mdx+Ndy=0$

If the Eqⁿ $Mdx+Ndy=0$ is of the form $yf(xy)dx + xg(x,y)dy=0$ and $Mx-Ny \neq 0$ then $\frac{1}{Mx-Ny}$ is an integrating factor of

$Mdx+Ndy=0$

Problems:

(1) Solve $y(x^2y^2+2)dx + x(2-2x^2y^2)dy=0$

Sol: Given Eqⁿ is $y(x^2y^2+2)dx + x(2-2x^2y^2)dy=0$ — (1)

It is in the form of $Mdx+Ndy=0$ where

$M = y(x^2y^2+2) \Rightarrow M = y^3x^2 + 2y \Rightarrow \frac{\partial M}{\partial y} = 3x^2y^2 + 2$

$N = x(2-2x^2y^2) \Rightarrow N = 2x - 2x^3y^2 \Rightarrow \frac{\partial N}{\partial x} = 2 - 6x^2y^2$

$\therefore \frac{\partial M}{\partial y} \neq \frac{\partial N}{\partial x}$

$\therefore$ ① is not Exact, But ① is of the form

$y f(x,y)dx + x g(x,y)dy = 0$ and $Mx - Ny = (y^3x^2+2y)x - (2x-2x^3y^2)y$

$$Mx - Ny = x^3y^3 + \cancel{2yx} - \cancel{2xy} + 2x^3y^3$$

$$Mx - Ny = 3x^3y^3 \neq 0.$$

$\therefore$ Integrating factor $= \frac{1}{Mx-Ny} = \frac{1}{3x^3y^3}$, ~~we get~~

Multiply $\frac{1}{3x^3y^3}$ with Eq^n ①, we get

$$\left[\frac{\cancel{x^2}\cancel{y^3}}{3x^{\cancel{3}}\cancel{y^3}} + \frac{2y}{3x^3y^3}\right]dx + \left[\frac{2x}{3x^3y^3} - \frac{2x^{\cancel{3}}y^{\cancel{2}}}{3\cancel{x^3}y^{\cancel{3}}}\right]dy = 0$$

$$\left[\frac{1}{3x} + \frac{2}{3x^3y^2}\right]dx + \left[\frac{2}{3x^2y^3} - \frac{2}{3y}\right]dy = 0 \quad \text{②}$$

It is in the form of $M_1dx + N_1dy = 0$

here $M_1 = \frac{1}{3x} + \frac{2}{3x^3y^2} \Rightarrow \frac{\partial M_1}{\partial y} = \frac{2}{3x^3}\left(\frac{-2}{y^3}\right) = \frac{-4}{3x^3y^3}$

$N_1 = \frac{2}{3x^2y^3} - \frac{2}{3y} \Rightarrow \frac{\partial N_1}{\partial x} = \frac{2}{3y^3}\left(\frac{-2}{x^3}\right) = \frac{-4}{3x^3y^3}$

$\therefore \frac{\partial M_1}{\partial y} = \frac{\partial N_1}{\partial x}$, so that ② is Exact

General solution is given by

$\int M_1dx + \int N_1dy = c$
(y const) (without x)

$$\int\left(\frac{1}{3x} + \frac{2}{3x^3y^2}\right)dx + \int -\frac{2}{3y}dy = c$$

$$\frac{1}{3}\int \frac{1}{x}dx + \frac{2}{3y^2}\int \frac{1}{x^3}dx - \frac{2}{3}\int \frac{1}{y}dy = c$$

$$\frac{1}{3}\log x + \frac{\cancel{2}}{3y^2}\left(\frac{-1}{\cancel{2}x^2}\right) - \frac{2}{3}\log y = \log c$$

$\log x^{1/3} - \frac{\cancel{2}}{\cancel{2}\times 3x^2y^2} - \log y^{2/3} = \log c$

$$\frac{-1}{3x^2y^2} + \log\left(\frac{x^{1/3}}{y^{2/3}}\right) = \log c$$

$$\log\left(\frac{x^{1/3}}{y^{2/3}}\right) - \frac{1}{3x^2y^2} = \log c$$

This is the General solⁿ of ② and hence of ①.

② Solve $(xy\sin xy + \cos xy)y\,dx + (xy\sin xy - \cos xy)x\,dy = 0$

Solⁿ Given Eqⁿ is

$(xy\sin xy + \cos xy)\,y\,dx + (xy\sin xy - \cos xy)\,x\,dy = 0$ ①

$(xy^2\sin xy + y\cos xy)\,dx + (x^2y\sin xy - x\cos xy)\,dy = 0$

It is in the form of $M\,dx + N\,dy = 0$

Here $M = xy^2\sin xy + y\cos xy \Rightarrow \frac{\partial M}{\partial y} = x[2y\sin xy + y^2\cos xy.x] + (1)\cos xy - \sin xy.x.y$

$= 2xy\sin xy + xy^2\cos xy + \cos xy - xy\sin xy$

$\frac{\partial M}{\partial y} = xy^2\cos xy + xy\sin xy + \cos xy.$

$N = x^2y\sin xy - x\cos xy \Rightarrow \frac{\partial N}{\partial x} = y[2x\sin xy + x^2\cos xy.y] + x\sin xy.y - \cos xy.1]$

$= 2xy\sin xy + yx^2\cos xy + yx\sin xy - \cos xy$

$\therefore \frac{\partial N}{\partial x} = x^2y\cos xy + 3xy\sin xy - \cos xy.$

$\therefore \frac{\partial M}{\partial y} \neq \frac{\partial N}{\partial x}$, ① is not Exact

But ① is of the form $yf(x,y)dx + xg(x,y)dy = 0$

then $Mx - Ny = (xy^2\sin xy + y\cos xy)x - (x^2y\sin xy - x\cos xy)y$

$= x^2y^2\sin xy + xy\cos xy - x^2y^2\sin xy + xy\cos xy$

$= \cancel{x^2y^2\sin xy} + xy\cos xy - \cancel{x^2y^2\sin xy} + xy\cos xy$

$Mx - Ny. = xy\cos xy + xy\cos xy = 2xy\cos xy.$

Integrating factor $= \frac{1}{Mx - Ny} = \frac{1}{2xy\cos xy}$

Multiply $\frac{1}{2xy\cos xy}$ with Eqn (1)

$$\left[\frac{xy^2\sin xy}{2xy\cos xy} + \frac{y\cos xy}{2xy\cos xy}\right]dx + \left[\frac{x^2y\sin xy}{2xy\cos xy} - \frac{x\cos xy}{2xy\cos xy}\right]dy = 0$$

$$\left[\frac{y}{2}\tan xy + \frac{1}{2x}\right]dx + \left[\frac{x}{2}\tan xy - \frac{1}{2y}\right]dy = 0 \quad -(2)$$

It is in the form of $M_1dx + N_1dy = 0$

Here $M_1 = \frac{y}{2}\tan yx + \frac{1}{2x} \Rightarrow \frac{\partial M_1}{\partial y} = \frac{1}{2}\left[y\sec^2 xy . x + \tan xy\right]$

$= \frac{1}{2}\left[xy\sec^2 xy + \tan xy\right]$

$N_1 = \frac{1}{2}\left[x\tan xy\right] - \frac{1}{2y}$

$\Rightarrow \frac{\partial N_1}{\partial x} = \frac{1}{2}\left[x\sec^2 xy . y + \tan xy\right] = \frac{1}{2}\left[xy\sec^2 xy + \tan xy\right]$

$\therefore \frac{\partial M_1}{\partial y} = \frac{\partial N_1}{\partial x}$.

$\therefore$ Eqn (2) is Exact

The general soln of Eqn (2) is

$\int M_1 dx + \int N_1(\text{terms without } x)dy = c$

(y const)

$\int \frac{y}{2}\tan xy\,dx + \int \frac{1}{2x}dx + \int -\frac{1}{2y}dy = c$

$\int y\tan xy\,dx + \int \frac{1}{x}dx - \int \frac{1}{y}dy = c$

$y\log(\sec^2 xy) + \log x - \log y = \log c$

$\log(\sec xy) + \log(x/y) = \log c \Rightarrow \frac{x}{y}\sec(xy) = c$

which is required soln.

(3) Solve $y(1+xy)dx + x(1-xy)dy = 0$

Sol: $\log(x/y) - \frac{1}{xy} = c$

(4) $y(x^4y^4 + x^2y^2 + xy)dx + x(x^4y^4 - x^2y^2 + xy)dy = 0$

Sol: $\frac{x^2y^2}{2} - \frac{1}{xy} + \log(x/y) = c$

(5) $y(xy + 2x^2y^2)dx + x(xy - x^2y^2)dy = 0$

Sol: $\frac{2}{3}\log x - \frac{1}{3}\log y - \frac{1}{3xy} = c$

(6) $(y - xy^2)dx - (x + x^2y)dy = 0$

Sol: $\log\left(\frac{x}{y}\right)^2 - x^2y^2 = c$

Method-4: To find an integrating factor of $Mdx + Ndy = 0$

If $\exists$ a continuous single variable function $f(x)$ such that $\frac{1}{N}\left[\frac{\partial M}{\partial y} - \frac{\partial N}{\partial x}\right] = f(x)$ then $e^{\int f(x)dx}$ is an integrating factor of $Mdx + Ndy = 0$.

(1) Solve $2xydy - (x^2 + y^2 + 1)dx = 0$

Sol: Given Equation is $2xydy - (x^2+y^2+1)dx = 0$ — (1)

This is in the form of $Mdx + Ndy = 0$

Here $M = -(x^2+y^2+1) \Rightarrow \frac{\partial M}{\partial y} = -2y$

$N = 2xy \Rightarrow \frac{\partial N}{\partial x} = 2y$

$\therefore \frac{\partial M}{\partial y} \neq \frac{\partial N}{\partial x}$

$\therefore$ The Eqn is not Exact.

we have $\frac{1}{N}\left[\frac{\partial M}{\partial y} - \frac{\partial N}{\partial x}\right] = \frac{1}{2xy}\left[-2y - 2y\right] = \frac{-\cancel{4}^{2}\cancel{y}}{\cancel{2}x\cancel{y}} = \frac{-2}{x} = f(x)$

$\therefore f(x) = -2/x$.

Integrating factor is $e^{\int f(x)dx} = e^{-2\int \frac{1}{x}dx} = e^{-2\log x} = \frac{1}{x^2}$

Multiply $\frac{1}{x^2}$ with Eq^n (1), we get

$$\frac{2xy\,dy}{x^2} - \frac{(x^2+y^2+1)}{x^2}\,dx = 0$$

$$\frac{2y}{x}\,dy - \left(1+\frac{y^2}{x^2}+\frac{1}{x^2}\right)dx = 0 \quad -(2)$$

It is in the form of $M_1dx+N_1dy=0$

Here $M_1 = -\left(1+\frac{y^2}{x^2}+\frac{1}{x^2}\right)$

$$\frac{\partial M_1}{\partial y} = -\frac{2y}{x^2}$$

$$N_1 = \frac{2y}{x} \Rightarrow \frac{\partial N_1}{\partial x} = \frac{-2y}{x^2}$$

$\therefore \frac{\partial M_1}{\partial y} = \frac{\partial N_1}{\partial x}$, (2) is Exact.

The general sol^n of Eq^n (2) is

$$\int M_1\,dx + \int N_1\,dy = C$$

$$-\left[\int 1\,dx + \int \frac{y^2}{x^2}dx + \int \frac{1}{x^2}dx\right] + \int 0\,dy = C$$

$$-x - y^2\left(-\frac{1}{x}\right) + \left(-\frac{1}{x}\right) = C$$

$$-x + \frac{y^2}{x} - \frac{1}{x} = C$$

$$-x^2+y^2-1 = Cx$$

$y^2-x^2-1 = Cx$. is the general solution of Eq^n (2) & hence of (1).

2) Solve $(3y^2+4xy-x)dx + x(x+2y)dy = 0$

Sol: Given D.Eq^n is $(3y^2+4xy-x)\,dx + x(x+2y)dy = 0 \quad -(1)$

It is in the form of $Mdx+Ndy=0$

$$M = 3y^2+4xy-x \Rightarrow \frac{\partial M}{\partial y} = 6y+4x$$

$$N = x^2+2yx \Rightarrow \frac{\partial N}{\partial x} = 2x+2y$$

$\therefore \frac{\partial M}{\partial y} \neq \frac{\partial N}{\partial x}$, (1) is not Exact we have $\frac{1}{N}\left[\frac{\partial M}{\partial y} - \frac{\partial N}{\partial x}\right] = f(x)$

$\Rightarrow \frac{1}{x^2+2yx}\left[6y+4x-2x-2y\right] = f(x)$

$\Rightarrow \frac{4y+2x}{x^2+2yx} = f(x) \Rightarrow \frac{2(2y+x)}{x(x+2y)} = f(x)$

$\Rightarrow \frac{2}{x} = f(x).$

Integrating factor is $e^{\int f(x)dx}$

$= e^{2\int \frac{1}{x}dx} = e^{2\log x} = x^2$

Multiply ① with x^2, we get.

$(3y^2+4xy-x)x^2\,dx + (x^2+2xy)x^2\,dy = 0$

$(3x^2y^2+4x^3y-x^3)dx + (x^4+2x^3y)dy = 0$ — ②

It is in the form of $M_1dx + N_1dy = 0$.

$M_1 = 3x^2y^2+4x^3y-x^3 \Rightarrow \frac{\partial M_1}{\partial y} = 6x^2y+4x^3$

$N_1 = x^4+2x^3y \Rightarrow \frac{\partial N_1}{\partial x} = 4x^3+6x^2y$

$\therefore \frac{\partial M_1}{\partial y} = \frac{\partial N_1}{\partial x}$, ② is Exact.

The general solution of Eqn ② is

$\int M_1dx + \int N_1dy = c$

$\int 3x^2y^2dx + 4\int x^3y\,dx - \int x^3dx + \int 0\,dy = c$

$\int 3x^2y^2dx + 4\int x^3y\,dx - \int x^3dx = c$

$3y^2\int x^2dx + 4y\int x^3dx - \int x^3dx$

$\cancel{3}y^2\frac{x^3}{\cancel{3}} + \cancel{4}y\frac{x^4}{\cancel{4}} - \frac{x^4}{4} = c$

$x^3y^2 + yx^4 - \frac{x^4}{4} = c$ is the general solⁿ of Eqⁿ ② and hence of ①.

③ Solve $(x^4e^x - 2mxy^2)dx + 2mx^2y\,dy = 0$

Sol: $e^x + \frac{my}{x^2} = c$

④ Solve $y(2x^2 - xy + 1)dx + (x-y)dy = 0$

Sol: $e^{x^2}(2xy - y^2) = c$

⑤ $\left[y + \frac{y^3}{3} + \frac{x^2}{2}\right]dx + \frac{1}{4}(x + xy^2)dy = 0$

Sol: $3x^4y + x^4y^3 + x^6 = c$

Method 5:- To find an integrating factor of $Mdx + Ndy = 0$

If $\exists$ a continuous and differentiable single variable function $g(y)$ such that $\frac{1}{M}\left[\frac{\partial N}{\partial x} - \frac{\partial M}{\partial y}\right] = g(y)$ then $e^{\int g(y)dy}$ is an integrating factor of $Mdx + Ndy = 0$

Problems:-

$(y^4 + 2y)dx + (xy^3 + 2y^4 - 4x)dy = 0$

1) Solve $(y^4 + 2y)dx + (xy^3 + 2y^4 - 4x)dy = 0$ — ①

Sol: Given equation is $(y^4 + 2y)dx + (xy^3 + 2y^4 - 4x)dy = 0$

It is of the form $Mdx + Ndy = 0$

where $M = y^4 + 2y \Rightarrow \frac{\partial M}{\partial y} = 4y^3 + 2$

$N = xy^3 + 2y^4 - 4x \Rightarrow \frac{\partial N}{\partial x} = y^3 \cancel{+ 8y} - 4$

$\therefore \frac{\partial M}{\partial y} \neq \frac{\partial N}{\partial x}$ ① is not exact

we have $\frac{1}{M}\left[\frac{\partial N}{\partial x} - \frac{\partial M}{\partial y}\right] = g(y)$

$$\frac{1}{y^4 + 2y}\left[4y^3 + 2 - y^3 + 4\right] = g(y)$$

$$\frac{3y^3 + 6}{y^4 + 2y} = g(y) \Rightarrow \frac{3\cancel{(y^3+2)}}{y\cancel{(y^3+2)}} = g(y)$$

$$\frac{3}{y} = g(y)$$

$\therefore g(y) = \frac{3}{y}$

Integrating factor $e^{\int g(y)dy} = e^{\int \frac{3}{y}dy} = e^{3\log y}$
$= y^3$

Multiply y^3 with Eq^n (1), we get

$$\left(\frac{y^4+2y}{y^3}\right) dx + \left(\frac{xy^3}{y^3} + \frac{2y^4}{y^3} - \frac{4x}{y^3}\right) dy = 0$$

$$\left(y + \frac{2}{y^2}\right) dx + \left(x + 2y - \frac{4x}{y^3}\right) dy = 0 \quad \text{--- (2)}$$

It is in the form of $M_1 dx + N_1 dy = 0$

where $M_1 = y + \frac{2}{y^2} \Rightarrow \frac{\partial M_1}{\partial y} = 1 + \frac{2(-2)}{y^3} = 1 - \frac{4}{y^3}$

$N_1 = x + 2y - \frac{4x}{y^3} \Rightarrow \frac{\partial N_1}{\partial x} = 1 + \left(-\frac{4}{y^3}\right) = 1 - \frac{4}{y^3}$

$\therefore \frac{\partial M_1}{\partial y} = \frac{\partial N_1}{\partial x}$, (2) is Exact.

The general sol^n of Eq^n (2) is

$\int M_1 dx + \int N_1 (\text{terms of } N_1 \text{ without } 'x') dy = c$
(y const)

$\int \left(y + \frac{2}{y^2}\right) dx + \int 2y \, dy = c$

$\int y \, dx + \int \frac{2}{y^2} dx + \int 2y \, dy = c$

$xy + \frac{2x}{y^2} + \cancel{2}\frac{y^2}{\cancel{2}} = c$

$xy + \frac{2x}{y^2} + y^2 = c$

$x\left[y + \frac{2}{y^2}\right] + y^2 = c$ is the General sol^n of (2)
and hence of (1).

2) Solve the D.Eq^n $y(xy+e^x)dx - e^x dy = 0$

Sol: Given D.Eq^n is $(xy^2 + ye^x)dx - e^x dy = 0$ — (1)

It is in the form of $Mdx + Ndy = 0$

where $M = xy^2 + ye^x \Rightarrow \frac{\partial M}{\partial y} = 2xy + e^x$

$N = -e^x \Rightarrow \frac{\partial N}{\partial x} = -e^x$.

$\therefore \frac{\partial M}{\partial y} \neq \frac{\partial N}{\partial x}$, (1) is not Exact.

we have $\frac{1}{M}\left[\frac{\partial N}{\partial x} - \frac{\partial M}{\partial y}\right] = \frac{1}{xy^2+ye^x}\left[-e^x - 2xy - e^x\right]$

$$= \frac{-2xy - 2e^x}{xy^2+ye^x}$$

$$= \frac{-2(\cancel{xy+e^x})}{y(\cancel{xy+e^x})}$$

$$= -\frac{2}{y} = g(y).$$

$\therefore g(y) = -\frac{2}{y}$.

Integrating factor $e^{\int g(y)dy} = e^{-2\int \frac{1}{y}dy}$
$= e^{-2\log y} = y^{-2} = \frac{1}{y^2}$

Multiply $\frac{1}{y^2}$ with Eq^n (1), we get

$$\frac{xy^2+ye^x}{y^2}dx - \frac{e^x}{y^2}dy = 0$$

$$\left(x + \frac{e^x}{y}\right)dx - \frac{e^x}{y^2}dy = 0 \quad \text{— (2)}$$

It is in the form of $M_1dx + N_1dy = 0$

where $M_1 = x + \frac{e^x}{y} \Rightarrow \frac{\partial M_1}{\partial y} = e^x\left(\frac{-1}{y^2}\right) = \frac{-e^x}{y^2}$

$N_1 = -\frac{e^x}{y^2} \Rightarrow \frac{\partial N_1}{\partial x} = \frac{-e^x}{y^2}$

$$\frac{y}{1-x^2} = (1-x^2)^{-1/2} + c$$

$$\frac{y}{1-x^2} = \frac{1}{\sqrt{1-x^2}} + c$$

$$y = \frac{1-x^2}{\sqrt{1-x^2}} + c(1-x^2)$$

$y = \sqrt{1-x^2} + c(1-x^2)$, which is the required soln of Eqn ② of ①.

③ Solve $\frac{dy}{dx} + 2xy = e^{-x^2}$

Sol: Given $\frac{dy}{dx} + 2xy = e^{-x^2}$ —①

It is in the form of $\frac{dy}{dx} + p(x)y = Q(x)$

which linear differential Eqn in 'y'.

where $p(x) = 2x \quad Q(x) = e^{-x^2}$

$$I.F = e^{\int p(x)dx} = e^{\int 2x\,dx} = e^{2\frac{x^2}{2}} = e^{x^2}$$

General solution of Eqn ① is

$$y(I.F) = \int Q(x)(I.F)\,dx + c$$

$$y(e^{x^2}) = \int e^{-x^2} e^{x^2}\,dx + c$$

$$y(e^{x^2}) = \int 1\,dx + c$$

$y(e^{x^2}) = x + c$ which is required soln of Eqn ①.

$$\frac{dy}{dx} + \frac{2x}{1-x^2} \cdot y = \frac{x}{\sqrt{1-x^2}} \quad -②$$

which is linear differential Eqn in y.

where $p(x) = \frac{2x}{1-x^2}$ $\quad Q(x) = \frac{x}{\sqrt{1-x^2}}$

$$I.F = e^{\int p(x)dx} = e^{\int \frac{2x}{1-x^2}dx} = e^{-\int \frac{-2x}{1-x^2}dx}$$

$$= e^{-\log(1-x^2)} = (1-x^2)^{-1}$$

$$= \frac{1}{1-x^2}$$

$$I.F = \frac{1}{1-x^2}$$

The general soln of Eqn ② is

$$y(I.F) = \int Q(x)\,(I.F)\,dx + C$$

$$y\left(\frac{1}{1-x^2}\right) = \int \frac{x}{\sqrt{1-x^2}} \left(\frac{1}{1-x^2}\right) dx + C$$

$$\frac{y}{1-x^2} = \int \frac{x}{(1-x^2)^{1/2}(1-x^2)}\,dx + C$$

$$\frac{y}{1-x^2} = \int \frac{x}{(1-x^2)^{3/2}}\,dx + C$$

$$\frac{y}{1-x^2} = \int x \cdot (1-x^2)^{-3/2}\,dx + C$$

$$\frac{y}{1-x^2} = \frac{-2}{-2}\int x\,(1-x^2)^{-3/2}\,dx + C$$

$$\frac{y}{1-x^2} = \frac{-1}{2}\int -2x\,(1-x^2)^{-3/2}\,dx + C \quad \left[\because \int f'(x)\,f^n(x) = \frac{f(x)^{n+1}}{n+1}\right]$$

$$\frac{y}{1-x^2} = -\frac{1}{2}\,\frac{(1-x^2)^{-3/2+1}}{-\frac{3}{2}+1} + C$$

$$\frac{y}{1-x^2} = -\frac{\cancel{1}}{2}\,\frac{(1-x^2)^{-1/2}}{-1/2} + C$$

PROBLEMS

(1) solve $x\frac{dy}{dx}+y=\log x$

Sol Given $x\frac{dy}{dx}+y=\log x$ —(1)

divide Eq^n (1) with x, we get

$$\frac{dy}{dx}+\frac{y}{x}=\frac{\log x}{x}$$

$$\frac{dy}{dx}+\frac{1}{x}\cdot y=\frac{\log x}{x} \quad -(2)$$

which is Linear D.Eq^n in y.

where $p(x)=\frac{1}{x}$, $Q(x)=\frac{\log x}{x}$

Integrating factor is $e^{\int p(x)dx}=e^{\int \frac{1}{x}dx}=e^{\log x}=x$

$$\therefore I.F=x.$$

The General sol^n of Eq^n (2) is.

$$y(I.F)=\int Q(x)(I.F)\,dx+C$$

$$y(x)=\int \frac{\log x}{x}\cdot(x)\,dx+c$$

$$xy=\int \log x\,dx+c \qquad \left[\int \log x\,dx=x\log x+x\right]$$

$$xy=x\log x+x+c$$

$$xy=x(\log x+1)+c$$

which is required General sol^n of Eq^n (2) of (1)

(2) solve $(1-x^2)\frac{dy}{dx}+2xy=x\sqrt{1-x^2}$

Sol Given $(1-x^2)\frac{dy}{dx}+2xy=x\sqrt{1-x^2}$ —(1)

Divide Eq^n (1) with $1-x^2$, we get

$$\frac{dy}{dx}+\frac{2x}{1-x^2}y=\frac{x}{1-x^2}(\sqrt{1-x^2})$$

$$\frac{dy}{dx}+\frac{2x}{1-x^2}\cdot y=\frac{x\cancel{\sqrt{1-x^2}}}{\cancel{\sqrt{1-x^2}}\sqrt{1-x^2}}$$

$\therefore \frac{\partial M_1}{\partial y} = \frac{\partial N_1}{\partial x}$, (2) is Exact.

The general soln of Eqn (2) is.

$\int M_1 dx + \int N_1 (\text{terms without } x) dy = c$
(y const)

$\int\left(x+\frac{e^x}{y}\right) dx + \int 0 dy = c$

$\int x dx + \frac{1}{y}\int e^x dx = c$

$\frac{x^2}{2} + \frac{1}{y} e^x = c$

$\frac{x^2}{2} + \frac{e^x}{y} = c$ is the general soln of Eqn (2)

and hence of (1).

LINEAR DIFFERENTIAL EQATIONS

*An Equation is of the form $\boxed{\frac{dy}{dx} + p(x)\cdot y = Q(x)}$

where p and Q are Either constants or functions of y only is called a linear differential Equation of first order in y.

→ The general soln of linear differential Equation is

$\boxed{y(I.F) = \int Q(x)(I.F)\, dx + c}$ where

$\boxed{e^{\int p(x) dx}}$ is an integrating factor.

Another form of Linear Differential Eqn.

An Eqn is of the form $\frac{dx}{dy} + p(y)\cdot x = Q(y)$

which is Linear differential eqn in 'x'.

The general soln is $x(I.F) = \int Q(y)(I.F)\, dy + c$ where $I.F = e^{\int p(y) dy}$.

Q) solve $dr + (2r\cot\theta + \sin 2\theta)d\theta = 0$

Sol) Given Eqn is

$$dr + (2r\cot\theta + \sin 2\theta)d\theta = 0$$

Eqn canbe written as

$$\frac{dr}{d\theta} + 2r\cot\theta + \sin 2\theta = 0$$

$$\frac{dr}{d\theta} + 2r\cot\theta = -\sin 2\theta \quad \text{--- (1)}$$

which is linear D. Eqn in r.

$$p = 2\cot\theta \qquad Q = -\sin 2\theta$$

$$I.F = e^{\int p\, d\theta} = e^{\int 2\cot\theta\, d\theta} = e^{2\log\sin\theta} = \sin^2\theta$$

General soln of Eqn (1) is

$$r(I.F) = \int Q(\theta)\,(I.F)\,.d\theta + c$$

$$r(\sin^2\theta) = \int -\sin 2\theta\,(\sin^2\theta)\,d\theta + c$$

$$r(\sin^2\theta) = -\int 2\sin\theta\cos\theta\,\sin^2\theta\,d\theta + c$$

$$r(\sin^2\theta) = -\int 2\sin^3\theta\cos\theta\,d\theta + c$$

put $\sin\theta = t \Rightarrow \cos\theta\, d\theta = dt$

$$\therefore r\sin^2\theta = -2\int t^3\,dt + c$$

$$= -\cancel{2}\frac{t^4}{\cancel{4}\,2} + c$$

$$\therefore r\sin^2\theta = -\frac{\sin^4\theta}{2} + c.$$

which is required soln of Eqn (1).

Q) solve the D. Eqn $\frac{dy}{dx} + 2y = e^x + x,\ y(0) = 1$

Sol) The given D.E is $\frac{dy}{dx} + 2y = e^x + x,\ y(0) = 1$

This is of the form $\frac{dy}{dx} + Py = Q$, where $P = 2$, $Q = e^x + x$.

Now I.F $= e^{\int P dx} = e^{2\int dx} = e^{2x}$

The general sol^n is given by

$y \cdot e^{2x} = \int (e^{x}+x) e^{2x} dx + c = \int (e^{3x} + xe^{2x}) dx + c$

$$y e^{2x} = \frac{e^{3x}}{3} + x\frac{e^{2x}}{2} - \frac{1}{4}e^{2x} + c$$

Given $y=1$ when $x=0$

$$1 e^{2(0)} = \frac{e^{0}}{3} + 0 - \frac{1}{4}e^{0} + c$$

$$1 = \frac{1}{3} - \frac{1}{4} + c$$

$$1 - \frac{1}{3} + \frac{1}{4} = c$$

$$\boxed{c = \frac{11}{12}}$$

Q) $\frac{dy}{dx} + \frac{y}{x} = x^3 - 3$

Sol $xy = \frac{x^5}{5} - \frac{3x^2}{2} + c$

Q) solve $(1-x^2)\frac{dy}{dx} + xy = ax$

Sol $y = a + c\sqrt{1-x^2}$

Q) solve $(x+1)\frac{dy}{dx} - y = e^{3x}(x+1)^2$

Sol $y = \left(\frac{1}{3}e^{3x} + c\right)(x+1)$

Q) solve $\frac{dy}{dx} - \frac{2y}{x+1} = (x+1)^3$

Sol $y = \frac{(x+1)^4}{2} + c(x+1)^2$

Q) $(1+y^2) + (x - e^{\tan^{-1}y})\frac{dy}{dx} = 0$

Sol $x e^{\tan^{-1}y} = \frac{e^{2\tan^{-1}y}}{2} + c$

Q) solve $(x+2y^3)\frac{dy}{dx} = y$

Sol $x = y^3 + cy$

Q) $\frac{dy}{dx} + \frac{y}{x\log x} = \frac{\sin 2x}{\log x}$

Sol $y\log x = -\frac{\cos 2x}{2} + c$

BERNOULLI'S EQUATIONS

An Equation is of the form $\frac{dy}{dx} + p(x)y = Q(x)y^n$ is called Bernaulli's Equation if p and Q are constants of functions of x alone and n is real constant.

Another form:-

An Equation of the form $\frac{dx}{dy} + P(y)x = Q(y)x^n$ where p and Q are constants or functions of y alone is also called Bernaullis Eqn.

PROBLEMS

Q) Solve $x\frac{dy}{dx} + y = x^3y^6$

Sol: Given $x\frac{dy}{dx} + y = x^3y^6$ — ①

Divide Eqn ① with x

$\frac{dy}{dx} + \frac{1}{x}y = x^2y^6$ — ②

which is Bernaullis Equation in y.

Divide Eqn ② with y^6

$y^{-6}\frac{dy}{dx} + \frac{1}{x}\cdot y^{-5} = x^2$ — ③

put $y^{-5} = t \Rightarrow -5y^{-6}\frac{dy}{dx} = \frac{dt}{dx} \Rightarrow y^{-6}\frac{dy}{dx} = \frac{-1}{5}\frac{dt}{dx}$

from ③ $\Rightarrow -\frac{1}{5}\frac{dt}{dx} + \frac{1}{x}\cdot t = x^2$ — ④

which is linear differential Equation in t.

where $p(x) = -\frac{5}{x}$, $Q(x) = -5x^2$

$I.F = e^{\int p\,dx} = e^{-5\int\frac{1}{x}dx} = e^{\log x^{-5}} = \frac{1}{x^5}$

$I.F = \frac{1}{x^5}$

The General solution of Eqn ④ is

$t(I.F) = \int Q(x)(I.F)\,dx + c$

$$y^{-5}\left(\frac{-1}{x^5}\right) = \int -5\cancel{x^2}\cdot\frac{1}{x^{\cancel{5}}}\,dx + c$$

$$\frac{-1}{x^5y^5} = -5\int x^{-3}\,dx + c$$

$$\frac{-1}{x^5y^5} = -5\frac{x^{-3+1}}{-3+1} + c$$

$$\frac{-1}{x^5y^5} = +5\frac{x^{-2}}{+2} + c$$

$$1 = \frac{+1}{2\cancel{x^2}}(\cancel{x^5}y^5) + c$$

$$1 = \frac{+5y^5x^3}{2} + c$$

$$2 = 5x^3y^5 + 2c \quad \text{which is required sol}^n$$

Q (4) of (1)

) Solve $\frac{dy}{dx}(x^2y^3+xy)=1$

Given $\frac{dy}{dx}(x^2y^3+xy)=1$

$$x^2y^3+xy = \frac{dx}{dy}$$

$$\frac{dx}{dy} - xy = x^2y^3 \quad \text{—(1)}$$

∴ which is Bernoulli's in 'x'.

Divide ~~wi~~ Eq^n (1) with x^2

$$\frac{1}{x^2}\frac{dx}{dy} - x^{-1}y = y^3$$

$$x^{-2}\frac{dx}{dy} - yx^{-1} = y^3 \quad \text{—(2)}$$

put $x^{-1} = t \Rightarrow (-1)x^{-1-1}\frac{dx}{dy} = \frac{dt}{dy} \Rightarrow -x^{-2}\frac{dx}{dy} = \frac{dt}{dy}$

from (2) $\Rightarrow -\frac{dt}{dy} - yt = y^3 \Rightarrow \frac{dt}{dy} + yt = -y^3$ —(3)

Eq^n (3) is linear D.Eq^n in 't'.

where $P = y \quad Q = -y^3.$

$$I.F = e^{\int P dy} = e^{\int y dy} = e^{y^2/2}$$

The General solution of Eq^n (3) is

$$t(I.F) = \int Q(y)(I.F)\,dy + c$$

$$\frac{1}{x}\left(e^{y^2/2}\right) = \int -y^3 e^{y^2/2} dy + c$$

$$\frac{e^{y^2/2}}{x} = -\int y^2 \cdot y\, e^{y^2/2} dy + c$$

put $\frac{y^2}{2} = t \Rightarrow y^2 = 2t$

$$\frac{2y}{2} dy = dt \Rightarrow y\,dy = dt$$

Now $$\frac{e^{y^2/2}}{x} = -\int 2t \cdot e^t dt + c$$

$$\frac{e^{y^2/2}}{x} = -2\int t \cdot e^t dt + c$$

$$\frac{e^{y^2/2}}{x} = -2\left[e^t(t-1)\right] + c$$

$$\frac{e^{y^2/2}}{x} = -2\left[e^{y^2/2}\left(\frac{y^2}{2} - 1\right)\right] + c$$

$$\frac{e^{y^2/2}}{x} = -\cancel{2}\left[e^{y^2/2}\left[\frac{y^2-2}{\cancel{2}}\right]\right] + c$$

$$\frac{e^{y^2/2}}{x} = -e^{y^2/2}\left[-2 + y^2\right] + c$$

$$\frac{e^{y^2/2}}{x} = e^{y^2/2}\left[y^2 - 2\right] + c$$

which is required sol^n of Eq^n (3) of (1).

Q) Solve $(1-x^2)\frac{dy}{dx}+xy=y^3\sin^{-1}x$

Sol: Given $(1-x^2)\frac{dy}{dx}+xy=y^3\sin^{-1}x$

Divide $1-x^2$ on both sides

$$\frac{dy}{dx}+\frac{x}{1-x^2}\cdot y=y^3\frac{\sin^{-1}x}{1-x^2} \quad -(1)$$

which Bernoulli's Equation in y.

divide y^3 with Eq^n (1).

$$y^{-3}\frac{dy}{dx}+\frac{x}{1-x^2}y^{-2}=\frac{\sin^{-1}x}{1-x^2} \quad -(2)$$

put $y^{-2}=t \Rightarrow -2y^{-2-1}\frac{dy}{dx}=\frac{dt}{dx} \Rightarrow y^{-3}\frac{dy}{dx}=-\frac{1}{2}\frac{dt}{dx}$

from-(3) $\Rightarrow -\frac{1}{2}\frac{dt}{dx}+\frac{x}{1-x^2}t=\frac{\sin^{-1}x}{1-x^2}$

$$\frac{dt}{dx}+\left(\frac{-2x}{1-x^2}\right)t=-\frac{2\sin^{-1}x}{1-x^2} \quad -(3)$$

which is linear differential equation in 't'.

where $P(x)=\frac{-2x}{1-x^2}$, $Q(x)=\frac{-2\sin^{-1}x}{1-x^2}$

$I.F=e^{\int P dx}=e^{\int\frac{-2x}{1-x^2}dx}=e^{\log(1-x^2)}=1-x^2$

$$I.F.=1-x^2$$

The general solution of Eq^n (3) is

$t(I.F)=\int Q(x)(I.F)\,dx+c$

$y^{-2}(1-x^2)=\int\frac{-2\sin^{-1}x}{\cancel{1-x^2}}\cancel{(1-x^2)}dx+c$

$=-2\int\sin^{-1}x\cdot 1\,dx+c$ [By part] $\left[\int uv=u\int v\,dx-\int(u'\int v\,dx)dx\right]$

$\frac{1-x^2}{y^2}=-2\left[x\sin^{-1}x+\sqrt{1-x^2}\right]+c$

$\Rightarrow 1-x^2=-2y^2\left[x\sin^{-1}x+\sqrt{1-x^2}\right]+cy^2$

which is G. Sol^n of Eq^n (3) of (1).

Q) $x\frac{dy}{dx} + y = x^2 y^6$

Q) solve $(x^3y^2 + xy)dx = dy$

sol: $\frac{1}{y} e^{x^2/2} = -2e^{x^2/2}\left[\frac{x^2}{2} - 1\right] + c$

Q) Solve $\frac{dy}{dx} + y\tan x = y^2 \sec x$

sol: $\frac{1}{y}\cos x = -x + c$

Q) Solve $(1-x^2)\frac{dy}{dx} + xy = y^3 \sin^{-1} x$

sol: $\frac{1-x^2}{y^2} = -2\left[x\sin^{-1}x + \sqrt{1-x^2}\right] + c$

Q) Solve $\frac{dy}{dx} + y\cos x = y^3 \sin 2x$

sol: $\frac{1}{y^2} = (1 + 2\sin x) + ce^{2\sin x}$

Q) solve $\cos x\, dy = y(\sin x - y)dx$

sol: $\frac{1}{y}(\sec x) = \tan x + c$ or $\sec x = y(\tan x + c)$

Q) solve the D.E $r\sin\theta - \cos\theta \frac{dr}{d\theta} = r^2$

sol: $\frac{1}{r} = \sin\theta + c\cos\theta$

Q) Solve $\frac{dy}{dx} + x\sin 2y = x^3 \cos^2 y$

sol: $(\tan y)e^{x^2} = \frac{1}{2}e^{x^2}(x^2 - 1) + c$

Q) Solve $\frac{dy}{dx} - \frac{\tan y}{1+x} = (1+x)e^x \sec y$

sol: $\sin y = (1+x)(e^x + c)$

Applications:

Orthogonal Trajectories:

Trajectory: A curve which cuts every member of a given family of curves is called Trajectory to that family of curves.

Orthogonal Trajectory: A curve which cuts every member of a given family of curves at right ang[les] is called "orthogonal Trajectory" to that family of cur[ves].

Working Rule: Orthogonal Trajectory in "cartesian form" (x

* Let $f(x,y,c)=0 \rightarrow ①$ be the given family of curves
* Differentiate Eqn ① w.r.t 'x' and Eliminate the arbitrary constant and form D.E. $f\left(x,y,\frac{dy}{dx}\right)=0$.
* For orthogonality replace $\frac{dy}{dx}$ with $-\frac{dx}{dy}$ (or) y' with $\frac{-1}{y'}$

  we get $f\left(x,y,\frac{dx}{dy}\right)=0$ — ③
* Solve Eqn ③ by using any one of the known methods.

Working Rule: Orthogonal Trajectory in polar form (r,θ)

* Let $f(r,\theta,c)=0 \rightarrow ①$ be the given family of curves
* Differentiate Eqn ① with respect to ①, and Eliminate the arbitrary constant and form D.E $f\left(r,\theta,\frac{dr}{d\theta}\right)=0$
* for orthogonality replace $\frac{dr}{d\theta}$ with $-r^2\frac{d\theta}{dr}$ (or) $-r^2\frac{d\theta}{dr}$

  we get $f\left(r,\theta,-r^2\frac{d\theta}{dr}\right) \rightarrow ③$
* Solve Eqn ③ by using any one of the known methods

Problem-1

find the Orthogonal Trajectories of the family of parabolas

$y^2 = 4ax$

Sol: Given that $y^2 = 4ax \to (1) \Rightarrow 4a = \frac{y^2}{x}$

Differentiate Eq (1) w.r.t. x

$$2y\frac{dy}{dx} = 4a \quad -(2)$$

Substitute 4a value in Eq (2)

$$2y\frac{dy}{dx} = \frac{y^2}{x}$$

$$2\frac{dy}{dx} = \frac{y}{x}$$

$$y = 2x\frac{dy}{dx} \quad -(3)$$

Replace $\frac{dy}{dx}$ with $-\frac{dx}{dy}$ in (3), we get

$$y = -2x\frac{dx}{dy}$$

$$y\,dy = -2x\,dx$$

Integrating on both sides

$$\int y\,dy = -2\int x\,dx + c$$

$$\frac{y^2}{2} = -\cancel{2}\frac{x^2}{\cancel{2}} + c$$

$$y^2 = -2x^2 + 2c$$

$$2x^2 + y^2 = 2c$$

This is our required orthogonal Trajectory.

(2) find the orthogonal Trajectories of the circles

$x^2 + (y-c)^2 = c^2$

Sol: Given eqn is $x^2 + (y-c)^2 = c^2 \quad -(1)$

Differentiating (1) w.r.t x, we get

$$2x + 2(y-c)\frac{dy}{dx} = 0$$

$$x + (y-c)\frac{dy}{dx} = 0$$

$$y - c = -x\frac{dx}{dy} \quad —(2)$$

$$c = y + x\frac{dx}{dy} \quad —(3)$$

from (1), (2) and (3), we get

$$x^2 + \left(-x\frac{dx}{dy}\right)^2 = \left(y + x\frac{dx}{dy}\right)^2$$

$$x^2 + \cancel{x^2\left(\frac{dx}{dy}\right)^2} = y^2 + \cancel{x^2\left(\frac{dx}{dy}\right)^2} + 2xy\frac{dx}{dy}$$

$$x^2 = y^2 + 2xy\frac{dx}{dy}$$

$$2xy\frac{dx}{dy} = x^2 - y^2$$

$$\frac{dy}{dx} = \frac{2xy}{x^2 - y^2}$$

Replace $\frac{dy}{dx}$ by $-\frac{dx}{dy}$, we get

$$-\frac{dx}{dy} = \frac{2xy}{x^2-y^2} \Rightarrow +\frac{dx}{dy} = +\frac{2xy}{(y^2-x^2)}$$

$$\Rightarrow \frac{dx}{dy} = \frac{2xy}{y^2-x^2}$$

$$\Rightarrow \frac{dy}{dx} = \frac{y^2-x^2}{2xy} \quad —(4)$$

which is homogeneous D.E

put $y = vx$ so that $\frac{dy}{dx} = v + x\frac{dv}{dx}$

from (4) $\Rightarrow$ $v + x\frac{dv}{dx} = \frac{v^2x^2 - x^2}{2xv.x} = \frac{\cancel{x^2}(v^2-1)}{2\cancel{x^2}v}$

$$v + x\frac{dv}{dx} = \frac{v^2-1}{2v} \Rightarrow x\frac{dv}{dx} = \frac{v^2-1}{2v} - v$$

$$\Rightarrow x\frac{dv}{dx} = \frac{v^2-1-2v^2}{2v}$$

$$\Rightarrow x\frac{dv}{dx} = \frac{-v^2-1}{2v}$$

$$\Rightarrow x\frac{dv}{dx} = \frac{-(1+v^2)}{2v}$$

$$\Rightarrow x\frac{dv}{dx} = -\frac{2v}{1+v^2}$$

$$\Rightarrow -x\frac{dv}{dx} = \frac{2v}{1+v^2}$$

$$\Rightarrow \frac{2v}{1+v^2}dv = -\frac{1}{x}dx + c$$

I.O.B.S

$$\Rightarrow \int\frac{2v}{1+v^2}dv + \int\frac{1}{x}dx + c$$

$$\Rightarrow \log(1+v^2) + \log x = \log c$$

$$\Rightarrow \log(1+v^2).x = \log c$$

$$\Rightarrow x(1+v^2) = c$$

$$\Rightarrow x\left(1+\frac{y^2}{x^2}\right) = c$$

$$\Rightarrow x + \frac{xy^2}{x^2} = c$$

$$\Rightarrow x^2+y^2 = cx$$

which is required Equation.

(8) find the Orthogonal Trajectory of the family of confocal conics $\frac{x^2}{a^2}+\frac{y^2}{a^2+\lambda}=1$, where λ is parameter

Sol: Given, the family of confocal conics is

$$\frac{x^2}{a^2}+\frac{y^2}{a^2+\lambda} = 1 \quad \text{—①}$$

Differentiating ① w.r.t 'x', we get

$$\frac{2x}{a^2} + \frac{2y}{a^2+\lambda}\frac{dy}{dx} = 0$$

$$\Rightarrow \frac{x}{a^2}+\frac{y}{a^2+\lambda}\frac{dy}{dx} = 0$$

$$\frac{y}{a^2+\lambda}\frac{dy}{dx} = -\frac{x}{a^2} \Rightarrow \frac{y^2}{a^2+\lambda} = \frac{-xy}{a^2}\cdot\frac{dx}{dy} \quad \text{—②}$$

Substitute ② in ①.

$$\frac{x^2}{a^2} + \frac{(-xy)}{a^2}\frac{dx}{dy} = 1$$

$$\frac{-xy}{a^2}\frac{dx}{dy} = 1 - \frac{x^2}{a^2}$$

$$\frac{-xy}{a^2}\frac{dx}{dy} = \frac{a^2-x^2}{a^2}$$

$$-xy\frac{dx}{dy} = a^2 - x^2 \quad \text{--- (3)}$$

Eq^n(3) is the Differential Equation of the Eq^n(1).

Replace $-\frac{dx}{dy}$ by $\frac{dy}{dx}$

$$xy\frac{dy}{dx} = a^2 - x^2$$

$$y\,dy = \frac{a^2-x^2}{x}dx$$

$$y\,dy = \frac{a^2}{x}dx - x\,dx$$

Integrating on both sides

$$\int y\,dy = a^2\int \frac{1}{x}dx - \int x\,dx + c$$

$$\frac{y^2}{2} = a^2\log x - \frac{x^2}{2} + \log c$$

$$\frac{y^2+x^2}{2} = a^2\log x + \log c$$

$$\therefore x^2+y^2 = 2a^2\log x + c$$

which is required orthogonal Trajectory of the Equation (1).

(4) Show that the System of confocal Conics $\frac{x^2}{a^2+\lambda} + \frac{y^2}{b^2+\lambda} = 1$, where λ is a parameter, is self orthogonal.

Sol Given Equation of the family of confocal Conics is

$$\frac{x^2}{a^2+\lambda} + \frac{y^2}{b^2+\lambda} = 1 \quad \text{— (i)}$$

Differentiating (1) with respect to 'x'.

$$\frac{2x}{a^2+\lambda} + \frac{2y}{b^2+\lambda}\frac{dy}{dx} = 0$$

$$\frac{x}{a^2+\lambda} + \frac{y}{b^2+\lambda}\frac{dy}{dx} = 0$$

Put $\frac{dy}{dx} = p$

$$\frac{x}{a^2+\lambda} + \frac{yp}{b^2+\lambda} = 0 \Rightarrow x(b^2+\lambda) + yp(a^2+\lambda) = 0$$

$$xb^2 + \lambda x + ypa^2 + yp\lambda = 0$$

$$\lambda(x+yp) + xb^2 + ypa^2 = 0$$

$$\lambda(x+yp) = -(xb^2+ypa^2)$$

$$\lambda = \frac{-(xb^2+ypa^2)}{x+yp} \quad \text{— (2)}$$

Substitute (2) in (1), we get

$$\frac{x^2}{a^2 - \frac{xb^2-ypa^2}{x+yp}} + \frac{y^2}{b^2 - \frac{xb^2-ypa^2}{x+yp}} = 1$$

$$\frac{x^2}{\frac{a^2x+a^2yp-xb^2-y\cancel{p}a^2}{x+yp}} + \frac{y^2}{\frac{\cancel{b^2x}+b^2yp-\cancel{xb^2}-ypa^2}{x+yp}} = 1$$

$$\frac{x^2}{\frac{x(a^2-b^2)}{x+yp}} + \frac{y^2}{\frac{yp(b^2-a^2)}{x+yp}} = 1$$

$$\frac{x^2\cdot(x+yp)}{x(a^2-b^2)} - \frac{y^2(x+yp)}{yp(a^2-b^2)} = 1$$

$$\frac{x(x+yp)}{a^2-b^2} - \frac{y(x+yp)}{p(a^2-b^2)} = 1$$

$$\frac{x+yp}{a^2-b^2}\left[x - \frac{y}{p}\right] = 1 \quad \text{--- (3)}$$

Eq^n (3) is the Differential Equation of Eq^n (1).

Replace p by $-\frac{1}{p}$, we get

$$\frac{x+y\left(-\frac{1}{p}\right)}{a^2-b^2}\left[x+yp\right] = 1$$

$$x - \frac{y}{p}\left[\frac{x+yp}{a^2-b^2}\right] = 1 \quad \text{--- (4)}$$

is same as the Eq^n (3).

$\therefore$ Eq^n (4) is same as the Eq^n (3). Self orthogonal family of curves.

Hence it is a Self orthogonal family of curves.

(5) find the orthogonal trajectories of the family of curves

$$x^{2/3} + y^{2/3} = a^{2/3}$$

Sol: $x^{4/3} - y^{4/3} = c$ is the Equation of the orthogonal trajectories of the given family of curve.

(6) find the orthogonal trajectories of family of circles.

$x^2+y^2+2fy+1=0$, f being the parameter

Sol: $x^2+y^2-cx-1=0$ is the required orthogonal trajectory.

Self-orthogonal: If each member of a given family of curves cuts every other member of the same family at right angles, then the given family of curves is said to be self-orthogonal.

(*) Orthogonal Trajectories in polar form:

Problems:

(1) Find the orthogonal trajectories of the family of cardioids $r = a(1-\cos\theta)$, where a is the parameter

Sol:- Given equation of the family of cardioids is

$$r = a(1-\cos\theta) \quad -(1)$$

Differentiating with respect to θ, we get

$$\frac{dr}{d\theta} = a\sin\theta \Rightarrow a = \frac{1}{\sin\theta}\frac{dr}{d\theta} \quad -(2)$$

Eliminating a from (1) and (2), we get

$$r = \frac{1}{\sin\theta}(1-\cos\theta)\frac{dr}{d\theta}$$

$$\frac{dr}{d\theta} = \frac{r\sin\theta}{1-\cos\theta} = \frac{\cancel{2}\, r\sin\theta/2\cos\theta/2}{\cancel{2}\sin^{2}\theta/2}$$

$$\Rightarrow \frac{dr}{d\theta} = r\cot\theta/2 \quad -(3)$$

This is the Differential Equation of family of curves.

Replace $\frac{dr}{d\theta}$ by $-r^2\frac{d\theta}{dr}$

$$-r^2\frac{d\theta}{dr} = r\cot\theta/2$$

$$\Rightarrow \frac{dr}{r} = -\tan\theta/2\, d\theta$$

Integrating on both sides

$$\int\frac{dr}{r} = -\int\tan\theta/2\, d\theta + c$$

$$\log r = 2\log\cos\theta/2 + \log c$$

$$\log r = 2\log\cos\theta/2 + \log c$$
$$\log r = \log\cos^2\theta/2 + \log c$$
$$\log r = \log(c\cdot\cos^2\theta/2)$$
$$\log r = \log(c(1+\cos\theta))$$
$$r = c(1+\cos\theta)$$

This is the Equation of family of orthogonal trajectories

Note:- family of cardioids is self-orthogonal.

② Find the Equation of the System of orthogonal trajectories of the confocal and co-axial parabolas $r = \frac{2a}{1+\cos\theta}$

Sol: Given family of confocal and coaxial parabolas.

$$r = \frac{2a}{1+\cos\theta} \quad -①$$

Differentiating ① w.r.t θ, $\frac{dr}{d\theta} = \frac{-2a}{(1+\cos\theta)^2}(0-\sin\theta$

$$\frac{dr}{d\theta} = \frac{-2a}{(1+\cos\theta)^2}(-\sin\theta)$$

$$\frac{dr}{d\theta} = \frac{2a\sin\theta}{(1+\cos\theta)^2} \quad -②$$

Dividing ② with ①, we get

$$\frac{dr}{d\theta}/r = \frac{\sin\theta}{(1+\cos\theta)^2}(1+\cos\theta)$$

$$\frac{1}{r}\frac{dr}{d\theta} = \frac{\sin\theta}{1+\cos\theta} \quad -③$$

Equation ③ differential equation of orthogonal trajectori of the parabola ①.

Replace $\frac{dr}{d\theta}$ by $-r^2 \frac{d\theta}{dr}$ in (3), we get

$$\frac{1}{r}\left(-r^2 \frac{d\theta}{dr}\right) = \frac{\sin\theta}{1+\cos\theta}$$

$$-r\frac{d\theta}{dr} = \frac{\cancel{2}\sin\theta/2\,\cos\theta/2}{\cancel{2}\cos^2\theta/2}$$

$$\frac{dr}{r} = -\cot(\theta/2)\,d\theta$$

Integrating on both sides, we get

$$\int \frac{1}{r}dr = -\int \cot(\theta/2)\,dr + c$$

$$\log r = -2\log\sin\left(\frac{\theta}{2}\right) + \log c$$

$$\log r = -\log\sin^2\theta/2 + \log c$$

$$\log r = \log\left(\frac{c}{\sin^2\theta/2}\right)$$

$$\therefore r = \frac{c}{1-\cos\theta}.$$

This is the required orthogonal trajectories of (1).

(3) Find the orthogonal trajectories of the family of curves

(i) $r^n = a^n\cos n\theta$ (ii) $r^n = a^n \sin n\theta$.

Sol: i) The given equation of the family of curves is

$$r^n = a^n\cos n\theta \quad \text{—(1)}$$

Taking logarithms on both sides,

$$n\log r = n\log a + \log\cos n\theta$$

Differentiating w.r.t θ on both sides

$$n\cdot\frac{1}{r}\frac{dr}{d\theta} = \frac{1}{\cos n\theta}\cdot \cancel{n}(-\sin n\theta)$$

$$\Rightarrow \frac{1}{r}\frac{dr}{d\theta} = -\tan n\theta$$

This is the differential equation of the family of curves.

Replace $\frac{dr}{d\theta}$ with $-r^2\frac{d\theta}{dr}$

$$\frac{1}{r} + r^{2}\frac{d\theta}{dr} = +\tan n\theta$$

$$r\frac{d\theta}{dr} = \tan n\theta$$

By Seperation, we get

$$\frac{1}{r}dr = \frac{1}{\tan n\theta}d\theta$$

$$\frac{1}{r}dr = \cot n\theta \, d\theta$$

Integrating on both sides, we get

$$\int\frac{1}{r}dr = \int\cot n\theta \, d\theta + c$$

$$\log r = \frac{1}{n}\log|\sin n\theta| + \log c$$

$$\log r = \frac{1}{n}\log\sin n\theta + \frac{1}{n}\log c$$

$$\log r^{n} = \log(c.\sin n\theta)$$

$$r^{n} = c\sin n\theta.$$

This is the Equation of the family of orthogonal trajectories.

(4) find the orthogonal trajectory of $r = a(\sec\theta + \tan\theta)$

Sol $r = ce^{-\sin\theta}$

which is the required orthogonal trajectory.

(5) find the orthogonal trajectory of the family of curves $r = 2a(\cos\theta + \sin\theta)$

Sol $r = c(\cos\theta - \sin\theta)$ is the required orthogonal trajectory.

(6) find the Equation of the System of orthogonal trajectories of the family of curves $r^n \sin n\theta = a^n$, where a is the parameter.

Sol: $\log r^n = \log(c^n \sec n\theta)$

$r^n = c^n \sec n\theta$ is the required orthogonal trajectory of family of given curve.

(7) find the orthogonal trajectories of the curve

$r = a(1+\cos\theta)$

Sol: $r = c(1-\cos\theta)$ is the required orthogonal trajectory of the given curve.

Newton's law of cooling

The rate of change of temparature of a body is proportional to the difference of the temparature of body and that of surrounding Medium.

i.e., $\frac{d\theta}{dt} \propto (\theta - \theta_0)$, where

→ θ is the temparature of a body

→ θ_0 is the temparature of air (room) or surrounding

→ t is time period.

$$\frac{d\theta}{dt} \propto (\theta - \theta_0)$$

$$\Rightarrow \frac{d\theta}{dt} = -K(\theta - \theta_0)$$

By separation

$$\Rightarrow \frac{1}{\theta - \theta_0} d\theta = -Kt\,dt$$

I.O.B.S

$$\int \frac{1}{\theta - \theta_0} d\theta = -K\int t\,dt + c \qquad \int \frac{1}{x-a}dx = \log|x-a|$$

$$\log(\theta - \theta_0) = -Kt + \log c$$

$$\log(\theta - \theta_0) - \log c = -Kt$$

$$\log\left(\frac{\theta - \theta_0}{c}\right) = -Kt$$

$$\theta - \theta_0 = ce^{-Kt}$$

$$\boxed{\theta = \theta_0 + ce^{-Kt}}$$

Problems :-

(1) The temparature of a body cools from $100^\circ c$ to $70^\circ c$ in 4 min at $30^\circ c$ temparature.

i) what is the temparature after 8 min

ii) when will be temparature be $40^\circ c$

sol: Given

$\theta = 100^\circ c, \; t=0, \; \theta_0 = 30^\circ$

$\theta = 70^\circ c, \; t=4, \; \theta_0 = 30^\circ.$

i) $\theta = ?, t = 8$ min

ii) $\theta = 40^\circ c, t = ?$

By Newton's law of cooling., we have

$$\theta = \theta_0 + ce^{-kt} \quad \text{--- (1)}$$

$$100 = 30 + ce^{-k(0)} \Rightarrow 100-30 = ce^0$$

$$\Rightarrow 70 = c$$

$$\Rightarrow \boxed{c = 70}$$

$$(1) \Rightarrow 70 = 30 + 70e^{-k4}$$

$$70-30 = 70e^{-4k} \Rightarrow 40 = 70e^{-4k}$$

$$\frac{40}{70} = e^{-4k}$$

$$\boxed{e^{-4k} = 4/7}$$

i) Given $\theta = ?$, $t = 8$ min

$$(1) \Rightarrow \theta = 30 + 70e^{-8k}$$

$$\theta = 30 + 70(e^{-4k})^2$$

$$\theta = 30 + 70\left(\frac{4}{7}\right)^2$$

$$\theta = 30 + 70 \times \frac{16}{49}$$

$$\theta = 52.85 \Rightarrow \theta = 53^\circ c \text{ approx.}$$

iii) $\theta = 40°C$, $t = ?$

$$① \Rightarrow 40 = 30 + 70e^{-Kt}$$

$$40-30 = 70e^{-Kt}$$

$$\frac{10}{70} = e^{-Kt} \Rightarrow e^{-Kt} = 1/7$$

$$\Rightarrow \left(e^{-4K}\right)^{\frac{t}{4}} = \frac{1}{7}$$

$$\Rightarrow \left(\frac{4}{7}\right)^{t/4} = \frac{1}{7}.$$

$$\Rightarrow \log\left[\left(\frac{4}{7}\right)\right]^{t/4} = \log\left(\frac{1}{7}\right)$$

$$\frac{t}{4}\left[\log 4 - \log 7\right] = \log 1 - \log 7$$

$$t = 4\left[\frac{\log 1 - \log 7}{\log 4 - \log 7}\right]$$

$$t = 13.908$$

$t = 14$ min (approx)

② A body is originally at $80°C$ and cools down to $60°C$ in 20 min if the temp of air is $40°C$

i) find the temp of the body after 40 min

ii) when will be the temp be $50°C$.

Sol: Given 1) $\theta = 80°C$ 2) $\theta = 60°$ $\theta_0 = 40°$
$t = 0$ $t = 20$

By Newton's law of cooling, we have

$$\theta = \theta_0 + ce^{-Kt} \quad — ①$$

1)

$$80 = 40 + ce^{-K(0)}$$

$$80 = 40 + c$$

$$\boxed{c = 40}$$

$$(1) \Rightarrow \quad \theta = \theta_0 + c e^{-Kt}$$

$$60^\circ = 40 + 40 e^{-K(20)}$$

$$60 - 40 = 40 e^{-20K}$$

$$20 = 40 e^{-20K}.$$

$$\frac{\cancel{20}}{4\cancel{0}} = e^{-20K} \Rightarrow \boxed{e^{-20K} = \frac{1}{2}}$$

i) Given $t = 40\,\text{min}$ $\theta = ?$, $\theta_0 = 40^\circ$.

$$\theta = \theta_0 + c e^{-Kt}$$

$$\theta = 40 + 40 e^{-K(40)}$$

$$\theta = 40 + 40 (e^{-20K})^2$$

$$\theta = 40 + 40 \left(\tfrac{1}{2}\right)^2$$

$$\theta = 40 + \overset{10}{\cancel{40}} \left(\tfrac{1}{\cancel{4}}\right)$$

$$\boxed{\theta = 50}$$

ii) Given $\theta = 50^\circ C$, $t = ?$

$$(1) \Rightarrow \theta = \theta_0 + c e^{-Kt}$$

$$50 = 40 + 40 e^{-Kt}$$

$$50 - 40 = 40 e^{-Kt}$$

$$\frac{1\cancel{0}}{4\cancel{0}} = e^{-Kt}$$

$$e^{-Kt} = \frac{1}{4}.$$

$$(e^{-20K})^{t/20} = \frac{1}{4}.$$

$$\left(\frac{1}{2}\right)^{t/20} = \frac{1}{4}$$

$$\frac{t}{20} \log\left(\frac{1}{2}\right) = \log\left(\frac{1}{4}\right)$$

$$\frac{t}{20} [\log 1 - \log 2] = \log 1 - \log 4$$

$$t = 20 \left[\frac{\log 1 - \log 4}{\log 1 - \log 2}\right] \Rightarrow t = 40\,\text{min}.$$

(3) The temparature of a body cools from 100°c to 70°c in 15min i) find the time temp will be 40°c, if the temp of air is 30°c.

ii) what is the temp after 20 min

Sol:

$c = 70$

$e^{-15K} = 4/7$

i) $t = 52.15$ min

ii) $\theta = 63.25°C$

(4) The temp of body drops from 100°c to 75°c in 10 min when the surrounding air is at 20°c temp

i) what will be it's temp after half an hour (30min)

ii) when will be the temp be 25°c

Sol:

$c = 80$

$e^{-10K} = \frac{55}{80} = \frac{11}{16}$

i) $\theta = 46°C$

ii) $t = 74$ min.

NATURAL LAW of GROWTH (or) DECAY

The rate of change of amount of chemical substance is proportional to amount of the substance available at that time.

Let N be the amount of substance

$$\frac{dN}{dt} \propto N$$

$$\Rightarrow \frac{dN}{dt} = KN$$

$$\Rightarrow \frac{dN}{N} = K dt.$$

$$\Rightarrow \int \frac{1}{N} dN = K \int dt + \log c$$

$$\Rightarrow \log N = Kt + \log c$$

$$\Rightarrow \log N - \log c = Kt$$

$$\Rightarrow \log\left(\frac{N}{c}\right) = Kt$$

$$\Rightarrow \frac{N}{c} = e^{Kt}$$

$$\Rightarrow \boxed{N = ce^{Kt}}$$

$\therefore$ of Growth $\Rightarrow N = ce^{Kt}$

of Decay $\Rightarrow N = ce^{-Kt}$.

Problems

① The number N of bacteria in culture grew at a rate proportional to N. The value of N initially 100 and increasing to 332 in one hour.

i) what was the value of N after $1\frac{1}{2}$ hours

A: Given bacteria in culture grew of a rate proportional to N.

Hence by Natural law of growth

$$N = ce^{Kt} \quad -①$$

1) Given $N = 100$
$t = 0$

$① \Rightarrow 100 = ce^{0}$

$\boxed{c = 100}$

2) Given $N = 332$, $t = 1hr$

$① \Rightarrow 332 = 100e^{K}$

$e^{K} = \frac{332}{100}$

3) Given $t = 1\frac{1}{2}$ hr $\Rightarrow t = \frac{3}{2}$, $N = ?$

$① \Rightarrow N = 100e^{\frac{3}{2}K}$

$N = 100(e^{K})^{3/2}$

$N = 100\left[\frac{332}{100}\right]^{3/2}$

$N = 100 \times \left(\frac{332}{100}\right)^{3/2}$

$N = 100 \times (3.3)^{3/2}$

$N = 100 \times 6.0$

$N = 605$ approx.

② The rate at which bacteria multiply is proportional to the instantaneous N number present if the original number doubles in two hours

1) when it will be tripled.

self let N_1 be the amount of the original substance

Hence by the law of natural growth

$N = ce^{Kt}$ — ①

i) Given $N = N_1$, $t = 0$

$① \Rightarrow N_1 = ce^{0}$

$\boxed{c = N_1}$

2) Given $N = 2N_1$, $t = 2hr$

$① \Rightarrow 2N_1 = N_1 e^{2K}$

$$\boxed{2 = e^{2K}}$$

3) Given $N = 3N_1$, $t = ?$

$① \Rightarrow 3N_1 = N_1 e^{Kt}$

$$e^{Kt} = 3$$

$$(e^{2K})^{t/2} = 3$$

$$2^{t/2} = 3$$

$$\log(2)^{t/2} = \log 3$$

$$\frac{t}{2}\log 2 = \log 3$$

$$t = 2\frac{\log 3}{\log 2} \Rightarrow t = 3hr \text{ (approx)}$$

3) If radio active carbon-14 has a half-life of 5750 years. what will remain of one gram after 3000 years.

Sol: let mass of radio active carbon-14 at any time be denoted by N. ; $N = c e^{-Kt}$.

1) Given $N = 1$, $t = 0$

$① \Rightarrow 1 = c e^{-0}$

$$\boxed{c = 1}$$

2) Given $N = \frac{1}{2}$, $t = 5750$ yrs

$① \Rightarrow \frac{1}{2} = (1)e^{-5750K}$

$$e^{-5750K} = \frac{1}{2}$$

3) Given $t = 3000$ yrs

$① \Rightarrow N = (1)e^{-3000K} \Rightarrow N = \left(e^{-5750K}\right)^{\frac{3000}{5750}}$

$N = \left(\frac{1}{2}\right)^{\frac{3000}{5750}} \Rightarrow N = 0.696$ gms.

(4) If 30% of a radio active Substance disappears in 10 days. How long will it take for 90% of it to disappear?

Sol: Let N_1 be the amount of the radio active Substance originally

Hence by law of Natural decay

$$N = ce^{-kt} \quad -(1)$$

1) Given $N = N_1$, $t = 0$.

$$(1) \Rightarrow N_1 = ce^0$$

$$\boxed{c = N_1}$$

2) Given $N = \frac{70 N_1}{100}$, $t = 10$ days

$$(1) \Rightarrow \frac{70 N_1}{100} = N_1 e^{-10K}$$

$$e^{-10K} = \frac{7}{10}$$

3) Given $N = \frac{10 N_1}{100}$, $t = ?$

$$(1) \Rightarrow \frac{10}{100} N_1 = N_1 e^{-Kt}$$

$$\frac{1}{10} = e^{-Kt}$$

$$\left(e^{-10K}\right)^{t/10} = \frac{1}{10}$$

$$\left(\frac{7}{10}\right)^{t/10} = \frac{1}{10}$$

$$\frac{t}{10} \log\left(\frac{7}{10}\right) = \log\left(\frac{1}{10}\right)$$

$$\frac{t}{10}\left[\log 7 - \log 10\right] = \log 1 - \log 10$$

$$t = 10\left[\frac{\log 1 - \log 10}{\log 7 - \log 10}\right] = 64.55 \text{ days.}$$

Electrical circuits

Electrical circuits made up of

i) voltage source which may be a battery (or) a generator

ii) Resistance, Inductance and Capacitance

Notations :

Symbol	Element	Unit
1. i	- current	Amphere
2. q	- Charge	Coulomb.
3. R	- Resistance	ohm
4. ~~I~~ L	- Inductance	Henry
5. C	- Capacitance	farad
6. E	- Electromotive force or voltage (Const V)	volt
7. ~~v.~~ E	- variable voltage (variable v)	volt.

Formulae: Let i be the current and q be the charge in the condenser plate at any time t.

Then $i = \frac{dq}{dt}$ (or) $q = \int i\,dt$

voltage drop across the resistance $R = Ri$

voltage drop across the inductance $L = L\frac{di}{dt} = L\frac{d^2q}{dt^2}$

voltage drop across the capacitance $C = \frac{q}{c}$

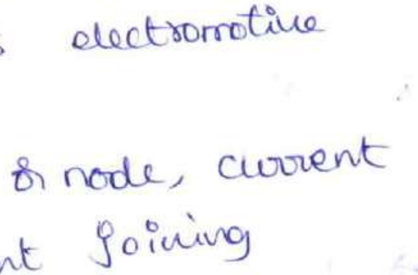
Kirchoff's law:

1. Voltage law: The algebraic sum of the voltage drops in each part of any closed circuit is equal to the resultant electromotive force (e.m.f) in that circuit.

2. Current law: At a junction or node, current comming is equal to the current going

L-R circuit: Let i be the current flowing in the circuit containing resistance R and inductance L in series with voltage source E, at anytime 't'.

By Kirchoff's voltage law, we have



$$Ri + L\frac{di}{dt} = E$$

$$\Rightarrow \frac{di}{dt} + \frac{R}{L}i = \frac{E}{L}$$

which is linear equation in i.

Here $P = \frac{R}{L}$, $Q = \frac{E}{L}$

$$I.F = e^{\int P dt} = e^{\int \frac{R}{L}dt} = e^{\frac{R}{L}t}$$

solution is $i(I.F) = \int Q(I.F)\,dt + c$

$$i\left(e^{\frac{R}{L}t}\right) = \int \frac{E}{L} e^{\frac{R}{L}t}\,dt + c = \frac{E}{L}\frac{e^{\frac{R}{L}t}}{\frac{R}{L}} + c$$

$$\therefore i\left(e^{\frac{R}{L}t}\right) = \frac{E}{R}e^{\frac{R}{L}t} + c$$

$\therefore \quad i = \frac{E}{R} + ce^{-\frac{R}{L}t}$

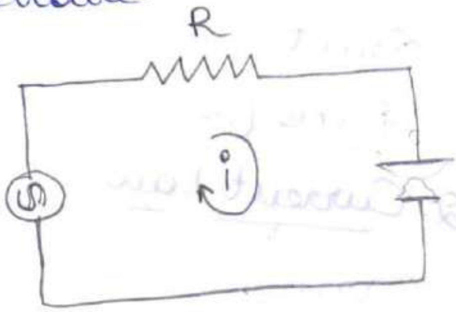
At $t=0$, $i=0$, $c = -\frac{E}{R}$

Hence $\quad i = \frac{E}{R}\left(1-e^{-\frac{R}{L}t}\right)$

C-R circuit :- Let i be the current flowing in the circuit containing resistance R and capacitance C in a series, with voltage source, E, at any time t.

The voltage drop across resistance is iR and capacitance is $\frac{q}{C}$

By Kirchoff's Voltage law, we have



$$Ri + \frac{q}{C} = E.$$

$$\Rightarrow R\frac{dq}{dt} + \frac{q}{C} = E \quad \left(\because i = \frac{dq}{dt}\right)$$

$$\Rightarrow \frac{dq}{dt} + \frac{q}{RC} = \frac{E}{R}$$

which is linear Eq^n in 'q'.

Here $P = \frac{1}{RC}$, $Q = \frac{E}{R}$

$$I.F = e^{\int P dt} = e^{\int \frac{1}{RC} dt} = e^{\frac{1}{RC}t}$$

Solution is $\quad q(I.F) = \int Q(I.F)dt + C_1$

$$q(I.F) = \int \frac{E}{R} e^{\frac{1}{RC}t} dt + C_1$$

$$= \frac{E}{R} \cdot \frac{e^{\frac{1}{RC}t}}{\frac{1}{RC}} + C_1$$

$$= EC\, e^{\frac{1}{RC}t} + C_1$$

$$q\left(e^{\frac{1}{RC}t}\right) = EC\, e^{\frac{1}{RC}t} + C_1$$

$$q = EC + C_1 e^{-\frac{1}{RC}t}$$

when $t=0$, $q=0$

Now $\quad 0 = EC + C_1 \Rightarrow C_1 = -EC$

$i = 10e^{-0.05t}$ is the required current in the circuit.

(4) A voltage Ee^{-at} is applied to a circuit containing inductance L and resistance R, then find the current in the circuit, if initially there is no current in the circuit.

Sol: The differential equation of LR circuit is

$$\frac{di}{dt} + \frac{R}{L} i = \frac{E}{L} \quad -(1)$$

Here $E = Ee^{-at}$

$$\frac{di}{dt} + \frac{R}{L} i = \frac{Ee^{-at}}{L}$$

which is linear equation in i

Here $P = R/L$, $Q = \frac{Ee^{-at}}{L}$

$$I.F = e^{\int Pdt} = e^{\int R/L\, dt} = e^{\frac{R}{L}t}$$

solution is $i(I.F) = \int Q(I.F)\,dt + c$

$$i e^{R/L\, t} = \int \frac{Ee^{-at}}{L} e^{\frac{R}{L}t}\, dt + c$$

$$i e^{(R/L)t} = \frac{E}{L}\int e^{t(-a+\frac{R}{L})}\, dt + c$$

$$i e^{(R/L)t} = \frac{E}{L}\int e^{t(\frac{R}{L}-a)}\, dt + c$$

$$i e^{(R/L)t} = \frac{E}{L}\, \frac{e^{t(\frac{R}{L}-a)}}{\frac{R}{L}-a} + c$$

$$i e^{(R/L)t} = \frac{E}{R-aL}\, e^{t(R/L)-at} + c$$

$$i = \frac{E}{R-aL} e^{-at} + ce^{-(R/L)t} \quad -(2)$$

Given $i=0$ when $t=0$, from (2)

$$0 = \frac{E}{R-aL} + c \Rightarrow c = -\frac{E}{R-aL}$$

from (2)

$$\therefore i = \frac{E}{R-aL}\left(e^{-at}\right) - \frac{E}{R-aL} e^{(R/L)t}$$

$\therefore i = \frac{E}{R-aL}\left[e^{-at} - e^{-R/L}\right]$ is the required current in circuit

⑥ find the charge and current in CR-circuit if $R = 10$ ohms, $C = 2$ farad and $E = 100$ volts with $q(0)=0$

The differential equation of CR-circuit is

8/5

$$\frac{dq}{dt} + \frac{1}{RC}q = \frac{E}{R} \rightarrow ①$$

Given $R = 10$ ohms, $C = 2$ farad and $E = 100$ volts

Substituting these values in ①, we get

$$\frac{dq}{dt} + \frac{q}{10 \times 2} = \frac{100}{10}$$

$$\frac{dq}{dt} + \frac{q}{20} = 10 \quad — ②$$

which is linear equation in q.

Here $P = \frac{1}{20}$, $Q = 10$.

$$I.F = e^{\int P dt} = e^{\int \frac{1}{20} dt} = e^{\frac{1}{20}t}.$$

Solution is $q\,(I.F) = \int Q\,(I.F)\,dt + c$

$$q\,(e^{\frac{1}{20}t}) = 10\int e^{\frac{1}{20}t}\,dt + c$$

$$q\,e^{t/20} = 10\,\frac{e^{t/20}}{\frac{1}{20}} + c$$

$$q\,e^{t/20} = 200\,e^{t/20} + c$$

$$q = 200 + c\,e^{-t/20} \quad — ③$$

Given $q(0) = 0 \Rightarrow 200 + c\,e^{-\frac{1}{20}(0)} = 0$

$$200 + c = 0$$

$$c = -200$$

from ③ $\Rightarrow q = 200 - 200\,e^{-t/20}$

$$q = 200\left(1 - e^{-t/20}\right)$$

current $i = \frac{dq}{dt} = -200\,e^{-\frac{1}{20}t}\left(-\frac{1}{20}\right) = 10\,e^{-0.05t}$

solution is

$i(I.F) = \int Q(I.F)\,dt + c$

$i(e^{5t}) = \int 10\cos 5t\, e^{5t}\,dt + c$

$i(e^{5t}) = 10\int e^{5t}\cos 5t\,dt + c$

$$\int e^{ax}\cos bx\,dx = \frac{e^{ax}}{a^2+b^2}\left[a\cos bx + b\sin bx\right] + c$$

$i\,e^{5t} = 10\left[\frac{e^{5t}}{5^2+5^2}\left(5\cos 5t + 5\sin 5t\right)\right] + c$

$i\,e^{5t} = 10\left[\left[\frac{e^{5t}}{25+25}\right]\left(5\cos 5t + 5\sin 5t\right)\right] + c$

$i = \frac{10}{e^{5t}}\,\frac{e^{5t}}{50}\left(5\cos 5t + 5\sin 5t\right) + ce^{-5t}$

$i = \frac{5}{5}\cos 5t + \frac{5}{5}\sin 5t + ce^{-5t}$

$i = \cos 5t + \sin 5t + ce^{-5t}$ — (3)

Given $i = 0$, when $t = 0$

$0 = 1 + c \Rightarrow c = -1$

from (3) $\Rightarrow$

$\therefore i = \cos 5t + \sin 5t + ce^{-5t}$

$[i = \cos(0) + \sin(0) + ce^{0}$

$i = 1 + 0 + (-1)$

$i = 0]$

$i = \cos 5t + \sin 5t - e^{-5t}$ is the required current.

$$i = 10 + ce^{-5t} \quad \text{—— (2)}$$

Given $i = 0$, when $t = 0$

substitute these values in (2)

$$0 = 10 + ce^{0}$$

$$c = -10$$

from (2) $\Rightarrow$ $i = 10 - 10e^{-5t}$

$i = 10(1 - e^{-5t})$ is the required current in the circuit.

5) If a voltage of $20\cos 5t$ is applied to a series circuit consisting of 10 ohm resistor and 2 henry inductor, determine the current at any time t.

Sol: The differential equation of LR-circuit is

$$L\frac{di}{dt} + Ri = E$$

$$\frac{di}{dt} + \frac{R}{L}i = \frac{E}{L} \quad \text{—— (1)}$$

Given $E = 20\cos 5t$, $R = 10$ ohms, $L = 2$ henry

Substituting these values in (1), we get

$$\frac{di}{dt} + \frac{10}{2}i = \frac{20\cos 5t}{2}$$

$$\frac{di}{dt} + 5i = 10\cos 5t \quad \text{—— (2)}$$

Eq (2) is the linear equation in 'i'.

Here $P = 5$, $Q = 10\cos 5t$

$$I.F = e^{\int P\,dt} = e^{\int 5\,dt} = e^{5t}$$

$$i = \frac{1}{5} + e^{-200t} \quad \text{---} (3)$$

when $t=0$, $i=0$

from (3) $\Rightarrow$ $0 = \frac{1}{5} + c \Rightarrow c = -1/5$

$$\therefore \; i = \frac{1}{5} - \frac{1}{5} e^{-200t}$$

$i = \frac{1}{5}(1 - e^{-200t})$ is the required current.

4) A generator having e.m.f 100 volts is Connected in series with a 10 ohm resistor and an inductor of 2 henries. If the switch is closed at a time $t=0$, find the current at time $t>0$

Sol: Differential equation of the given circuit is

$$Ri + L\frac{di}{dt} = E$$

$$\frac{di}{dt} + \frac{R}{L} i = \frac{E}{L} \quad \text{---} (1)$$

Given $R = 10$ ohm, $L = 2$ henries and $E = 100$ volts

Substitute these values in (1), we get

$$\frac{di}{dt} + \frac{10}{2} i = \frac{100}{2}$$

which is linear Equation in i.

Here $P = 5$, $Q = 50$

$$I.F = e^{\int P dt} = e^{\int 5 dt} = e^{5t}$$

Solution is $i(I.F) = \int Q(I.F)\,dt + C$

$$i(e^{5t}) = \int 50(e^{5t})\,dt + C$$

$$i e^{5t} = 50 \frac{e^{5t}}{5} + C$$

$$i e^{5t} = 10 e^{5t} + C$$

$$0 = \frac{-2}{29} + c$$

$$c = \frac{2}{29}$$

$$q = \frac{1}{29}\left[5\sin 2t - 2\cos 2t\right] + \frac{2}{29}e^{-5t}$$

$$\therefore \text{ current } i = \frac{dq}{dt} = \frac{1}{29}\left[10\cos 2t + 4\sin 2t\right] - \frac{10}{29}e^{-5t}.$$

(3) A resistance of 100 ohms, an inductance of 0.5 Henry is connected in series with a battery of 20 volts. find the current in the circuit, if initially there is no current in the circuit.

Sol: The differential equation of the given LR-circuit is

$$Ri + L\frac{di}{dt} = E$$

$$L\frac{di}{dt} + Ri = E$$

$$\frac{di}{dt} + \frac{R}{L}i = \frac{E}{L} \quad \text{--- (1)}$$

Given $R = 100$ ohms, $L = 0.5$ henry, $E = 20$ volts.

$$\therefore \frac{di}{dt} + \frac{100}{0.5}i = \frac{20}{0.5}$$

$$\frac{di}{dt} + 200i = 40.$$

which is a linear equation in i

Here $P = 200$, $Q = 40$

$$I.F = e^{\int P\,dt} = e^{\int 200\,dt} = e^{200t}$$

Solution is

$$i(I.F) = \int Q(I.F)\,dt + c$$

$$i e^{200t} = \int 40\left(e^{200t}\right)dt + c$$

$$ie^{200t} = \cancel{40}\,\frac{e^{200t}}{\cancel{200}_{5}} + c$$

$$i = \frac{1}{5}\frac{e^{200t}}{e^{200t}} + c e^{-200t} \quad \text{--- (2)}$$

$$0 = \frac{1}{626}(-1) + c$$

$$c = \frac{1}{626}.$$

Hence $i = \frac{1}{626}[25\sin t - \cos t] + \frac{1}{626}e^{-25t}$ is the required current in the circuit.

② find the charge and current in RC-circuit if $R = 20$ ohms, $C = 0.01$ farad and $E(t) = 20\sin 2t$ with $q(0) = 0$.

Sol: The differential Equation of the RC-circuit is $\frac{dq}{dt} + \frac{q}{RC} = \frac{E}{R}$

Given $R = 20$ ohms, $C = 0.01$ farad $E = 20\sin 2t$

$$\therefore \frac{dq}{dt} + \frac{q}{20 \times 0.01} = \frac{20\sin 2t}{20}$$

$$\Rightarrow \frac{dq}{dt} + 5q = \sin 2t$$

which is linear Equation in q.

Here $P = 5$, $Q = \sin 2t$.

$$I.F = e^{\int P dt} = e^{\int 5 dt} = e^{5t}$$

solution is $q(I.F) = \int Q(I.F)\,dt + c$

$$q(e^{5t}) = \int \sin 2t\, e^{5t}\,dt + c$$

$$q(e^{5t}) = \frac{e^{5t}}{25+4}[5\sin 2t - 2\cos 2t] + c$$

$$q e^{5t} = \frac{e^{5t}}{29}[5\sin 2t - 2\cos 2t] + c$$

$$q = \frac{1}{29}[5\sin 2t - 2\cos 2t] + ce^{-5t}$$

when $q = 0$ where $t = 0$, $0 = \frac{1}{29}[0 - 2] + c$

$$0 = -\frac{2}{29} + c$$

$$\therefore q = EC\left(1 - e^{-\frac{1}{RC}t}\right)$$

Now the current in the circuit is $i = \frac{dq}{dt}$

$$i = \frac{dq}{dt} = EC\frac{1}{RC}e^{-\frac{1}{RC}t} = \frac{E}{R}e^{-\frac{1}{RC}t}$$

(1) An RL circuit has an Emf given (in volts) by $4\sin t$, a resistance of 100 ohms an inductance of 4 henries with no initial current. find the current at any time.

Ans The differential equation of the RL-circuit is

$$L\frac{di}{dt} + Ri = E$$

$$\Rightarrow \frac{di}{dt} + \frac{Ri}{L} = \frac{E}{L}$$

Given $R = 100$ ohms, $L = 4$ henries and $E = 4\sin t$

$$\therefore \frac{di}{dt} + \frac{\overset{25}{\cancel{100}}}{\cancel{4}}i = \frac{\cancel{4}\sin t}{\cancel{4}}$$

$$\frac{di}{dt} + 25i = \sin t.$$

$$I.F = e^{\int P\,dt} = e^{\int 25\,dt} = e^{25t}$$

The solution is $i(I.F) = \int Q(I.F)\,dt + c$

$$i(e^{25t}) = \int \sin t\, e^{25t}\,dt + c$$

$$= \frac{e^{25t}}{625+1}(25\sin t - \cos t) + c$$

$$\left[\int e^{ax}\sin bx\,dx = \frac{e^{ax}}{a^2+b^2}\left[a\sin bx - b\cos bx\right]\right]$$

$$\therefore i = \frac{1}{626}\left[25\sin t - \cos t\right] + ce^{-25t}$$

Given $i = 0$ where $t = 0$.

$$0 = \frac{1}{626}\left[25\sin(0) - \cos(0)\right] + ce^{0}.$$

Linear Differential Equations of Second and Higher Order

A linear differential equation with constant coefficients is of the form

$$\frac{d^n y}{dx^n} + a_1 \frac{d^{n-1}y}{dx^{n-1}} + a_2 \frac{d^{n-2}y}{dx^{n-2}} + \cdots + a_n y = X \rightarrow (1), \text{ where}$$

$a_1, a_2, a_3, \cdots a_n$ are all constants and X is a function of x only. Let $D = \frac{d}{dx}$ then the equation (1) can be written as $(D^n + a_1 D^{n-1} + a_2 D^{n-2} + \cdots + a_{n-1} D + a_n) y = X$

i.e $f(D) y = X$, where $f(D) = D^n + a_1 D^{n-1} + a_2 D^{n-2} + \cdots + a_{n-1} D + a_n$. is a polynomial in D.

* The Complete solution of $f(D)y = X$ is $y = C.F + P.I$.
Thus, to solve the equation (1) first we have to find the complementary function and then particular integral.

* Replace 'D' by 'm' in $f(D)$ and equate to zero i.e $f(m) = 0$ is called an Auxiliary Equation (A.E)

* To find the C.F depending on the roots of the A.E. Three cases are arise.

(1) The roots $m_1, m_2, m_3, \cdots$ are real and distinct.

C.F is $y_c = c_1 e^{m_1 x} + c_2 e^{m_2 x} + c_3 e^{m_3 x} + \cdots$

(2) The roots $m_1, m_2, m_3, \cdots$ are real and equal

C.F is $y_c = (c_1 + c_2 x + c_3 x^2 + \cdots) e^{m_1 x}$.

(3) The roots m_1 and m_2 are complex conjugate remaining distinct.

i.e $m_1 = \alpha + i\beta$, $m_2 = \alpha - i\beta$

C.F is $y_c = e^{\alpha x}(c_1 \cos\beta x + c_2 \sin\beta x) + c_3 e^{m_3 x} + c_4 e^{m_4 x} + \ldots$

Where $c_1, c_2, c_3, \ldots$ are arbitrary constants.

Particular Integrals

There are no arbitrary constants..

$$P.I = \frac{1}{f(D)} X.$$

* $\frac{1}{D} X = \int X\, dx.$

* $\frac{1}{D-a} X = e^{ax} \int X e^{-ax} dx.$

* $\frac{1}{D+a} X = e^{-ax} \int X e^{ax} dx.$

1. If $X = e^{ax}$ then $P.I = \frac{1}{f(D)} e^{ax} = \begin{cases} \frac{1}{f(a)} e^{ax}, & f(a) \neq 0 \\ \frac{x}{f'(a)} e^{ax} & f(a) = 0,\ f'(a) \neq 0 \\ \frac{x^2}{f''(a)} e^{ax} & f'(a) = 0,\ f''(a) \neq 0 \end{cases}$

and so on

2. If $X = \sin ax$ (or) $\cos ax$ then $P.I = \frac{1}{f(D)} \sin ax$

$$= \begin{cases} \frac{1}{f(-a^2)} \sin ax & \text{if } f(-a^2) \neq 0 \quad \text{Replace } D^2 = -a^2 \\ \frac{x}{f'(-a^2)} \sin ax & \text{if } f(-a^2) = 0,\ f'(-a^2) \neq 0 \quad \text{failure case} \\ \frac{x^2}{f''(-a^2)} \sin ax & \text{if } f'(-a^2) = 0,\ f''(-a^2) \neq 0 \end{cases}$$

3. If $X = x^m$, where m is a positive integer

then $P.I = \frac{1}{f(D)} x^m.$

Reduce $\frac{1}{f(D)}$ to the form $\frac{1}{1+\phi(D)}$ by taking out the lowest degree term from $f(D)$.

Now write $\frac{1}{f(D)}$ as $[1+\phi(D)]^{-1}$ and expand it in ascending powers of D regarding D as a number by Binomial theorem upto the term containing D^k. Then operate on x^k with each term of the expansion $[1+\phi(D)]^{-1}$.

<u>Note</u>: use the formula $(1+D)^{-1} = 1 - D + D^2 - D^3 + \cdots\cdots$

$(1-D)^{-1} = 1 + D + D^2 + D^3 + \cdots\cdots$

for the expansion of $[1+\phi(D)]^{-1}$.

4. If $X = e^{ax}V$ where V is any function of x then

$$P.I = \frac{1}{f(D)}X = \frac{1}{f(D)}e^{ax}V = e^{ax}\frac{1}{f(D+a)}V.$$

5. If $X = xV$ where V is any function of x then

$$P.I = \frac{1}{f(D)}(xV) = x\frac{1}{f(D)}V - \frac{f'(D)}{[f(D)]^2}V.$$

This method can be applied only when the degree of x is 1.

Exercises

1. Solve $(D^2+4)y = e^x + \sin 2x$.

<u>Sol</u>: Given equation is $(D^2+4)y = e^x + \sin 2x$.

Here, $f(D) = D^2+4$

$X = e^x + \sin 2x$

To find the Complementary function :—

The Auxiliary equation is $f(m) = 0$.

$\Rightarrow m^2+4=0 \Rightarrow m^2=-4 \Rightarrow m=\pm 2i$.

The roots are Complex Conjugate.

$\therefore$ C.F is $y_c = c_1\cos 2x + c_2 \sin 2x$, where c_1 and c_2 are arbitrary Constants.

Next to find the (Complemens) particular Integral:

$$P.I = \frac{1}{f(D)} X = \frac{1}{D^2+4}(e^x + \sin 2x)$$

$$= \frac{1}{D^2+4} e^x + \frac{1}{D^2+4}\sin 2x$$

$$= P.I_1 + P.I_2.$$

Now, $P.I_1 = \frac{1}{D^2+4} e^x = \frac{1}{1^2+4} e^x = \frac{1}{5} e^x$.

$P.I_2 = \frac{1}{D^2+4}\sin 2x = \frac{1}{-2^2+4}\sin 2x$ failure case

$$= \frac{x}{2D}\sin 2x = \frac{x}{2}\int \sin 2x\, dx$$

$$= -\frac{x}{2}\frac{\cos 2x}{2} = -\frac{x\cos 2x}{4}$$

$\therefore P.I = P.I_1 + P.I_2 = \frac{1}{5}e^x - \frac{x\cos 2x}{4}$.

Hence the general solution of the given equation is $y = C.F + P.I = c_1\cos 2x + c_2\sin 2x + \frac{1}{5}e^x - \frac{x\cos 2x}{4}$

2. Solve $(D^2-3D+2)y = \cosh x$.

Sol: Given equation is $(D^2-3D+2)y = \cosh x$

Here, $f(D) = D^2-3D+2$, $X = \cosh x = \frac{e^x+e^{-x}}{2}$

To find the Complementary function :-

The Auxiliary equation is $f(m)=0$.

$$\Rightarrow m^2-3m+2=0$$

$$\Rightarrow m^2-2m-m+2=0$$

$$\Rightarrow m(m-2)-1(m-2)=0.$$

$$\Rightarrow (m-1)(m-2)=0.$$

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$\Rightarrow m = 1, 2.$

The roots are real and distinct.

$\therefore$ C.F is $y_c = c_1 e^{x} + c_2 e^{2x}$, where c_1 and c_2 are arbitrary constants.

Next to find the particular Integral:

$$P.I = \frac{1}{f(D)} X = \frac{1}{D^2-3D+2} \cosh x = \frac{1}{D^2-3D+2}\left(\frac{e^{x}+e^{-x}}{2}\right)$$

$$= \frac{1}{2}\frac{1}{D^2-3D+2} e^{x} + \frac{1}{2}\frac{1}{D^2-3D+2} e^{-x} = P.I_1 + P.I_2.$$

Now, $P.I_1 = \frac{1}{2}\frac{1}{D^2-3D+2} e^{x} = \frac{1}{2}\frac{1}{1^2-3(1)+2} e^{x}$ failure case

$$= \frac{1}{2}\frac{x}{2D-3} e^{x} = \frac{1}{2}\frac{x}{2-3} e^{x} = -\frac{1}{2} x e^{x}.$$

$$P.I_2 = \frac{1}{2}\frac{1}{D^2-3D+2} e^{-x} = \frac{1}{2}\frac{1}{(-1)^2-3(-1)+2} e^{-x} = \frac{1}{2}\frac{1}{6} e^{-x}$$

$$= \frac{1}{12} e^{-x}.$$

$$\therefore P.I = P.I_1 + P.I_2$$

$$= -\frac{1}{2} x e^{x} + \frac{1}{12} e^{-x}.$$

Hence the complete solution is $y = y_c + y_p$

i.e $y = c_1 e^{x} + c_2 e^{2x} - \frac{1}{2} x e^{x} + \frac{1}{12} e^{-x}.$

3. Solve $(D^3 - 6D^2 + 11D - 6) y = e^{-2x} + e^{-3x}$

Sol: Given equation is $(D^3 - 6D^2 + 11D - 6) y = e^{-2x} + e^{-3x}$

Here, $f(D) = D^3 - 6D^2 + 11D - 6$

$X = e^{-2x} + e^{-3x}.$

To find the Complementary function:

The Auxiliary equation is $f(m) = 0$

$$\Rightarrow m^3 - 6m^2 + 11m - 6 = 0.$$

$$\begin{array}{r|rrrr} m=1 & 1 & -6 & 11 & -6 \\ & 0 & 1 & -5 & 6 \\ \hline & 1 & -5 & 6 & \lfloor 0 \end{array}$$

($\because$ Sum of the coefficients is zero, 1 is a root)

$m^2-5m+6=0$

$\Rightarrow m^2-3m-2m+6=0$

$\Rightarrow m(m-3)-2(m-3)=0$

$\Rightarrow (m-2)(m-3)=0$

$\Rightarrow m=2,3$

$\therefore m=1,2,3$

The roots are real and distinct.

C.F, $y_c = c_1e^{x}+c_2e^{2x}+c_3e^{3x}$, where c_1, c_2 and c_3 are arbitrary Constants.

Next to find the <u>particular Integral</u>:

$$P.I = \frac{1}{f(D)}X = \frac{1}{D^3-6D^2+11D-6}\left(e^{-2x}+e^{-3x}\right).$$

$$= \frac{1}{D^3-6D^2+11D-6}e^{-2x} + \frac{1}{D^3-6D^2+11D-6}e^{-3x}$$

$$= \frac{1}{(-2)^3-6(-2)^2+11(-2)-6}e^{-2x} + \frac{1}{(-3)^3-6(-3)^2+11(-3)-6}e^{-3x}.$$

$$= \frac{1}{-8-24-22-6}e^{-2x} + \frac{1}{-27-36-33-6}e^{-3x}$$

$$= -\frac{1}{60}e^{-2x} - \frac{1}{102}e^{-3x}.$$

Hence the complete solution of the given equation is

$$y = y_c + y_p = c_1e^{x}+c_2e^{2x}+c_3e^{3x}-\frac{1}{60}e^{-2x}-\frac{1}{102}e^{-3x}$$

4. Solve $(D^2-4D+2)y = x^2e^{2x}$.

<u>Sol:</u> Given equation is $(D^2-4D+2)y = x^2e^{2x}$.

Here, $f(D) = D^2-4D+2$, $X = x^2e^{2x}$.

To find <u>the C.F</u>:

The Auxiliary equation is $f(m)=0$.

$\Rightarrow m^2-4m+2=0$.

$$\Rightarrow m = \frac{4 \pm \sqrt{16-8}}{2} = \frac{4 \pm \sqrt{8}}{2} = 2 \pm \sqrt{2}$$

The roots are real and distinct.

C.F, $y_c = c_1 e^{(2-\sqrt{2})x} + c_2 e^{(2+\sqrt{2})x}$, where c_1 and c_2 are arbitrary constants.

<u>Next to find P.I:</u>

$$P.I = \frac{1}{f(D)} X = \frac{1}{D^2-4D+2} x^2 e^{2x}$$

$$= e^{2x} \frac{1}{(D+2)^2 - 4(D+2) + 2} x^2 \qquad \left[\because \frac{1}{f(D)} e^{ax} V = e^{ax} \frac{1}{f(D+a)} V\right]$$

$$= e^{2x} \frac{1}{D^2 + \cancel{4D} + 4 - \cancel{4D} - 8 + 2} x^2$$

$$= e^{2x} \frac{1}{D^2 - 2} x^2 = e^{2x} \frac{1}{-2\left(1 - \frac{D^2}{2}\right)} x^2$$

$$= e^{2x} \frac{1}{-2} \left(1 - \frac{D^2}{2}\right)^{-1} (x^2)$$

$$= -\frac{e^{2x}}{2} \left(1 + \frac{D^2}{2} + \left(\frac{D^2}{2}\right)^2 + \left(\frac{D^2}{2}\right)^3 + \cdots\cdots\right)(x^2)$$

$$= -\frac{e^{2x}}{2}\left(1 + \frac{D^2}{2}\right)(x^2) = -\frac{e^{2x}}{2}(x^2+1)$$

$D^2(x^2)$
$D(2x)$
2

Hence the complete solution of the given equation is

$$y = y_c + y_p = c_1 e^{(2-\sqrt{2})x} + c_2 e^{(2+\sqrt{2})x} - \frac{e^{2x}}{2}(x^2+1).$$

(5) Solve $(D^3-1)y = \cos(2x-1) + x^2 e^{-x}$

<u>Sol:</u> Given equation is $(D^3+1)y = \cos(2x-1) + x^2 e^{-x}$.

Here, $f(D) = D^3 - 1$

$X = \cos(2x-1) + x^2 e^{-x}$.

To find the complementary function:

The Auxiliary equation is $f(m) = 0$

$\Rightarrow m^3 + 1 = 0$

$\Rightarrow (m+1)(m^2-m+1) = 0$ $\qquad a^3+b^3 = (a+b)(a^2-ab+b^2)$

$\Rightarrow m = -1, \quad m = \frac{1 \pm \sqrt{1-4}}{2} = \frac{1 \pm \sqrt{-3}}{2} = \frac{1 \pm \sqrt{3}\,i}{2}$

$\therefore y_c = c_1 e^{-x} + e^{\frac{1}{2}x}\left(c_2 \cos\frac{\sqrt{3}}{2}x + c_3 \sin\frac{\sqrt{3}}{2}x \right)$, where

c_1, c_2 and c_3 are arbitrary constants.

Next to find the particular solution:

$$P.I = \frac{1}{f(D)} X$$

$$= \frac{1}{D^3+1} \cos(2x-1) + x^2 e^{-x}$$

$$= \frac{1}{D^3+1} \cos(2x-1) + \frac{1}{D^3+1} x^2 e^{-x} = P.I_1 + P.I_2$$

Now, $\frac{1}{D^3+1} \cos(2x-1) = \frac{1}{D^2(D)+1} \cos(2x-1)$ $\qquad D^2 = -2^2$

$$= \frac{1}{-2^2(D)+1} \cos(2x-1)$$

$$= \frac{1}{-4D+1} \cos(2x-1) = \frac{1+4D}{(1-4D)(1+4D)} \cos(2x-1)$$

$$= \frac{1+4D}{1-16D^2} \cos(2x-1) = \frac{1+4D}{1-16(-2^2)} \cos(2x-1)$$

$$= \frac{1+4D}{1+64} \cos(2x-1) = \frac{1}{65}\left(\cos(2x-1) - 8\sin(2x-1) \right).$$

$$P.I_2 = \frac{1}{D^3+1}(x^2 e^{-x}) = e^{-x} \frac{1}{(D-1)^3+1} x^2$$

$$= e^{-x} \frac{1}{D^3-3D^2+3D-\cancel{1}+\cancel{1}} x^2 = e^{-x} \frac{1}{3D\left(1+\frac{D^3-3D^2}{3D}\right)} x^2$$

$$= \frac{e^{-x}}{3D}\left[1 + \frac{D^3-3D^2}{3D} \right]^{-1} (x^2)$$

$$= \frac{e^{-x}}{3D}\left[1+\left(\frac{D^2}{3}-D\right)\right]^{-1}(x^2)$$

$$= \frac{e^{-x}}{3D}\left[1-\left(\frac{D^2}{3}+D\right)+\left(\frac{D^2}{3}-D\right)^2-\cdots\cdots\right](x^2)$$

$$= \frac{e^{-x}}{3D}\left[1-\frac{D^2}{3}+D+D^2\right](x^2)$$

$$= \frac{e^{-x}}{3D}\left[x^2-\frac{2}{3}+2x+2\right] = \frac{e^{-x}}{3}\int\left(x^2+2x+\frac{4}{3}\right)dx$$

$$= \frac{e^{-x}}{3}\left(\frac{x^3}{3}+\cancel{2}\frac{x^2}{\cancel{2}}+\frac{4}{3}x\right) = \frac{e^{-x}}{9}\left(x^3+3x^2+4x\right).$$

$\therefore P.I = P.I_1 + P.I_2 = \frac{1}{65}\left(\cos(2x-1)-8\sin(2x-1)\right)+\frac{e^{-x}}{9}(x^3+3x^2+4x)$

Hence $y = c_1 e^{-x} + e^{\frac{1}{2}x}\left(c_2\cos\frac{\sqrt{3}}{2}x + c_3\sin\frac{\sqrt{3}}{2}x\right) +$

$$\frac{1}{65}\left(\cos(2x-1)-8\sin(2x-1)\right)+\frac{e^{-x}}{9}\left(x^3+3x^2+4x\right)$$

is the required solution.

(6) Solve $(D^2-4)y = x\sin ax$.

Sol:- Given equation is $(D^2-4)y = x\sin ax$.

Here, $f(D) = D^2-4$, $X = x\sin ax$.

To find the complementary function:

The Auxiliary equation is $f(m)=0$.

$\Rightarrow m^2-4=0 \Rightarrow m^2=4 \Rightarrow m=\pm 2$.

The roots are real and distinct.

$\therefore$ C.F is $y_c = c_1 e^{-2x} + c_2 e^{2x}$, where c_1 and c_2 are arbitrary constants.

Next to find the particular solution:

$$P.I = \frac{1}{f(D)}X$$

$$= \frac{1}{D^2-4}\,x\sin ax \qquad \left(\because \frac{1}{f(D)}(xV) = x\frac{1}{f(D)}V - \frac{f'(D)}{(f(D))^2}V\right)$$

$$= x\,\frac{1}{D^2-4}\,\sin ax - \frac{2D}{(D^2-4)^2}\,\sin ax$$

$$= x\,\frac{1}{-a^2-4}\,\sin ax - \frac{2D}{(-a^2-4)^2}\,\sin ax$$

$$= -\frac{x\sin ax}{a^2+4} - \frac{2a\cos ax}{(a^2+4)^2}$$

Hence the complete solution of the given equation is $y = y_c + y_p$

$$y = c_1 e^{-2x} + c_2 e^{2x} - \frac{x\sin ax}{a^2+4} - \frac{2a\cos ax}{(a^2+4)^2}.$$

(7). Solve $(D^2+1)\,y = \sin x \sin ax + e^x x^2$.

Sol: Given equation is $(D^2+1)\,y = \sin x \sin ax + e^x x^2$.

Here, $f(D) = D^2+1$.

$$X = \sin x \sin ax + e^x x^2.$$

To find the complementary function:

The auxiliary equation is $f(m) = 0$.

$\Rightarrow m^2+1 = 0 \Rightarrow m^2 = -1 \Rightarrow m = \pm i$.

The roots are complex conjugate.

C.F is $y_c = c_1\cos x + c_2 \sin x$, where c_1 and c_2 are arbitrary constants.

Next to find the particular integral:

$$P.I = \frac{1}{f(D)}X = \frac{1}{D^2+1}\left(\sin x \sin ax + e^x x^2\right)$$

$$= \frac{1}{D^2+1}\sin x \sin ax + \frac{1}{D^2+1}e^x x^2$$

$$= P.I_1 + P.I_2.$$

$P.I_1 = \frac{1}{D^2+1} \sin x \sin 2x$

$= \frac{1}{2} \frac{1}{D^2+1} \left(\cos(x-2x) - \cos(x+2x) \right)$ $\left(\because 2\sin A \sin B = \cos(A-B) - \cos(A+B) \right)$

$= \frac{1}{2}\left[\frac{1}{D^2+1} \cos x - \frac{1}{D^2+1} \cos 3x\right]$

$= \frac{1}{2}\left[\frac{x}{2D} \cos x + \frac{1}{8} \cos 3x\right]$

$= \frac{1}{2}\left[\frac{x}{2} \sin x + \frac{1}{8} \cos 3x\right] = \frac{1}{4} x \sin x + \frac{1}{16} \cos 3x$.

$P.I_2 = \frac{1}{D^2+1} e^x x^2 = e^x \frac{1}{(D+1)^2+1} x^2$

$= e^x \frac{1}{D^2+2D+2} x^2 = e^x \frac{1}{2\left(1+\frac{D^2+2D}{2}\right)} x^2$

$= \frac{e^x}{2}\left(1 + \frac{D^2+2D}{2}\right)^{-1} (x^2)$

$\left(\because (1+D)^{-1} = 1 - D + D^2 - D^3 + \cdots\right)$

$= \frac{e^x}{2}\left(1 - \frac{D^2+2D}{2} + \left(\frac{D^2+2D}{2}\right)^2 - \cdots\cdots\right)(x^2)$

$= \frac{e^x}{2}\left(1 - \frac{D^2}{2} - D + D^2\right)(x^2) = \frac{e^x}{2}\left(1 + \frac{D^2}{2} - D\right)(x^2)$

$= \frac{e^x}{2}\left(x^2 - 2x + 1\right)$.

$P.I = P.I_1 + P.I_2 = \frac{x \sin x}{4} + \frac{1}{16} \cos 3x + \frac{e^x}{2}(x^2 - 2x + 1)$.

Hence the Complete Solution of the given equation is

$y = C.F + P.I = C_1 \cos x + C_2 \sin x + \frac{x \sin x}{4} + \frac{1}{16} \cos 3x + \frac{e^x}{2}(x^2 - 2x + 1)$.

8\. Solve $(D^2+4D+3)y = e^x \cos 2x - \cos 3x - 3x^3$.

Sol:- Given equation is $(D^2+4D+3)y = e^x \cos 2x - \cos 3x - 3x^3$.

Here, $f(D) = D^2+4D+3$, $X = e^x \cos 2x - \cos 3x - 3x^3$.

First to find the Complementary function:

The Auxiliary equation is $f(m) = 0$.

$\Rightarrow m^2 + 4m + 3 = 0$

$\Rightarrow (m+1)(m+3) = 0 \Rightarrow m = -1, -3$.

$\therefore$ C.F is $y_c = c_1 e^{-x} + c_2 e^{-3x}$, where c_1 and c_2 are arbitrary Constants.

Next to find the particular Integral:

$$P.I = \frac{1}{f(D)} X = \frac{1}{D^2+4D+3} \left(e^x \cos 2x - \cos 3x - 3x^3 \right).$$

$$= \frac{1}{D^2+4D+3} e^x \cos 2x - \frac{1}{D^2+4D+3} \cos 3x - 3 \cdot \frac{1}{D^2+4D+3} x^3.$$

$$= P.I_1 + P.I_2 + P.I_3.$$

Now, $$P.I_1 = \frac{1}{D^2+4D+3} e^x \cos 2x$$

$$= e^x \frac{1}{(D+1)^2 + 4(D+1) + 3} \cos 2x.$$

$$= e^x \frac{1}{D^2+2D+1+4D+4+3} \cos 2x$$

$$= e^x \frac{1}{D^2+6D+8} \cos 2x = e^x \frac{1}{-2^2+6D+8} \cos 2x.$$

$$= e^x \frac{6D-4}{36D^2-16} \cos 2x = e^x \frac{6D-4}{36(-2^2)-16} \cos 2x.$$

$$= e^x \frac{6D-4}{-160} \cos 2x = e^x \left(\frac{-12 \sin 2x - 4 \cos 2x}{-160} \right)$$

$$= \frac{3}{40} e^x \sin 2x + \frac{1}{40} e^x \cos 2x.$$

$$P.I_2 = \frac{1}{D^2+4D+3}\cos 3x = \frac{4D+6}{16D^2-36}\cos 3x$$

$$= \frac{4D+6}{16(-3^2)-36}\cos 3x = \frac{4D+6}{-180}\cos 3x$$

$$= -\frac{1}{180}\left(-12\sin 3x + 6\cos 3x\right)$$

$$= \frac{1}{15}\sin 3x - \frac{1}{30}\cos 3x.$$

$$P.I_3 = \frac{1}{D^2+4D+3}\,3x^3$$

$$= 3\,\frac{1}{3\left(1+\frac{D^2+4D}{3}\right)}x^3 = \left(1+\frac{D^2+4D}{3}\right)^{-1}(x^3).$$

$$= \left(1-\frac{D^2+4D}{3}+\left(\frac{D^2+4D}{3}\right)^2-\left(\frac{D^2+4D}{3}\right)^3+\cdots\right)(x^3)$$

$$= \left(1-\frac{D^2}{3}-\frac{4}{3}D+\frac{8}{9}D^3+\frac{16}{9}D^2-\frac{64}{27}D^3\right)(x^3)$$

$$= \left(1-\frac{4}{3}D+\frac{5}{9}D^2-\frac{40}{27}D^3\right)(x^3).$$

$$= \left(x^3-\frac{4}{3}(3x^2)+\frac{5}{9}(6x)-\frac{40}{27}(6)\right).$$

$$= x^3-4x^2+\frac{10}{3}x-\frac{80}{9}.$$

x^3
1 – $3x^2$
2 – $6x$
3 – 6.

$$\therefore P.I = P.I_1 + P.I_2 + P.I_3.$$

$$= \frac{3}{40}e^x\sin 2x + \frac{1}{40}e^x\cos 2x + \frac{1}{15}\sin 3x - \frac{1}{30}\cos 3x + x^3-4x^2+\frac{10}{3}x-\frac{80}{9}.$$

Hence the complete solution of the given equation is

$$y = C.F + P.I = c_1e^{-x}+c_2e^{-3x}+\frac{3}{40}e^x\sin 2x+\frac{1}{40}e^x\cos 2x + \frac{1}{15}\sin 3x-\frac{1}{30}\cos 3x + x^3-4x^2+\frac{10}{3}x-\frac{80}{9}.$$

9) Solve $(D^2+4)y = \tan 2x$.

Sol:- The given equation is $(D^2+4)y = \tan 2x \rightarrow (1)$

Here, $f(D) = D^2+4$, $X = \tan 2x$.

First to find the Complementary function:

The Auxiliary equation is $f(m) = 0$.

$\Rightarrow m^2+4=0 \Rightarrow m^2=-4 \Rightarrow m = \pm 2i$.

The roots are complex conjugate.

C.F is $y_c = c_1 \cos 2x + c_2 \sin 2x$, where c_1 and c_2 are arbitrary constants.

Let $y_p = y_1 u + y_2 v$ be the particular solution of (1). Then $u = -\int \frac{y_2 X}{W(y_1,y_2)}\,dx$.

$$v = \int \frac{y_1 X}{W(y_1,y_2)}\,dx.$$

Here, $y_1 = \cos 2x$, $y_2 = \sin 2x$.

Now, $W(y_1,y_2) = \begin{vmatrix} y_1 & y_2 \\ y_1' & y_2' \end{vmatrix} = \begin{vmatrix} \cos 2x & \sin 2x \\ -2\sin 2x & 2\cos 2x \end{vmatrix}$

$$= 2\cos^2 2x + 2\sin^2 2x = 2(1) = 2 \neq 0.$$

$$u = -\int \frac{(\sin 2x)(\tan 2x)}{2}\,dx = -\frac{1}{2}\int \frac{\sin^2 2x}{\cos 2x}\,dx$$

$$= -\frac{1}{2}\int\left(\frac{1-\cos^2 2x}{\cos 2x}\right)dx = -\frac{1}{2}\int(\sec 2x - \cos 2x)\,dx$$

$$= -\frac{1}{2}\log\left(\frac{\sec 2x+\tan 2x}{2}\right) + \frac{1}{4}\sin 2x.$$

$$= -\frac{1}{4}\log(\sec 2x + \tan 2x) + \frac{1}{4}\sin 2x.$$

$$v = \int \frac{(\cos 2x)(\tan 2x)}{2}\,dx = \frac{1}{2}\int \sin 2x\,dx$$

$$= -\frac{1}{2}\frac{\cos 2x}{2} = -\frac{\cos 2x}{4}$$

$\therefore\ y_p = y_1 u + y_2 v$

$$= \cos 2x\left(-\frac{1}{4}\log(\sec 2x + \tan 2x) + \frac{1}{4}\sin 2x\right)$$

$$+ \sin 2x\left(-\frac{\cos 2x}{4}\right).$$

$$= -\frac{\cos 2x}{4}\log(\sec 2x + \tan 2x).$$

Hence the Complete solution is $y = y_c + y_p$

$$y = c_1\cos 2x + c_2 \sin 2x - \frac{\cos 2x}{4}\log(\sec 2x + \tan 2x)$$

(10) Solve $(D^2+1)y = \operatorname{cosec} x$.

Sol:- The given equation is $(D^2+1)y = \operatorname{cosec} x \rightarrow (1)$

Here, $f(D) = D^2+1$, $X = \operatorname{cosec} x$.

First to find the complementary function:

The Auxiliary equation is $f(m) = 0$.

$\Rightarrow m^2+1 = 0 \Rightarrow m^2 = -1 \Rightarrow m = \pm i$.

The roots are complex conjugate.

C.F is $y_c = c_1\cos x + c_2 \sin x$, where c_1 and c_2 are arbitrary constants.

Let $y_p = y_1 u + y_2 v$ be the particular solution of (1);

then $u = -\int \frac{y_2 X}{W(y_1,y_2)}\,dx$, $v = \int \frac{y_1 X}{W(y_1,y_2)}\,dx$.

Here $y_1 = \cos x$, $y_2 = \sin x$.

$$W(y_1,y_2) = \begin{vmatrix} y_1 & y_2 \\ y_1' & y_2' \end{vmatrix} = \begin{vmatrix} \cos x & \sin x \\ -\sin x & \cos x \end{vmatrix} = \cos^2 x + \sin^2 x = 1 \neq 0.$$

$u = -\int \frac{(\sin x)(\operatorname{cosec} x)}{1}\,dx = -\int dx = -x$

$v = \int \frac{(\cos x)(\operatorname{cosec} x)}{1}\,dx = \int \frac{\cos x}{\sin x}\,dx = \log(\sin x).$

$\therefore y_p = -x\cos x + \sin x \log(\sin x).$

Hence the Complete Solution of (1) is $y = y_c + y_p$.

$y = c_1\cos x + c_2 \sin x - x\cos x + \sin x \log(\sin x).$

(11) Solve $(D^2+a^2)y = \sec ax$.

Sol:- Given equation is $(D^2+a^2)y = \sec ax \rightarrow (1)$.

Here, $f(D) = D^2+a^2$, $X = \sec ax$.

To find the complementary function:

The Auxiliary equation is $f(m)=0$.

$\Rightarrow m^2+a^2 = 0 \Rightarrow m^2 = -a^2 \Rightarrow m = \pm ai$.

The roots are Complex Conjugate.

$\therefore$ C.F is $y_c = c_1\cos ax + c_2 \sin ax$, where c_1 and c_2 are arbitrary functions.

Let, $y_p = uy_1 + vy_2$ be the particular integral of (1).

Then $u = -\int \frac{y_2 X}{W(y_1,y_2)}\,dx$ and $v = \int \frac{y_1 X}{W(y_1,y_2)}\,dx$.

Here, $y_1 = \cos ax$, $y_2 = \sin ax$.

Now $W(y_1; y_2) = \begin{vmatrix} y_1 & y_2 \\ y_1' & y_2' \end{vmatrix} = \begin{vmatrix} \cos ax & \sin ax \\ -a\sin ax & a\cos ax \end{vmatrix}$

$= a\cos^2 ax + a\sin^2 ax = a(\cos^2 ax + \sin^2 ax) = a(1) \neq 0.$

$u = -\int \frac{\sin ax \sec ax}{a}\,dx = -\frac{1}{a}\int \frac{\sin ax}{\cos ax}\,dx = \frac{1}{a}\frac{\log(\cos ax)}{a}$

$= \frac{1}{a^2}\log(\cos ax)$

$$v = \int \frac{\cos ax \sec ax}{a}\, dx = \frac{1}{a}\int dx = \frac{1}{a}x.$$

$$\therefore\ y_p = \frac{1}{a^2}\cos ax \log(\cos ax) + \frac{1}{a}(\sin ax)\, x.$$

Hence the complete solution of the given equation is $y = y_c + y_p$.

$$y = c_1 \cos ax + c_2 \sin ax + \frac{\cos ax}{a^2}\log(\cos ax) + \frac{x}{a}\sin ax$$

UNIT-IV
partial differentiation

JACOBIANS

If u and v are functions of two independent variables x and y, then the determinant $\begin{vmatrix} \frac{\partial u}{\partial x} & \frac{\partial u}{\partial y} \\ \frac{\partial v}{\partial x} & \frac{\partial v}{\partial y} \end{vmatrix}$ is called the Jacobian of u, v with respect to x, y and is written as $\frac{\partial(u,v)}{\partial(x,y)}$ (or) $J\left(\frac{u,v}{x,y}\right)$

$$\frac{\partial(u,v)}{\partial(x,y)} = J\left(\frac{u,v}{x,y}\right) = \begin{vmatrix} \frac{\partial u}{\partial x} & \frac{\partial u}{\partial y} \\ \frac{\partial v}{\partial x} & \frac{\partial v}{\partial y} \end{vmatrix}.$$

Similarly the Jacobian of u, v, w with respect to x, y, z is $\frac{\partial(u,v,w)}{\partial(x,y,z)} = \begin{vmatrix} \frac{\partial u}{\partial x} & \frac{\partial u}{\partial y} & \frac{\partial u}{\partial z} \\ \frac{\partial v}{\partial x} & \frac{\partial v}{\partial y} & \frac{\partial v}{\partial z} \\ \frac{\partial w}{\partial x} & \frac{\partial w}{\partial y} & \frac{\partial w}{\partial z} \end{vmatrix}$

The Jacobian of n functions of n independent variables can be defined in similar way.

Properties of Jacobians:

1. Let u and v be functions of x and y, and $J = \frac{\partial(u,v)}{\partial(x,y)}$

   $J' = \frac{\partial(x,y)}{\partial(u,v)}$ then $JJ' = 1$.

2. Chain Rule for Jacobians:

   If u, v are functions of r, s and r, s are functions of x, y then $\frac{\partial(u,v)}{\partial(x,y)} = \frac{\partial(u,v)}{\partial(r,s)} \frac{\partial(r,s)}{\partial(x,y)}$.

3. Jacobian of Implicit functions

If u, v, w and x, y, z are implicitly connected by the equations such as

$$f_1(u, v, w, x, y, z) = 0$$
$$f_2(u, v, w, x, y, z) = 0$$
$$f_3(u, v, w, x, y, z) = 0 \quad \text{then}$$

$$\frac{\partial(u, v, w)}{\partial(x, y, z)} = (-1)^3 \frac{\partial(f_1, f_2, f_3)/\partial(x, y, z)}{\partial(f_1, f_2, f_3)/\partial(u, v, w)}.$$

Exercises

1. If $u = x^2 - 2y$, $v = x + y$ then prove that $\frac{\partial(u,v)}{\partial(x,y)} = 2x + 2$.

Sol: Given $u = x^2 - 2y$, $\quad v = x + y$

$$\frac{\partial u}{\partial x} = 2x \qquad \frac{\partial v}{\partial x} = 1$$
$$\frac{\partial u}{\partial y} = -2 \qquad \frac{\partial v}{\partial y} = 1.$$

$$\therefore \frac{\partial(u,v)}{\partial(x,y)} = \begin{vmatrix} \frac{\partial u}{\partial x} & \frac{\partial u}{\partial y} \\ \frac{\partial v}{\partial x} & \frac{\partial v}{\partial y} \end{vmatrix} = \begin{vmatrix} 2x & -2 \\ 1 & 1 \end{vmatrix} = (2x)(1) - (1)(-2)$$
$$= \underline{\underline{2x + 2}}$$

2. In polar coordinates, $x = r\cos\theta$, $y = r\sin\theta$.
Show that $\frac{\partial(x,y)}{\partial(r,\theta)} = r$.

Sol: Given $x = r\cos\theta$, $\quad y = r\sin\theta$

$$\frac{\partial x}{\partial r} = \cos\theta \qquad \frac{\partial y}{\partial r} = \sin\theta$$
$$\frac{\partial x}{\partial \theta} = -r\sin\theta \qquad \frac{\partial y}{\partial \theta} = r\cos\theta$$

$$\therefore \frac{\partial(x,y)}{\partial(r,\theta)} = \begin{vmatrix} \frac{\partial x}{\partial r} & \frac{\partial x}{\partial \theta} \\ \frac{\partial y}{\partial r} & \frac{\partial y}{\partial \theta} \end{vmatrix} = \begin{vmatrix} \cos\theta & -r\sin\theta \\ \sin\theta & r\cos\theta \end{vmatrix} = r\cos^2\theta + r\sin^2\theta$$
$$= r(\cos^2\theta + \sin^2\theta)$$
$$= r(1) = \underline{\underline{r}}$$

3. In Cylindrical coordinates, $x = \rho\cos\phi$, $y = \rho\sin\phi$, $z = z$ Show that $\frac{\partial(x,y,z)}{\partial(\rho,\phi,z)} = \rho$.

Sol: Given $x = \rho\cos\phi$, $y = \rho\sin\phi$, $z = z$

$$\frac{\partial x}{\partial \rho} = \cos\phi \qquad \frac{\partial y}{\partial \rho} = \sin\phi \qquad \frac{\partial z}{\partial \rho} = 0$$

$$\frac{\partial x}{\partial \phi} = -\rho\sin\phi \qquad \frac{\partial y}{\partial \phi} = \rho\cos\phi \qquad \frac{\partial z}{\partial \phi} = 0$$

$$\frac{\partial x}{\partial z} = 0 \qquad \frac{\partial y}{\partial z} = 0 \qquad \frac{\partial z}{\partial z} = 1$$

Consider $$\frac{\partial(x,y,z)}{\partial(\rho,\phi,z)} = \begin{vmatrix} \frac{\partial x}{\partial \rho} & \frac{\partial x}{\partial \phi} & \frac{\partial x}{\partial z} \\ \frac{\partial y}{\partial \rho} & \frac{\partial y}{\partial \phi} & \frac{\partial y}{\partial z} \\ \frac{\partial z}{\partial \rho} & \frac{\partial z}{\partial \phi} & \frac{\partial z}{\partial z} \end{vmatrix}$$

$$= \begin{vmatrix} \cos\phi & -\rho\sin\phi & 0 \\ \sin\phi & \rho\cos\phi & 0 \\ 0 & 0 & 1 \end{vmatrix}$$

$$= \cos\phi(\rho\cos\phi) + \rho\sin\phi(\sin\phi)$$

$$= \rho\cos^2\phi + \rho\sin^2\phi = \rho(\cos^2\phi + \sin^2\phi) = \rho(1) = \underline{\rho}.$$

4.** In Spherical polar coordinates $x = r\sin\theta\cos\phi$, $y = r\sin\theta\sin\phi$, $z = r\cos\theta$. Show that

$$\frac{\partial(x,y,z)}{\partial(r,\theta,\phi)} = r^2\sin\theta$$

Sol: Given, $x = r\sin\theta\cos\phi$, $y = r\sin\theta\sin\phi$, $z = r\cos\theta$

$$\frac{\partial x}{\partial r} = \sin\theta\cos\phi \qquad \frac{\partial y}{\partial r} = \sin\theta\sin\phi, \qquad \frac{\partial z}{\partial r} = \cos\theta$$

$$\frac{\partial x}{\partial \theta} = r\cos\theta\cos\phi \qquad \frac{\partial y}{\partial \theta} = r\cos\theta\sin\phi \qquad \frac{\partial z}{\partial \theta} = -r\sin\theta$$

$$\frac{\partial x}{\partial \phi} = -r\sin\theta\sin\phi \qquad \frac{\partial y}{\partial \phi} = r\sin\theta\cos\phi \qquad \frac{\partial z}{\partial \phi} = 0$$

consider $\dfrac{\partial(x,y,z)}{\partial(r,\theta,\phi)} = \begin{vmatrix} \frac{\partial x}{\partial r} & \frac{\partial x}{\partial \theta} & \frac{\partial x}{\partial \phi} \\ \frac{\partial y}{\partial r} & \frac{\partial y}{\partial \theta} & \frac{\partial y}{\partial \phi} \\ \frac{\partial z}{\partial r} & \frac{\partial z}{\partial \theta} & \frac{\partial z}{\partial \phi} \end{vmatrix}$

$$= \begin{vmatrix} \sin\theta\cos\phi & r\cos\theta\cos\phi & -r\sin\theta\sin\phi \\ \sin\theta\sin\phi & r\cos\theta\sin\phi & r\sin\theta\cos\phi \\ \cos\theta & -r\sin\theta & 0 \end{vmatrix}$$

$$= \sin\theta\cos\phi\left[0 + r^2\sin^2\theta\cos\phi\right] - r\cos\theta\cos\phi\left[0 - r\sin\theta\cos\phi\cos\theta\right]$$
$$- r\sin\theta\sin\phi\left[-r\sin^2\theta\sin\phi - r\cos^2\theta\sin\phi\right]$$

$$= r^2\sin^3\theta\cos^2\phi + r^2\sin\theta\cos^2\theta\cos^2\phi + r^2\sin^3\theta\sin^3\phi$$
$$+ r^2\sin\theta\sin^2\phi\cos^2\theta$$

$$= r^2\sin\theta\left[\sin^2\theta\cos^2\phi + \cos^2\theta\cos^2\phi + \sin^2\theta\sin^2\phi\right.$$
$$\left. + \sin^2\phi * \cos^2\theta\right]$$

$$= r^2\sin\theta\left[\cos^2\phi(\sin^2\theta + \cos^2\theta) + \sin^2\phi(\sin^2\theta + \cos^2\theta)\right]$$

$$= r^2\sin\theta\left[\cos^2\phi + \sin^2\phi\right] = \underline{\underline{r^2\sin\theta}} = R.H.S$$

(5) If $u = \dfrac{yz}{x}$, $v = \dfrac{xz}{y}$, $w = \dfrac{xy}{z}$ then show that the Jacobian of u, v, w with respect to x, y, z is 4.

Sol:- Given, $u = \dfrac{yz}{x}$, $v = \dfrac{xz}{y}$, $w = \dfrac{xy}{z}$

$$\frac{\partial u}{\partial x} = -\frac{yz}{x^2} \qquad \frac{\partial v}{\partial x} = \frac{z}{y} \qquad \frac{\partial w}{\partial x} = \frac{y}{z}$$

$$\frac{\partial u}{\partial y} = \frac{z}{x} \qquad \frac{\partial v}{\partial y} = -\frac{xz}{y^2} \qquad \frac{\partial w}{\partial y} = \frac{x}{z}$$

$$\frac{\partial u}{\partial z} = \frac{y}{x} \qquad \frac{\partial v}{\partial z} = \frac{x}{y} \qquad \frac{\partial w}{\partial z} = -\frac{xy}{z^2}$$

Consider
$$\frac{\partial(u,v,w)}{\partial(x,y,z)} = \begin{vmatrix} \frac{\partial u}{\partial x} & \frac{\partial u}{\partial y} & \frac{\partial u}{\partial z} \\ \frac{\partial v}{\partial x} & \frac{\partial v}{\partial y} & \frac{\partial v}{\partial z} \\ \frac{\partial w}{\partial x} & \frac{\partial w}{\partial y} & \frac{\partial w}{\partial z} \end{vmatrix}$$

$$= \begin{vmatrix} -\frac{yz}{x^2} & \frac{z}{x} & \frac{y}{x} \\ \frac{z}{y} & -\frac{xz}{y^2} & \frac{x}{y} \\ \frac{y}{z} & \frac{x}{z} & -\frac{xy}{z^2} \end{vmatrix}$$

$$= \frac{1}{x^2y^2z^2} \begin{vmatrix} -yz & xz & xy \\ zy & -xz & xy \\ yz & xz & -xy \end{vmatrix}$$

$$= \frac{(yz)(xz)(xy)}{x^2y^2z^2} \begin{vmatrix} -1 & 1 & 1 \\ 1 & -1 & 1 \\ 1 & 1 & -1 \end{vmatrix}$$

$$= -1(1-1) - 1(-1-1) + 1(1+1)$$

$$= 0 + 2 + 2 = 4 = R.H.S$$

6.* If $u = x+y+z$, $uv = y+z$, $uvw = z$ then prove that $\frac{\partial(x,y,z)}{\partial(u,v,w)} = u^2v$.

Sol:- Given $u = x+y+z$, $uv = y+z$, $uvw = z$.

Now, $z = uvw$

$y+z = uv \Rightarrow y = uv - uvw = uv(1-w)$.

$x+y+z = u \Rightarrow x = u - uv = u(1-v)$.

$x = u(1-v)$ $y = uv(1-w)$, $z = uvw$.

$\frac{\partial x}{\partial u} = 1-v$ $\frac{\partial y}{\partial u} = v(1-w)$ $\frac{\partial z}{\partial u} = vw$

$\frac{\partial x}{\partial v} = -u$ $\frac{\partial y}{\partial v} = u(1-w)$ $\frac{\partial z}{\partial v} = uw$

$\frac{\partial x}{\partial w} = 0$ $\frac{\partial y}{\partial w} = -uv$ $\frac{\partial z}{\partial w} = uv$

Consider, $\dfrac{\partial(x,y,z)}{\partial(u,v,w)} = \begin{vmatrix} \frac{\partial x}{\partial u} & \frac{\partial x}{\partial v} & \frac{\partial x}{\partial w} \\ \frac{\partial y}{\partial u} & \frac{\partial y}{\partial v} & \frac{\partial y}{\partial w} \\ \frac{\partial z}{\partial u} & \frac{\partial z}{\partial v} & \frac{\partial z}{\partial w} \end{vmatrix}$

$$= \begin{vmatrix} 1-v & -u & 0 \\ v(1-w) & u(1-w) & -uv \\ vw & uw & uv \end{vmatrix} = (1-v)\left[u^2v - u^2vw + u^2vw\right] + u\left[uv^2 - uv^2w + uv^2w\right]$$

$$= (1-v)u^2v + u(uv^2)$$

$$= u^2v - u^2v^2 + u^2v^2 = u^2v$$

$$= \underline{\underline{R.H.S.}}$$

6. If $x = r\cos\theta$, $y = r\sin\theta$, evaluate $J = \dfrac{\partial(x,y)}{\partial(r,\theta)}$ and $J' = \dfrac{\partial(r,\theta)}{\partial(x,y)}$. Also show that $JJ' = 1$.

<u>Sol:</u> Given $x = r\cos\theta$, $y = r\sin\theta$

$\frac{\partial x}{\partial r} = \cos\theta$, $\frac{\partial x}{\partial \theta} = -r\sin\theta$ $\qquad$ $\frac{\partial y}{\partial r} = \sin\theta$, $\frac{\partial y}{\partial \theta} = r\cos\theta$

$$J = \frac{\partial(x,y)}{\partial(r,\theta)} = \begin{vmatrix} \frac{\partial x}{\partial r} & \frac{\partial x}{\partial \theta} \\ \frac{\partial y}{\partial r} & \frac{\partial y}{\partial \theta} \end{vmatrix} = \begin{vmatrix} \cos\theta & -r\sin\theta \\ \sin\theta & r\cos\theta \end{vmatrix} = r\cos^2\theta + r\sin^2\theta$$

$$= r(\cos^2\theta + \sin^2\theta)$$

$$= r(1) = r.$$

Now, $x = r\cos\theta$, $y = r\sin\theta$

squaring and adding, we get

$x^2 + y^2 = r^2$

differentiating w.r.to 'x'

$$2x = 2r\frac{\partial r}{\partial x}$$

$$\Rightarrow \frac{\partial r}{\partial x} = \frac{x}{r}$$

Similarly $\frac{\partial r}{\partial y} = \frac{y}{r}$

Also, $\frac{y}{x} = \tan\theta \Rightarrow \theta = \tan^{-1}\left(\frac{y}{x}\right)$

$$\frac{\partial\theta}{\partial x} = \frac{1}{1+\left(\frac{y}{x}\right)^2}\left(-\frac{y}{x^2}\right) = -\frac{y}{x^2+y^2} = -\frac{y}{r^2}$$

$$\frac{\partial\theta}{\partial y} = \frac{1}{1+\left(\frac{y}{x}\right)^2}\left(\frac{1}{x}\right) = \frac{x}{x^2+y^2} = \frac{x}{r^2}$$

$$J^1 = \frac{\partial(r,\theta)}{\partial(x,y)} = \begin{vmatrix} \frac{\partial r}{\partial x} & \frac{\partial r}{\partial y} \\ \frac{\partial \theta}{\partial x} & \frac{\partial \theta}{\partial y} \end{vmatrix} = \begin{vmatrix} \frac{x}{r} & \frac{y}{r} \\ -\frac{y}{r^2} & \frac{x}{r^2} \end{vmatrix} = \frac{x^2}{r^3} + \frac{y^2}{r^3}$$

$$= \frac{x^2+y^2}{r^3} = \frac{r^2}{r^3} = \frac{1}{r}$$

Hence, $JJ^1 = (r)\left(\frac{1}{r}\right) = 1$.

7. If $x = u(1-v)$, $y = uv$ prove that $JJ^1 = 1$.

Sol: Given $x = u(1-v)$, $y = uv$

$$\frac{\partial x}{\partial u} = 1-v \qquad \frac{\partial y}{\partial u} = v$$

$$\frac{\partial x}{\partial v} = -u \qquad \frac{\partial y}{\partial v} = u$$

$$J = \frac{\partial(x,y)}{\partial(u,v)} = \begin{vmatrix} \frac{\partial x}{\partial u} & \frac{\partial x}{\partial v} \\ \frac{\partial y}{\partial u} & \frac{\partial y}{\partial v} \end{vmatrix} = \begin{vmatrix} 1-v & -u \\ v & u \end{vmatrix} = (1-v)u + uv$$

$$= u - uv + uv$$

$$= u.$$

Now, $x = u - uv = u - y$

$$\Rightarrow u = x + y$$

Also, $v = \frac{y}{u} = \frac{y}{x+y}$

$$\frac{\partial u}{\partial x} = 1, \quad \frac{\partial u}{\partial y} = 1, \quad \frac{\partial v}{\partial x} = -\frac{y}{(x+y)^2}, \quad \frac{\partial v}{\partial y} = \frac{(x+y)(1) - y(1)}{(x+y)^2}$$

$$= \frac{x}{(x+y)^2}$$

$$J^1 = \frac{\partial(u,v)}{\partial(x,y)} = \begin{vmatrix} \frac{\partial u}{\partial x} & \frac{\partial u}{\partial y} \\ \frac{\partial v}{\partial x} & \frac{\partial v}{\partial y} \end{vmatrix} = \begin{vmatrix} 1 & 1 \\ -\frac{y}{(x+y)^2} & \frac{x}{(x+y)^2} \end{vmatrix} = \frac{x}{(x+y)^2} + \frac{y}{(x+y)^2}$$

$$= \frac{x+y}{(x+y)^2} = \frac{1}{x+y} = \frac{1}{u}$$

Hence, $JJ^1 = u \cdot \frac{1}{u} = \underline{1}$

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8. If $u = x^2 - 2y$, $v = x + y + z$, $w = x - 2y + 3z$ then find $\dfrac{\partial(u,v,w)}{\partial(x,y,z)}$. Sol: $10x + 4$

9. If $u = x + y + z$, $u^2 v = y + z$, $u^3 w = z$ then find $J\left(\dfrac{u,v,w}{x,y,z}\right)$.

Sol: Let, $f_1 = u - x - y - z$
$f_2 = u^2 v - y - z$
$f_3 = u^3 w - z$

We have $J\left(\dfrac{u,v,w}{x,y,z}\right) = \dfrac{\partial(u,v,w)}{\partial(x,y,z)}$

$$= (-1)^3 \frac{\dfrac{\partial(f_1,f_2,f_3)}{\partial(x,y,z)}}{\dfrac{\partial(f_1,f_2,f_3)}{\partial(u,v,w)}}$$

Now, $$\frac{\partial(f_1,f_2,f_3)}{\partial(x,y,z)} = \begin{vmatrix} \frac{\partial f_1}{\partial x} & \frac{\partial f_1}{\partial y} & \frac{\partial f_1}{\partial z} \\ \frac{\partial f_2}{\partial x} & \frac{\partial f_2}{\partial y} & \frac{\partial f_2}{\partial z} \\ \frac{\partial f_3}{\partial x} & \frac{\partial f_3}{\partial y} & \frac{\partial f_3}{\partial z} \end{vmatrix} = \begin{vmatrix} -1 & -1 & -1 \\ 0 & -1 & -1 \\ 0 & 0 & -1 \end{vmatrix}$$

$$= -1(1-0) + 1(0) - 1(0) = -1$$

and $$\frac{\partial(f_1,f_2,f_3)}{\partial(u,v,w)} = \begin{vmatrix} \frac{\partial f_1}{\partial u} & \frac{\partial f_1}{\partial v} & \frac{\partial f_1}{\partial w} \\ \frac{\partial f_2}{\partial u} & \frac{\partial f_2}{\partial v} & \frac{\partial f_2}{\partial w} \\ \frac{\partial f_3}{\partial u} & \frac{\partial f_3}{\partial v} & \frac{\partial f_3}{\partial w} \end{vmatrix} = \begin{vmatrix} 1 & 0 & 0 \\ 2uv & u^2 & 0 \\ 3u^2 w & 0 & u^3 \end{vmatrix}$$

$$= 1(u^5 - 0) - 0 + 0 = u^5.$$

Hence $$J\left(\frac{u,v,w}{x,y,z}\right) = (-1)\frac{(-1)}{u^5} = \frac{1}{u^5}.$$

10. If $x = \sqrt{vw}$, $y = \sqrt{wu}$, $z = \sqrt{uv}$ and $u = r\sin\theta\cos\phi$, $v = r\sin\theta\sin\phi$, $w = r\cos\theta$ find $\dfrac{\partial(x,y,z)}{\partial(r,\theta,\phi)}$.

Sol: Given $x = \sqrt{vw}$, $y = \sqrt{wu}$, $z = \sqrt{uv}$

$$\frac{\partial x}{\partial u} = 0 \qquad \frac{\partial y}{\partial u} = \frac{1}{2\sqrt{wu}}\,w \qquad \frac{\partial z}{\partial u} = \frac{1}{2\sqrt{uv}}\,v$$

$$\frac{\partial x}{\partial v} = \frac{1}{2\sqrt{vw}}\,w \qquad \frac{\partial y}{\partial v} = 0 \qquad \frac{\partial z}{\partial v} = \frac{1}{2\sqrt{uv}}\,u$$

$$\frac{\partial x}{\partial w} = \frac{1}{2\sqrt{vw}}\,v \qquad \frac{\partial y}{\partial w} = \frac{1}{2\sqrt{wu}}\,u \qquad \frac{\partial z}{\partial w} = 0$$

Now,
$$\frac{\partial(x,y,z)}{\partial(u,v,w)} = \begin{vmatrix} \frac{\partial x}{\partial u} & \frac{\partial x}{\partial v} & \frac{\partial x}{\partial w} \\ \frac{\partial y}{\partial u} & \frac{\partial y}{\partial v} & \frac{\partial y}{\partial w} \\ \frac{\partial z}{\partial u} & \frac{\partial z}{\partial v} & \frac{\partial z}{\partial w} \end{vmatrix} = \begin{vmatrix} 0 & \frac{w}{2\sqrt{vw}} & \frac{v}{2\sqrt{vw}} \\ \frac{w}{2\sqrt{wu}} & 0 & \frac{u}{2\sqrt{wu}} \\ \frac{v}{2\sqrt{uv}} & \frac{u}{2\sqrt{uv}} & 0 \end{vmatrix}$$

$$= \frac{1}{2\sqrt{vw}\,2\sqrt{wu}\,2\sqrt{uv}} \begin{vmatrix} 0 & w & v \\ w & 0 & u \\ v & u & 0 \end{vmatrix}$$

$$= \frac{1}{8uvw}\left[0(0-u^2) - w(0-uv) + v(wu-0)\right]$$

$$= \frac{1}{8uvw}(2uvw) = \frac{1}{4}.$$

Also, given
$$u = r\sin\theta\cos\phi$$
$$v = r\sin\theta\sin\phi$$
$$w = r\cos\theta$$

$$\frac{\partial(u,v,w)}{\partial(r,\theta,\phi)} = r^2\sin\theta.$$

By chain rule we have
$$\frac{\partial(x,y,z)}{\partial(r,\theta,\phi)} = \frac{\partial(x,y,z)}{\partial(u,v,w)}\,\frac{\partial(u,v,w)}{\partial(r,\theta,\phi)}$$
$$= \frac{1}{4}\,r^2\sin\theta.$$

Functional Dependence :-

Functional relationship: If u, v, w are functions of x, y, z then the necessary and sufficient condition for the existence of a functional relationship of the form $f(u, v, w) = 0$

(i.e to be functionally dependent) is

$$J\left(\frac{u, v, w}{x, y, z}\right) = 0.$$

If $J \neq 0$ then the functions u, v, w are said to be functionally independent.

1. If $u = x\sqrt{1-y^2} + y\sqrt{1-x^2}$, $v = \sin^{-1}x + \sin^{-1}y$, Show that u, v are functionally related and find the relationship.

Sol:- Given $u = x\sqrt{1-y^2} + y\sqrt{1-x^2}$, $v = \sin^{-1}x + \sin^{-1}y$

$$\frac{\partial u}{\partial x} = \sqrt{1-y^2} - \frac{2xy}{2\sqrt{1-x^2}} = \sqrt{1-y^2} - \frac{xy}{\sqrt{1-x^2}} \qquad \frac{\partial v}{\partial x} = \frac{1}{\sqrt{1-x^2}}$$

$$\frac{\partial u}{\partial y} = -\frac{xy}{\sqrt{1-y^2}} + \sqrt{1-x^2} \qquad \frac{\partial v}{\partial y} = \frac{1}{\sqrt{1-y^2}}.$$

$$\frac{\partial(u,v)}{\partial(x,y)} = \begin{vmatrix} \frac{\partial u}{\partial x} & \frac{\partial u}{\partial y} \\ \frac{\partial v}{\partial x} & \frac{\partial v}{\partial y} \end{vmatrix} = \begin{vmatrix} \sqrt{1-y^2} - \frac{xy}{\sqrt{1-x^2}} & -\frac{xy}{\sqrt{1-y^2}} + \sqrt{1-x^2} \\ \frac{1}{\sqrt{1-x^2}} & \frac{1}{\sqrt{1-y^2}} \end{vmatrix}$$

$$= 1 - \frac{xy}{\sqrt{1-x^2}\sqrt{1-y^2}} + \frac{xy}{\sqrt{1-x^2}\sqrt{1-y^2}} - 1 = 0$$

Hence u and v are functionally related.

Now. $v = \sin^{-1}x + \sin^{-1}y$.

$= \sin^{-1}\left[x\sqrt{1-y^2} + y\sqrt{1-x^2}\right] = \sin^{-1}u$.

i.e $u = \sin v$

which is the required relationship between u and v.

2. If $u = \frac{x+y}{1-xy}$, $v = \tan^{-1}x + \tan^{-1}y$, find $\frac{\partial(u,v)}{\partial(x,y)}$. Are u and v functionally dependent? If so, what is the relation between them?

Sol: Given $u = \frac{x+y}{1-xy}$, $v = \tan^{-1}x + \tan^{-1}y$.

$$\frac{\partial u}{\partial x} = \frac{(1-xy)(1)-(x+y)(-y)}{(1-xy)^2} = \frac{1-\cancel{xy}+\cancel{xy}+y^2}{(1-xy)^2} = \frac{1+y^2}{(1-xy)^2}$$

$$\frac{\partial u}{\partial y} = \frac{(1-xy)(1)-(x+y)(-x)}{(1-xy)^2} = \frac{1-\cancel{xy}+x^2+\cancel{xy}}{(1-xy)^2} = \frac{1+x^2}{(1-xy)^2}$$

$$\frac{\partial v}{\partial x} = \frac{1}{1+x^2}, \quad \frac{\partial v}{\partial y} = \frac{1}{1+y^2}$$

Consider $\frac{\partial(u,v)}{\partial(x,y)} = \begin{vmatrix} \frac{\partial u}{\partial x} & \frac{\partial u}{\partial y} \\ \frac{\partial v}{\partial x} & \frac{\partial v}{\partial y} \end{vmatrix} = \begin{vmatrix} \frac{1+y^2}{(1-xy)^2} & \frac{1+x^2}{(1-xy)^2} \\ \frac{1}{1+x^2} & \frac{1}{1+y^2} \end{vmatrix}$

$$= \frac{1}{(1-xy)^2} - \frac{1}{(1-xy)^2} = 0$$

Hence, u and v are functionally dependent.

Now, $v = \tan^{-1}x + \tan^{-1}y = \tan^{-1}\frac{x+y}{1-xy} = \tan^{-1}(u)$

i.e $u = \tan v$

Which is the required relationship between u and v.

3. Find whether the following functions are functionally dependent and if so find the relation

$$u = x + y + z, \quad v = x^2 + y^2 + z^2, \quad w = xy + yz + zx.$$

Sol:- Given $u = x + y + z$, $v = x^2 + y^2 + z^2$, $w = xy + yz + zx$

$$\frac{\partial u}{\partial x} = 1, \quad \frac{\partial v}{\partial x} = 2x, \quad \frac{\partial w}{\partial x} = y + z$$

$$\frac{\partial u}{\partial y} = 1, \quad \frac{\partial v}{\partial y} = 2y \quad \frac{\partial w}{\partial y} = x + z$$

$$\frac{\partial u}{\partial z} = 1, \quad \frac{\partial v}{\partial z} = 2z \quad \frac{\partial w}{\partial z} = y + x.$$

Consider $\dfrac{\partial(u,v,w)}{\partial(x,y,z)} = \begin{vmatrix} \frac{\partial u}{\partial x} & \frac{\partial u}{\partial y} & \frac{\partial u}{\partial z} \\ \frac{\partial v}{\partial x} & \frac{\partial v}{\partial y} & \frac{\partial v}{\partial z} \\ \frac{\partial w}{\partial x} & \frac{\partial w}{\partial y} & \frac{\partial w}{\partial z} \end{vmatrix} = \begin{vmatrix} 1 & 1 & 1 \\ 2x & 2y & 2z \\ y+z & x+z & y+x \end{vmatrix}$

$$= 2 \begin{vmatrix} 1 & 1 & 1 \\ x & y & z \\ y+z & x+z & y+x \end{vmatrix}$$

$$R_3 \to R_3 + R_2$$

$$= 2 \begin{vmatrix} 1 & 1 & 1 \\ x & y & z \\ x+y+z & x+y+z & x+y+z \end{vmatrix} = 2(x+y+z) \begin{vmatrix} 1 & 1 & 1 \\ x & y & z \\ 1 & 1 & 1 \end{vmatrix}$$

$$= 2(x+y+z)(0) = 0.$$

Hence u, v and w are functionally related.

Now, $u^2 = (x+y+z)^2$

$$= x^2 + y^2 + z^2 + 2(xy + yz + zx)$$

$$= v + 2w.$$

$\therefore u^2 = v + 2w.$

Which is the required relation ship between u, v and w.

Generalized Mean Value Theorem

Taylor's Series for a function of two variables:

$$f(x,y) = f(a,b) + [(x-a) f_x(a,b) + (y-b) f_y(a,b)] + \frac{1}{2!}[(x-a)^2 f_{xx}(a,b) + 2(x-a)(y-b) f_{xy}(a,b) + (y-b)^2 f_{yy}(a,b)] + \cdots\cdots$$

This is Taylor's series expansion of $f(x,y)$ in powers of $(x-a)$ and $(y-b)$. It is used to expand $f(x,y)$ in the neighbourhood of (a,b).

Taking $a=0$, $b=0$ in Taylor's series we get

$$f(x,y) = f(0,0) + [x f_x(0,0) + y f_y(0,0)] + \frac{1}{2!}[x^2 f_{xx}(0,0) + 2xy f_{xy}(0,0) + y^2 f_{yy}(0,0)] + \cdots\cdots$$

This is Maclaurin's expansion of $f(x,y)$.

1. Expand $f(x,y) = x^y$ in powers of $(x-1)(y-1)$ using Taylor's series.

Sol: Given $f(x,y) = x^y$ $\qquad f(1,1) = 1$

$f_x(x,y) = y x^{y-1}$ $\qquad f_x(1,1) = 1$

$f_y(x,y) = x^y \log x$ $\qquad f_y(1,1) = 0$ $\qquad (\because \log 1 = 0)$

$f_{xx}(x,y) = y(y-1) x^{y-1}$ $\qquad f_{xx}(1,1) = 0$

$$f_{xy}(x,y) = \frac{\partial}{\partial x}\left(\frac{\partial f}{\partial y}\right) = \frac{\partial}{\partial x}\left(x^y \log x\right) \qquad f_{xy}(1,1) = 1$$
$$= y x^{y-1} \log x + x^y \frac{1}{x}$$
$$= x^{y-1}(y \log x + 1)$$
$$f_{yy}(x,y) = x^y (\log x)^2 \qquad f_{yy}(1,1) = 0$$
. . . .

The Taylor's series expansion of $f(x,y)$ in powers of $(x-1)$ and $(y-1)$ is

$$f(x,y) = f(1,1) + \left[(x-1) f_x(1,1) + (y-1) f_y(1,1)\right] + \frac{1}{2!}\left[(x-1)^2 f_{xx}(1,1) + 2(x-1)(y-1) f_{xy}(1,1) + (y-1)^2 f_{yy}(1,1)\right] + \cdots$$

$$\therefore x^y = 1 + (x-1)(1) + (y-1)(0) + \frac{1}{2}\left[(x-1)^2(0) + 2(x-1)(y-1)(1) + (y-1)^2(0)\right] + \cdots$$
$$= 1 + (x-1) + (x-1)(y-1) + \cdots$$

Which is the required Taylor's series expansion in powers of $(x-1)$ and $(y-1)$.

2. Expand $e^x \sin y$ in powers of x and y.

Sol:- Let $f(x,y) = e^x \sin y$.

The Maclaurin's series is

$$f(x,y) = f(0,0) + \left[x f_x(0,0) + y f_y(0,0)\right] + \frac{1}{2!}\left[x^2 f_{xx}(0,0) + 2xy f_{xy}(0,0) + y^2 f_{yy}(0,0)\right] + \frac{1}{3!}\left[x^3 f_{xxx}(0,0) + 3x^2 y f_{xxy}(0,0) + 3xy^2 f_{xyy}(0,0) + y^3 f_{yyy}(0,0)\right] + \cdots \rightarrow (1)$$

Now $f(x,y) = e^x \sin y$ $\qquad f(0,0) = e^0 \sin 0 = 0$

$f_x(x,y) = \frac{\partial f}{\partial x} = e^x \sin y$ $\qquad f_x(0,0) = e^0 \sin 0 = 0$

$f_y(x,y) = \frac{\partial f}{\partial y} = e^x \cos y$ $\qquad f_y(0,0) = e^0 \cos 0 = 1$

$f_{xx}(x,y) = \frac{\partial^2 f}{\partial x^2} = \frac{\partial}{\partial x}\left(\frac{\partial f}{\partial x}\right) = \frac{\partial}{\partial x}(e^x \sin y)$
$= e^x \sin y$ $\qquad f_{xx}(0,0) = e^0 \sin 0 = 0$

$f_{xy}(x,y) = \frac{\partial^2 f}{\partial x \partial y} = \frac{\partial}{\partial x}\left(\frac{\partial f}{\partial y}\right) = \frac{\partial}{\partial x}(e^x \cos y)$
$= e^x \cos y$ $\qquad f_{xy}(0,0) = e^0 \cos 0 = 1$

$f_{yy}(x,y) = \frac{\partial^2 f}{\partial y^2} = \frac{\partial}{\partial y}\left(\frac{\partial f}{\partial y}\right) = \frac{\partial}{\partial y}(e^x \cos y)$
$= -e^x \sin y$ $\qquad f_{yy}(0,0) = 0$

$f_{xxx}(x,y) = \frac{\partial^3 f}{\partial x^3} = \frac{\partial}{\partial x}\left(\frac{\partial^2 f}{\partial x^2}\right) = \frac{\partial}{\partial x}(e^x \sin y)$
$= e^x \sin y$ $\qquad f_{xxx}(0,0) = 0$

$f_{xxy}(x,y) = \frac{\partial}{\partial x}\left(\frac{\partial^2 f}{\partial x \partial y}\right) = \frac{\partial}{\partial x}(e^x \cos y) = e^x \cos y$ $\qquad f_{xxy}(0,0) = 1$

$f_{xyy}(x,y) = \frac{\partial}{\partial x}\left(\frac{\partial^2 f}{\partial y^2}\right) = \frac{\partial}{\partial x}(-e^x \sin y) = -e^x \sin y$ $\qquad f_{xyy}(0,0) = 0$

$f_{yyy}(x,y) = \frac{\partial}{\partial y}\left(\frac{\partial^2 f}{\partial y^2}\right) = \frac{\partial}{\partial y}(-e^x \sin y) = -e^x \cos y$
$f_{yyy}(0,0) = -1$

Substituting these values in (1), we get

$$e^x \sin y = 0 + 0 + y + \frac{1}{2!}[0 + 2xy + 0] + \frac{1}{3!}[x^3 \cdot 0 + 3x^2 y \cdot 1 + 3xy^2 \cdot 0 + y^3(-1)] + \cdots$$
$$= y + xy + \frac{1}{2}x^2 y - \frac{1}{6}y^3 + \cdots\cdots$$

which is the required series in powers of x and y.

3. Expand $e^x \log(1+y)$ in the neighbourhood of the point $(0,0)$.

Sol:- Let $f(x,y) = e^x \log(1+y)$

The Maclaurin's series is

$$f(x,y) = f(0,0) + [x f_x(0,0) + y f_y(0,0)] + \frac{1}{2!}[x^2 f_{xx}(0,0) + 2xy f_{xy}(0,0) + y^2 f_{yy}(0,0)] + \frac{1}{3!}[x^3 f_{xxx}(0,0) + 3x^2y f_{xxy}(0,0) + 3xy^2 f_{xyy}(0,0) + y^3 f_{yyy}(0,0)] + \cdots \rightarrow (1)$$

Now, $f(x,y) = e^x \log(1+y)$ $\qquad f(0,0) = e^0 \log(1+0) = 0$

$f_x = \frac{\partial f}{\partial x} = e^x \log(1+y)$ $\qquad f_x(0,0) = e^0 \log(1+0) = 0$

$f_y = \frac{\partial f}{\partial y} = e^x \frac{1}{1+y}$ $\qquad f_y(0,0) = e^0 \frac{1}{1+0} = 1$

$f_{xx} = \frac{\partial^2 f}{\partial x^2} = \frac{\partial}{\partial x}\left(\frac{\partial f}{\partial x}\right) = e^x \log(1+y)$, $\quad f_{xx}(0,0) = 0$

$f_{xy} = \frac{\partial^2 f}{\partial x \partial y} = \frac{\partial}{\partial x}\left(\frac{\partial f}{\partial y}\right) = e^x \frac{1}{1+y}$ $\qquad f_{xy}(0,0) = e^0 \frac{1}{1+0} = 1$

$f_{yy} = \frac{\partial^2 f}{\partial y^2} = \frac{\partial}{\partial y}\left(\frac{\partial f}{\partial y}\right) = -e^x \frac{1}{(1+y)^2}$ $\qquad f_{yy}(0,0) = -1$

$f_{xxx} = \frac{\partial^3 f}{\partial x^3} = \frac{\partial}{\partial x}\left(\frac{\partial^2 f}{\partial x^2}\right) = e^x \log(1+y)$ $\qquad f_{xxx}(0,0) = 0$

$f_{xxy} = \frac{\partial^3 f}{\partial x^2 \partial y} = \frac{\partial}{\partial x}\left(\frac{\partial^2 f}{\partial x \partial y}\right) = \frac{\partial}{\partial x}\left(e^x \frac{1}{1+y}\right) = e^x \frac{1}{1+y}$ $\qquad f_{xxy}(0,0) = 1$

$f_{xyy} = \frac{\partial^3 f}{\partial x \partial y^2} = \frac{\partial}{\partial x}\left(\frac{\partial^2 f}{\partial y^2}\right) = -e^x \frac{1}{(1+y)^2}$ $\qquad f_{xyy}(0,0) = -1$

$f_{yyy} = \frac{\partial^3 f}{\partial y^3} = \frac{\partial}{\partial y}\left(\frac{\partial^2 f}{\partial y^2}\right) = e^x \frac{2}{(1+y)^3}$ $\qquad f_{yyy}(0,0) = 2$

. . . .

Substituting all these values in (1), we get

$$e^{x}\log(1+y) = 0+[x\cdot 0 + y\cdot 1] + \frac{1}{2!}\left[x^2(0) + 2xy(1) + y^2(-1)\right] + \frac{1}{3!}\left[x^3(0) + 3x^2y(1) + 3xy^2(-1) + y^3(2)\right] + \cdots$$

$$= y + xy - \frac{1}{2}y^2 + \frac{1}{2}x^2y - \frac{1}{2}xy^2 + \frac{1}{3}y^3 + \cdots$$

which is the required series in the neighbourhood of the point $(0,0)$.

4. Expand $e^{y}\log(1+x)$ in powers of x and y using Maclaurins series.

Sol: $e^{y}\log(1+x) = x - \frac{x^2}{2} + xy + \frac{x^3}{3} - \frac{x^2y}{2} + \frac{xy^2}{2} + \cdots$

5. Expand e^{xy} in the neighbourhood of $(1,1)$

(or) Expand e^{xy} in powers of $(x-1)$ and $(y-1)$.

Sol:- Let, $f(x,y) = e^{xy}$

The Taylors series expansion of $f(x,y)$ in the neighbourhood of (a,b) is

$$f(x,y) = f(a,b) + \left[(x-a)f_x(a,b) + (y-b)f_y(a,b)\right] + \frac{1}{2!}\left[(x-a)^2 f_{xx}(a,b) + 2(x-a)(y-b)f_{xy}(a,b) + (y-b)^2 f_{yy}(a,b)\right] + \cdots \rightarrow (1)$$

Now, $f(x,y) = e^{xy}$, $\quad f(1,1) = e$.

$f_x(x,y) = y e^{xy}$ $\quad f_x(1,1) = e$

$f_y(x,y) = x e^{xy}$ $\quad f_y(1,1) = e$

$f_{xx} = \frac{\partial^2 f}{\partial x^2} = \frac{\partial}{\partial x}(ye^{xy}) = y^2 e^{xy}$ $\quad\quad f_{xx}(1,1) = e$

$f_{xy} = \frac{\partial^2 f}{\partial x \partial y} = \frac{\partial}{\partial x}\left(\frac{\partial f}{\partial y}\right) = xye^{xy} + e^{xy}$. $\quad\quad f_{xy}(1,1) = 2e$

$f_{yy} = \frac{\partial^2 f}{\partial y^2} = \frac{\partial}{\partial y}\left(\frac{\partial f}{\partial y}\right) = \frac{\partial}{\partial y}(xe^{xy}) = x^2 e^{xy}$ $\quad\quad f_{yy}(1,1) = e$.

Substituting all these values in (1), we get

$$e^{xy} = e + (x-1)e + (y-1)e + \frac{1}{2!}\left[(x-1)^2 e + 2(x-1)(y-1)\,2e + (y-1)^2 e\right] + \cdots\cdots$$

$$= e\left[1 + (x-1) + (y-1) + \frac{(x-1)^2}{2!} + 2(x-1)(y-1) + \frac{(y-1)^2}{2!} + \cdots\right]$$

Which is the required series in powers of $(x-1)$ and $(y-1)$.

6. Expand $e^x \cos y$ near $(1, \frac{\pi}{4})$ by Taylor's series method.

Sol:- Let $f(x,y) = e^x \cos y$.

The Taylor's series of $f(x,y)$ near (a,b) is

$$f(x,y) = f(a,b) + \left[(x-a) f_x(a,b) + (y-b) f_y(a,b)\right] + \frac{1}{2!}\left[(x-a)^2 f_{xx}(a,b) + 2(x-a)(y-b) f_{xy}(a,b) + (y-b)^2 f_{yy}(a,b)\right] + \cdots\cdots \rightarrow (1)$$

Now $f(x,y) = e^x \cos y$ $\quad\quad f(1, \frac{\pi}{4}) = e^1 \cos\frac{\pi}{4} = \frac{e}{\sqrt{2}}$

$f_x(x,y) = \frac{\partial f}{\partial x} = e^x \cos y$ $\quad\quad f_x(1, \frac{\pi}{4}) = e^1 \cos\frac{\pi}{4} = \frac{e}{\sqrt{2}}$

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$f_y(x,y) = \frac{\partial f}{\partial y} = -e^x \sin y$ $\quad f_y(1, \frac{\pi}{4}) = -e^1 \sin\frac{\pi}{4} = -\frac{e}{\sqrt{2}}$

$f_{xx}(x,y) = \frac{\partial^2 f}{\partial x^2} = e^x \cos y$ $\quad f_{xx}(1, \frac{\pi}{4}) = e^1 \cos\frac{\pi}{4} = \frac{e}{\sqrt{2}}$

$f_{xy}(x,y) = \frac{\partial^2 f}{\partial x \partial y} = -e^x \sin y$ $\quad f_{xy}(1, \frac{\pi}{4}) = -\frac{e}{\sqrt{2}}$

$f_{yy}(x,y) = \frac{\partial^2 f}{\partial y^2} = -e^x \cos y$ $\quad f_{yy}(1, \frac{\pi}{4}) = -\frac{e}{\sqrt{2}}$

Substituting all these values in (1), we get

$$e^x \cos y = \frac{e}{\sqrt{2}} + \left[(x-1)\frac{e}{\sqrt{2}} + \left(y-\frac{\pi}{4}\right)\left(-\frac{e}{\sqrt{2}}\right)\right] + \frac{1}{2!}\left[(x-1)^2\frac{e}{\sqrt{2}} + 2(x-1)\left(y-\frac{\pi}{4}\right)\left(-\frac{e}{\sqrt{2}}\right) + \left(y-\frac{\pi}{4}\right)^2\left(-\frac{e}{\sqrt{2}}\right)\right] + \cdots$$

$$= \frac{e}{\sqrt{2}}\left[1 + (x-1) - \left(y-\frac{\pi}{4}\right) + \frac{(x-1)^2}{2!} - (x-1)\left(y-\frac{\pi}{4}\right) - \frac{\left(y-\frac{\pi}{4}\right)^2}{2!} + \cdots\right]$$

Which the required series in powers of $(x-1)$ and $\left(y-\frac{\pi}{4}\right)$.

(7) Expand $f(x,y) = \tan^{-1}\left(\frac{y}{x}\right)$ in powers of $(x-1)$ and $(y-1)$ upto third degree terms. Hence compute $f(1.1, 0.9)$ approximately.

Sol:- Given $f(x,y) = \tan^{-1}\left(\frac{y}{x}\right)$.

The Taylor's series expansion of $f(x,y)$ in powers of $(x-a)$ and $(y-b)$ is

$$f(x,y) = f(a,b) + [(x-a) f_x(a,b) + (y-b) f_y(a,b)] +$$
$$\frac{1}{2!}\{(x-a)^2 f_{xx}(a,b) + 2(x-a)(y-b) f_{xy}(a,b) + (y-b)^2 f_{yy}(a,b)]$$
$$+ \frac{1}{3!}[(x-a)^3 f_{xxx}(a,b) + 3(x-a)^2(y-b) f_{xxy}(a,b) + 3(x-a)$$
$$(y-b)^2 f_{xyy}(a,b) + (y-b)^3 f_{yyy}(a,b)] + \cdots\cdots \to (1)$$

Here $a = 1, \quad b = 1$.

Now, $f(x,y) = \tan^{-1}\left(\frac{y}{x}\right) \qquad f(1,1) = \tan^{-1}(1) = \frac{\pi}{4}$.

$$f_x = \frac{\partial f}{\partial x} = \frac{1}{1+\left(\frac{y}{x}\right)^2}\left(-\frac{y}{x^2}\right) = -\frac{y}{x^2+y^2} \qquad f_x(1,1) = -\frac{1}{2}$$

$$f_y = \frac{\partial f}{\partial y} = \frac{1}{1+\left(\frac{y}{x}\right)^2}\left(\frac{1}{x}\right) = \frac{x}{x^2+y^2} \qquad f_y(1,1) = \frac{1}{2}.$$

$$f_{xy} = \frac{\partial^2 f}{\partial x \partial y} = \frac{\partial}{\partial x}\left(\frac{\partial f}{\partial y}\right) = \frac{(x^2+y^2) - \cancel{(x^2+y^2)}\, x(2x)}{(x^2+y^2)^2}$$

$$= \frac{y^2-x^2}{(x^2+y^2)^2} \qquad f_{xy}(1,1) = 0$$

$$f_{xx} = \frac{\partial^2 f}{\partial x^2} = \frac{\partial}{\partial x}\left(-\frac{y}{x^2+y^2}\right) = \frac{2xy}{(x^2+y^2)^2}, \quad f_{xx}(1,1) = \frac{2}{4} = \frac{1}{2}.$$

$$f_{yy} = \frac{\partial^2 f}{\partial y^2} = \frac{\partial}{\partial y}\left(\frac{\partial f}{\partial y}\right) = \frac{\partial}{\partial y}\left(\frac{x}{x^2+y^2}\right) = -\frac{2xy}{(x^2+y^2)^2}, \quad f_{yy}(1,1) = -\frac{2}{4} = -\frac{1}{2}$$

$$f_{xxx} = \frac{\partial^3 f}{\partial x^3} = \frac{\partial}{\partial x}\left(\frac{\partial^2 f}{\partial x^2}\right) = \frac{\partial}{\partial x}\left(\frac{2xy}{(x^2+y^2)^2}\right) = \frac{(x^2+y^2)^2(2y) - 2xy\,2(x^2+y^2)(2x)}{(x^2+y^2)^4}$$

$$= \frac{2yx^2 + 2y^3 - 8x^2y}{(x^2+y^2)^3} = \frac{2y^3 - 6x^2y}{(x^2+y^2)^3}.$$

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$$b_{xxx}(1,1) = \frac{2-6}{(1+1)^3} = -\frac{4}{8} = -\frac{1}{2}.$$

$$b_{xxy} = \frac{\partial^3 b}{\partial x^2 \partial y} = \frac{\partial}{\partial x}\left(\frac{\partial^2 b}{\partial x \partial y}\right)$$

$$= \frac{\partial}{\partial x}\left(\frac{y^2-x^2}{(x^2+y^2)^2}\right) = \frac{(x^2+y^2)^2(-2x) - (y^2-x^2)\,2(x^2+y^2)\,2x}{(x^2+y^2)^4}$$

$$= \frac{-2x(x^2+y^2) - 4x(y^2-x^2)}{(x^2+y^2)^3}$$

$$= \frac{-2x^3 - 2xy^2 - 4xy^2 + 4x^3}{(x^2+y^2)^3}$$

$$= \frac{2x^3 - 6xy^2}{(x^2+y^2)^3}.$$

$$b_{xxy}(1,1) = \frac{2-6}{(1^2+1^2)^3} = -\frac{4}{8} = -\frac{1}{2}.$$

$$b_{xyy} = \frac{\partial^3 b}{\partial x \partial y^2} = \frac{\partial}{\partial x}\left(\frac{\partial^2 b}{\partial y^2}\right) = \frac{\partial}{\partial x}\left(-\frac{2xy}{(x^2+y^2)^2}\right)$$

$$= \frac{(x^2+y^2)^2(-2y) + 2xy\cdot 2(x^2+y^2)(2x)}{(x^2+y^2)^4}$$

$$= \frac{-2y(x^2+y^2) + 8x^2y}{(x^2+y^2)^3} = \frac{6x^2y - 2y^3}{(x^2+y^2)^3}$$

$$b_{xyy}(1,1) = \frac{6-2}{(1^2+1^2)^3} = \frac{4}{8} = \frac{1}{2}.$$

$$b_{yyy} = \frac{\partial^3 b}{\partial y^3} = \frac{\partial}{\partial y}\left(\frac{\partial^2 b}{\partial y^2}\right)$$

$$= \frac{\partial}{\partial y}\left(-\frac{2xy}{(x^2+y^2)^2}\right) = \frac{(x^2+y^2)^2(-2x) + (2xy)2(x^2+y^2)(2y)}{(x^2+y^2)^4}$$

$$= \frac{-2x(x^2+y^2) + 8xy^2}{(x^2+y^2)^4} = \frac{6xy^2 - 2x^3}{(x^2+y^2)^3}.$$

$$b_{yyy}(1,1) = \frac{6-2}{(1^2+1^2)^2} = \frac{4}{8} = \frac{1}{2}.$$

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Substituting these values in (1), we get

$$\tan^{-1}\left(\frac{y}{x}\right) = \frac{\pi}{4} + \left[(x-1)\left(-\frac{1}{2}\right) + (y-1)\frac{1}{2}\right] + \frac{1}{2!}\left[(x-1)^2\left(\frac{1}{2}\right) + 2(x-1)(y-1)(0) + (y-1)^2\left(-\frac{1}{2}\right)\right] +$$

$$\frac{1}{3!}\left[(x-1)^3\left(-\frac{1}{2}\right) + 3(x-1)^2(y-1) - 3(x-1)(y-1)^2 - (y-1)^3\right] + \cdots\cdots$$

Taking $x = 1.1$ and $y = 0.9$ we get

$$f(1.1, 0.9) = \frac{\pi}{4} - \frac{1}{2}(0.2) + \frac{1}{4}(0) - \frac{1}{12}\left[(0.1)^3 - 3(0.1) - 3(0.1)^3 - (0.1)^3\right].$$

$$= 0.7854 - 0.1000 + 0.0003$$

$$= \underline{\underline{0.6857}}$$

Applications

Maxima and Minima of functions of two variables without Constraints

A function $f(x, y)$ is said to have a maximum value at $x = a$, $y = b$ if $f(a,b) > f(a+h, b+k)$ for small and independent values of h and k, positive (or) negative.

A function $f(x, y)$ is said to have a minimum value at $x = a$, $y = b$ if $f(a,b) < f(a+h, b+k)$ for small and independent values of h and k, positive (or) negative.

A maximum (or) a minimum value of a function is called its extreme value.

Working Rule:

Step 1: Calculate $\frac{\partial f}{\partial x}$ and $\frac{\partial f}{\partial y}$.

Step 2: Solve $\frac{\partial f}{\partial x} = 0$ and $\frac{\partial f}{\partial y} = 0$ simultaneously

Let (a,b), (c,d), ... be the solutions of these equations.

Step 3: Calculate $r = \frac{\partial^2 f}{\partial x^2}$, $s = \frac{\partial^2 f}{\partial x \partial y}$, $t = \frac{\partial^2 f}{\partial y^2}$.

Step 4: For each solution in step 2

a) If $rt - s^2 > 0$ and $r < 0$ for a particular solution (a,b) of step 2 then the given function f has a maximum value at (a,b).

b) If $rt - s^2 > 0$ and $r > 0$ for a particular solution (a,b) of step 2 then f has a minimum value at (a,b).

c) If $rt - s^2 < 0$ for a particular solution (a,b) of step 2 then f have neither maximum nor minimum at (a,b). The point (a,b) is called a saddle point.

d) If $rt - s^2 = 0$ the case is ~~to~~ doubtful and have further investigation is required.

1. Find the extreme values of $x^3+3xy^2-3x^2-3y^2+7$

Sol: Let $f(x,y) = x^3+3xy^2-3x^2-3y^2+7$

Now $\frac{\partial f}{\partial x} = 3x^2+3y^2-6x$

$\frac{\partial f}{\partial y} = 6xy-6y$

Equating $\frac{\partial f}{\partial x}=0$ and $\frac{\partial f}{\partial y}=0$

i.e $3x^2+3y^2-6x=0$ and $6xy-6y=0$.

$\Rightarrow x^2+y^2=2x$ and $y(x-1)=0$.

$\Rightarrow x^2+y^2=2x$ and $y=0$ (or) $x=1$.

If $y=0$ then $x^2=2x$

$\Rightarrow x^2-2x=0$

$\Rightarrow x(x-2)=0 \Rightarrow x=0, x=2$.

If $x=1$ then $y^2=1 \Rightarrow y=\pm 1$.

So the stationary points are $(0,0)$, $(2,0)$, $(1,-1)$ and $(1,1)$.

Calculate $r=\frac{\partial^2 f}{\partial x^2}$, $s=\frac{\partial^2 f}{\partial x\partial y}$, $t=\frac{\partial^2 f}{\partial y^2}$.

$r = \frac{\partial^2 f}{\partial x^2} = \frac{\partial}{\partial x}\left(\frac{\partial f}{\partial x}\right) = \frac{\partial}{\partial x}\left(3x^2+3y^2-6x\right) = 6x-6$.

$s = \frac{\partial^2 f}{\partial x\partial y} = \frac{\partial}{\partial x}\left(\frac{\partial f}{\partial y}\right) = \frac{\partial}{\partial x}\left(6xy-6y\right) = 6y$

$t = \frac{\partial^2 f}{\partial y^2} = \frac{\partial}{\partial y}\left(\frac{\partial f}{\partial y}\right) = \frac{\partial}{\partial y}\left(6xy-6y\right) = 6x-6$.

Now, $rt-s^2 = (6x-6)(6x-6)-(6y)^2$

$= (6x-6)^2-(6y)^2$.

At $(0,0)$: $rt-s^2 = (6(0)-6)^2-(6\times 0)^2 = 36 > 0$

$r = 6(0) - 6 = -6 < 0.$

At the point $(0,0)$ the function $f(x,y)$ has maximum.

At $(2,0)$: $\quad rt - s^2 = (6x-6)^2 - (6y)^2$

$$= (12-6)^2 - (6(0))^2 = 36 > 0.$$

$$r = 6(2) - 6 = 6 > 0.$$

At the point $(2,0)$ the function $f(x,y)$ has minimum.

At $(1,1)$: $\quad rt - s^2 = (6(1)-6)^2 - (6(1))^2 = -36 < 0.$

At the point $(1,1)$ the function $f(x,y)$ has neither maximum nor minimum.

At $(1,-1)$: $\quad rt - s^2 = (6(1)-6)^2 - (6(-1))^2 = -36 < 0$

At the point $(1,-1)$, the function $f(x,y)$ has neither maximum nor minimum.

(2) Examine the following function for extreme values

$$f(x,y) = x^4 + y^4 - 2x^2 + 4xy - 2y^2.$$

Sol: Given $f(x,y) = x^4 + y^4 - 2x^2 + 4xy - 2y^2$

Now, $\dfrac{\partial f}{\partial x} = 4x^3 - 4x + 4y$

$$\frac{\partial f}{\partial y} = 4y^3 + 4x - 4y.$$

$$r = \frac{\partial^2 f}{\partial x^2} = \frac{\partial}{\partial x}\left(\frac{\partial f}{\partial x}\right) = \frac{\partial}{\partial x}\left(4x^3 - 4x + 4y\right) = 12x^2 - 4$$

$$s = \frac{\partial^2 f}{\partial x \partial y} = \frac{\partial}{\partial x}\left(\frac{\partial f}{\partial y}\right) = \frac{\partial}{\partial x}(4y^2 + 4x - 4y) = 4$$

$$t = \frac{\partial^2 f}{\partial y^2} = \frac{\partial}{\partial y}\left(\frac{\partial f}{\partial y}\right) = \frac{\partial}{\partial y}(4y^3 + 4x - 4y) = \cancel{16y - 4}\ 12y^2 - 4$$

Equating $\frac{\partial f}{\partial x} = 0$ and $\frac{\partial f}{\partial y} = 0$

$\Rightarrow \quad 4x^3 - 4x + 4y = 0$ and $4y^3 + 4x - 4y = 0$

Adding these two equations, we get

$$4(x^3 + y^3) = 0$$

$$\Rightarrow y = -x$$

putting $y = -x$ in $4x^3 - 4x + 4y = 0$, we get

$$4x^3 - 8x = 0 \Rightarrow x^3 - 2x = 0$$

$$\Rightarrow x(x^2 - 2) = 0$$

$$\Rightarrow x = 0,\ x^2 - 2 = 0$$

$$\Rightarrow x = 0,\ x = \pm\sqrt{2} \qquad \therefore x = 0, -\sqrt{2}, \sqrt{2}$$

Corresponding y values are $y = 0, \sqrt{2}, -\sqrt{2}$

So the stationary points are $(0,0)$, $(-\sqrt{2}, \sqrt{2})$ and $(\sqrt{2}, -\sqrt{2})$.

At $(0,0)$: $rt - s^2 = \cancel{(12x^2-4)(12y^2-4)}\ (12x^2 - 4)(16y - 4) - 4^2$

$$= 16 - 16 = 0$$

further investigation is needed.

At $(0,0)$, further investigation

At $(-\sqrt{2}, \sqrt{2})$: $rt - s^2 = (24 - 4)(\cancel{16\sqrt{2}}\ 24 - 4) - 16 = 20 \times \cancel{18.62}\ 20 - 16$

$$= \cancel{356.54}\ 384 > 0$$

$$r = 12x^2 - 4 = 120 > 0$$

At $(-\sqrt{2}, \sqrt{2})$ the function $f(x,y)$ has minimum.

At $(\sqrt{2}, -\sqrt{2})$: $rt - s^2 = (24 - 4)(24 - 4) - 16 = 384 > 0$

$$r = 120 > 0$$

At $(-\sqrt{2}, \sqrt{2})$ the function $f(x,y)$ has minimum.

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A maximum (or) a minimum value of a function is called its extreme value.

Working Rule:

Step 1: calculate $\frac{\partial f}{\partial x}$ and $\frac{\partial f}{\partial y}$.

Step 2: Solve $\frac{\partial f}{\partial x} = 0$ and $\frac{\partial f}{\partial y} = 0$ Simultaneously

let (a,b), (c,d), ... be the solutions of these equations.

Step 3: calculate $r = \frac{\partial^2 f}{\partial x^2}$, $s = \frac{\partial^2 f}{\partial x \partial y}$, $t = \frac{\partial^2 f}{\partial y^2}$.

Step 4: For each solution in Step 2

a) If $rt - s^2 > 0$ and $r < 0$ for a particular solution (a,b) of step 2 then the given function f has a maximum value at (a,b).

b) If $rt - s^2 > 0$ and $r > 0$ for a particular Solution (a,b) of step 2 then f has a minimum value at (a,b).

c) If $rt - s^2 < 0$ for a particular solution (a,b) of step 2 then f have neither maximum nor minimum at (a,b). The point (a,b) is called a saddle point.

d) If $rt - s^2 = 0$ the case is ~~be~~ doubtful and have further investigation is required.

1. Find the extreme values of $x^3+3xy^2-3x^2-3y^2+7$

Sol: Let $f(x,y) = x^3+3xy^2-3x^2-3y^2+7$

Now $\frac{\partial f}{\partial x} = 3x^2+3y^2-6x$

$\frac{\partial f}{\partial y} = 6xy-6y$

Equating $\frac{\partial f}{\partial x}=0$ and $\frac{\partial f}{\partial y}=0$

i.e $3x^2+3y^2-6x=0$ and $6xy-6y=0$.

$\Rightarrow x^2+y^2=2x$ and $y(x-1)=0$.

$\Rightarrow x^2+y^2=2x$ and $y=0$ (or) $x=1$.

If $y=0$ then $x^2=2x$.

$\Rightarrow x^2-2x=0$

$\Rightarrow x(x-2)=0 \Rightarrow x=0, x=2$

If $x=1$ then $y^2=1 \Rightarrow y=\pm 1$.

So the stationary points are $(0,0)$, $(2,0)$, $(1,-1)$ and $(1,1)$.

Calculate $r = \frac{\partial^2 f}{\partial x^2}$, $s = \frac{\partial^2 f}{\partial x \partial y}$, $t = \frac{\partial^2 f}{\partial y^2}$.

$r = \frac{\partial^2 f}{\partial x^2} = \frac{\partial}{\partial x}\left(\frac{\partial f}{\partial x}\right) = \frac{\partial}{\partial x}\left(3x^2+3y^2-6x\right) = 6x-6$.

$s = \frac{\partial^2 f}{\partial x \partial y} = \frac{\partial}{\partial x}\left(\frac{\partial f}{\partial y}\right) = \frac{\partial}{\partial x}\left(6xy-6y\right) = 6y$

$t = \frac{\partial^2 f}{\partial y^2} = \frac{\partial}{\partial y}\left(\frac{\partial f}{\partial y}\right) = \frac{\partial}{\partial y}\left(6xy-6y\right) = 6x-6$.

Now, $rt-s^2 = (6x-6)(6x-6)-(6y)^2$

$= (6x-6)^2-(6y)^2$.

At $(0,0)$: $rt-s^2 = (6(0)-6)^2-(6\times 0)^2 = 36 > 0$

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$r = 6(0) - 6 = -6 < 0$

At the point $(0,0)$ the function $f(x,y)$ has maximum.

At $(2,0)$: $rt - s^2 = (6x-6)^2 - (6y)^2$

$= (12-6)^2 - (6(0))^2 = 36 > 0.$

$r = 6(2) - 6 = 6 > 0.$

At the point $(2,0)$ the function $f(x,y)$ has minimum.

At $(1,1)$: $rt - s^2 = (6(1)-6)^2 - (6(1))^2 = -36 < 0.$

At the point $(1,1)$ the function $f(x,y)$ has neither maximum nor minimum.

At $(1,-1)$: $rt - s^2 = (6(1)-6)^2 - (6(-1))^2 = -36 < 0$

At the point $(1,-1)$ the function $f(x,y)$ has neither maximum nor minimum.

(8) Examine the following function for extreme values

$f(x,y) = x^4 + y^4 - 2x^2 + 4xy - 2y^2.$

Sol: Given $f(x,y) = x^4 + y^4 - 2x^2 + 4xy - 2y^2$

Now, $\frac{\partial f}{\partial x} = 4x^3 - 4x + 4y$

$\frac{\partial f}{\partial y} = 4y^3 + 4x - 4y$

$r = \frac{\partial^2 f}{\partial x^2} = \frac{\partial}{\partial x}\left(\frac{\partial f}{\partial x}\right) = \frac{\partial}{\partial x}(4x^3 - 4x + 4y) = 12x^2 - 4$

$$s = \frac{\partial^2 f}{\partial x \partial y} = \frac{\partial}{\partial x}\left(\frac{\partial f}{\partial y}\right) = \frac{\partial}{\partial x}(4y^2 + 4x - 4y) = 4$$

$$t = \frac{\partial^2 f}{\partial y^2} = \frac{\partial}{\partial y}\left(\frac{\partial f}{\partial y}\right) = \frac{\partial}{\partial y}(4y^3 + 4x - 4y) = \cancel{16y - 4}\ 12y^2 - 4$$

Equating $\frac{\partial f}{\partial x} = 0$ and $\frac{\partial f}{\partial y} = 0$.

$\Rightarrow \quad 4x^3 - 4x + 4y = 0$ and $4y^3 + 4x - 4y = 0$.

Adding these two equations we get

$$4(x^3 + y^3) = 0$$

$$\Rightarrow y = -x$$

putting $y = -x$ in $4x^3 - 4x + 4y = 0$, we get

$$4x^3 - 8x = 0 \Rightarrow x^3 - 2x = 0$$
$$\Rightarrow x(x^2 - 2) = 0$$
$$\Rightarrow x = 0, \ x^2 - 2 = 0$$
$$\Rightarrow x = 0, \ x = \pm\sqrt{2} \quad \therefore x = 0, -\sqrt{2}, \sqrt{2}$$

Corresponding y values are $y = 0, \sqrt{2}, -\sqrt{2}$.

So the stationary points are $(0,0)$, $(-\sqrt{2}, \sqrt{2})$ and $(\sqrt{2}, -\sqrt{2})$.

At $(0,0)$: $rt - s^2 = \cancel{(12x^2 - 4)}\ \cancel{(12y^2 - 4)}\ (12x^2 - 4)(16y - 4) - 4^2$

$$= 16 - 16 = 0.$$

At $(0,0)$, further investigation is needed.

At $(-\sqrt{2}, \sqrt{2})$: $rt - s^2 = (24 - 4)(\cancel{16\sqrt{2}}^{24} - 4) - 16 = 20 \times \cancel{18 - 62}^{20} - 16$

$$= \cancel{356 - 54}\ 384 > 0$$

$$r = 12x^2 - 4 = 120 > 0.$$

At $(-\sqrt{2}, \sqrt{2})$ the function $f(x,y)$ has minimum.

At $(\sqrt{2}, -\sqrt{2})$: $rt - s^2 = (24 - 4)(24 - 4) - 16 = 384 > 0$

$$r = 120 > 0.$$

At $(-\sqrt{2}, \sqrt{2})$ the function $f(x,y)$ has minimum.

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UNIT- IV

3. Find the maximum and minimum values of $x^3 + 3xy^2 - 15x^2 - 15y^2 + 72x$.

Sol: Let $f(x,y) = x^3 + 3xy^2 - 15x^2 - 15y^2 + 72x$.

Now, $\frac{\partial f}{\partial x} = 3x^2 + 3y^2 - 30x + 72$

$\frac{\partial f}{\partial y} = 6xy - 30y$

$r = \frac{\partial^2 f}{\partial x^2} = \frac{\partial}{\partial x}\left(\frac{\partial f}{\partial x}\right) = \frac{\partial}{\partial x}(3x^2 + 3y^2 - 30x + 72)$

$= 6x - 30$

$s = \frac{\partial^2 f}{\partial x \partial y} = \frac{\partial}{\partial x}\left(\frac{\partial f}{\partial y}\right) = \frac{\partial}{\partial x}(6xy - 30y) = 6y$

$t = \frac{\partial^2 f}{\partial y^2} = \frac{\partial}{\partial y}\left(\frac{\partial f}{\partial y}\right) = \frac{\partial}{\partial y}(6xy - 30y) = 6x - 30$.

Equating $\frac{\partial f}{\partial x} = 0$ and $\frac{\partial f}{\partial y} = 0$.

$\Rightarrow 3x^2 + 3y^2 - 30x + 72 = 0$ and $6xy - 30y = 0$

$\Rightarrow x^2 + y^2 - 10x + 24 = 0$ and $6y(x-5) = 0$

$y = 0, \ x = 5$.

If $y = 0$ then $x^2 - 10x + 24 = 0$.

$\Rightarrow (x-6)(x-4) = 0$

$\Rightarrow x = 4, 6$.

If $x = 5$ then $25 + y^2 - 50 + 24 = 0$

$\Rightarrow y^2 - 1 = 0 \Rightarrow y^2 = 1 \Rightarrow y = \pm\sqrt{1} = \pm 1$.

The stationary points of f are $(4,0)$, $(6,0)$, $(5,-1)$ and $(5,1)$.

Now, $rt - s^2 = (6x-30)(6x-30) - (6y)^2$

$= (6x-30)^2 - 36y^2$

$r = (6x - 30)$

At $(4,0)$: $rt - s^2 = (24-30)^2 - 36(0) = (-6)^2 = 36 > 0$

$r = 24 - 30 = -6 < 0$

At the point $(4,0)$, the function $f(x,y)$ has maximum

At $(6,0)$: $rt - s^2 = (36-30)^2 - 36(0) = 6^2 = 36 > 0$

$r = 36 - 30 = 6 > 0$

At the point $(6,0)$ the function $f(x,y)$ has minimum.

At $(5,-1)$: $rt - s^2 = (30-30)^2 - (6(-1))^2 = -36 < 0$

At the point $(5,-1)$ the function $f(x,y)$ has neither maximum nor minimum.

At $(5,1)$: $rt - s^2 = (30-30)^2 - (6(1))^2 = -36 < 0$

At the point $(5,1)$ the function $f(x,y)$ has neither maximum nor minimum.

$(5,-1)$ and $(5,1)$ are saddle points.

4. Investigate the maxima and minima, if any of the function $f(x,y) = x^3y^2(1-x-y)$.

Sol:- Given $f(x,y) = x^3y^2(1-x-y) = x^3y^2 - x^4y^2 - x^3y^3$

Now $\dfrac{\partial f}{\partial x} = 3x^2y^2 - 4x^3y^2 - 3x^2y^3$

$\dfrac{\partial f}{\partial y} = 2x^3y - 2x^4y - 3x^3y^2$.

$r = \dfrac{\partial^2 f}{\partial x^2} = \dfrac{\partial}{\partial x}(3x^2y^2 - 4x^3y^2 - 3x^2y^3) = 6xy^2 - 12x^2y^2 - 6xy^3$

$s = \dfrac{\partial^2 f}{\partial x \partial y} = \dfrac{\partial}{\partial x}\left(\dfrac{\partial f}{\partial y}\right) = \dfrac{\partial}{\partial x}\left(2x^3y - 2x^4y - 3x^3y^2\right)$

$$= 6x^2y - 8x^3y - 9x^2y^2$$

$$t = \frac{\partial^2 f}{\partial y^2} = \frac{\partial}{\partial y}\left(\frac{\partial f}{\partial y}\right) = \frac{\partial}{\partial y}\left(2x^3y - 2x^4y - 3x^3y^2\right)$$

$$= 2x^3 - 2x^4 - 6x^3y.$$

Equating $\frac{\partial f}{\partial x} = 0$ and $\frac{\partial f}{\partial y} = 0$

$\Rightarrow$ $3x^2y^2 - 4x^3y^2 - 3x^2y^3 = 0$ and $2x^3y - 2yx^4 - 3x^3y^2 = 0$

$\Rightarrow$ $x^2y^2(3 - 4x - 3y) = 0$ and $x^3y(2 - 2x - 3y) = 0$

$\Rightarrow$ $x = 0,\ y = 0, (3 - 4x - 3y) = 0$ and $x = 0, y = 0, (2 - 2x - 3y) = 0$

$\Rightarrow$ $(x = 0, y = 0)$, $(x = 0, 3 - 4x - 3\overset{=0}{y})$, $(y = 0,\ 3 - 4x - 3y = 0)$,

$(x = 0,\ 2 - 2x - 3y = 0)$ and $(y = 0,\ 2 - 2x - 3y = 0)$.
and $(3 - 4x - 3y = 0,\ 2 - 2x - 3y = 0)$

The critical points are $(0,0), (0,1), (0,\frac{3}{4}), (0,\frac{2}{3})$ and $(\frac{1}{2}, \frac{1}{3})$.

$$4x + 3y = 3$$
$$2x + 3y = 2$$
$$2x = 1$$
$$x = \frac{1}{2}$$
$$1 + 3y = 2$$
$$3y = 1 \Rightarrow y = 1/3$$

Now $rt - s^2 = (6xy^2 - 12x^2y^2 - 6xy^3)(2x^3 - 2x^4 - 6x^3y) - (6x^2y - 8x^3y - 9x^2y^2)^2$

$$r = (6xy^2 - 12x^2y^2 - 6xy^3)$$

There is no extreme value at all points except at $(\frac{1}{2}, \frac{1}{3})$.

At $(\frac{1}{2}, \frac{1}{3})$, $rt - s^2 = \frac{1}{9 \cdot 64} > 0$

$$r = 6\left(\frac{1}{2}\right)\left(\frac{1}{3}\right)^2\left(1 - 2\left(\frac{1}{2}\right) - \frac{1}{3}\right) = -\frac{1}{9} < 0$$

The function $f(x,y)$ is maximum at $(\frac{1}{2}, \frac{1}{3})$.

Maximum value is $f(\frac{1}{2}, \frac{1}{3}) = \left(\frac{1}{8} \cdot \frac{1}{9}\right)\left(1 - \frac{1}{2} - \frac{1}{3}\right)$

$$= \frac{1}{72}\left(\frac{1}{2} - \frac{1}{3}\right) = \underline{\underline{\frac{1}{432}}}$$

5. Find the shortest distance from origin to the surface $xyz^2 = 2$.

<u>Sol:</u> Let $P(x, y, z)$ be any point on the surface

$xyz^2 = 2$. Then $OP = d = \sqrt{(x-0)^2+(y-0)^2+(z-0)^2} = \sqrt{x^2+y^2+z^2}$.

$$\Rightarrow OP^2 = d^2 = x^2+y^2+z^2.$$

Let $f(x,y) = d^2 = x^2+y^2+z^2$

$$= x^2+y^2+\frac{2}{xy} \qquad \left(\because xyz^2 = 2,\ z^2 = \frac{2}{xy}\right)$$

Now $\frac{\partial f}{\partial x} = 2x - \frac{2}{x^2y}$

$$\frac{\partial f}{\partial y} = 2y - \frac{2}{xy^2}$$

$$r = \frac{\partial^2 f}{\partial x^2} = \frac{\partial}{\partial x}\left(\frac{\partial f}{\partial x}\right) = 2 + \frac{4}{x^3y}$$

$$s = \frac{\partial^2 f}{\partial x \partial y} = \frac{\partial}{\partial x}\left(\frac{\partial f}{\partial y}\right) = \frac{\partial}{\partial x}\left(2y - \frac{2}{xy^2}\right) = \frac{2}{x^2y^2}$$

$$t = \frac{\partial^2 f}{\partial y^2} = \frac{\partial}{\partial y}\left(\frac{\partial f}{\partial y}\right) = \frac{\partial}{\partial y}\left(2y - \frac{2}{xy^2}\right) = 2 + \frac{4}{xy^3}.$$

Equating $\frac{\partial f}{\partial x} = 0$ and $\frac{\partial f}{\partial y} = 0$

$\Rightarrow 2x - \frac{2}{x^2y} = 0$ and $2y - \frac{2}{xy^2} = 0$

$\Rightarrow x^3y - 1 = 0$ and $xy^3 - 1 = 0$

$\Rightarrow x^3y = 1$ and $xy^3 = 1$.

$\therefore x^3y = xy^3 \Rightarrow xy(x^2-y^2) = 0$

$$\Rightarrow x^2 - y^2 = 0 \quad (\because x \neq 0,\ y \neq 0)$$

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$\Rightarrow x^2 = y^2 \Rightarrow x = \pm y$.

The stationary points are $(1,1)$ and $(1,-1)$.

At $(1,1)$, $r = \frac{\partial^2 f}{\partial x^2} = 2+4 = 6 > 0$.

$$s = \frac{\partial^2 f}{\partial x \partial y} = 2$$

$$t = \frac{\partial^2 f}{\partial t^2} = 6.$$

$$rt - s^2 = 6 \times 6 - 2^2 = 36 - 4 = 32 > 0.$$

But $z^2 = \frac{2}{xy} = \frac{2}{1} = 2$

$$z = \pm\sqrt{2}.$$

So minimum occurs at $(1, 1, \sqrt{2})$.

Hence, the shortest distance from the origin is

$\sqrt{1+1+2} = \sqrt{4} = \underline{\underline{2}}$.

6. Find the minimum value of $x^2+y^2+z^2$ given that $xyz = a^3$.

Sol:- Let $f(x,y,z) = x^2+y^2+z^2 \rightarrow (1)$

$$xyz = a^3 \rightarrow (2).$$

From (2), $z = \frac{a^3}{xy}$.

Substituting $z = \frac{a^3}{xy}$ in (1), we get

$x^2+y^2+\frac{a^3}{xy} = f(x,y)$ (say).

Now, $f(x,y) = x^2+y^2+\left(\frac{a^3}{xy}\right)^2$

$\frac{\partial f}{} \ldots \frac{a^3}{} \quad \frac{\partial f}{} \ldots \frac{a^3}{}$

Here, $f(x,y) = x^2 + y^2 + \frac{a^6}{x^2 y^2}$

$$\frac{\partial f}{\partial x} = 2x + \frac{a^6}{y^2}\left(-\frac{2}{x^3}\right) = 2x - \frac{2a^6}{x^3 y^2}$$

$$\frac{\partial f}{\partial y} = 2y + \frac{a^6}{x^2}\left(-\frac{2}{y^3}\right) = 2y - \frac{2a^6}{x^2 y^3}$$

$$r = \frac{\partial^2 f}{\partial x^2} = \frac{\partial}{\partial x}\left(2x - \frac{2a^6}{x^3 y^2}\right) = 2 + \frac{6a^6}{x^4 y^2}$$

$$s = \frac{\partial^2 f}{\partial x \partial y} = \frac{\partial}{\partial x}\left(\frac{\partial f}{\partial y}\right) = \frac{\partial}{\partial x}\left(2y - \frac{2a^6}{x^2 y^3}\right) = \frac{4a^6}{x^3 y^3}$$

$$t = \frac{\partial^2 f}{\partial y^2} = \frac{\partial}{\partial y}\left(2y - \frac{2a^6}{x^2 y^3}\right) = 2 + \frac{6a^6}{x^2 y^4}$$

Equating $\frac{\partial f}{\partial x} = 0$ and $\frac{\partial f}{\partial y} = 0$

$\Rightarrow 2x - \frac{2a^6}{x^3 y^2} = 0$ and $2y - \frac{2a^6}{x^2 y^3} = 0$

$\Rightarrow x^4 y^2 = a^6$ and $x^2 y^4 = a^6$

$\Rightarrow x^4 y^2 = x^2 y^4$

$\Rightarrow x^2 = y^2$

$\Rightarrow x = y = a.$ $\quad\left(\begin{matrix} x^6 = a^6 \\ x = a \end{matrix}\right)$

The stationary point is (a,a).

At (a,a) : $r = 2 + 6 = 8 > 0$

$rt - s^2 = (8)(8) - 16 = 64 - 16 = 48 > 0$

f is minimum at (a,a) and the minimum value is $a^2 + a^2 + \frac{a^6}{a^2 \times a^2}$

$= 3a^2$

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7. The sum of three numbers is constant. Prove that their product is a maximum when they are equal.

Sol:- Let x, y, z be the given numbers.

Given that $x+y+z = c$

$$\Rightarrow z = c-x-y.$$

The product of the numbers is xyz

Let, $p = xyz = xy(c-x-y)$

Now, $\frac{\partial p}{\partial x} = cy - 2xy - y^2$

$$\frac{\partial p}{\partial y} = cx - x^2 - 2xy$$

$$r = \frac{\partial^2 p}{\partial x^2} = \frac{\partial}{\partial x}\left(\frac{\partial p}{\partial x}\right) = -2y$$

$$s = \frac{\partial^2 p}{\partial x \partial y} = \frac{\partial}{\partial x}\left(\frac{\partial p}{\partial y}\right) = \frac{\partial}{\partial x}(cx - x^2 - 2xy) = c-2x-2y$$

$$t = \frac{\partial^2 p}{\partial y^2} = \frac{\partial}{\partial y}\left(\frac{\partial p}{\partial y}\right) = -2x.$$

Equating $\frac{\partial p}{\partial x} = 0$ and $\frac{\partial p}{\partial y} = 0$.

$\Rightarrow cy - 2xy - y^2 = 0$ and $cx - x^2 - 2xy = 0$

$\Rightarrow c = 2x + y \rightarrow (1)$ and $c = x + 2y \rightarrow (2)$.

From (1) and (2), we get $x = y$

Substituting in (1), we get $c = 3x$

$$\therefore z = 3x - x - x = x.$$

$$\therefore x = y = z$$

At $x = y = z$, $rt - s^2 = (-2y)(-2x) - (c-2x-2y)^2$

$$= 4xy - (c-2x-2y)^2$$

$$= 4x^2 - x^2 = 3x^2 > 0$$

[illegible] xy [illegible] 0

f is maximum for $x = y = z$.

The product is maximum if the numbers are equal.

8. Find the extreme points $f(x, y) = 1 - x^2 - y^2$.

9. Discuss the maxima and minima of

$u = \sin x \sin y \sin(x+y)$.

Lagrange's method of undetermined multiplier

Consider the function $f(x, y, z)$ where x, y, z are connected by the relation $\phi(x, y, z) = 0$.

Now to find the stationary values of $f(x, y, z)$ under the constraint $\phi(x, y, z) = 0$.

Write $F(x, y, z) = f(x, y, z) + \lambda\, \phi(x, y, z)$.

Obtain the equations $\frac{\partial F}{\partial x} = 0$, $\frac{\partial F}{\partial y} = 0$, $\frac{\partial F}{\partial z} = 0$.

Solve the above equations together with $\phi(x, y, z) = 0$. The values of x, y, z so obtained will give the stationary value of $f(x, y, z)$.

1. Find a point on the plane $2x+3y-z=5$, which is nearest to the origin.

Sol: Let $P(x,y,z)$ be a point on the plane. The distance between $O(0,0,0)$ and $P(x,y,z)$ is

$d = \sqrt{(x-0)^2+(y-0)^2+(z-0)^2} = \sqrt{x^2+y^2+z^2}$

$\Rightarrow d^2 = x^2+y^2+z^2$

Let, $f = x^2+y^2+z^2 \quad \cdots (1)$

Now the problem is to minimize $f = x^2+y^2+z^2$

Subject to the condition $\phi(x,y,z) = 2x+3y-z-5 \quad \cdots (2)$

Let $F(x,y,z) = f(x,y,z) + \lambda\,\phi(x,y,z)$

$= (x^2+y^2+z^2) + \lambda(2x+3y-z-5)$

$\frac{\partial F}{\partial x} = 2x+2\lambda, \quad \frac{\partial F}{\partial y} = 2y+3\lambda, \quad \frac{\partial F}{\partial z} = 2z-\lambda$

Now, $\frac{\partial F}{\partial x} = 0 \Rightarrow 2x+2\lambda = 0 \Rightarrow x = -\lambda$

$\frac{\partial F}{\partial y} = 0 \Rightarrow 2y+3\lambda = 0 \Rightarrow y = -\frac{3}{2}\lambda$

$\frac{\partial F}{\partial z} = 0 \Rightarrow 2z-\lambda = 0 \Rightarrow z = \frac{1}{2}\lambda$

Substitute x, y, z in (2), we get

$-2\lambda + 3\left(-\frac{3}{2}\lambda\right) - \frac{1}{2}\lambda = 5$

$\Rightarrow -2\lambda - \frac{9\lambda}{2} - \frac{\lambda}{2} = 5 \Rightarrow -4\lambda - 10\lambda = 10$

$\Rightarrow \lambda = -\frac{10}{14} = -\frac{5}{7}$

$\therefore x = -\frac{5}{7}, \quad y = \frac{15}{14}, \quad z = -\frac{5}{14}$

Hence $\left(\frac{5}{7}, \frac{15}{14}, -\frac{5}{14}\right)$ is the point on the plane nearest to the origin.

(3) Find the minimum value of $x^2+y^2+z^2$ if $ax+by+cz = p$

Sol. Let $f(x,y,z) = x^2+y^2+z^2 \rightarrow (1)$

and $\phi(x,y,z) = ax+by+cz-p = 0 \rightarrow (2)$

Let $F(x,y,z) = f(x,y,z) + \lambda\, \phi(x,y,z)$

$F(x,y,z) = x^2+y^2+z^2 + \lambda(ax+by+cz-p)$

$\frac{\partial F}{\partial x} = 2x + a\lambda$

$\frac{\partial F}{\partial y} = 2y + b\lambda$

$\frac{\partial F}{\partial z} = 2z + c\lambda$

Now, $\frac{\partial F}{\partial x} = 0 \Rightarrow 2x + a\lambda = 0 \Rightarrow x = -\frac{a\lambda}{2}$

$\frac{\partial F}{\partial y} = 0 \Rightarrow 2y + b\lambda = 0 \Rightarrow y = -\frac{b\lambda}{2}$

$\frac{\partial F}{\partial z} = 0 \Rightarrow 2z + c\lambda = 0 \Rightarrow z = -\frac{c\lambda}{2}$

Substituting x, y, z in (2), we get

$$a\left(-\frac{a\lambda}{2}\right) + b\left(-\frac{b\lambda}{2}\right) + c\left(-\frac{c\lambda}{2}\right) = p$$

$$\Rightarrow \lambda\left(-\frac{a^2}{2} - \frac{b^2}{2} - \frac{c^2}{2}\right) = p$$

$$\Rightarrow \lambda = -\frac{2p}{a^2+b^2+c^2}$$

$$\therefore x = -\frac{a}{2}\left(-\frac{2p}{a^2+b^2+c^2}\right) = \frac{ap}{a^2+b^2+c^2}$$

$$y = -\frac{b}{2}\left(-\frac{2p}{a^2+b^2+c^2}\right) = \frac{bp}{a^2+b^2+c^2}$$

$$z = -\frac{c}{2}\left(-\frac{2p}{a^2+b^2+c^2}\right) = \frac{cp}{a^2+b^2+c^2}$$

Minimum value of f is $x^2+y^2+z^2$

$$\left(\frac{ap}{a^2+b^2+c^2}\right)^2+\left(\frac{bp}{a^2+b^2+c^2}\right)^2+\left(\frac{cp}{a^2+b^2+c^2}\right)^2$$

$$\frac{a^2p^2}{(a^2+b^2+c^2)^2}+\frac{b^2p^2}{(a^2+b^2+c^2)^2}+\frac{c^2p^2}{(a^2+b^2+c^2)^2}$$

$$\frac{p^2(a^2+b^2+c^2)}{(a^2+b^2+c^2)^2}=\frac{p^2}{a^2+b^2+c^2}$$

(3) Find the minimum value of $x^2+y^2+z^2$ given $x+y+z=3a$

Sol: Let $f(x,y,z)=x^2+y^2+z^2 \rightarrow (1)$

and $\phi(x,y,z)=x+y+z-3a=0 \rightarrow (2)$

Let $F(x,y,z)=f(x,y,z)+\lambda\,\phi(x,y,z)$

$F(x,y,z)=x^2+y^2+z^2+\lambda(x+y+z-3a)$

$\frac{\partial F}{\partial x}=2x+\lambda$, $\frac{\partial F}{\partial y}=2y+\lambda$, $\frac{\partial F}{\partial z}=2z+\lambda$

Now, $\frac{\partial F}{\partial x}=0$, $\frac{\partial F}{\partial y}=0$, $\frac{\partial F}{\partial z}=0$

$2x+\lambda=0 \qquad 2y+\lambda=0 \qquad 2z+\lambda=0$

$x=-\frac{\lambda}{2} \qquad y=-\frac{\lambda}{2} \qquad z=-\frac{\lambda}{2}$

Substituting x, y, z in (2), we get

$$-\frac{\lambda}{2}-\frac{\lambda}{2}-\frac{\lambda}{2}=3a \Rightarrow \lambda\left(-\frac{3}{2}\right)=3a$$

$$\Rightarrow \lambda=-2a$$

$\therefore x=a,\quad y=a,\quad z=a$

The minimum value of is $x^2+y^2+z^2=a^2+a^2+a^2$

$$=3a^2$$

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Find the maximum value of $x^2 y^3 z^4$ if $2x + 3y + 4z = a$.

Let $f(x, y, z) = x^2 y^3 z^4 \rightarrow (1)$

and $\phi(x, y, z) = 2x + 3y + 4z - a = 0 \rightarrow (2)$

Let $F(x, y, z) = f(x, y, z) + \lambda\, \phi(x, y, z)$.

$F(x, y, z) = x^2 y^3 z^4 + \lambda(2x + 3y + 4z - a)$

$\frac{\partial F}{\partial x} = 2x y^3 z^4 + 2\lambda$, $\frac{\partial F}{\partial y} = 3x^2 y^2 z^4 + 3\lambda$,

$\frac{\partial F}{\partial z} = 4x^2 y^3 z^3 + 4\lambda$.

Now $\frac{\partial F}{\partial x} = 0$, $\frac{\partial F}{\partial y} = 0$, $\frac{\partial F}{\partial z} = 0$.

$\Rightarrow x y^3 z^4 = -\lambda \rightarrow (3)$ $x^2 y^2 z^4 = -\lambda \rightarrow (4)$ $x^2 y^3 z^3 = -\lambda \rightarrow (5)$

From (3) and (4), we get $x = y$

(4) and (5) we get $y = z$.

Substituting x, y, z in (2) we get $x = y = z = \frac{a}{9}$.

$\therefore$ maximum value of f is $\left(\frac{a}{9}\right)^2 \left(\frac{a}{9}\right)^3 \left(\frac{a}{9}\right)^4$

$= \left(\frac{a}{9}\right)^9$.

— x —

The chain Rule of partial differentiation:

If $z = f(x,y)$ where $x = \phi(t)$, $y = \psi(t)$ then z is called a composite function of a variable t.

If $z = f(x,y)$ where $x = \phi(u,v)$, $y = \psi(u,v)$ then z is called a composite function of two variables u and v.

Result: Let $z = f(u,v)$ where $u = \phi(x,y)$ and $v = \psi(x,y)$. Then

$$\frac{\partial z}{\partial x} = \frac{\partial z}{\partial u}\frac{\partial u}{\partial x} + \frac{\partial z}{\partial v}\frac{\partial v}{\partial x}$$

and $$\frac{\partial z}{\partial y} = \frac{\partial z}{\partial u}\frac{\partial u}{\partial y} + \frac{\partial z}{\partial v}\frac{\partial v}{\partial y}$$

These are referred to as the chain rule of partial differentiation. The above rule can be extended to functions of more than two independent variables.

Total differential Coefficient:

Let $z = f(x,y)$ where $x = \phi(t)$ and $y = \psi(t)$. Substituting x and y in $z = f(x,y)$, z becomes a function of a single variable t. Then the derivative of z with respect to 't' i.e, $\frac{dz}{dt}$ is called the total differential coefficient (or) total derivative of z.

$$\therefore \frac{dz}{dx} = \frac{\partial z}{\partial x}\frac{dx}{dt} + \frac{\partial z}{\partial y}\frac{dy}{dt}$$

UNIT - IV 30.04.2021

If $u = lx + my$ and $v = mx - ly$. Show that

$$\left(\frac{\partial u}{\partial x}\right)_y \left(\frac{\partial x}{\partial u}\right)_v = \frac{l^2}{l^2+m^2} \text{ and } \left(\frac{\partial y}{\partial v}\right)_x \left(\frac{\partial v}{\partial y}\right)_u = \frac{l^2+m^2}{l^2}$$

Given $u = lx + my \rightarrow (1)$

$v = mx - ly \rightarrow (2)$

$\left(\frac{\partial u}{\partial x}\right)_y =$ The partial derivative of u w.r.to x keeping y as constant $= l$

$\left(\frac{\partial x}{\partial u}\right)_v =$ The partial derivative of x w.r.to u keeping v as constant.

First express the variable x interms of u and v.

$(1)\times l + (2)\times m$, we get $lu + mv = l^2x + lmy + m^2x - lmy$

$= l^2x + m^2x = (l^2+m^2)x$.

$$\therefore x = \frac{l}{l^2+m^2}u + \frac{m}{l^2+m^2}v$$

$$\left(\frac{\partial x}{\partial u}\right)_v = \frac{l}{l^2+m^2}$$

Hence $\left(\frac{\partial u}{\partial x}\right)_y \left(\frac{\partial x}{\partial u}\right)_v = l\cdot\frac{l}{l^2+m^2} = \frac{l^2}{l^2+m^2}$

$\left(\frac{\partial y}{\partial v}\right)_x =$ The partial derivative of y w.r.to 'v' keeping x as constant

Now, $v = mx - ly \Rightarrow -l\frac{\partial y}{\partial v} = 1 \Rightarrow \frac{\partial y}{\partial v} = -\frac{1}{l}$.

$\left(\frac{\partial v}{\partial y}\right)_u =$ The partial derivative of v w.r.to 'y' keeping u as constant.

$(1)\times m - (2)\times l$, we get $mu - vl = lmx + m^2y - lmx + l^2y$

$= m^2y + l^2y = (m^2+l^2)y$

$$-l\cdot\frac{\partial v}{\partial y} = (m^2+l^2) \Rightarrow \frac{\partial v}{\partial y} = -\frac{m^2+l^2}{l}.$$

$$\therefore \left(\frac{\partial y}{\partial v}\right)_x \left(\frac{\partial v}{\partial y}\right)_u = \left(-\frac{1}{l}\right)\left(-\frac{m^2+l^2}{l}\right) = \frac{m^2+l^2}{l^2}.$$

Example 3 : Find $\dfrac{\partial u}{\partial x}+\dfrac{\partial u}{\partial y}$ if $u=f(x+y,x-y)$ [JNTU (K) Dec. 2016 (Set N

Solution : Let $v=x+y$ and $w=x-y$. Then $u=f(v,w)$

Now $\dfrac{\partial v}{\partial x}=1,\dfrac{\partial v}{\partial y}=1$ and $\dfrac{\partial w}{\partial x}=1,\dfrac{\partial w}{\partial y}=-1$

By Chain rule of differentiation, we have

$$\frac{\partial u}{\partial x}=\frac{\partial u}{\partial v}\frac{\partial v}{\partial x}+\frac{\partial u}{\partial w}\frac{\partial w}{\partial x}=\frac{\partial u}{\partial v}(1)+\frac{\partial u}{\partial w}(1)=\frac{\partial u}{\partial v}+\frac{\partial u}{\partial w} \quad ...(1)$$

$$\frac{\partial u}{\partial y}=\frac{\partial u}{\partial v}\frac{\partial v}{\partial y}+\frac{\partial u}{\partial w}\frac{\partial w}{\partial y}=\frac{\partial u}{\partial v}(1)+\frac{\partial u}{\partial w}(-1)=\frac{\partial u}{\partial v}-\frac{\partial u}{\partial w} \quad ...(2)$$

(1) + (2) gives

$$\frac{\partial u}{\partial x}+\frac{\partial u}{\partial y}=\left(\frac{\partial u}{\partial v}+\frac{\partial u}{\partial w}\right)+\left(\frac{\partial u}{\partial v}-\frac{\partial u}{\partial w}\right)=2\frac{\partial u}{\partial v}$$

Example 4 : If $u=f(2x-3y,3y-4z,4z-2x)$ then prove that $\dfrac{1}{2}\dfrac{\partial u}{\partial x}+\dfrac{1}{3}\dfrac{\partial u}{\partial y}+\dfrac{1}{4}\dfrac{\partial u}{\partial z}=$

Solution : Given $u=f(2x-3y,3y-4z,4z-2x)$

Let $r=2x-3y,s=3y-4z$ and $t=4z-2x$

Now $\dfrac{\partial u}{\partial x}=\dfrac{\partial u}{\partial r}.\dfrac{\partial r}{\partial x}+\dfrac{\partial u}{\partial s}.\dfrac{\partial s}{\partial x}+\dfrac{\partial u}{\partial t}.\dfrac{\partial t}{\partial x}$

$$=\frac{\partial u}{\partial r}(2)+\frac{\partial u}{\partial s}(0)+\frac{\partial u}{\partial t}(-2)=2\frac{\partial u}{\partial r}-2\frac{\partial u}{\partial t}$$

$$\Rightarrow \frac{1}{2}\frac{\partial u}{\partial x}=\frac{\partial u}{\partial r}-\frac{\partial u}{\partial t} \quad ...(1)$$

$$\frac{\partial u}{\partial y}=\frac{\partial u}{\partial r}.\frac{\partial r}{\partial y}+\frac{\partial u}{\partial s}.\frac{\partial s}{\partial y}+\frac{\partial u}{\partial t}.\frac{\partial t}{\partial y}$$

$$= \frac{\partial u}{\partial r}(-3) + \frac{\partial u}{\partial s}(3) + \frac{\partial u}{\partial t}(0) = -3\frac{\partial u}{\partial r} + 3\frac{\partial u}{\partial s}$$

$$\Rightarrow \frac{1}{3}\frac{\partial u}{\partial y} = \frac{\partial u}{\partial s} - \frac{\partial u}{\partial r} \qquad \ldots(2)$$

and $\dfrac{\partial u}{\partial z} = \dfrac{\partial u}{\partial r}\cdot\dfrac{\partial r}{\partial z} + \dfrac{\partial u}{\partial s}\cdot\dfrac{\partial s}{\partial z} + \dfrac{\partial u}{\partial t}\cdot\dfrac{\partial t}{\partial z}$

$$= \frac{\partial u}{\partial r}(0) + \frac{\partial u}{\partial s}(-4) + \frac{\partial u}{\partial t}(4) = -4\frac{\partial u}{\partial s} + 4\frac{\partial u}{\partial t}$$

$$\Rightarrow \frac{1}{4}\frac{\partial u}{\partial z} = \frac{\partial u}{\partial t} - \frac{\partial u}{\partial s} \qquad \ldots(3)$$

$(1)+(2)+(3)$ gives

$$\frac{1}{2}\frac{\partial u}{\partial x} + \frac{1}{3}\frac{\partial u}{\partial y} + \frac{1}{4}\frac{\partial u}{\partial z} = \left(\frac{\partial u}{\partial r} - \frac{\partial u}{\partial t}\right) + \left(\frac{\partial u}{\partial s} - \frac{\partial u}{\partial r}\right) + \left(\frac{\partial u}{\partial t} - \frac{\partial u}{\partial s}\right) = 0$$

Example 5 : If $u = f(y-z, z-x, x-y)$ prove that $\dfrac{\partial u}{\partial x} + \dfrac{\partial u}{\partial y} + \dfrac{\partial u}{\partial z} = 0$

(or) If $u = f(x-y, y-z, z-x)$, find $\dfrac{\partial u}{\partial x} + \dfrac{\partial u}{\partial y} + \dfrac{\partial u}{\partial z}$

Solution : Let $r = y-z,\ s = z-x,\ t = x-y$. Then $u = f(r,s,t)$

Now $\dfrac{\partial r}{\partial x} = 0,\ \dfrac{\partial r}{\partial y} = 1,\ \dfrac{\partial r}{\partial z} = -1$

$\dfrac{\partial s}{\partial x} = -1,\ \dfrac{\partial s}{\partial y} = 0,\ \dfrac{\partial s}{\partial z} = 1$

and $\dfrac{\partial t}{\partial x} = 1,\ \dfrac{\partial t}{\partial y} = -1,\ \dfrac{\partial t}{\partial z} = 0$

$\therefore$ By chain rule of partial differentiation, we have

$$\frac{\partial u}{\partial x} = \frac{\partial u}{\partial r}\frac{\partial r}{\partial x} + \frac{\partial u}{\partial s}\frac{\partial s}{\partial x} + \frac{\partial u}{\partial t}\frac{\partial t}{\partial x}$$

$$= \frac{\partial u}{\partial r}(0) + \frac{\partial u}{\partial s}(-1) + \frac{\partial u}{\partial t}(1) = -\frac{\partial u}{\partial s} + \frac{\partial u}{\partial t} \qquad \ldots(1)$$

$$\frac{\partial u}{\partial y} = \frac{\partial u}{\partial r}\frac{\partial r}{\partial y} + \frac{\partial u}{\partial s}\frac{\partial s}{\partial y} + \frac{\partial u}{\partial t}\frac{\partial t}{\partial y}$$

$$= \frac{\partial u}{\partial r}(1) + \frac{\partial u}{\partial s}(0) + \frac{\partial u}{\partial t}(-1) = \frac{\partial u}{\partial r} - \frac{\partial u}{\partial t} \qquad \ldots(2)$$

and $\dfrac{\partial u}{\partial z} = \dfrac{\partial u}{\partial r}\dfrac{\partial r}{\partial z} + \dfrac{\partial u}{\partial s}\dfrac{\partial s}{\partial z} + \dfrac{\partial u}{\partial t}\dfrac{\partial t}{\partial z}$

$$= \frac{\partial u}{\partial r}(-1) + \frac{\partial u}{\partial s}(1) + \frac{\partial u}{\partial t}(0) = -\frac{\partial u}{\partial r} + \frac{\partial u}{\partial s} \qquad \ldots(3)$$

(1) + (2) + (3) gives

$$\frac{\partial u}{\partial x}+\frac{\partial u}{\partial y}+\frac{\partial u}{\partial z}=\left(-\frac{\partial u}{\partial s}+\frac{\partial u}{\partial t}\right)+\left(\frac{\partial u}{\partial r}-\frac{\partial u}{\partial t}\right)+\left(-\frac{\partial u}{\partial r}+\frac{\partial u}{\partial s}\right)=0$$

Hence the result.

Example 6 : If $u=f(r,s,t)$ where $r=\frac{x}{y}$, $s=\frac{y}{z}$ and $t=\frac{z}{x}$ show that $x\frac{\partial u}{\partial x}+y\frac{\partial u}{\partial y}+z\frac{\partial u}{\partial z}=0$.

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(or) If $u=f\left(\frac{x}{y},\frac{y}{z},\frac{z}{x}\right)$ then prove that $x\frac{\partial u}{\partial x}+y\frac{\partial u}{\partial y}+z\frac{\partial u}{\partial z}=0$

Solution : We have

$u=f(r,s,t)$ and $r=\frac{x}{y}$, $s=\frac{y}{z}$, $t=\frac{z}{x}$

$$\therefore\quad \frac{\partial r}{\partial x}=\frac{1}{y},\quad \frac{\partial r}{\partial y}=\frac{-x}{y^2},\quad \frac{\partial r}{\partial z}=0$$

$$\frac{\partial s}{\partial x}=0,\quad \frac{\partial s}{\partial y}=\frac{1}{z},\quad \frac{\partial s}{\partial z}=\frac{-y}{z^2}$$

and $\frac{\partial t}{\partial x}=\frac{-z}{x^2}$, $\frac{\partial t}{\partial y}=0$, $\frac{\partial t}{\partial z}=\frac{1}{x}$

By chain rule of partial differentiation, we have

$$\frac{\partial u}{\partial x}=\frac{\partial u}{\partial r}\frac{\partial r}{\partial x}+\frac{\partial u}{\partial s}\frac{\partial s}{\partial x}+\frac{\partial u}{\partial t}\frac{\partial t}{\partial x}$$

$$=\frac{\partial u}{\partial r}\left(\frac{1}{y}\right)+\frac{\partial u}{\partial s}(0)+\frac{\partial u}{\partial t}\left(\frac{-z}{x^2}\right)=\frac{1}{y}\frac{\partial u}{\partial r}-\frac{z}{x^2}\frac{\partial u}{\partial t}$$

$$\therefore x\frac{\partial u}{\partial x}=\frac{x}{y}\frac{\partial u}{\partial r}-\frac{z}{x}\frac{\partial u}{\partial t} \qquad \ldots(1)$$

Now $\frac{\partial u}{\partial y}=\frac{\partial u}{\partial r}\frac{\partial r}{\partial y}+\frac{\partial u}{\partial s}\frac{\partial s}{\partial y}+\frac{\partial u}{\partial t}\frac{\partial t}{\partial y}$

$$=\frac{\partial u}{\partial r}\left(\frac{-x}{y^2}\right)+\frac{\partial u}{\partial s}\left(\frac{1}{z}\right)+\frac{\partial u}{\partial t}(0)=-\frac{x}{y^2}\frac{\partial u}{\partial r}+\frac{1}{z}\frac{\partial u}{\partial s}$$

$$\therefore y\frac{\partial u}{\partial y}=-\frac{x}{y}\frac{\partial u}{\partial r}+\frac{y}{z}\frac{\partial u}{\partial s} \qquad \ldots(2)$$

and $\frac{\partial u}{\partial z}=\frac{\partial u}{\partial r}\frac{\partial r}{\partial z}+\frac{\partial u}{\partial s}\frac{\partial s}{\partial z}+\frac{\partial u}{\partial t}\frac{\partial t}{\partial z}$

$$=\frac{\partial u}{\partial r}(0)+\frac{\partial u}{\partial s}\left(-\frac{y}{z^2}\right)+\frac{\partial u}{\partial t}\left(\frac{1}{x}\right)=\frac{-y}{z^2}\frac{\partial u}{\partial s}+\frac{1}{x}\frac{\partial u}{\partial t}$$

$$\therefore z\frac{\partial u}{\partial z}=\frac{-y}{z}\frac{\partial u}{\partial s}+\frac{z}{x}\frac{\partial u}{\partial t} \qquad \ldots(3)$$

(1) + (2) + (3) gives

$$x\frac{\partial u}{\partial x}+y\frac{\partial u}{\partial y}+z\frac{\partial u}{\partial z}=\left(\frac{x}{y}\frac{\partial u}{\partial r}-\frac{z}{x}\frac{\partial u}{\partial t}\right)+\left(-\frac{x}{y}\frac{\partial u}{\partial r}+\frac{y}{z}\frac{\partial u}{\partial s}\right)+\left(-\frac{y}{z}\frac{\partial u}{\partial s}+\frac{z}{x}\frac{\partial u}{\partial t}\right)=0$$

Hence the result.

A maximum (or) a minimum value of a function is called its extreme value.

Working Rule:

Step 1: calculate $\frac{\partial f}{\partial x}$ and $\frac{\partial f}{\partial y}$.

Step 2: Solve $\frac{\partial f}{\partial x} = 0$ and $\frac{\partial f}{\partial y} = 0$ Simultaneously

Let (a,b), (c,d), ... be the solutions of these equations.

Step 3: calculate $r = \frac{\partial^2 f}{\partial x^2}$, $s = \frac{\partial^2 f}{\partial x \partial y}$, $t = \frac{\partial^2 f}{\partial y^2}$.

Step 4: for each solution in step 2

a) If $rt - s^2 > 0$ and $r < 0$ for a particular solution (a, b) of step 2 then the given function f has a maximum value at (a,b).

b) If $rt - s^2 > 0$ and $r > 0$ for a particular solution (a, b) of step 2 then f has a minimum value at (a, b).

c) If $rt - s^2 < 0$ for a particular solution (a, b) of step 2 then f have neither maximum nor minimum at (a,b). The point (a,b) is called a saddle point.

d) If $rt - s^2 = 0$ the case is ~~so~~ doubtful and have further investigation is required.

1. Find the extreme values of $x^3 + 3xy^2 - 3x^2 - 3y^2 + 7$

Sol: Let $f(x,y) = x^3 + 3xy^2 - 3x^2 - 3y^2 + 7$

Now $\frac{\partial f}{\partial x} = 3x^2 + 3y^2 - 6x$

$\frac{\partial f}{\partial y} = 6xy - 6y$

Equating $\frac{\partial f}{\partial x} = 0$ and $\frac{\partial f}{\partial y} = 0$

i.e $3x^2 + 3y^2 - 6x = 0$ and $6xy - 6y = 0$.

$\Rightarrow x^2 + y^2 = 2x$ and $y(x-1) = 0$.

$\Rightarrow x^2 + y^2 = 2x$ and $y = 0$ (or) $x = 1$.

If $y = 0$ then $x^2 = 2x$

$\Rightarrow x^2 - 2x = 0$

$\Rightarrow x(x-2) = 0 \Rightarrow x = 0,\ x = 2$

If $x = 1$ then $y^2 = 1 \Rightarrow y = \pm 1$.

So the stationary points are $(0,0)$, $(2,0)$, $(1,-1)$ and $(1,1)$.

<u>Calculate</u> $r = \frac{\partial^2 f}{\partial x^2}$, $s = \frac{\partial^2 f}{\partial x \partial y}$, $t = \frac{\partial^2 f}{\partial y^2}$.

$r = \frac{\partial^2 f}{\partial x^2} = \frac{\partial}{\partial x}\left(\frac{\partial f}{\partial x}\right) = \frac{\partial}{\partial x}\left(3x^2 + 3y^2 - 6x\right) = 6x - 6$.

$s = \frac{\partial^2 f}{\partial x \partial y} = \frac{\partial}{\partial x}\left(\frac{\partial f}{\partial y}\right) = \frac{\partial}{\partial x}\left(6xy - 6y\right) = 6y$

$t = \frac{\partial^2 f}{\partial y^2} = \frac{\partial}{\partial y}\left(\frac{\partial f}{\partial y}\right) = \frac{\partial}{\partial y}\left(6xy - 6y\right) = 6x - 6$.

Now, $rt - s^2 = (6x-6)(6x-6) - (6y)^2$

$= (6x-6)^2 - (6y)^2$.

At $(0,0)$: $rt - s^2 = (6(0)-6)^2 - (6\times 0)^2 = 36 > 0$

If $u = lx + my$ and $v = mx - ly$, Show that

$\left(\frac{\partial u}{\partial x}\right)_y \left(\frac{\partial x}{\partial u}\right)_v = \frac{l^2}{l^2+m^2}$ and $\left(\frac{\partial y}{\partial v}\right)_x \left(\frac{\partial v}{\partial y}\right)_u = \frac{l^2+m^2}{l^2}$

- Given $u = lx + my \rightarrow (1)$

$v = mx - ly \rightarrow (2)$

$\left(\frac{\partial u}{\partial x}\right)_y$ = The partial derivative of u w.r.to x keeping y as constant $= l$

$\left(\frac{\partial x}{\partial u}\right)_v$ = The partial derivative of x w.r.to u keeping v as constant.

First express the variable x interms of u and v.

$(1) \times l + (2) \times m$, we get $lu + mv = l^2x + lmy + m^2x - lmy$

$= l^2x + m^2x = (l^2+m^2)x$

$\therefore x = \frac{l}{l^2+m^2}u + \frac{m}{l^2+m^2}v$

$\left(\frac{\partial x}{\partial u}\right)_v = \frac{l}{l^2+m^2}$

Hence $\left(\frac{\partial u}{\partial x}\right)_y \left(\frac{\partial x}{\partial u}\right)_v = l \cdot \frac{l}{l^2+m^2} = \frac{l^2}{l^2+m^2}$.

$\left(\frac{\partial y}{\partial v}\right)_x$ = The partial derivative of y w.r.to 'v' keeping x as constant

Now, $v = mx - ly \Rightarrow -l\frac{\partial y}{\partial v} = 1 \Rightarrow \frac{\partial y}{\partial v} = -\frac{1}{l}$.

$\left(\frac{\partial v}{\partial y}\right)_u$ = The partial derivative of v w.r.to 'y' keeping u as constant

$(1) \times m - (2) \times l$, we get $mu - vl = lmx + m^2y - lmx + l^2y$

$= m^2y + l^2y = (m^2+l^2)y$

$-l \cdot \frac{\partial v}{\partial y} = (m^2+l^2) \Rightarrow \frac{\partial v}{\partial y} = -\frac{m^2+l^2}{l}$.

$\therefore \left(\frac{\partial y}{\partial v}\right)_x \left(\frac{\partial v}{\partial y}\right)_u = \left(-\frac{1}{l}\right)\left(-\frac{m^2+l^2}{l}\right) = \frac{m^2+l^2}{l^2}$.

$r = 6(0) - 6 = -6 < 0$

At the point $(0,0)$ the function $f(x,y)$ has maximum.

At $(2,0)$: $rt - s^2 = (6x-6)^2 - (6y)^2$

$$= (12-6)^2 - (6(0))^2 = 36 > 0.$$

$$r = 6(2) - 6 = 6 > 0.$$

At the point $(2,0)$ the function $f(x,y)$ has minimum.

At $(1,1)$: $rt - s^2 = (6(1)-6)^2 - (6(1))^2 = -36 < 0.$

At the point $(1,1)$ the function $f(x,y)$ has neither maximum nor minimum.

At $(1,-1)$: $rt - s^2 = (6(1)-6)^2 - (6(-1))^2 = -36 < 0$

At the point $(1,-1)$. the function $f(x,y)$ has neither maximum nor minimum.

(8) Examine the following function for extreme values

$f(x,y) = x^4 + y^4 - 2x^2 + 4xy - 2y^2$.

Sol: Given $f(x,y) = x^4 + y^4 - 2x^2 + 4xy - 2y^2$

Now, $\frac{\partial f}{\partial x} = 4x^3 - 4x + 4y$

$\frac{\partial f}{\partial y} = 4y^3 + 4x - 4y$

$r = \frac{\partial^2 f}{\partial x^2} = \frac{\partial}{\partial x}\left(\frac{\partial f}{\partial x}\right) = \frac{\partial}{\partial x}(4x^3 - 4x + 4y) = 12x^2 - 4$

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$$s = \frac{\partial^2 f}{\partial x \partial y} = \frac{\partial}{\partial x}\left(\frac{\partial f}{\partial y}\right) = \frac{\partial}{\partial x}(4y^2 + 4x - 4y) = 4$$

$$t = \frac{\partial^2 f}{\partial y^2} = \frac{\partial}{\partial y}\left(\frac{\partial f}{\partial y}\right) = \frac{\partial}{\partial y}(4y^3 + 4x - 4y) = \cancel{16y - 4} \; 12y^2 - 4$$

Equating $\frac{\partial f}{\partial x} = 0$ and $\frac{\partial f}{\partial y} = 0$.

$\Rightarrow \quad 4x^3 - 4x + 4y = 0$ and $4y^3 + 4x - 4y = 0$.

Adding these two equations, we get

$$4(x^3 + y^3) = 0$$

$$\Rightarrow y = -x$$

putting $y = -x$ in $4x^3 - 4x + 4y = 0$, we get

$$4x^3 - 8x = 0 \Rightarrow x^3 - 2x = 0$$

$$\Rightarrow x(x^2 - 2) = 0$$

$$\Rightarrow x = 0, \; x^2 - 2 = 0$$

$$\Rightarrow x = 0, \; x = \pm\sqrt{2} \quad \therefore x = 0, -\sqrt{2}, \sqrt{2}$$

corresponding y values are $y = 0, \sqrt{2}, -\sqrt{2}$.

So the stationary points are $(0,0)$, $(-\sqrt{2}, \sqrt{2})$ and $(\sqrt{2}, -\sqrt{2})$.

At $(0,0)$: $rt - s^2 = \cancel{(12x^2 - 4)} \cancel{(12y^2 - 4)} (12x^2 - 4)(16y - 4) - 4^2$

$$= 16 - 16 = 0.$$

At $(0,0)$, further investigation is needed.

At $(-\sqrt{2}, \sqrt{2})$: $rt - s^2 = (24 - 4)(\cancel{16\sqrt{2}}^{\,24} - 4) - 16 = 20 \times \cancel{18.62}^{\,20} - 16$

$$= \cancel{356.54}\; 384 > 0$$

$$r = 12x^2 - 4 = 120 > 0.$$

At $(-\sqrt{2}, \sqrt{2})$ the function $f(x,y)$ has minimum.

At $(\sqrt{2}, -\sqrt{2})$: $rt - s^2 = (24 - 4)(24 - 4) - 16 = 384 > 0$

$$r = 120 > 0.$$

At $(-\sqrt{2}, \sqrt{2})$ the function $f(x,y)$ has minimum.

UNIT- IV

3. Find the maximum and minimum values of $x^3 + 3xy^2 - 15x^2 - 15y^2 + 72x$.

Sol: Let $f(x, y) = x^3 + 3xy^2 - 15x^2 - 15y^2 + 72x$.

Now, $\frac{\partial f}{\partial x} = 3x^2 + 3y^2 - 30x + 72$

$\frac{\partial f}{\partial y} = 6xy - 30y$

$r = \frac{\partial^2 f}{\partial x^2} = \frac{\partial}{\partial x}\left(\frac{\partial f}{\partial x}\right) = \frac{\partial}{\partial x}(3x^2 + 3y^2 - 30x + 72)$

$= 6x - 30$

$s = \frac{\partial^2 f}{\partial x \partial y} = \frac{\partial}{\partial x}\left(\frac{\partial f}{\partial y}\right) = \frac{\partial}{\partial x}(6xy - 30y) = 6y$

$t = \frac{\partial^2 f}{\partial y^2} = \frac{\partial}{\partial y}\left(\frac{\partial f}{\partial y}\right) = \frac{\partial}{\partial y}(6xy - 30y) = 6x - 30$.

Equating $\frac{\partial f}{\partial x} = 0$ and $\frac{\partial f}{\partial y} = 0$.

$\Rightarrow 3x^2 + 3y^2 - 30x + 72 = 0$ and $6xy - 30y = 0$

$\Rightarrow x^2 + y^2 - 10x + 24 = 0$ and $6y(x - 5) = 0$

$y = 0, \quad x = 5$.

If $y = 0$ then $x^2 - 10x + 24 = 0$.

$\Rightarrow (x-6)(x-4) = 0$

$\Rightarrow x = 4, 6$.

If $x = 5$ then $25 + y^2 - 50 + 24 = 0$

$\Rightarrow y^2 - 1 = 0 \Rightarrow y^2 = 1 \Rightarrow y = \pm\sqrt{1} = \pm 1$.

The stationary points of f are $(4,0)$, $(6,0)$, $(5,-1)$ and $(5,1)$.

Now, $rt - s^2 = (6x-30)(6x-30) - (6y)^2$

$= (6x-30)^2 - 36y^2$

$r = (6x - 30)$

At $(4,0)$: $rt - s^2 = (24 - 30)^2 - 36(0) = (-6)^2 = 36 > 0$

$r = 24 - 30 = -6 < 0$

At the point $(4,0)$, the function $f(x,y)$ has maximum

At $(6,0)$: $rt - s^2 = (36 - 30)^2 - 36(0) = 6^2 = 36 > 0$

$r = 36 - 30 = 6 > 0$.

At the point $(6,0)$ the function $f(x,y)$ has minimum.

At $(5,-1)$: $rt - s^2 = (30 - 30)^2 - (6(-1))^2 = -36 < 0$

At the point $(5,-1)$ the function $f(x,y)$ has neither maximum nor minimum.

At $(5,1)$: $rt - s^2 = (30 - 30)^2 - (6(1))^2 = -36 < 0$

At the point $(5,1)$ the function $f(x,y)$ has neither maximum nor minimum.

$(5,-1)$ and $(5,1)$ are saddle points.

4. Investigate the maxima and minima, if any of the function $f(x,y) = x^3y^2(1-x-y)$.

Sol:- Given $f(x,y) = x^3y^2(1-x-y) = x^3y^2 - x^4y^2 - x^3y^3$

Now $\dfrac{\partial f}{\partial x} = 3x^2y^2 - 4x^3y^2 - 3x^2y^3$

$\dfrac{\partial f}{\partial y} = 2x^3y - 2x^4y - 3x^3y^2$

$r = \dfrac{\partial^2 f}{\partial x^2} = \dfrac{\partial}{\partial x}(3x^2y^2 - 4x^3y^2 - 3x^2y^3) = 6xy^2 - 12x^2y^2 - 6xy^3$

$s = \dfrac{\partial^2 f}{\partial x \partial y} = \dfrac{\partial}{\partial x}\left(\dfrac{\partial f}{\partial y}\right) = \dfrac{\partial}{\partial x}(2x^3y - 2x^4y - 3x^3y^2)$

$$= 6x^2y - 8x^3y - 9x^2y^2$$

$$t = \frac{\partial^2 f}{\partial y^2} = \frac{\partial}{\partial y}\left(\frac{\partial f}{\partial y}\right) = \frac{\partial}{\partial y}\left(2x^3y - 2x^4y - 3x^3y^2\right)$$

$$= 2x^3 - 2x^4 - 6x^3y.$$

Equaling $\frac{\partial f}{\partial x} = 0$ and $\frac{\partial f}{\partial y} = 0$

$\Rightarrow 3x^2y^2 - 4x^3y^2 - 3x^2y^3 = 0$ and $2x^3y - 2yx^4 - 3x^3y^2 = 0$

$\Rightarrow x^2y^2(3 - 4x - 3y) = 0$ and $x^3y(2 - 2x - 3y) = 0$

$\Rightarrow x = 0, y = 0, (3 - 4x - 3y) = 0$ and $x = 0, y = 0, (2 - 2x - 3y) = 0$

$\Rightarrow (x = 0, y = 0), (x = 0, 3 - 4x - 3y = 0), (y = 0, 3 - 4x - 3y = 0)$

$(x = 0, 2 - 2x - 3y = 0)$ and $(y = 0, 2 - 2x - 3y = 0)$.

and $(3 - 4x - 3y = 0, 2 - 2x - 3y = 0)$

The critical points are $(0,0), (0,1), (0, \frac{3}{4}), (0, \frac{2}{3})$

and $(\frac{1}{2}, \frac{1}{3})$.

$4x + 3y = 3$
$2x + 3y = 2$

$2x = 1$
$x = \frac{1}{2}$
$1 + 3y = 2$
$3y = 1 \Rightarrow y = \frac{1}{3}$

Now $rt - s^2 = (6xy^2 - 12x^2y^2 - 6xy^3)(2x^3 - 2x^4 - 6x^3y) - (6x^2y - 8x^3y - 9x^2y^2)^2$

$r = (6xy^2 - 12x^2y^2 - 6xy^3)$

there is no extreme value at all points except at $(\frac{1}{2}, \frac{1}{3})$.

At $(\frac{1}{2}, \frac{1}{3})$, $rt - s^2 = \frac{1}{9 \cdot 64} > 0$

$$r = 6\left(\frac{1}{2}\right)\left(\frac{1}{3}\right)^2\left(1 - 2\left(\frac{1}{2}\right) - \frac{1}{3}\right) = -\frac{1}{9} < 0$$

The function $f(x,y)$ is maximum at $(\frac{1}{2}, \frac{1}{3})$.

Maximum value is $f\left(\frac{1}{2}, \frac{1}{3}\right) = \left(\frac{1}{8} \cdot \frac{1}{9}\right)\left(1 - \frac{1}{2} - \frac{1}{3}\right)$

$$= \frac{1}{72}\left(\frac{1}{2} - \frac{1}{3}\right) = \frac{1}{432}$$

5. Find the shortest distance from origin to the surface $xyz^2 = 2$.

Sol: Let $P(x, y, z)$ be any point on the surface $xyz^2 = 2$. Then $OP = d = \sqrt{(x-0)^2+(y-0)^2+(z-0)^2} = \sqrt{x^2+y^2+z^2}$.

$$\Rightarrow OP^2 = d^2 = x^2+y^2+z^2.$$

Let $f(x,y) = d^2 = x^2+y^2+z^2$

$$= x^2+y^2+\frac{2}{xy} \qquad \left(\because xyz^2 = 2,\ z^2 = \frac{2}{xy}\right)$$

Now $\frac{\partial f}{\partial x} = 2x - \frac{2}{x^2y}$

$$\frac{\partial f}{\partial y} = 2y - \frac{2}{xy^2}$$

$$r = \frac{\partial^2 f}{\partial x^2} = \frac{\partial}{\partial x}\left(\frac{\partial f}{\partial x}\right) = 2 + \frac{4}{x^3y}$$

$$s = \frac{\partial^2 f}{\partial x \partial y} = \frac{\partial}{\partial x}\left(\frac{\partial f}{\partial y}\right) = \frac{\partial}{\partial x}\left(2y - \frac{2}{xy^2}\right) = \frac{2}{x^2y^2}$$

$$t = \frac{\partial^2 f}{\partial y^2} = \frac{\partial}{\partial y}\left(\frac{\partial f}{\partial y}\right) = \frac{\partial}{\partial y}\left(2y - \frac{2}{xy^2}\right) = 2 + \frac{4}{xy^3}.$$

Equating $\frac{\partial f}{\partial x} = 0$ and $\frac{\partial f}{\partial y} = 0$

$$\Rightarrow 2x - \frac{2}{x^2y} = 0 \quad \text{and} \quad 2y - \frac{2}{xy^2} = 0$$

$$\Rightarrow x^3y - 1 = 0 \quad \text{and} \quad xy^3 - 1 = 0$$

$$\Rightarrow x^3y = 1 \quad \text{and} \quad xy^3 = 1.$$

$$\therefore x^3y = xy^3 \Rightarrow xy(x^2-y^2) = 0$$

$$\Rightarrow x^2 - y^2 = 0 \quad (\because x \neq 0, y \neq 0)$$

$\Rightarrow x^2 = y^2 \Rightarrow x = \pm y$.

The stationary points are $(1,1)$ and $(1,-1)$.

At $(1,1)$, $r = \frac{\partial^2 f}{\partial x^2} = 2 + 4 = 6 > 0$

$s = \frac{\partial^2 f}{\partial x \partial y} = 2$

$t = \frac{\partial^2 f}{\partial t^2} = 6$

$rt - s^2 = 6 \times 6 - 2^2 = 36 - 4 = 32 > 0$.

But $z^2 = \frac{2}{xy} = \frac{2}{1} = 2$

$z = \pm\sqrt{2}$.

So minimum occurs at $(1, 1, \sqrt{2})$.

Hence, the shortest distance from the origin is

$\sqrt{1+1+2} = \sqrt{4} = \underline{\underline{2}}$.

6. Find the minimum value of $x^2+y^2+z^2$ given that $xyz = a^3$.

Sol:- Let $f(x,y,z) = x^2+y^2+z^2 \rightarrow (1)$

$xyz = a^3 \rightarrow (2)$

From (2), $z = \frac{a^3}{xy}$.

Substituting $z = \frac{a^3}{xy}$ in (1), we get

$x^2+y^2+\frac{a^3}{xy} = f(x,y)$ (say).

Now, $f(x,y) = x^2+y^2+\left(\frac{a^3}{xy}\right)^2$

$\frac{\partial f}{} \quad \frac{a^3}{}$ [illegible]

Here, $f(x,y) = x^2 + y^2 + \frac{a^6}{x^2 y^2}$

$$\frac{\partial f}{\partial x} = 2x + \frac{a^6}{y^2}\left(-\frac{2}{x^3}\right) = 2x - \frac{2a^6}{x^3 y^2}$$

$$\frac{\partial f}{\partial y} = 2y + \frac{a^6}{x^2}\left(-\frac{2}{y^3}\right) = 2y - \frac{2a^6}{x^2 y^3}$$

$$r = \frac{\partial^2 f}{\partial x^2} = \frac{\partial}{\partial x}\left(2x - \frac{2a^6}{x^3 y^2}\right) = 2 + \frac{6a^6}{x^4 y^2}$$

$$s = \frac{\partial^2 f}{\partial x \partial y} = \frac{\partial}{\partial x}\left(\frac{\partial f}{\partial y}\right) = \frac{\partial}{\partial x}\left(2y - \frac{2a^6}{x^2 y^3}\right) = \frac{4a^6}{x^3 y^3}$$

$$t = \frac{\partial^2 f}{\partial y^2} = \frac{\partial}{\partial y}\left(2y - \frac{2a^6}{x^2 y^3}\right) = 2 + \frac{6a^6}{x^2 y^4}$$

Equating $\frac{\partial f}{\partial x} = 0$ and $\frac{\partial f}{\partial y} = 0$

$\Rightarrow 2x - \frac{2a^6}{x^3 y^2} = 0$ and $2y - \frac{2a^6}{x^2 y^3} = 0$

$\Rightarrow x^4 y^2 = a^6$ and $x^2 y^4 = a^6$

$\Rightarrow x^4 y^2 = x^2 y^4$

$\Rightarrow x^2 = y^2$

$\Rightarrow x = y = a.$

The stationary point is (a, a). $\quad (x^6 = a^6,\ x = a)$

At $\underline{(0, a)}$: $r = 2 + 6 = 8 > 0$

$rt - s^2 = (8)(8) - 16 = 64 - 16 = 48 > 0$

f is minimum at (a, a) and the minimum value is $a^2 + a^2 + \frac{a^6}{a^2 \times a^2}$

$$= \underline{\underline{3a^2}}$$

7. The Sum of three numbers is Constant. Prove that their Product is a maximum when they are equal.

Sol:- Let x, y, z be the given numbers.

Given that $x+y+z = C$

$\Rightarrow z = C-x-y$.

The product of the numbers is xyz

Let, $f = xyz = xy(C-x-y)$

Now, $\frac{\partial f}{\partial x} = Cy - 2xy - y^2$

$\frac{\partial f}{\partial y} = Cx - x^2 - 2xy$

$r = \frac{\partial^2 f}{\partial x^2} = \frac{\partial}{\partial x}\left(\frac{\partial f}{\partial x}\right) = -2y$

$s = \frac{\partial^2 f}{\partial x \partial y} = \frac{\partial}{\partial x}\left(\frac{\partial f}{\partial y}\right) = \frac{\partial}{\partial x}(Cx - x^2 - 2xy) = C-2x-2y$

$t = \frac{\partial^2 f}{\partial y^2} = \frac{\partial}{\partial y}\left(\frac{\partial f}{\partial y}\right) = -2x$.

Equating $\frac{\partial f}{\partial x} = 0$ and $\frac{\partial f}{\partial y} = 0$.

$\Rightarrow Cy - 2xy - y^2 = 0$ and $Cx - x^2 - 2xy = 0$

$\Rightarrow C = 2x + y \rightarrow (1)$ and $C = x + 2y \rightarrow (2)$.

From (1) and (2), we get $x = y$

Substituting in (1), we get $C = 3x$

$\therefore z = 3x - x - x = x$.

$\therefore x = y = z$

At $x=y=z$, $rt - s^2 = (-2y)(-2x) - (C-2x-2y)^2$

$= 4xy - (C-2x-2y)^2$

$= 4x^2 - x^2 = 3x^2 > 0$

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[illegible]

f is maximum for $x = y = z$.

The product is maximum if the numbers are equal.

Q. Find the extreme points $f(x,y) = 1 - x^2 - y^2$.

9. Discuss the maxima and minima of

$u = \sin x \sin y \sin(x+y)$.

Lagrange's method of undetermined multiplier

Consider the function $f(x, y, z)$ where x, y, z are connected by the relation $\phi(x, y, z) = 0$.

How to find the stationary values of $f(x,y,z)$ under the constraint $\phi(x,y,z) = 0$.

Write $F(x,y,z) = f(x,y,z) + \lambda\, \phi(x,y,z)$.

Obtain the equations $\frac{\partial F}{\partial x} = 0$, $\frac{\partial F}{\partial y} = 0$, $\frac{\partial F}{\partial z} = 0$.

Solve the above equations together with $\phi(x,y,z) = 0$.

The values of x, y, z so obtained will give the stationary value of $f(x, y, z)$.

1. Find a point on the plane $2x+3y-z=5$ which is nearest to the origin.

Sol: Let $P(x,y,z)$ be a point on the plane. Then distance between $O(0,0,0)$ and $P(x,y,z)$ is

$d=\sqrt{(x-0)^2+(y-0)^2+(z-0)^2}=\sqrt{x^2+y^2+z^2}$

$\Rightarrow d^2=x^2+y^2+z^2$

Let, $f=x^2+y^2+z^2 \rightarrow (1)$

Now the problem is to minimize $f=x^2+y^2+z^2$

Subject to the condition $\phi(x,y,z)=2x+3y-z-5=0 \rightarrow (2)$

Let $F(x,y,z)=f(x,y,z)+\lambda\,\phi(x,y,z)$

$=(x^2+y^2+z^2)+\lambda(2x+3y-z-5)$

$\frac{\partial F}{\partial x}=2x+2\lambda, \quad \frac{\partial F}{\partial y}=2y+3\lambda, \quad \frac{\partial F}{\partial z}=2z-\lambda$

Now, $\frac{\partial F}{\partial x}=0 \Rightarrow 2x+2\lambda=0 \Rightarrow x=-\lambda$

$\frac{\partial F}{\partial y}=0 \Rightarrow 2y+3\lambda=0 \Rightarrow y=-\frac{3}{2}\lambda$

$\frac{\partial F}{\partial z}=0 \Rightarrow 2z-\lambda=0 \Rightarrow z=\frac{1}{2}\lambda$

Substitute x, y, z in (2), we get

$-2\lambda+3\left(-\frac{3}{2}\lambda\right)-\frac{1}{2}\lambda=5$

$\Rightarrow -2\lambda-\frac{9\lambda}{2}-\frac{\lambda}{2}=5 \Rightarrow -4\lambda-10\lambda=10$

$\Rightarrow \lambda=-\frac{10}{14}=-\frac{5}{7}$

$\therefore x=-\frac{5}{7}, \quad y=\frac{15}{14}, \quad z=-\frac{5}{14}$

Hence $\left(\frac{5}{7}, \frac{15}{14}, -\frac{5}{14}\right)$ is the point on the plane nearest to the origin.

(3) Find the minimum value of $x^2+y^2+z^2$ if $ax+by+cz = p$

Sol: Let $f(x,y,z) = x^2+y^2+z^2 \rightarrow (1)$

and $\phi(x,y,z) = ax+by+cz - p = 0 \rightarrow (2)$

Let $F(x,y,z) = f(x,y,z) + \lambda\, \phi(x,y,z)$

$F(x,y,z) = x^2+y^2+z^2 + \lambda(ax+by+cz-p)$

$\frac{\partial F}{\partial x} = 2x + a\lambda$

$\frac{\partial F}{\partial y} = 2y + b\lambda$

$\frac{\partial F}{\partial z} = 2z + c\lambda$

Now, $\frac{\partial F}{\partial x} = 0 \Rightarrow 2x + a\lambda = 0 \Rightarrow x = -\frac{a\lambda}{2}$

$\frac{\partial F}{\partial y} = 0 \Rightarrow 2y + b\lambda = 0 \Rightarrow y = -\frac{b\lambda}{2}$

$\frac{\partial F}{\partial z} = 0 \Rightarrow 2z + c\lambda = 0 \Rightarrow z = -\frac{c\lambda}{2}$

Substituting x, y, z in (2), we get

$$a\left(-\frac{a\lambda}{2}\right) + b\left(-\frac{b\lambda}{2}\right) + c\left(-\frac{c\lambda}{2}\right) = p$$

$$\Rightarrow \lambda\left(-\frac{a^2}{2} - \frac{b^2}{2} - \frac{c^2}{2}\right) = p$$

$$\Rightarrow \lambda = -\frac{2p}{a^2+b^2+c^2}$$

$$\therefore x = -\frac{a}{2}\left(-\frac{2p}{a^2+b^2+c^2}\right) = \frac{ap}{a^2+b^2+c^2}$$

$$y = -\frac{b}{2}\left(-\frac{2p}{a^2+b^2+c^2}\right) = \frac{bp}{a^2+b^2+c^2}$$

$$z = -\frac{c}{2}\left(-\frac{2p}{a^2+b^2+c^2}\right) = \frac{cp}{a^2+b^2+c^2}$$

Minimum value of f is $x^2+y^2+z^2$

$$\left(\frac{ap}{a^2+b^2+c^2}\right)^2+\left(\frac{bp}{a^2+b^2+c^2}\right)^2+\left(\frac{cp}{a^2+b^2+c^2}\right)^2$$

$$=\frac{a^2p^2}{(a^2+b^2+c^2)^2}+\frac{b^2p^2}{(a^2+b^2+c^2)^2}+\frac{c^2p^2}{(a^2+b^2+c^2)^2}$$

$$=\frac{p^2(a^2+b^2+c^2)}{(a^2+b^2+c^2)^2}=\frac{p^2}{a^2+b^2+c^2}$$

(3) Find the minimum value of $x^2+y^2+z^2$ given $x+y+z=3a$

Sol: Let $f(x,y,z)=x^2+y^2+z^2 \rightarrow (1)$

and $\phi(x,y,z)=x+y+z-3a=0 \rightarrow (2)$

Let $F(x,y,z)=f(x,y,z)+\lambda\,\phi(x,y,z)$

$F(x,y,z)=x^2+y^2+z^2+\lambda(x+y+z-3a)$

$\frac{\partial F}{\partial x}=2x+\lambda$, $\frac{\partial F}{\partial y}=2y+\lambda$, $\frac{\partial F}{\partial z}=2z+\lambda$

Now, $\frac{\partial F}{\partial x}=0$, $\frac{\partial F}{\partial y}=0$, $\frac{\partial F}{\partial z}=0$

$2x+\lambda=0$ $\quad 2y+\lambda=0$ $\quad 2z+\lambda=0$

$x=-\frac{\lambda}{2}$ $\quad y=-\frac{\lambda}{2}$ $\quad z=-\frac{\lambda}{2}$

Substituting x, y, z in (2), we get

$$-\frac{\lambda}{2}-\frac{\lambda}{2}-\frac{\lambda}{2}=3a \Rightarrow \lambda\left(-\frac{3}{2}\right)=3a$$

$$\Rightarrow \lambda=-2a$$

$\therefore x=a,\ y=a,\ z=a$

The minimum value of f is $x^2+y^2+z^2=a^2+a^2+a^2$

$=\underline{3a^2}$

Find the maximum value of $x^2y^3z^4$ if

$2x+3y+4z=a$.

let $f(x,y,z) = x^2y^3z^4 \rightarrow (1)$

and $\phi(x,y,z) = 2x+3y+4z-a=0 \rightarrow (2)$

let $F(x,y,z) = f(x,y,z) + \lambda\,\phi(x,y,z)$.

$F(x,y,z) = x^2y^3z^4 + \lambda\,(2x+3y+4z-a)$

$\frac{\partial F}{\partial x} = 2xy^3z^4 + 2\lambda$, $\frac{\partial F}{\partial y} = 3x^2y^2z^4 + 3\lambda$,

$\frac{\partial F}{\partial z} = 4x^2y^3z^3 + 4\lambda$.

Now $\frac{\partial F}{\partial x} = 0$, $\frac{\partial F}{\partial y} = 0$, $\frac{\partial F}{\partial z} = 0$.

$\Rightarrow xy^3z^4 = -\lambda \rightarrow (3)$ $x^2y^2z^4 = -\lambda \rightarrow (4)$ $x^2y^3z^3 = -\lambda \rightarrow (5)$

From (3) and (4), we get $x = y$

(4) and (5) we get $y = z$.

Substituting x, y, z in (2) we get $x = y = z = \frac{a}{9}$.

$\therefore$ maximum value of f is $\left(\frac{a}{9}\right)^2\left(\frac{a}{9}\right)^3\left(\frac{a}{9}\right)^4$

$= \underline{\underline{\left(\frac{a}{9}\right)^9}}$.

— x —

Example 3 : Find $\frac{\partial u}{\partial x}+\frac{\partial u}{\partial y}$ if $u=f(x+y,x-y)$ [JNTU (K) Dec. 2016 (Set No

Solution : Let $v=x+y$ and $w=x-y$. Then $u=f(v,w)$

Now $\frac{\partial v}{\partial x}=1, \frac{\partial v}{\partial y}=1$ and $\frac{\partial w}{\partial x}=1, \frac{\partial w}{\partial y}=-1$

By Chain rule of differentiation, we have

$$\frac{\partial u}{\partial x}=\frac{\partial u}{\partial v}\frac{\partial v}{\partial x}+\frac{\partial u}{\partial w}\frac{\partial w}{\partial x}=\frac{\partial u}{\partial v}(1)+\frac{\partial u}{\partial w}(1)=\frac{\partial u}{\partial v}+\frac{\partial u}{\partial w} \quad \ldots(1)$$

$$\frac{\partial u}{\partial y}=\frac{\partial u}{\partial v}\frac{\partial v}{\partial y}+\frac{\partial u}{\partial w}\frac{\partial w}{\partial y}=\frac{\partial u}{\partial v}(1)+\frac{\partial u}{\partial w}(-1)=\frac{\partial u}{\partial v}-\frac{\partial u}{\partial w} \quad \ldots(2)$$

(1) + (2) gives

$$\frac{\partial u}{\partial x}+\frac{\partial u}{\partial y}=\left(\frac{\partial u}{\partial v}+\frac{\partial u}{\partial w}\right)+\left(\frac{\partial u}{\partial v}-\frac{\partial u}{\partial w}\right)=2\frac{\partial u}{\partial v}$$

Example 4 : If $u=f(2x-3y,3y-4z,4z-2x)$ then prove that $\frac{1}{2}\frac{\partial u}{\partial x}+\frac{1}{3}\frac{\partial u}{\partial y}+\frac{1}{4}\frac{\partial u}{\partial z}=$

Solution : Given $u=f(2x-3y,3y-4z,4z-2x)$

Let $r=2x-3y, s=3y-4z$ and $t=4z-2x$

Now $\frac{\partial u}{\partial x}=\frac{\partial u}{\partial r}\cdot\frac{\partial r}{\partial x}+\frac{\partial u}{\partial s}\cdot\frac{\partial s}{\partial x}+\frac{\partial u}{\partial t}\cdot\frac{\partial t}{\partial x}$

$$=\frac{\partial u}{\partial r}(2)+\frac{\partial u}{\partial s}(0)+\frac{\partial u}{\partial t}(-2)=2\frac{\partial u}{\partial r}-2\frac{\partial u}{\partial t}$$

$$\Rightarrow \frac{1}{2}\frac{\partial u}{\partial x}=\frac{\partial u}{\partial r}-\frac{\partial u}{\partial t} \quad \ldots(1)$$

$$\frac{\partial u}{\partial y}=\frac{\partial u}{\partial r}\cdot\frac{\partial r}{\partial y}+\frac{\partial u}{\partial s}\cdot\frac{\partial s}{\partial y}+\frac{\partial u}{\partial t}\cdot\frac{\partial t}{\partial y}$$

$$= \frac{\partial u}{\partial r}(-3) + \frac{\partial u}{\partial s}(3) + \frac{\partial u}{\partial t}(0) = -3\frac{\partial u}{\partial r} + 3\frac{\partial u}{\partial s}$$

$$\Rightarrow \frac{1}{3}\frac{\partial u}{\partial y} = \frac{\partial u}{\partial s} - \frac{\partial u}{\partial r} \qquad \ldots(2)$$

and $\dfrac{\partial u}{\partial z} = \dfrac{\partial u}{\partial r}\cdot\dfrac{\partial r}{\partial z} + \dfrac{\partial u}{\partial s}\cdot\dfrac{\partial s}{\partial z} + \dfrac{\partial u}{\partial t}\cdot\dfrac{\partial t}{\partial z}$

$$= \frac{\partial u}{\partial r}(0) + \frac{\partial u}{\partial s}(-4) + \frac{\partial u}{\partial t}(4) = -4\frac{\partial u}{\partial s} + 4\frac{\partial u}{\partial t}$$

$$\Rightarrow \frac{1}{4}\frac{\partial u}{\partial z} = \frac{\partial u}{\partial t} - \frac{\partial u}{\partial s} \qquad \ldots(3)$$

$(1)+(2)+(3)$ gives

$$\frac{1}{2}\frac{\partial u}{\partial x} + \frac{1}{3}\frac{\partial u}{\partial y} + \frac{1}{4}\frac{\partial u}{\partial z} = \left(\frac{\partial u}{\partial r} - \frac{\partial u}{\partial t}\right) + \left(\frac{\partial u}{\partial s} - \frac{\partial u}{\partial r}\right) + \left(\frac{\partial u}{\partial t} - \frac{\partial u}{\partial s}\right) = 0$$

Example 5 : If $u = f(y-z, z-x, x-y)$ prove that $\dfrac{\partial u}{\partial x} + \dfrac{\partial u}{\partial y} + \dfrac{\partial u}{\partial z} = 0$

(or) If $u = f(x-y, y-z, z-x)$, find $\dfrac{\partial u}{\partial x} + \dfrac{\partial u}{\partial y} + \dfrac{\partial u}{\partial z}$

Solution : Let $r = y-z$, $s = z-x$, $t = x-y$. Then $u = f(r,s,t)$

Now $\dfrac{\partial r}{\partial x} = 0, \dfrac{\partial r}{\partial y} = 1, \dfrac{\partial r}{\partial z} = -1$

$\dfrac{\partial s}{\partial x} = -1, \dfrac{\partial s}{\partial y} = 0, \dfrac{\partial s}{\partial z} = 1$

and $\dfrac{\partial t}{\partial x} = 1, \dfrac{\partial t}{\partial y} = -1, \dfrac{\partial t}{\partial z} = 0$

$\therefore$ By chain rule of partial differentiation, we have

$$\frac{\partial u}{\partial x} = \frac{\partial u}{\partial r}\frac{\partial r}{\partial x} + \frac{\partial u}{\partial s}\frac{\partial s}{\partial x} + \frac{\partial u}{\partial t}\frac{\partial t}{\partial x}$$

$$= \frac{\partial u}{\partial r}(0) + \frac{\partial u}{\partial s}(-1) + \frac{\partial u}{\partial t}(1) = -\frac{\partial u}{\partial s} + \frac{\partial u}{\partial t} \qquad \ldots(1)$$

$$\frac{\partial u}{\partial y} = \frac{\partial u}{\partial r}\frac{\partial r}{\partial y} + \frac{\partial u}{\partial s}\frac{\partial s}{\partial y} + \frac{\partial u}{\partial t}\frac{\partial t}{\partial y}$$

$$= \frac{\partial u}{\partial r}(1) + \frac{\partial u}{\partial s}(0) + \frac{\partial u}{\partial t}(-1) = \frac{\partial u}{\partial r} - \frac{\partial u}{\partial t} \qquad \ldots(2)$$

and $\dfrac{\partial u}{\partial z} = \dfrac{\partial u}{\partial r}\dfrac{\partial r}{\partial z} + \dfrac{\partial u}{\partial s}\dfrac{\partial s}{\partial z} + \dfrac{\partial u}{\partial t}\dfrac{\partial t}{\partial z}$

$$= \frac{\partial u}{\partial r}(-1) + \frac{\partial u}{\partial s}(1) + \frac{\partial u}{\partial t}(0) = -\frac{\partial u}{\partial r} + \frac{\partial u}{\partial s} \qquad \ldots(3)$$

(1) + (2) + (3) gives

$$\frac{\partial u}{\partial x}+\frac{\partial u}{\partial y}+\frac{\partial u}{\partial z}=\left(-\frac{\partial u}{\partial s}+\frac{\partial u}{\partial t}\right)+\left(\frac{\partial u}{\partial r}-\frac{\partial u}{\partial t}\right)+\left(-\frac{\partial u}{\partial r}+\frac{\partial u}{\partial s}\right)=0$$

Hence the result.

Example 6 : If $u=f(r,s,t)$ where $r=\frac{x}{y}$, $s=\frac{y}{z}$ and $t=\frac{z}{x}$ show that $x\frac{\partial u}{\partial x}+y\frac{\partial u}{\partial y}+z\frac{\partial u}{\partial z}=0$.

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(or) If $u=f\left(\frac{x}{y},\frac{y}{z},\frac{z}{x}\right)$ then prove that $x\frac{\partial u}{\partial x}+y\frac{\partial u}{\partial y}+z\frac{\partial u}{\partial z}=0$

Solution : We have

$u=f(r,s,t)$ and $r=\frac{x}{y}, s=\frac{y}{z}, t=\frac{z}{x}$

$$\therefore \quad \frac{\partial r}{\partial x}=\frac{1}{y}, \quad \frac{\partial r}{\partial y}=\frac{-x}{y^2}, \quad \frac{\partial r}{\partial z}=0$$

$$\frac{\partial s}{\partial x}=0, \quad \frac{\partial s}{\partial y}=\frac{1}{z}, \quad \frac{\partial s}{\partial z}=\frac{-y}{z^2}$$

and $\frac{\partial t}{\partial x}=\frac{-z}{x^2}, \quad \frac{\partial t}{\partial y}=0, \quad \frac{\partial t}{\partial z}=\frac{1}{x}$

By chain rule of partial differentiation, we have

$$\frac{\partial u}{\partial x}=\frac{\partial u}{\partial r}\frac{\partial r}{\partial x}+\frac{\partial u}{\partial s}\frac{\partial s}{\partial x}+\frac{\partial u}{\partial t}\frac{\partial t}{\partial x}$$

$$=\frac{\partial u}{\partial r}\left(\frac{1}{y}\right)+\frac{\partial u}{\partial s}(0)+\frac{\partial u}{\partial t}\left(\frac{-z}{x^2}\right)=\frac{1}{y}\frac{\partial u}{\partial r}-\frac{z}{x^2}\frac{\partial u}{\partial t}$$

$$\therefore x\frac{\partial u}{\partial x}=\frac{x}{y}\frac{\partial u}{\partial r}-\frac{z}{x}\frac{\partial u}{\partial t} \quad \ldots(1)$$

Now $\frac{\partial u}{\partial y}=\frac{\partial u}{\partial r}\frac{\partial r}{\partial y}+\frac{\partial u}{\partial s}\frac{\partial s}{\partial y}+\frac{\partial u}{\partial t}\frac{\partial t}{\partial y}$

$$=\frac{\partial u}{\partial r}\left(\frac{-x}{y^2}\right)+\frac{\partial u}{\partial s}\left(\frac{1}{z}\right)+\frac{\partial u}{\partial t}(0)=-\frac{x}{y^2}\frac{\partial u}{\partial r}+\frac{1}{z}\frac{\partial u}{\partial s}$$

$$\therefore y\frac{\partial u}{\partial y}=-\frac{x}{y}\frac{\partial u}{\partial r}+\frac{y}{z}\frac{\partial u}{\partial s} \quad \ldots(2)$$

and $\frac{\partial u}{\partial z}=\frac{\partial u}{\partial r}\frac{\partial r}{\partial z}+\frac{\partial u}{\partial s}\frac{\partial s}{\partial z}+\frac{\partial u}{\partial t}\frac{\partial t}{\partial z}$

$$=\frac{\partial u}{\partial r}(0)+\frac{\partial u}{\partial s}\left(-\frac{y}{z^2}\right)+\frac{\partial u}{\partial t}\left(\frac{1}{x}\right)=\frac{-y}{z^2}\frac{\partial u}{\partial s}+\frac{1}{x}\frac{\partial u}{\partial t}$$

$$\therefore z\frac{\partial u}{\partial z}=\frac{-y}{z}\frac{\partial u}{\partial s}+\frac{z}{x}\frac{\partial u}{\partial t} \quad \ldots(3)$$

(1) + (2) + (3) gives

$$x\frac{\partial u}{\partial x}+y\frac{\partial u}{\partial y}+z\frac{\partial u}{\partial z}=\left(\frac{x}{y}\frac{\partial u}{\partial r}-\frac{z}{x}\frac{\partial u}{\partial t}\right)+\left(-\frac{x}{y}\frac{\partial u}{\partial r}+\frac{y}{z}\frac{\partial u}{\partial s}\right)+\left(-\frac{y}{z}\frac{\partial u}{\partial s}+\frac{z}{x}\frac{\partial u}{\partial t}\right)=0$$

Hence the result.

UNIT I

Applications

Maxima and Minima of functions of two variables without Constraints

A function $f(x, y)$ is said to have a maximum value at $x = a$, $y = b$ if $f(a,b) > f(a+h, b+k)$ for small and independent values of h and k, positive (or) negative.

A function $f(x, y)$ is said to have a minimum value at $x = a$, $y = b$ if $f(a,b) < f(a+h, b+k)$ for small and independent values of h and k, positive (or) negative.

UNIT-V

MULTIPLE INTEGRALS

In previous classes, we evaluated the definite integrals of the type $\int_a^b f(x)\,dx$. In this unit, we shall discuss the methods for evaluating double and triple integrals. These integrals are called multiple integrals.

Evaluation of Double integrals:

Evaluate double integral with respect to one variable (treating the other variable as constant) and reduce it to an integral of one variable.

In General, we evaluate the integral from inner most integral to outermost integral. For example, $\iint f(x,y)\,dx\,dy$ shows that the function should be integrated first with respect to 'x' keeping y as Constant and then with respect to 'y' keep 'x' as Constant. This process is known as "the order of integration".

1. Evaluate $\int_0^2\int_0^3 (x+y)\,dx\,dy$.

Sol:- Consider $\int_0^2\int_0^3 (x+y)\,dx\,dy = \int_0^2 \left(xy + \frac{x^2}{2}\right)_0^3 dy$

$$= \int_0^2 \left[\left(\frac{9}{2}-0\right) + y(3-0)\right] dy$$

$$= \int_0^2 \left(\frac{9}{2} + 3y\right) dy = \left(\frac{9}{2}y + 3\frac{y^2}{2}\right)_0^2$$

$$= \frac{9}{2}(2-0) + \frac{3}{2}(4-0) = 9 + 6 = 15.$$

$$\therefore \int_0^2\int_0^3 (x+y)\,dx\,dy = 15$$

2. Evaluate $\int_0^1 \int_x^{\sqrt{x}} (x^2+y^2)\, dy\, dx$

Sol:- Consider $\int_0^1 \int_x^{\sqrt{x}} (x^2+y^2)\, dy\, dx$

$$= \int_0^1 \left(x^2 y + \frac{y^3}{3}\right)_x^{\sqrt{x}} dx = \int_0^1 \left[x^2(\sqrt{x}-x) + \frac{1}{3}\left((\sqrt{x})^3 - x^3\right)\right] dx$$

$$= \int_0^1 \left(-x^3 + x^{5/2} + \frac{1}{3}x^{3/2} - \frac{1}{3}x^3\right) dx$$

$$= \left[-\frac{x^4}{4} + \frac{2}{7}x^{7/2} + \frac{1}{3}\frac{2}{5}x^{5/2} - \frac{1}{3}\frac{x^4}{4}\right]_0^1$$

$$= -\frac{1}{4} + \frac{2}{7} + \frac{2}{15} - \frac{1}{12} = \frac{-105+120+56-35}{420} = \frac{36}{420} = \underline{\underline{\frac{3}{35}}}$$

3. Evaluate $\int_0^1 \int_0^{\sqrt{1+x^2}} \frac{1}{1+x^2+y^2}\, dx\, dy$

Sol: Consider $\int_0^1 \int_0^{\sqrt{1+x^2}} \frac{1}{1+x^2+y^2}\, dx\, dy$

put $\sqrt{1+x^2} = p \Rightarrow 1+x^2 = p^2$

$$= \int_0^1 \int_0^p \frac{1}{p^2+y^2}\, dy\, dx \qquad \because \int \frac{1}{a^2+x^2}dx = \frac{1}{a}\tan^{-1}\left(\frac{x}{a}\right)$$

$$= \int_0^1 \left(\frac{1}{p}\tan^{-1}\left(\frac{y}{p}\right)\right)_0^p dx$$

$$= \int_0^1 \frac{1}{p}\left[\tan^{-1}(1) - \tan^{-1}(0)\right) dx$$

$$= \int_0^1 \frac{1}{p}\left(\frac{\pi}{4} - 0\right) dx = \frac{\pi}{4}\int_0^1 \frac{1}{\sqrt{1+x^2}}dx$$

$$= \frac{\pi}{4}\left(\log\left(x + \sqrt{1+x^2}\right)\right)_0^1$$

$$= \frac{\pi}{4}\left(\log(1+\sqrt{2}) - \log(0+\sqrt{1+0})\right)$$

$$= \frac{\pi}{4}\left(\log(1+\sqrt{2}) - \log 1\right)$$

$$= \frac{\pi}{4}\log \underline{\underline{(1+\sqrt{2})}} \qquad (\because \log 1 = 0)$$

4. Evaluate $\int_0^2\int_0^x e^{x+y}\,dx\,dy$.

Sol: Consider $\int_0^2\int_0^x e^{x+y}\,dx\,dy = \int_0^2\int_0^x e^{x+y}\,dy\,dx$

$$= \int_0^2 \left(e^{x+y}\right)_0^x dx$$

$$= \int_0^2 (e^{2x} - e^{x})\,dx = \left(\frac{e^{2x}}{2} - e^{x}\right)_0^2$$

$$= \left(\frac{e^4}{2} - e^2\right) - \left(\frac{1}{2} - 1\right) = \frac{e^4}{2} - e^2 + \frac{1}{2}.$$

5. Evaluate $\int_0^a\int_0^{\sqrt{a^2-x^2}} \sqrt{a^2-x^2-y^2}\,dx\,dy$.

Sol: Consider $\int_0^a\int_0^{\sqrt{a^2-x^2}} \sqrt{a^2-x^2-y^2}\,dx\,dy$.

$$= \int_0^a\int_0^p \sqrt{p^2-y^2}\,dy\,dx.$$

put $\sqrt{a^2-x^2} = p$

$\Rightarrow a^2-x^2 = p^2$

$$= \int_0^a \left[\frac{y}{2}\sqrt{p^2-y^2} + \frac{p^2}{2}\sin^{-1}\left(\frac{y}{p}\right)\right]_0^p dx \qquad \left(\because \int\sqrt{a^2-x^2}\,dx = \frac{x}{2}\sqrt{a^2-x^2} + \frac{a^2}{2}\sin^{-1}\left(\frac{x}{a}\right)\right)$$

$$= \int_0^a \left(0 + \frac{p^2}{2}\sin^{-1}(1)\right) - (0+0)\,dx.$$

$$= \frac{\pi}{2}\frac{1}{2}\int_0^a (a^2-x^2)\,dx \qquad \left(\because \sin^{-1}1 = \frac{\pi}{2}\right)$$

$$= \frac{\pi}{4}\left(a^2x - \frac{x^3}{3}\right)_0^a = \frac{\pi}{4}\left(a^3 - \frac{a^3}{3}\right) = \frac{\pi}{4}\,\frac{2a^3}{3} = \frac{\pi a^3}{6}.$$

6. Evaluate $\int_0^5\int_0^{x^2} x(x^2+y^2)\,dx\,dy$.

Sol:- Consider $\int_0^5\int_0^{x^2} (x^3+xy^2)\,dx\,dy = \int_0^5\int_0^{x^2} (x^3+xy^2)\,dy\,dx$

$$= \int_0^5 \left(x^3 y + \frac{x y^3}{3} \right)_0^{x^2} dx$$

$$= \int_0^5 \left[x^3(x^2 - 0) + \frac{x}{3}(x^6 - 0) \right] dx$$

$$= \int_0^5 \left(x^5 + \frac{x^7}{3} \right) dx = \left(\frac{x^6}{6} + \frac{x^8}{24} \right)_0^5 = \frac{5^6}{6} + \frac{5^8}{24}$$

$$= \frac{5^6}{6}\left(1 + \frac{5^2}{4}\right) = \frac{5^6}{6}\left(\frac{29}{4}\right)$$

$$= 5^6 \left(\frac{29}{24}\right).$$

7. Evaluate $\int_0^4 \int_{y^2/4}^{y} \frac{y}{x^2+y^2}\, dx\, dy.$

Sol: $\int_0^4 \int_{y^2/4}^{y} \frac{y}{x^2+y^2}\, dx\, dy$ $\left(\because \int \frac{1}{x^2+a^2} dx = \frac{1}{a} \tan^{-1}\left(\frac{x}{a}\right) \right)$

$$= \int_0^4 y \left(\frac{1}{y} \tan^{-1}\left(\frac{x}{y}\right) \right)_{y^2/4}^{y} dy$$

$$= \int_0^4 \left(\tan^{-1}\left(\frac{y}{y}\right) - \tan^{-1}\left(\frac{y}{4}\right) \right) dy$$

$$= \int_0^4 \left(\tan^{-1}(1) - \tan^{-1}\left(\frac{y}{4}\right) \right) dy = \int_0^4 \left(\frac{\pi}{4} - \tan^{-1}\left(\frac{y}{4}\right) \right) dy.$$

$$= \frac{\pi}{4}(y)_0^4 - \left[\tan^{-1}\left(\frac{y}{4}\right) y - \int_0^4 \frac{1}{1+\left(\frac{y}{4}\right)^2} \frac{1}{4} y\, dy \right]_0^4$$

$$= \frac{\pi}{4}(4-0) - \left[\frac{\pi}{4}(4) - \int_0^4 \frac{4}{16+y^2} y\, dy \right].$$

$$= \cancel{\pi} - \cancel{\pi} + \int_0^4 \frac{4y}{16+y^2} dy.$$

$$= 2 \int_0^4 \frac{2y}{16+y^2} dy = 2\left(\log(16+y^2) \right)_0^4$$

$$= 2(\log 32 - \log 16)$$

$$= 2 \log\left(\frac{32}{16}\right) = 2 \log 2 = \log 4.$$

8. Evaluate $\int_0^1 \int_0^{x^2} e^{y/x}\, dx\, dy$

Sol: Consider $\int_0^1\int_0^{x^2} e^{y/x}\,dx\,dy = \int_0^1\int_0^{x^2} e^{y/x}\,dy\,dx$

$$= \int_0^1 \left(\frac{e^{y/x}}{1/x}\right)_0^{x^2} dx \qquad \left(\because \int e^{ax}dx = \frac{e^{ax}}{a}\right)$$

$$= \int_0^1 x\left(e^{\frac{x^2}{x}} - e^0\right)dx = \int_0^1 x(e^x - 1)\,dx$$

$$= \int_0^1 (xe^x - x)\,dx = \left(xe^x - e^x - \frac{x^2}{2}\right)_0^1 = \left(e^1 - e^1 - \frac{1}{2}\right) - (0-1-0)$$

$$= 1 - \frac{1}{2} = \frac{1}{2}.$$

$$\therefore \int_0^1\int_0^{x^2} e^{y/x}\,dx\,dy = \frac{1}{2}$$

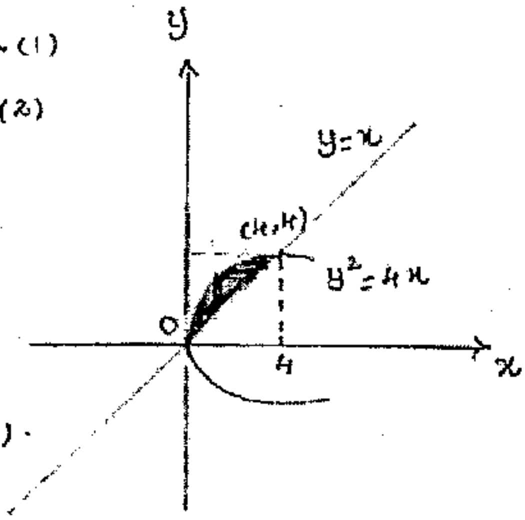
Note: Sometimes the limits are not given, first identify the region of integration by drawing the rough sketch of the curves in the xy-plane.

1. Evaluate $\iint_R (x^2+y^2)\,dx\,dy$ Where R is bounded by $y = x$, $y^2 = 4x$.

Sol:- Let, $I = \iint_R (x^2+y^2)\,dx\,dy$.

Given curves are $y = x \rightarrow (1)$

and $y^2 = 4x \rightarrow (2)$



Substitute (1) in (2), we get

$x^2 = 4x$

$\Rightarrow x^2 - 4x = 0 \Rightarrow x(x-4) = 0$

$\Rightarrow x = 0, \; x = 4$

The points are (0,0) and (4,4).

x varies from 0 to 4

y varies from x to $2\sqrt{x}$.

$$\therefore I = \iint_R (x^2+y^2)\,dx\,dy = \int_0^4\int_x^{2\sqrt{x}} (x^2+y^2)\,dy\,dx$$

$$= \int_0^4 \left(x^2 y + \frac{y^3}{3}\right)_x^{2\sqrt{x}} dx$$

$$= \int_0^4 \left[x^2 (2\sqrt{x} - x) + \frac{1}{3}\left((2\sqrt{x})^3 - x^3\right)\right] dx$$

$$= \int_0^4 \left(2x^{5/2} - x^3 + \frac{2^3}{3} x^{3/2} - \frac{1}{3} x^3\right) dx$$

$$= \left(2 \frac{x^{7/2}}{7/2} - \frac{x^4}{4} + \frac{8}{3} \frac{x^{5/2}}{5/2} - \frac{1}{3} \frac{x^4}{4}\right)_0^4$$

$$= \frac{4}{7} (4)^{7/2} - \frac{1}{4} (4)^4 + \frac{8}{3} \frac{2}{5} (4)^{5/2} - \frac{1}{3} \frac{1}{4} (4)^4$$

$$= \frac{4}{7} (2)^7 - \frac{256}{4} + \frac{16}{15} (32) - \frac{1}{12} (256)$$

$$= 73.14 - 64 + 34.13 - 21.33$$

$$= 107.27 - 85.33 = \underline{\underline{21.94}}$$

2. Evaluate $\iint_D y \, dx\, dy$ where D is region bounded by the parabolas $y^2 = 4x$ and $x^2 = 4y$.

Sol:- Let $I = \iint_D y \, dx \, dy$

Given curves are $y^2 = 4x$ and $x^2 = 4y \rightarrow (2)$

$$\Rightarrow x = \frac{y^2}{4} \rightarrow (1)$$

Substituting (1) in (2), we get $\left(\frac{y^2}{4}\right)^2 = 4y$

$$\Rightarrow \frac{y^4}{16} = 4y$$

$$\Rightarrow y^4 = 64y$$

$$\Rightarrow y(y^3 - 64) = 0$$

$$\Rightarrow y = 0, \quad y^3 - 64 = 0$$

$$\Rightarrow y = 0, \quad y^3 = 64 = 4^3$$

$$\Rightarrow y = 0, \quad y = 4$$

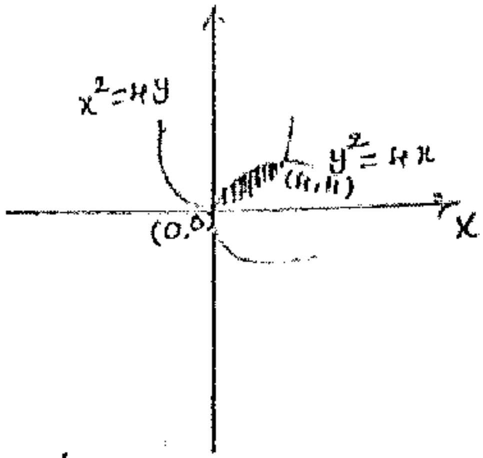
$y = 0 \Rightarrow x = 0$

$y = 4 \Rightarrow x = 4$

$\therefore$ The points are $(0,0)$ and $(4,4)$

x varies from 0 to 4.

y varies from $\frac{x^2}{4}$ to $2\sqrt{x}$.



$$I = \iint_D y\,dx\,dy$$

$$= \int_0^4 \int_{\frac{x^2}{4}}^{2\sqrt{x}} y\,dy\,dx$$

$$= \int_0^4 \left(\frac{y^2}{2}\right)_{\frac{x^2}{2}}^{2\sqrt{x}} dx = \frac{1}{2}\int_0^4 \left(4x - \frac{x^4}{16}\right) dx$$

$$= \frac{1}{2}\left(4\frac{x^2}{2} - \frac{x^5}{80}\right)_0^4 = \frac{1}{2}\left(2x^2 - \frac{x^5}{80}\right)_0^4$$

$$= \frac{1}{2}\left(32 - \frac{4^5}{80}\right)$$

$$= \frac{1}{2}\left(32 - \frac{64}{5}\right) = \frac{1}{2}\left(\frac{160-64}{5}\right)$$

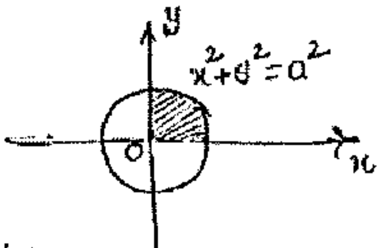
$$= \frac{48}{5}$$

3. Evaluate $\iint_R xy\,dx\,dy$ where R is the positive quadrant of the circle $x^2+y^2=a^2$.

Sol: Let $I = \iint xy\,dx\,dy$

x varies from 0 to a

y varies from 0 to $\sqrt{a^2-x^2}$.



$$\therefore I = \iint xy\,dx\,dy = \int_0^a \int_0^{\sqrt{a^2-x^2}} xy\,dy\,dx$$

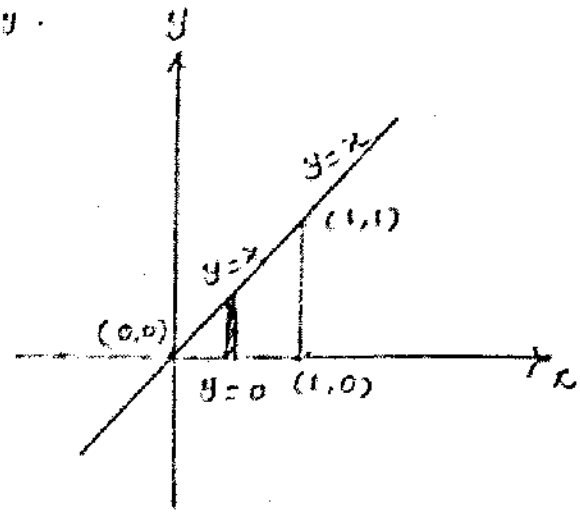
$$= \int_0^a x\frac{y^2}{2}\Big)_0^{\sqrt{a^2-x^2}} dx = \frac{1}{2}\int_0^a x(a^2-x^2)\,dx$$

$$= \frac{1}{2}\left[a^2\frac{x^2}{2} - \frac{x^4}{4}\right]_0^a = \frac{1}{2}\left[\frac{a^4}{2} - \frac{a^4}{4}\right] = \frac{1}{2}\,\frac{a^4}{4}$$

$$= \frac{a^4}{8}$$

4. Evaluate $\iint_R (\sqrt{xy} - y^2)\, dx\, dy$ where R is a triangle with vertices $(0,0)$, $(1,0)$ and $(1,1)$.

Sol: Let $I = \iint_R (\sqrt{xy} - y^2)\, dx\, dy$.



x varies from 0 to 1

y varies from 0 to x

$$\therefore I = \int_0^1 \int_0^x (\sqrt{xy} - y^2)\, dy\, dx$$

$$= \int_0^1 \left(\sqrt{x}\, \frac{y^{3/2}}{3/2} - \frac{y^3}{3} \right)_0^x dx$$

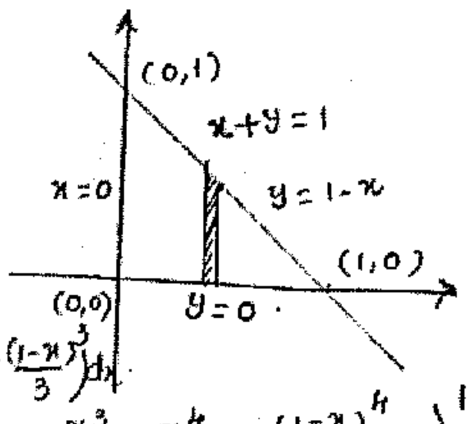
$$= \int_0^1 \left(\frac{2}{3} \sqrt{x}\, x^{3/2} - \frac{x^3}{3} \right) dx$$

$$= \int_0^1 \left(\frac{2}{3} x^2 - \frac{x^3}{3} \right) dx = \left(\frac{2}{3} \cdot \frac{x^3}{3} - \frac{x^4}{12} \right)_0^1$$

$$= \left(\frac{2}{3} \cdot \frac{1}{3} - \frac{1}{12} \right) = \left(\frac{2}{9} - \frac{1}{12} \right) = \frac{24 - 9}{108} = \frac{15}{108} = \frac{5}{36}.$$

5. Evaluate $\iint_R (x^2 + y^2)\, dx\, dy$ where R is the region bounded by $x = 0$, $y = 0$, $x + y = 1$

Sol: Given $I = \iint_R (x^2 + y^2)\, dx\, dy$.



x varies from 0 to 1

y varies from 0 to $1-x$.

$$\therefore I = \int_0^1 \int_0^{1-x} (x^2 + y^2)\, dy\, dx$$

$$= \int_0^1 \left(x^2 y + \frac{y^3}{3} \right)_0^{1-x} dx = \int_0^1 \left(x^2(1-x) + \frac{(1-x)^3}{3} \right) dx$$

$$= \int_0^1 \left(x^2 - x^3 + \frac{(1-x)^3}{3} \right) dx = \left(\frac{x^3}{3} - \frac{x^4}{4} + \frac{(1-x)^4}{12(-1)} \right)_0^1$$

$$= \frac{1}{3} - \frac{1}{4} + \frac{1}{12} = \frac{2}{12} = \frac{1}{6}$$

Double Integrals in polar coordinates :-

1. Evaluate $\int_0^{\pi}\int_0^{a\sin\theta} r\,dr\,d\theta$

Sol:- Consider $\int_0^{\pi}\int_0^{a\sin\theta} r\,dr\,d\theta = \int_0^{\pi}\left(\frac{r^2}{2}\right)_0^{a\sin\theta} d\theta$

$$= \frac{1}{2}\int_0^{\pi} a^2\sin^2\theta\,d\theta$$

$$= \frac{a^2}{2}\int_0^{\pi}\sin^2\theta\,d\theta = \frac{a^2}{2}\int_0^{\pi}\left(\frac{1-\cos 2\theta}{2}\right)d\theta$$

$$= \frac{a^2}{4}\left(\theta - \frac{\sin 2\theta}{2}\right)_0^{\pi}$$

$$= \frac{a^2}{4}\left((\pi - 0) - (0-0)\right) = \frac{a^2\pi}{4}$$

2. Evaluate $\int_0^{\pi/4}\int_0^{a\sin\theta} \frac{r}{\sqrt{a^2-r^2}}\,dr\,d\theta$

Sol:- Consider $\int_0^{\pi/4}\int_0^{a\sin\theta} \frac{r}{\sqrt{a^2-r^2}}\,dr\,d\theta$

$$= -\frac{1}{2}\int_0^{\pi/4}\int_0^{a\sin\theta} \frac{-2r}{\sqrt{a^2-r^2}}\,dr\,d\theta$$

$$= -\frac{1}{2}\int_0^{\pi/4}\left(2\sqrt{a^2-r^2}\right)_0^{a\sin\theta} d\theta \qquad \left(\because \int\frac{f'(x)}{\sqrt{f(x)}}dx = 2\sqrt{f(x)}\right)$$

$$= -\frac{1}{2}\cdot 2\int_0^{\pi/4}\left(\sqrt{a^2-a^2\sin^2\theta} - \sqrt{a^2-0}\right)d\theta$$

$$= -\int_0^{\pi/4}(a\cos\theta - a)\,d\theta = -a\int_0^{\pi/4}(\cos\theta - 1)\,d\theta$$

$$= -a\left(\sin\theta - \theta\right)_0^{\pi/4}$$

$$= -a\left(\sin\frac{\pi}{4} - \frac{\pi}{4}\right) = -a\left(\frac{1}{\sqrt{2}} - \frac{\pi}{4}\right) = a\left(\frac{\pi}{4} - \frac{1}{\sqrt{2}}\right)$$

3. Evaluate $\int_0^{\pi/2}\int_0^{\infty} \frac{r}{(r^2+a^2)^2}\,dr\,d\theta$

Sol: Consider $\int_0^{\pi/2}\int_0^{\infty} \frac{r}{(r^2+a^2)^2}\,dr\,d\theta = \frac{1}{2}\int_0^{\pi/2}\int_0^{\infty} \frac{2r}{(r^2+a^2)^2}\,dr\,d\theta$

$$= \frac{1}{2}\int_0^{\pi/2}\left(-\frac{1}{r^2+a^2}\right)_0^{\infty} d\theta \qquad \left(\because \int \frac{f'(x)}{(f(x))^n}\,dx = -\frac{1}{n-1}\,\frac{1}{f^{n-1}}\right).$$

$$= \frac{1}{2}\int_0^{\pi/2}\left(0+\frac{1}{a^2}\right)d\theta \qquad \left(\because r \to \infty,\ \frac{1}{r} \to 0\right)$$

$$= \frac{1}{2a^2}\int_0^{\pi/2} d\theta = \frac{1}{2a^2}(\theta)_0^{\pi/2} = \frac{1}{2a^2}\left(\frac{\pi}{2}-0\right) = \underline{\underline{\frac{\pi}{4a^2}}}.$$

Change of order of Integration:

Change of order of integration changes the limits of integration.

Working procedure:

1. Identify the variables for the limits.
2. Trace the curve
3. If we are evaluating with respect to 'y' first then take the strip parallel to y-axis (i.e vertical strip)
4. If the evaluation is with respect to 'x' first then take the strip parallel to x-axis (i.e horizontal).
4. Rotate the strip 90° in anti-clock wise direction and identify the starting and the ending points

of the strip which will be lower and upper limits of the variable.

5. Identify the limits for other variables for the region of consideration.

6. Evaluate the double integral with new order of Integration.

1. Change the order of integration and evaluate $\int_0^{4a}\int_{x^2/4a}^{2\sqrt{ax}} dy\,dx$.

Sol: In the given integral, x varies from 0 to $4a$.

y varies from $\frac{x^2}{4a}$ to $2\sqrt{ax}$.

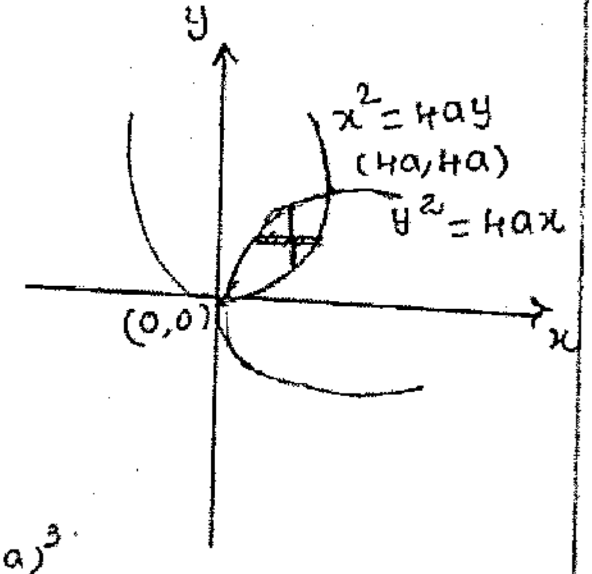
To draw the curves $y=\frac{x^2}{4a}$ and $y=2\sqrt{ax}$

i.e $x^2=4ay$ and $y^2=4ax$

$y=\frac{x^2}{4a} \to (1)$

$y=2\sqrt{ax} \to (2)$

$y^2=4ax$



From (1), $\left(\frac{x^2}{4a}\right)^2=4ax$

$\Rightarrow x^4=64a^3x$

$\Rightarrow x^4-64a^3x=0$

$\Rightarrow x(x^3-64a^3)=0$

$\Rightarrow x=0,\ x^3=64a^3=(4a)^3$

$\Rightarrow x=0,\ x=4a$

The intersecting points are $(0,0)$ and $(4a,4a)$.

To change the order of integration,

y varies from 0 to $4a$

x varies from $\frac{y^2}{4a}$ to $2\sqrt{ay}$.

$$\therefore \int_0^{4a}\int_{x^2/4a}^{2\sqrt{ax}} dy\,dx = \int_0^{4a}\int_{y^2/4a}^{2\sqrt{ay}} dx\,dy$$

$$= \int_0^{4a} (x)_{y^2/4a}^{2\sqrt{ay}}\, dy = \int_0^{4a}\left(2\sqrt{ay} - \frac{y^2}{4a}\right) dy$$

$$= \left(2\sqrt{a}\,\frac{y^{3/2}}{3/2} - \frac{1}{4a}\,\frac{y^3}{3}\right)_0^{4a}$$

$$= \left(\frac{4}{3}\sqrt{a}\,(4a)^{3/2} - \frac{1}{4a}\cdot\frac{(4a)^3}{3}\right).$$

$$= \left(\frac{4}{3}\,2^3\,a^{1/2}a^{3/2} - \frac{16a^2}{3}\right) = \frac{32}{3}a^2 - \frac{16}{3}a^2 = \frac{16}{3}a^2$$

(2) By change of order of integration evaluate

$$\int_0^a\int_x^a (x^2+y^2)\,dy\,dx.$$

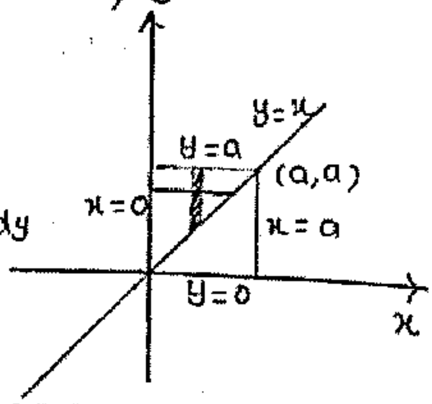
Sol:- In the given integral, x varies from 0 to a.

y varies from x to a.

To change the order of integration,

y varies from 0 to a

x varies from 0 to y.



$$\therefore \int_0^a\int_x^a (x^2+y^2)\,dy\,dx = \int_0^a\int_0^y (x^2+y^2)\,dx\,dy$$

$$= \int_0^a \left(\frac{x^3}{3} + xy^2\right)_0^y dy$$

$$= \int_0^a \left(\frac{y^3}{3} + y^3\right) dy = \int_0^a \frac{4}{3} y^3 \, dy = \frac{4}{3}\left(\frac{y^4}{4}\right)_0^a = \frac{a^4}{3}$$

3. By change of integration evaluate $\int_0^1 \int_{x^2}^{x} xy \, dx \, dy$.

Sol:- In the given integral x varies from 0 to 1.

y varies from x^2 to x.

Now, $y = x^2$, $y = x$.

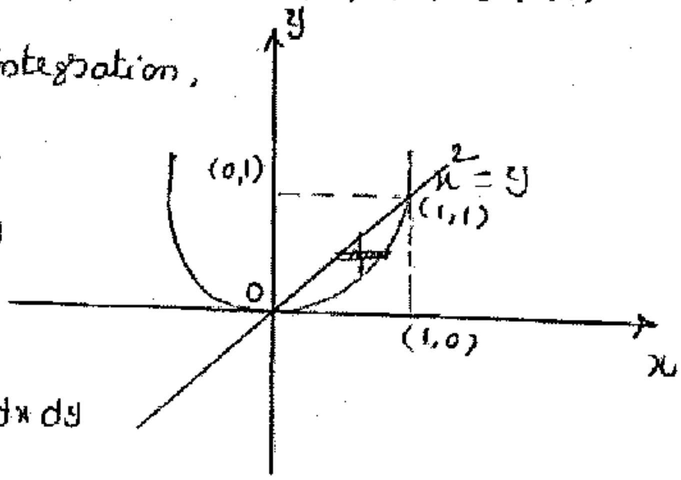
$$x^2 = x \Rightarrow x^2 - x = 0$$
$$\Rightarrow x(x-1) = 0$$
$$\Rightarrow x = 0, x = 1$$

The intersecting points are $(0,0)$ and $(1,1)$.

To change the order integration,

y varies from 0 to 1

x varies from y to $\sqrt{y}$



$$\therefore \int_0^1 \int_{x^2}^{x} xy \, dx \, dy = \int_0^1 \int_y^{\sqrt{y}} xy \, dx \, dy$$

$$= \int_0^1 \left(\frac{x^2}{2} y\right)_y^{\sqrt{y}} dy = \int_0^1 \frac{y}{2}\left((\sqrt{y})^2 - y^2\right) dy$$

$$= \frac{1}{2}\int_0^1 (y^2 - y^3) \, dy = \frac{1}{2}\left(\frac{y^3}{3} - \frac{y^4}{4}\right)_0^1$$

$$= \frac{1}{2}\left(\frac{1}{3} - \frac{1}{4}\right) = \frac{1}{2}\left(\frac{4-3}{12}\right) = \frac{1}{24}$$

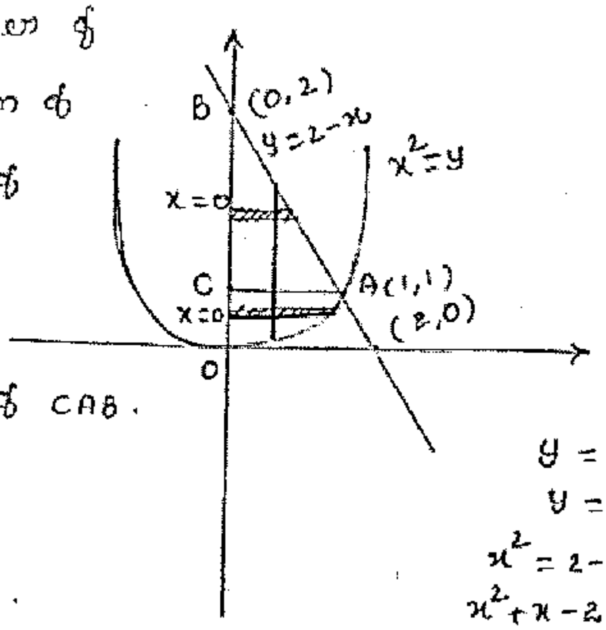
4. Change the order of integration and evaluate

$$\int_0^1 \int_{x^2}^{2-x} xy \, dy \, dx.$$

Sol:- In the given integral, x varies from 0 to 1.

y varies from x^2 to $2-x$.

By changing the order of integration, the region of integration is Area of OABO.



Area of OABO = Area of OAC + Area of CAB.

$y = x^2$

$y = 2 - x$ ✓ (2,0) (0,2)

$x^2 = 2 - x$

$x^2 + x - 2 = 0$

$x = 1, -2$.

<u>Area</u> of <u>OAC</u>:

x varies from 0 to $\sqrt{y}$

y varies from 0 to 1.

$$\therefore \int_0^1 \int_{x^2}^{2-x} xy\,dy\,dx = \int_0^1 \int_0^{\sqrt{y}} xy\,dx\,dy$$

$$= \int_0^1 \left.\frac{x^2}{2}y\right)_0^{\sqrt{y}} dy = \frac{1}{2}\int_0^1 y(\sqrt{y})^2\,dy = \frac{1}{2}\int_0^1 y^2\,dy$$

$$= \frac{1}{2}\left(\frac{y^3}{3}\right) = \left.\frac{y^3}{6}\right)_0^1 = \frac{1}{6}$$

<u>Area</u> of <u>CAB</u>:- x varies from 0 to $2 - y$.

y varies from 1 to 2.

$$\therefore \int_0^1 \int_{x^2}^{2-x} xy\,dy\,dx = \int_1^2 \int_0^{2-y} xy\,dx\,dy = \int_1^2 \left(\frac{x^2}{2}y\right)_0^{2-y} dy$$

$$= \frac{1}{2}\int_1^2 (2-y)^2 y\,dy = \frac{1}{2}\int_1^2 (4 - 4y + y^2)y\,dy.$$

$$= \frac{1}{2}\int_1^2 (4y - 4y^2 + y^3)\,dy = \frac{1}{2}\left(4\frac{y^2}{2} - 4\frac{y^3}{3} + \frac{y^4}{4}\right)_1^2$$

$$= \frac{1}{2}\left[2(4-1) - \frac{4}{3}(8-1) + \frac{1}{4}(16-1)\right]$$

$$= \frac{1}{2}\left[6 - \frac{28}{3} + \frac{15}{4}\right] = \frac{1}{2}\left[\frac{72 - 112 + 45}{12}\right]$$

$$= \frac{1}{2}\left[\frac{117 - 112}{12}\right] = \frac{5}{24}$$

$\therefore$ <u>Required Area</u> $= \frac{1}{6} + \frac{5}{24} = \frac{4+5}{24}$

$= \frac{9}{24} = \frac{3}{8}$ ✓

Triple Integrals :

It is a generalization of a double integral.

1. Evaluate $\int_0^1\int_0^1\int_0^1 xyz\,dx\,dy\,dz$.

Sol: Consider $\int_0^1\int_0^1\int_0^1 xyz\,dx\,dy\,dz = \int_0^1\int_0^1 \left((yz)\frac{x^2}{2}\right)_0^1 dy\,dz$

$$= \int_0^1\int_0^1 yz\left(\frac{1}{2}-0\right)dy\,dz = \frac{1}{2}\int_0^1 z\left(\frac{y^2}{2}\right)_0^1 dz$$

$$= \frac{1}{2}\int_0^1 z\left(\frac{1}{2}-0\right)dz = \frac{1}{4}\int_0^1 z\,dz$$

$$= \frac{1}{4}\left(\frac{z^2}{2}\right)_0^1 = \frac{1}{4}\left(\frac{1}{2}-0\right) = \frac{1}{8}$$

2. Evaluate $\int_0^1\int_0^x\int_0^{x+y} (x+y+z)\,dx\,dy\,dz$.

Sol:- Consider $\int_0^1\int_0^x\int_0^{x+y} (x+y+z)\,dx\,dy\,dz$

$$= \int_0^1\int_0^x\int_0^{x+y} (x+y+z)\,dz\,dy\,dx = \int_0^1\int_0^x \left((x+y)z + \frac{z^2}{2}\right)_0^{x+y} dy\,dx$$

$$= \int_0^1\int_0^x \left[(x+y)^2 + \frac{(x+y)^2}{2}\right] dy\,dx$$

$$= \frac{3}{2}\int_0^1\int_0^x (x^2+2xy+y^2)\,dy\,dx$$

$$= \frac{3}{2}\int_0^1 \left(x^2y + 2x\frac{y^2}{2} + \frac{y^3}{3}\right)_0^x dx$$

$$= \frac{3}{2}\int_0^1 \left(x^3 + x^3 + \frac{x^3}{3}\right)dx = \frac{3}{2}\int_0^1 \frac{7}{3}x^3\,dx$$

$$= \frac{3}{2}\cdot\frac{7}{3}\left(\frac{x^4}{4}\right)_0^1 = \frac{7}{2}\left(\frac{1}{4}-0\right) = \frac{7}{8}$$

3. Evaluate $\int_0^a \int_0^x \int_0^y x^3 y^2 z \, dx\, dy\, dz$.

Sol: Consider $\int_0^a \int_0^x \int_0^y x^3 y^2 z \, dx\, dy\, dz = \int_0^a \int_0^x \int_0^y x^3 y^2 z \, dz\, dy\, dx$

$$= \int_0^a \int_0^x x^3 y^2 \left(\frac{z^2}{2}\right)_0^y dy\, dx = \int_0^a \int_0^x x^3 y^2 \left(\frac{y^2}{2} - 0\right) dy\, dx$$

$$= \frac{1}{2} \int_0^a \int_0^x x^3 y^4 \, dy\, dx = \frac{1}{2} \int_0^a x^3 \left(\frac{y^5}{5}\right)_0^x dx$$

$$= \frac{1}{10} \int_0^a x^8 \, dx = \frac{1}{90} a^8 (a^9 - 0) = \frac{a^9}{90}$$

4. Evaluate $\int_0^1 \int_0^{\sqrt{1-x^2}} \int_0^{\sqrt{1-x^2-y^2}} \frac{1}{\sqrt{1-x^2-y^2-z^2}} \, dx\, dy\, dz$.

Sol: Consider $\int_0^1 \int_0^{\sqrt{1-x^2}} \int_0^{\sqrt{1-x^2-y^2}} \frac{1}{\sqrt{1-x^2-y^2-z^2}} \, dx\, dy\, dz$.

$$= \int_0^1 \int_0^{\sqrt{1-x^2}} \int_0^a \frac{1}{\sqrt{a^2-z^2}} \, dz\, dy\, dx. \qquad \text{put } \sqrt{1-x^2-y^2} = a$$

$$= \int_0^1 \int_0^{\sqrt{1-x^2}} \left(\sin^{-1}\left(\frac{z}{a}\right)\right)_0^a dy\, dx$$

$$= \int_0^1 \int_0^{\sqrt{1-x^2}} \left(\sin^{-1}(1) - \sin^{-1}(0)\right) dy\, dx$$

$$= \int_0^1 \int_0^{\sqrt{1-x^2}} \left(\frac{\pi}{2} - 0\right) dy\, dx = \frac{\pi}{2} \int_0^1 (y)_0^{\sqrt{1-x^2}} dx$$

$$= \frac{\pi}{2} \int_0^1 \sqrt{1-x^2} \, dx.$$

$$\left(\because \int \sqrt{a^2-x^2}\, dx = \frac{x}{2}\sqrt{a^2-x^2} + \frac{a^2}{2} \sin^{-1}\left(\frac{x}{a}\right)\right).$$

$$= \frac{\pi}{2} \left(\frac{x}{2}\sqrt{1-x^2} + \frac{1}{2}\sin^{-1}(x)\right)_0^1$$

$$= \frac{\pi}{2} \left(\frac{1}{2}(0) + \frac{1}{2}\sin^{-1}(1) - 0\right) = \frac{\pi}{2} \cdot \frac{1}{2} \cdot \frac{\pi}{2} = \frac{\pi^2}{8}$$

5. Evaluate $\iiint xyz\,dx\,dy\,dz$ taken over the volume bounded by $x=0, y=0, z=0$ and $x+y+z=1$.

Sol:- Given integral $I = \iiint xyz\,dx\,dy\,dz$

The limits of integration are $x=0, x=1$

$y=0,\ y=1-x$

$z=0,\ z=1-x-y$.

$$\therefore \iiint xyz\,dx\,dy\,dz = \int_0^1\int_0^{1-x}\int_0^{1-x-y}(xyz)\,dz\,dy\,dx.$$

$$= \int_0^1\int_0^{1-x} xy\left(\frac{z^2}{2}\right)_0^{1-x-y} dy\,dx$$

$$= \int_0^1\int_0^{1-x} \frac{xy(1-x-y)^2}{2}\,dy\,dx$$

$$= \int_0^1\int_0^{1-x} \frac{x}{2}\left[y(1-x)^2 - 2(1-x)y^2 + y^3\right] dy\,dx.$$

$$= \int_0^1 \frac{x}{2}\left[(1-x)^2\frac{y^2}{2} - 2(1-x)\frac{y^3}{3} + \frac{y^4}{4}\right]_0^{1-x} dx$$

$$= \int_0^1 \frac{x}{2}\left[\frac{(1-x)^2(1-x)^2}{2} - \frac{2}{3}(1-x)(1-x)^3 + \frac{1}{4}(1-x)^4\right]dx$$

$$= \int_0^1 \frac{x}{2}\frac{(1-x)^4}{12}\,dx \qquad \frac{1}{2}-\frac{2}{3}+\frac{1}{4} = \frac{6-8+3}{12} = \frac{1}{12}$$

$$= \frac{1}{24}\int_0^1 x(1-x)^4\,dx \qquad \int_0^1 x^{m-1}(1-x)^{n-1}dx = \beta(m,n)$$

$$= \frac{1}{24}\beta(2,5) \qquad = \frac{\Gamma m\,\Gamma n}{\Gamma m+n}$$

$$= \frac{1}{24}\frac{\Gamma 2\,\Gamma 5}{\Gamma 2+5} = \frac{1}{24}\frac{1!\,4!}{6!} = \frac{1}{24}\cdot\frac{1}{6\times5} \qquad = \frac{(m-1)!\,(n-1)!}{(m+n-1)!}$$

$$= \frac{1}{720}.$$

6. Evaluate $\iiint_V (x+y+z)\,dx\,dy\,dz$ where V is the region bounded by the planes $x=0, x=1, y=0, y=1, z=0, z=1$.

Sol:- Given $I = \iiint_V (x+y+z)\,dx\,dy\,dz$.

The limits of integration are x from 0 to 1.
y from 0 to 1.
z from 0 to 1.

$$\therefore \iiint_V (x+y+z)\,dx\,dy\,dz = \int_0^1\int_0^1\int_0^1 (x+y+z)\,dx\,dy\,dz$$

$$= \int_0^1\int_0^1 \left(\frac{x^2}{2} + (y+z)x\right)_0^1 dy\,dz.$$

$$= \int_0^1\int_0^1 \left(\frac{1}{2} + (y+z)\right) dy\,dz.$$

$$= \int_0^1 \left(\frac{1}{2}y + \frac{y^2}{2} + zy\right)_0^1 dz.$$

$$= \int_0^1 \left(\frac{1}{2} + \frac{1}{2} + z\right) dz = \int_0^1 (1+z)\,dz$$

$$= z + \frac{z^2}{2}\Big)_0^1 = 1 + \frac{1}{2} = \frac{3}{2}.$$

7. Evaluate $\iiint 45x^3y\,dx\,dy\,dz$ where V is the region bounded by $x=y=z=0$ and $4x+2y+z=8$.

Sol:- Let $I = \iiint 45x^3y\,dx\,dy\,dz$.

The limits of integration are $x=0$ to $x=2$.
$y=0$ to $y=4-2x$
$z=0$ to $z=8-4x-2y$.

$$\therefore \iiint 45\,x^3y\,dx\,dy\,dz = \int_0^2\int_0^{4-2x}\int_0^{8-4x-2y} 45\,x^3y\,dz\,dy\,dx$$

$$= \int_0^2\int_0^{4-2x} (45x^3y)(z)_0^{8-4x-2y}\,dy\,dx$$

$$= \int_0^2\int_0^{4-2x} (45x^3y)\,(8-4x-2y)\,dy\,dx$$

$$= 45\int_0^2\int_0^{4-2x} x^3\,(8y-4xy-2y^2)\,dy\,dx$$

$$= 45\int_0^2 x^3\left(8\frac{y^2}{2}-4x\frac{y^2}{2}-2\frac{y^3}{3}\right)_0^{4-2x} dx$$

$$= 45\int_0^2 x^3\left(4(4-2x)^2-\frac{4}{2}x(4-2x)^2-\frac{2}{3}(4-2x)^3\right]dx$$

$$= 45\int_0^2 x^3\left[(4-2x)^2(4-2x)-\frac{2}{3}(4-2x)^3\right]dx$$

$$= 45\int_0^2 x^3\left[\frac{3(4-2x)^3-2(4-2x)^3}{3}\right]dx$$

$$= \frac{45}{3}\int_0^2 x^3(4-2x)^3\,dx$$

$$= \frac{45}{3}\int_0^2 x^3(64-8x^3-96x+48x^2)\,dx$$

$$= \frac{45}{3}\int_0^2 (64x^3-8x^6-96x^4+48x^5)\,dx$$

$$= \frac{45}{3}\left[64\frac{x^4}{4}-8\frac{x^7}{7}-96\frac{x^5}{5}+48\frac{x^6}{6}\right]_0^2$$

$$= \frac{45}{3}\left[16(2^4)-\frac{8}{7}(2^7)-\frac{96}{5}(2)^5+8(2^6)\right]$$

$$= 15\left[16\times16-\frac{8}{7}(128)-\frac{96}{5}(32)+8(64)\right]$$

$$= \underline{\underline{128}}$$

Evaluate $\iiint_R xy\,dx\,dy\,dz$ where R is the positive octant of the sphere $x^2+y^2+z^2=a^2$.

Sol: Let $I = \iiint_R xy\,dx\,dy\,dz$

x varies from 0 to a

y varies from 0 to $\sqrt{a^2-x^2}$

z varies from 0 to $\sqrt{a^2-x^2-y^2}$.

$\therefore I = \iiint_R xy\,dx\,dy\,dz = \int_0^a \int_0^{\sqrt{a^2-x^2}} \int_0^{\sqrt{a^2-x^2-y^2}} (xy)\,dz\,dy\,dx$

$= \int_0^a \int_0^{\sqrt{a^2-x^2}} xy\,(z)_0^{\sqrt{a^2-x^2-y^2}}\,dy\,dx$

put, $a^2-x^2-y^2 = t$

d.w.r.to y, we get

$-2y = \frac{dt}{dy}$

$y\,dy = -\frac{dt}{2}$

Limits:-

Lower limit: a^2-x^2

upper limit: 0

$= \int_0^a \int_0^{\sqrt{a^2-x^2}} xy\,(\sqrt{a^2-x^2-y^2})\,dy\,dx$

$= \int_0^a \int_{a^2-x^2}^0 x(\sqrt{t})\left(-\frac{dt}{2}\right)dx$

$= \frac{1}{2}\int_0^a \int_0^{a^2-x^2} x\left(t^{1/2}\right)dt\,dx$

$= \frac{1}{2}\int_0^a x\left(\frac{t^{3/2}}{3/2}\right)_0^{a^2-x^2} dx = \frac{1}{2}\int_0^a \frac{3}{2}\,x\left(a^2-x^2\right)^{3/2} dx.$

put, $a^2-x^2 = s$

$-2x\,dx = ds$

$x\,dx = -\frac{ds}{2}$

Limits: a^2, 0

$= \frac{1}{2}\cdot\frac{2}{3}\int_{a^2}^0 (s)^{3/2}\left(-\frac{ds}{2}\right)$

$= -\frac{1}{6}\left(\frac{s^{5/2}}{5/2}\right)_{a^2}^0 = -\frac{1}{15}\left(0-(a^2)^{5/2}\right)$

$= \frac{1}{15}a^5$

5. Evaluate $\iiint xyz\,dx\,dy\,dz$ taken over the volume bounded by $x=0, y=0, z=0$ and $x+y+z=1$.

Sol:- Given integral $I = \iiint xyz\,dx\,dy\,dz$.

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$$= \int_0^a \int_{a^2-x^2}^{0} x(\sqrt{t})\left(-\frac{dt}{2}\right) dx$$

$$= \frac{1}{2}\int_0^a \int_0^{a^2-x^2} x\left(t^{1/2}\right) dt\,dx$$

$$= \frac{1}{2}\int_0^a x\left(\frac{t^{3/2}}{3/2}\right)_0^{a^2-x^2} dx = \frac{1}{2}\int_0^a \frac{2}{3}\,x\left(a^2-x^2\right)^{3/2} dx.$$

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$x\,dx = -\frac{ds}{2}$

Limits: a^2, 0

$$= \frac{1}{2}\cdot\frac{2}{3}\int_{a^2}^{0} (s)^{3/2}\left(-\frac{ds}{2}\right)$$

$$= -\frac{1}{6}\left(\frac{s^{5/2}}{5/2}\right)_{a^2}^{0} = -\frac{1}{15}\left(0-(a^2)^{5/2}\right)$$

$$= \frac{1}{15}a^5$$

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DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

COURSE FILE 2022-2023

MALINENI LAKSHMAIAH WOMEN'S ENGINEERING COLLEGE

ESTD : 2008

NAME OF THE FACULTY: Dr. **Syed Nageena Parveen**

SUBJECT&COURSE CODE: **Digital Communications (C304)**

YEAR &SEMESTER: **B.Tech (ECE) III Year & I Semester (2022-23)**

PRINCIPAL
MALINENI LAKSHMAIAH
WOMEN'S ENGINEERING COLLEGE
PULLADIGUNTA, GUNTUR-17

DEPARTMENT VISION

To be a centre of excellence in Electronics and Communication Engineering by providing quality education and producing competent women engineers to address global challenges of the society.

DEPARTMENT MISSION

- To inculcate professional excellence and research culture through industry-institute interaction.

- To impart a deep thirst for a lifelong learning by employing practical teaching and learning methodologies.

- To strengthen professional and soft skills through co-curricular and extracurricular activities.

- To nurture ethical and socio-economical values amongst the learners through conducive learning environment.

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DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

VISION, MISSION AND PROGRAM EDUCATIONAL OBJECTIVES

Vision

To be a center of excellence in Electronics and Communication Engineering by providing quality education and producing competent women engineers to address global challenges of the society.

Mission

- To inculcate professional excellence and research culture through industry-institute interaction.
- To impart a deep thirst for a lifelong learning by employing practical teaching and learning methodologies.
- To strengthen professional and soft skills through co-curricular and extracurricular activities.
- To nurture ethical and socio-economical values amongst the learners through conducive learning environment.

Program Educational Objectives (PEOs)

PEO1: Graduates will be able to showcase their skills in solving real-time engineering problems by using cutting edge technologies.

PEO2: Graduates will be able to succeed in the areas of Electronics and Communication Engineering and other diverse fields by updating themselves with the advanced techniques through lifelong learning skills.

PEO3: Graduates will be able to establish a definite caliber in various interpersonal skills to facilitate excellent expression of their ideas and knowledge.

PEO4: Graduates will be able to develop an all-round personality which abides by superior social and ethical standards to add maximum value to the society.

Program Specific Outcomes (PSOs)

PSO1: Analyze real time problems and provide solutions in the field of advanced communications, signal, and image processing applications.

PSO2: Analyze and develop the components of a system or sub-system using the concepts of embedded systems and VLSI technology.

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(An ISO9001:2008 Certified Institution)
Pulladigunta (Vil), Vatticherukuru (Md), Prathipadu Road, Guntur – 522 017 A.P.

ESTD : 2008

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

List of contents in the Course File

Department Vision /Mission/PO's/PSO's common to all course files

Sl. No			Description	Available /Not Available
0			Cover Page	
1	A	I.	Contents of Course File	
2	B	I.	Syllabus with Prescribed text books	✓
3		II.	Course Objectives and Outcomes	✓
4		III.	CO-PO and PSO mapping with justification	✓
5		IV.	Gap Identification and Contents Beyond Syllabus with mapping	
6	C	I.	Academic Calendar	✓
7		II.	Teaching/Instructional Plan	✓
8		III.	Instructional Methodology – Pedagogical initiatives and Innovation	✓
9		IV.	Assessment of Attainment of COs Plan – Direct and Indirect	✓
10		V.	University Results for Previous years and Current Attainment Target	✓
11		VI.	Individual Time Table	
12	D	I.	Course Materials/Notes – Unit wise	✓
13	E	I.	Previous Question papers – Internal and External	✓
14		II.	Question Bank – Unit wise	✓
15		III.	Assignment and Tutorial Questions with Solutions	✓
16		IV.	Internal Examination – Question Papers with Key and Scheme of Evaluation	✓
17	F	I.	Attendance Record	✓
18	G	II.	List of Slow Learners in the course	✓
19		III.	List of Advanced Learners and Programs conducted	✓
20		IV.	Remedial Classes to the Slow Learners	✓
21		V.	Remedial Classes Attendance Report	✓
22		VI.	Syllabus Coverage – Prescribed and Actual	
23		VII.	Make Up classes - Schedule	
24	H	I.	Evaluation Record – Internal, Quiz and Assignments	✓
25		II.	Sample Internal Answer Scripts and Assignments	✓
26	I	I.	Attainment Record – Direct and Indirect	✓
27		II.	Attainment Analysis – Corrective Action/Remedial Measures	✓
28	J	I.	University Results – Regular, Revaluation, Supplementary (1^{st})	✓
29	K	I.	Course Closure Report – Suggestion for Continuous Improvement	
30		II.	Remedial Classes for Backlog Students of this course	

Course Coordinator (s):

Module Coordinator (s):

Head of the Department:

HOD
Dept. of Electronics & Communication Engineering
Malineni Lakshmaiah Women's Engineering College
Pulladigunta, GUNTUR-522017

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PULLADIGUNTA. GUNTUR-17

PROGRAM OUTCOMES DEFINED BY NBA

PO 1: Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO 2: Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO 3: Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO 4: Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO 5: Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PO 6: The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO 7: Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO 8: Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO 9: Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO 10: Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO 11: Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO 12: Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

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DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

III Year - I Semester		L	T	P	C
		3	0	0	3

DIGITAL COMMUNICATIONS

Course Objectives:

The student will be able to

- Understand pulse digital modulation systems such as PCM, DPCM and DM.
- Understand various digital modulation techniques and able to analyze various systems fortheir performance in terms of probability of error.
- Study the concepts of information theory and need for source coding.
- Study Block codes, cyclic codes and convolution codes.

UNIT I

PULSE DIGITAL MODULATION: Elements of digital communication systems, advantages of digital communication systems, Elements of PCM: Sampling, Quantization & Coding, Quantization error, Companding in PCM systems. Differential PCM systems(DPCM). Delta modulation, its draw backs, adaptive delta modulation, comparison of PCM and DM systems, noise in PCM and DM systems.

UNIT II

DIGITAL MODULATION TECHNIQUES: Introduction, ASK, FSK, PSK, DPSK, DEPSK,QPSK, M-ary PSK, ASK, FSK, similarity of BFSK and BPSK.

UNIT III

Mohan Gupta, OxfordUniversity Press,4^{th} Edition,2017

Course Outcomes:

After going through this course the student will be able to

- Analyze the performance of a Digital Communication System for probability of error andare able to design a digital communication system.
- Analyze various source coding techniques.
- Compute and analyze Block codes, cyclic codes and convolution codes.
- Design a coded communication system.

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DATA TRANSMISSION : Base band signal receiver, probability of error, the optimum filter, matched filter, probability of error using matched filter, coherent reception, non-coherent detection of FSK, calculation of error probability of ASK, BPSK, BFSK,QPSK.

UNIT IV

INFORMATION THEORY: Discrete messages, concept of amount of information and its properties. Average information, Entropy and its properties. Information rate, Mutual informationand its properties.

SOURCE CODING: Introductions, Advantages, Shannon's theorem, Shanon-Fano coding, Huffman coding, efficiency calculations, channel capacity of discrete and analog Channels, capacity of a Gaussian channel, bandwidth –S/N trade off.

UNIT V

LINEAR BLOCK CODES: Introduction, Matrix description of Linear Block codes, Error detection and error correction capabilities of Linear block codes, Hamming codes, Binary cyclic codes, Algebraic structure, encoding, syndrome calculation, BCH Codes.

CONVOLUTION CODES: Introduction, encoding of convolution codes, time domain approach, transform domain approach. Graphical approach: state, tree and trellis diagram decoding using Viterbi algorithm.

TEXT BOOKS:

1. Digital communications - Simon Haykin, John Wiley,2005
2. Digital and Analog Communication Systems - Sam Shanmugam, John Wiley,2005.

REFERENCES:

1. Principles of Communication Systems – H. Taub and D. Schilling, TMH,2003
2. Digital Communications – John Proakis, TMH, 1983. Communication Systems Analog&Digital – Singh & Sapre, TMH,2004.
3. Modern Digital and Analog Communication Systems –B.P.Lathi,Zhi Ding,Hari

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DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

ESTD : 2008

NBA

ACADEMIC YEAR 2019-2020

Name of the Course:	DIGITAL COMMUNICATIONS	Course Code:	C304

Course Outcomes (COs):

After the completion of the course, the student will be able to

Course	Outcomes	
C304.1	Analyze the wave form Coding techniques of digital communication systems in PCM, DPCM, DM, ADM and also mention the effect of Noise, drawbacks.	4
C304.2	Analyze ASK, FSK, PSK, DPSK, DEPSK, QPSK, M-ary PSK, ASK, FSK, similarity of BFSK and BPSK Modulation and demodulation techniques with coherent and non coherent matched and optimum filters.	4
C304.3	Apply knowledge of average information, entropy, information rate and mutual information to evaluate channel capacity.	3
C304.4	Analyze Shannon- Fano , Huffman source encoder with efficiency and also linear block codes	4
C304.5	Apply Time domain, transform domain, graphical approach to encode convolution codes and decode convolution codes using viterbi algorithm.	3

Course Articulation Matrix: Mapping Course Outcomes (COs) with Program Outcomes (POs)

COs/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
C304.1	1	3	3	2	2	1	-	-	-	-	-	1		
C304.2	2	3	3	3	2	-	-	-	-	-	-	-		
C304.3	3	3	3	3	3	-	-	-	-	-	-	3		
C304.4	2	3	3	3	2	-	-	-	-	-	-	-		
C304.5	2	3	3	3	3	-	-	-	-	-	-	-		

1. Slight (20 < C < 40) **2. Moderate (40 < C < 70)** **3. Substantial (C > 70)**

Name and Signature of the Course Coordinator:	Dr.K.Gouthami	
Name and Signature of the Course Instructor(s):		

Head, ECE

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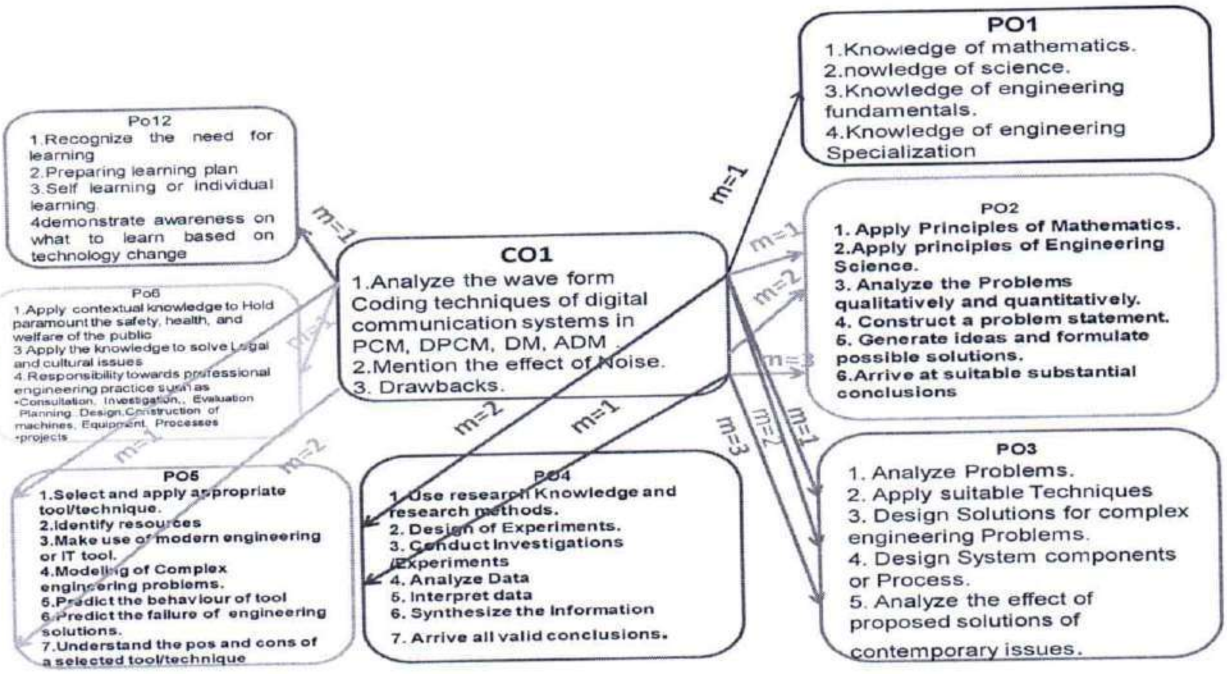
CO1: Analyze the wave form coding techniques of digital communication systems in PCM, DPCM, DM, and ADM and also mention the effect of Noise, drawbacks



- Number of Key elements in CO1: n = 3
- Number of key elements of CO1 mapping with key elements of PO1: m=1 Percentage of Correlation, %C = (m/n) * 100
  = (1/3) * 100 = 33.3% **(Slight)**
- Number of key elements of CO1 is mapping with key elements of PO2: m=3
  Percentage of Correlation, %C = (m/n) * 100
  = (3/3) * 100 = 100% **(Substantial)**
- Number of key elements of CO1 is mapping with key elements of PO3: m=3
  Percentage of Correlation, %C = (m/n) * 100
  = (3/3) * 100 = 100% **(Substantial)**
- Number of key elements of CO1 is mapping with key elements of PO4: m=2
  Percentage of Correlation, %C = (m/n) * 100
  = (2/3) * 100 = 66.6% **(Moderate)**
- Number of key elements of CO1 is mapping with key elements of PO5: m=2
  Percentage of Correlation, %C = (m/n) * 100
  = (2/3) * 100 = 66.6% **(Moderate)**
- Number of key elements of CO1 is mapping with key elements of PO6: m=1
  Percentage of Correlation, %C = (m/n) * 100
  = (1/3) * 100 = 33.3% **(Slight)**
- Number of key elements of CO1 is mapping with key elements of PO12: m=1
  Percentage of Correlation, %C = (m/n) * 100
  = (1/3) * 100 = 33.3% **(Slight)**

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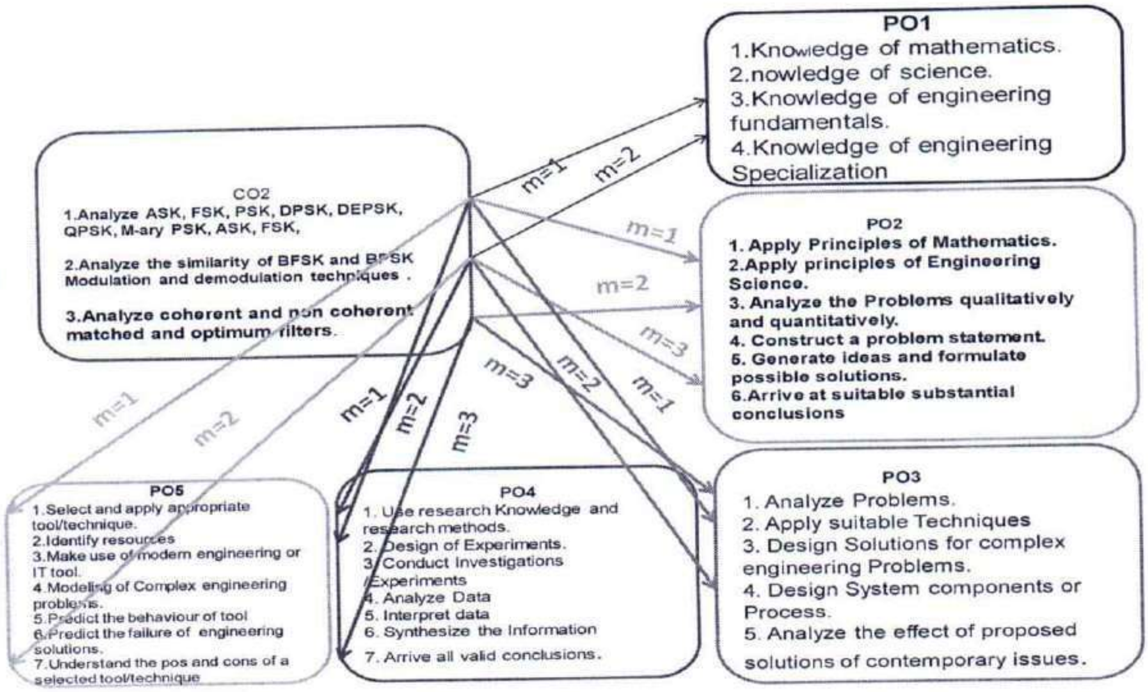
CO2. Analyze ASK, FSK, PSK, DPSK, DEPSK, QPSK, M-ary PSK, ASK, FSK, similarity of BFSK and BPSK Modulation and demodulation techniques with coherent and non coherent matched and optimum filters



- Number of Key elements in CO2: **n = 3**
- Number of key elements of CO2 mapping with key elements of PO1: m=2

  Percentage of Correlation, %C = (m/n) * 100

  = (2/3) * 100 = 66.6% **(Moderate)**
- Number of key elements of CO2 is mapping with key elements of PO2: m=3

  Percentage of Correlation, %C = (m/n) * 100

  = (3/3) * 100 = 100% **(Substantial)**
- Number of key elements of CO2 is mapping with key elements of PO3: m=3

  Percentage of Correlation, %C = (m/n) * 100

  = (3/3) * 100 = 100% **(Substantial)**
- Number of key elements of CO2 is mapping with key elements of PO4: m=3

  Percentage of Correlation, %C = (m/n) * 100

  = (3/3) * 100 = 100% **(Substantial)**
- Number of key elements of CO2 is mapping with key elements of PO5: m=2

  Percentage of Correlation, %C = (m/n) * 100

  = (2/3) * 100 = 100% **(Moderate)**

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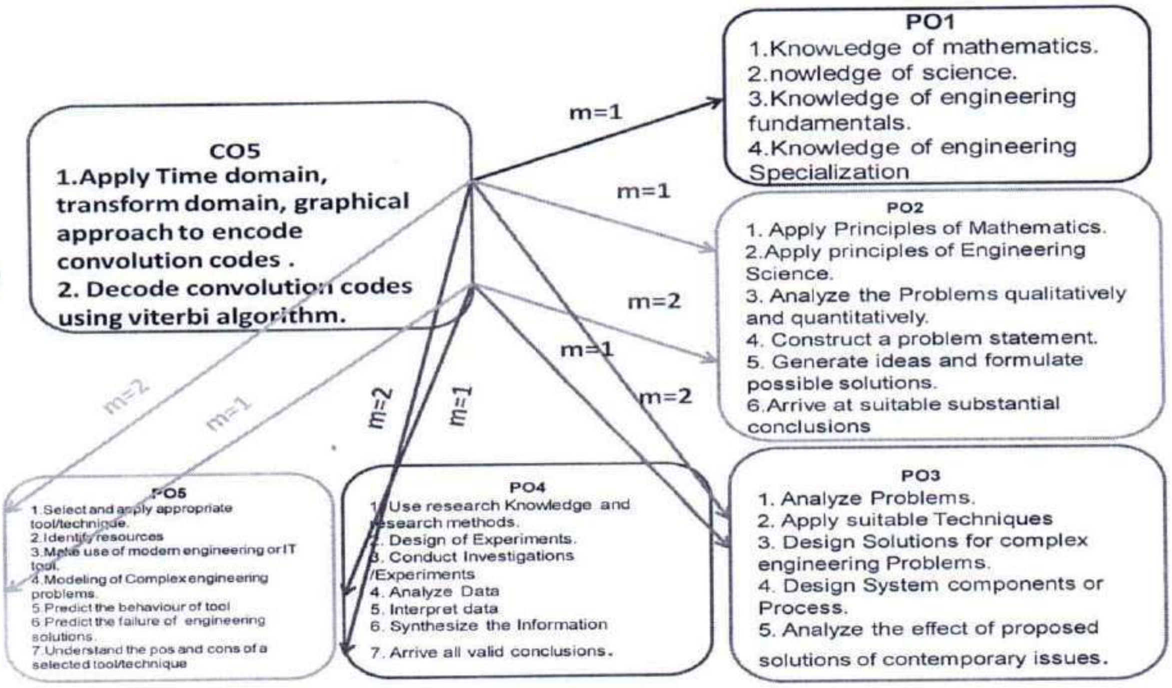
CO5: Apply Time domain, transform domain, graphical approach to encode convolution codes and decode convolution codes using Viterbi algorithm.



- Number of Key elements in CO5: n = 2
- Number of key elements of CO5 mapping with key elements of PO1: m=1

  Percentage of Correlation, %C = (m/n) * 100

  = (1/2) * 100 = 50% **(Moderate)**
- Number of key elements of CO5 is mapping with key elements of PO2: m=2

  Percentage of Correlation, %C = (m/n) * 100

  = (2/2) * 100 = 100% **(Substantial)**
- Number of key elements of CO5 is mapping with key elements of PO3: m=2

  Percentage of Correlation, %C = (m/n) * 100

  = (2/2) * 100 = 100% **(Substantial)**
- Number of key elements of CO5 is mapping with key elements of PO4: m=2

  Percentage of Correlation, %C = (m/n) * 100

  = (2/2) * 100 = 100% **(Substantial)**
- Number of key elements of CO5 is mapping with key elements of PO5: m=2

  Percentage of Correlation, %C = (m/n) * 100

  = (2/2) * 100 = 100% **(Substantial)**

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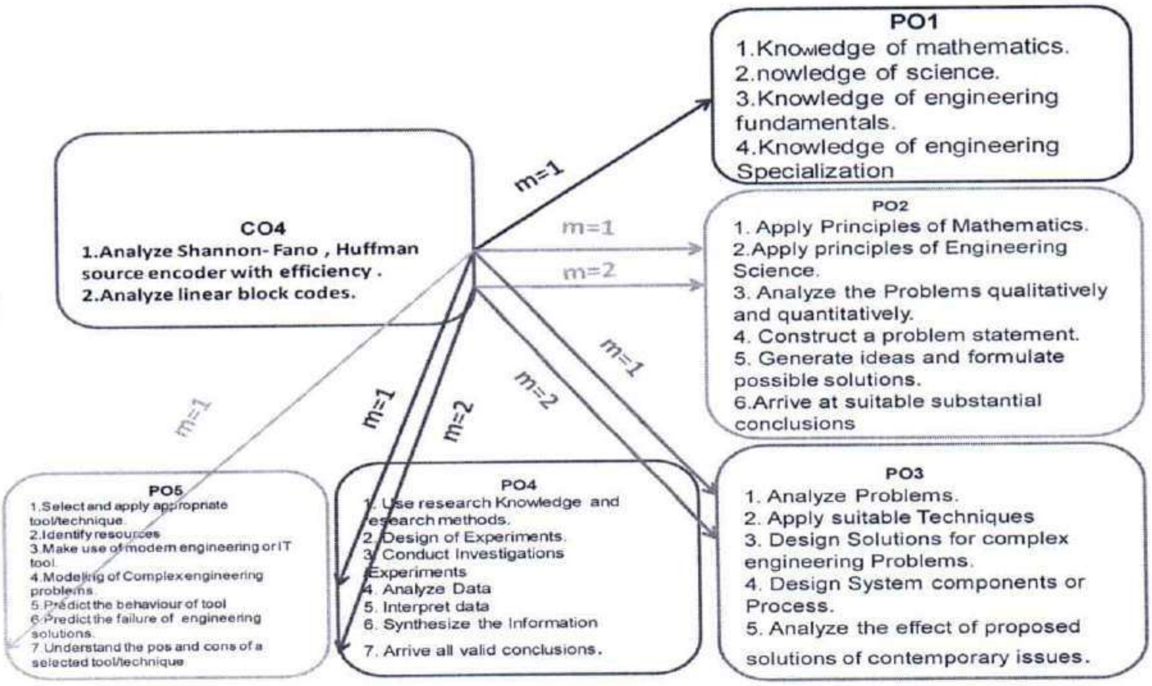
DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

CO4. Analyze Shannon- Fano, Huffman source encoder with efficiency and also linear block codes



- Number of Key elements in CO4: n = 2
- Number of key elements of CO4 mapping with key elements of PO1: m=1

  Percentage of Correlation, %C = (m/n) * 100

  = (1/2) * 100 = 50% **(Moderate)**
- Number of key elements of CO4 is mapping with key elements of PO2: m=2

  Percentage of Correlation, %C = (m/n) * 100

  = (2/2) * 100 = 100% **(Substantial)**
- Number of key elements of CO4 is mapping with key elements of PO3: m=2

  Percentage of Correlation, %C = (m/n) * 100

  = (2/2) * 100 = 100% **(Substantial)**
- Number of key elements of CO4 is mapping with key elements of PO4: m=2

  Percentage of Correlation, %C = (m/n) * 100

  = (2/2) * 100 = 100% **(Substantial)**
- Number of key elements of CO4 is mapping with key elements of PO5: m=1

  Percentage of Correlation, %C = (m/n) * 100

  = (1/2) * 100 = 50% **(Moderate)**

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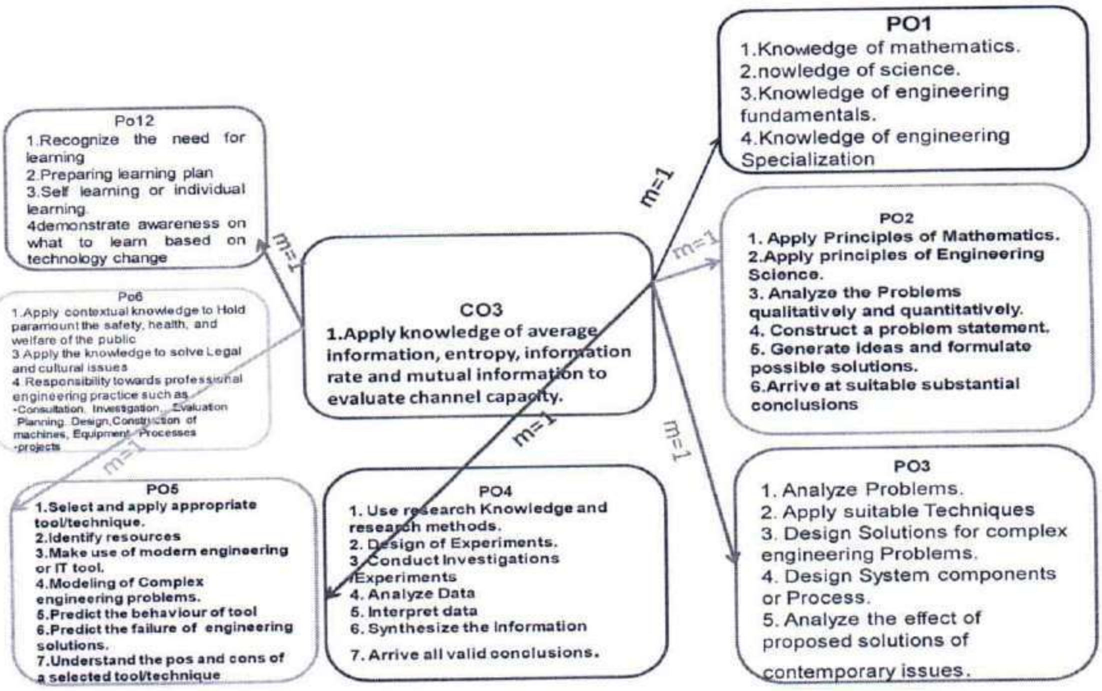
CO3: Apply knowledge of average information, entropy, information rate and mutual information to evaluate channel capacity.



- Number of Key elements in CO3: n = 1
- Number of key elements of CO3 mapping with key elements of PO1: m=1

  Percentage of Correlation, %C = (m/n) * 100
  = (1/1) * 100 = 100% **(Substantial)**
- Number of key elements of CO3 is mapping with key elements of PO2: m=1

  Percentage of Correlation, %C = (m/n) * 100
  = (1/1) * 100 = 100% **(Substantial)**
- Number of key elements of CO3 is mapping with key elements of PO3: m=1

  Percentage of Correlation, %C = (m/n) * 100
  = (1/1) * 100 = 100% **(Substantial)**
- Number of key elements of CO3 is mapping with key elements of PO4: m=1

  Percentage of Correlation, %C = (m/n) * 100
  = (1/1) * 100 = 100% **(Substantial)**
- Number of key elements of CO3 is mapping with key elements of PO5: m=1

  Percentage of Correlation, %C = (m/n) * 100
  (1/1) * 100 = 100% **(Substantial)**
- Number of key elements of CO3 is mapping with key elements of PO12: m=1

  Percentage of Correlation, %C = (m/n) * 100
  = (1/1) * 100 = 100% **(Substantial)**

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Directorate of Academic Planning
JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY KAKINADA
KAKINADA-533003, Andhra Pradesh, INDIA
(Established by AP Government Act No. 30 of 2008)

Lr. No. DAP/AC/III Year /B. Tech/B. Pharmacy/2022 *Date 14.07.2022*

Dr. KVSG Murali Krishna,
M.E. Ph.D.,
Director, Academic Planning
JNTUK, Kakinada

To
All the Principals of Affiliated Colleges,
JNTUK. Kakinada.

Academic Calendar for III Year - B. Tech/B. Pharmacy for the AY 2022-23
(2020-21 Admitted Batch)

I SEMESTER			
Description	From	To	Weeks
Community Service Project	15.07.2022	30.07.2022	2W
I Unit of Instruction	01.08.2022	24.09.2022	8W
I Mid Examinations	26.09.2022	01.10.2022	1W
II Unit of Instructions	03.10.2022	26.11.2022	8W
II Mid-Examinations	28.11.2022	03.12.2022	1W
Preparation & Practicals	05.12.2022	10.12.2022	1W
End Examinations	12.12.2022	25.12.2022	2W

*** As per the APSCHE Guidelines Out of the Total 180 hours of Community Service Project leading to 4 Credits, two weeks will be offline and remaining project work can be done during the III-I semester weekends and holidays.**

KVSG 14.7.22
Director,
Academics & Planning, JNTUK
Director
Academic Planning
JNTUK Kakinada

Copy to the Secretary to the Hon'ble Vice Chancellor, JNTUK
Copy to Rector, Registrar, JNTUK
Copy to Director Academic Audit, JNTUK
Copy to Director of Evaluation, JNTUK

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DEPARTMET OF ELECTRONICS & COMMUNICATION ENGINEERING

Academic Year 2022 – 2023

CLASS TIME TABLE

MLWEC/ECE/ TIMETABLES 22-23/CT/01

Class: III-B.Tech ECE   Semester: I   Section: A   LH. NO.   W.E.F. : 1-08-2022

2-Period/ Day	1	2	10:40 – 10:50	3	4	12:30-1:20	5	6	7
	9:00-09:50	09:50-10:40		10:50 – 11:40	11:40-12:30		01:20-02:10	02:10-03:00	03:00-03:50
Monday	AICA	EMTL	B	CAO	DC		AICA A1/DS WITH JAVA LAB A2		
Tuesday	EMI	AICA	R	DC	CAO		CRT		DC
Wednesday	DC	DC A2/DS WITH JAWA LAB A1				LUNCH BREAK	EMI	ITK	EMTL
Thursday	EMTL	EMI	E	CAO	LIB		AICA	DC	EMI
Friday	AICA	EMI	A	EMTL	CAO		AICA A2/DC LAB A1		
Saturday	DC	AICA	K	EMTL	EMI		ITK	CAO	SPORTS

* Tutorials will be handled by the respective course faculty

rse	Course Name (Code)	Name of the Faculty	Course	Course Name	Name of the Faculty
301	Electro Magnetic Waves & Transmission Lines[EMTL]	Mr. K. Ravi Kumar	C308	DC LAB	1. Mrs. S. Rama Tirisha. 2. Md. Saira Bhanu
302	ANALOG I C Applications[AICA]	Mrs. K. Nalini	C309	DS WITH JAVA LAB	Mr. A. Rama Krishna
303	Digital Communications[DC]	Mrs. S. Rama Tirisha		LIBRARY	Mrs Sk.Ayesha
304	Computer Organization and Architecture [COA]	Mrs. B. Jaswanthi			
305	Electronic Measurements & Instrumentation[EMI]	Md. Saira Bhanu			
306	Indian traditional knowledge[ITK]	Sk. Ayesha			
307	AICA LAB	1. Mrs. K. Nalini 2. B. Jaswanthi			

CLASS INCHARGE   TIME TABLE INCHARGE   HOD   PRINCIPAL

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MALINENI LAKSHMAIAH WOMEN'S ENGINEERING COLLEGE PULLADIGUNTA, GUNTUR-17.

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DEPARTMET OF ELECTRONICS & COMMUNICATION ENGINEERING

Academic Year 2022 – 23

CLASS TIME TABLE

MLWEC/ECE/ TIMETABLES /22-23/CT/01

Class: III-B.Tech ECE   Semester: I   Section: B   LH. NO.   W.E.F. 01-08-2022

2-Period/ Day	1	2	10:40 – 10:50	3	4	12:30-1:20	5	6	7
	9:00-09:50	09:50-10:40		10:50 – 11:40	11:40-12:30		01:20-02:10	02:10-03:00	03:00-03:50
Monday	EMI	DC	B	AICA	EMTL		CAO	ITK	AICA
Tuesday	CAO	DC	R	EMI	EMTL		AICA B1/DS LAB B2		
Wednesday	CAO	EMI	E	EMTL	AICA	LUNCH	LIB	DC	ITK
Thursday	CAO	DC B2/DS LAB B1				BREAK	DC	AICA	EMI
Friday	DC	EMI	A	AICA	EMI		EMTL	CAO	SPORTS
Saturday	EMTL	DC	K	CRT			AICA B2/DC LAB B1		

* Tutorials will be handled by the respective course faculty

ourse	Course Name (Code)	Name of the Faculty	Course	Course Name	Name of the Faculty
C301	Electro Magnetic Waves & Transmission Lines[EMTL]	Mr. K. Ravi Kumar	C308	DC LAB	1. Dr. Sd. Nageena Parveen 2. Mr. N. Nagaraju
C302	ANALOG I C Applications[AICA]	Dr. K. Gouthami	C309	DS WITH JAVA LAB	Mr. A. Rama Krishna
C303	Digital Communications[DC]	Dr. Sd. Nageena Parveen		LIBRARY	Mrs. K. Rajitha
C304	Computer Organization and Architecture [COA]	Mr. Y. Bhaskara Rao			
C305	Electronic Measurements & Instrumentation[EMI]	Mrs. K. Rajitha			
C306	Indian traditional knowledge[ITK]	Mrs. Sk. Ayesha			
C307	AICA LAB	1. Mrs. G. Nirmala Kumari 2. K. Rajitha			

CLASS INCHARGE   Y. Bhaskara Rao TIME TABLE INCHARGE   HOD   PRINCIPAL

PRINCIPAL
MALINENI LAKSHMAIAH
WOMEN'S ENGINEERING COLLEGE
PULLADIGUNTA, GUNTUR-17

MALINEENI LAKSHMAIAH WOMEN'S ENGINEERING COLLEGE (E) :: PULLADIGUNTA
(Approved by AICTE & Affiliated to JNTU, KAKINADA, *AN ISO 9001:2008 Certified Institution*)

DEPARTMET OF ELECTRONICS & COMMUNICATION ENGINEERING

Academic Year 2022– 2023

MLEW/ECE/TIMETABLES/22-23/CT/01

INDUVIDUAL TIME TABLE

Class: III-B.Tech ECE   Semester: I   Section: B   LH. NO.   W.E.F.: 17-12-2022

Period/ Day	1	2	10:40 – 10:50	3	4	12:30 - 1:20	5	6	7
	9:00-09:50	09:50-10:40		10:50 – 11:40	11:40-12:30		01:20-02:10	02:10-03:00	03:00-03:50
Monday		DC	B			LUNCH			
Tuesday		DC	R			BREAK			
Wednesday			E				DC		
Thursday			A						
Friday	DC		K						
Saturday		DC							

Signature of the Faculty

PRINCIPAL
MALINENI LAKSHMAIAH
WOMEN'S ENGINEERING COLLEGE
PULLADIGUNTA GUNTUR-17.

MALINENI LAKSHMAIAH WOMEN'S ENGINEERING COLLEGE (KE), PULLADIGUNTA

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DEPARTMET OF ELECTRONICS & COMMUNICATION ENGINEERING

Academic Year 2022 – 2023

CLASS TIME TABLE

MLWEC/ECE/ TIMETABLES /22-23/CT/01

Class: III-B.Tech ECE   Semester: I   Section: A   LH. NO.   W.E.F.: 1-08-2022

2-Period/ Day	1	2	10:40 – 10:50	3	4	12:30-1:20	5	6	7
	9:00-09:50	09:50-10:40		10:50 – 11:40	11:40-12:30		01:20-02:10	02:10-03:00	03:00-03:50
Monday	AICA	EMTL	B	CAO	DC		AICA A1/DS WITH JAVA LAB A2		
Tuesday	EMI	AICA	R	DC	CAO		CRT		DC
Wednesday	DC	DC A2/DS WITH JAWA LAB A1				LUNCH BREAK	EMI	ITK	EMTL
Thursday	EMTL	EMI	E	CAO	LIB		AICA	DC	EMI
Friday	AICA	EMI	A	EMTL	CAO		AICA A2/DC LAB A1		
Saturday	DC	AICA	K	EMTL	EMI		ITK	CAO	SPORTS

* Tutorials will be handled by the respective course faculty

rse	Course Name (Code)	Name of the Faculty	Course	Course Name	Name of the Faculty
301	Electro Magnetic Waves & Transmission Lines[EMTL]	Mr. K. Ravi Kumar	C308	DC LAB	1. Mrs. S. Rama Tirisha. 2. Md. Saira Bhanu
302	ANALOG I C Applications[AICA]	Mrs. K. Nalini	C309	DS WITH JAVA LAB	Mr. A. Rama Krishna
303	Digital Communications[DC]	Mrs. S. Rama Tirisha		LIBRARY	Mrs Sk.Ayesha
304	Computer Organization and Architecture [COA]	Mrs. B. Jaswanthi			
305	Electronic Measurements & Instrumentation[EMI]	Md. Saira Bhanu			
306	Indian traditional knowledge[ITK]	Sk. Ayesha			
307	AICA LAB	1. Mrs. K. Nalini 2. B. Jaswanthi			

CLASS INCHARGE   TIME TABLE INCHARGE   HOD   PRINCIPAL

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PULLADIGUNTA, GUNTUR-17

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DEPARTMET OF ELECTRONICS & COMMUNICATION ENGINEERING

Academic Year 2022 – 23

CLASS TIME TABLE

MLWEC/ECE/ TIMETABLES /22-23/CT/01

Class: III-B.Tech ECE **Semester: I** **Section: B** **LH. NO.** 2 **W.E.F.** 01-08-2022

2-Period/ Day	1 9:00-09:50	2 09:50-10:40	10:40 – 10:50	3 10:50 – 11:40	4 11:40-12:30	12:30-1:20	5 01:20-02:10	6 02:10-03:00	7 03:00-03:50
Monday	EMI	DC	B	AICA	EMTL		CAO	ITK	AICA
Tuesday	CAO	DC	R	EMI	EMTL		AICA B1/DS LAB B2		
Wednesday	CAO	EMI	E	EMTL	AICA	LUNCH BREAK	LIB	DC	ITK
Thursday	CAO	DC B2/DS LAB B1					DC	AICA	EMI
Friday	DC	EMI	A	AICA	EMI		EMTL	CAO	SPORTS
Saturday	EMTL	DC	K	CRT			AICA B2/DC LAB B1		

* Tutorials will be handled by the respective course faculty

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CLASS INCHARGE

Y. Bhaskara

TIME TABLE INCHARGE

HOD Electronics & Communications Engg Dept Malineni Lakshmaiah Women's Engg College PULLADIGUNTA, GUNTUR-522 017

HOD

PRINCIPAL

PRINCIPAL MALINENI LAKSHMAIAH WOMEN'S ENGINEERING COLLEGE PULLADIGUNTA, GUNTUR-17.

Website: www.jntuk.edu.in
Email: dap@jntuk.edu.in

Phone: 0884-2300991

Directorate of Academic Planning
JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY KAKINADA
KAKINADA-533003, Andhra Pradesh, INDIA
(Established by AP Government Act No. 30 of 2008)

Lr. No. DAP/RAC/ II,III & IV Year /B. Tech/B. Pharmacy/2021 *Date 08.10.2021*

Dr. R. Srinivasa Rao,
Director, Academic Planning
JNTUK, Kakinada

To
All the Principals of Affiliated Colleges,
JNTUK, Kakinada.

Revised Academic Calendar for II, III, IV Year - B. Tech/B. Pharmacy for the AY 2021-22
(As per G.O. Rt. No. 242, Higher Education (U.E) Dept., dated 13.09.2021)

I SEMESTER			
Description	**From**	**To**	**Weeks**
Commencement of Class Work	**01.10.2021**		
I Unit of Instruction	01.10.2021	20.11.2021	7W
I Mid Examinations	22.11.2021	27.11.2021	1W
II Unit of Instructions	29.11.2021	15.01.2022	7W
II Mid Examinations	17.01.2022	22.01.2022	1W
Preparation & Practicals	24.01.2022	29.01.2022	1W
End Examinations	31.01.2022	12.02.2022	2W
Commencement of II Semester Class Work	**14.02.2022**		
II SEMESTER			
I Unit of Instructions	**14.02.2022**	02.04.2022	7W
I Mid Examinations	04.04.2022	09.04.2022	1W
II Unit of Instructions	11.04.2022	28.05.2022	7W
II Mid Examinations	30.05.2022	04.06.2022	1W
Preparation & Practicals	06.06.2022	11.06.2022	1W
End Examinations	13.06.2022	25.06.2022	2W
Commencement of next Year Class Work			
Note: Calendar is prepared with 8 hrs/day hence 7 weeks per instruction period			

R. Srinivasa Rao
Director Academic Planning
Director
Academic Planning
JNTUK Kakinada

Copy to the Secretary to the Hon'ble Vice Chancellor, JNTUK
Copy to Rector, Registrar, JNTUK
Copy to Director Academic Audit, JNTUK
Copy to Director of Evaluation, JNTUK

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DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

A.Y.: 2022-23 Date: 01-12-2022

Subject Code	**C304**
Subject Name	**DIGITAL**
Regulation	**R20**
Year &	**III & I**
Academic	**2022-23**

LESSON PLAN

Pre-Requisites-Signals and Systems

S.No	Topic	Teaching Aid	Books
	UNIT-I INTRODUCTION TO PULSE DIGITAL MODULATION		
1	Introduction to digital communications	Chalk & Talk	T1
2	Elements of digital communication systems	Chalk & Talk, Video	T1
3	advantages of digital communication over analog communication systems	Chalk & Talk, PPT	T2
4	Elements of PCM block diagram, Concept of Sampling	Chalk & Talk	T1
5	Quantization and quantization error , Encoding	Chalk & Talk	R1
6	Companding in PCM, Problems on PCM	Chalk & Talk	T2
7	Differential PCM, Advantage of DPCM over PCM	Chalk & Talk	R2, T2
8	Delta modulation, Granular noise and Slope overload distortion	Chalk & Talk	T1, T1
9	Differences between DM and DPCM, Adaptive DM	Chalk & Talk	T2
10	Problems on PCM	Chalk & Talk	T1, T1
11	Problems on DM	Chalk & Talk, PPT	T2,
12	Revision classes	Chalk & Talk	T1
	II Unit: **DIGITAL MODULATION TECHNIQUES**		
13	Introduction to digital modulation methods, ASK, FSK	Chalk & Talk	R1, T1
14	PSK, DPSK and DEPSK	Chalk & Talk	T2

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15	QPSK and M-ary PSK	Guest Lecture	T1
16	M-ary ASK and FSK	Chalk & Talk	T1
17	Similarity between BPSK and BFSK	Chalk & Talk	T2
	III Unit: **DATA TRANSMISSION**		
18	Base band signal receiver, probability of error	Chalk & Talk	T2
19	Optimum filter, matched filter,	Chalk & Talk, PPT	R2, T1
20	Probability of error using matched filter	Chalk & Talk	R3, T2
21	Coherent reception, non-coherent detection of FSK	Chalk & Talk	T1
22	Calculation of error probability of ASK, BPSK, BFSK,QPSK	Chalk & Talk	R1, T1
23	Revision classes	Chalk & Talk	T1
	IV Unit: **INFORMATION THEORY**		
24	Introduction to information theory, Concept of information, Properties	Chalk & Talk	T2
25	Average Information, Entropy and its properties	Chalk & Talk	T2
26	Types of channel, probability matrix of a channel	Chalk & Talk, PPT	T2
27	Problem on channel probability matrix	Chalk & Talk	T1, T1
28	Information rate, Mutual information and its properties	Chalk & Talk	T1
29	Problems on information, entropy	Chalk & Talk	T2, T1
30	Problems on mutual information	Chalk & Talk	T1
31	Problems on capacity of channel	Chalk & Talk	R3, T2
32	Problems	Chalk & Talk	T1, T1
33	Revision classes	Chalk & Talk	T2
	V Unit: **SOURCE CODING**		
34	Introduction to source coding, Prefix coding, Advantages,	Chalk & Talk, PPT	T2

	Shannon's theorem		
35	Shanon-Fano coding, example	Chalk & Talk	T1
36	Shannon-Fano coding- problems	Chalk & Talk	R2, T2
37	Huffman coding, efficiency calculations	Chalk & Talk	T2
38	Huffman coding problems	Chalk & Talk	T1, T1
39	channel capacity of discrete and analog Channels	Chalk & Talk	T2
40	Capacity of a Gaussian channel, bandwidth–S/N trade off	Chalk & Talk	T1
41	Problems on Huffman coding	Chalk & Talk	R2, T2
42	Revision classes	Chalk & Talk	T2
	UNIT VI: **LINEAR BLOCK CODES**		
43	Introduction, Matrix description of Linear Block codes	Chalk & Talk	R2, T1
44	Error detection and error correction capabilities of Linear block codes	Chalk & Talk	T2
45	Hamming codes – (7,4) linear block code generation	Chalk & Talk	T2
46	(7,4) linear block code set - problem	Seminar	T1
47	(7,4) linear block code parity check & syndrome generation	Chalk & Talk, PPT	T2
48	Problem on linear block codes	Chalk & Talk	T2
49	Binary cyclic codes, Algebraic structure, encoding	Chalk & Talk	T1
50	Cyclic code generation	Chalk & Talk	T1, T1
51	Syndrome calculation	Chalk & Talk	T1
52	BCH Codes	Seminar	T1
53	Problems on Linear block codes	Seminar	R2, T2
54	Problems on Linear block codes	Seminar	R3, T1
55	Encoding of convolution codes, time domain approach	Chalk & Talk	T1

56	Time domain approach-Example	Chalk & Talk	T2, T1
57	Transform domain approach. Graphical approach	Chalk & Talk	T1
58	Transform domain approach-Example	Chalk & Talk	T2, T1
59	State, tree and trellis diagram of Convolution codes	Chalk & Talk	T1
60	Decoding convolution codes using Viterbi algorithm	Chalk & Talk	R3
61	Viterbi algorithm continued	Chalk & Talk	T2,A1
62	Problems on Convolution codes	Chalk & Talk, PPT	T1
63	Revision classes	Chalk & Talk	T1, T1
64	Revision classes	Chalk & Talk	R2, T2

TEXT BOOKS:

1. Digital communications - Simon Haykin, John Wiley,2005
2. Digital and Analog Communication Systems - Sam Shanmugam, John Wiley,2005.

REFERENCES:

1. Principles of Communication Systems – H. Taub and D. Schilling, TMH,2003
2. Digital Communications – John Proakis, TMH, 1983. Communication Systems Analog&Digital – Singh & Sapre, TMH,2004.
3. Modern Digital and Analog Communication Systems –B.P.Lathi,Zhi Ding,Hari Mohan Gupta,OxfordUniversity Press,4th Edition,2017

Course Outcomes:

After going through this course the student will be able to

- Analyze the performance of a Digital Communication System for probability of error andare able to design a digital communication system.

- Analyze various source coding techniques.
- Compute and analyze Block codes, cyclic codes and convolution codes.
- Design a coded communication system.

SIGNATURE OF FACULTY

SIGNATURE OF HOD

HOD
Dept. of Electronics & Communication Engineering
Malineni Lakshmaiah Women's Engineering College
Pulladigunta, GUNTUR-522017

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ESTD : 2008

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

Instructional Methodology

A.Y.: 2022-23

Date: 17-12-2022

Subject Code	C304
Subject Name	Digital Communications
Regulation	R20
Year & Sem	III & I
Academic Year	2022-23

S.No.	INSTRUCTIONAL METHODOLOGY	YES/NO
1.	ICT Methods	
	a. Chalk & Board	Yes
	b. PPT	Yes
	c. E-Learning	Yes
2.	MOOCS & Open Sources(NPTEL)	Yes
3.	Guest Lectures & Workshops	No
4.	Collaborative Learning (Peer Teaching)	No
5.	Role Play	No
6.	Group discussions & Group Activity	Yes
7.	Project based learning	No
8.	Learning from Industrial visits	No
9.	Seminar Method	Yes
10.	Use of online journals, subscriptions	No

Signature of the Faculty

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DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

A.Y.: 2022-23

Date: 17-12-2022

Subject Code	C304
Subject Name	Digital Communications
Regulation	R20
Year & Sem	III & I
Academic Year	2022-23

Pedagogical initiatives

The following innovative teaching methods are adopted by the faculty:

Computing devices with Internet facility are used for teaching purposes by the faculty to show PowerPoint presentations, Animations, Videos, Pictures etc., so that the students can easily understand the topic.

Pedagogical initiatives

- ✓ **ICT Methods**
- ✓ **Seminar by students**
- ✓ **Group Discussions**

ICT Methods:

The set of educational technology/tools such as

i. Chalk and Board
ii. Power point presentation (PPT)
iii. E-Learning

The faculty use chalk and board and audio visual aids in teaching. Students are also encouraged to actually interact during the lecture hour by getting the doubts clarified in the same class. The college has required number of LCD projectors in every class room. These are effectively used for teaching.

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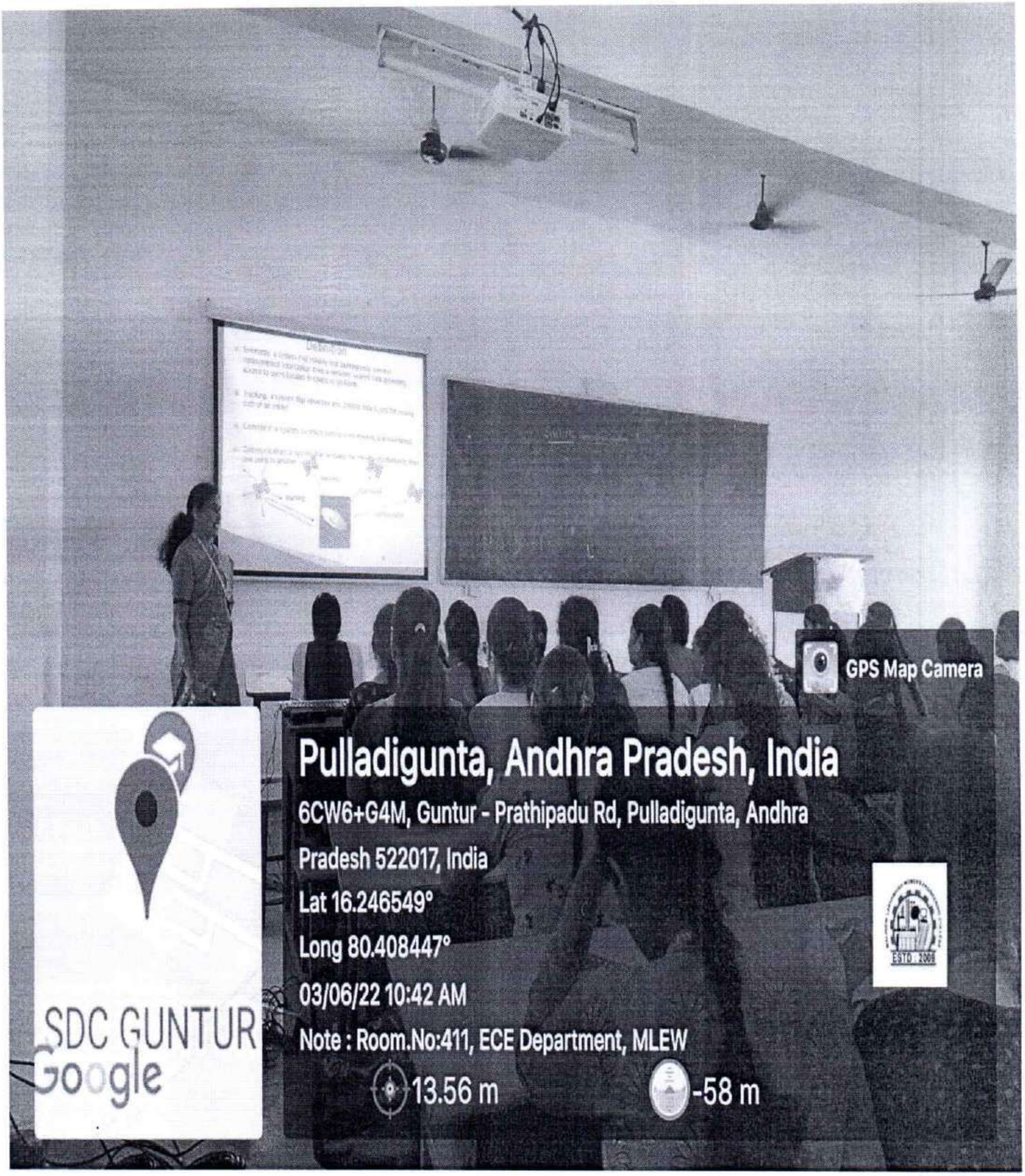
ECE DEPARTMENT CLASSROOMS



Room No 411: Electronics & Communication Engineering **Class Room** with Projector Stand & Screen

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✓ Seminar by students:

As per the Subject curriculum, every student is allotted with some seminar topic by the faculty members. The students are free to ask doubts to faculty at any time in their respective topics. Students prepare documentation or PPT of their respective allotted topic and then present a seminar before their classmates and faculty member. These seminars help the students to improve their communication skills and to overcome stage fear among the group of peoples.

✓ Group Discussions:

Collaborative learning:

Group Discussion (GD) is a method of collaborative learning activity. In this method of learning where students discuss issues and ideas together. In GD, students work in groups to solve problems and learn from each other. It helps students to develop their critical thinking skills, problem-solving abilities, and communication skills. Group Discussions are very important in teaching because it empowers teachers to help students in building their confidence in various aspects like

To get involved in the subjects

To build team Sprit

To improve listening Skills and

To improve critical thinking etc..

Signature of the Faculty

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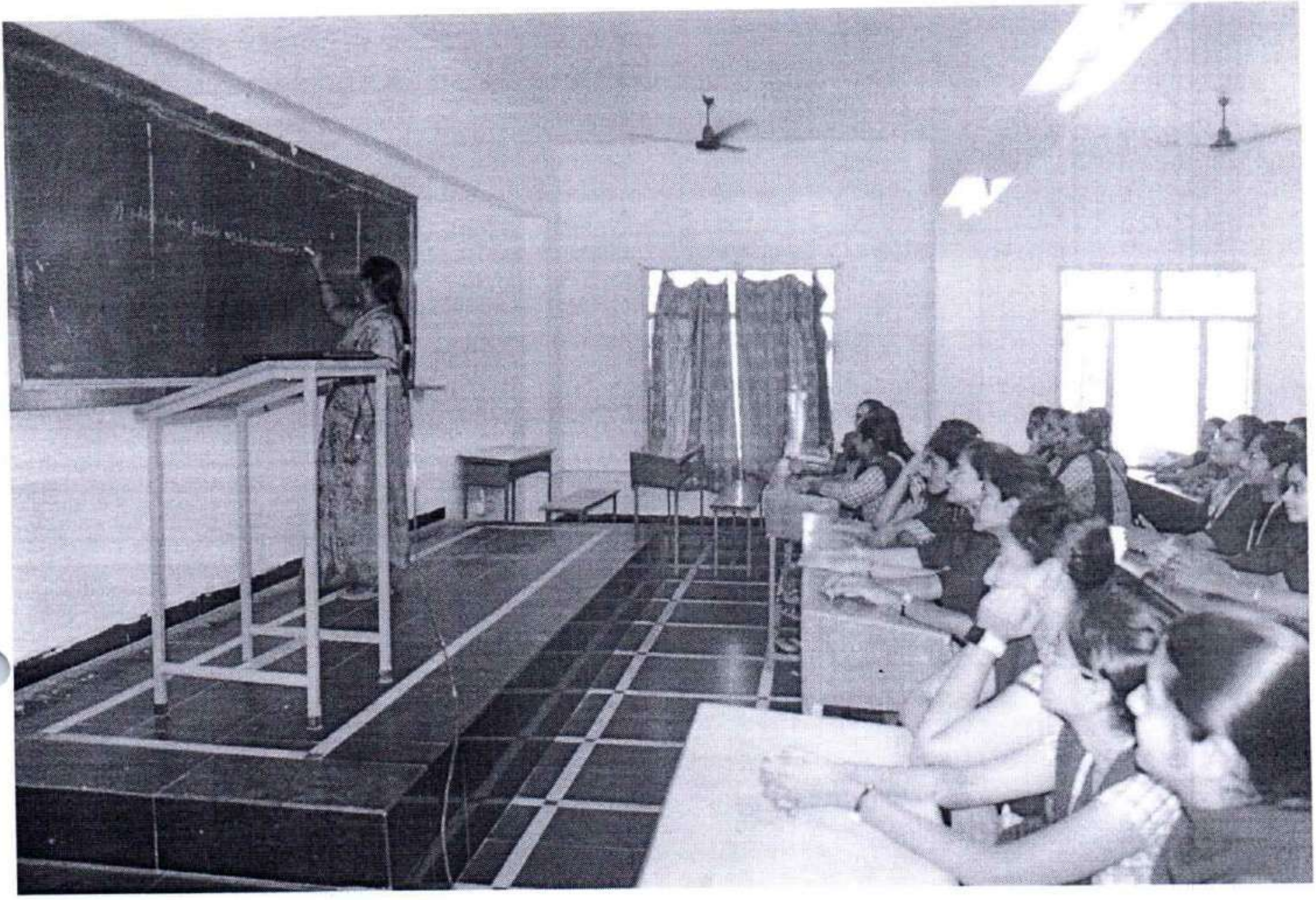

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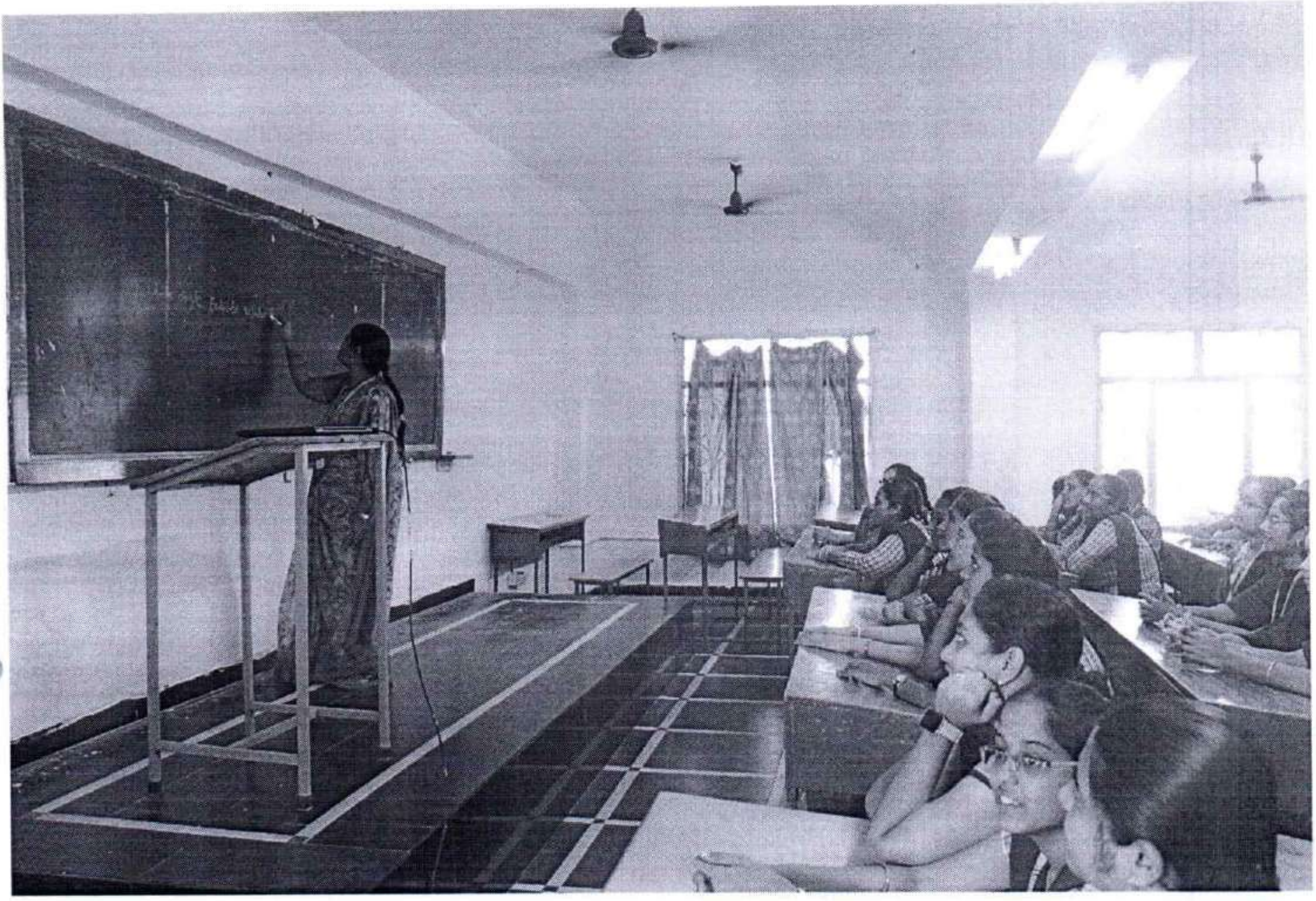

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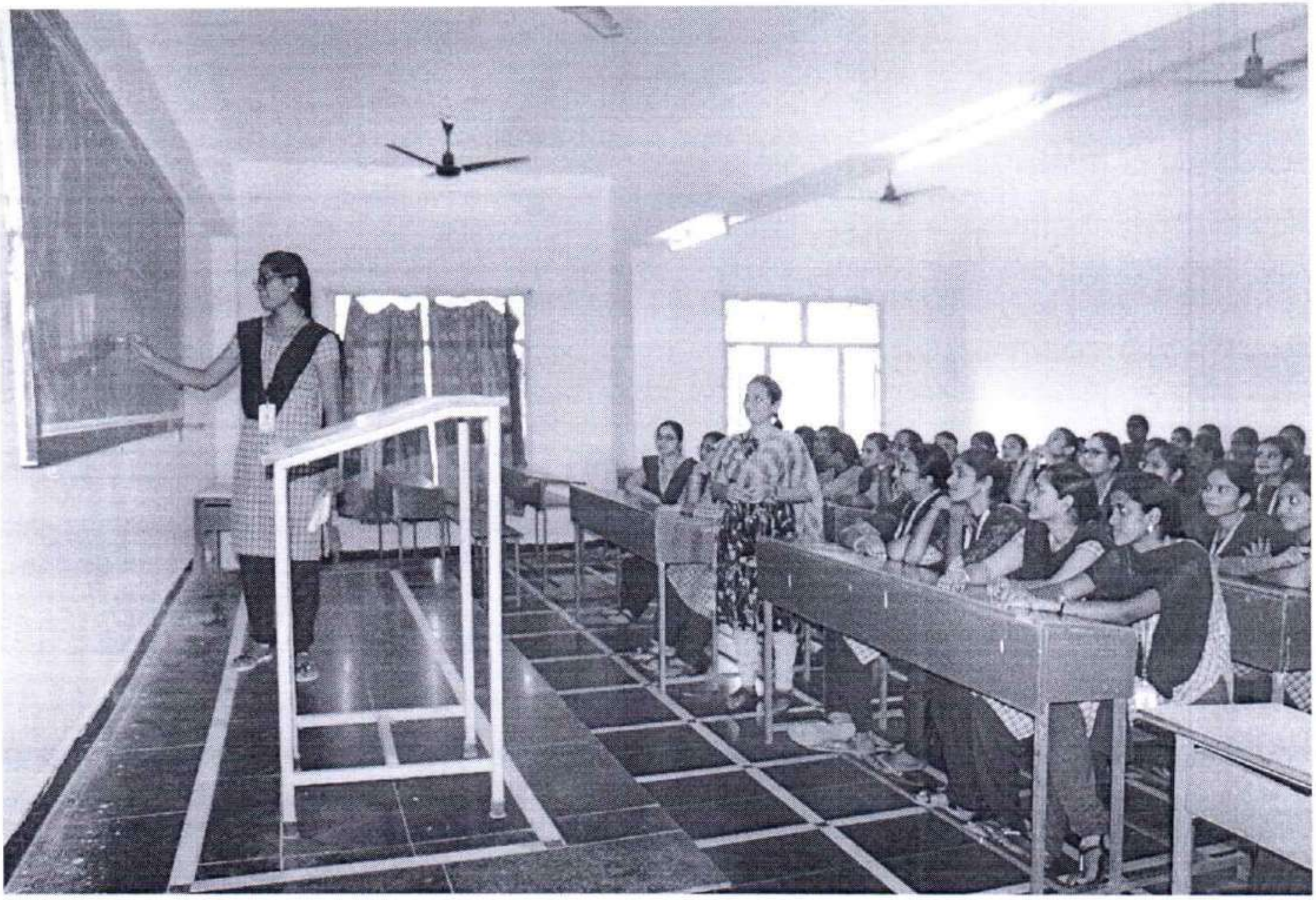

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DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

A.Y.: 2022-23

Date: 17-12-2022

Subject Code	C304
Subject Name	Digital Communications
Regulation	R20
Year & Sem	III & I
Academic Year	2022-23

ASSESSMENT OF ATTAINMENT OF COs PLAN–DIRECT AND INDIRECT

Evaluation of Course outcomes procedure (Direct):

The affiliating University – JNTUK is not providing the average marks for defining the Targets. The PAC collects the assessment data and conducts meetings with the course coordinators and proposes the targets. These targets and set attainment levels of the program are approved by the DAB.

The course outcomes are evaluated using Internal and External assessments as per the following:

Regulation	Internal Assessment–Set Target	External Assessment–Set Target
R16		

The attainment levels are as per the following

S.No	Attainment Level	% of students attaining the Set-Target
1	3	80%ofstudents Scoring more than the Set Target
2	2	60%ofstudents Scoring more than the Set Target
3	1	40% of students Scoring more than the Set Target
4	0	40% of students Scoring Less than the Set Target

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Evaluation of Attainment Level-CO

CO Attainment level = 20% of Internal Attainment level + 80% of External Attainment level

For R16 regulations:

Weightage for different internal assessment tools are based on % of total marks.

Theory Courses: Internal attainment level = (50% of DESCRIPTIVE + 33% of OBJECTIVE + 17% of ASSIGNMENT) attainment levels

Project Work: Internal attainment level= (50%ofReview1+50%ofReview2) attainment levels

Evaluation of Course outcomes procedure (Indirect):

The CO indirect attainment values are calculated using course end survey. A survey has been conducted at the end of every semester through online mode. All the students will participate in surveys and give rating as

(0: disagree, 1: fairly agree, 2: agree and 3: strongly agree) to course outcomes that how much they really achieved during coursework.

Signature of the Faculty

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DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

A.Y.: 2022-23

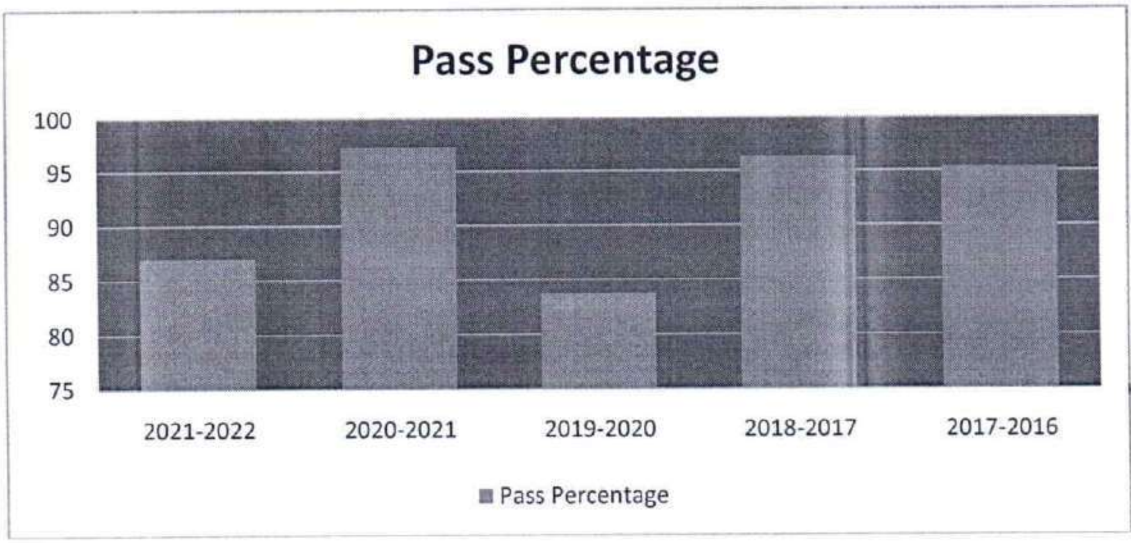
Date: 17-12-2022

Subject Code	C314
Subject Name	Digital Communications
Regulation	R20
Year & Sem	III & I
Academic Year	2022-23

UNIVERSITY RESULTS FOR BOTH PREVIOUS AND CURRENT YEAR

RESULTANALYSIS-PREVIOUS 3 YEARS

Academic Year	Year of Study	Semester	Pass Percentage
2021-2022	III	I	86.95
2020-2021	III	I	97.27
2019-2020	III	I	83.76
2018-2017	III	I	96.33
2017-2016	III	II	95.35



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PULLADIGUNTA. GUNTUR-17.

MALINENI LAKSHMAIAH WOMEN'S ENGINEERING COLLEGE, GUNTUR
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DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

A.Y.: 2022-23

Date: 17-12-2022

Subject Code	C304
Subject Name	Digital Communications
Regulation	R20
Year & Sem	III & I
Academic Year	2022-23

Digital Communications PPT Links

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Video lectures web links (NPTEL)

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COURSE MATERIAL – HARD COPY

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Digital Communications

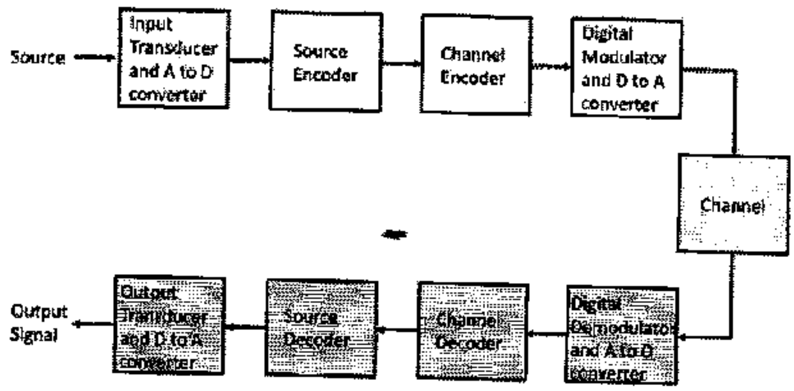
I Unit: Pulse Code Modulation

Advantages of Digital Communication over Analog Communication

As the signals are digitized, there are many advantages of digital communication over analog communication, such as −

1. The effect of distortion, noise, and interference is much less in digital signals as they are less affected.
2. Digital circuits are more reliable.
3. Digital circuits are easy to design and cheaper than analog circuits.
4. The hardware implementation in digital circuits is more flexible than analog.
5. The occurrence of cross-talk is very rare in digital communication.
6. Signal processing functions such as encryption and compression are employed in digital circuits to maintain the secrecy of the information.
7. The probability of error occurrence is reduced by employing error detecting and error correcting codes.
8. Combining digital signals using Time Division Multiplexing TDM is easier than combining analog signals using Frequency Division Multiplexing FDM
9. Digital signals can be saved and retrieved more conveniently than analog signals.
10. The capacity of the channel is effectively utilized by digital signals.

Digital Communication System Block Diagram:



Basic Elements of a Digital Communication System

Source

The source can be an **analog** signal. **Example**: A Sound signal

Input Transducer

This is a transducer which takes a physical input and converts it to an electrical signal (**Example**: microphone). This block also consists of an **analog to digital** converter where a digital signal is needed for further processes. A digital signal is generally represented by a binary sequence.

Source Encoder

The source encoder compresses the data into minimum number of bits. This process helps in effective utilization of the bandwidth. It removes the redundant bits unnecessary excess bits..

Channel Encoder

The channel encoder, does the coding for error correction. During the transmission of the signal, due to the noise in the channel, the signal may get altered and hence to avoid this, the channel encoder adds some redundant bits to the transmitted data. These are the error correcting bits.

Digital Modulator

The signal to be transmitted is modulated here by a carrier. The signal is also converted to analog from the digital sequence, in order to make it travel through the channel or medium.

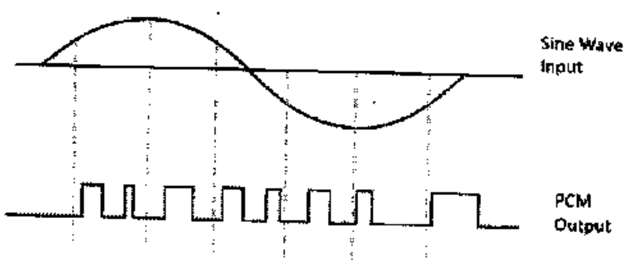
Channel
The channel or a medium, allows the analog signal to transmit from the transmitter end to the receiver end.
Digital Demodulator
This is the first step at the receiver end. The received signal is demodulated as well as converted again from analog to digital. The signal gets reconstructed here.
Channel Decoder
The channel decoder, after detecting the sequence, does some error corrections. The distortions which might occur during the transmission are corrected by adding some redundant bits. This addition of bits helps in the complete recovery of the original signal.
Source Decoder
The resultant signal is once again digitized by sampling and quantizing so that the pure digital output is obtained without the loss of information. The source decoder recreates the source output.
Output Transducer
This is the last block which converts the signal into the original physical form, which was at the input of the transmitter. It converts the electrical signal into physical output (**Example**: loud speaker).
Output Signal
This is the output which is produced after the whole process. **Example** – The sound signal received.

Modulation is the process of varying one or more parameters of a carrier signal in accordance with the instantaneous values of the message signal.

The message signal is the signal which is being transmitted for communication and the carrier signal is a high frequency signal which has no data, but is used for long distance transmission.

There are many modulation techniques, which are classified according to the type of modulation employed. Of them all, the digital modulation technique used is Pulse Code Modulation (PCM)

A signal is pulse code modulated to convert its analog information into a binary sequence, i.e., **1s** and **0s**. The output of a PCM will resemble a binary sequence. The following figure shows an example of PCM output with respect to instantaneous values of a given sine wave.



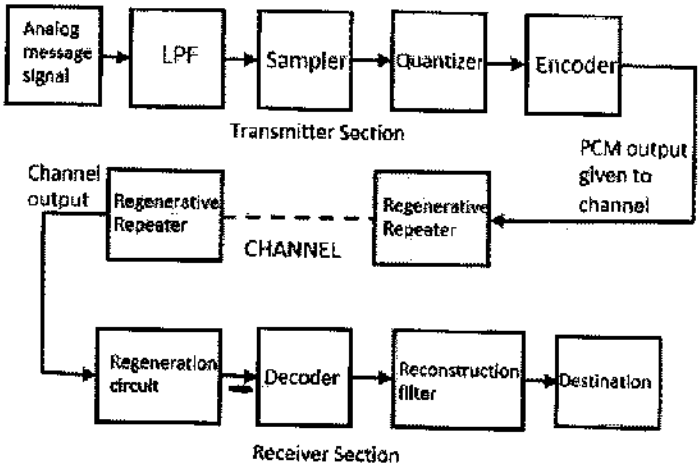
Instead of a pulse train, PCM produces a series of numbers or digits, and hence this is called as digital process. Each one of these digits, though in binary code, represents the approximate amplitude of the signal sample at that instant.

In Pulse Code Modulation, the message signal is represented by a sequence of coded pulses. This message signal is achieved by representing the signal in discrete form in both time and amplitude.

Basic Elements of PCM

The transmitter section of a Pulse Code Modulator circuit consists of **Sampling, Quantizing** and **Encoding**, which are performed in the analog-to-digital converter section. The low pass filter prior to sampling prevents aliasing of the message signal.

The basic operations in the receiver section are **regeneration of impaired signals, decoding,** and **reconstruction** of the quantized pulse train. Following is the block diagram of PCM which represents the basic elements of both the transmitter and the receiver sections.



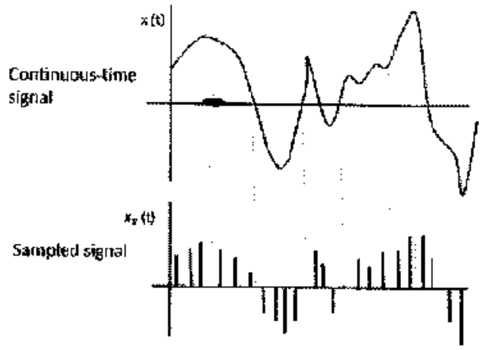
Low Pass Filter
This filter eliminates the high frequency components present in the input analog signal which is greater than the highest frequency of the message signal, to avoid aliasing of the message signal.
Sampler
This is the technique which helps to collect the sample data at instantaneous values of message signal, so as to reconstruct the original signal. The sampling rate must be greater than twice the highest frequency component **W** of the message signal, in accordance with the sampling theorem.
Quantizer
Quantizing is a process of reducing the excessive bits and confining the data. The sampled output when given to Quantizer, reduces the redundant bits and compresses the value.
Encoder
The digitization of analog signal is done by the encoder. It designates each quantized level by a binary code. The sampling done here is the sample-and-hold process. These three sections LPF, Sampler, and Quantizer will act as an analog to digital converter. Encoding minimizes the bandwidth used.
Regenerative Repeater
This section increases the signal strength. The output of the channel also has one regenerative repeater circuit, to compensate the signal loss and reconstruct the signal, and also to increase its strength.
Decoder
The decoder circuit decodes the pulse coded waveform to reproduce the original signal. This circuit acts as the demodulator.
Reconstruction Filter
After the digital-to-analog conversion is done by the regenerative circuit and the decoder, a low-pass filter is employed, called as the reconstruction filter to get back the original signal. Hence, the Pulse Code Modulator circuit digitizes the given analog signal, codes it and samples it, and then transmits it in an analog form. This whole process is repeated in a reverse pattern to obtain the original signal.

Sampling

Sampling is defined as, "The process of measuring the instantaneous values of continuous-time signal in a discrete form." **Sample** is a piece of data taken from the whole data which is continuous in the time domain. When a source generates an analog signal and if that has to be digitized, having **1s** and **0s** i.e., High or Low, the signal has to be discretized in time. This discretization of analog signal is called as Sampling.

The following figure indicates a continuous-time signal **x(*t*)** and a sampled signal $x_s(t)$

When **x(*t*)** is multiplied by a periodic impulse train, the sampled signal $x_s(t)$ is obtained.



Sampling Rate

To discretize the signals, the gap between the samples should be fixed. That gap can be termed as a **sampling period T_s.**

$$\text{Sampling Frequency} = 1/Ts = fs$$

Where, *Ts* is the sampling time *fs* is the sampling frequency or the sampling rate

Sampling frequency is the reciprocal of the sampling period. This sampling frequency, can be simply called as **Sampling rate.** The sampling rate denotes the number of samples taken per second, or for a finite set of values. For an analog signal to be reconstructed from the digitized signal, the sampling rate should be highly considered. The rate of sampling should be such that the data in the message signal should neither be lost nor it should get over-lapped. Hence, a rate was fixed for this, called as Nyquist rate.

Nyquist Rate

Suppose that a signal is band-limited with no frequency components higher than **W** Hertz. That means, **W** is the highest frequency. For such a signal, for effective reproduction of the original signal, the sampling rate should be twice the highest frequency.

Which means,

$$f_s = 2W$$

Where, f_s is the sampling rate **W** is the highest frequency This rate of sampling is called as **Nyquist rate.** A theorem called, Sampling Theorem, was stated on the theory of this Nyquist rate.

Sampling Theorem

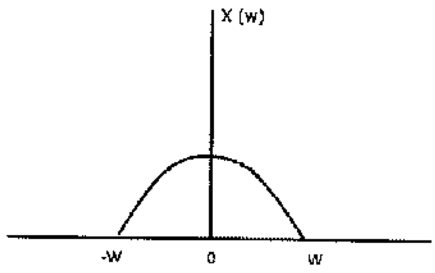
The sampling theorem, which is also called as **Nyquist theorem**, delivers the theory of sufficient sample rate in terms of bandwidth for the class of functions that are band limited.

The sampling theorem states that, "a signal can be exactly reproduced if it is sampled at the rate $\mathbf{f_s}$ which is greater than twice the maximum frequency W."

To understand this sampling theorem, let us consider a band-limited signal, i.e., a signal whose value is **non-zero** between some –**W** and **W** Hertz.

Such a signal is represented as $x(f) = 0$ *for* $|f| > W$

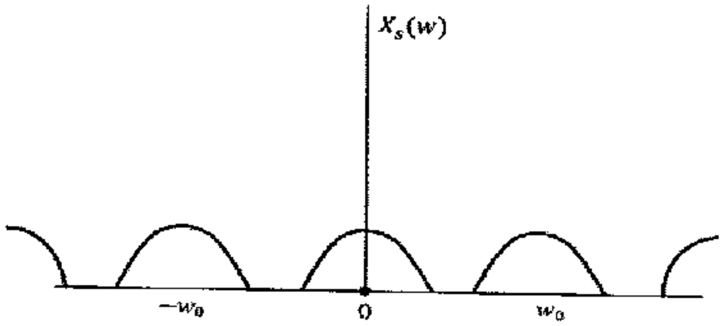
For the continuous-time signal **x (*t*)**, the band-limited signal in frequency domain, can be represented as shown in the following figure.



Band limited signal

We need a sampling frequency, a frequency at which there should be no loss of information, even after sampling. For this, we have the Nyquist rate that the sampling frequency should be two times the maximum frequency. It is the critical rate of sampling.
If the signal **x(*t*)** is sampled above the Nyquist rate, the original signal can be recovered, and if it is sampled below the Nyquist rate, the signal cannot be recovered.

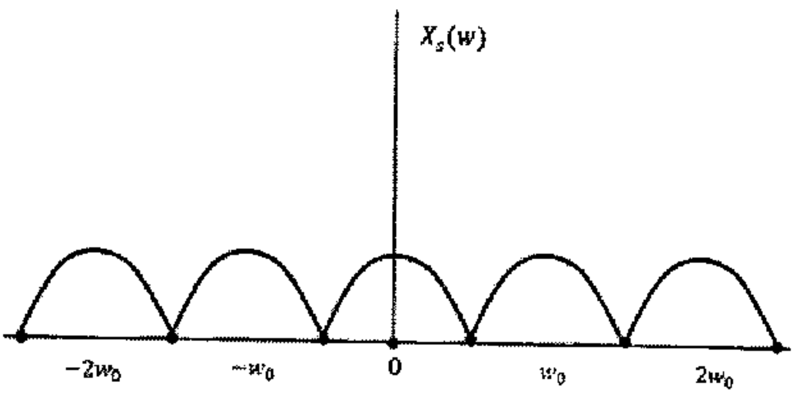
The following figure explains a signal, if sampled at a higher rate than **2w** in the frequency domain.



The above figure shows the Fourier transform of a signal $x_s(t)$. Here, the information is reproduced without any loss. There is no mixing up and hence recovery is possible.
The Fourier Transform of the signal $x_s(t)$ is

$$Xs(w) \;=\; 1/Ts \;\sum_n X(w-nw_0) \quad \text{Where } Ts = \textbf{Sampling Period} \text{ and } w_0 = 1/2\pi Ts$$

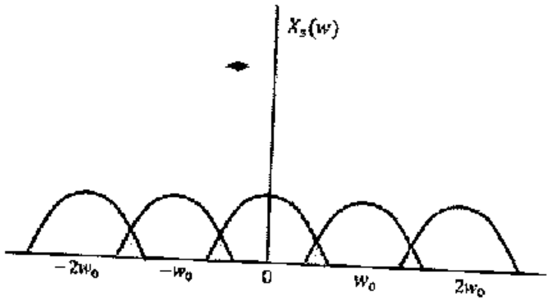
Let us see what happens if the sampling rate is equal to twice the highest frequency (2W)
That means, $fs = 2W$ Where, fs is the sampling frequency **W** is the highest frequency.



The result will be as shown in the above figure. The information is replaced without any loss. Hence, this is also a good sampling rate.

Now, let us look at the condition, $fs < 2W$

The resultant pattern will look like the following figure.



We can observe from the above pattern that the over-lapping of information is done, which leads to mixing up and loss of information. This unwanted phenomenon of over-lapping is called as Aliasing.

Aliasing Aliasing can be referred to as "the phenomenon of a high-frequency component in the spectrum of a signal, taking on the identity of a low-frequency component in the spectrum of its sampled version."

The corrective measures taken to reduce the effect of Aliasing are –

- In the transmitter section of PCM, a **low pass anti-aliasing filter** is employed, before the sampler, to eliminate the high frequency components, which are unwanted.
- The signal which is sampled after filtering is sampled at a rate slightly higher than the Nyquist rate.

This choice of having the sampling rate higher than Nyquist rate, also helps in the easier design of the **reconstruction filter** at the receiver.

Companding in PCM

The word **Companding** is a combination of Compressing and Expanding, which means that it does both. This is a non-linear technique used in PCM which compresses the data at the transmitter and expands the same data at the receiver. The effects of noise and crosstalk are reduced by using this technique.There are two types of Companding techniques. They are,

A-law Companding Technique

- Uniform quantization is achieved at **A = 1**, where the characteristic curve is linear and no compression is done.
- A-law has mid-rise at the origin. Hence, it contains a non-zero value.
- A-law companding is used for PCM telephone systems and it converts 12 bit data into 8 bits.

$$f(x) = \text{signum}(x)\begin{cases} \dfrac{A|x|}{1+\ln A}, & 0 \le |x| < \dfrac{1}{A} \\[2ex] \dfrac{1+\ln(A|x|)}{1+\ln A}, & \dfrac{1}{A} \le |x| < 1 \end{cases}$$

μ-law Companding Technique

- Uniform quantization is achieved at **μ = 0**, where the characteristic curve is linear and no compression is done.
- μ-law has mid-tread at the origin. Hence, it contains a zero value.
- μ-law companding is used for speech and music signals.

μ-law converts 13 bit data into 8 bits and is used in North America and Japan.

$$f(x) = \text{signum}(x)\left\{\frac{1 + \ln(\mu|x|)}{1 + \ln \mu}, \quad \mu \le |x| < 1\right\}$$

Types of Quantization

There are two types of Quantization - Uniform Quantization and Non-uniform Quantization.

The type of quantization in which the quantization levels are uniformly spaced is termed as a **Uniform Quantization**. The type of quantization in which the quantization levels are unequal and mostly the relation between them is logarithmic, is termed as a **Non-uniform Quantization.**

There are two types of uniform quantization. They are Mid-Rise type and Mid-Tread type. The following figures represent the two types of uniform quantization.

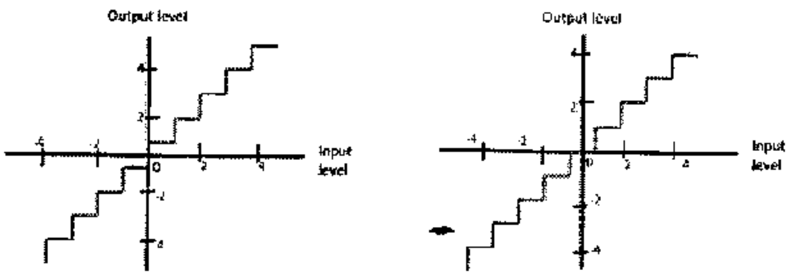


Fig 1 : Mid-Rise type Uniform Quantization

Fig 2 : Mid-Tread type Uniform Quantization

Figure 1 shows the mid-rise type and figure 2 shows the mid-tread type of uniform quantization.

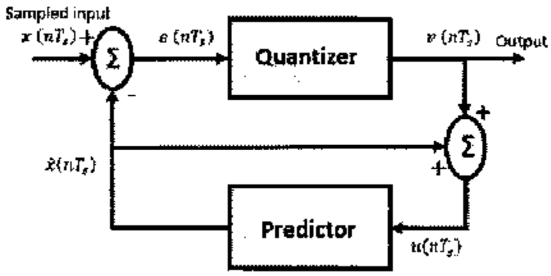
- The **Mid-Rise** type is so called because the origin lies in the middle of a raising part of the stair-case like graph. The quantization levels in this type are even in number.
- The **Mid-tread** type is so called because the origin lies in the middle of a tread of the stair-case like graph. The quantization levels in this type are odd in number.
- Both the mid-rise and mid-tread type of uniform quantizers are symmetric about the origin.

DPCM

For the samples that are highly correlated, when encoded by PCM technique, leave redundant information behind. To process this redundant information and to have a better output, it is a wise decision to take a predicted sampled value, assumed from its previous output and summarize them with the quantized values. Such a process is called as Differential PCM DPCM technique.

DPCM Transmitter

The DPCM Transmitter consists of Quantizer and Predictor with two summer circuits. Following is the block diagram of DPCM transmitter.



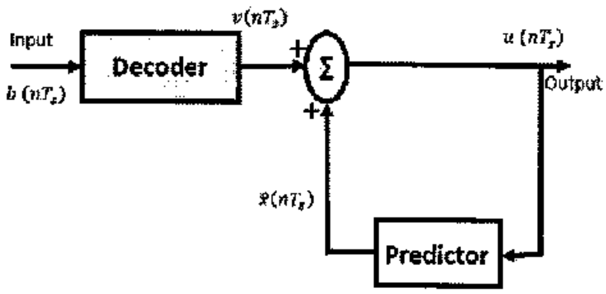
The signals at each point are named as $x(nTs)$ is the sampled input
$x\hat{}(nTs)$ is the predicted sample
$e(nTs)$ is the difference of sampled input and predicted output, often called as prediction error
$v(nTs)$ is the quantized output $u(nTs)$ is the predictor input which is actually the summer output of the predictor output and the quantizer output
The predictor produces the assumed samples from the previous outputs of the transmitter circuit. The input to this predictor is the quantized versions of the input signal $x(nTs)$
.Quantizer Output is represented as $v(nTs)=Q[e(nTs)] = e(nTs)+q(nTs)$
Where **q (nT$_s$)** is the quantization error
Predictor input is the sum of quantizer output and predictor output,

$$u(nTs)=x\hat{}(nTs)+v(nTs)$$
$$u(nTs)=x\hat{}(nTs)+e(nTs)+q(nTs)$$
$$u(nTs)=x(nTs)+q(nTs)$$

The same predictor circuit is used in the decoder to reconstruct the original input.

DPCM Receiver

The block diagram of DPCM Receiver consists of a decoder, a predictor, and a summer circuit. Following is the diagram of DPCM Receiver.



The notation of the signals is the same as the previous ones. In the absence of noise, the encoded receiver input will be the same as the encoded transmitter output.

As mentioned before, the predictor assumes a value, based on the previous outputs. The input given to the decoder is processed and that output is summed up with the output of the predictor, to obtain a better output.

The sampling rate of a signal should be higher than the Nyquist rate, to achieve better sampling. If this sampling interval in Differential PCM is reduced considerably, the sampleto-sample amplitude difference is very small, as if the difference is **1-bit quantization**, then the step-size will be very small i.e., Δ delta Delta Modulation

The type of modulation, where the sampling rate is much higher and in which the stepsize after quantization is of a smaller value **Δ**, such a modulation is termed as **delta modulation.**

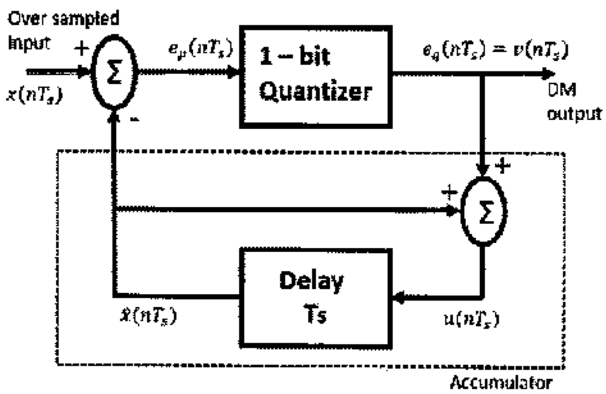
Features of Delta Modulation:

- An over-sampled input is taken to make full use of the signal correlation.
- The quantization design is simple.
- The input sequence is much higher than the Nyquist rate.
- The quality is moderate.
- The design of the modulator and the demodulator is simple.
- The stair-case approximation of output waveform.
- The step-size is very small, i.e., **Δ** delta
- The bit rate can be decided by the user.
- This involves simpler implementation.

Delta Modulation is a simplified form of DPCM technique, also viewed as **1-bit DPCM scheme**. As the sampling interval is reduced, the signal correlation will be higher.

Delta Modulator

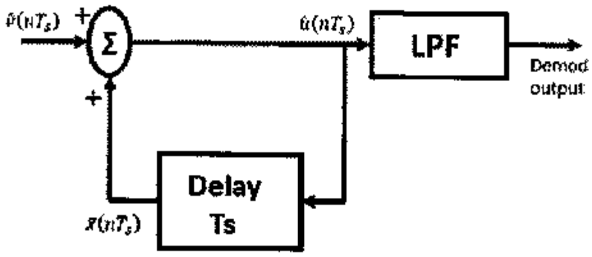
The Delta Modulator comprises of a 1-bit Quantizer and a delay circuit along with two summer circuits. Following is the block diagram of a delta modulator.



A Stair-case approximated waveform will be the output of the delta modulator with the step-size as delta (Δ). The output quality of the waveform is moderate.

Delta Demodulator

The delta demodulator comprises of a low pass filter, a summer, and a delay circuit. The predictor circuit is eliminated here and hence no assumed input is given to the demodulator.
Following is the diagram for delta demodulator.



A binary sequence will be given as an input to the demodulator. The stair-case approximated output is given to the LPF. Low pass filter is used for many reasons, but the prominent reason is noise elimination for out-of-band signals. The step-size error that may occur at the transmitter is called **granular noise**, which is eliminated here. If there is no noise present, then the modulator output equals the demodulator input.

Advantages of DM Over DPCM

- 1-bit quantizer
- Very easy design of the modulator and the demodulator

However, there exists some noise in DM.

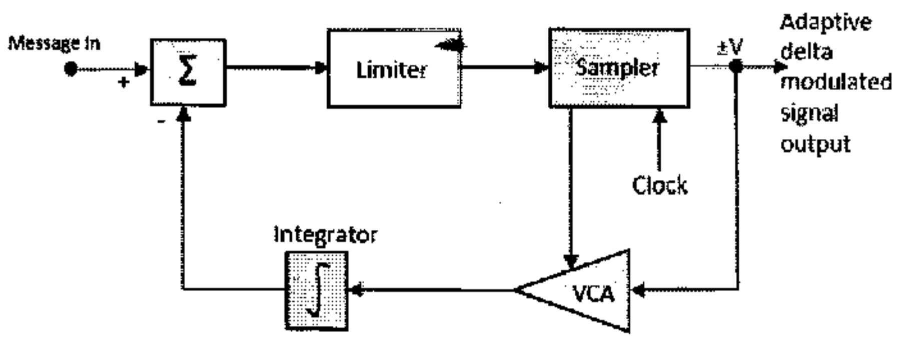
- Slope Over load distortion (when Δ is small)
- Granular noise (when Δ is large)

Adaptive Delta Modulation ADM

In digital modulation, we have come across certain problem of determining the step-size, which influences the quality of the output wave.

A larger step-size is needed in the steep slope of modulating signal and a smaller step size is needed where the message has a small slope. The minute details get missed in the process. So, it would be better if we can control the adjustment of step-size, according to our requirement in order to obtain the sampling in a desired fashion. This is the concept of **Adaptive Delta Modulation.**

Following is the block diagram of Adaptive delta modulator.



Adaptive delta modulator

The gain of the voltage controlled amplifier is adjusted by the output signal from the sampler. The amplifier gain determines the step-size and both are proportional. ADM quantizes the difference between the value of the current sample and the predicted value of the next sample. It uses a variable step height to predict the next values, for the faithful reproduction of the fast varying values.

Line Coding

A **line code** is the code used for data transmission of a digital signal over a transmission line. This process of coding is chosen so as to avoid overlap and distortion of signal such as inter-symbol interference.

Properties of Line Coding

Following are the properties of line coding –

- As the coding is done to make more bits transmit on a single signal, the bandwidth used is much reduced.
- For a given bandwidth, the power is efficiently used.
- The probability of error is much reduced.
- Error detection is done and the bipolar too has a correction capability.

- Power density is much favorable.
- The timing content is adequate.
- Long strings of **1s** and **0s** is avoided to maintain transparency.

Types of Line Coding

There are 3 types of Line Coding

* Unipolar * Polar * Bi-polar

Unipolar Signaling

Unipolar signaling is also called as **On-Off Keying** or simply **OOK**.

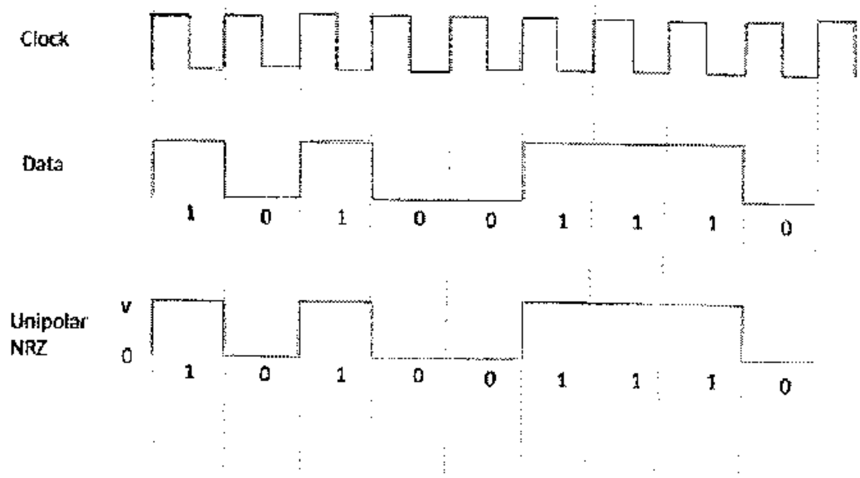
The presence of pulse represents a **1** and the absence of pulse represents a **0**.

There are two variations in Unipolar signaling: Non Return to Zero (NRZ) Return to Zero (RZ)

Unipolar Non-Return to Zero NRZ

In this type of unipolar signaling, a High in data is represented by a positive pulse called as **Mark**, which has a duration T_0 equal to the symbol bit duration. A Low in data input has no pulse.

The following figure clearly depicts this.



Advantages

The advantages of Unipolar NRZ are –

- It is simple.
- A lesser bandwidth is required.

Disadvantages

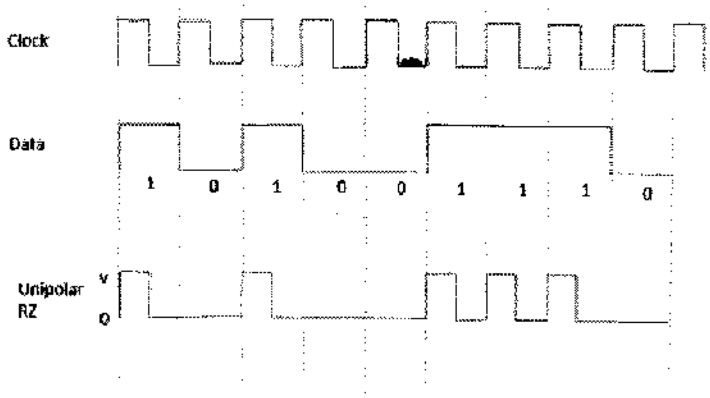
The disadvantages of Unipolar NRZ are –

- No error correction done.
- Presence of low frequency components may cause the signal droop.
- No clock is present.
- Loss of synchronization is likely to occur (especially for long strings of **1s** and **0s**).

Unipolar Return to Zero (RZ)

In this type of unipolar signaling, a High in data, though represented by a **Mark pulse**, its duration T_0 is less than the symbol bit duration. Half of the bit duration remains high but it immediately returns to zero and shows the absence of pulse during the remaining half of the bit duration.

It is clearly understood with the help of the following figure.



Advantages

The advantages of Unipolar RZ are −

- It is simple.
- The spectral line present at the symbol rate can be used as a clock.

Disadvantages

The disadvantages of Unipolar RZ are −

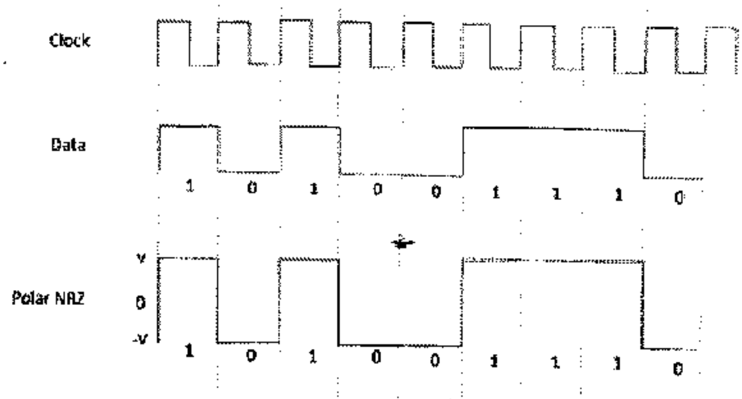
- No error correction.
- Occupies twice the bandwidth as unipolar NRZ.
- The signal droop is caused at the places where signal is non-zero at 0 Hz.

Polar Signaling

There are two methods of Polar Signaling. They are, Polar NRZ and Polar RZ

Polar NRZ

In this type of Polar signaling, a High in data is represented by a positive pulse, while a Low in data is represented by a negative pulse. The following figure depicts this well.



Advantages

The advantages of Polar NRZ are −

- It is simple.
- No low-frequency components are present.

Disadvantages

The disadvantages of Polar NRZ are −

- No error correction.
- No clock is present.
- The signal droop is caused at the places where the signal is non-zero at 0 Hz.

Polar RZ

- **Quantization** is representing the sampled values of the amplitude by a finite set of levels, which means converting a continuous-amplitude sample into a discrete-time signal
- Both sampling and quantization result in the loss of information.
- The quality of a Quantizer output depends upon the number of quantization levels used.
- The discrete amplitudes of the quantized output are called as **representation levels** or **reconstruction levels.**
- The spacing between the two adjacent representation levels is called a **quantum** or **step-size.**
- There are two types of Quantization
    - Uniform Quantization
    - Non-uniform Quantization.
- The type of quantization in which the quantization levels are uniformly spaced is termed as a **Uniform Quantization**.
- The type of quantization in which the quantization levels are unequal and mostly the relation between them is logarithmic, is termed as a **Non-uniform Quantization.**

Uniform Quantization:

- There are two types of uniform quantization.
    - Mid-Rise type
    - Mid-Tread type.
- The following figures represent the two types of uniform quantization.

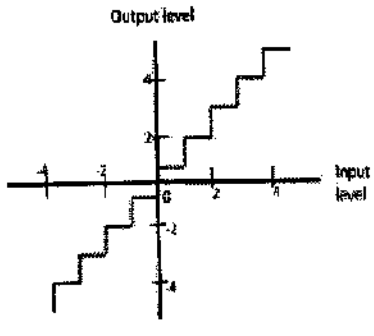


Fig 1 : Mid-Rise type Uniform Quantization

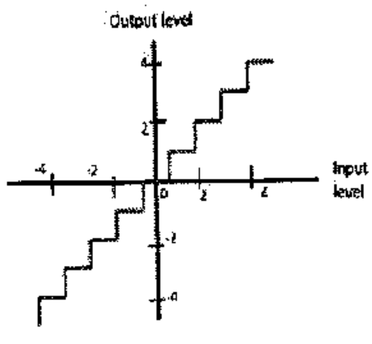
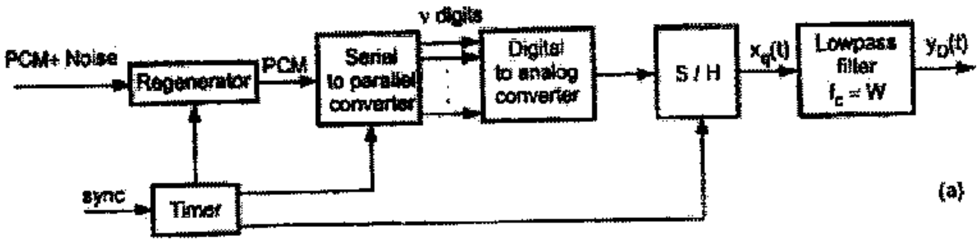


Fig 2 : Mid-Tread type Uniform Quantization

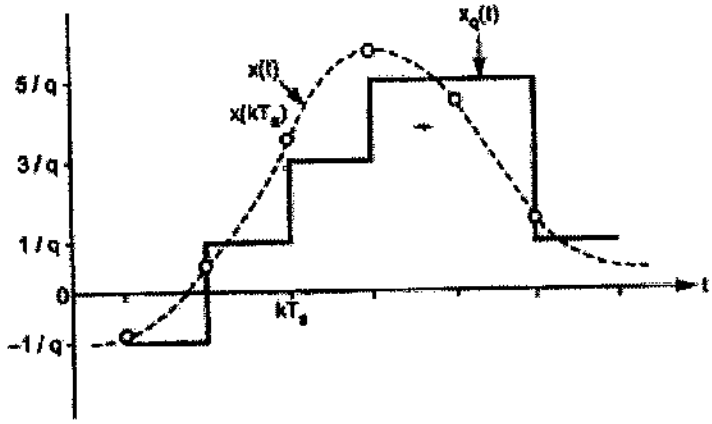
- The **Mid-Rise** type is so called because the origin lies in the middle of a raising part of the stair-case like graph. The quantization levels in this type are even in number.
- The **Mid-tread type** is so called because the origin lies in the middle of a tread of the stair-case like graph. The quantization levels in this type are odd in number.
- Both the mid-rise and mid-tread type of uniform quantizer is symmetric about the origin.

PCM Receiver:

Fig. 9 (a) shows the block diagram of PCM receiver and Fig. 9 (b) shows the reconstructed signal. The regenerator at the start of PCM receiver reshapes the pulses and removes the noise. This signal is then converted to parallel digital words for each sample.



(a)



(b)

Fig. 9 (a) PCM receiver
(b) Reconstructed waveform

The digital word is converted to its analog value $x_q(t)$ along with sample and hold. This signal, at the output of S/H is passed through lowpass reconstruction filter to get $y_D(t)$. As shown in reconstructed signal of Fig. 9 (b), it is impossible to reconstruct exact original signal $x(t)$ because of permanent quantization error introduced during quantization at the transmitter. This quantization error can be reduced by increasing the binary levels. This is equivalent to increasing binary digits (bits) per sample. But increasing bits 'v' increases the signaling rate as well as transmission bandwidth as we have seen in equation 3 and equation 6. Therefore the choice of these parameters is made, such that noise due to quantization error (called as quantization noise) is in tolerable limits.

Quantization

- The quantizing of an analog signal is done by discretizing the signal with a number of quantization levels.

Quantization Noise and Signal to Noise ratio in PCM System:

Derivation of Quantization Error/Noise or Noise Power for Uniform (Linear) Quantization

Step 1 : Quantization Error

Because of quantization, inherent errors are introduced in the signal. This error is called *quantization error*. We have defined quantization error as,

$$\varepsilon = x_q(nT_s) - x(nT_s) \quad \text{.......... (1)}$$

Step 2 : Step size

Let an input $x(nT_s)$ be of continuous amplitude in the range $-x_{max}$ to $+x_{max}$.

Therefore the total amplitude range becomes,

$$\text{Total amplitude range} = x_{max} - (-x_{max}) \quad \text{..........(2)}$$
$$= 2\,x_{max}$$

If this amplitude range is divided into 'q' levels of quantizer, then the step size 'δ' is given as,

$$\delta = \frac{x_{max} - (-x_{max})}{q}$$
$$= \frac{2\,x_{max}}{q} \quad \text{..........(3)}$$

If signal $x(t)$ is normalized to minimum and maximum values equal to 1, then

$$x_{max} = 1$$
$$-x_{max} = -1 \quad \text{..........(4)}$$

Therefore step size will be,

$$\delta = \frac{2}{q} \quad \text{(for normalized signal)} \quad \text{..........(5)}$$

Step 3 : Pdf of Quantization error

If step size 'δ' is sufficiently small, then it is reasonable to assume that the quantization error 'ε' will be uniformly distributed random variable. The maximum quantization error is given by

$$\varepsilon_{max} = \left|\frac{\delta}{2}\right| \quad \text{..........(6)}$$

i.e.

$$-\frac{\delta}{2} \geq \varepsilon_{max} \geq \frac{\delta}{2} \quad \text{..........(7)}$$

Thus over the interval $\left(-\frac{\delta}{2}, \frac{\delta}{2}\right)$ quantization error is uniformly distributed random variable.

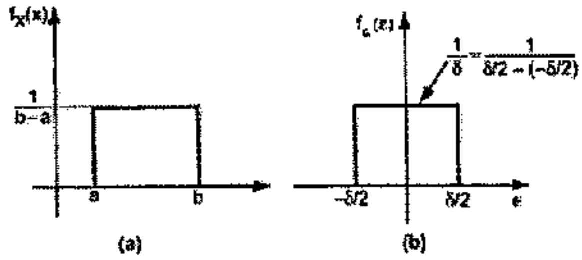


Fig. 10 (a) Uniform distribution
(b) Uniform distribution for quantization error

In above figure, a random variable is said to be uniformly distributed over an interval (a, b). Then PDF of 'X' is given by, (from equation of Uniform PDF).

$$f_X(x) = \begin{cases} 0 & \text{for} \quad x \le a \\ \dfrac{1}{b-a} & \text{for} \quad a < x \le b \\ 0 & \text{for} \quad x > b \end{cases} \qquad \text{..................(8)}$$

Thus with the help of above equation we can define the probability density function for quantization error 'ε' as,

$$f_\varepsilon(\varepsilon) = \begin{cases} 0 & \text{for} \quad \varepsilon \le \dfrac{\delta}{2} \\ \dfrac{1}{\delta} & \text{for} \quad -\dfrac{\delta}{2} < \varepsilon \le \dfrac{\delta}{2} \\ 0 & \text{for} \quad \varepsilon > \dfrac{\delta}{2} \end{cases} \qquad \text{..........................(9)}$$

Step 4 : Noise Power

quantization error 'ε' has zero average value. That is mean 'm_ε' of the quantization error is zero.

The signal to quantization noise ratio of the quantizer is defined as,

$$\frac{S}{N} = \frac{\text{Signal power (normalized)}}{\text{Noise power (normalized)}} \quad \cdots 10$$

If type of signal at input i.e., $x(t)$ is known, then it is possible to calculate signal power.

The noise power is given as,

$$\text{Noise power} = \frac{V_{noise}^2}{R} \quad \cdots (11)$$

Here V_{noise}^2 is the mean square value of noise voltage. Since noise is defined by random variable 'ε' and PDF $f_\varepsilon(\varepsilon)$, its mean square value is given as,

$$\text{mean square value} = E[\varepsilon^2] = \bar{\varepsilon}^2 \quad \cdots (12)$$

The mean square value of a random variable 'X' is given as,

$$\bar{X}^2 = E[X^2] = \int_{-\infty}^{\infty} x^2 f_X(x)\, dx \quad \text{By definition} \quad \cdots (13)$$

Here $$E[\varepsilon^2] = \int_{-\infty}^{\infty} \varepsilon^2 f_\varepsilon(\varepsilon)\, d\varepsilon \quad \cdots (14)$$

From equation 9 we can write above equation as,

$$E[\varepsilon^2] = \int_{-\delta/2}^{\delta/2} \varepsilon^2 \times \frac{1}{\delta}\, d\varepsilon$$

$$= \frac{1}{\delta}\left[\frac{\varepsilon^3}{3}\right]_{-\delta/2}^{\delta/2} = \frac{1}{\delta}\left[\frac{(\delta/2)^3}{3} + \frac{(\delta/2)^3}{3}\right]$$

$$= \frac{1}{3\delta}\left[\frac{\delta^3}{8} + \frac{\delta^3}{8}\right] = \frac{\delta^2}{12} \quad \cdots (15)$$

∴ From equation 1.8.25, the mean square value of noise voltage is,

$$V_{noise}^2 = \text{mean square value} = \frac{\delta^2}{12}$$

When load resistance, $R = 1$ ohm, then the noise power is normalized i.e.,

$$\text{Noise power (normalized)} = \frac{V_{noise}^2}{1} \qquad \text{[with } R = 1 \text{ in equation 11]}$$

$$= \frac{\delta^2 / 12}{1} = \frac{\delta^2}{12}$$

Thus we have,

Normalized noise power

or Quantization noise power $= \frac{\delta^2}{12}$ **; For linear quantization.**

or Quantization error (in terms of power) ... (16)

Derivation of Maximum Signal to Quantization Noise Ratio for Linear Quantization:

signal to quantization noise ratio is given as,

$$\frac{S}{N} = \frac{\text{Normalized signal power}}{\text{Normalized noise power}}$$

$$= \frac{\text{Normalized signal power}}{(\delta^2 / 12)} \qquad \text{... (17)}$$

The number of bits 'v' and quantization levels 'q' are related as,

$$q = 2^v \qquad \text{... (18)}$$

Putting this value in equation (3) we have,

$$\delta = \frac{2\, x_{max}}{2^v} \qquad \text{... (19)}$$

Putting this value in equation 1.8.30 we get,

$$\frac{S}{N} = \frac{\text{Normalized signal power}}{\left(\frac{2\, x_{max}}{2^v}\right)^2 + 12}$$

Let normalized signal power be denoted as 'P'.

$$\frac{S}{N} = \frac{P}{\frac{4\, x_{max}^2}{2^{2v}} \times \frac{1}{12}} = \frac{3P}{x_{max}^2} \cdot 2^{2v}$$

This is the required relation for maximum signal to quantization noise ratio. Thus,

$$\boxed{\textbf{Maximum signal to quantization noise ratio : } \frac{S}{N} = \frac{3P}{x_{max}^2} \cdot 2^{2v}} \quad \cdots (20)$$

This equation shows that signal to noise power ratio of quantizer increases exponentially with increasing bits per sample.

If we assume that input $x(t)$ is normalized, i.e.,

$$x_{max} = 1 \quad \cdots (21)$$

Then signal to quantization noise ratio will be,

$$\frac{S}{N} = 3 \times 2^{2v} \times P \quad \cdots (22)$$

If the destination signal power 'P' is normalized, i.e.,

$$P \leq 1 \quad \cdots (23)$$

Then the signal to noise ratio is given as,

$$\frac{S}{N} \leq 3 \times 2^{2v} \quad \cdots (24)$$

Since $x_{max} = 1$ and $P \leq 1$, the signal to noise ratio given by above equation is normalized.

Expressing the signal to noise ratio in decibels,

$$\left(\frac{S}{N}\right) dB = 10 \log_{10} \left(\frac{S}{N}\right) dB \quad \text{since power ratio.}$$

$$\leq 10 \log_{10} [3 \times 2^{2v}]$$

$$\leq (4.8 + 6v)\, dB$$

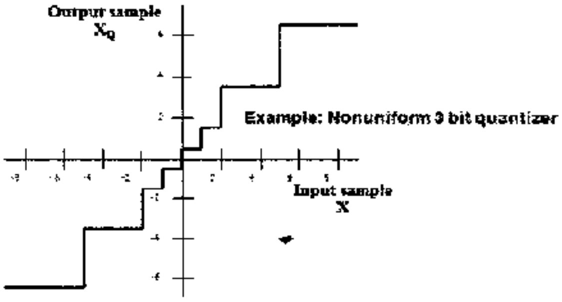
Thus,

Signal to Quantization noise ratio
for normalized values of power : $\left(\frac{S}{N}\right) dB \leq (4.8 + 6v)\, dB$
'P' and amplitude of input $x(t)$

$\cdots (25)$

Non-Uniform Quantization:

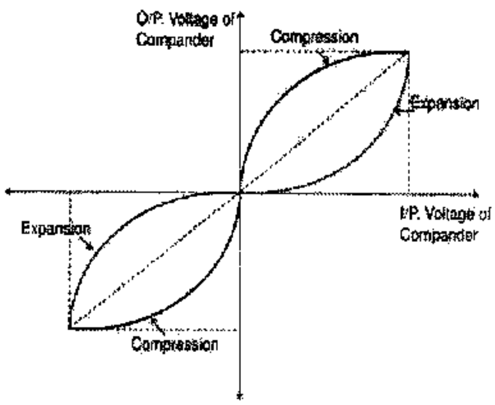
In non-uniform quantization, the step size is not fixed. It varies according to certain law or as per input signal amplitude. The following fig shows the characteristics of Non uniform quantizer.

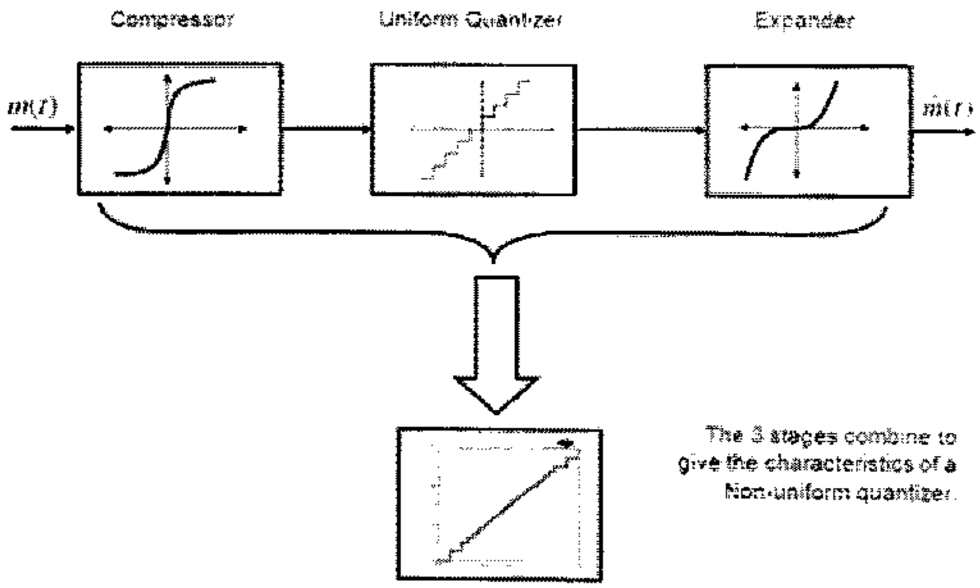


In this figure observe that step size is small at low input signal levels. Hence quantization error is also small at these inputs. Therefore signal to quantization noise power ratio is improved at low signal levels. Stepsize is higher at high input levels. Hence signal to noise power ratio remains almost same throughout the dynamic range of quantizer.

Companding PCM System:

- Non-uniform quantizers are difficult to make and expensive.
- An alternative is to first pass the speech signal through nonlinearity before quantizing with a uniform quantizer.
- The nonlinearity causes the signal amplitude to be ***compressed***.
  - The input to the quantizer will have a more uniform distribution.
- At the receiver, the signal is ***expanded*** by an inverse to the nonlinearity.
- The process of compressing and expanding is called ***Companding***.





μ - Law Companding for Speech Signals

Normally for speech and music signals a μ - law compression is used. This compression is defined by the following equation,

$$Z(x) = (\text{Sgn } x)\frac{ln(1+\mu|x|)}{ln(1+\mu)} \quad |x| \le 1 \qquad \cdots (1)$$

Below Fig shows the variation of signal to noise ratio with respect to signal level without companding and with companding.

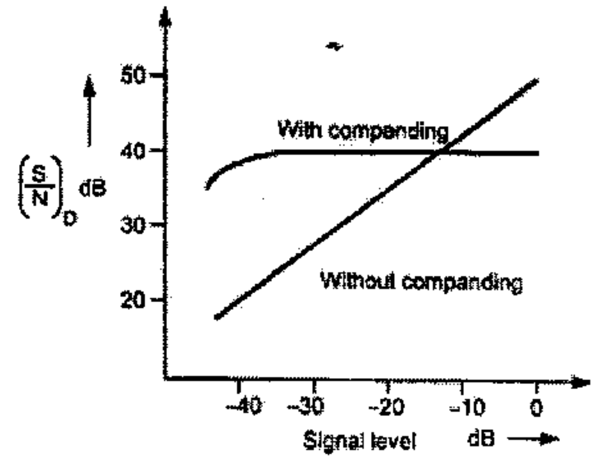


Fig. 11 PCM performance with μ - law companding

It can be observed from above figure that signal to noise ratio of PCM remains almost constant with companding.

A-Law for Companding

The A law provides piecewise compressor characteristic. It has linear segment for low level inputs and logarithmic segment for high level inputs. It is defined as,

$$Z(x) = \begin{cases} \dfrac{A|x|}{1+\ln A} & \text{for } 0 \le |x| \le \dfrac{1}{A} \\ \dfrac{1+\ln(A|x|)}{1+\ln A} & \text{for } \dfrac{1}{A} \le |x| \le 1 \end{cases} \quad \cdots (2)$$

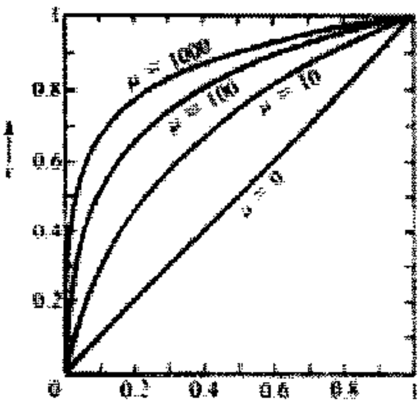
When A = 1, we get uniform quantization. The practical value for A is 87.56. Both A-law and μ-law companding is used for PCM telephone systems.

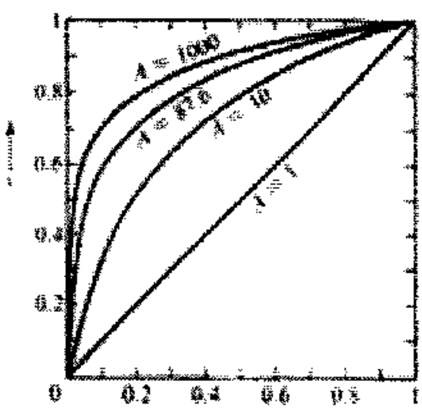
Signal to Noise Ratio of Companded PCM

The signal to noise ratio of companded PCM is given as,

$$\frac{S}{N} = \frac{3q^2}{[\ln(1+\mu)]^2} \quad \cdots (3)$$

Here $q = 2^{\nu}$ is number of quantization levels.





Differential Pulse Code Modulation (DPCM):

Redundant Information in PCM:

The samples of a signal are highly corrected with each other. This is because any signal does not change fast. That is its value from present sample to next sample does not differ by large amount. The adjacent samples of the signal carry the same information with little difference. When these samples are encoded by standard PCM system, the resulting encoded signal contains redundant information.

Fig. shows a continuous time signal $x(t)$ by dotted line. This signal is sampled by flat top sampling at intervals $T_s, 2T_s, 3T_s \dots nT_s$. The sampling frequency is selected to be higher than nyquist rate. The samples are encoded by using 3 bit (7 levels) PCM. The sample is quantized to the nearest digital level as shown by small

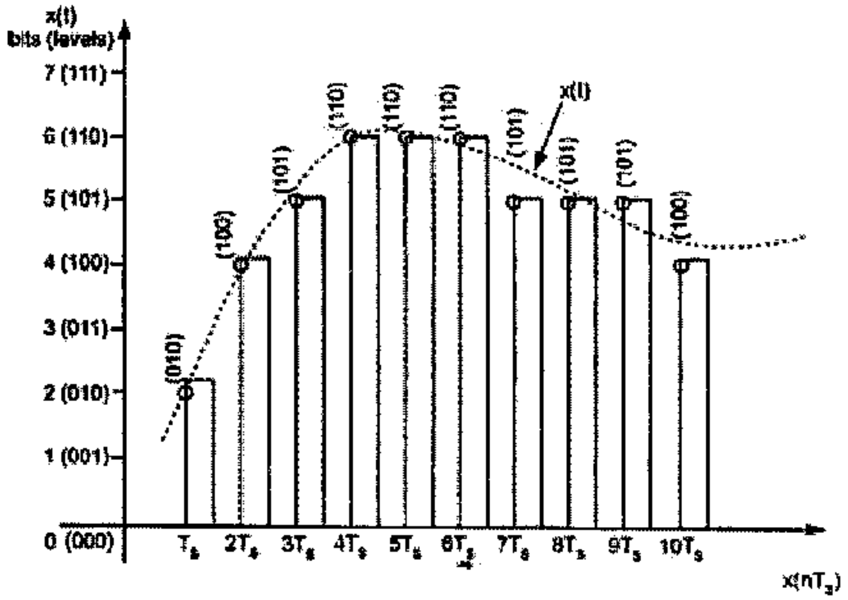


Fig. Redundant Information in PCM

circles in the diagram. The encoded binary value of each sample is written on the top of the samples. We can see from Fig. that the samples taken at $4T_s, 5T_s$ and $6T_s$ are encoded to same value of (110). This information can be carried only by one sample. But three samples are carrying the same information means it is redundant. Consider another example of samples taken at $9T_s$ and $10T_s$. The difference between these samples is only due to last bit and first two bits are redundant, since they do not change.

Principle of DPCM

If this redundancy is reduced, then overall bit rate will decrease and number of bits required to transmit one sample will also be reduced. This type of digital pulse modulation scheme is called Differential Pulse Code Modulation.

DPCM Transmitter

The differential pulse code modulation works on the principle of prediction. The value of the present sample is predicted from the past samples. The prediction may not be exact but it is very close to the actual sample value. Fig. shows the transmitter of Differential Pulse Code Modulation (DPCM) system. The sampled signal is denoted by $x(nT_s)$ and the predicted signal is denoted by $\hat{x}(nT_s)$. The comparator finds out the difference between the actual sample value $x(nT_s)$ and predicted sample value $\hat{x}(nT_s)$. This is called error and it is denoted by $e(nT_s)$. It can be defined as,

$$e(nT_s) = x(nT_s) - \hat{x}(nT_s) \qquad \ldots\ldots\ldots\ldots\ldots\ldots(1)$$

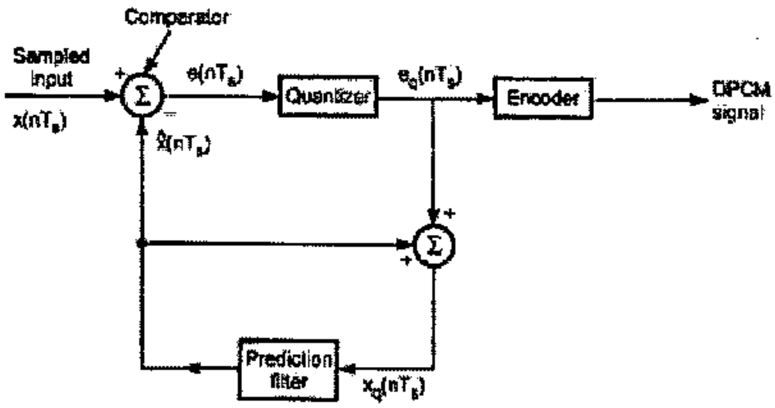


Fig. Differential pulse code modulation transmitter

Thus error is the difference between unquantized input sample $x(nT_s)$ and prediction of it $\hat{x}(nT_s)$. The predicted value is produced by using a prediction filter. The quantizer output signal $e_q(nT_s)$ and previous prediction is added and given as input to the prediction filter. This signal is called $x_q(nT_s)$. This makes the prediction more and more close to the actual sampled signal. We can see that the quantized error signal $e_q(nT_s)$ is very small and can be encoded by using small number of bits. Thus number of bits per sample are reduced in DPCM.

The quantizer output can be written as,

$$e_q(nT_s) = e(nT_s) + q(nT_s) \qquad \text{.................(2)}$$

Here $q(nT_s)$ is the quantization error. As shown in Fig. the prediction filter input $x_q(nT_s)$ is obtained by sum $\hat{x}(nT_s)$ and quantizer output i.e.,

$$x_q(nT_s) = \hat{x}(nT_s) + e_q(nT_s) \qquad \text{..................(3)}$$

Putting the value of $e_q(nT_s)$ from equation 2 in the above equation we get,

$$x_q(nT_s) = \hat{x}(nT_s) + e(nT_s) + q(nT_s) \qquad \text{...............(4)}$$

Equation 1 is written as,

$$e(nT_s) = x(nT_s) - \hat{x}(nT_s)$$

$$\therefore \quad e(nT_s) + \hat{x}(nT_s) = x(nT_s) \qquad \text{...............(5)}$$

$\therefore$ Putting the value of $e(nT_s) + \hat{x}(nT_s)$ from above equation into equation 4 we get,

$$x_q(nT_s) = x(nT_s) + q(nT_s) \qquad \text{...................(6)}$$

Thus the quantized version of the signal $x_q(nT_s)$ is the sum of original sample value and quantization error $q(nT_s)$. The quantization error can be positive or negative. Thus equation 6 does not depend on the prediction filter characteristics.

Reconstruction of DPCM Signal

Fig. shows the block diagram of DPCM receiver.

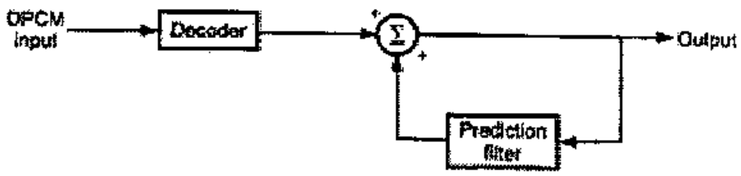


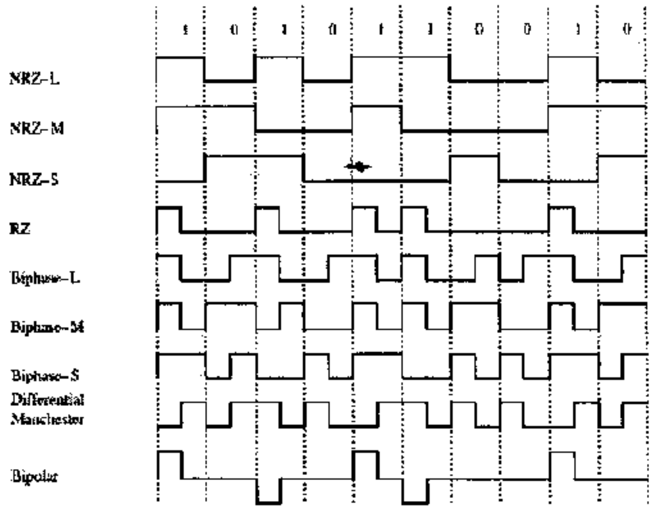
Fig. DPCM receiver

The decoder first reconstructs the quantized error signal from incoming binary signal. The prediction filter output and quantized error signals are summed up to give the quantized version of the original signal. Thus the signal at the receiver differs from actual signal by quantization error $q(nT_s)$, which is introduced permanently in the reconstructed signal.

Line Coding:

In telecommunication, a line code is a code chosen for use within a communications system for transmitting a digital signal down a transmission line. Line coding is often used for digital data transport.

The waveform pattern of voltage or current used to represent the 1s and 0s of a digital signal on a transmission link is called line encoding. The common types of line encoding are unipolar, polar, bipolar and Manchester encoding. Line codes are used commonly in computer communication networks over short distances.



Signal	Comments
NRZ-L	Non-return to zero level. This is the standard positive logic signal format used in digital circuits. 1 forces a high level 0 forces a low level
NRZ-M	Non return to zero mark 1 forces a transition 0 does nothing
NRZ-S	Non return to zero space 1 does nothing 0 forces a transition
RZ	Return to zero 1 goes high for half the bit period 0 does nothing
Biphase-L	Manchester. Two consecutive bits of the same type force a transition at the beginning of a bit period. 1 forces a negative transition in the middle of the bit 0 forces a positive transition in the middle of the bit
Biphase-M	There is always a transition at the beginning of a bit period. 1 forces a transition in the middle of the bit 0 does nothing
Biphase-S	There is always a transition at the beginning of a bit period. 1 does nothing 0 forces a transition in the middle of the bit
Differential Manchester	There is always a transition in the middle of a bit period. 1 does nothing 0 forces a transition at the beginning of the bit
Bipolar	The positive and negative pulses alternate. 1 forces a positive or negative pulse for half the bit period 0 does nothing

Time Division Multiplexing:

The sampling theorem provides the basis for transmitting the information contained in a band-limited message signal $m(t)$ as a sequence of samples of $m(t)$ taken uniformly at a rate that is usually slightly higher than the Nyquist rate. An important feature of the sampling process is a *conservation of time*. That is, the transmission of the message samples engages the communication channel for only a fraction of the sampling interval on a periodic basis, and in this way some of the time interval between adjacent samples is cleared for use by other independent message sources on a time-shared basis. We thereby obtain a *time-division multiplex* (TDM) *system*, which enables the joint utilization of a common communication channel by a plurality of independent message sources without mutual interference among them.

The concept of TDM is illustrated by the block diagram shown in Figure Each input message signal is first restricted in bandwidth by a low-pass anti-aliasing filter to remove the frequencies that are nonessential to an adequate signal representation. The low-pass filter outputs are then applied to a *commutator*, which is usually implemented using electronic switching circuitry. The function of the commutator is twofold: (1) to take a narrow sample of each of the N input messages at a rate f_s that is slightly higher than $2W$, where W is the cutoff frequency of the anti-aliasing filter, and (2) to sequentially interleave these N samples inside the sampling interval T_s. Indeed, this latter function is the essence of the time-division multiplexing operation. Following the commutation process, the multiplexed signal is applied to a *pulse modulator*, the purpose of which is to transform the multiplexed signal into a form suitable for transmission over the common channel. It is clear that the use of time-division multiplexing introduces a bandwidth expansion factor N, because the scheme must squeeze N samples derived from N independent message sources into a time slot equal to one sampling interval. At the receiving end of the system, the received signal is applied to a *pulse demodulator*, which performs the reverse operation of the pulse modulator. The narrow samples produced at the pulse demodulator output are distributed to the appropriate low-pass reconstruction filters by means of a *decommutator*, which operates in *synchronism* with the commutator in the transmitter. This synchronization is essential for a satisfactory operation of the system.

The way this synchronization is implemented depends naturally on the method of pulse modulation used to transmit the multiplexed sequence of samples.

The TDM system is highly sensitive to dispersion in the common channel, that is, to variations of amplitude with frequency or lack of proportionality of phase with frequency. Accordingly, accurate equalization of both magnitude and phase responses of the channel is necessary to ensure a satisfactory operation of the system;

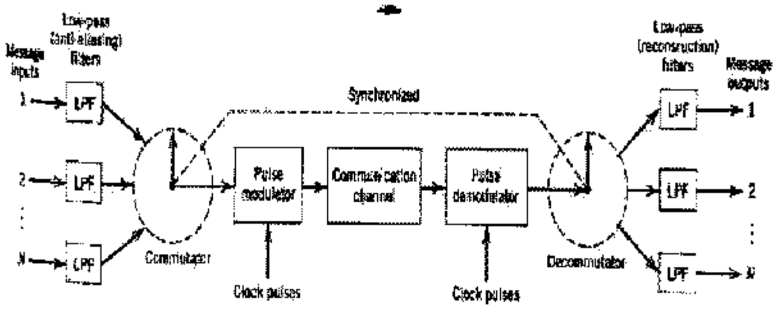


FIGURE Block diagram of TDM system.

TDM is immune to nonlinearities in the channel as a source of crosstalk. The reason for this behaviour is that different message signals are not simultaneously applied to the channel.

Introduction to Delta Modulation

PCM transmits all the bits which are used to code the sample. Hence signaling rate and transmission channel bandwidth are large in PCM. To overcome this problem Delta Modulation is used.

Delta Modulation

Operating Principle of DM

Delta modulation transmits only one bit per sample. That is the present sample value is compared with the previous sample value and the indication,whether the amplitude is increased or decreased is sent. Input signal $x(t)$ is approximated to step signal by the delta modulator. This step size is fixed. The difference between the input signal $x(t)$ and staircase approximated signal confined to two levels, i.e. $+\delta$ and $-\delta$. If the difference is positive, then approximated signal is increased by one step i.e. 'δ'. If the difference is negative, then approximated signal is reduced by 'δ'. When the step is reduced, '0' is transmitted and if the step is increased, '1' is transmitted. Thus for each sample, only one binary bit is transmitted. Fig. shows the analog signal $x(t)$ and its staircase approximated signal by the delta modulator.

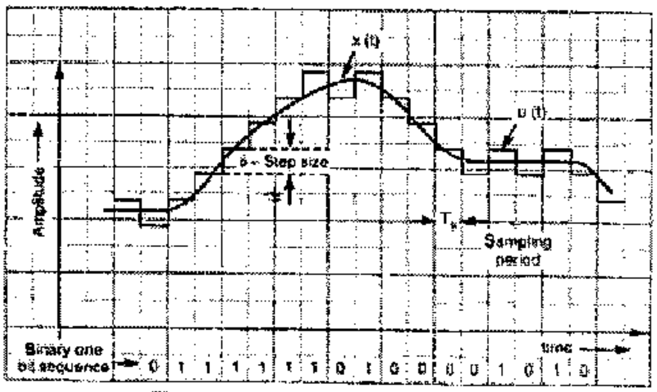


Fig. Delta modulation waveform

The principle of delta modulation can be explained by the following set of equations. The error between the sampled value of $x(t)$ and last approximated sample is given as,

$$e(nT_s) = x(nT_s) - \hat{x}(nT_s) \quad \ldots (1)$$

Here, $e(nT_s)$ = Error at present sample

$x(nT_s)$ = Sampled signal of $x(t)$

$\hat{x}(nT_s)$ = Last sample approximation of the staircase waveform.

We can call $u(nT_s)$ as the present sample approximation of staircase output.

Then, $u[(n-1)T_s] = \hat{x}(nT_s) \quad \ldots (2)$

= Last sample approximation of staircase waveform.

Let the quantity $b(nT_s)$ be defined as,

$$b(nT_s) = \delta \, sgn[e(nT_s)] \quad \ldots (3)$$

That is depending on the sign of error $e(nT_s)$ the sign of step size δ will be decided. In other words,

$$\begin{aligned} b(nT_s) &= +\delta \quad \text{if} \quad x(nT_s) \geq \hat{x}(nT_s) \\ &= -\delta \quad \text{if} \quad x(nT_s) < \hat{x}(nT_s) \end{aligned} \quad \ldots (4)$$

If $b(nT_s) = +\delta$; binary '1' is transmitted

and if $b(nT_s) = -\delta$; binary '0' is transmitted.

T_s = Sampling interval.

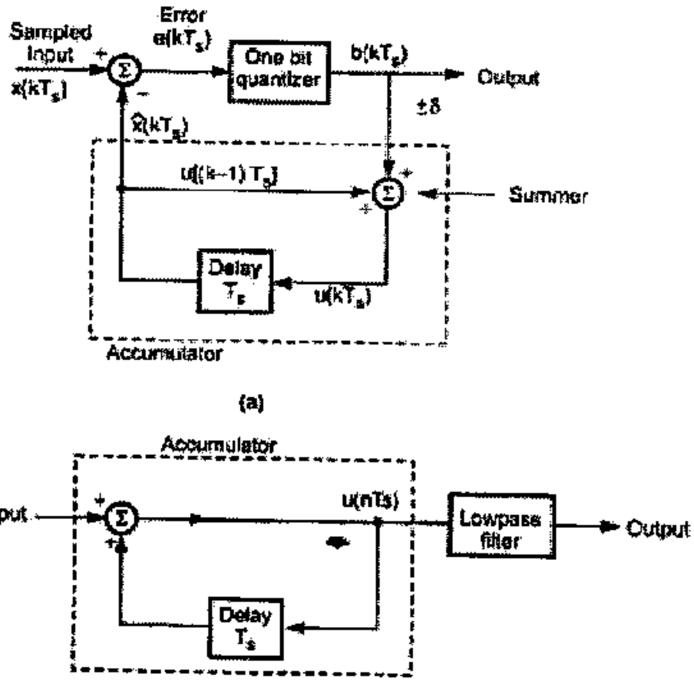
DM Transmitter

Fig. (a) shows the transmitter based on equations 3 to 5.

The summer in the accumulator adds quantizer output ($\pm\delta$) with the previous sample approximation. This gives present sample approximation. i.e.,

$$u(nT_s) = u(nT_s - T_s) + [\pm\delta] \quad \text{or}$$
$$= u[(n-1)T_s] + b(nT_s) \qquad \dots (5)$$

The previous sample approximation $u[(n-1)T_s]$ is restored by delaying one sample period T_s. The sampled input signal $x(nT_s)$ and staircase approximated signal $\hat{x}(nT_s)$ are subtracted to get error signal $e(nT_s)$.



(a)

(b)

Fig. **(a) Delta modulation transmitter and**
(b) Delta modulation receiver

Depending on the sign of $e(nT_s)$ one bit quantizer produces an output step of $+\delta$ or $-\delta$. If the step size is $+\delta$, then binary '1' is transmitted and if it is $-\delta$, then binary '0' is transmitted.

DM Receiver

At the receiver shown in Fig. (b), the accumulator and low-pass filter are used. The accumulator generates the staircase approximated signal output and is delayed by one sampling period T_s. It is then added to the input signal. If input is binary '1' then it adds $+\delta$ step to the previous output (which is delayed). If input is binary '0' then one step 'δ' is subtracted from the delayed signal. The low-pass filter has the cutoff frequency equal to highest frequency in $x(t)$. This filter smoothen the staircase signal to reconstruct $x(t)$.

Advantages and Disadvantages of Delta Modulation

Advantages of Delta Modulation

The delta modulation has following advantages over PCM,

1. Delta modulation transmits only one bit for one sample. Thus the signaling rate and transmission channel bandwidth is quite small for delta modulation.
2. The transmitter and receiver implementation is very much simple for delta modulation. There is no analog to digital converter involved in delta modulation.

Disadvantages of Delta Modulation

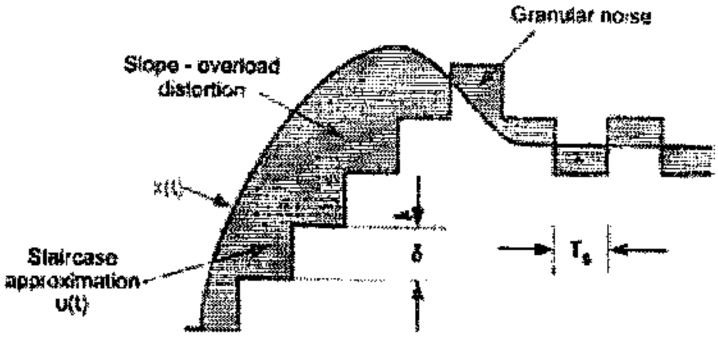


Fig. Quantization errors in delta modulation

The delta modulation has two drawbacks -

Slope Overload Distortion (Startup Error)

This distortion arises because of the large dynamic range of the input signal.

As can be seen from Fig. the rate of rise of input signal $x(t)$ is so high that the staircase signal cannot approximate it, the step size 'δ' becomes too small for staircase signal $u(t)$ to follow the steep segment of $x(t)$. Thus there is a large error between the staircase approximated signal and the original input signal $x(t)$. This error is called *slope overload distortion*. To reduce this error, the step size should be increased when slope of signal of $x(t)$ is high.

Since the step size of delta modulator remains fixed, its maximum or minimum slopes occur along straight lines. Therefore this modulator is also called Linear Delta Modulator (LDM).

Granular Noise (Hunting)

Granular noise occurs when the step size is too large compared to small variations in the input signal. That is for very small variations in the input signal, the staircase signal is changed by large amount (δ) because of large step size. Fig shows that when the input signal is almost flat, the staircase signal $u(t)$ keeps on oscillating by $\pm\delta$ around the signal. The error between the input and approximated signal is called *granular noise*. The solution to this problem is to make step size small.

Thus large step size is required to accommodate wide dynamic range of the input signal (to reduce slope overload distortion) and small steps are required to reduce granular noise. Adaptive delta modulation is the modification to overcome these errors.

Adaptive Delta Modulation

Operating Principle

To overcome the quantization errors due to slope overload and granular noise, the step size (δ) is made adaptive to variations in the input signal $x(t)$. Particularly in the steep segment of the signal $x(t)$, the step size is increased. When the input is varying slowly, the step size is reduced. Then the method is called *Adaptive Delta Modulation (ADM)*.

The adaptive delta modulators can take continuous changes in step size or discrete changes in step size.

Transmitter and Receiver

Fig. (a) shows the transmitter and (b) shows receiver of adaptive delta modulator. The logic for step size control is added in the diagram. The step size increases or decreases according to certain rule depending on one bit quantizer output.

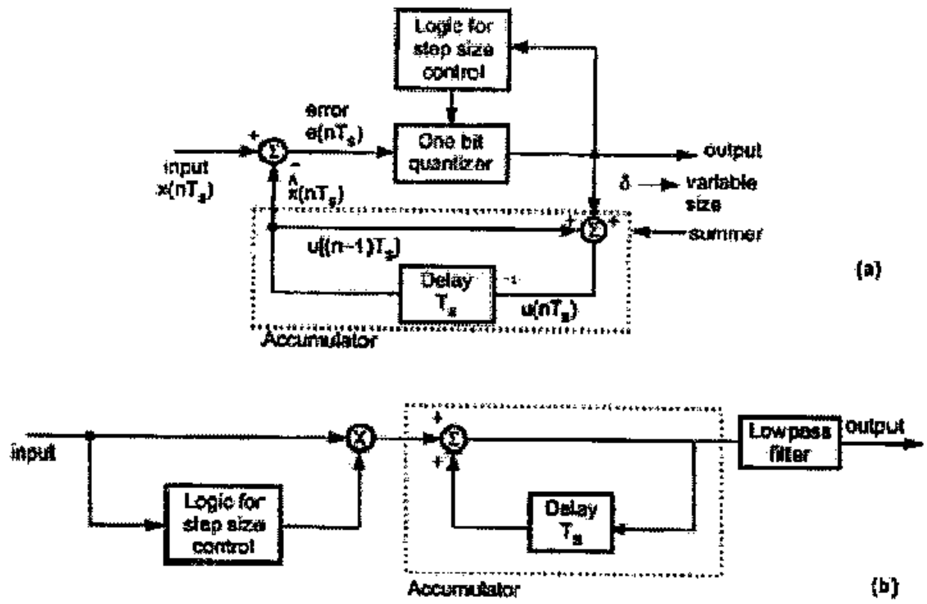


Fig. Adaptive delta modulator (a) Transmitter (b) Receiver

For example if one bit quantizer output is high (1), then step size may be doubled for next sample. If one bit quantizer output is low, then step size may be reduced by one step. Fig. shows the waveforms of adaptive delta modulator and sequence of bits transmitted.

In the receiver of adaptive delta modulator shown in Fig. (b) the first part generates the step size from each incoming bit. Exactly the same process is followed as that in transmitter. The previous input and present input decides the step size. It is then given to an accumulator which builds up staircase waveform. The low-pass filter then smoothens out the staircase waveform to reconstruct the smooth signal.

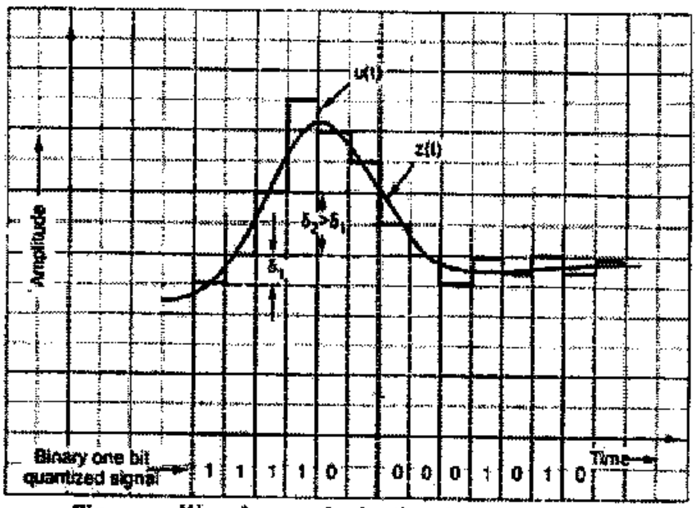


Fig. Waveforms of adaptive delta modulation

Advantages of Adaptive Delta Modulation

Adaptive delta modulation has certain advantages over delta modulation. i.e.,

1. The signal to noise ratio is better than ordinary delta modulation because of the reduction in slope overload distortion and granular noise.
2. Because of the variable step size, the dynamic range of ADM is wide.
3. Utilization of bandwidth is better than delta modulation.

Plus other advantages of delta modulation are, only one bit per sample is required and simplicity of implementation of transmitter and receiver.

Condition for Slope overload distortion occurrence:

Slope overload distortion will occur if

$$A_m > \frac{\delta}{2\pi f_m T_s}$$

where T_s is the sampling period.

Let the sine wave be represented as,

$$x(t) = A_m \sin(2\pi f_m t)$$

Slope of $x(t)$ will be maximum when derivative of $x(t)$ with respect to 't' will be maximum. The maximum slope of delta modulator is given

$$\text{Max. slope} = \frac{\text{Step size}}{\text{Sampling period}}$$

$$= \frac{\delta}{T_s} \qquad \text{..............(1)}$$

Slope overload distortion will take place if slope of sine wave is greater than slope of delta modulator i.e.

$$\max\left|\frac{d}{dt}x(t)\right| > \frac{\delta}{T_s}$$

$$\max\left|\frac{d}{dt}A_m \sin(2\pi f_m t)\right| > \frac{\delta}{T_s}$$

$$\max\left|A_m\, 2\pi f_m \cos(2\pi f_m t)\right| > \frac{\delta}{T_s}$$

$$A_m\, 2\pi f_m > \frac{\delta}{T_s}$$

or $$\boxed{A_m > \frac{\delta}{2\pi f_m T_s}} \qquad \text{..............(2)}$$

Expression for Signal to Quantization Noise power ratio for Delta Modulation:

To obtain signal power :

slope overload distortion will not occur if

$$A_m \le \frac{\delta}{2\pi f_m T_s}$$

Here A_m is peak amplitude of sinusoided signal

δ is the step size

f_m is the signal frequency and

T_s is the sampling period.

From above equation, the maximum signal amplitude will be,

$$A_m = \frac{\delta}{2\pi f_m T_s} \qquad \text{.................(1)}$$

Signal power is given as,

$$P = \frac{V^2}{R}$$

Here V is the rms value of the signal. Here $V = \frac{A_m}{\sqrt{2}}$. Hence above equation becomes,

$$P = \left(\frac{A_m}{\sqrt{2}}\right)^2 / R$$

Normalized signal power is obtained by taking R = 1. Hence,

$$P = \frac{A_m^2}{2}$$

Putting for A_m from equation 1

$$P = \frac{\delta^2}{8\pi^2 f_m^2 T_s^2} \qquad \text{.................(2)}$$

This is an expression for signal power in delta modulation.

(ii) To obtain noise power

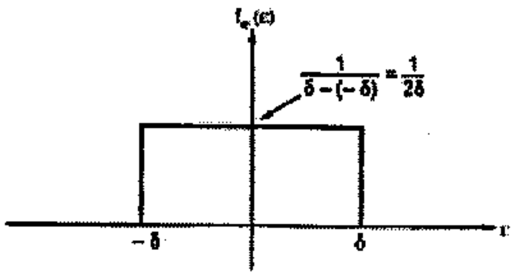


Fig. **Uniform distribution of quantization error**

We know that the maximum quantization error in delta modulation is equal to step size 'δ'. Let the quantization error be uniformly distributed over an interval $[-\delta, \delta]$. This is shown in Fig. From this figure the PDF of quantization error can be expressed as,

$$f_\varepsilon(\varepsilon) = \begin{cases} 0 & \text{for} \quad \varepsilon < \delta \\ \frac{1}{2\delta} & \text{for} \quad -\delta < \varepsilon < \delta \\ 0 & \text{for} \quad \varepsilon > \delta \end{cases} \qquad \text{................(3)}$$

The noise power is given as,

$$\text{Noise power} = \frac{V_{noise}^2}{R}$$

Here V_{noise}^2 is the mean square value of noise voltage. Since noise is defined by random variable 'ε' and PDF $f_\varepsilon(\varepsilon)$, its mean square value is given as,

$$\text{mean square value} = E[\varepsilon^2] = \overline{\varepsilon^2}$$

mean square value is given as,

$$E[\varepsilon^2] = \int_{-\infty}^{\infty} \varepsilon^2 f_\varepsilon(\varepsilon)\, d\varepsilon$$

From equation 3

$$E[\varepsilon^2] = \int_{-\delta}^{\delta} \varepsilon^2 \cdot \frac{1}{2\delta}\, d\varepsilon$$

$$= \frac{1}{2\delta}\left[\frac{\varepsilon^3}{3}\right]_{-\delta}^{\delta}$$

$$= \frac{1}{2\delta}\left[\frac{\delta^3}{3} + \frac{\delta^3}{3}\right] = \frac{\delta^2}{3} \qquad \text{....................(4)}$$

Hence noise power will be,

$$\text{noise power} = \left(\frac{\delta^2}{3}\right) / R$$

Normalized noise power can be obtained with R = 1. Hence,

$$\text{noise power} = \frac{\delta^2}{3} \qquad \text{................(5)}$$

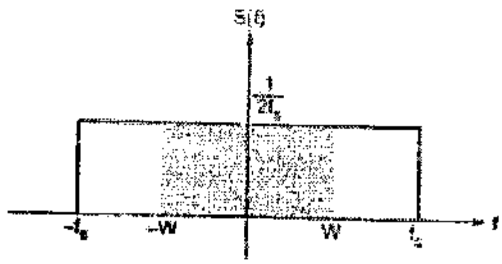


Fig. PSD of noise

This noise power is uniformly distributed over $-f_s$ to f_s range. This is illustrated in Fig. At the output of delta modulator receiver there is lowpass reconstruction filter whose cutoff frequency is 'W'. This cutoff frequency is equal to highest signal frequency. The reconstruction filter passes part of the noise power at the output as Fig. From the geometry of Fig. output noise power will be,

$$\text{Output noise power} = \frac{W}{f_s} \times \text{noise power} = \frac{W}{f_s} \times \frac{\delta^2}{3}$$

We know that $f_s = \frac{1}{T_s}$, hence above equation becomes,

$$\text{Output noise power} = \frac{WT_s\delta^2}{3} \qquad \ldots\ldots\ldots\ldots\ldots\ldots(6)$$

(iii) To obtain signal to noise power ratio

Signal to noise power ratio at the output of delta modulation receiver is given as,

$$\frac{S}{N} = \frac{\textit{Normalized signal power}}{\textit{Normalized noise power}}$$

From equation 2. and equation 6

$$\frac{S}{N} = \frac{\dfrac{\delta^2}{8\pi^2 f_m^2 T_s^2}}{\dfrac{WT_s\delta^2}{3}}$$

$$\boxed{\frac{S}{N} = \frac{3}{8\pi^2 W f_m^2 T_s^3}} \qquad \ldots\ldots\ldots\ldots\ldots(7)$$

This is an expression for signal to noise power ratio in delta modulation.

UNIT-2

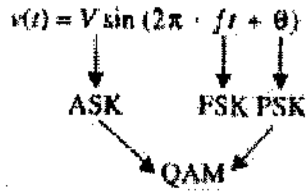
DIGITAL MODULATION TECHNIQUES

Digital Modulation provides more information capacity, high data security, quicker system availability with great quality communication. Hence, digital modulation techniques have a greater demand, for their capacity to convey larger amounts of data than analog ones.

There are many types of digital modulation techniques and we can even use a combination of these techniques as well. In this chapter, we will be discussing the most prominent digital modulation techniques.

if the information signal is digital and the amplitude (lV of the carrier is varied proportional to the information signal, a digitally modulated signal called amplitude shift keying (ASK) is produced.

If the frequency (f) is varied proportional to the information signal, frequency shift keying (FSK) is produced, and if the phase of the carrier (0) is varied proportional to the information signal, phase shift keying (PSK) is produced. If both the amplitude and the phase are varied proportional to the information signal, quadrature amplitude modulation (QAM) results. ASK, FSK, PSK, and QAM are all forms of digital modulation:



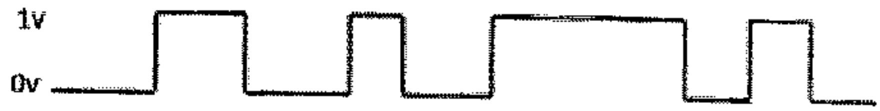
a simplified block diagram for a digital modulation system.

Amplitude Shift Keying

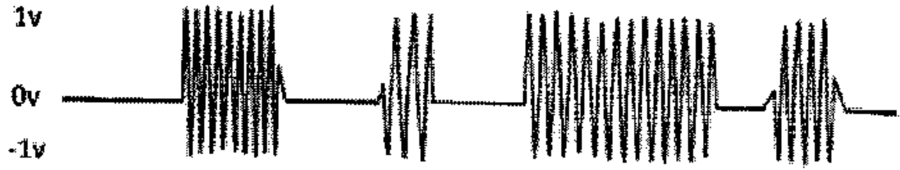
The amplitude of the resultant output depends upon the input data whether it should be a zero level or a variation of positive and negative, depending upon the carrier frequency.

Amplitude Shift Keying (ASK) is a type of Amplitude Modulation which represents the binary data in the form of variations in the amplitude of a signal.

Following is the diagram for ASK modulated waveform along with its input.



Input binary sequence



ASK Modulated output wave

Any modulated signal has a high frequency carrier. The binary signal when ASK is modulated, gives a zero value for LOW input and gives the carrier output for HIGH input.

Mathematically, amplitude-shift keying is

$$v_{(ask)}(t) = [1 + v_m(t)]\left[\frac{A}{2}\cos(\omega_c t)\right]$$

where vask(t) = amplitude-shift keying wave

vm(t) = digital information (modulating) signal (volts)

A/2 = unmodulated carrier amplitude (volts)

ωc= analog carrier radian frequency (radians per second, 2πfct)

In above Equation, the modulating signal [vm(t)] is a normalized binary waveform, where + 1 V = logic 1 and -1 V = logic 0. Therefore, for a logic 1 input, vm(t) = + 1 V, Equation 2.12 reduces to

$$v_{(ask)}(t) = [1 + 1]\left[\frac{A}{2}\cos(\omega_c t)\right]$$

$$= A\cos(\omega_c t)$$

Mathematically, amplitude-shift keying is (2.12) where vask(t) = amplitude-shift keying wave vm(t) = digital information (modulating) signal (volts) A/2 = unmodulated carrier amplitude (volts) ωc= analog carrier radian frequency (radians per second, 2πfct) In Equation 2.12, the modulating signal [vm(t)] is a normalized binary waveform, where + 1 V = logic 1 and -1 V = logic 0. Therefore, for a logic 1 input, vm(t) = + 1 V, Equation 2.12 reduces to and for a logic 0 input, vm(t) = -1 V,Equation reduces to

$$v_{(ask)}(t) = [1 - 1]\left[\frac{A}{2}\cos(\omega_c t)\right]$$

Thus, the modulated wave vask(t),is either A cos(ωct) or 0. Hence, the carrier is either "on "or "off," which is why amplitude-shift keying is sometimes referred to as on-off keying (OOK).
it can be seen that for every change in the input binary data stream, there is one change in the ASK waveform, and the time of one bit (tb) equals the time of one analog signaling element (t,).
B = fb/1 = fb   baud = fb/1 = fb

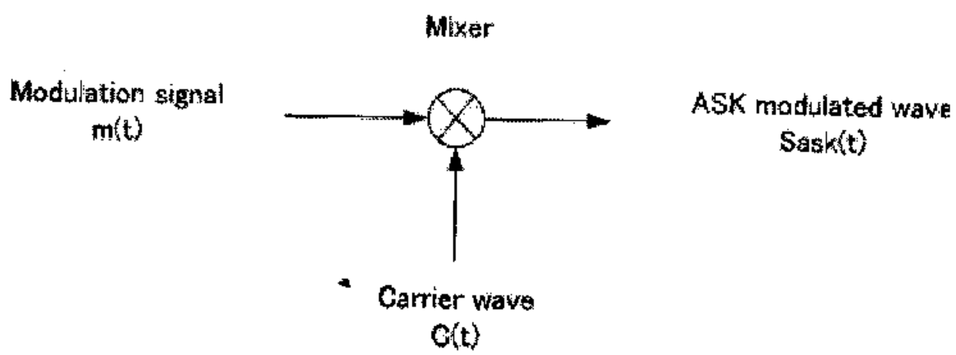
Example :

Determine the baud and minimum bandwidth necessary to pass a 10 kbps binary signal using amplitude shift keying. 10Solution For ASK, N = 1, and the baud and minimum bandwidth are determined from Equations 2.11 and 2.10, respectively:

$$B = 10{,}000 / 1 = 10{,}000$$
$$\text{baud} = 10{,}000 / 1 = 10{,}000$$

The use of amplitude-modulated analog carriers to transport digital information is a relatively low-quality, low-cost type of digital modulation and, therefore, is seldom used except for very low-speed telemetry circuits.

ASK TRANSMITTER:



The input binary sequence is applied to the product modulator. The product modulator amplitude modulates the sinusoidal carrier .it passes the carrier when input bit is '1' .it blocks the carrier when input bit is '0.'

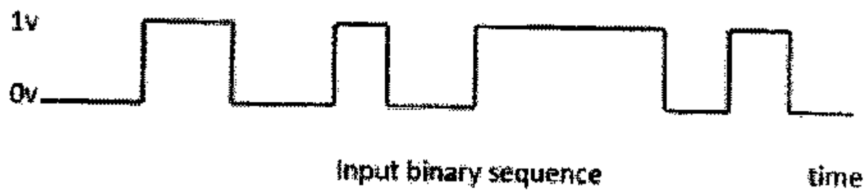
Coherent ASK DETECTOR:

FREQUENCYSHIFT KEYING

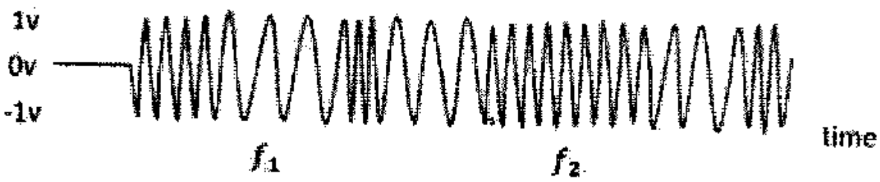
The frequency of the output signal will be either high or low, depending upon the input data applied.

Frequency Shift Keying (FSK) is the digital modulation technique in which the frequency of the carrier signal varies according to the discrete digital changes. FSK is a scheme of frequency modulation.

Following is the diagram for FSK modulated waveform along with its input.



Input binary sequence



FSK Modulated output wave

The output of a FSK modulated wave is high in frequency for a binary HIGH input and is low in frequency for a binary LOW input. The binary 1s and 0s are called **Mark** and **Space frequencies**.

FSK is a form of constant-amplitude angle modulation similar to standard frequency modulation (FM) except the modulating signal is a binary signal that varies between two discrete voltage levels rather than a continuously changing analog waveform.Consequently, FSK is sometimes called *binary FSK* (BFSK). The general expression for FSK is where $$v_{fsk}(t) = V_c \cos[2\pi[f_c + v_m(t)\,\Delta f]t]$$

$v_{fsk}(t)$ = binary FSK waveform

V_c = peak analog carrier amplitude (volts)

f_c = analog carrier center frequency (hertz)

f=peak change (shift)in the analog carrier frequency(hertz)

$v_m(t)$ = binary input (modulating) signal (volts)

From Equation 2.13, it can be seen that the peak shift in the carrier frequency (f) is proportional to the amplitude of the binary input signal ($v_m[t]$), and the direction of the shift is determined by the polarity.

The modulating signal is a normalized binary waveform where a logic 1 = + 1 V and a logic 0 = -1 V. Thus, for a logic 1 input, $v_m(t)$ = + 1, Equation 2.13 can be rewritten as

$$v_{fsk}(t) = V_c \cos[2\pi(f_c + \Delta f)t]$$

For a logic 0 input, $v_m(t)$ = -1, Equation becomes

$$v_{fsk}(t) = V_c \cos[2\pi(f_c - \Delta f)t]$$

With binary FSK, the carrier center frequency (f_c) is shifted (deviated) up and down in the frequency domain by the binary input signal as shown in Figure 2-3.

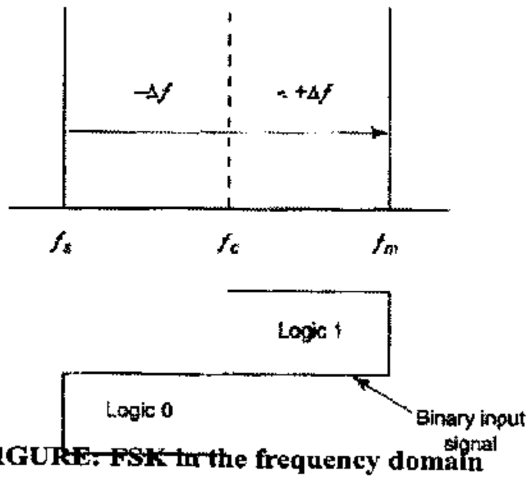


FIGURE: ~~FSK in~~ the frequency domain

As the binary input signal changes from a logic 0 to a logic 1 and vice versa, the output frequency shifts between two frequencies: a mark, or logic 1 frequency (f_m), and a space, or logic 0 frequency (f_s). The mark and space frequencies are separated from the carrier frequency by the peak frequency deviation (f) and from each other by 2 f.

Frequency deviation is illustrated in Figure 2-3 and expressed mathematically as

$$f = |f_m - f_s| / 2 \qquad (2.14)$$

where f = frequency deviation (hertz)

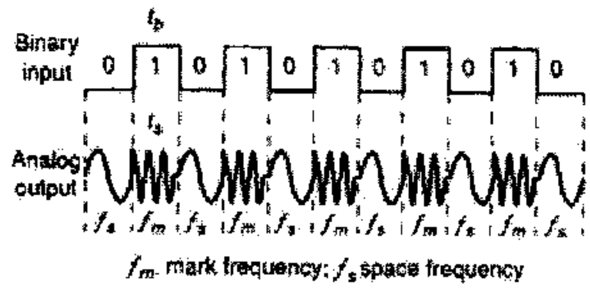
$|f_m - f_s|$ = absolute difference between the mark and space frequencies (hertz)

Figure 2-4a shows in the time domain the binary input to an FSK modulator and the corresponding FSK output.

When the binary input *(f_b)* changes from a logic 1 to a logic 0 and vice versa, the FSK output frequency shifts from a mark (f_m) to a space (f_s) frequency and vice versa.

In Figure 2-4a, the mark frequency is the higher frequency *(f_c* + f) and the space frequency is the lower frequency (f_c - f), although this relationship could be just the opposite.

Figure 2-4b shows the truth table for a binary FSK modulator. The truth table shows the input and output possibilities for a given digital modulation scheme.



(a)

binary input	frequency output
0	space (f_s)
1	mark (f_m)

(b)

FIGURE 2-4 FSK in the time domain: (a) waveform: (b) truth table

FSK Bit Rate, Baud, and Bandwidth

In Figure 2-4a, it can be seen that the time of one bit *(t_b)* is the same as the time the FSK output is a mark of space frequency *(t_s)*. Thus, the bit time equals the time of an FSK signaling element, and the bit rate equals the baud.

The baud for binary FSK can also be determined by substituting N = 1 in Equation 2.11:

baud = $f_b / 1 = f_b$

The minimum bandwidth for FSK is given as

$$B= |(f_s - f_b) - (f_m - f_b)|$$

$$=|(f_s - f_m)| + 2f_b$$

and since $|(f_s - f_m)|$ equals 2 f, the minimum bandwidth can be approximated as

$$B= 2(f + f_b) \qquad (2.15)$$

where

B= minimum Nyquist bandwidth (hertz)

f= frequency deviation $|(f_m - f_s)|$ (hertz)

f_b = input bit rate (bps)

Example 2-2

Determine (a) the peak frequency deviation, (b) minimum bandwidth, and (c) baud for a binary FSK signal with a mark frequency of 49 kHz, a space frequency of 51 kHz, and an input bit rate of 2 kbps.

Solution

a. The peak frequency deviation is determined from Equation 2.14:

$$f= |149\text{kHz} - 51\text{ kHz}| / 2 =1\text{ kHz}$$

b. The minimum bandwidth is determined from Equation 2.15:

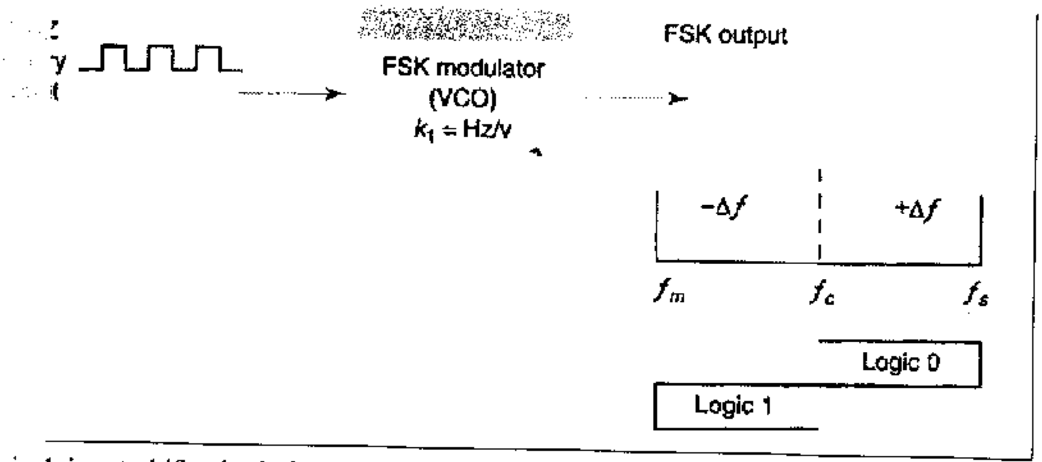
$$B = 2(100+ 2000)$$
$$=6\text{ kHz}$$

c. For FSK, $N = 1$, and the baud is determined from Equation 2.11 as

$$\text{baud} = 2000 / 1 = 2000$$

FSK TRANSMITTER:

Figure 2-6 shows a simplified binary FSK modulator, which is very similar to a conventional FM modulator and is very often a voltage-controlled oscillator (VCO).The center frequency (f_c) is chosen such that it falls halfway between the mark and space frequencies.



A logic 1 input shifts the VCO output to the mark frequency, and a logic 0 input shifts the VCO output to the space frequency. Consequently, as the binary input signal changes back and forth between logic 1 and logic 0 conditions, the VCO output shifts or deviates back and forth between the mark and space frequencies.

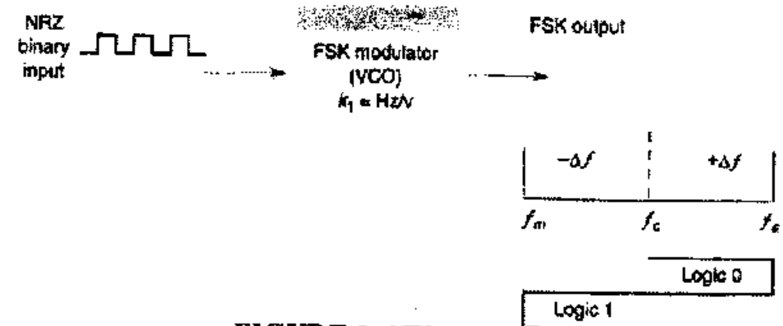


FIGURE 2-6 FSK modulator

A VCO-FSK modulator can be operated in the sweep mode where the peak frequency deviation is simply the product of the binary input voltage and the deviation sensitivity of the VCO.

With the sweep mode of modulation, the frequency deviation is expressed mathematically as

$$f = v_m(t)k_l \qquad (2\text{-}19)$$

$v_m(t)$ = peak binary modulating-signal voltage (volts)

k_l = deviation sensitivity (hertz per volt).

FSK Receiver

FSK demodulation is quite simple with a circuit such as the one shown in Figure 2-7.

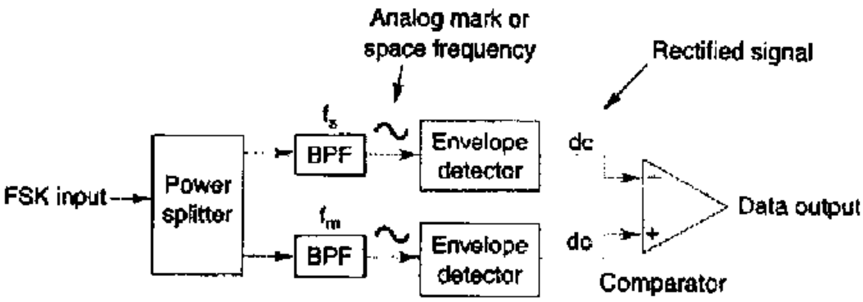


FIGURE 2-7 Noncoherent FSK demodulator

The FSK input signal is simultaneously applied to the inputs of both bandpass filters (BPFs) through a power splitter.The respective filter passes only the mark or only the space frequency on to its respective envelope detector.The envelope detectors, in turn, indicate the total power in each passband, and the comparator responds to the largest of the two powers.This type of FSK detection is referred to as noncoherent detection.

Figure 2-8 shows the block diagram for a coherent FSK receiver.The incoming FSK signal is multiplied by a recovered carrier signal that has the exact same frequency and phase as the transmitter reference.

However, the two transmitted frequencies (the mark and space frequencies) are not generally continuous; it is not practical to reproduce a local reference that is coherent with both of them. Consequently, coherent FSK detection is seldom used.

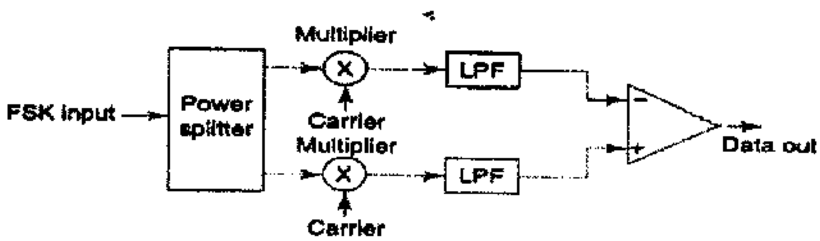
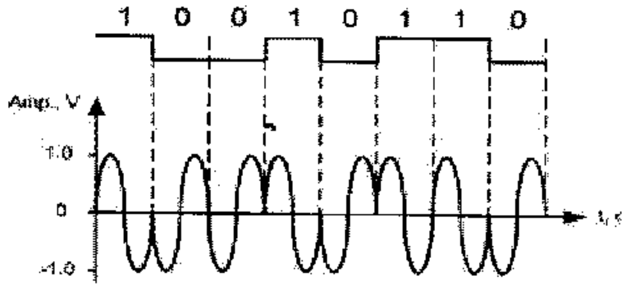


FIGURE 2-8 Coherent FSK demodulator

PHASESHIFT KEYING:

The phase of the output signal gets shifted depending upon the input. These are mainly of two types, namely BPSK and QPSK, according to the number of phase shifts. The other one is DPSK which changes the phase according to the previous value.



Phase shift keying (PSK)

Phase Shift Keying (PSK) is the digital modulation technique in which the phase of the carrier signal is changed by varying the sine and cosine inputs at a particular time. PSK technique is widely used for wireless LANs, bio-metric, contactless operations, along with RFID and Bluetooth communications.

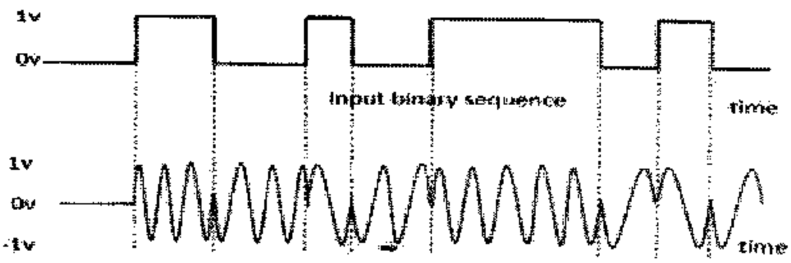
PSK is of two types, depending upon the phases the signal gets shifted. They are –

Binary Phase Shift Keying (BPSK)

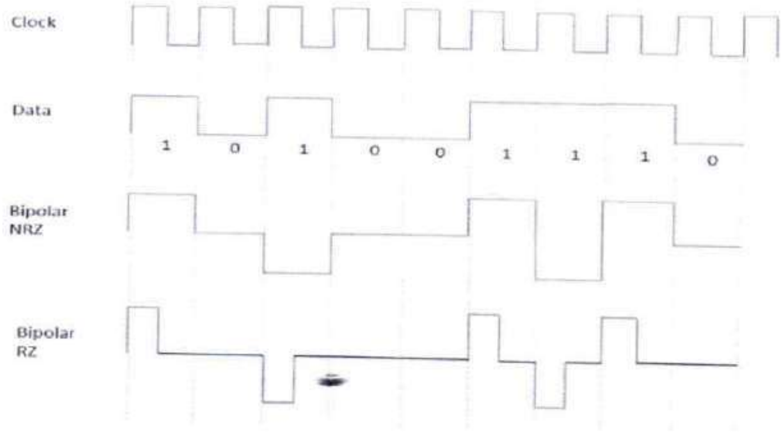
This is also called as **2-phase PSK (or) Phase Reversal Keying**. In this technique, the sine wave carrier takes two phase reversals such as 0° and 180°.

BPSK is basically a DSB-SC (Double Sideband Suppressed Carrier) modulation scheme, for message being the digital information.

Following is the image of BPSK Modulated output wave along with its input.



BPSK Modulated output wave



The above figure has both the Bipolar NRZ and RZ waveforms. The pulse duration and symbol bit duration are equal in NRZ type, while the pulse duration is half of the symbol bit duration in RZ type.

Advantages

Following are the advantages

- It is simple.
- No low-frequency components are present.
- Occupies low bandwidth than unipolar and polar NRZ schemes.
- This technique is suitable for transmission over AC coupled lines, as signal drooping doesn't occur here.
- A single error detection capability is present in this.

Disadvantages

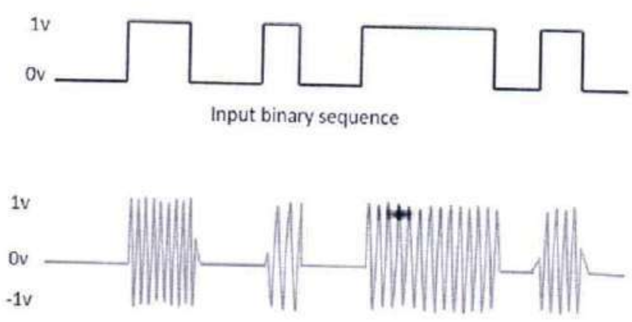
Following are the disadvantages

- No clock is present.
- Long strings of data cause loss of synchronization.

II Unit: Digital signal modulation schemes

Amplitude Shift Keying ASK is a type of Amplitude Modulation which represents the binary data in the form of variations in the amplitude of a signal.

Any modulated signal has a high frequency carrier. The binary signal when ASK modulated, gives a **zero** value for **Low** input while it gives the **carrier output** for **High** input. The following figure represents ASK modulated waveform along with its input.



ASK Modulated output wave

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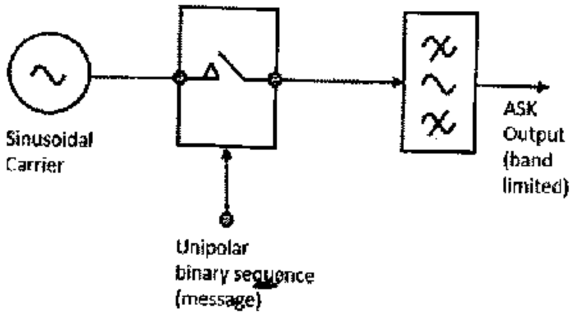
PULLADIGUNTA, GUNTUR-17

ASK Modulator

The ASK modulator block diagram comprises of the carrier signal generator, the binary sequence from the message signal and the band-limited filter. Following is the block diagram of the ASK Modulator.

ASK Generation method



The carrier generator, sends a continuous high-frequency carrier. The binary sequence from the message signal makes the unipolar input to be either High or Low. The high signal closes the switch, allowing a carrier wave. Hence, the output will be the carrier signal at high input. When there is low input, the switch opens, allowing no voltage to appear. Hence, the output will be low.

The band-limiting filter shapes the pulse depending upon the amplitude and phase characteristics of the band-limiting filter or the pulse-shaping filter.

ASK Demodulator

There are two types of ASK Demodulation techniques. They are,

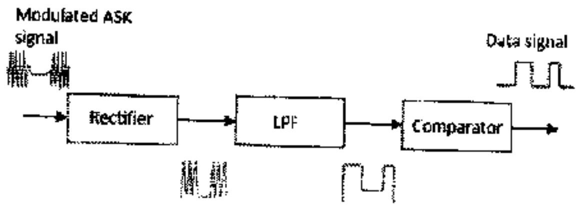
- Asynchronous ASK Demodulation/detection

Synchronous ASK Demodulation/detection and Asynchronous ASK Demodulator

The clock frequency at the transmitter when matches with the clock frequency at the receiver, it is known as a **Synchronous method**, as the frequency gets synchronized. Otherwise, it is known as **Asynchronous.**

Asynchronous ASK Demodulator

The Asynchronous ASK detector consists of a half-wave rectifier, a low pass filter, and a comparator. Following is the block diagram for the same.

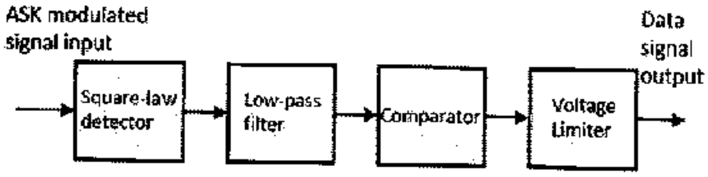


Asynchronous ASK detector

The modulated ASK signal is given to the half-wave rectifier, which delivers a positive half output. The low pass filter suppresses the higher frequencies and gives an envelope detected output from which the comparator delivers a digital output.

Synchronous ASK Demodulator

Synchronous ASK detector consists of a Square law detector, low pass filter, a comparator, and a voltage limiter. Following is the block diagram for the same.

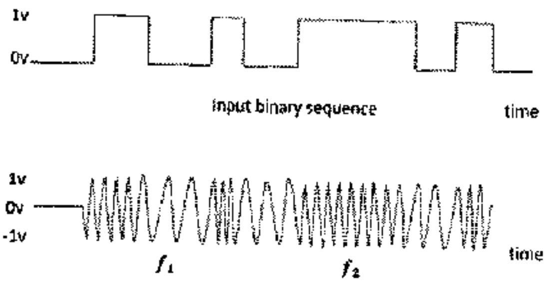


Synchronous ASK detector

The ASK modulated input signal is given to the Square law detector. A square law detector is one whose output voltage is proportional to the square of the amplitude modulated input voltage. The low pass filter minimizes the higher frequencies. The comparator and the voltage limiter help to get a clean digital output.

Frequency Shift Keying FSK is the digital modulation technique in which the frequency of the carrier signal varies according to the digital signal changes. FSK is a scheme of frequency modulation.

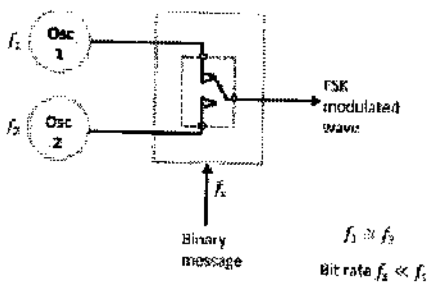
The output of a FSK modulated wave is high in frequency for a binary High input and is low in frequency for a binary Low input. The binary **1s** and **0s** are called Mark and Space frequencies. The following image is the diagrammatic representation of FSK modulated waveform along with its input.



FSK Modulated output wave

FSK Modulator

The FSK modulator block diagram comprises of two oscillators with a clock and the input binary sequence. Following is its block diagram.



The two oscillators, producing a higher and a lower frequency signals, are connected to a switch along with an internal clock. To avoid the abrupt phase discontinuities of the output waveform during the transmission of the message, a clock is applied to both the oscillators, internally. The binary input sequence is applied to the transmitter so as to choose the frequencies according to the binary input.

FSK Demodulator

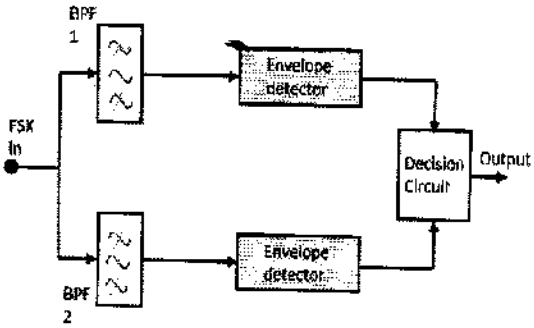
There are different methods for demodulating a FSK wave. The main methods of FSK detection are **asynchronous detector** and **synchronous detector**. The synchronous detector is a coherent one, while asynchronous detector is a non-coherent one.

Asynchronous FSK Detector

The block diagram of Asynchronous FSK detector consists of two band pass filters, two envelope detectors, and a decision circuit. Following is the diagrammatic representation.

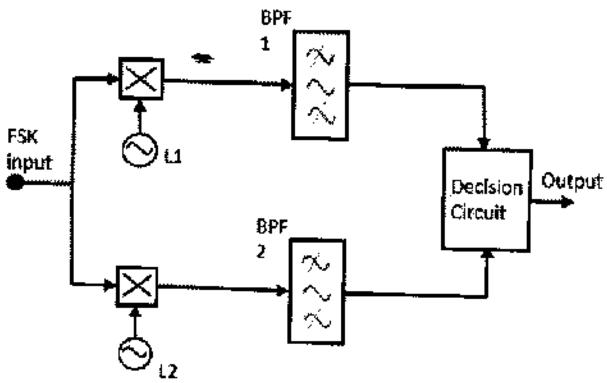
The FSK signal is passed through the two Band Pass Filters *BPFs*, tuned to **Space** and **Mark** frequencies. The output from these two BPFs look like ASK signal, which is given to the envelope detector. The signal in each envelope detector is modulated asynchronously.

The decision circuit chooses which output is more likely and selects it from any one of the envelope detectors. It also re-shapes the waveform to a rectangular one.



Synchronous FSK Detector

The block diagram of Synchronous FSK detector consists of two mixers with local oscillator circuits, two band pass filters and a decision circuit. Following is the diagrammatic representation.



The FSK signal input is given to the two mixers with local oscillator circuits. These two are connected to two band pass filters. These combinations act as demodulators and the decision circuit chooses which output is more likely and selects it from any one of the detectors. The two signals have a minimum frequency separation.

For both of the demodulators, the bandwidth of each of them depends on their bit rate. This synchronous demodulator is a bit complex than asynchronous type demodulators.

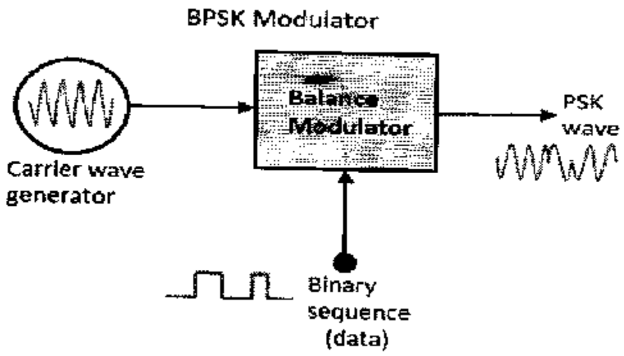
Phase Shift Keying *PSK* is the digital modulation technique in which the phase of the carrier signal is changed by varying the sine and cosine inputs at a particular time. PSK technique is widely used for wireless LANs, bio-metric, contactless operations, along with RFID and Bluetooth communications. PSK is of two types, depending upon the phases the signal gets shifted. They are,

Binary Phase Shift Keying *BPSK*

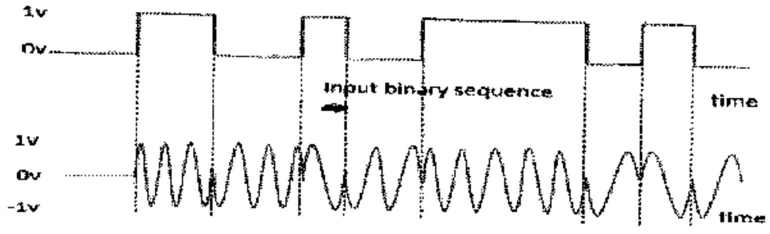
This is also called as 2-phase PSK or Phase Reversal Keying. In this technique, the sine wave carrier takes two phase reversals such as 0° and 180°. BPSK is basically a Double Side Band Suppressed Carrier DSBSC modulation scheme, for message being the digital information.

Quadrature Phase Shift Keying *QPSK* This is the phase shift keying technique, in which the sine wave carrier takes four phase reversals such as 0°, 90°, 180°, and 270°. If these kinds of techniques are further extended, PSK can be done by eight or sixteen values also, depending upon the requirement.

BPSK Modulator : The block diagram of Binary Phase Shift Keying consists of the balance modulator which has the carrier sine wave as one input and the binary sequence as the other input. Following is the diagrammatic representation.



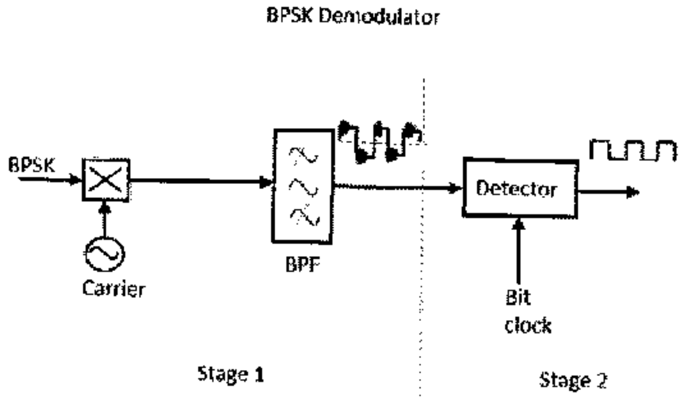
The modulation of BPSK is done using a balance modulator, which multiplies the two signals applied at the input. For a zero binary input, the phase will be **0°** and for a high input, the phase reversal is of **180°**.



BPSK Modulated output wave

The output sine wave of the modulator will be the direct input carrier or the inverted 180° phase shifted input carrier, which is a function of the data signal.

BPSK Demodulator The block diagram of BPSK demodulator consists of a mixer with local oscillator circuit, a bandpass filter, a two-input detector circuit. The diagram is as follows.



By recovering the band-limited message signal, with the help of the mixer circuit and the band pass filter, the first stage of demodulation gets completed. The base band signal which is band limited is obtained and this signal is used to regenerate the binary message bit stream.

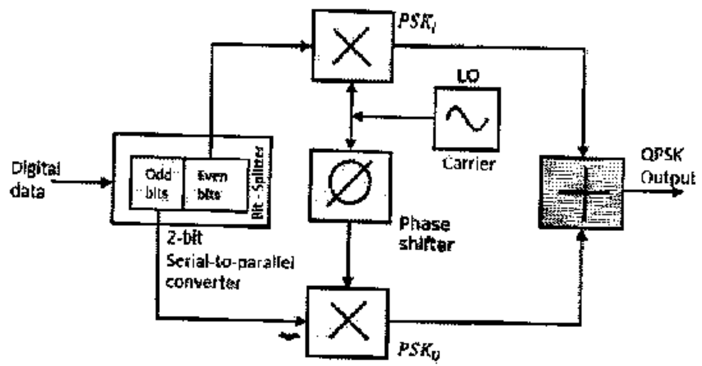
In the next stage of demodulation, the bit clock rate is needed at the detector circuit to produce the original binary message signal. If the bit rate is a sub-multiple of the carrier frequency, then the bit clock regeneration is simplified. To make the circuit easily understandable, a decision-making circuit may also be inserted at the 2nd stage of detection.

The **Quadrature Phase Shift Keying** QPSK is a variation of BPSK, and it is also a Double Side Band Suppressed Carrier DSBSC modulation scheme, which sends two bits of digital information at a time, called as **bigits.**

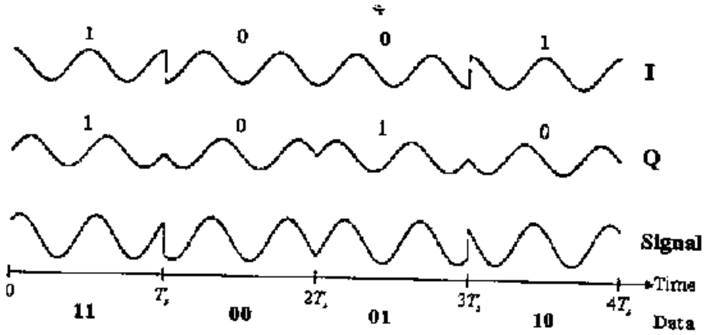
Instead of the conversion of digital bits into a series of digital stream, it converts them into bit pairs. This decreases the data bit rate to half, which allows space for the other users.

QPSK Modulator

The QPSK Modulator uses a bit-splitter, two multipliers with local oscillator, a 2-bit serial to parallel converter, and a summer circuit. Following is the block diagram for the same.

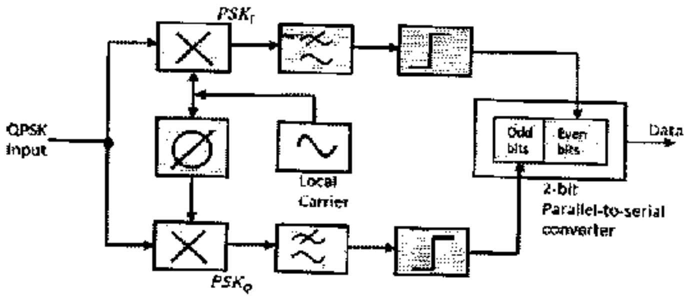


At the modulator's input, the message signal's even bits (i.e., 2nd bit, 4th bit, 6th bit, etc.) and odd bits (i.e., 1st bit, 3rd bit, 5th bit, etc.) are separated by the bits splitter and are multiplied with the same carrier to generate odd BPSK (called as **PSK_I**) and even BPSK (called as **PSK_Q**). The **PSK_Q** signal is anyhow phase shifted by 90° before being modulated. The QPSK waveform for two-bits input is as follows, which shows the modulated result for different instances of binary inputs.



QPSK Demodulator

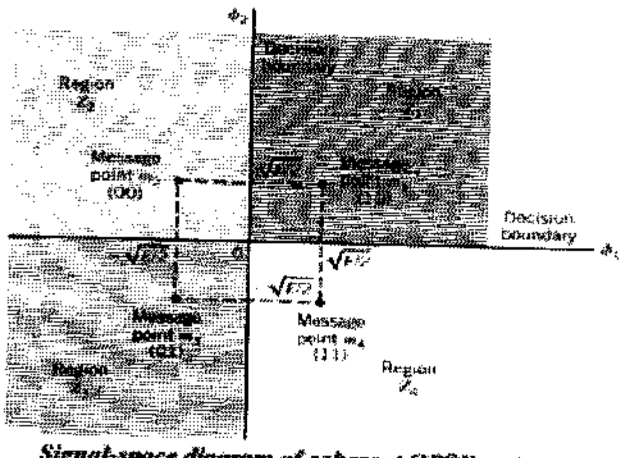
The QPSK Demodulator uses two product demodulator circuits with local oscillator, two band pass filters, two integrator circuits, and a 2-bit parallel to serial converter. Following is the diagram for the same.



The two product detectors at the input of demodulator simultaneously demodulate the two BPSK signals. The pair of bits is recovered here from the original data. These signals after processing, are passed to the parallel to serial converter.

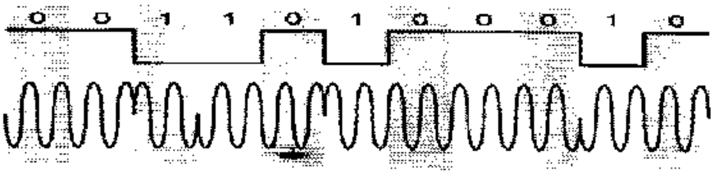
Quadriphase - Shift Keying (QPSK)

$$S_i(t) = \begin{cases} \sqrt{\dfrac{2E}{T}} \cos\left[2\pi f_c t + (2i-1)\dfrac{\pi}{4}\right], 0 \le t \le T & i = 1,2,3,4 \\ 0 \quad , \text{ elsewhere} \end{cases}$$



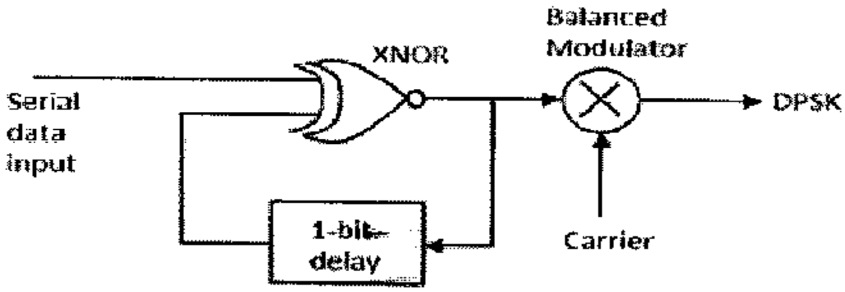
Signal-space diagram of coherent QPSK system.

Differential Phase Shift Keying DPSK: Here the phase of the modulated signal is shifted relative to the previous signal element. No reference signal is considered here. The signal phase follows the high or low state of the previous element. This DPSK technique doesn't need a reference oscillator. The following figure represents the model waveform of DPSK.



It is seen from the above figure that, if the data bit is Low i.e., 0, then the phase of the signal is not reversed, but continued as it was. If the data is a High i.e., 1, then the phase of the signal is reversed, as with NRZI, invert on 1 a form of differential encoding. If we observe the above waveform, we can say that the High state represents an M in the modulating signal and the Low state represents a W in the modulating signal.

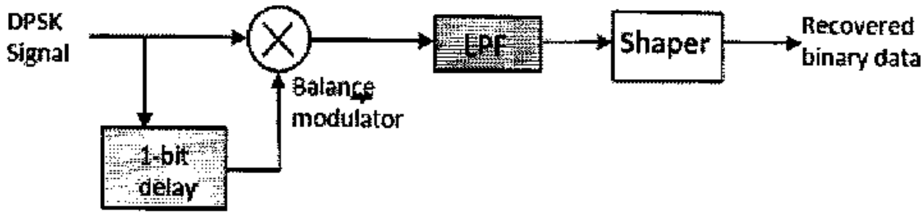
DPSK Modulator: DPSK is a technique of BPSK, in which there is no reference phase signal. Here, the transmitted signal itself can be used as a reference signal. Following is the diagram of DPSK Modulator.



DPSK Modulator

DPSK encodes two distinct signals, i.e., the carrier and the modulating signal with 180° phase shift each. The serial data input is given to the XNOR gate and the output is again fed back to the other input through 1-bit delay. The output of the XNOR gate along with the carrier signal is given to the balance modulator, to produce the DPSK modulated signal.

DPSK Demodulator: In DPSK demodulator, the phase of the reversed bit is compared with the phase of the previous bit. Following is the block diagram of DPSK demodulator.



From the above figure, it is evident that the balance modulator is given the DPSK signal along with 1-bit delay input. That signal is made to confine to lower frequencies with the help of LPF. Then it is passed to a shaper circuit, which is a comparator or a Schmitt trigger circuit, to recover the original binary data as the output.

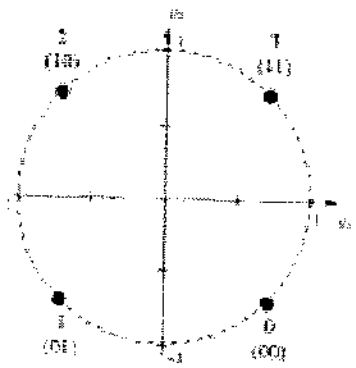
M-ary PSK: This scheme the data bits select one of the M phase versions of the carrier.

$M = 2^n$, where $n = \{1,2,3\ldots\ldots M\}$

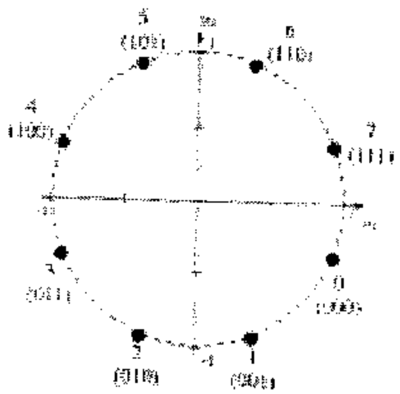
$$S_i(t) = \sqrt{\frac{2E}{T}}\cos(2\pi ft + \emptyset_i) \text{ for } \quad 0 < t \leq T, \quad \emptyset_i(t) = \frac{2\pi(i-1)}{M} \quad \text{and} \quad i = 1,2,3,..M$$

Some features of M-ary PSK are –

- The envelope is constant with more phase possibilities.
- This method was used during the early days of space communication.
- Better performance than ASK and FSK.
- Minimal phase estimation error at the receiver.
- The bandwidth efficiency of M-ary PSK decreases and the power efficiency increases with the increase in **M**.



4-PSK

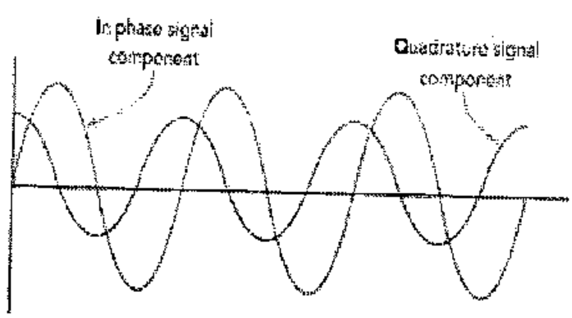


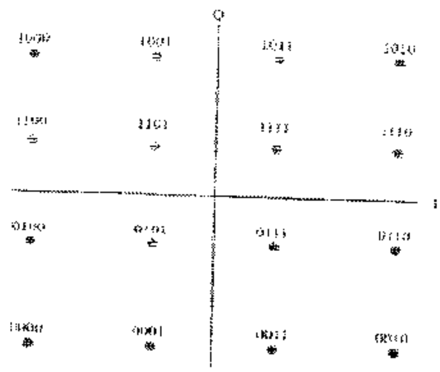
8-PSK

Quadrature Amplitude Modulation (QAM)

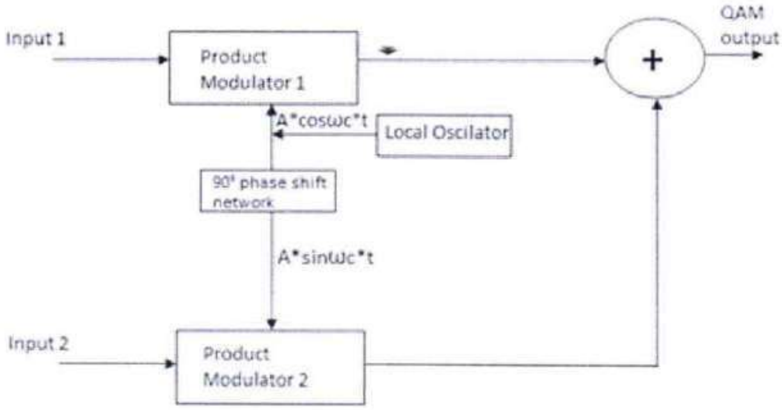
QAM utilizes both amplitude and phase components to provide a form of modulation that is able to provide high levels of spectrum usage efficiency. QAM is a signal in which two carriers shifted in phase by 90 degrees (i.e. sine and cosine) are modulated and combined. As a result of their 90° phase difference they are in quadrature and this gives rise to the name. Often one signal is called the In-phase or "I" signal, and the other is the quadrature or "Q" signal.

The resultant overall signal consisting of the combination of both I and Q carriers contains of both amplitude and phase variations. In view of the fact that both amplitude and phase variations are present it may also be considered as a mixture of amplitude and phase modulation.





I = A cos(2πf$_c$t)   and   Q = A sin(2πf$_c$t)



Bit Error Rate (BER)

Bit error rate can be defined as the ratio of total number of error bit to the total number of transmitted bit. It is very essential way to govern the transmission superiority. It is often expressed as a percentage.

$$BER = \frac{\text{Total number of error bits}}{\text{Total number of transmitted bits}}$$

As an example, let the transmitted bit sequence: 0 1 0 1 0 0 0 1 1 0

And the following received bit sequence: 0 1 **1** 1 0 **1** 0 **0** 1 **1**

In this case the number of bit errors is 4. BER= 0.4 × 100% =40% error

Bit Error Rate (BER) in BPSK

$$P_b = Q\left(\sqrt{\frac{2E_b}{N_0}}\right) \quad or \quad P_e = \frac{1}{2}\; erfc\left(\sqrt{\frac{E_b}{N_0}}\right)$$

UNIT-1

Digital Pulse Modulation

Elements of Digital Communication Systems:

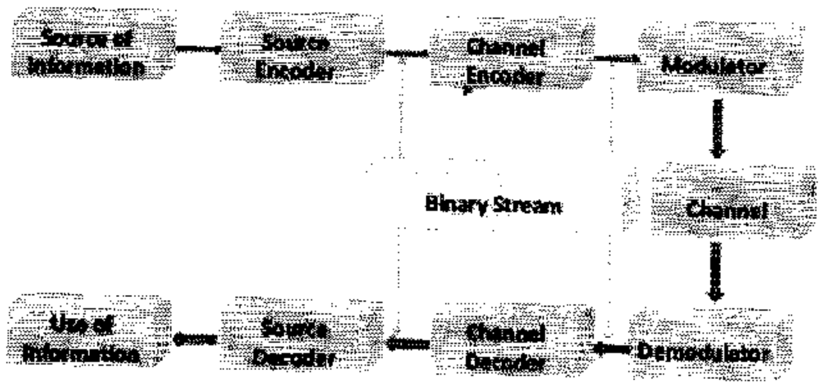


Fig. 1 Elements of Digital Communication Systems

1. **Information Source and Input Transducer:**

   The source of information can be analog or digital, e.g. analog: audio or video signal, digital: like teletype signal. In digital communication the signal produced by this source is converted into digital signal which consists of 1's and 0's. For this we need a source encoder.

2. **Source Encoder:**

   In digital communication we convert the signal from source into digital signal as mentioned above. The point to remember is we should like to use as few binary digits as possible to represent the signal. In such a way this efficient representation of the source output results in little or no redundancy. This sequence of binary digits is called ***Information sequence.***

   Source Encoding or Data Compression: the process of efficiently converting the output of whether analog or digital source into a sequence of binary digits is known as source encoding.

3. **Channel Encoder:**

    The information sequence is passed through the channel encoder. The purpose of the channel encoder is to introduce, in controlled manner, some redundancy in the binary information sequence that can be used at the receiver to overcome the effects of noise and interference encountered in the transmission on the signal through the channel.

    For example take k bits of the information sequence and map that k bits to unique n bit sequence called code word. The amount of redundancy introduced is measured by the ratio *n/k* and the reciprocal of this ratio (k/n) is known as *rate of code or code rate.*

4. **Digital Modulator:**

    The binary sequence is passed to digital modulator which in turns convert the sequence into electric signals so that we can transmit them on channel (we will see channel later). The digital modulator maps the binary sequences into signal wave forms , for example if we represent 1 by sin x and 0 by cos x then we will transmit sin x for 1 and cos x for 0. (a case similar to BPSK)

5. **Channel:**

    The communication channel is the physical medium that is used for transmitting signals from transmitter to receiver. In wireless system, this channel consists of atmosphere , for traditional telephony, this channel is wired , there are optical channels, under water acoustic channels etc.We further discriminate this channels on the basis of their property and characteristics, like AWGN channel etc.

6. **Digital Demodulator:**

    The digital demodulator processes the channel corrupted transmitted waveform and reduces the waveform to the sequence of numbers that represents estimates of the transmitted data symbols.

7. **Channel Decoder:**

    This sequence of numbers then passed through the channel decoder which attempts to reconstruct the original information sequence from the knowledge of the code used by the channel encoder and the redundancy contained in the received data

Note: The average probability of a bit error at the output of the decoder is a measure of the performance of the demodulator – decoder combination.

8. **Source Decoder:**

    At the end, if an analog signal is desired then source decoder tries to decode the sequence from the knowledge of the encoding algorithm. And which results in the approximate replica of the input at the transmitter end.

9. **Output Transducer:**

Finally we get the desired signal in desired format analog or digital.

Advantages of digital communication:

- **Can withstand channel noise and distortion much better as long as the noise and the distortion are within limits.**
- **Regenerative repeaters prevent accumulation of noise along the path.**
- **Digital hardware implementation is flexible.**
- **Digital signals can be coded to yield extremely low error rates, high fidelity and well as privacy.**
- **Digital communication is inherently more efficient than analog in realizing the exchange of SNR for bandwidth.**
- **It is easier and more efficient to multiplex several digital signals.**
- **Digital signal storage is relatively easy and inexpensive.**
- **Reproduction with digital messages is extremely reliable without deterioration.**
- **The cost of digital hardware continues to halve every two or three years, while performance or capacity doubles over the same time period.**

Disadvantages

- **TDM digital transmission is not compatible with the FDM**
- **A Digital system requires large bandwidth.**

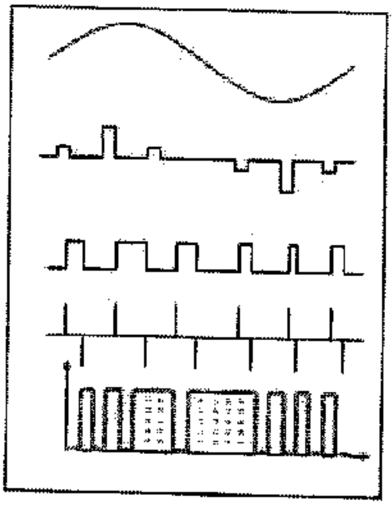
Introduction to Pulse Modulation

What is the need for Pulse Modulation?

- Many Signals in Modern Communication Systems are digital
- Also, analog signals are transmitted digitally.
- Reduced distortion and improvement in signal to noise ratios.
- PAM, PWM, PPM, PCM and DM.
- In CW modulation schemes some parameter of modulated wave varies continuously with message.
- In Analog pulse modulation some parameter of each pulse is modulated by a particular sample value of the message.
- Pulse modulation is of two types
  - Analog Pulse Modulation
    - Pulse Amplitude Modulation (PAM)
    - Pulse width Modulation (PWM)
    - Pulse Position Modulation (PPM)
  - Digital Pulse Modulation
    - Pulse code Modulation (PCM)
    - Delta Modulation (DM)

PULSE MODULATION

- **Pulse Amplitude Modulation**
- **Pulse Width Modulation**
- **Pulse Position Modulation**
- **Pulse Code Modulation**
- **Delta Modulation**



Pulse Code Modulation:

Three steps involved in conversion of analog signal to digital signal

- Sampling
- Quantization
- Binary encoding

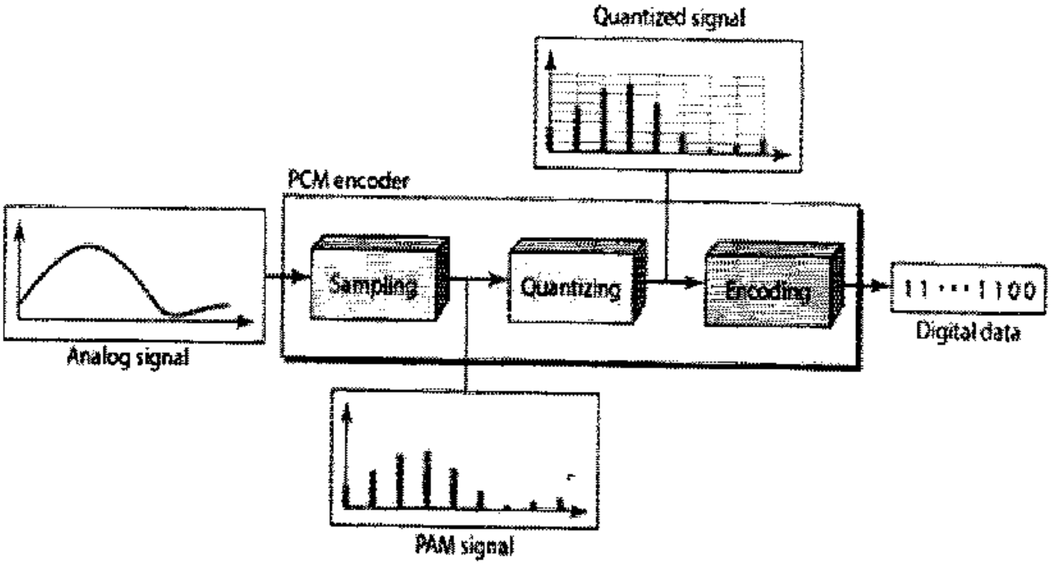


Fig. 2 Conversion of Analog Signal to Digital Signal

Note: Before sampling the signal is filtered to limit bandwidth.

Elements of PCM System:

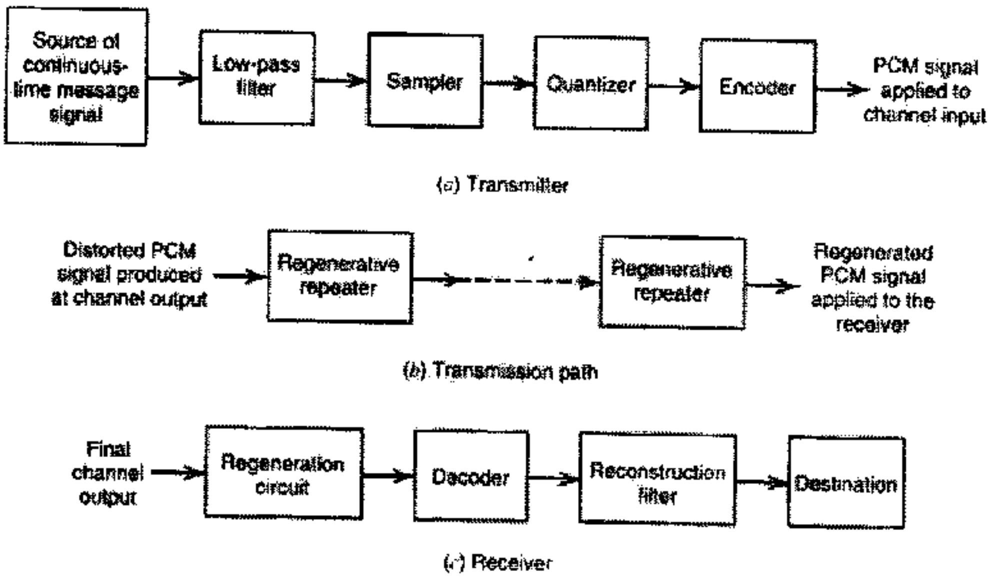


Fig. 3 Elements of PCM System

Sampling:

- Process of converting analog signal into discrete signal.
- Sampling is common in all pulse modulation techniques

- The signal is sampled at regular intervals such that each sample is proportional to amplitude of signal at that instant
- Analog signal is sampled every $T_s\,Secs$, called sampling interval. f_s=1/T_s is called sampling rate or sampling frequency.
- f_s=2f_m is Min. sampling rate called **Nyquist rate.** Sampled spectrum (ω) is repeating periodically without overlapping.
- Original spectrum is centered at ω=0 and having bandwidth of ω_m. Spectrum can be recovered by passing through low pass filter with cut-off ω_m.
- For f_s<2f_m sampled spectrum will overlap and cannot be recovered back. This is called **aliasing.**

Sampling methods:

- Ideal – An impulse at each sampling instant.
- Natural – A pulse of Short width with varying amplitude.
- Flat Top – Uses sample and hold, like natural but with single amplitude value.

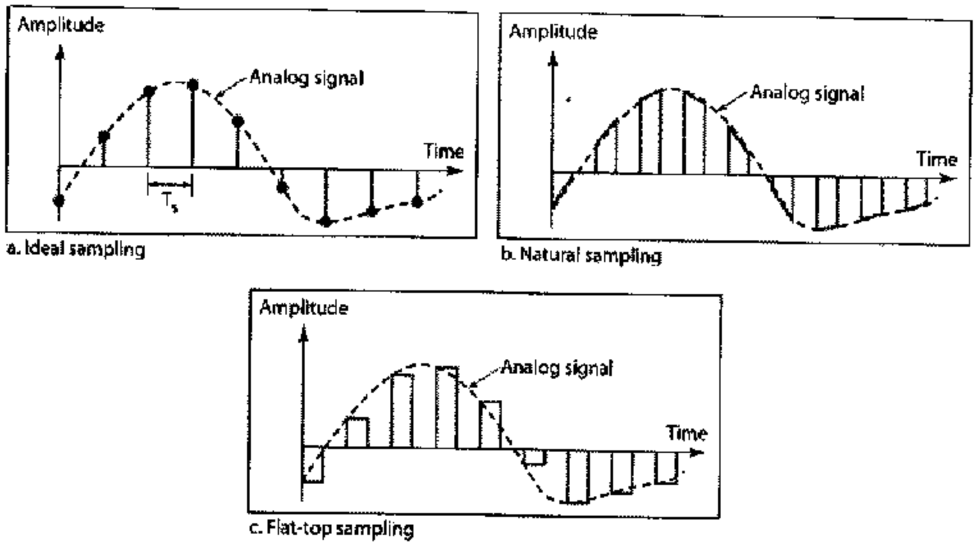


Fig. 4 Types of Sampling

Sampling of band-pass Signals:

- A band-pass signal of bandwidth 2f_m can be completely recovered from its samples.

  Min. sampling rate =2×$Bandwidth$

  =2×2f_m=4f_m

- Range of minimum sampling frequencies is in the range of 2×BW to 4×BW

Instantaneous Sampling or Impulse Sampling:

- Sampling function is train of spectrum remains constant impulses throughout frequency range. It is not practical.

Natural sampling:

- The spectrum is weighted by a **sinc** function.
- Amplitude of high frequency components reduces.

Flat top sampling:

- Here top of the samples remains constant.
- In the spectrum high frequency components are attenuated due sinc pulse roll off. This is known as **Aperture effect.**
- If pulse width increases aperture effect is more i.e. more attenuation of high frequency components.

Sampling Theorem:

Statement of sampling theorem

> 1) ***A band limited signal of finite energy, which has no frequency components higher than W Hertz, is completely described by specifying the values of the signal at instants of time separated by $\frac{1}{2W}$ seconds and***
>
> 2) ***A band limited signal of finite energy, which has no frequency components higher than W Hertz, may be completely recovered from the knowledge of its samples taken at the rate of 2W samples per second.***

The first part of above statement tells about sampling of the signal and second part tells about reconstruction of the signal. Above statement can be combined and stated alternately as follows :

A continuous time signal can be completely represented in its samples and recovered back if the sampling frequency is twice of the highest frequency content of the signal. i.e.,

$$f_s \geq 2W$$

Here f_s is the sampling frequency and

W is the higher frequency content

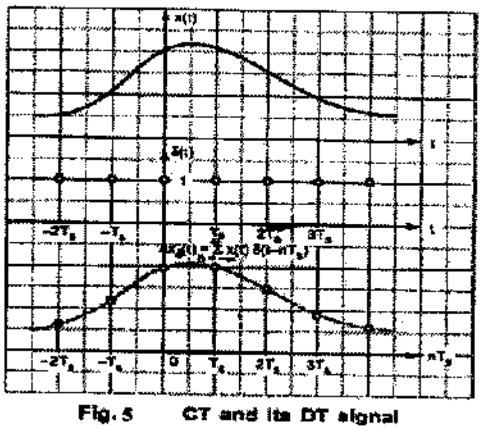


Fig. 5 CT and its DT signal

Proof of sampling theorem

There are two parts : (I) Representation of $x(t)$ in terms of its samples

(II) Reconstruction of $x(t)$ from its samples.

Part I : Representation of $x(t)$ in its samples $x(nT_s)$

Step 1 : Define $x_\delta(t)$

Step 2 : Fourier transform of $x_\delta(t)$ i.e. $X_\delta(f)$

Step 3 : Relation between $X(f)$ and $X_\delta(f)$

Step 4 : Relation between $x(t)$ and $x(nT_s)$

Step 1 : Define $x_\delta(t)$

The sampled signal $x_\delta(t)$ is given as,

$$x_\delta(t) = \sum_{n=-\infty}^{\infty} x(t)\,\delta(t-nT_s) \quad \ldots 1$$

Here observe that $x_\delta(t)$ is the product of x_δ and impulse train $\delta(t)$ as shown in above fig In the above equation $\delta(t-nT_s)$ indicates the samples placed at $\pm T_s$, $\pm 2T_s$, $\pm 3T_s$ ... and so on.

Step 2 : FT of $x_\delta(t)$ i.e. $X_\delta(f)$

Taking FT of equation (1.3.1).

$$X_\delta(f) = \text{FT}\left\{\sum_{n=-\infty}^{\infty} x(t)\,\delta(t-nT_s)\right\}$$

$$= \text{FT }\{\text{Product of } x(t) \text{ and impulse train}\}$$

We know that FT of product in time domain becomes convolution in frequency domain. i.e.,

$$X_\delta(f) = \text{FT }\{x(t)\} * FT\{\delta(t-nT_s)\} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad 2$$

By definitions, $x(t) \xleftrightarrow{FT} X(f)$ and

$$\delta(t-nT_s) \xleftrightarrow{FT} f_s \sum_{n=-\infty}^{\infty} \delta(f-nf_s)$$

Hence equation (1.3.2) becomes,

$$X_\delta(f) = X(f) * f_s \sum_{n=-\infty}^{\infty} \delta(f-nf_s)$$

Since convolution is linear,

$$X_\delta(f) = f_s \sum_{n=-\infty}^{\infty} X(f) * \delta(f-nf_s)$$

$$= f_s \sum_{n=-\infty}^{\infty} X(f - nf_s) \qquad \textit{By shifting property of impulse function}$$

$$= \cdots f_s X(f-2f_s) + f_s X(f-f_s) + f_s X(f) + f_s X(f-f_s) + f_s X(f-2f_s) + \cdots$$

Comments

(i) The RHS of above equation shows that X(f) is placed at $\pm f_s, \pm 2f_s, \pm 3f_s, \cdots$

(ii) This means X(f) is periodic in f_s.

(iii) If sampling frequency is $f_s = 2W$, then the spectrums $X(f)$ just touch each other.

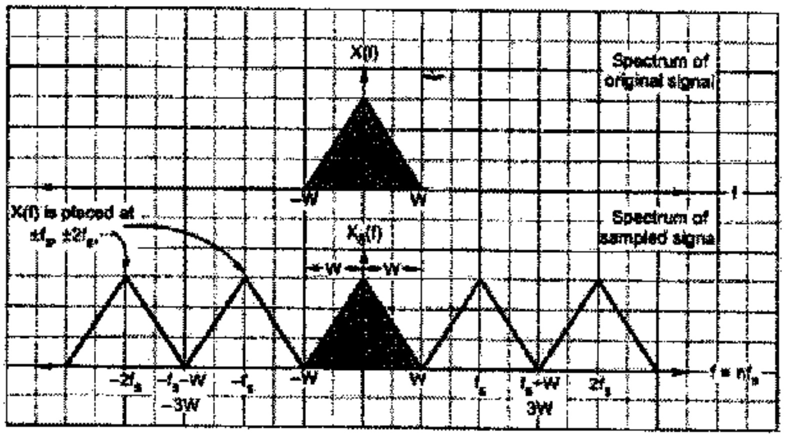


Fig. 6 Spectrum of original signal and sampled signal

Step 3 : Relation between $X(f)$ and $X_\delta(f)$

Important assumption : Let us assume that $f_s = 2W$, then as per above diagram.

$$X_\delta(f) = f_s X(f) \qquad \text{for } -W \le f \le W \text{ and } f_s = 2W$$

or
$$X(f) = \frac{1}{f_s} X_\delta(f) \qquad \ldots \quad 3$$

Step 4 : Relation between $x(t)$ and $x(nT_s)$

DTFT is,
$$X(\Omega) = \sum_{n=-\infty}^{\infty} x(n) e^{-j\Omega n}$$

$\therefore$
$$X(f) = \sum_{n=-\infty}^{\infty} x(n) e^{-j2\pi f n} \qquad \ldots \quad 4$$

In above equation 'f' is the frequency of DT signal. If we replace $X(f)$ by $X_\delta(f)$, then 'f' becomes frequency of CT signal. i.e.,

$$X_\delta(f) = \sum_{n=-\infty}^{\infty} x(n) e^{-j2\pi \frac{f}{f_s} n}$$

In above equation 'f' is frequency of CT signal. And $\frac{f}{f_s}$ = Frequency of DT signal in equation 4. Since $x(n) = x(nT_s)$, i.e. samples of $x(t)$, then we have,

$$X_\delta(f) = \sum_{n=-\infty}^{\infty} x(nT_s) e^{-j2\pi f n T_s} \quad \text{since } \frac{1}{f_s} = T_s$$

Putting above expression in equation 3,

$$X(f) = \frac{1}{f_s} \sum_{n=-\infty}^{\infty} x(nT_s) e^{-j2\pi f n T_s}$$

Inverse Fourier Transform (IFT) of above equation gives $x(t)$ i.e.,

$$x(t) = IFT\left\{\frac{1}{f_s} \sum_{n=-\infty}^{\infty} x(nT_s) e^{-j2\pi f n T_s}\right\} \qquad \ldots \quad 5$$

Comments :

i) Here $x(t)$ is represented completely in terms of $x(nT_s)$.

ii) Above equation holds for $f_s = 2W$. This means if the samples are taken at the rate of 2W or higher, $x(t)$ is completely represented by its samples.

iii) First part of the sampling theorem is proved by above two comments.

Part II : Reconstruction of $x(t)$ from its samples

Step 1 : Take inverse Fourier transform of $X(f)$ which is in terms of $X_\delta(f)$.

Step 2 : Show that $x(t)$ is obtained back with the help of interpolation function.

Step 1 : The IFT of equation 5 becomes,

$$x(t) = \int_{-\infty}^{\infty} \left\{\frac{1}{f_s} \sum_{n=-\infty}^{\infty} x(nT_s) e^{-j2\pi f n T_s}\right\} e^{j2\pi f t}\, df$$

Here the integration can be taken from $-W \le f \le W$. Since $X(f) = \frac{1}{f_s} X_\delta(f)$ for $-W \le f \le W$. (See Fig. 6).

$$\therefore \qquad x(t) = \int_{-W}^{W} \frac{1}{f_s} \sum_{n=-\infty}^{\infty} x(nT_s) e^{-j2\pi f n T_s} \cdot e^{j2\pi f t}\, df$$

Interchanging the order of summation and integration,

$$x(t) = \sum_{n=-\infty}^{\infty} x(nT_s) \frac{1}{f_s} \int_{-W}^{W} e^{j2\pi f(t-nT_s)}\, df$$

$$= \sum_{n=-\infty}^{\infty} x(nT_s) \cdot \frac{1}{f_s} \cdot \left[\frac{e^{j2\pi f(t-nT_s)}}{j2\pi(t-nT_s)} \right]_{-W}^{W}$$

$$= \sum_{n=-\infty}^{\infty} x(nT_s) \cdot \frac{1}{f_s} \left\{ \frac{e^{j2\pi W(t-nT_s)} - e^{-j2\pi W(t-nT_s)}}{j2\pi(t-nT_s)} \right\}$$

$$= \sum_{n=-\infty}^{\infty} x(nT_s) \cdot \frac{1}{f_s} \cdot \frac{\sin 2\pi W(t-nT_s)}{\pi(t-nT_s)}$$

$$= \sum_{n=-\infty}^{\infty} x(nT_s) \frac{\sin \pi(2Wt - 2W\, nT_s)}{\pi(f_s t - f_s\, nT_s)}$$

Here $f_s = 2W$, hence $T_s = \frac{1}{f_s} = \frac{1}{2W}$. Simplifying above equation,

$$x(t) = \sum_{n=-\infty}^{\infty} x(nT_s) \frac{\sin \pi(2Wt-n)}{\pi(2Wt-n)}$$

$$= \sum_{n=-\infty}^{\infty} x(nT_s) \operatorname{sinc}(2Wt-n) \qquad \text{since } \frac{\sin \pi\theta}{\pi\theta} = \operatorname{sinc}\theta \qquad \ldots \quad 6$$

Step 2 : Let us interpret the above equation. Expanding we get,

$$x(t) = \cdots + x(-2T_s)\operatorname{sinc}(2Wt+2) + x(-T_s)\operatorname{sinc}(2Wt+1) + x(0)\operatorname{sinc}(2Wt) + x(T_s)\operatorname{sinc}(2Wt-1) + \cdots$$

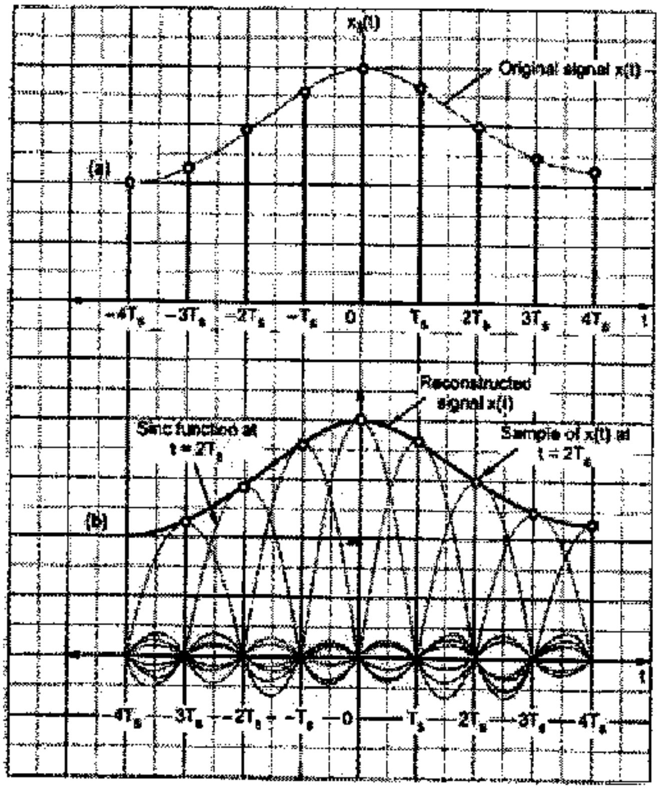


Fig. 7 (a) Sampled version of signal x(t)
(b) Reconstruction of x(t) from its samples

Comments :

i) The samples $x(nT_s)$ are weighted by sinc functions.

ii) The sinc function is the interpolating function. Fig. 7 shows, how $x(t)$ is interpolated.

Step 3 : Reconstruction of $x(t)$ by lowpass filter

When the interpolated signal of equation 6 is passed through the lowpass filter of bandwidth $-W \leq f \leq W$, then the reconstructed waveform shown in above Fig. 7 (b) is obtained. The individual sinc functions are interpolated to get smooth $x(t)$.

PCM Generator:

The pulse code modulator technique samples the input signal $x(t)$ at frequency $f_s \geq 2W$. This sampled 'Variable amplitude' pulse is then digitized by the analog to digital converter. The parallel bits obtained are converted to a serial bit stream. Fig. 8 shows the PCM generator.

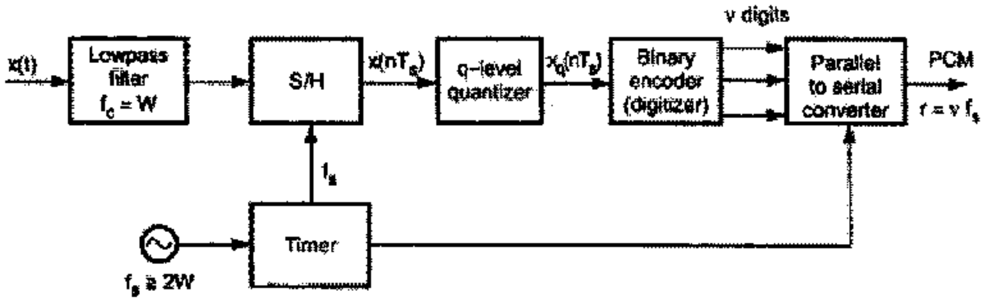


Fig. 8 PCM generator

In the PCM generator of above figure, the signal $x(t)$ is first passed through the lowpass filter of cutoff frequency 'W' Hz. This lowpass filter blocks all the frequency components above 'W' Hz. Thus $x(t)$ is bandlimited to 'W' Hz. The sample and hold circuit then samples this signal at the rate of f_s. Sampling frequency f_s is selected sufficiently above Nyquist rate to avoid aliasing i.e.,

$$f_s \geq 2W$$

In Fig. 8 output of sample and hold is called $x(nT_s)$. This $x(nT_s)$ is discrete in time and continuous in amplitude. A q-level quantizer compares input $x(nT_s)$ with its fixed digital levels. It assigns any one of the digital level to $x(nT_s)$ with its fixed digital levels. It then assigns any one of the digital level to $x(nT_s)$ which results in minimum distortion or error. This error is called *quantization error*. Thus output of quantizer is a digital level called $x_q(nT_s)$.

Now coming back to our discussion of PCM generation, the quantized signal level $x_q(nT_s)$ is given to binary encoder. This encoder converts input signal to 'v' digits binary word. Thus $x_q(nT_s)$ is converted to 'V' binary bits. The encoder is also called digitizer.

It is not possible to transmit each bit of the binary word separately on transmission line. Therefore 'v' binary digits are converted to serial bit stream to generate single baseband signal. In a parallel to serial converter, normally a shift register does this job. The output of PCM generator is thus a single baseband signal of binary bits.

An oscillator generates the clocks for sample and hold an parallel to serial converter. In the pulse code modulation generator discussed above ; sample and hold, quantizer and encoder combinely form an analog to digital converter.

Transmission BW in PCM:

Let the quantizer use 'v' number of binary digits to represent each level. Then the number of levels that can be represented by 'v' digits will be,

$$q = 2^v \quad \dots \quad 1$$

Here 'q' represents total number of digital levels of q-level quantizer.

For example if $v = 3$ bits, then total number of levels will be,

$$q = 2^3 = 8 \text{ levels}$$

Each sample is converted to 'v' binary bits. i.e. Number of bits per sample = v

We know that, Number of samples per second = f_s

∴ Number of bits per second is given by,

$$\begin{aligned}(\text{Number of bits per second}) &= (\text{Number of bits per samples}) \\ &\quad \times (\text{Number of samples per second}) \\ &= v \text{ bits per sample} \times f_s \text{ samples per second} \quad \dots \quad 2\end{aligned}$$

The number of bits per second is also called signaling rate of PCM and is denoted by 'r' i.e.,

$$\boxed{\text{Signaling rate in PCM} : r = v f_s} \quad \dots \quad 3$$

Here $f_s \geq 2W$.

Bandwidth needed for PCM transmission will be given by half of the signaling rate i.e.,

$$\text{Transmission Bandwidth of PCM} : \begin{cases} B_T \geq \frac{1}{2} r & \dots \quad 4 \\ B_T \geq \frac{1}{2} v f_s \quad \text{Since } f_s \geq 2W & \dots \quad 5 \\ B_T \geq v W & \dots \quad 6 \end{cases}$$

Binary Phase-Shift Keying

The simplest form of PSK is *binary phase-shift keying* (BPSK), where N = 1 and M = 2.Therefore, with BPSK, two phases ($2^1 = 2$) are possible for the carrier.One phase represents a logic 1, and the other phase represents a logic 0. As the input digital signal changes state (i.e., from a 1 to a 0 or from a 0 to a 1), the phase of the output carrier shifts between two angles that are separated by 180°.

Hence, other names for BPSK are *phase reversal keying* (PRK) and *biphase modulation.* BPSK is a form of square-wave modulation of a *continuous wave (CW)* signal.

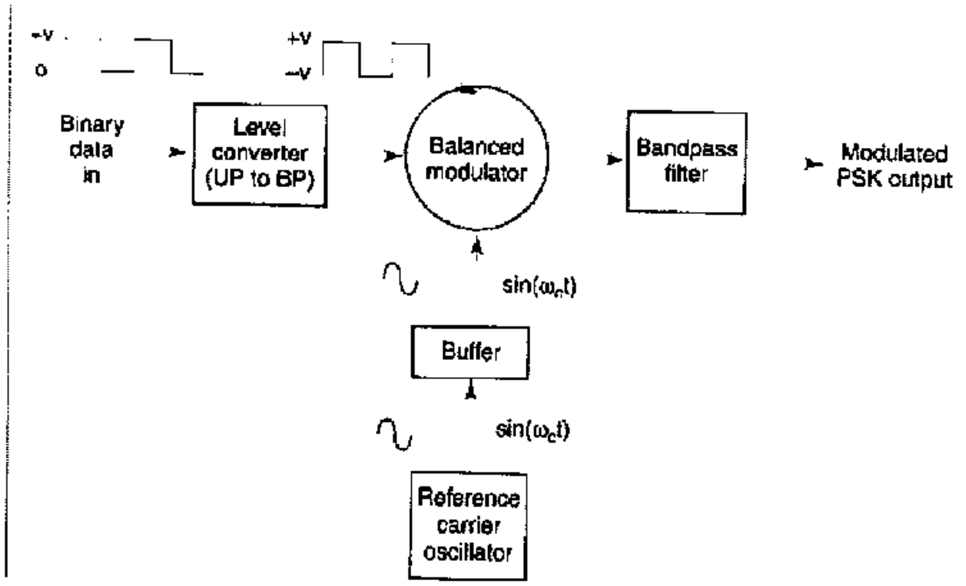


FIGURE 2-12 BPSK transmitter

BPSK TRANSMITTER:

Figure 2-12 shows a simplified block diagram of a BPSK transmitter. The balanced modulator acts as a phase reversing switch. Depending on the logic condition of the digital input, the carrier is transferred to the output either in phase or 180° out of phase with the reference carrier oscillator.

Figure 2-13 shows the schematic diagram of a balanced ring modulator. The balanced modulator has two inputs: a carrier that is in phase with the reference oscillator and the binary digital data. For the balanced modulator to operate properly, the digital input voltage must be much greater than the peak carrier voltage.

This ensures that the digital input controls the on/off state of diodes D1 to D4. If the binary input is a logic 1(positive voltage), diodes D 1 and D2 are forward biased and on, while diodes D3 and D4 are reverse biased and off (Figure 2-13b). With the polarities shown, the carrier voltage is developed across transformer T2 in phase with the carrier voltage across T

1. Consequently, the output signal is in phase with the reference oscillator.

If the binary input is a logic 0 (negative voltage), diodes Dl and D2 are reverse biased and off, while diodes D3 and D4 are forward biased and on (Figure 9-13c). As a result, the carrier voltage is developed across transformer T2 180° out of phase with the carrier voltage across T 1.

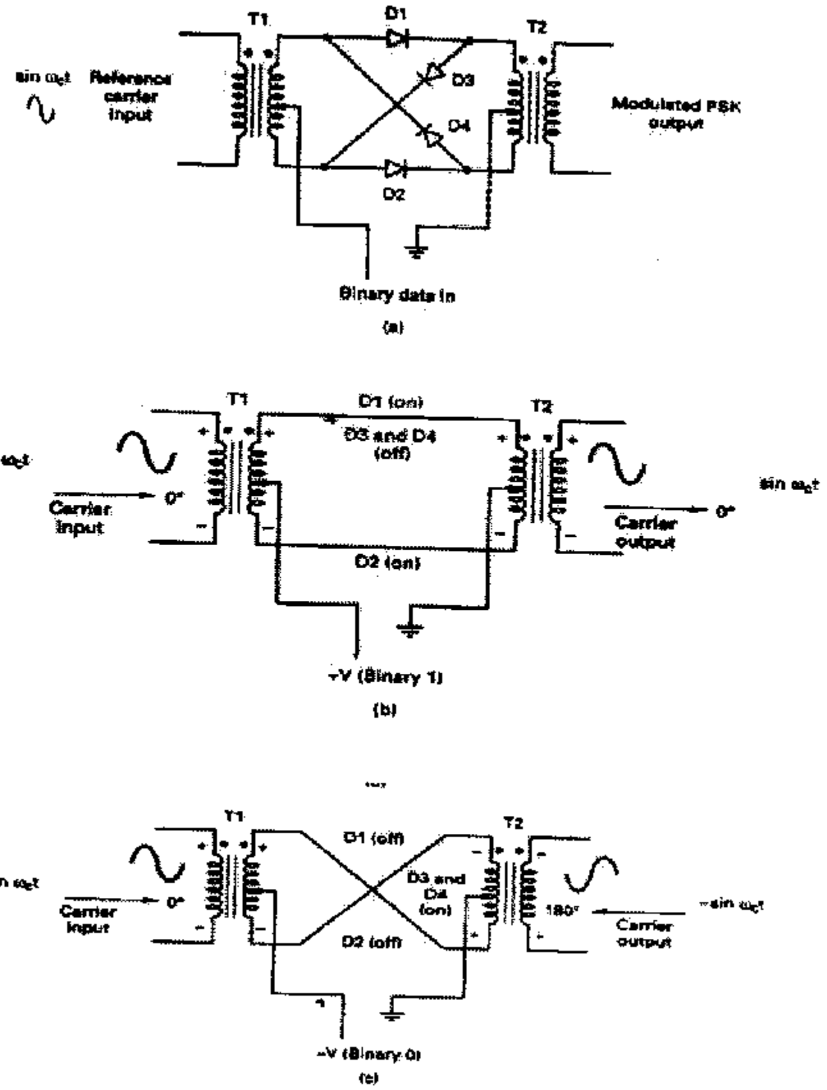
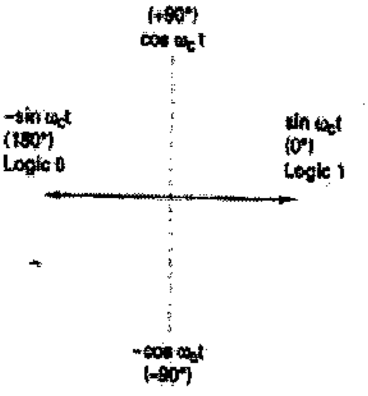


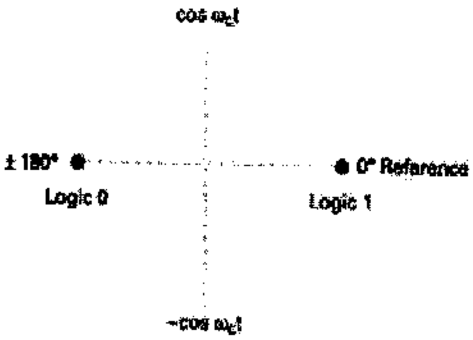
FIGURE 9-13 (a) Balanced ring modulator; (b) logic 1 input; (c) logic 0 input

Binary input	Output phase
Logic 0	180°
Logic 1	0°

(a)



(b)



(c)

FIGURE 2-14 BPSK modulator: (a) truth table; (b) phasor diagram; (c) constellation diagram

BANDWIDTH CONSIDERATIONS OF BPSK:

In a BPSK modulator. the carrier input signal is multiplied by the binary data.

If + 1 V is assigned to a logic 1 and -1 V is assigned to a logic 0, the input carrier (sin $\omega_c t$) is multiplied by either a + or - 1 .

The output signal is either + 1 sin $\omega_c t$ or -1 sin $\omega_c t$ the first represents a signal that is *in phase* with the reference oscillator, the latter a signal that is 180° out of phase with the reference oscillator.Each time the input logic condition changes, the output phase changes.

Mathematically, the output of a BPSK modulator is proportional to

$$\text{BPSK output} = [\sin(2\pi f_a t)] \times [\sin(2\pi f_c t)] \qquad (2.20)$$

where

f_a = maximum fundamental frequency of binary input (hertz)

f_c = reference carrier frequency (hertz)

Solving for the trig identity for the product of two sine functions,

$0.5\cos[2\pi(f_c - f_a)t] - 0.5\cos[2\pi(f_c + f_a)t]$

Thus, the minimum double-sided Nyquist bandwidth *(B) is*

$$\begin{array}{r} f_c + f_a \\ -(f_c + f_a) \end{array} \quad \text{or} \quad \begin{array}{r} f_c + f_a \\ \underline{-f_c + f_a} \\ 2f_a \end{array}$$

and because $f_a = f_b / 2$, where f_b = input bit rate,

where *B is* the minimum double-sided Nyquist bandwidth.

Figure 2-15 shows the output phase-versus-time relationship for a BPSK waveform. Logic 1 input produces an analog output signal with a 0° phase angle, and a logic 0 input produces an analog output signal with a 180° phase angle.

As the binary input shifts between a logic 1 and a logic 0 condition and vice versa, the phase of the BPSK waveform shifts between 0° and 180°, respectively.

BPSK signaling element *(t_s)* is equal to the time of one information bit *(t_b)*, which indicates that the bit rate equals the baud.

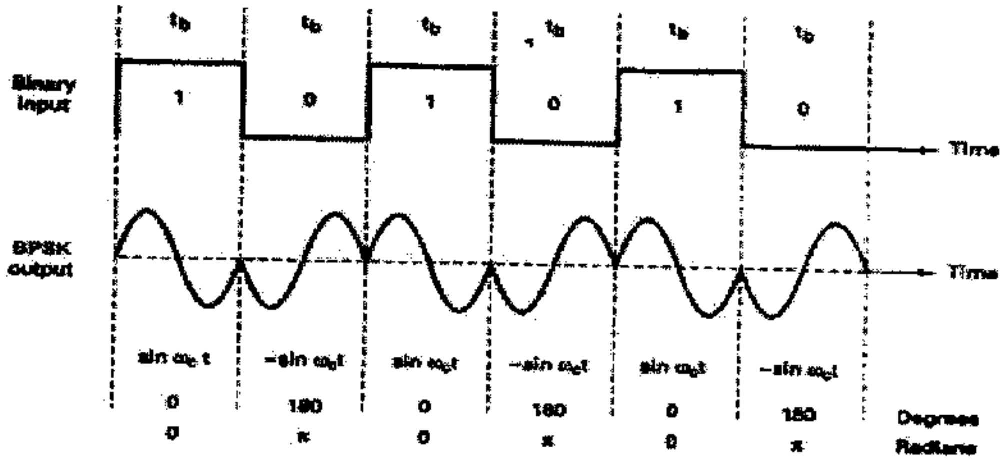


FIGURE 2-15 Output phase-versus-time relationship for a BPSK modulator

Example:

For a BPSK modulator with a carrier frequency of 70 MHz and an input bit rate of 10 Mbps, determine the maximum and minimum upper and lower side frequencies, draw the output spectrum, de-termine the minimum Nyquist bandwidth, and calculate the baud..

Solution

Substituting into Equation 2-20 yields

$$\text{output} = [\sin(2\pi f_a t)] \times [\sin(2\pi f_c t)];\; f_a = f_b / 2 = 5\text{ MHz}$$

$$= [\sin 2\pi(5\text{MHz})t)] \times [\sin 2\pi(70\text{MHz})t)]$$

$$= \underbrace{0.5\cos[2\pi(70\text{MHz} - 5\text{MHz})t]}_{\text{lower side frequency}} - \underbrace{0.5\cos[2\pi(70\text{MHz} + 5\text{MHz})t]}_{\text{upper side frequency}}$$

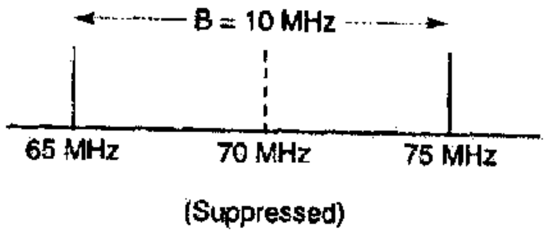
Minimum lower side frequency (LSF):

LSF=70MHz - 5MHz = 65MHz

Maximum upper side frequency (USF):

USF = 70 MHz + 5 MHz = 75 MHz

Therefore, the output spectrum for the worst-case binary input conditions *is* as follows: The minimum Nyquist bandwidth *(B) is*



B = 75 MHz - 65 MHz = 10 MHz

and the baud = f_b or 10 megabaud.

BPSK receiver:.

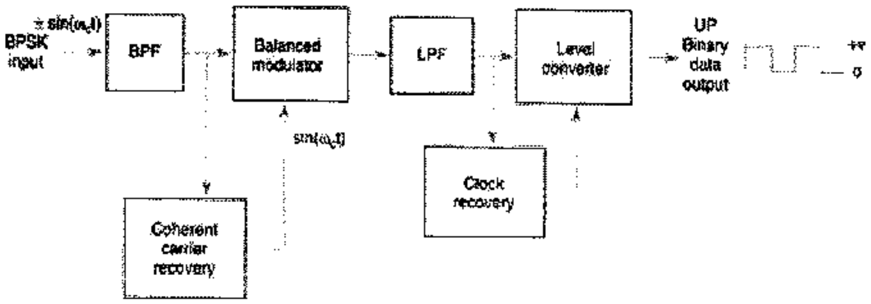
Figure 2-16 shows the block diagram of a BPSK receiver.

The input signal maybe+ sin $\omega_c t$ or - sin $\omega_c t$ .The coherent carrier recovery circuit detects and regenerates a carrier signal that is both frequency and phase coherent with the original transmit carrier.

The balanced modulator is a product detector; the output is the product d the two inputs (the BPSK signal and the recovered carrier).

The low-pass filter (LPF) operates the recovered binary data from the complex demodulated signal.

FIGURE 2-16 Block diagram of a BPSK receiver



Mathematically, the demodulation process is as follows.

For a BPSK input signal of + sin $\omega_c t$ (logic 1), the output of the balanced modulator is

$$\text{output} = (\sin \omega_c t)(\sin \omega_c t) = \sin^2\omega_c t \qquad (2.21)$$

or

$$\sin^2\omega_c t = 0.5(1 - \cos 2\omega_c t) = 0.5 - 0.5\cos 2\omega_c t$$

filtered out

leaving output = + 0.5 V = logic 1

It can be seen that the output of the balanced modulator contains a positive voltage (+[1/2]V) and a cosine wave at twice the carrier frequency (2 $\omega_c t$).

The LPF has a cutoff frequency much lower than 2 $\omega_c t$, and, thus, blocks the second harmonic of the carrier and passes only the positive constant component. A positive voltage represents a demodulated logic 1.

For a BPSK input signal of -sin $\omega_c t$ (logic 0), the output of the balanced modulator is

$$\text{output} = (-\sin \omega_c t)(\sin \omega_c t) = \sin^2\omega_c t$$

or

$$\sin^2\omega_c t = -0.5(1 - \cos 2\omega_c t) = 0.5 + 0.5\cos 2\omega_c t$$

filtered out

leaving

output = - 0.5 V = logic 0

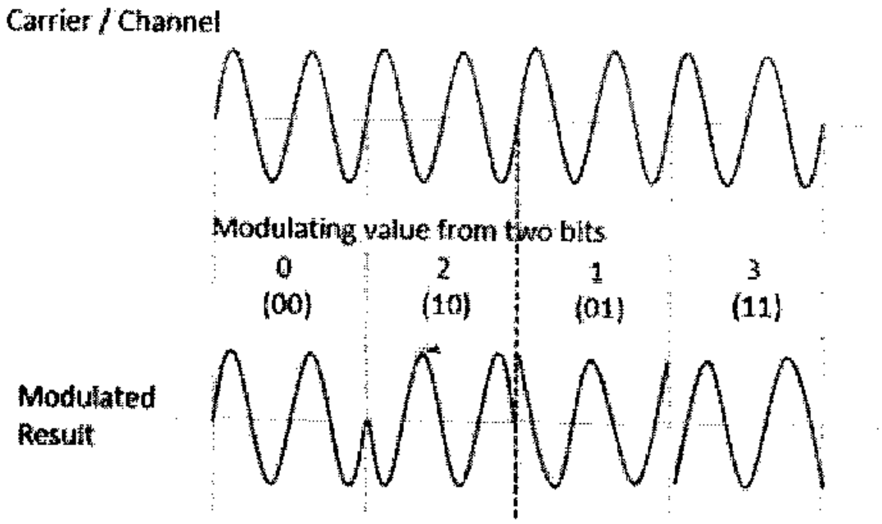
The output of the balanced modulator contains a negative voltage (-[l/2]V) and a cosine wave at twice the carrier frequency ($2\omega_c t$).

Again, the LPF blocks the second harmonic of the carrier and passes only the negative constant component. A negative voltage represents a demodulated logic 0.

QUADRATURE PHASE SHIFT KEYING (QPSK):

This is the phase shift keying technique, in which the sine wave carrier takes four phase reversals such as 0°, 90°, 180°, and 270°.

If this kind of techniques are further extended, PSK can be done by eight or sixteen values also, depending upon the requirement. The following figure represents the QPSK waveform for two bits input, which shows the modulated result for different instances of binary inputs.



QPSK is a variation of BPSK, and it is also a DSB-SC (Double Sideband Suppressed Carrier) modulation scheme, which sends two bits of digital information at a time, called as **bigits.**

Instead of the conversion of digital bits into a series of digital stream, it converts them into bit-pairs. This decreases the data bit rate to half, which allows space for the other users.

QPSK transmitter.

A block diagram of a QPSK modulator is shown in Figure 2-17Two bits (a dibit) are clocked into the bit splitter. After both bits have been serially inputted, they are simultaneously parallel outputted.

The I bit modulates a carrier that is in phase with the reference oscillator (hence the name "I" for "in phase" channel), and theQ bit modulate, a carrier that is 90° out of phase.

For a logic 1 = + 1 V and a logic 0= - 1 V, two phases are possible at the output of the I balanced modulator (+sin $\omega_c t$ and - sin $\omega_c t$), and two phases are possible at the output of the Q balanced modulator (+cos $\omega_c t$), and (-cos $\omega_c t$).

When the linear summer combines the two quadrature (90° out of phase) signals, there are four possible resultant phasors given by these expressions: + sin $\omega_c t$ + cos $\omega_c t$, + sin $\omega_c t$ - cos $\omega_c t$, -sin $\omega_c t$ + cos $\omega_c t$, and -sin $\omega_c t$ - cos $\omega_c t$.

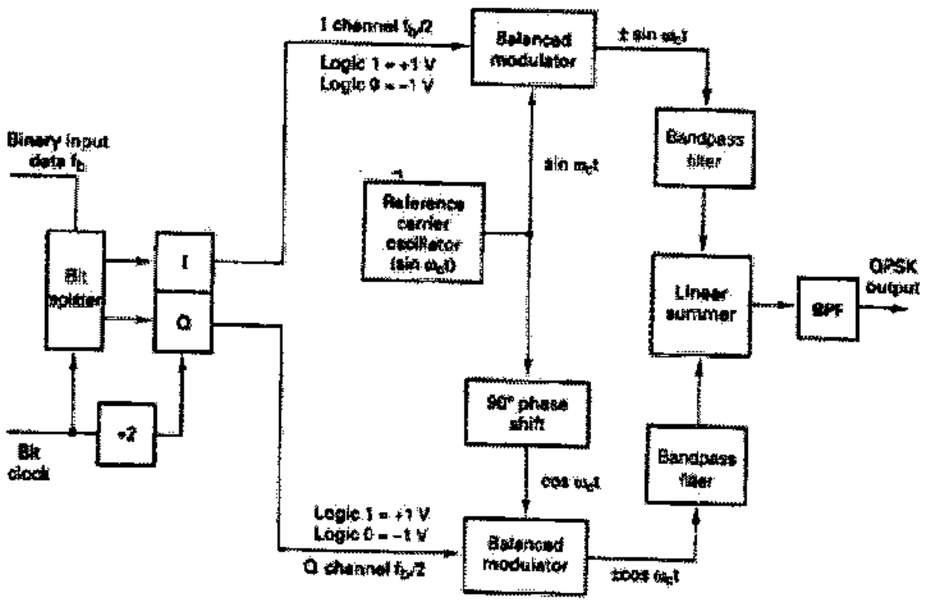


FIGURE 2-17 QPSK modulator

Example:

For the QPSK modulator shown in Figure 2-17, construct the truthtable, phasor diagram, and constellation diagram.

Solution

For a binary data input of Q = O and I= 0, the two inputs to the Ibalanced modulator are -1 and sin $\omega_c t$, and the two inputs to the Q balanced modulator are -1 and cos $\omega_c t$.

Consequently, the outputs are

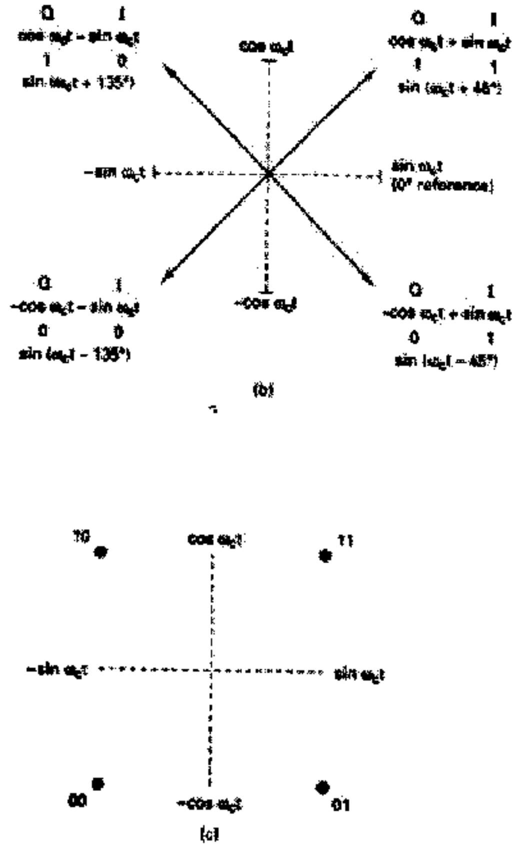
I balanced modulator $=(-1)(\sin \omega_c t) = -1 \sin \omega_c t$

Q balanced modulator $=(-1)(\cos \omega_c t) = -1 \cos \omega_c t$ and the output of the linear summer is
$-1 \cos \omega_c t - 1 \sin \omega_c t = 1.414 \sin(\omega_c t - 135°)$

For the remaining dibit codes (01, 10, and 11), the procedure is the same. The results are shown in Figure 2-18a.

Binary input Q	Binary input I	QPSK output phase
0	0	−135°
0	1	−45°
1	0	+135°
1	1	+45°

(a)



(b)

(c)

FIGURE 2-18 QPSK modulator: (a) truth table; (b) phasor diagram; (c) constellation diagram

In Figures 2-18b and c, it can be seen that with QPSK each of the four possible output phasors has exactly the same amplitude. Therefore, the binary information must be encoded entirely in the phase of the output signal

Figure 2-18b, it can be seen that the angular separation between any two adjacent phasors in QPSK is 90°.Therefore, a QPSK signal can undergo almost a+45° or -45° shift in phase during transmission and still retain the correct encoded information when demodulated at the receiver.

Figure 2-19 shows the output phase-versus-time relationship for a QPSK modulator.

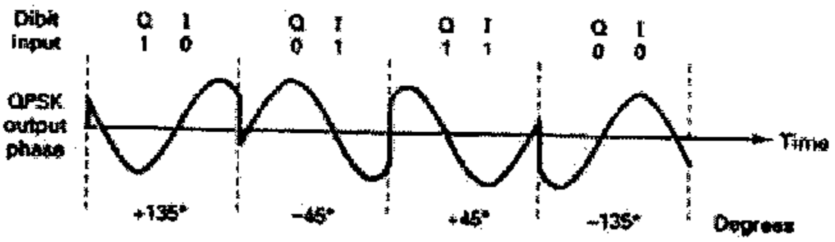


FIGURE 2-19 Output phase-versus-time relationship for a PSK modulator

Bandwidth considerations of QPSK

With QPSK, because the input data are divided into two channels, the bit rate in either the I or the Q channel is equal to one-half of the input data rate ($f_b/2$) (one-half of $f_b/2 = f_b/4$).

QPSK RECEIVER:

The block diagram of a QPSK receiver is shown in Figure 2-21

The power splitter directs the input QPSK signal to the I and Q product detectors and the carrier recovery circuit. The carrier recovery circuit reproduces the original transmit carrier oscillator signal. The recovered carrier must be frequency and phase coherent with the transmit reference carrier. The QPSK signal is demodulated in the I and Q product detectors, which generate the original I and Q data bits. The outputs of the product detectors are fed to the bit combining circuit, where they are converted from parallel I and Q data channels to a single binary output data stream. The incoming QPSK signal may be any one of the four possible output phases shown in Figure 2-18. To illustrate the demodulation process, let the incoming QPSK signal be $-\sin \omega_c t + \cos \omega_c t$. Mathematically, the demodulation process is as follows.

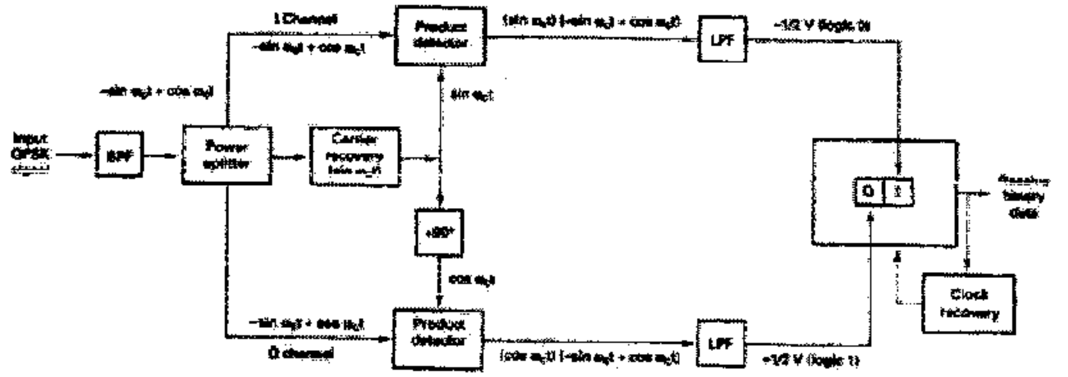


FIGURE 2-21 QPSK receiver

The receive QPSK signal (-sin ω_ct + cos ω_ct) is one of the inputs to the I product detector. The other input is the recovered carrier (sin ω_ct). The output of the I product detector is

$$\begin{aligned}
I &= \underbrace{(-\sin \omega_c t + \cos \omega_c t)}_{\text{QPSK input signal}}\underbrace{(\sin \omega_c t)}_{\text{carrier}} \\
&= (-\sin \omega_c t)(\sin \omega_c t) + (\cos \omega_c t)(\sin \omega_c t) \\
&= -\sin^2 \omega_c t + (\cos \omega_c t)(\sin \omega_c t) \\
&= -\frac{1}{2}(1 - \cos 2\omega_c t) + \frac{1}{2}\sin(\omega_c + \omega_c)t + \frac{1}{2}\sin(\omega_c - \omega_c)t \\
I &= -\frac{1}{2} + \underbrace{\frac{1}{2}\cos 2\omega_c t}_{\text{(filtered out)}} + \frac{1}{2}\sin 2\omega_c t + \underbrace{\frac{1}{2}\sin 0}_{\text{(equals 0)}} \\
&= -\frac{1}{2}\text{V (logic 0)}
\end{aligned} \tag{2.23}$$

Again, the receive QPSK signal (-sin ω_ct + cos ω_ct) is one of the inputs to the Q product detector. The other input is the recovered carrier shifted 90° in phase (cos ω_ct). The output of the Q product detector is

$$Q = \underbrace{(-\sin \omega_c t + \cos \omega_c t)}_{\text{QPSK input signal}}\underbrace{(\cos \omega_c t)}_{\text{carrier}}$$

$$= \cos^2 \omega_c t - (\sin \omega_c t)(\cos \omega_c t)$$

$$= \frac{1}{2}(1 + \cos 2\omega_c t) - \frac{1}{2}\sin(\omega_c + \omega_c)t - \frac{1}{2}\sin(\omega_c - \omega_c)t$$

$$Q = \frac{1}{2} + \underbrace{\frac{1}{2}\cos 2\omega_c t - \frac{1}{2}\sin 2\omega_c t}_{\text{(filtered out)}} - \underbrace{\frac{1}{2}\sin 0}_{\text{(equals 0)}}$$

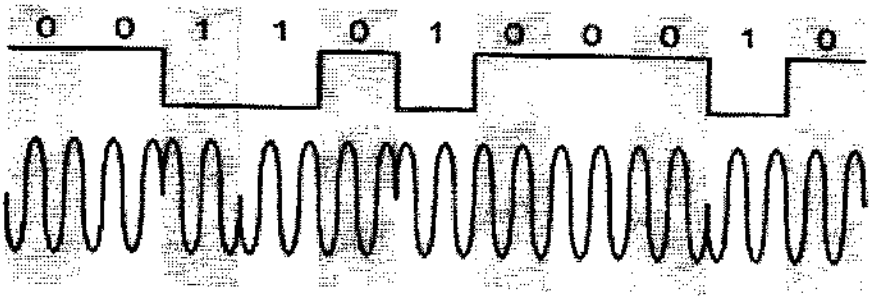
$$= \frac{1}{2}\text{V(logic 1)} \tag{2.24}$$

The demodulated I and Q bits (0 and 1, respectively) correspond to the constellation diagram and truth table for the QPSK modulator shown in Figure 2-18.

DIFFERENTIAL PHASE SHIFT KEYING (DPSK):

In DPSK (Differential Phase Shift Keying) the phase of the modulated signal is shifted relative to the previous signal element. No reference signal is considered here. The signal phase follows the high or low state of the previous element. This DPSK technique doesn't need a reference oscillator.

The following figure represents the model waveform of DPSK.



It is seen from the above figure that, if the data bit is LOW i.e., 0, then the phase of the signal is not reversed, but is continued as it was. If the data is HIGH i.e., 1, then the phase of the signal is reversed, as with NRZI, invert on 1 (a form of differential encoding).

If we observe the above waveform, we can say that the HIGH state represents an M in the modulating signal and the LOW state represents a W in the modulating signal.

The word binary represents two-bits. M simply represents a digit that corresponds to the number of conditions, levels, or combinations possible for a given number of binary variables.

This is the type of digital modulation technique used for data transmission in which instead of one-bit, two or **more bits are transmitted at a time**. As a single signal is used for multiple bit transmission, the channel bandwidth is reduced.

DBPSK TRANSMITTER.:

Figure 2-37a shows a simplified block diagram of a *differential binary phase-shift keying* (DBPSK) transmitter. An incoming information bit is XNORed with the preceding bit prior to entering the BPSK modulator (balanced modulator).

For the first data bit, there is no preceding bit with which to compare it. Therefore, an initial reference bit is assumed. Figure 2-37b shows the relationship between the input data, the XNOR output data, and the phase at the output of the balanced modulator. If the initial reference bit is assumed a logic 1, the output from the XNOR circuit is simply the complement of that shown.

In Figure 2-37b, the first data bit is XNORed with the reference bit. If they are the same, the XNOR output is a logic 1; if they are different, the XNOR output is a logic 0. The balanced modulator operates the same as a conventional BPSK modulator; a logic 1 produces +sin $\omega_c t$ at the output, and A logic 0 produces –sin $\omega_c t$ at the output.

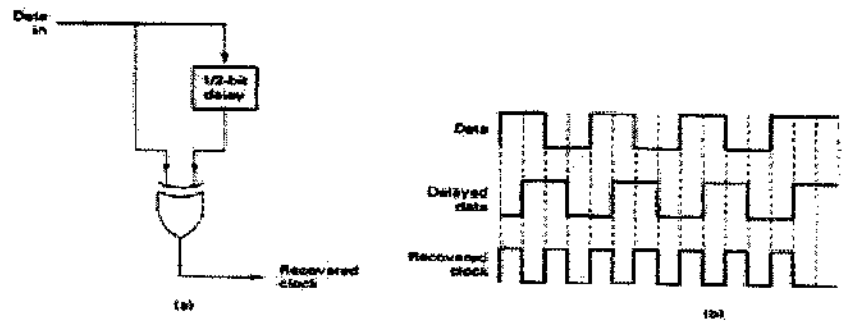


FIGURE 9-40 (a) Clock recovery circuit; (b) timing diagram

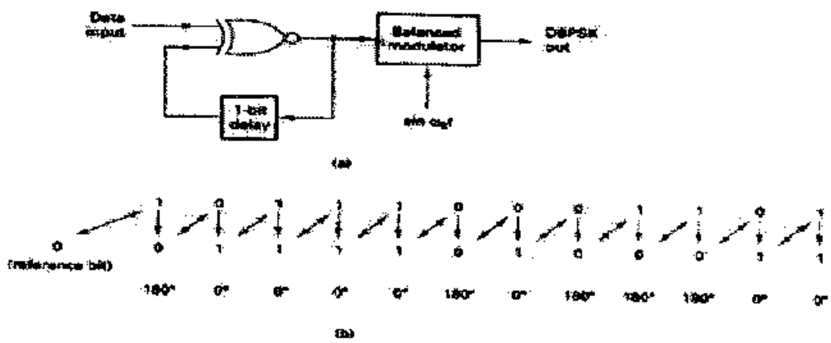


FIGURE 2-37 DBPSK modulator (a) block diagram (b) timing diagram

BPSK RECEIVER:

Figure 9-38 shows the block diagram and timing sequence for a DBPSK receiver. The received signal is delayed by one bit time, then compared with the next signaling element in the balanced modulator. If they are the same. J logic 1(+ voltage) is generated. If they are different, a logic 0 (- voltage) is generated. [f the reference phase is incorrectly assumed, only the first demodulated bit is in error. Differential encoding can be implemented with higher-than-binary digital modulation schemes, although the differential algorithms are much more complicated than for DBPS K.

The primary advantage of DBPSK is the simplicity with which it can be implemented. With DBPSK, no carrier recovery circuit is needed. A disadvantage of DBPSK is, that it requires between 1 dB and 3 dB more signal-to-noise ratio to achieve the same bit error rate as that of absolute PSK.

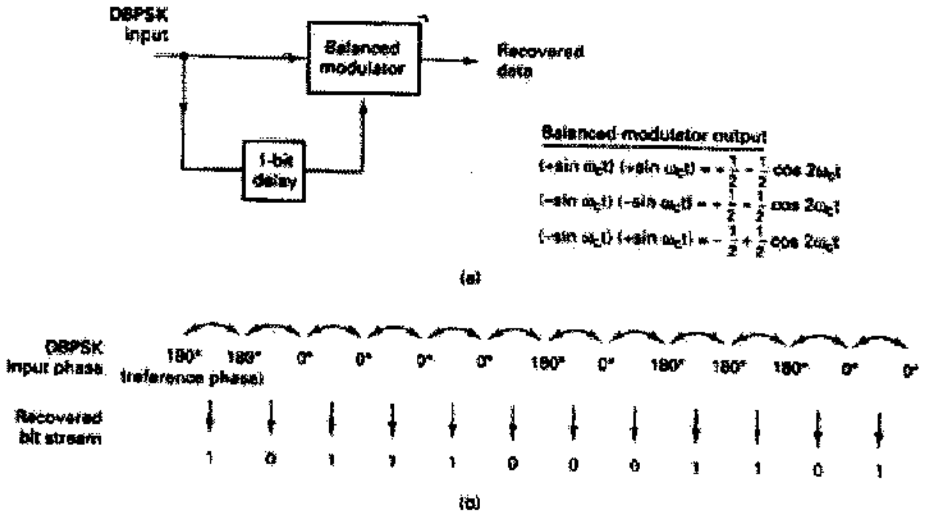


FIGURE 2-38 DBPSK demodulator: (a) block diagram; (b) timing sequence

COHERENT RECEPTION OF FSK:

The coherent demodulator for the coherent FSK signal falls in the general form of coherent demodulators described in Appendix B. The demodulator can be implemented with two correlators as shown in Figure 3.5, where the two reference signals are cos(27r f t) and cos(27r fit). They must be synchronized with the received signal. The receiver is optimum in the sense that it minimizes the error probability for equally likely binary signals. Even though the receiver is rigorously derived in Appendix B, some heuristic explanation here may help understand its operation. When s 1 (t) is transmitted, the upper correlator yields a signal 1 with a positive signal component and a noise component. However, the lower correlator output 12, due to the signals' orthogonality, has only a noise component. Thus the output of the summer is most likely above zero, and the threshold detector will most likely produce a 1. When s2(t) is transmitted, opposite things happen to the two correlators and the threshold detector will most likely produce a 0. However, due to the noise nature that its values range from -00 to m, occasionally the noise amplitude might overpower the signal amplitude, and then detection errors will happen. An alternative to Figure 3.5 is to use just one correlator with the reference signal cos (27r f t) - cos(2s f2t) (Figure 3.6). The correlator in Figure can be replaced by a matched filter that matches cos(27r fit) - cos(27r f2t) (Figure 3.7). All implementations are equivalent in terms of error performance (see Appendix B). Assuming an AWGN channel, the received signal is

$$r(t) = s_i(t) + n(t), \quad i = 1, 2$$

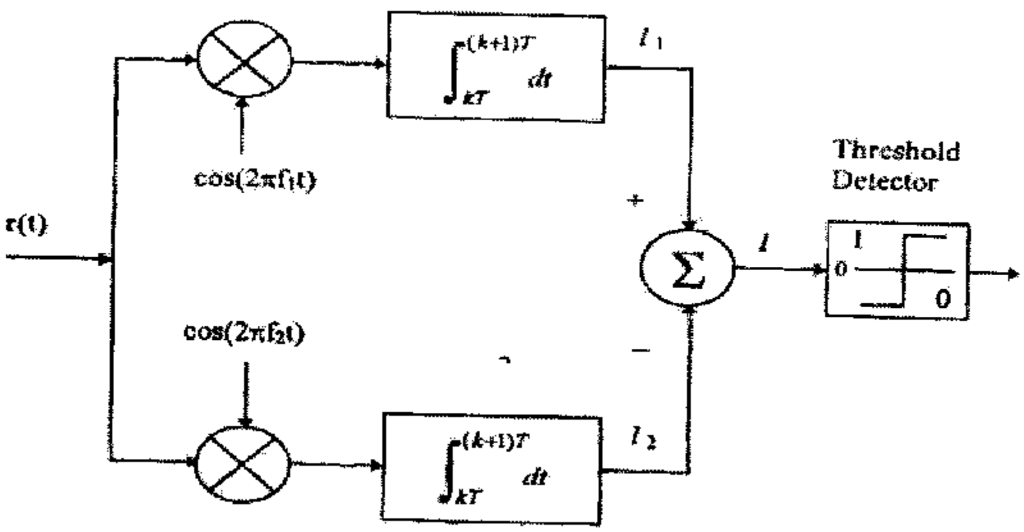
where n(t) is the additive white Gaussian noise, with zero mean and a two-sided power spectral density A',/2. From (B.33) the bit error probability for any equally likely binary signals is

$$P_b = Q\left(\sqrt{\frac{E_1 + E_2 - 2\rho_{12}\sqrt{E_1 E_2}}{2N_o}}\right)$$

where No/2 is the two-sided power spectral density of the additive white Gaussian noise. For Sunde's FSK signals El = Ez = Eb, pl2 = 0 (orthogonal). thus the error probability is

$$P_b = Q\left(\sqrt{\frac{E_b}{N_o}}\right)$$

where Eb = A2T/2 is the average bit energy of the FSK signal. The above Pb is plotted in Figure 3.8 where Pb of noncoherently demodulated FSK, whose expression will be given shortly, is also plotted for comparison.



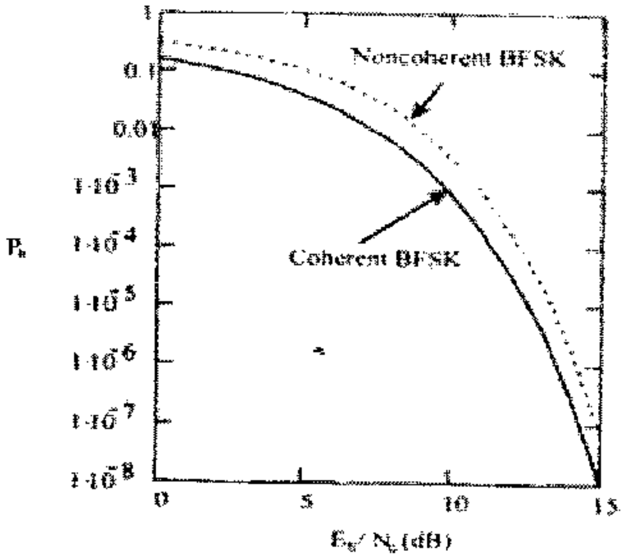


Figure: Pb of coherently and non-coherently demodulated FSK signal.

NONCOHERENT DEMODULATION AND ERROR PERFORMANCE:

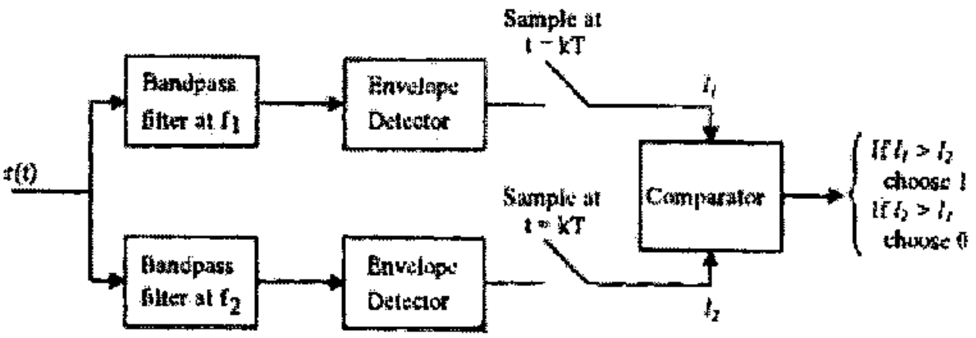
Coherently FSK signals can be noncoherently demodulated to avoid the carrier recovery. Noncoherently generated FSK can only be noncoherently demodulated. We refer to both cases as noncoherent FSK. In both cases the demodulation problem becomes a problem of detecting signals with unknown phases. In Appendix B we have shown that the optimum receiver is a quadrature receiver. It can be implemented using correlators or equivalently, matched filters. Here we assume that the binary noncoherent FSK signals are equally likely and with equal energies. Under these assumptions, the demodulator using correlators is shown in Figure 3.9. Again, like in the coherent case, the optimality of the receiver has been rigorously proved (Appendix B). However, we can easily understand its operation by some heuristic argument as follows. The received signal (ignoring noise for the moment) with an unknown phase can be written as

$$\begin{aligned} s_i(t,\theta) &= A\cos(2\pi f_i t + \theta), \quad i = 1,2 \\ &= A\cos\theta\cos 2\pi f_i t - A\sin\theta\sin 2\pi f_i t \end{aligned}$$

The signal consists of an in phase component A cos 8 cos 27r f t and a quadrature component A sin 8 sin 2x f,t sin 0. Thus the signal is partially correlated with cos 2s fit and partiah'y correlated with sin 27r fit. Therefore we use two correlators to collect the signal energy in these two parts. The outputs of the in phase and quadrature correlators will be cos 19 and sin 8, respectively. Depending on the value of the unknown phase 8, these two outputs could be anything in (- 5, y). Fortunately the squared sum of these two signals is not dependent on the unknown phase. That is

$$(\frac{AT}{2}\cos\theta)^2 + (\frac{AT}{2}\sin\theta)^2 = \frac{A^2T^2}{2}$$

This quantity is actually the mean value of the statistics I? when signal si (t) is transmitted and noise is taken into consideration. When si (t) is not transmitted the mean value of 1: is 0. The comparator decides which signal is sent by checking these I?. The matched filter equivalence to Figure 3.9 is shown in Figure 3.10 which has the same error performance. For implementation simplicity we can replace the matched filters by bandpass filters centered at f and fi, respectively (Figure 3.1 1). However, if the bandpass filters are not matched to the FSK signals, degradation to



various extents will result. The bit error probability can be derived using the correlator demodulator (Appendix B). Here we further assume that the FSK signals are orthogonal, then from Appendix B the error probability is

$$P_b = \frac{1}{2}e^{-E_b/2N_o}$$

PART-2

DATATRANSMISSION

BASE BAND SIGNAL RECEIVER:

Consider that a binary encoded signal consists of a time sequence of voltage levels +V or –V. if there is a guard interval between the bits, the signal forms a sequence of positive and negative pulses. in either case there is no particular interest in preserving the waveform of the signal after reception .we are interested only in knowing within each bit interval whether the transmitted voltage was +V or –V. With noise present, the receives signal and noise together will yield sample values generally different from ±V. In this case, what deduction shall we make from the sample value concerning the transmitted bit?

Suppose that the noise is gaussian and therefore the noise voltage has a probability density which is entirely symmetrical with respect to zero volts. Then the probability that the noise has increased the sample value is the same as the probability that the noise has decreased the sample value. It then seems entirely reasonable that we can do no better than to assume that if the sample value is positive the transmitted level was $+V$, and if the sample value is negative the transmitted level was $-V$. It is, of course, possible that at the sampling time the noise voltage may be of magnitude larger than V and of a polarity opposite to the polarity assigned to the transmitted bit. In this case an error will be made as indicated in Fig. 11.1-1. Here the transmitted bit is represented by the voltage $+V$ which is sustained over an interval T from t_1 to t_2. Noise has been superimposed on the level $+V$ so that the voltage v represents the received signal and noise. If now the sampling should happen to take place at a time $t = t_1 + \Delta t$, an error will have been made.

We can reduce the probability of error by processing the received signal plus noise in such a manner that we are then able to find a sample time where the sample voltage due to the signal is emphasized relative to the sample voltage due to the noise. Such a processer (receiver) is shown in Fig. 11.1-2. The signal input during a bit interval is indicated. As a matter of convenience we have set $t = 0$ at the beginning of the interval. The waveform of the signal $s(t)$ before $t = 0$ and after $t = T$ has not been indicated since, as will appear, the operation of the receiver during each bit interval is independent of the waveform during past and future bit intervals.

The signal $s(t)$ with added white gaussian noise $n(t)$ of power spectral density $\eta/2$ is presented to an integrator. At time $t = 0+$ we require that capacitor C be uncharged. Such a discharged condition may be ensured by a brief closing of switch SW_1 at time $t = 0-$, thus relieving C of any charge it may have acquired during the previous interval. The sample is taken at the output of the integrator by closing this sampling switch SW_2. This sample is taken at the end of the bit interval, at $t = T$. The signal processing indicated in Fig. 11.1-2 is described by the phrase *integrate and dump*, the term *dump* referring to the abrupt discharge of the capacitor after each sampling.

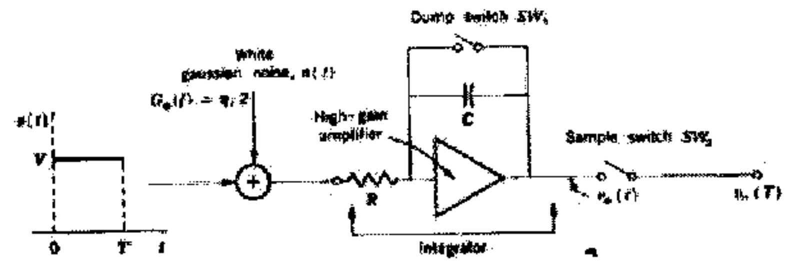
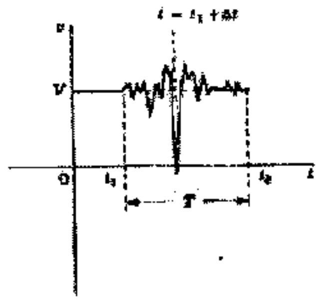


Figure 11.1-2 A receiver for a binary coded signal.



Peak Signal to RMS Noise Output Voltage Ratio

The integrator yields an output which is the integral of its input multiplied by $1/RC$. Using $\tau = RC$, we have

$$v_o(T) = \frac{1}{\tau}\int_0^T [s(t) + n(t)]\,dt = \frac{1}{\tau}\int_0^T s(t)\,dt + \frac{1}{\tau}\int_0^T n(t)\,dt \qquad (11.1\text{-}1)$$

The sample voltage due to the signal is

$$s_o(T) = \frac{1}{\tau}\int_0^T V\,dt = \frac{VT}{\tau} \qquad (11.1\text{-}2)$$

The sample voltage due to the noise is

$$n_o(T) = \frac{1}{\tau}\int_0^T n(t)\,dt \qquad (11.1\text{-}3)$$

This noise-sampling voltage $n_o(T)$ is a gaussian random variable in contrast with $n(t)$, which is a gaussian random process.

The variance of $n_o(T)$ was found in Sec. 7.9 [see Eq. (7.9-17)] to be

$$\sigma_o^2 = \overline{n_o^2(T)} = \frac{\eta T}{2\tau^2} \qquad (11.1\text{-}4)$$

and, as noted in Sec. 7.3, $n_o(T)$ has a gaussian probability density.

The output of the integrator, before the sampling switch, is $v_o(t) = s_o(t) + n_o(t)$. As shown in Fig. 11.1-3a, the signal output $s_o(t)$ is a ramp, in each bit interval, of duration T. At the end of the interval the ramp attains the voltage $s_o(T)$ which is $+VT/\tau$ or $-VT/\tau$, depending on whether the bit is a 1 or a 0. At the end of each interval the switch SW_1 in Fig. 11.1-2 closes momentarily to discharge the capacitor so that $s_o(t)$ drops to zero. The noise $n_o(t)$, shown in Fig. 11.1-3b, also starts each interval with $n_o(0) = 0$ and has the random value $n_o(T)$ at the end of each interval. The sampling switch SW_2 closes briefly just before the closing of SW_1 and hence reads the voltage

$$v_o(T) = s_o(T) + n_o(T) \qquad (11.1\text{-}5)$$

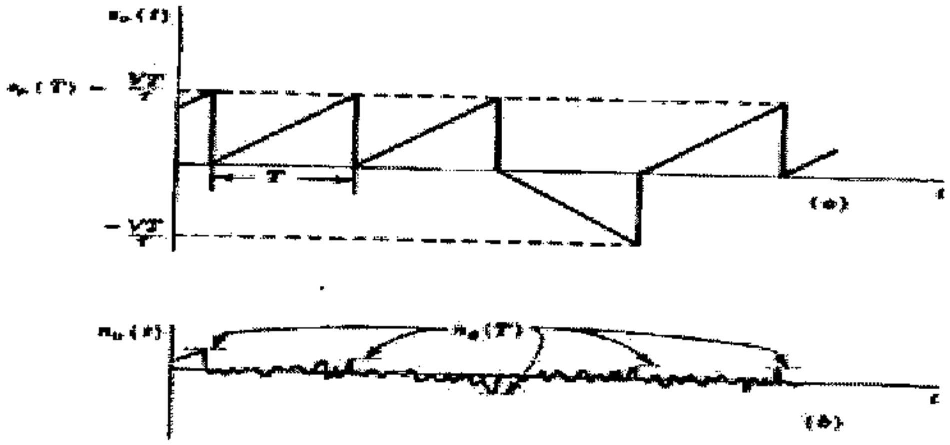


Figure 11.1-3 (a) The signal output and (b) the noise output of the integrator of Fig. 11.1-2.

We would naturally like the output signal voltage to be as large as possible in comparison with the noise voltage. Hence a figure of merit of interest is the signal-to-noise ratio

$$\frac{[s_o(T)]^2}{[n_o(T)]^2} = \frac{2}{\eta} V^2 T \tag{11.1-6}$$

This result is calculated from Eqs. (11.1-2) and (11.1-4). Note that the signal-to-noise ratio increases with increasing bit duration T and that it depends on $V^2 T$ which is the normalized energy of the bit signal. Therefore, a bit represented by a narrow, high amplitude signal and one by a wide, low amplitude signal are equally effective, provided $V^2 T$ is kept constant.

It is instructive to note that the integrator filters the signal and the noise such that the signal voltage increases linearly with time, while the standard deviation (rms value) of the noise increases more slowly, as $\sqrt{T}$. Thus, the integrator enhances the signal relative to the noise, and this enhancement increases with time as shown in Eq. (11.1-6).

PROBABILITY OF ERROR

Since the function of a receiver of a data transmission is to ditinguish the bit 1 from the bit 0 in the presence of noise, a most important charcteristic is the probability that an error will be made in such a determination.we now calculate this error probabilty P_e for the integrate and dump receiver of fig 11.1-2

We have seen that the probability density of the noise sample $n_o(T)$ is gaussian and hence appears as in Fig. 11.2-1. The density is therefore given by

$$f[n_o(T)] = \frac{e^{-n_o^2(T)/2\sigma_o^2}}{\sqrt{2\pi\sigma_o^2}} \tag{11.2-1}$$

where σ_o^2, the variance, is $\sigma_o^2 \equiv \overline{n_o^2(T)}$ given by Eq. (11.1-4). Suppose, then, that during some bit interval the input-signal voltage is held at, say, $-V$. Then, at the sample time, the signal sample voltage is $s_o(T) = -VT/\tau$, while the noise sample is $n_o(T)$. If $n_o(T)$ is positive and larger in magnitude than VT/τ, the total sample voltage $v_o(T) = s_o(T) + n_o(T)$ will be positive. Such a positive sample voltage will result in an error, since as noted earlier, we have instructed the receiver to interpret such a positive sample voltage to mean that the signal voltage was $+V$ during the bit interval. The probability of such a misinterpretation, that is, the probability that $n_o(T) > VT/\tau$, is given by the area of the shaded region in Fig. 11.2-1. The probability of error is, using Eq. (11.2-1),

$$P_e = \int_{VT/\tau}^{\infty} f[n_o(T)]\, dn_o(T) = \int_{VT/\tau}^{\infty} \frac{e^{-n_o^2(T)/2\sigma_o^2}}{\sqrt{2\pi\sigma_o^2}}\, dn_o(T) \tag{11.2-2}$$

Defining $x \equiv n_o(T)/\sqrt{2}\sigma_o$, and using Eq. (11.1-4), Eq. (11.2-2) may be rewritten as

$$P_e = \frac{1}{2}\frac{2}{\sqrt{\pi}}\int_{x=V\sqrt{T/\eta}}^{\infty} e^{-x^2}\, dx$$

$$= \frac{1}{2}\operatorname{erfc}\left(V\sqrt{\frac{T}{\eta}}\right) = \frac{1}{2}\operatorname{erfc}\left(\frac{V^2T}{\eta}\right)^{1/2} = \frac{1}{2}\operatorname{erfc}\left(\frac{E_s}{\eta}\right)^{1/2} \tag{11.2-3}$$

in which $E_s = V^2T$ is the signal energy of a bit.

If the signal voltage were held instead at $+V$ during some bit interval, then it is clear from the symmetry of the situation that the probability of error would again be given by P_e in Eq. (11.2-3). Hence Eq. (11.2-3) gives P_e quite generally.

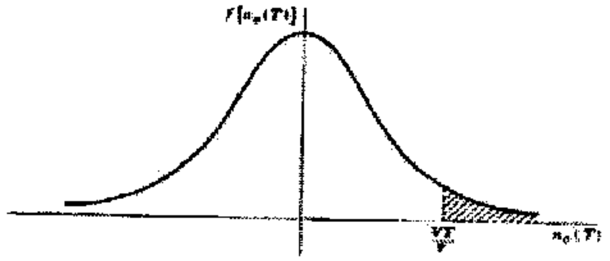


Figure 11.2-1 The gaussian probability density of the noise sample $n_o(T)$.

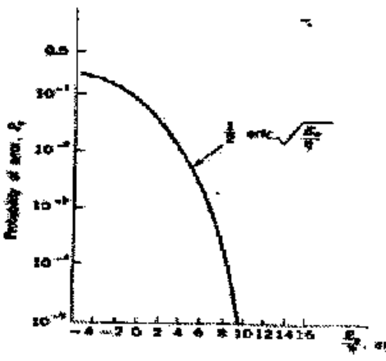


Figure 11.2-2 Variation of P_e versus E_s/η.

The probability of error p_e, as given in eq.(11.2-3),is plotted in fig.11.2-2.note that p_e decreases rapidly as E_s/η increases. The maximum value of p_e is ½.thus ,even if the signal is entirely lost in the noise so that any determination of the receiver is a sheer guess, the receiver cannot bi wrong more than half the time on the average.

THE OPTIMUM FILTER:

In the receiver system of Fig 11.1-2, the signal was passed through a filter(integrator),so that at the sampling time the signal voltage might be emphasized in comparison with the noise voltage. We are naturally led to risk whether the integrator is the optimum filter for the purpose of minimizing the probability of error. We shall find that the received signal contemplated in system of fig 11.1-2 the integrator is indeed the optimum filter. However, before returning specifically to the integrator receiver.

We assume that the received signal is a binary waveform. One binary digit is represented by a signal waveformS_1 (t) which persists for time T, while the4 other bit is represented by the waveform $S_2(t)$ which also lasts for an interval T. For example, in the transmission at baseband, as shown in fig 11.1-2 $S_1(t)=+V$; for other modulation systems, different waveforms are transmitted. for example for PSK signaling , $S_1(t)=A\cos w_0 t$ and $S_2(t)=-A\cos w_0 t$;while for FSK, $S_1(t)=A\cos(w_{0+\Omega})t$.

As shown in Fig. 11.3-1 the input, which is $s_1(t)$ or $s_2(t)$, is corrupted by the addition of noise $n(t)$. The noise is gaussian and has a spectral density $G(f)$. [In most cases of interest the noise is white, so that $G(f) = \eta/2$. However, we shall assume the more general possibility, since it introduces no complication to do so.] The signal and noise are filtered and then sampled at the end of each bit interval. The output sample is either $v_o(T) = s_{o1}(T) + n_o(T)$ or $v_o(T) = s_{o2}(T) + n_o(T)$. We assume that immediately after each sample, every energy-storing element in the filter has been discharged.

We have already considered in Sec. 2.22, the matter of signal determination in the presence of noise. Thus, we note that in the absence of noise the output sample would be $v_o(T) = s_{o1}(T)$ or $s_{o2}(T)$. When noise is present we have shown that to minimize the probability of error one should assume that $s_1(t)$ has been transmitted if $v_o(T)$ is *closer* to $s_{o1}(T)$ than to $s_{o2}(T)$. Similarly, we assume $s_2(t)$ has been transmitted if $v_o(T)$ is *closer* to $s_{o2}(T)$. The decision boundary is therefore midway between $s_{o1}(T)$ and $s_{o2}(T)$. For example, in the baseband system of Fig. 11.1-2, where $s_{o1}(T) = VT/\tau$ and $s_{o2}(T) = -VT/\tau$, the decision boundary is $v_o(T) = 0$. In general, we shall take the decision boundary to be

$$v_o(T) = \frac{s_{o1}(T) + s_{o2}(T)}{2} \qquad (11.3\text{-}1)$$

The probability of error for this general case may be deduced as an extension of the considerations used in the baseband case. Suppose that $s_{o1}(T) > s_{o2}(T)$ and that $s_2(t)$ was transmitted. If, at the sampling time, the noise $n_o(T)$ is positive and larger in magnitude than the voltage difference $\frac{1}{2}[s_{o1}(T) + s_{o2}(T)] - s_{o2}(T)$, an error will have been made. That is, an error [we decide that $s_1(t)$ is transmitted rather than $s_2(t)$] will result if

$$n_o(T) \geq \frac{s_{o1}(T) - s_{o2}(T)}{2} \qquad (11.3\text{-}2)$$

Hence probability of error is

$$P_e = \int_{[s_{o1}(T) - s_{o2}(T)]/2}^{\infty} \frac{e^{-n_o^2(T)/2\sigma_o^2}}{\sqrt{2\pi\sigma_o^2}}\, dn_o(T) \tag{11.3-3}$$

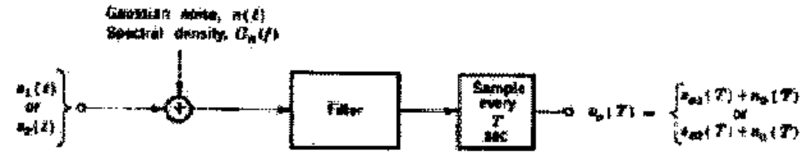


Figure 11.3-1 A receiver for binary coded signalling.

If we make the substitution $x \equiv n_o(T)/\sqrt{2}\sigma_o$, Eq. (11.3-3) becomes

$$P_e = \frac{1}{2}\frac{2}{\sqrt{\pi}}\int_{[s_{o1}(T) - s_{o2}(T)]/2\sqrt{2}\sigma_o}^{\infty} e^{-x^2}\, dx \tag{11.3-4a}$$

$$P_e = \frac{1}{2}\,\mathrm{erfc}\left[\frac{s_{o1}(T) - s_{o2}(T)}{2\sqrt{2}\sigma_o}\right] \tag{11.3-4b}$$

Note that for the case $s_{o1}(T) = VT/\tau$ and $s_{o2}(T) = -VT/\tau$, and, using Eq. (11.1-4), Eq. (11.3-4b) reduces to Eq. (11.2-3) as expected.

The complementary error function is a monotonically decreasing function of its argument. (See Fig. 11.2-2.) Hence, as is to be anticipated, P_e decreases as the difference $s_{o1}(T) - s_{o2}(T)$ becomes larger and as the rms noise voltage σ_o becomes smaller. The optimum filter, then, is the filter which maximizes the ratio

$$\gamma = \frac{s_{o1}(T) - s_{o2}(T)}{\sigma_o} \tag{11.3-5}$$

We now calculate the transfer function $H(f)$ of this optimum filter. As a matter of mathematical convenience we shall actually maximize γ^2 rather than γ.

Calculation of the Optimum-Filter Transfer Function $H(f)$

The fundamental requirement we make of a binary encoded data receiver is that it distinguishes the voltages $s_1(t) + n(t)$ and $s_2(t) + n(t)$. We have seen that the ability of the receiver to do so depends on how large a particular receiver can make γ. It is important to note that γ is proportional not to $s_1(t)$ nor to $s_2(t)$, but rather to the *difference* between them. For example, in the baseband system we represented the signals by voltage levels $+V$ and $-V$. But clearly, if our only interest was in distinguishing levels, we would do just as well to use $+2$ volts and 0 volt, or $+8$ volts and $+6$ volts, etc. (The $+V$ and $-V$ levels, however, have the advantage of requiring the least average power to be transmitted.) Hence, while $s_1(t)$ or $s_2(t)$ is the received signal, the signal which is to be compared with the noise, i.e., the signal which is relevant in all our error-probability calculations, is the difference signal

$$p(t) \equiv s_1(t) - s_2(t) \tag{11.3-6}$$

Thus, for the purpose of calculating the minimum error probability, we shall assume that the input signal to the optimum filter is $p(t)$. The corresponding *output signal* of the filter is then

$$p_o(t) \equiv s_{o1}(t) - s_{o2}(t) \tag{11.3-7}$$

We shall let $P(f)$ and $P_o(f)$ be the Fourier transforms, respectively, of $p(t)$ and $p_o(t)$.

If $H(f)$ is the transfer function of the filter,

$$P_o(f) = H(f)P(f) \tag{11.3-8}$$

and

$$p_o(T) = \int_{-\infty}^{\infty} P_o(f)e^{j2\pi fT}\,df = \int_{-\infty}^{\infty} H(f)P(f)e^{j2\pi fT}\,df \tag{11.3-9}$$

The input noise to the optimum filter is $n(t)$. The output noise is $n_o(t)$ which has a power spectral density $G_{no}(f)$ and is related to the power spectral density of the input noise $G_n(f)$ by

$$G_{no}(f) = |H(f)|^2 G_n(f) \tag{11.3-10}$$

Using Parseval's theorem (Eq. 1.13-5), we find that the normalized output noise power, i.e., the noise variance σ_o^2, is

$$\sigma_o^2 = \int_{-\infty}^{\infty} G_{no}(f)\,df = \int_{-\infty}^{\infty} |H(f)|^2 G_n(f)\,df \tag{11.3-11}$$

From Eqs. (11.3-9) and (11.3-11) we now find that

$$\gamma^2 = \frac{p_o^2(T)}{\sigma_o^2} = \frac{|\int_{-\infty}^{\infty} H(f)P(f)e^{j2\pi Tf}\,df|^2}{\int_{-\infty}^{\infty} |H(f)|^2 G_n(f)\,df} \tag{11.3-12}$$

Equation (11.3-12) is unaltered by the inclusion or deletion of the absolute value sign in the numerator since the quantity within the magnitude sign $p_o(T)$ is a positive real number. The sign has been included, however, in order to allow further development of the equation through the use of the *Schwarz inequality*.

The *Schwarz inequality* states that given arbitrary complex functions $X(f)$ and $Y(f)$ of a common variable f, then

$$\left|\int_{-\infty}^{\infty} X(f)Y(f)\,df\right|^2 \le \int_{-\infty}^{\infty} |X(f)|^2\,df \int_{-\infty}^{\infty} |Y(f)|^2\,df \tag{11.3-13}$$

The equal sign applies when

$$X(f) = K\,Y^*(f) \tag{11.3-14}$$

where K is an arbitrary constant and $Y^*(f)$ is the complex conjugate of $Y(f)$.

We now apply the Schwarz inequality to Eq. (11.3-12) by making the identification

$$X(f) \equiv \sqrt{G_n(f)}\,H(f) \tag{11.3-15}$$

and

$$Y(f) \equiv \frac{1}{\sqrt{G_n(f)}}\,P(f)e^{j2\pi Tf} \tag{11.3-16}$$

Using Eqs. (11.3-15) and (11.3-16) and using the Schwarz inequality, Eq. (11.3-13), we may rewrite Eq. (11.3-12) as

$$\frac{p_o^2(T)}{\sigma_o^2} = \frac{|\int_{-\infty}^{\infty} X(f)Y(f)\,df|^2}{\int_{-\infty}^{\infty} |X(f)|^2\,df} \le \int_{-\infty}^{\infty} |Y(f)|^2\,df \tag{11.3-17}$$

or, using Eq. (11.3-16),

$$\frac{p_o^2(T)}{\sigma_o^2} \leq \int_{-\infty}^{\infty} |Y(f)|^2 \, df = \int_{-\infty}^{\infty} \frac{|P(f)|^2}{G_n(f)} \, df \tag{11.3-18}$$

The ratio $p_o^2(T)/\sigma_o^2$ will attain its maximum value when the equal sign in Eq. (11.3-18) may be employed as is the case when $X(f) = KY^*(f)$. We then find from Eqs. (11.3-15) and (11.3-16) that the optimum filter which yields such a maximum ratio $p_o^2(T)/\sigma_o^2$ has a transfer function

$$H(f) = K \frac{P^*(f)}{G_n(f)} e^{-j2\pi fT} \tag{11.3-19}$$

Correspondingly, the maximum ratio is, from Eq. (11.3-18),

$$\left[\frac{p_o^2(T)}{\sigma_o^2}\right]_{\max} = \int_{-\infty}^{\infty} \frac{|P(f)|^2}{G_n(f)} \, df \tag{11.3-20}$$

In succeeding sections we shall have occasion to apply Eqs. (11.13-19) and (11.13-20) to a number of cases of interest.

11.4 WHITE NOISE: THE MATCHED FILTER

An optimum filter which yields a maximum ratio $p_o^2(T)/\sigma_o^2$ is called a *matched filter* when the input noise is *white*. In this case $G_n(f) = \eta/2$, and Eq. (11.3-19) becomes

$$H(f) = K \frac{P^*(f)}{\eta/2} e^{-j2\pi fT} \tag{11.4-1}$$

The impulsive response of this filter, i.e., the response of the filter to a unit strength impulse applied at $t = 0$, is

$$h(t) = \mathscr{F}^{-1}[H(f)] = \frac{2K}{\eta} \int_{-\infty}^{\infty} P^*(f) e^{-j2\pi fT} e^{j2\pi ft} \, df \tag{11.4-2a}$$

$$= \frac{2K}{\eta} \int_{-\infty}^{\infty} P^*(f) e^{j2\pi f(t-T)} \, df \tag{11.4-2b}$$

A physically realizable filter will have an impulse response which is real, i.e., not complex. Therefore $h(t) = h^*(t)$. Replacing the right-hand member of Eq. (11.4-2b) by its complex conjugate, an operation which leaves the equation unaltered, we have

$$h(t) = \frac{2K}{\eta} \int_{-\infty}^{\infty} P(f) e^{j2\pi f(T-t)} \, df \tag{11.4-3a}$$

$$= \frac{2K}{\eta} p(T-t) \tag{11.4-3b}$$

Finally, since $p(t) \equiv s_1(t) - s_2(t)$ [see Eq. (11.3-6)], we have

$$h(t) = \frac{2K}{\eta} [s_1(T-t) - s_2(T-t)] \tag{11.4-4}$$

The significance of these results for the matched filter may be more readily appreciated by applying them to a specific example. Consider then, as in Fig. 11.4-1*a*, that $s_1(t)$ is a triangular waveform of duration T, while $s_2(t)$, as shown in Fig. 11.4-1*b*, is of identical form except of reversed polarity. Then $p(t)$ is as shown in Fig. 11.4-1*c*, and $p(-t)$ appears in Fig. 11.4-1*d*. The waveform $p(-t)$ is the waveform $p(t)$ rotated around the axis $t = 0$. Finally, the waveform $p(T - t)$ called for as the impulse response of the filter in Eq. (11.4-3*b*) is this rotated waveform $p(-t)$ translated in the positive t direction by amount T. This last translation ensures that $h(t) = 0$ for $t < 0$ as is required for a *causal* filter.

In general, the impulsive response of the matched filter consists of p(t) rotated about t=0 and then delayed long enough(i.e., a time T) to make the filter realizable. We may note in passing, that any additional delay that a filter might introduce would in no way interfere with the performance of the filter ,for both signal and noise would be delayed by the same amount, and at the sampling time (which would need similarity to be delayed)the ratio of signal to noise would remain unaltered.

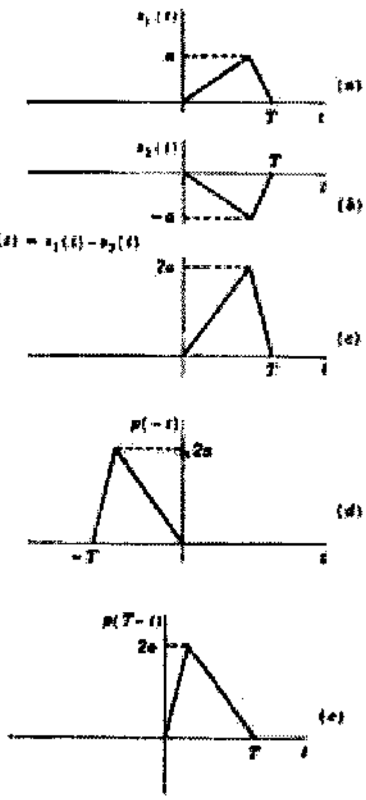


Figure 11.4-1 The signals (a) $s_1(t)$, (b) $s_2(t)$, and (c) $p(t) = s_1(t) - s_2(t)$. (d) $p(t)$ rotated about the axis $t = 0$. (e) The waveform in (d) translated to the right by amount T.

11.5 PROBABILITY OF ERROR OF THE MATCHED FILTER

The probability of error which results when employing a matched filter, may be found by evaluating the maximum signal-to-noise ratio $[p_o^2(T)/\sigma_o^2]_{max}$ given by Eq. (11.3-20). With $G_n(f) = \eta/2$, Eq. (11.3-20) becomes

$$\left[\frac{p_o^2(T)}{\sigma_o^2}\right]_{max} = \frac{2}{\eta}\int_{-\infty}^{\infty} |P(f)|^2 df \qquad (11.5\text{-}1)$$

External
Previous Q&P

Code No: R1631044 **R16** SET - 1

III B. Tech I Semester Supplementary Examinations, May - 2019

DIGITAL COMMUNICATIONS

(Electronics and Communication Engineering)

Time: 3 hours Max. Marks: 70

Note: 1. Question Paper consists of two parts (**Part-A** and **Part-B**)
2. Answer **ALL** the question in **Part-A**
3. Answer any **FOUR** Questions from **Part-B**

PART –A

1. a) Discuss about the different noise effects in Delta Modulation. [2M]
   b) Explain the non-coherent detection of binary FSK signals. [2M]
   c) Compare a correlator and matched filter. [2M]
   d) Calculate the amount of information if binary digits occur with equal likelihood in binary PCM systems. [3M]
   e) What is discrete memory less channels? [3M]
   f) Explain about BCH codes. [2M]

PART -B

2. a) Explain quantization error and derive an expression for maximum SNR in PCM system that uses linear quantization. [7M]
   b) In a binary PCM system, the output signal to quantizing noise ratio is to be held to a minimum value of 40dB. Determine the number of levels and find the corresponding signal to quantizing noise ratio. [7M]

3. a) Explain how integrator is used to detect the baseband signal. Obtain an expression for S/N of integrator and dump receiver. [7M]
   b) Obtain the probability of error for Matched filter. [7M]

4. a) Draw and explain the coherent system of signal reception. [7M]
   b) Binary data is transmitted over a telephone line with usable bandwidth of 2400 Hz using the FSK signaling scheme. The transmit frequencies are 2025 and 2225 Hz, and the data rate is 300 bits/Sec. The average signal to noise power ratio at the output of the channel is 6dB. Calculate Probability of error for the coherent and non coherent demodulation schemes. [7M]

5. a) Explain the concept of entropy and its properties. [7M]
   b) An analog signal band limited to 10kHz is quantized in 8 levels of a PCM system with probabilities of 1/4, 1/5, 1/5, 1/10, 1/10, 1/20, 1/20 and 1/20 respectively. Calculate the entropy and the rate of information. [7M]

6. a) Discuss in brief about continuous channel capacity. [7M]
   b) Calculate the capacity of the discrete channel shown in Fig.1. Assume r_s=1symbol/sec, [7M]

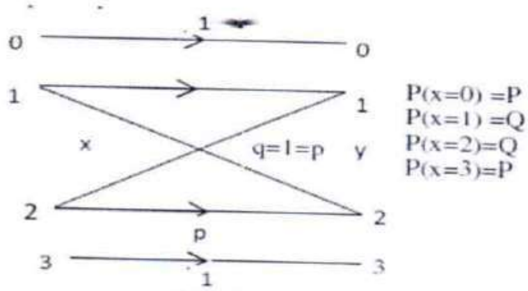


Fig -1

7. a) Explain sequential decoding for convolutional codes. [7M]
   b) Draw the state diagram, tree diagram, and trellis diagram for k=3, rate 1/3 code generated by $g_1(x) = 1+x^2$, $g_2(x) = 1+x$ and $g_3(x) = 1+x+x^2$. [7M]

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III B. Tech I Semester Regular Examinations, October/November - 2018

(Electronics and Communication Engineering)

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PART –A

1. a) What is uniform quantization? [2M]
   b) Draw the block diagram of BPSK demodulator. [2M]
   c) Give the expression for the BER of polar signaling. [2M]
   d) Define source entropy. [3M]
   e) What is the relation between channel capacity, channel bandwidth and S/N? [3M]
   f) Define the code rate of convolutional encoder. [2M]

PART -B

2. a) Derive an expression for mean-square value of quantization error. [7M]
   b) What is aliasing? What causes it? How can it be reduced? [7M]

3. a) Explain the process of generating FSK signals. [7M]
   b) Describe the process of detecting DPSK signals. [7M]

4. Derive an expression for BER of BPSK scheme. [14M]

5. a) A memory less source emits messages m_1 and m_2 with probabilities 0.8 and 0.2, respectively. Find the Huffman binary code for this source. Determine the code efficiency. [7M]
   b) A message source generates one of four messages randomly every microsecond. The probabilities of these messages are 0.4, 0.3, 0.2, and 0.1. Each emitted message is independent of the other messages in the sequence. Find the source entropy. [7M]

6. a) Given a generator matrix $G = [1 \;\; 1 \;\; 1]$. Construct a (3, 1) code. How many errors can this code correct? [7M]
   b) Determine the Hamming bound for a ternary code (whose three code symbols are 0, 1, 2). [7M]

7. a) What is a binary symmetric channel? Write down its transition matrix in terms of p, the transition probability. [7M]
   b) Write notes on syndrome decoding. [7M]

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PART –A

1. a) What is the difference between uniform and non-uniform quantization? [2M]
   b) Draw the ASK waveform for the data 1 1 0 1 0 1 1 0 1 using unipolar signaling. [2M]
   c) Give the expression for BER of coherent BPSK scheme. [2M]
   d) Define information rate. [3M]
   e) Define channel capacity. [3M]
   f) What are the different representations of convolutional encoder? [2M]

PART -B

2. a) Draw the PCM system block diagram and explain its operation. [7M]
   b) A DM system can handle message signals of bandwidth up to 5 kHz and has a sampling rate of 50 kHz. A sinusoidal signal of 1.5 volts peak amplitude and frequency 2 kHz is applied to the system. Determine [7M]
   i) the step-size Δ required to avoid slope overload
   ii) the $(S/N)_q$ for the system for the given sinusoidal signal.

3. a) Explain the process of detection of BPSK signals. [7M]
   b) Is it possible to detect BFSK signals non-coherently? If yes, explain. [7M]

4. Explain why the matched filter is called as an optimum filter. Why the name matched filter? [14M]

5. A memory less source emits six messages with probabilities 0.3, 0.25, 0.15, 0.12, 0.1 and 0.08. Find the Huffman code. Determine its average word length, the efficiency and the redundancy. [14M]

6. a) If G and H are the generator and parity check matrices, respectively, then show that $GH^T = 0$. [7M]
   b) A generator matrix $G = \begin{bmatrix} 1 & 0 & 1 & 1 \\ 0 & 1 & 1 & 0 \end{bmatrix}$ generates a (4,2) code. What is the parity check matrix of this code? [7M]

7. What are the different methods of decoding of convolutional codes? Explain. [14M]

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PART –A

1. a) What is the difference between PCM and DPCM? [2M]
   b) Draw the block diagram of BFSK detector. [2M]
   c) Give the expression for optimum demodulation of DPSK signals. [2M]
   d) Define mutual information. [3M]
   e) Give the transition matrix of binary symmetric channel. [3M]
   f) Draw the state diagram of a convolutional encoder with $k = 1$, $n = 2$ and $r = 1/2$. [2M]

PART -B

2. a) Explain the operation of delta modulator and demodulator. [7M]
   b) With the help of block schematic diagrams of the transmitter and the receiver, explain the working of binary PCM system. [7M]

3. a) For a fixed bit-error probability, comment on the bandwidth efficiencies and the average transmitted power requirements of BPSK and QPSK schemes. [7M]
   b) Draw the power spectrum of BPSK and BFSK signals. [7M]

4. a) Explain the properties of the matched filter. [7M]
   b) What is the need for synchronization in digital communication system? [7M]

5. a) Define the following terms: [7M]
   i) optimal code
   ii) instantaneous code
   iii) average length of a code
   b) A message source generates one of four messages randomly every microsecond. The probabilities of these messages are 0.4, 0.3, 0.2, and 0.1. Each emitted message is independent of the other messages in the sequence. Find the rate of information generated by this source (in bits per second). [7M]

6. a) Find a generator polynomial $g(x)$ for a (7, 4) cyclic code. Determine the code vectors for the data vector: **1010** [7M]
   b) Write notes on syndrome decoding. [7M]

7. Explain the trellis diagram decoding using Viterbi decoding algorithm. [14M]

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2. Answer **ALL** the question in **Part-A**
3. Answer any **FOUR** Questions from **Part-B**

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PART –A

1. a) What is the need for adaptive delta modulation? [2M]
b) Draw the DPSK signal generator block diagram. [2M]
c) Give the expression for BER of QPSK receiver. [2M]
d) A source generates two symbols with probability 0.5 and 0.5. Find the source entropy. [3M]
e) What is binary symmetric channel? [3M]
f) What is the difference between hard-decision decoding and soft-decision decoding? [2M]

PART -B

2. a) Compare PCM and DM systems. [7M]
b) What are the different types of noise in DM system? Explain. [7M]

3. a) Explain the method of detecting BPSK signals. [7M]
b) What are the similarities between BPSK and BFSK signals? [7M]

4. Derive a general expression for probability of error. [14M]

5. a) Define mutual information and list its properties. [7M]
b) Define the following: [7M]
i) Shannon's Source Coding Theorem ii) Channel Capacity

6. a) Find a generator polynomial $g(x)$ for a (7,4) cyclic code, and find code vectors for the data: **0001** [7M]
b) Construct a systematic (7,4) cyclic code using the generator polynomial $g(x) = x^3 + x^2 + 1$ [7M]

7. A convolutional encoder is shown in Figure.1.Draw the state diagram of it. [14M]

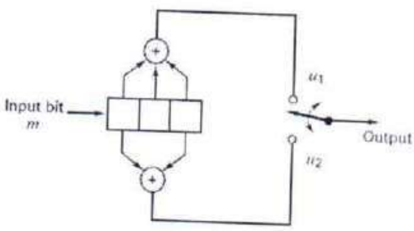

Figure.1

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III B. Tech I Semester Supplementary Examinations, May - 2019
DIGITAL COMMUNICATIONS
(Electronics and Communication Engineering)

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PART –A

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PART -B

2. a) Explain quantization error and derive an expression for maximum SNR in PCM system that uses linear quantization. [7M]
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4. a) Draw and explain the coherent system of signal reception. [7M]
   b) Binary data is transmitted over a telephone line with usable bandwidth of 2400 Hz using the FSK signaling scheme. The transmit frequencies are 2025 and 2225 Hz, and the data rate is 300 bits/Sec. The average signal to noise power ratio at the output of the channel is 6dB. Calculate Probability of error for the coherent and non coherent demodulation schemes. [7M]

5. a) Explain the concept of entropy and its properties. [7M]
   b) An analog signal band limited to 10kHz is quantized in 8 levels of a PCM system with probabilities of 1/4, 1/5, 1/5, 1/10, 1/10, 1/20, 1/20 and 1/20 respectively. Calculate the entropy and the rate of information. [7M]

6. a) Discuss in brief about continuous channel capacity. [7M]
   b) Calculate the capacity of the discrete channel shown in Fig.1. Assume r_s=1symbol/sec, [7M]

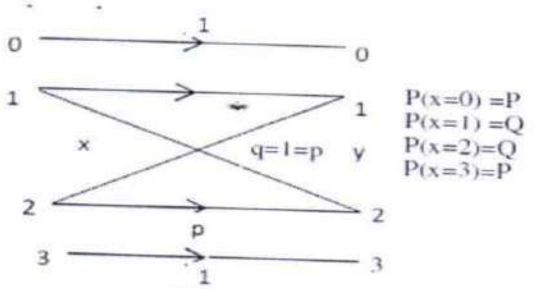

Fig -1

7. a) Explain sequential decoding for convolutional codes. [7M]
   b) Draw the state diagram, tree diagram, and trellis diagram for k=3, rate 1/3 code generated by $g_1(x) = 1+x^2$, $g_2(x) = 1+x$ and $g_3(x) = 1+x+x^2$. [7M]

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Code No: R1631044 **R16** SET - 1

III B. Tech I Semester Regular/Supplementary Examinations, October/November - 2019

DIGITAL COMMUNICATIONS

(Electronics and Communication Engineering)

Time: 3 hours Max. Marks: 70

Note: 1. Question Paper consists of two parts (**Part-A** and **Part-B**)
2. Answer **ALL** the question in **Part-A**
3. Answer any **FOUR** Questions from **Part-B**

PART –A

(14 Marks)

1. a) What is the bandwidth requirement of a PCM system? [2M]
   b) What are the advantages of M-ary Signalling Schemes? [2M]
   c) Distinguish between coherent and non-coherent reception. [2M]
   d) Explain the significance of H(X/Y) of a communication system where, X is the transmitter and Y is the Receiver. [3M]
   e) What is the difference between Channel coding and Source coding? [3M]
   f) Explain the error correction capability of Hamming codes. [2M]

PART –B

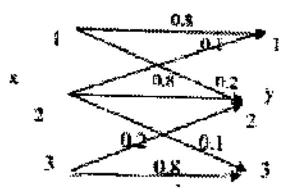
(56 Marks)

2. a) What are the two major sources of noise in a PCM system? Derive the expression for the output signal to quantization noise ratio in PCM. [7M]
   b) A voice frequency signal band limited to 3 MHz is transmitted with the use of the DM system. The pulse repetition frequency is 30,000 pulses per second, and the step size is 40 mV. Determine the maximum possible speech signal amplitude to avoid a slope overload. [7M]

3. a) With a neat sketch, explain the modulation and detection of 8-PSK. [7M]
   b) Compare binary signalling schemes and M-ary Signalling Schemes. [7M]

4. a) Find the probability of error using matched filter. [7M]
   b) Derive the error probability of BFSK modulation system. [7M]

5. a) What are the properties of Entropy and with suitable example, explain the entropy of binary memory less source. [7M]
   b) Find the capacity of the discrete channel shown in following figure: [7M]



r_s=10,000 bits/sec.

6. a) Explain the trade-off between bandwidth and signal to noise ratio. [7M]

   b) A source is transmitting six messages with probability 0.30, 0.25, 0.15, 0.12, 0.10 and 0.08 respectively. [7M]
   i) Find the binary Huffman code.
   ii) Determine its average word length, efficiency and redundancy.

7. a) Prove that a linear block code with a minimum distance d_{min} can correct up to $(d_{min}-1)/2$ errors in each code word, where $(d_{min}-1)/2$ denote the largest integer number greater than $(d_{min}-1)/2$. [7M]

   b) Consider (7, 4) linear code whose generator matrix is [7M]

$$G = \begin{bmatrix} 1 & 0 & 0 & 0 & : & 1 & 0 & 1 \\ 0 & 1 & 0 & 0 & : & 1 & 1 & 1 \\ 0 & 0 & 1 & 0 & : & 1 & 1 & 0 \\ 0 & 0 & 0 & 1 & : & 0 & 1 & 1 \end{bmatrix}$$

   i) Find the minimum weight of this code.
   ii) Prove equation $\mathcal{E}H^T=0$.

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Code No: R1631044 **R16** SET - 2

III B. Tech I Semester Regular/Supplementary Examinations, October/November - 2019

DIGITAL COMMUNICATIONS

(Electronics and Communication Engineering)

Time: 3 hours Max. Marks: 70

Note: 1. Question Paper consists of two parts (**Part-A and Part-B**)
2. Answer **ALL** the question in **Part-A**
3. Answer any **FOUR** Questions from **Part-B**

PART –A (14 Marks)

1. a) What are the different Line coding techniques? [2M]
b) Give the Signal Space representation of QPSK. [2M]
c) What is the significance of Matched Filter? [2M]
d) Calculate the entropy of the source with a symbol set containing 64 symbols each with a probability Pi= 1/64. [3M]
e) What is the trade-off between bandwidth and S/N? [3M]
f) What is the significance of Trellis Diagram? [2M]

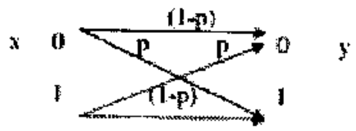
PART –B (56 Marks)

2. a) With a neat sketch explain the principle and operation of Delta Modulation. [7M]
b) Explain the differences between TDM and FDM systems. [7M]

3. a) With a neat sketch, explain the modulation and detection of Differential Phase shift Keying. [7M]
b) Compare QPSK, 16-PSK, QASK and 16-QASK modulation systems. [7M]

4. a) With a neat sketch explain the Base band signal receiver? [7M]
b) Derive the expression for signal to RMS noise ratio for the Base band signal receiver. [7M]

5. a) Define Information rate. A Binary symmetric channel shown in the following figure. Find the rate of information transmission over this channel when p=0.8. Assume that the symbol (or bit) rate is 1000 bits/sec.? [7M]



b) Prove: H(X,Y) = H(X)+ H(Y / X) = H(Y) + H(X / Y). [7M]

6. a) A discrete memory less source has an alphabet of seven symbols with probability for its output as described here: [7M]

Symbol	prob.
S_0	0.25
S_1	0.25
S_2	0.125
S_3	0.125
S_4	0.125
S_5	0.0625
S_6	0.0625

i) Compute the Huffman code for this source and explain why the computed source code has an efficiency of 100 percent?
ii) Calculate H.

b) Find the capacity of a Gaussian channel. [7M]

7. a) Consider a (7,4) linear block code with the parity-check matrix H given by: [7M]

$$H = \begin{bmatrix} 1 & 0 & 1 & 1 & 1 & 0 & 0 \\ 1 & 1 & 0 & 1 & 0 & 1 & 0 \\ 0 & 1 & 1 & 1 & 0 & 0 & 1 \end{bmatrix}$$

Construct code words for this (7, 4) code and show that this code is a Hamming code.

b) With an example, explain the decoding using Viterbi algorithm. [7M]

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Code No: R1631044 **R16** SET - 3

III B. Tech I Semester Regular/Supplementary Examinations, October/November - 2019

DIGITAL COMMUNICATIONS

(Electronics and Communication Engineering)

Time: 3 hours Max. Marks: 70

Note: 1. Question Paper consists of two parts (**Part-A and Part-B**)
2. Answer **ALL** the question in **Part-A**
3. Answer any **FOUR** Questions from **Part-B**

PART -A (14 Marks)

1. a) Give the classifications of Digital communication systems. [2M]
   b) What are the drawbacks of DPSK? [2M]
   c) What is an Optimum Filter? [2M]
   d) What is memory less source? Give one example. [3M]
   e) Give the expression for channel capacity of a Gaussian Channel. [3M]
   f) Distinguish between Linear Codes and Convolutional codes. [2M]

PART -B (56 Marks)

2. a) With a neat sketch explain the principle and operation of PCM. [6M]
   b) The information in an analog signal voltage waveform is to be transmitted over a PCM system in an accuracy of ±0.1% (full scale). The analog voltage waveform has a bandwidth of 100 Hz and an amplitude range of -10 V to +10 V. [8M]
   i) Find the minimum sampling rate required.
   ii) Find the number of bits in each PCM word.
   iii) Minimum bit rate required in the PCM signal.
   iv) Find the minimum absolute channel bandwidth required for the transmission of the PCM signal.

3. a) With a neat sketch, explain the modulation and detection of M-ary QASK. [7M]
   b) Compare 16-ary PSK, 16-ary FSK, and 16-ary QASK in context to error probability and transmission BW. [7M]

4. a) With a neat sketch, explain the non-coherent detection of FSK. [7M]
   b) Find the Probability of error of Integrate and Dump circuit. [7M]

5. a) Explain the following: i) Average Information, ii) Mutual Information. [7M]
   b) Find the relation between the mutual information and the joint entropy of the channel input and channel output. [7M]

6. a) A discrete memory less source has an alphabet of seven symbols with probability for its output as described here: [7M]

Symbol	prob.
S_0	0.25
S_1	0.25
S_2	0.125
S_3	0.125
S_4	0.125
S_5	0.0625
S_6	0.0625

i) Use the Shanon-fano algorithm to develop an efficient code, and
ii) For that code, calculate the average number of bits/message.

b) Write short note on Shannon's theorem and its bound. [7M]

7. a) What is a block-code? Analytically compare the error performance of a block coded system with other codes. [7M]

b) Explain encoding of convolution codes using time domain approach. [7M]

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Code No: R1631044 **R16** SET - 4

III B. Tech I Semester Regular/Supplementary Examinations, October/November - 2019

DIGITAL COMMUNICATIONS

(Electronics and Communication Engineering)

Time: 3 hours Max. Marks: 70

Note: 1. Question Paper consists of two parts (**Part-A** and **Part-B**)
2. Answer **ALL** the question in **Part-A**
3. Answer any **FOUR** Questions from **Part-B**

PART –A **(14 Marks)**

1. a) What are the drawbacks of DM system? [2M]
   b) Define Mark and Space frequencies. [2M]
   c) What is integrator and Dump circuit? [2M]
   d) State the channel coding theorem for a discrete memory less channel. [3M]
   e) State Shannon Hartley theorem. [3M]
   f) Define Linear Codes and Systematic Linear codes. [2M]

PART –B **(56 Marks)**

2. a) With a neat sketch, explain the principle and operation of ADM. [7M]
   b) What is the significance of Companding? Explain μ law companding in detail. [7M]
3. a) With neat sketch, explain the modulation and detection of M-ary FSK. [7M]
   b) What are the draw backs of DPSK and how can they overcome by DEPSK? [7M]
4. a) Find the Probability of error of Optimum Filter. [7M]
   b) Calculate the error probability of BPSK. [7M]
5. a) With examples, explain the concept of amount of information. [7M]
   b) An analog signal band limited to 10 KHz quantize at 8 levels of PCM System with probability of 1/4, 1/5, 1/5, 1/5, 1/10, 1/20,1/20, and 1/20 respectively. Find the entropy and rate of information. [7M]
6. a) An analog signal having 4 kHz bandwidth is sampled at 1.25 times the Nyquist rate and each sample is quantized into one of 256 equally likely levels. Assume that the successive samples are statistically independent: [7M]
   i) Can the output of this source be transmitted without error over an AWGN channel with a bandwidth of 10k Hz and S/N ratio of 20dB?
   ii) Find the S/N ratio required for error free transmission for part (i)
   iii) Find the bandwidth required for an AWGN channel for error free transmission of the output of this source if the S/N ratio is 20dB.
   b) Define mutual information and equivocation in transmission of information. Describe Shannon-Hartley law. [7M]
7. a) Consider (7, 4) linear code whose generator matrix is [7M]

$$G = \begin{bmatrix} 1 & 0 & 0 & 0 & : & 1 & 0 & 1 \\ 0 & 1 & 0 & 0 & : & 1 & 1 & 1 \\ 0 & 0 & 1 & 0 & : & 1 & 1 & 0 \\ 0 & 0 & 0 & 1 & : & 0 & 1 & 1 \end{bmatrix}$$

   i) Find all code vectors of this code, ii) Find the parity check matrix for this code.
   b) Write short notes on BCH Codes. [7M]

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Code No: R1631044 **R16** SET - 1

III B. Tech I Semester Regular Examinations, October/November - 2018

DIGITAL COMMUNICATIONS

(Electronics and Communication Engineering)

Time: 3 hours Max. Marks: 70

Note: 1. Question Paper consists of two parts (**Part-A** and **Part-B**)
2. Answer ALL the question in **Part-A**
3. Answer any FOUR Questions from **Part-B**

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PART –A

1. a) What is uniform quantization? [2M]
   b) Draw the block diagram of BPSK demodulator. [2M]
   c) Give the expression for the BER of polar signaling. [2M]
   d) Define source entropy. [3M]
   e) What is the relation between channel capacity, channel bandwidth and S/N? [3M]
   f) Define the code rate of convolutional encoder. [2M]

PART -B

2. a) Derive an expression for mean-square value of quantization error. [7M]
   b) What is aliasing? What causes it? How can it be reduced? [7M]

3. a) Explain the process of generating FSK signals. [7M]
   b) Describe the process of detecting DPSK signals. [7M]

4. Derive an expression for BER of BPSK scheme. [14M]

5. a) A memory less source emits messages m_1 and m_2 with probabilities 0.8 and 0.2, respectively. Find the Huffman binary code for this source. Determine the code efficiency. [7M]
   b) A message source generates one of four messages randomly every microsecond. The probabilities of these messages are 0.4, 0.3, 0.2, and 0.1. Each emitted message is independent of the other messages in the sequence. Find the source entropy. [7M]

6. a) Given a generator matrix $G = [1\ 1\ 1]$. Construct a (3, 1) code. How many errors can this code correct? [7M]
   b) Determine the Hamming bound for a ternary code (whose three code symbols are 0, 1, 2). [7M]

7. a) What is a binary symmetric channel? Write down its transition matrix in terms of p, the transition probability. [7M]
   b) Write notes on syndrome decoding. [7M]

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Code No: R1631044 **R16** SET - 2

III B. Tech I Semester Regular Examinations, October/November - 2018

DIGITAL COMMUNICATIONS

(Electronics and Communication Engineering)

Time: 3 hours Max. Marks: 70

Note: 1. Question Paper consists of two parts (**Part-A** and **Part-B**)
2. Answer ALL the question in **Part-A**
3. Answer any FOUR Questions from **Part-B**

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PART –A

1. a) What is the difference between uniform and non-uniform quantization? [2M]
   b) Draw the ASK waveform for the data 1 1 0 1 0 1 1 0 1 using unipolar signaling. [2M]
   c) Give the expression for BER of coherent BPSK scheme. [2M]
   d) Define information rate. [3M]
   e) Define channel capacity. [3M]
   f) What are the different representations of convolutional encoder? [2M]

PART -B

2. a) Draw the PCM system block diagram and explain its operation. [7M]
   b) A DM system can handle message signals of bandwidth up to 5 kHz and has a sampling rate of 50 kHz. A sinusoidal signal of 1.5 volts peak amplitude and frequency 2 kHz is applied to the system. Determine [7M]
   i) the step-size Δ required to avoid slope overload
   ii) the $(S/N)_q$ for the system for the given sinusoidal signal.

3. a) Explain the process of detection of BPSK signals. [7M]
   b) Is it possible to detect BFSK signals non-coherently? If yes, explain. [7M]

4. Explain why the matched filter is called as an optimum filter. Why the name matched filter? [14M]

5. A memory less source emits six messages with probabilities 0.3, 0.25, 0.15, 0.12, 0.1 and 0.08. Find the Huffman code. Determine its average word length, the efficiency and the redundancy. [14M]

6. a) If G and H are the generator and parity check matrices, respectively, then show that $GH^T = 0$. [7M]
   b) A generator matrix $G = \begin{bmatrix} 1 & 0 & 1 & 1 \\ 0 & 1 & 1 & 0 \end{bmatrix}$ generates a (4,2) code. What is the parity check matrix of this code? [7M]

7. What are the different methods of decoding of convolutional codes? Explain. [14M]

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Code No: R1631044 **R16** SET - 3

III B. Tech I Semester Regular Examinations, October/November - 2018

DIGITAL COMMUNICATIONS

(Electronics and Communication Engineering)

Time: 3 hours Max. Marks: 70

Note: 1. Question Paper consists of two parts (**Part-A** and **Part-B**)
2. Answer ALL the question in **Part-A**
3. Answer any FOUR Questions from **Part-B**

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PART –A

1. a) What is the difference between PCM and DPCM? [2M]
   b) Draw the block diagram of BFSK detector. [2M]
   c) Give the expression for optimum demodulation of DPSK signals. [2M]
   d) Define mutual information. [3M]
   e) Give the transition matrix of binary symmetric channel. [3M]
   f) Draw the state diagram of a convolutional encoder with $k = 1,\ n = 2$ and $r = 1/2$. [2M]

PART -B

2. a) Explain the operation of delta modulator and demodulator. [7M]
   b) With the help of block schematic diagrams of the transmitter and the receiver, explain the working of binary PCM system. [7M]

3. a) For a fixed bit-error probability, comment on the bandwidth efficiencies and the average transmitted power requirements of BPSK and QPSK schemes. [7M]
   b) Draw the power spectrum of BPSK and BFSK signals. [7M]

4. a) Explain the properties of the matched filter. [7M]
   b) What is the need for synchronization in digital communication system? [7M]

5. a) Define the following terms: [7M]
   i) optimal code
   ii) instantaneous code
   iii) average length of a code
   b) A message source generates one of four messages randomly every microsecond. The probabilities of these messages are 0.4, 0.3, 0.2, and 0.1. Each emitted message is independent of the other messages in the sequence. Find the rate of information generated by this source (in bits per second). [7M]

6. a) Find a generator polynomial $g(x)$ for a (7, 4) cyclic code. Determine the code vectors for the data vector [illegible] [7M]
   b) Write notes on syndrome decoding. [7M]

7. Explain the trellis diagram for decoding using Viterbi decoding algorithm. [14M]

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Code No: R1631044 **R16** SET - 4

III B. Tech I Semester Regular Examinations, October/November - 2018

DIGITAL COMMUNICATIONS

(Electronics and Communication Engineering)

Time: 3 hours Max. Marks: 70

Note: 1. Question paper consists of two parts (**Part-A** and **Part-B**)
2. Answer ALL the question in **Part-A**
3. Answer any FOUR Questions from **Part-B**

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PART –A

1.	a)	What is the need for adaptive delta modulation?	[2M]
	b)	Draw the DPSK signal generator block diagram.	[2M]
	c)	Give the expression for BER of QPSK receiver.	[2M]
	d)	A source generates two symbols with probability 0.5 and 0.5. Find the source entropy.	[3M]
	e)	What is binary symmetric channel?	[3M]
	f)	What is the difference between hard-decision decoding and soft-decision decoding?	[2M]

PART -B

2.	a)	Compare PCM and DM systems.	[7M]
	b)	What are the different types of noise in DM system? Explain.	[7M]
3.	a)	Explain the method of detecting BPSK signals.	[7M]
	b)	What are the similarities between BPSK and BFSK signals?	[7M]
4.		Derive a general expression for probability of error.	[14M]
5.	a)	Define mutual information and list its properties.	[7M]
	b)	Define the following: i) Shannon's Source Coding Theorem ii) Channel Capacity	[7M]
6.	a)	Find a generator polynomial $g(x)$ for a (7,4) cyclic code, and find code vectors for the data: **0001**	[7M]
	b)	Construct a systematic (7,4) cyclic code using the generator polynomial $g(x) = x^3 + x^2 + 1$	[7M]
7.		A convolutional encoder is shown in Figure.1.Draw the state diagram of it.	[14M]

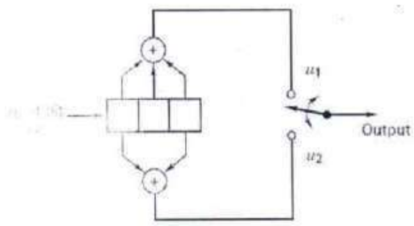

Figure.1

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Code No: R1631044 **R16** SET - 1

III B. Tech I Semester Supplementary Examinations, October/November - 2020

DIGITAL COMMUNICATIONS

(Electronics and Communication Engineering)

Time: 3 hours Max. Marks: 70

Note: 1. Question Paper consists of two parts (**Part-A** and **Part-B**)
2. Answer **ALL** the question in **Part-A**
3. Answer any **FOUR** Questions from **Part-B**

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PART –A **(14 Marks)**

1. a) Discuss the different noise effects in Delta Modulation. [2M]
   b) Explain the non-coherent detection of binary FSK signals. [2M]
   c) Compare a correlator and matched filter. [2M]
   d) Calculate the amount of information if binary digits occur with an equal likelihood in binary PCM systems. [3M]
   e) What are discrete memoryless channels? [3M]
   f) Explain about BCH codes. [2M]

PART –B **(56 Marks)**

2. a) Explain quantization error and derive an expression for maximum SNR in a PCM system that uses linear quantization. [7M]
   b) In a binary PCM system, the output signal to quantizing noise ratio is to be held to a minimum value of 40dB. Determine the number of levels and find the corresponding signal to quantizing noise ratio. [7M]

3. a) Explain how the integrator is used to detect the baseband signal? Obtain an expression for S/N of integrator and dump receiver. [7M]
   b) Obtain the probability of error for a Matched filter. [7M]

4. a) Draw and explain the coherent system of signal reception. [7M]
   b) Binary data is transmitted over a telephone line with a usable bandwidth of 2400 Hz using the FSK signaling scheme. The transmit frequencies are 2025 Hz and 2225 Hz, and the data rate is 300 bits/sec. The average signal to noise power ratio at the output of the channel is 6 dB. Calculate the Probability of error for the coherent and non-coherent demodulation schemes. [7M]

5. a) Explain the concept of entropy and its properties. [7M]
   b) An analog signal band-limited to 10 kHz is quantized in 8 levels of a PCM system with probabilities of 1/4, f/5, 1/5, 1/10, 1/10, 1/20, 1/20, and 1/20 respectively. Calculate the entropy and the rate of information. [7M]
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6. a) Discuss in brief about continuous channel capacity. [7M]
   b) Calculate the capacity of the discrete channel shown in Fig.1. Assume r_s=1 symbol/sec. [7M]

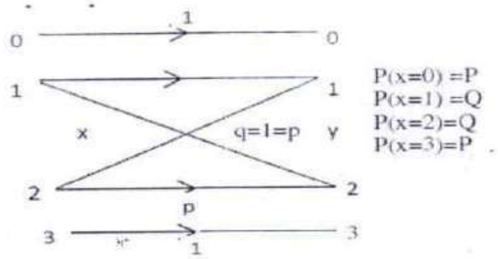

Fig -1

7. a) Explain the sequential decoding of convolutional codes with one example. [7M]
   b) Draw the state diagram, tree diagram, and trellis diagram for k=3, rate 1/3 code generated by $g_1(x) = 1+x^2$, $g_2(x) = 1+x$ and $g_3(x) = 1+x+x^2$. [7M]

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Code No: R1631044 **R16** SET - 1

III B. Tech I Semester Regular/Supplementary Examinations, October/November - 2019

DIGITAL COMMUNICATIONS

(Electronics and Communication Engineering)

Time: 3 hours Max. Marks: 70

Note: 1. Question Paper consists of two parts (**Part-A** and **Part-B)**
2. Answer **ALL** the question in **Part-A**
3. Answer any **FOUR** Questions from **Part-B**

PART –A (14 Marks)

1. a) What is the bandwidth requirement of a PCM system? [2M]
b) What are the advantages of M-ary Signalling Schemes? [2M]
c) Distinguish between coherent and non-coherent reception. [2M]
d) Explain the significance of H(X/Y) of a communication system where, X is the transmitter and Y is the Receiver. [3M]
e) What is the difference between Channel coding and Source coding? [3M]
f) Explain the error correction capability of Hamming codes. [2M]

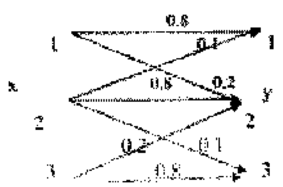
PART –B (56 Marks)

2. a) What are the two major sources of noise in a PCM system? Derive the expression for the output signal to quantization noise ratio in PCM. [7M]
b) A voice frequency signal band limited to 3 MHz is transmitted with the use of the DM system. The pulse repetition frequency is 30,000 pulses per second, and the step size is 40 mV. Determine the maximum possible speech signal amplitude to avoid a slope overload. [7M]

3. a) With a neat sketch, explain the modulation and detection of 8-PSK. [7M]
b) Compare binary signalling schemes and M-ary Signalling Schemes. [7M]

4. a) Find the probability of error using matched filter. [7M]
b) Derive the error probability of BFSK modulation system. [7M]

5. a) What are the properties of Entropy and with suitable example, explain the entropy of binary memory less source. [7M]
b) Find the capacity of the discrete channel shown in following figure: [7M]



r_s=10,000 bits/sec.

6. a) Explain the trade-off between bandwidth and signal to noise ratio. [7M]

b) A source is transmitting six messages with probability 0.30, 0.25, 0.15, 0.12, 0.10 and 0.08 respectively. [7M]
i) Find the binary Huffman code.
ii) Determine its average word length, efficiency and redundancy.

7. a) Prove that a linear block code with a minimum distance d_{min} can correct up to $(d_{min}-1)/2$ errors in each code word, where $(d_{min}-1)/2$ denote the largest integer number greater than $(d_{min}-1)/2$. [7M]

b) Consider (7, 4) linear code whose generator matrix is [7M]

$$G = \begin{bmatrix} 1 & 0 & 0 & 0 & : & 1 & 0 & 1 \\ 0 & 1 & 0 & 0 & : & 1 & 1 & 1 \\ 0 & 0 & 1 & 0 & : & 1 & 1 & 0 \\ 0 & 0 & 0 & 1 & : & 0 & 1 & 1 \end{bmatrix}$$

i) Find the minimum weight of this code.
ii) Prove equation $\mathcal{E}H^T=0$.

*****

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Code No: R1631044 **R16** SET - 2

III B. Tech I Semester Regular/Supplementary Examinations, October/November - 2019

DIGITAL COMMUNICATIONS

(Electronics and Communication Engineering)

Time: 3 hours Max. Marks: 70

Note: 1. Question Paper consists of two parts (**Part-A** and **Part-B**)
2. Answer **ALL** the question in **Part-A**
3. Answer any **FOUR** Questions from **Part-B**

PART –A (14 Marks)

1\. a) What are the different Line coding techniques? [2M]
b) Give the Signal Space representation of QPSK. [2M]
c) What is the significance of Matched Filter? [2M]
d) Calculate the entropy of the source with a symbol set containing 64 symbols each with a probability Pi= 1/64. [3M]
e) What is the trade-off between bandwidth and S/N? [3M]
f) What is the significance of Trellis Diagram? [2M]

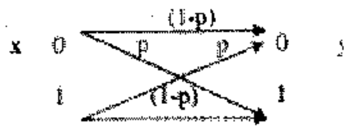
PART –B (56 Marks)

2\. a) With a neat sketch explain the principle and operation of Delta Modulation. [7M]
b) Explain the differences between TDM and FDM systems. [7M]

3\. a) With a neat sketch, explain the modulation and detection of Differential Phase shift Keying. [7M]
b) Compare QPSK, 16-PSK, QASK and 16-QASK modulation systems. [7M]

4\. a) With a neat sketch explain the Base band signal receiver? [7M]
b) Derive the expression for signal to RMS noise ratio for the Base band signal receiver. [7M]

5\. a) Define Information rate. A Binary symmetric channel shown in the following figure. Find the rate of information transmission over this channel when p=0.8. Assume that the symbol (or bit) rate is 1000 bits/sec.? [7M]



b) Prove: H(X,Y) = H(X)+ H(Y / X) = H(Y) + H(X / Y). [7M]

6\. a) A discrete memory less source has an alphabet of seven symbols with probability for its output as described here: [7M]

Symbol	prob.
S_0	0.25
S_1	0.25
S_2	0.125
S_3	0.125
S_4	0.125
S_5	0.0625
S_6	0.0625

i) Compute the Huffman code for this source and explain why the computed source code has an efficiency of 100 percent?

ii) Calculate H.

b) Find the capacity of a Gaussian channel. [7M]

7\. a) Consider a (7,4) linear block code with the parity-check matrix H given by: [7M]

$$H = \begin{bmatrix} 1 & 0 & 1 & 1 & 1 & 0 & 0 \\ 1 & 1 & 0 & 1 & 0 & 1 & 0 \\ 0 & 1 & 1 & 1 & 0 & 0 & 1 \end{bmatrix}$$

Construct code words for this (7, 4) code and show that this code is a Hamming code.

b) With an example, explain the decoding using Viterbi algorithm. [7M]

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Code No: R1631044 **R16** SET - 3

III B. Tech I Semester Regular/Supplementary Examinations, October/November - 2019

DIGITAL COMMUNICATIONS

(Electronics and Communication Engineering)

Time: 3 hours Max. Marks: 70

Note: 1. Question Paper consists of two parts (**Part-A** and **Part-B**)
2. Answer **ALL** the question in **Part-A**
3. Answer any **FOUR** Questions from **Part-B**

PART –A **(14 Marks)**

1. a) Give the classifications of Digital communication systems. [2M]
   b) What are the drawbacks of DPSK? [2M]
   c) What is an Optimum Filter? [2M]
   d) What is memory less source? Give one example. [3M]
   e) Give the expression for channel capacity of a Gaussian Channel. [3M]
   f) Distinguish between Linear Codes and Convolutional codes. [2M]

PART –B **(56 Marks)**

2. a) With a neat sketch explain the principle and operation of PCM. [6M]
   b) The information in an analog signal voltage waveform is to be transmitted over a PCM system in an accuracy of ±0.1% (full scale). The analog voltage waveform has a bandwidth of 100 Hz and an amplitude range of -10 V to +10 V. [8M]
   i) Find the minimum sampling rate required.
   ii) Find the number of bits in each PCM word.
   iii) Minimum bit rate required in the PCM signal.
   iv) Find the minimum absolute channel bandwidth required for the transmission of the PCM signal.

3. a) With a neat sketch, explain the modulation and detection of M-ary QASK. [7M]
   b) Compare 16-ary PSK, 16-ary FSK, and 16-ary QASK in context to error probability and transmission BW. [7M]

4. a) With a neat sketch, explain the non-coherent detection of FSK. [7M]
   b) Find the Probability of error of Integrate and Dump circuit. [7M]

5. a) Explain the following: i) Average Information, ii) Mutual Information. [7M]
   b) Find the relation between the mutual information and the joint entropy of the channel input and channel output. [7M]

6\. a) A discrete memory less source has an alphabet of seven symbols with probability for its output as described here: [7M]

Symbol	prob.
S_0	0.25
S_1	0.25
S_2	0.125
S_3	0.125
S_4	0.125
S_5	0.0625
S_6	0.0625

i) Use the Shanon-fano algorithm to develop an efficient code, and
ii) For that code, calculate the average number of bits/message.

b) Write short note on Shannon's theorem and its bound. [7M]

7\. a) What is a block-code? Analytically compare the error performance of a block coded system with other codes. [7M]

b) Explain encoding of convolution codes using time domain approach. [7M]

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Code No: R1631044 **R16** SET - 4

III B. Tech I Semester Regular/Supplementary Examinations, October/November - 2019

DIGITAL COMMUNICATIONS

(Electronics and Communication Engineering)

Time: 3 hours Max. Marks: 70

Note: 1. Question Paper consists of two parts (**Part-A** and **Part-B)**
2. Answer **ALL** the question in **Part-A**
3. Answer any **FOUR** Questions from **Part-B**

PART –A **(14 Marks)**

1. a) What are the drawbacks of DM system? [2M]
   b) Define Mark and Space frequencies. [2M]
   c) What is integrator and Dump circuit? [2M]
   d) State the channel coding theorem for a discrete memory less channel. [3M]
   e) State Shannon Hartley theorem. [3M]
   f) Define Linear Codes and Systematic Linear codes. [2M]

PART –B **(56 Marks)**

2. a) With a neat sketch, explain the principle and operation of ADM. [7M]
   b) What is the significance of Companding? Explain μ law companding in detail. [7M]

3. a) With neat sketch, explain the modulation and detection of M-ary FSK. [7M]
   b) What are the draw backs of DPSK and how can they overcome by DEPSK? [7M]

4. a) Find the Probability of error of Optimum Filter. [7M]
   b) Calculate the error probability of BPSK. [7M]

5. a) With examples, explain the concept of amount of information. [7M]
   b) An analog signal band limited to 10 KHz quantize at 8 levels of PCM System with probability of 1/4, 1/5, 1/5, 1/5, 1/10, 1/20,1/20, and 1/20 respectively. Find the entropy and rate of information. [7M]

6. a) An analog signal having 4 kHz bandwidth is sampled at 1.25 times the Nyquist rate and each sample is quantized into one of 256 equally likely levels. Assume that the successive samples are statistically independent: [7M]
   i) Can the output of this source be transmitted without error over an AWGN channel with a bandwidth of 10k Hz and S/N ratio of 20dB?
   ii) Find the S/N ratio required for error free transmission for part (i)
   iii) Find the bandwidth required for an AWGN channel for error free transmission of the output of this source if the S/N ratio is 20dB.
   b) Define mutual information and equivocation in transmission of information. Describe Shannon-Hartley law. [7M]

7. a) Consider (7, 4) linear code whose generator matrix is [7M]

$$G = \begin{bmatrix} 1 & 0 & 0 & 0 & \vdots & 1 & 0 & 1 \\ 0 & 1 & 0 & 0 & \vdots & 1 & 1 & 1 \\ 0 & 0 & 1 & 0 & \vdots & 1 & 1 & 0 \\ 0 & 0 & 0 & 1 & \vdots & 0 & 1 & 1 \end{bmatrix}$$

   i) Find all code vectors of this code, ii) Find the parity check matrix for this code.
   b) Write short notes on BCH Codes. [7M]

*****

Code No: R1631044 **R16** SET - 1

III B. Tech I Semester Supplementary Examinations, May - 2019

DIGITAL COMMUNICATIONS

(Electronics and Communication Engineering)

Time: 3 hours Max. Marks: 70

Note: 1. Question Paper consists of two parts (**Part-A** and **Part-B**)
2. Answer **ALL** the question in **Part-A**
3. Answer any **FOUR** Questions from **Part-B**

PART –A

1. a) Discuss about the different noise effects in Delta Modulation. [2M]
   b) Explain the non-coherent detection of binary FSK signals. [2M]
   c) Compare a correlator and matched filter. [2M]
   d) Calculate the amount of information if binary digits occur with equal likelihood in binary PCM systems. [3M]
   e) What is discrete memory less channels? [3M]
   f) Explain about BCH codes. [2M]

PART -B

2. a) Explain quantization error and derive an expression for maximum SNR in PCM system that uses linear quantization. [7M]
   b) In a binary PCM system, the output signal to quantizing noise ratio is to be held to a minimum value of 40dB. Determine the number of levels and find the corresponding signal to quantizing noise ratio. [7M]

3. a) Explain how integrator is used to detect the baseband signal. Obtain an expression for S/N of integrator and dump receiver. [7M]
   b) Obtain the probability of error for Matched filter. [7M]

4. a) Draw and explain the coherent system of signal reception. [7M]
   b) Binary data is transmitted over a telephone line with usable bandwidth of 2400 Hz using the FSK signaling scheme. The transmit frequencies are 2025 and 2225 Hz, and the data rate is 300 bits/Sec. The average signal to noise power ratio at the output of the channel is 6dB. Calculate Probability of error for the coherent and non coherent demodulation schemes. [7M]

5. a) Explain the concept of entropy and its properties. [7M]
   b) An analog signal band limited to 10kHz is quantized in 8 levels of a PCM system with probabilities of 1/4, 1/5, 1/5, 1/10, 1/10, 1/20, 1/20 and 1/20 respectively. Calculate the entropy and the rate of information. [7M]

6. a) Discuss in brief about continuous channel capacity. [7M]

   b) Calculate the capacity of the discrete channel shown in Fig.1. Assume r_s=1symbol/sec, [7M]

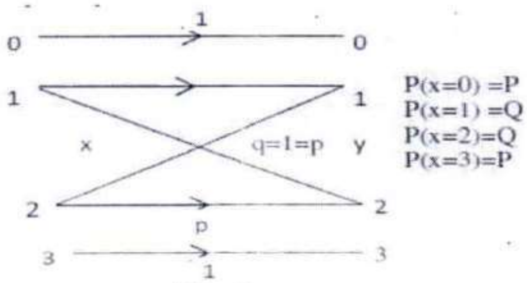

Fig -1

7. a) Explain sequential decoding for convolutional codes. [7M]

   b) Draw the state diagram, tree diagram, and trellis diagram for k=3, rate 1/3 code generated by $g_1(x) = 1+x^2$, $g_2(x) = 1+x$ and $g_3(x) = 1+x+x^2$. [7M]

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Question Bank

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DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

ESTD : 2008

A.Y.: 2022-23

Date: 17-12-2022

Subject Code	C304
Subject Name	Digital Communications
Regulation	R20
Year & Sem	III & I
Academic Year	2022-23

DC Question bank

1. What are the disadvantages of uniform quantization over the non-uniform quantization? Explain.
2. Explain delta modulation in detail with suitable diagram.
3. What is the necessity of non-uniform quantization and explain companding.
4. What is slope overload distortion and granular noise in Delta Modulation? How is it removed in ADM?
5. Derive the expression for Signal to Quantization Noise ratio in PCM.
6. Explain μ - law and A - law companding techniques in detail.
7. Derive the expression for signal to noise ratio of PCM system?
8. Derive the expression for Signal to Quantization noise ratio in Delta modulation. Discuss about Granular noise and slope overload error in Delta modulation.
9. Explain the advantages of digital communication systems.
10. What is Delta modulation? Discuss different types of noise effects in delta modulation with waveforms.
11. Describe the process of uniform and non uniform type quantization and derive an expression for signal to quantization noise ratio.

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12. Given a sine wave of frequency fm and amplitude Am applied to a delta modulator having step size Δ. Find the condition on Am for which slope overload distortion will occur.

13. Consider a DM system designed to accommodate analog message signals limited to a bandwidth w=5KHz. A sinusoidal test signal of amplitude A=1 volt and frequency fm=1KHz is applied to the system. The sampling rate of the system is 50KHz.
    (i) Calculate the step size required to minimize slope overload.
    (ii) Calculate the signal to quantization noise ratio of the system for the specified sinusoidal test signal.

14. A DM system is designed to operate at three times the Nyquist rate for a signal with 3 KHz bandwidth. The quantizing step size is 250 mV
    i) Determine the maximum amplitude of a 1 KHz input sinusoid for which the delta modulator does not show slope overload
    ii) Determine the post filtered output SNR for the signal of part (i)

15. A television (TV) signal with a bandwidth of 4.2 MHz is transmitted using binary PCM. The number of representation levels is 512. Calculate the following parameters. (i) The code word length (ii) The final bit rate (ii) The transmission bandwidth, assume that k=2.

16. The input to a DM is m(t)=0.01t. The DM operates at a sampling frequency of 20 Hz and has a step size of 2 mV. Sketch the Delta modulator output.

17. In a binary PCM system, the output signal to quantizing noise ratio is to be held to a minimum value of 40dB. Determine the number of levels and find the corresponding signal to quantizing noise ratio.

18. A speech signal of maximum frequency 3.4KHz is applied to a delta modulator whose bit rate is 20Kbps. Determine minimum step size for the delta modulation so that there is no slope overload.

19. If mp = 20V and 256 quantizing levels are employed, what is the voltage between levels when there is no compression? For μ = 255, what is the smallest and what is the largest effective separation between levels?

20. Determine the bandwidth required for M-ary FSK system. Draw the geometrical representation of M-ary FSK signals and find out the distance between the signals.

21. What are power spectra? Explain power spectra of BPSK and BFSK signals along with graphs.

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22. Explain with neat block diagram the generation and recovery of BPSK.

23. Explain the generation of M-ary ASK with a neat block diagram.

24. Explain the principle of QPSK system. Compare binary PSK and QPSK schemes.

25. Draw the block diagram of DPSK modulator and explain how synchronization problem is avoided for its detection.

26. Sketch the QPSK waveform for the sequence 1101010010, assuming the carrier frequency equal to bit rate.

27. Write the power spectral density of BPSK and QPSK signals and draw the power spectrum of each.

28. Explain the generation and reception of DPSK signal with example.

29. Explain with neat block diagram the generation and recover of BPSK.

30. Explain BFSK modulation in detail. Draw signal space representation and PSD of BFSK.

31. Sketch the QPSK waveform for binary data 11100100. Draw Geometrical representation of QPSK. Compare QPSK with BPSK with respect to bandwidth and Probability of error

32. Explain the Generation and Detection of QPSK Signals with the help of Block Diagram and mathematical descriptions.

33. Explain in detail about DEPSK with necessary Block diagram and compare DPSK and DEPSK.

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34. The binary sequence 1100100010 is applied to DPSK transmitter. i) Sketch the resulting waveform at the transmitter output. ii) Applying this waveform to the DPSK receiver show that the original binary sequence is reconstructed in the receiver output.

35. Explain QPSK modulation in detail with relevant waveforms.

36. Explain the working of BPSK modulation and Demodulation

37. Explain the principle of binary phase shift keying.

38. Name different modulation techniques and explain which technique is good for digital modulation.

39. Explain non-coherent detection methods of binary frequency shift keying scheme.

40. Draw and explain the coherent system of signal reception.

41. Binary data is transmitted over a telephone line with usable bandwidth of 2400 Hz using the FSK signaling scheme. The transmit frequencies are 2025 and 2225 Hz, and the data rate is 300 bits/Sec. The average signal to noise power ratio at the output of the channel is 6dB. Calculate Pe for the coherent and non coherent demodulation schemes.

42. Explain about ASK system and derive the relation for error probability of binary ASK.

43. A binary receiver system receives a bit rate of 1Mbps. The waveform amplitude is 5mV and the noise power spectral density is 0.5x10-11 W/Hz. Calculate the average bit error probability if the modulation schemes are ASK, FSK and PSK.

44. Explain about coherent binary PSK transmitter and receiver. Assuming channel noise to be additive white Gaussian obtain expression for probability of error.

45. Calculate the transfer function of the Optimum filter.

46. What is matched filter? How it differs from optimum filter? Derive an expression for impulse response of matched filter

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47. In a binary PCM system on/off signaling is used. The matched filter receiver is used for detection of signal. Calculate the probability of error if signaling rate is doubled.

48. Calculate the probability of error for BFSK and BPSK.

49. Derive the expression for transfer function of the Optimum filter.

50. Explain the significance of Baseband receiver? Derive the expression for probability of error in case of Baseband receiver.

51. Derive the expression for maximum signal to noise ratio in case of optimum filter

52. Compare baseband and passband modulation techniques.

53. Explain the concept of matched filter. Derive an expression for its impulse response

54. Obtain an expression for the probability of error for BPSK and ASK.

55. What is probability of error and explain its significance?

56. Derive the expression for probability of error of ASK.

57. What is correlator? Explain the optimum filter reception using correlator.

58. Derive the probability error of BFSK system and explain its operation.

Signature of the faculty

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Assignment Questions with schemes

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DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

III –I SEM | DC ASSIGNMENT-I QUESTIONS | A.Y:2022-23

Q.No.	Assignment Question	Marks Allotted	Course Outcome mapping	Taxonomy level
1	Analyze the M-ary modulation technique and write about M-ary Ask with neat sketch?	1	C304.1	Level 4 Analyze
2	With neat Sketch analyze DPSK and its advantages & disadvantages?	2	C304.2	Level 4 Apply
3	Derive the probability of error of Optimum Filter and give the definition of Optimum Filter?	2	C304.3	Level 3 Apply

ASSIGNMENT-II QUESTIONS

Q.No.	Assignment Question	Marks Allotted	Course Outcome mapping	Taxonomy level
1	a) Compute error probability in ASK? b) Compute error probability in FSK? c) Compute error probability in PSK?	3	C304.3	Level 3 Analyze
2	An analog signal is band limited to fm Hz, & sampled at Nyquist rate. The samples are quantized into 4 levels each level represents one symbol. Thus there are 4 symbols. The probabilities of occurrence of these 4 levels are P(x1)=P(x4)=1/8 and P(x2)=P(x3)=3/8. Obtain the information rate of the same?	1	C304.4	Level 3 Apply
3	Given a telegraph source having two symbols. Dot & dash. The dot duration is 0.2 sec, the dash duration is 3 times of the dot duration. The probability of the dots occurring is twice that of the dash and the time between symbols is 0.2sec. Compute the information rate of the telegraph source?	1	C304.5	Level 3 Understand

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1. Define M-ary Modulation technique and explain the M-ary ASK.

In any Communication system, the two major resources that are used efficiently are 1. Transmit Power
2. Bandwidth of the channel

M-ary (multilevel) signaling scheme

1. In w.k.t BASK, BFSK, BPSK and DPSK are binary modulation Technique. In these techniques signals are represented using only two symbols consisting of single bit either '1' or '0'.
2. It means either two amplitude, two frequencies (or) two phases are used to represent two symbol respectively.
3. The maximum bandwidth requirement of BASK = $2f_b$
BFSK = $4f_b$
BPSK = $2f_b$
DPSK = f_b
4. Hence to reduce the bandwidth requirement two (or) more bits are Combined to form one symbol.
5. Thus, the symbol is always greater than two and is given by $m = 2^n$ where n = no. of bits Combined (n = 2, 3, 4 ...)
M = total no. of symbols (or) levels.
6. The signal representation which uses the Combination of two (or) bits to represent which a single symbol is known as M-ary (multi-level signaling scheme)
7. Fig. shows the binary and M-ary digital signal representation in fig (a): only two amplitude levels are used to represent the signal.

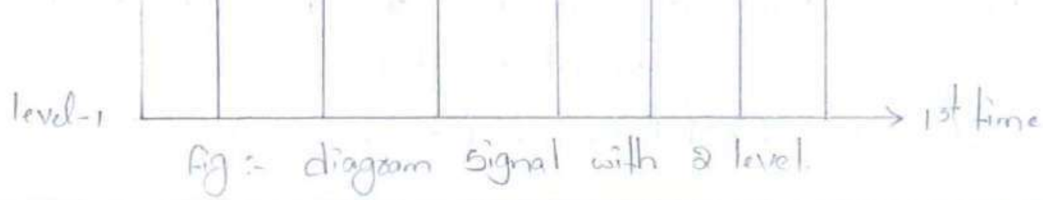


fig :- diagram signal with 2 level.

for $i = 1, 2 \dots m$ $\quad A_i = (2i - 1 - m)d$

where $2d$ = difference between two Consecutive Signal amplitudes

3. let $M = 4$ and $d = 1$; $i = 1, 2, 3, 4$.

The four signal Amplitudes will be $A_1 = [2.1 - 4].1$

$= 2 - 5$

$= -3$

$A_2 = (2.2 - 1 - 4).1$

$= -1$

$A_3 = (2.3 - 1.4).1$

$= (6 - 5).1$

$= 1$

$A_4 = (2.4 - 1 - 4).1 = (8 - 5) = 3$

$A_i = -3, -1, 1, 3\,V$

The M-ASK signal will be for $0 \leq t \leq T_s$

$s_1(t) = -3\cos(2\pi f_c t)$; $s_2(t) = -\cos(2\pi f_c t)$

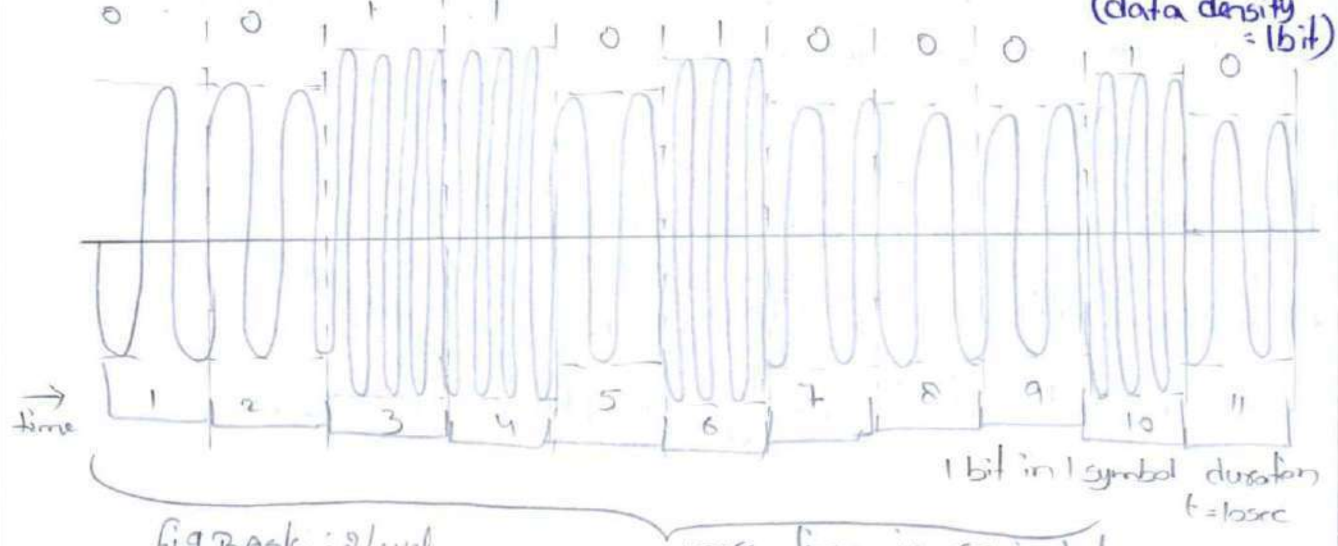
$s_3(t) = \cos(2\pi f_c t)$; $s_4(t) = 3\cos(2\pi f_c t)$

Sub $A_i = -3, -1, 1, 3$ in (1)

W.k.T in BASK ; 2 level

1 bit in 1 symbol duration

Amplitude modulation (data density = 1bit)



1 bit in 1 symbol duration
t = 10sec

fig BASK : 2 level

more time is required to transmit 10 bit

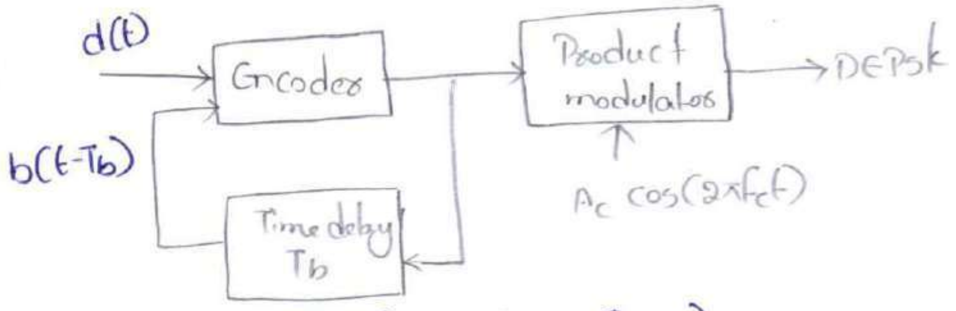
2. With a neat sketch analyzer differentially Encoded Phase shift keying (DEPSK).

DEPSK is a non-coherent modulation technique.

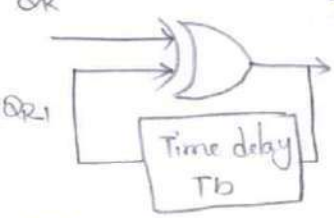
Differential :- Procedure of encoding the data differentially, In the receiver Previously received bits are used to detect the Present bits.

- There is no need of synchronization.

Transmitter Part



$$b(t) = d(t) \oplus b(t-T_b)$$



0	0	0
0	1	1
1	0	1
1	1	0

next bit = 0 No change
next bit = 1 change

1. The eliminate the need for Phase synchronization of coherent receiver with PSK, a differential encoding system can be used with PSK.
2. The digital information Content of the binary data is encoded in terms of signal transitions.
 Ex:: The symbol '0' may be used to represent transition in a given binary sequence and symbol '1' to indicate no transition.
3. This "new signaling technique" which Combines "differentially encoding with PSK" is known as 'DEPSK'.

→ The data stream b(t) is applied to the i/p of the encoder The o/p of encoder is applied to one i/p of the Product modulator. other i/p is sinusoidal carrier of fixed amplitude & frequency.

4. Now from this received signal a Carrier is seperated. Because this is Coherent detection

Square law device :- The received signal is Pass through a square law device and the o/P of this device is $\cos^2(2\pi f_c t+\theta)$

Amplitude = neglected

w.k.T ; $\cos^2\theta = \frac{1+\cos 2\theta}{2}$

$$\cos^2(2\pi f_c t+\theta) = \frac{1+\cos(2\pi f_c t+\theta)}{2}$$

$$= 1/2 + 1/2 \cos(2\pi f_c t+\theta) \quad -(1)$$

where 1/2 is DC level

5. This signal is Passed through a band Pass filter whose Pass band is Centred around 2fc. Band Pass filter removes the DC level of 1/2 and the o/P of BPF is $\cos(2\pi f_c t+\theta)$. Now the signal freq of o/P of BPF is 2fc. Now it is Passed through a freq divider by two

6. The o/P of frequency divider, we get Carrier signal whose frequency is f_c i.e ; $\cos(2\pi f_c t+\theta)$

7. The synchronous demodulator multiplies the i/P signal and the recovered carrier.

The o/P of multiplier

$$b(t)\sqrt{2P}\cos(2\pi f_c t+\theta)\times\cos(2\pi f_c t+\theta) = b(t)\cos^2(2\pi f_c t+\theta)\sqrt{2P}$$

$$= b(t)\sqrt{2P}\times 1/2\left[1+\cos 2(2\pi f_c t+\theta)\right]$$

$$= b(t)\sqrt{P/2}\left[1+\cos 2(2\pi f_c t+\theta)\right]$$

Integrator :- It integrates the signal over one bit Period $\int_0^{T_b}$

Bit synchronizer :- It takes care of starting and ending times of a bit; at the end of bit duration T_b, the bit synchronizer close switch S_2 temporarily.

→ This Connects the o/P of an integrator to the decision device. The synchronizer then opens switch S_2 & S_1 is closed temporarily.

1. calculate the probability of error in ASK, PSK, FSK

Calculation of error probability in ASK

Know That: in ASK The output equations are

$$x_1(t) = \sqrt{2P_s}\cos(2\pi f_c t) \text{ for binary '1'}$$

$$x_2(t) = 0 \text{ for binary '0'}$$

Here P_s = normalized Power of the signal for 1Ω load

i.e: Power $P = \left(\frac{A}{\sqrt{2}}\right)^2 = \left(\frac{A}{2}\right)^2 = \boxed{A = \sqrt{2P_s}}$

we know that: The probability of error of the optimum filter

$$P_e = \frac{1}{2}\operatorname{erfc}\left[\frac{x_{01}(T) - x_{02}(T)}{2\sqrt{2}\sigma}\right]$$

where erfc of $u = \frac{2}{\pi}\int_{u}^{\infty} e^{-y^2}dy$

Here $\left[\frac{x_{01}(T) - x_{02}(T)}{\sigma}\right]^2_{max} = \int_{-\infty}^{\infty}\frac{|X(f)|^2}{S_{ni}(f)}df \longrightarrow (1)$

These equations can be applied to matched filter. when we consider white gaussian noise and power spectral density of white gaussian noise is

$S_{ni}(f) = \frac{N_0}{2}$

sub in eqn (1) $\Rightarrow \int_{-\infty}^{\infty}\frac{|X(f)|^2}{\frac{N_0}{2}}.df$

$$= \frac{2}{N_0}\int_{-\infty}^{\infty}|X(f)|^2 df \longrightarrow (2)$$

from Parseval's Theorem, we have

$$\int_{-\infty}^{\infty}|X(f)|^2 df = \int_{-\infty}^{\infty}x^2(t)dt = \int_{0}^{T}x^2(t)\,dt$$

from eqn (2) $\left[\frac{x_{01}(T) - x_{02}(T)}{\sigma}\right]^2_{max} = \frac{2}{N_0}\int_0^T x^2(t)dt \longrightarrow (3)$

we Know That: $x(t)$ is present from (0 to T)

from eqn (3) $\left[\frac{x_{01}(T) - x_{02}(T)}{\sigma}\right]^2_{max} = \frac{2}{N_0}\int_0^T x^2(t)\,dt \longrightarrow (4)$

further w.k.T: $x(t) = x_1(t) - x_2(t)$

$$= \sqrt{2P_s}\cos(2\pi f_c t) - 0$$

$$x(t) = \sqrt{2P_s}\cdot\cos(2\pi f_c t)$$

$$\int_{-\infty}^{\infty}|X(f)|^2 dt = \int_0^T[\sqrt{2P_s}\cdot\cos(2\pi f_c t)]^2\,dt$$

calculation of Pe in BPSK

we know that o/p of BPSK

$x_1(t) = \sqrt{2P}\cos(2\pi f_c t)$ for binary '1'

$x_2(t) = \sqrt{2P}\cos(2\pi f_c t)$ for binary '0'.

here 'P' = normalized power of the carrier and $P = A^2/2$

where 'A' is amplitude we can write

$n_2(t) = -n_1(t)$

w.k.T: The probability of error of the optimum filter is

$$P_e = \frac{1}{2}\,\mathrm{Erfc}\left[\frac{x_{01}(T) - x_{02}(T)}{2\sqrt{2}\,\sigma}\right]$$

$$\text{here}\left[\frac{x_{01}(T) - x_{02}(T)}{\sigma}\right]^2_{max} = \frac{2}{N_0}\int_0^T x^2(t)\,dt \rightarrow (1)$$

w.k.T $x(t) = x_1(t) - x_2(t)$

for PSK $x_2(t) = -x_1(t)$

Thus $x(t) = x_1(t) \cdot [-x_2(t)] = 2x_1(t)$

$$\text{from eqn (1)} \left[\frac{x_{01}(T) - x_{02}(T)}{\sigma}\right]^2_{max} = \frac{2}{N_0}\int_0^T 4x_1^2(t)\,dt$$

$$= \frac{8}{N_0}\int_0^T x_1^2(t)\,dt \rightarrow (2)$$

sub the values

$$\int_0^T x_1^2(t)\,dt = \int_0^T 2P\cos^2(2\pi f_c t)\,dt$$

$$= \cancel{2}P\,\tfrac{1}{\cancel{2}}\int_0^T (1 + \cos 4\pi f_c t)\,dt$$

$$\int_0^T x_1^2(t)\,dt = P\left[\int_0^1 1\,dt + \int_0^1 \cos(4\pi f_c t)\,dt\right]$$

hence the above eqn becomes

In the above eqn, second integration will be zero since it is integration of cosine over one bit period so

$$\int_0^T x_1^2(t)\,dt = SP\int_0^T dt \rightarrow (3) \quad (\because 2^{nd}\ \text{term} = 0)$$

$$= P(t)_0^T = PT = E_b$$

Thus, energy E = Power(P) x bit duration (T)

sub in eqn (2) we get

$$\left[\frac{x_{01}(T) - x_{02}(T)}{\sigma}\right]^2_{max} = \frac{8}{N_0}E_b$$

$$\left[\frac{x_{01}(T) - x_{02}(T)}{\sigma}\right]_{max} = \sqrt{\frac{8E_b}{N_0}} \rightarrow (4)$$

$$= \frac{4P_s}{N_0}\left[\int_0^T \frac{1+\cos 2(\omega_0+\Omega)t}{2}\,dt + \int_0^T \frac{1+\cos^2(\omega_0-\Omega)t}{2}\,dt - 2\int_0^T \cos(2\omega_0 t)\,dt - \int_0^T \cos 2\Omega t\,dt\right]$$

$$= \frac{4P_s}{N_0}\left[\int_0^T \tfrac{1}{2}\cdot dt + \int_0^T \frac{\cos 2(\omega_0+\Omega)t}{2}\,dt + \int_0^T \tfrac{1}{2}\,dt + \int_0^T \frac{\cos^2(\omega_0-\Omega)t}{2}\,dt - \int_0^T \cos 2\omega_0 t\,dt\right]$$

$$= \frac{4P_s}{N_0}\left[\tfrac{1}{2}(t)_0^T + \tfrac{1}{2}\left(\frac{\sin 2(\omega_0+\Omega)t}{2(\omega_0+\Omega)}\right)_0^T + \tfrac{1}{2}(T-0) + \tfrac{1}{2}\left(\frac{\sin 2(\omega_0-\Omega)}{2(\omega_0-\Omega)}\right)_0^T - \left(\frac{\sin 2\omega_0 t}{2\omega_0}\right)_0^T\right]$$

$$= \frac{4P_s}{2N_0}\left(T + \frac{\sin 2(\omega_0+\Omega)T}{\omega_0+\Omega} + T + \frac{\sin 2(\omega_0-\Omega)T}{\omega_0-\Omega} - \frac{\sin 2\omega_0 T}{\omega_0} - \frac{\sin 2\Omega T}{\Omega}\right] \longrightarrow (4)$$

As $\omega_0 T \gg 1$ eq (4) is simplified as

$$\left(\frac{x_{01}(T)-x_{02}(T)}{\sigma}\right]_{max}^2 = \frac{2P_s}{N_0}\left[2T - \frac{\sin 2\Omega T}{\Omega}\right] \Rightarrow \frac{4P_sT}{N_0}\left(1 - \frac{\sin 2\Omega T}{2\Omega T}\right]$$

for othrogonal spacing

$$\Omega T = n\pi \text{ and } \frac{\sin 2\Omega T}{2\Omega T} \longrightarrow 0$$

$$\left[\frac{x_{01}(T)-x_{02}(T)}{\sigma}\right]_{max}^2 = \frac{4P_sT}{N_0}$$

$$\left[\frac{x_{01}(T)-x_{02}(T)}{\sigma}\right]_{max} = \sqrt{\frac{4P_sT}{N_0}}$$

$$P_e = \tfrac{1}{2}\,\mathrm{Erfc}\left[\frac{x_{01}(T)-x_{02}(T)}{2\sqrt{2}\sigma}\right]$$

$$= \frac{1}{2}\,\mathrm{erfc}\left[\frac{1}{2\sqrt{2}}\left(2\sqrt{\frac{P_sT}{N_0}}\right)\right]$$

$$\boxed{P_e = \tfrac{1}{2}\,\mathrm{Erfc}\sqrt{\frac{P_sT}{2N_0}}}$$

2 An analog signal is band limited to f_m Hz and simpled at nyquist rate. The samples are quantized into 4 levels. each level represent one symbols. Thus there are 4 symbols. The probabilities of occurence of these 4 levels (symbols) are $P(x_1) = P(x_4) = 1/8$ and $P(x_2) = P(x_3) = 3/8$. obtain information rate of the source.

Sol:- we are given four symbols wnit probababilities $P(x_1) = P(x_4) = 1/8$; $P(x_2) = P(x_3) = 3/8$

Average information $H(x)$ is expressed as:

$$H(n) = P(x_1)\log_2\frac{1}{P(x_1)} + P(x_2)\log_2\frac{1}{P(x_2)} + P(x_3)\log_2\frac{1}{P(x_3)} + P(x_4)\log_2\frac{1}{P(x_4)}$$

sol: Given That ;

$P(dot) = 2P(dash)$

$P(dot) + P(dash) = 3P(dash) = 1$

from above two eqn's we have

$P(dash) = 1/3$ and $P(dot) = 2/3$

we know That The entropy is given by

$$H(x) = -\sum_{i=1}^{n} P(x_i) \log_2 P(x_i) \text{ bits/symbol}$$

expanding accordingly, we get

$$H(x) = -P(dot)\log_2 P(dot) - P(dash)\log_2 P(dash)$$

substituting all The values, we get

$$H(x) = 0.667(0.585) + 0.333(1.585)$$

$$= 0.92 \text{ bits/symbol}$$

Given That ;

$t_{dot} = 0.2s$; $t_{dash} = 0.6s$, & $t_{space} = 0.2s$

Thus, The average time per symbol will be

$$T_S = P(dot)t_{dot} + P(dash)t_{dash} + t_{space}$$

$$= 0.5333 \text{ sec/symbol}$$

∴ The average symbol rate will be given by

$$r = 1/T_S = 1.875 \text{ symbols/sec}$$

∴ The average information rate of The telegraph source will

be $R = rH(x)$

$= 1.875(0.92)$

$= 1.725 b/s$

4 determine The Shannon-Fano code and Huffman code for The following messages with Their probabilities given

x_1	x_2	x_3	x_4	x_5	x_6	x_7
0.05	0.15	0.25	0.03	0.15	0.3	0.35

sol: arranging and grouping of messages is done as shown below

x_i	$P(x_i)$	step-1	step 2	step3	step4	code	n_i
x_7	0.35	0	0			00	2
x_6	0.3	0	1			01	2
x_3	0.25	1	0			10	2
x_2	0.15	1	1	0		110	3
x_5	0.15	1	1	1	0	1110	4
x_1	0.05	1	1	1	1 0	11100	5
x_4	0.03	1	1	1	1 1	11111	4 5

$$H(x) = -\sum_{i=1}^{n} P(x_i) \log_2 P(x_i)$$

$$= -[0.35 \cdot \log_2(0.35) + 0.3 \log_2(0.3) + 0.25 \log_2(0.15) + 0.15 \log_2(0.15) + 0.05 \log_2(0.05) + 0.03 \log_2(0.03)]$$

$$H(x) = 2.739 \text{ bits/symbols}$$

$$L = \sum_{i=1}^{n} P(x_i) \cdot n_i$$

$$= 0.35\times2 + 0.3\times2 + 0.25\times8 + 0.15\times3 + 0.15\times4 + 0.05\times5 + 0.03\times5$$

$$= 3.35$$

$$\eta = \frac{H(x)}{L} = \frac{2.739}{3.35}$$

$$= 81.7\%$$

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Scheme of Evaluation of Assignments.

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DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

A.Y.: 2022-23

Date: 17-12-2022

Subject Code	C304
Subject Name	Digital Communications
Regulation	R20
Year & Sem	III & I
Academic Year	2022-23

SCHEME OF EVALUATION – ASSIGNMENT I EXAMINATION

Q.No.	Assignment Question	Marks Allotted	Course Outcome mapping	Taxonomy level
A1.1	Analyze the M-ary modulation technique and write about M-ary Ask with neat sketch?	1	C304.1	Level 4 Analyze
A1.2	With neat Sketch analyze DPSK and its advantages & disadvantages?	2	C304.2	Level 4 Apply
A1.3	Derive the probability of error of Optimum Filter and give the definition of Optimum Filter?	2	C304.3	Level 3 Apply

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A.Y.: 2022-23

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Subject Code	C304
Subject Name	Digital Communications
Regulation	R20
Year & Sem	III & I
Academic Year	2022-23

SCHEME OF EVALUATION – ASSIGNMENT II EXAMINATION

Q.No.	Assignment Question	Marks Allotted	Course Outcome mapping	Taxonomy level
A2.1	a) Compute error probability in ASK? b) Compute error probability in FSK? c) Compute error probability in PSK?	3	C304.3	Level 3 Analyze
A2.2	An analog signal is band limited to fm Hz, & sampled at Nyquist rate. The samples are quantized into 4 levels each level represents one symbol. Thus there are 4 symbols. The probabilities of occurrence of these 4 levels are P(x1)=P(x4)=1/8 and P(x2)=P(x3)=3/8. Obtain the information rate of the same?	1	C304.4	Level 3 Apply
A2.3	Given a telegraph source having two symbols. Dot & dash. The dot duration is 0.2 sec, the dash duration is 3 times of the dot duration. The probability of the dots occurring is twice that of the dash and the time between symbols is 0.2sec. Compute the information rate of the telegraph source?	1	C304.5	Level 3 Understanc

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CO & BL EVALUATION – ASSIGNMENT I EXAMINATION

Date: 17-12-2022

Subject Name : Digital Communications
Year / Semester : III/ I
Degree / Branch : B.Tech / ECE
Academic Year : 2022-2023

Course Outcome Number	Marks Allotted	CO %		Taxonomy level	Marks Allotted	Taxonomy Level %
C304.1	1	20		Remember	0	0.00
C304.2	2	40		Understand	0	0.00
C304.3	2	40		Apply	4	80.00
Total Marks	5	100		Analyze	1	20.00
				Evaluate	0	0
				Create	0	
				Total Marks	5	100

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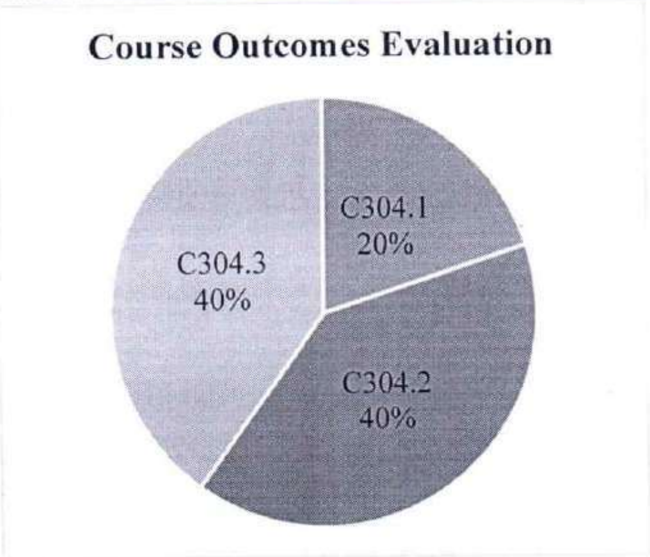

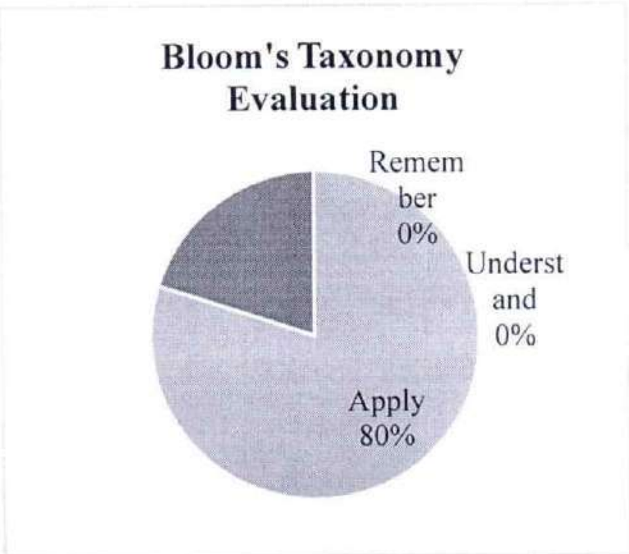

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CO & BL EVALUATION – ASSIGNMENT II EXAMINATION

Date: 17-12-2022

Subject Name : Digital Communications
Year / Semester : III/ I
Degree / Branch : B.Tech / ECE
Academic Year : 2022-2023

Course Outcome Number	Marks Allotted	CO %	Taxonomy level	Marks Allotted	Taxonomy Level %
C304.3	3	60.00	Remember	0	0
C304.4	1	20.00	Understand	1	20
C304.5	1	33.33	Apply	1	20.00
Total Marks	5	100	Analyze	3	60.00
			Evaluate	0	0.00
			Create	0	0.00
			Total Marks	5	100

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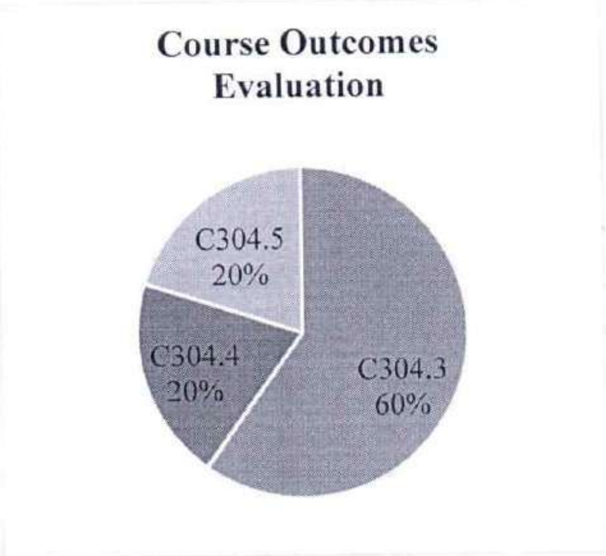

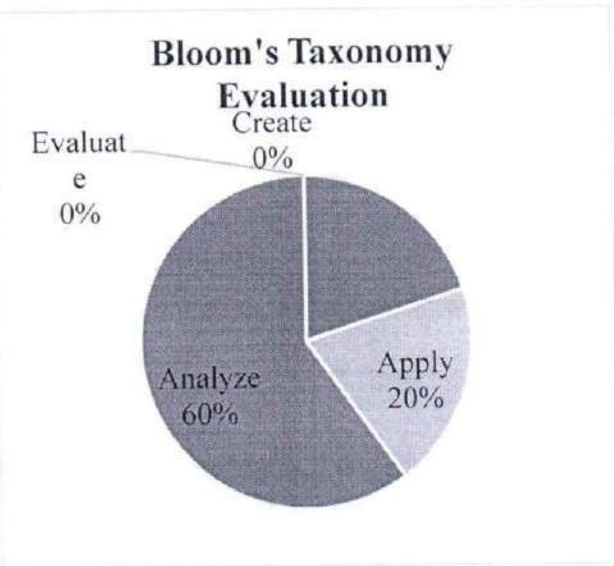

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CO & BL EVALUATION – ASSIGNMENT I & II EXAMINATION

Date: 17-12-2022

Subject Name : Digital Communications
Year / Semester : III/ I
Degree / Branch : B.Tech / ECE
Academic Year : 2022-2023

Course Outcome Number	Marks Allotted	CO %		Taxonomy level	Marks Allotted	Taxonomy Level %
C304.1	1	10.00		Remember	0	0
C304.2	2	20.00		Understand	1	10
C304.3	5	50.00		Apply	5	50.00
C304.4	1	10.00		Analyze	4	40.00
C304.5	1	10.00		Evaluate	0	0.00
				Create	0	0.00
Total Marks	10	100		Total Marks	10	100

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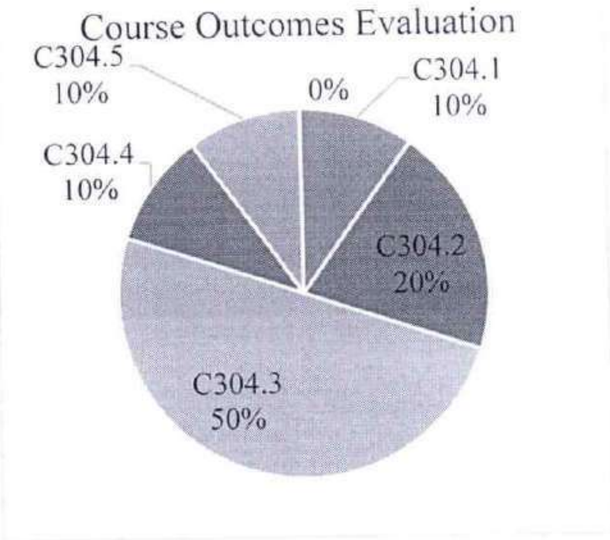

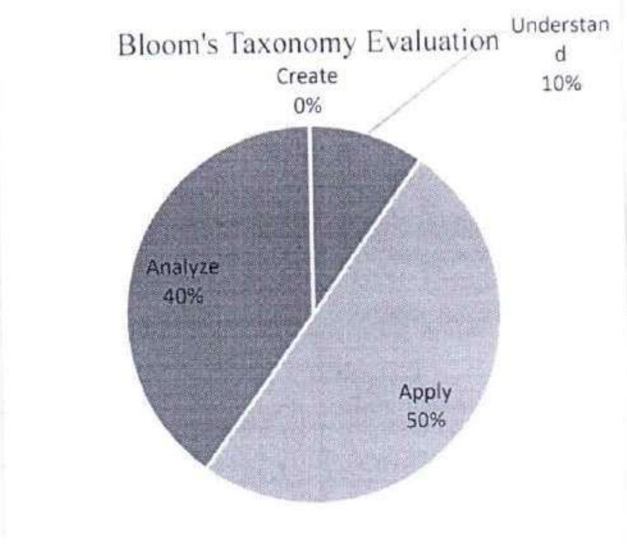

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Internal Question Papers.

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III B.TECH, I SEM II INTERNAL EXAMINATIOS, DEC: 2022 (R20)

Max. Marks: 15

COURSE: **Digital Communications** (DC) (R2031043)

Date: 30/12/2022

Branch: ECE

Time: 1:30 min

Answer all the questions

REG.NO:

Q. N0	Question description	CO	BTL	Marks
1	a) Define the mutual information? State and prove the properties of mutual information. b) A source is transmitting the symbols A and B with probabilities 1/16 and 15/16 respectively. Calculate the Entropy of the source and the required channel capacity using the simplest code and also coding efficiency?	C303.3, C303.4	Level 2 (Understand)	3 5
2	Apply Shannon-Fano Coding For The 5 Messages With Probabilities 0.4, 0.15, 0.15, 0.15, 0.15 and Find The coding Efficiency?	C303.4	Level 4 (Analyze)	3
3	Write Error Detection And Error Correction Capabilities Of Linear Block Codes?	C303.5	Level 3 (Apply)	4

*Level 1(Remembering): * Level 2 (Understanding): *level 3 (apply): *level 4 (analyze):

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III B.TECH, I SEM I INTERNAL EXAMINATIOS, SEP: 2022 (R20)

Max. Marks: 15 COURSE: Digital Communications (DC) (R2031043) Date: 28/09/2022

Branch: ECE Time: 1:30 min

Answer all the questions REG.NO:

Q. N0	Question description	CO	BTL	Marks
1	a. Derive the expression for quantization noise and signal to noise ratio in PCM? b. The information in an analog signal voltage waveform is to be transmitted over a PCM system with an accuracy of ±0.1% (full scale). The analog voltage waveform has a bandwidth of 100 Hz and an amplitude range of -10 to +10 volts. i. Find the minimum sampling rate required ii. Find the no of bits in each PCM word. iii. Find minimum bit rate required in the PCM signal. iv. Find the minimum absolute channel bandwidth required for the transmission of the PCM signal.	C304.1	Level 3 (Apply), Level 4 (Analyze)	5 4
2	With neat diagrams, discuss the DEPSK Transmitter and receiver Sketch and draw the waveforms?	C304.2, C304.3	Level 4 (Analyze)	3
3	Explain the probability of error calculation in optimum filter? Define optimum filter?	C304.3	Level 4 (Analyze)	3

*Level 1(Remembering): * Level 2 (Understanding): *level 3 (apply): *level 4 (analyze):

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P. Bhaskari

15

Name of the Student : Paladugu Dharani Regd. No. 20KE1A0464 Branch : ECE

B.Tech / M.Tech / MBA Year : III Sem : II Subject : DC Sign of the Invigilator :

Date 29/9/22

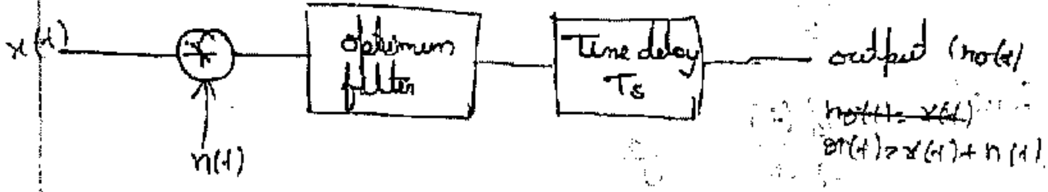
3A) Optimum filter:

→ To reduce the probability error we use the optimum filter.

- $x_1(t) = A$ if binary '1'
- $x_2(t) = -A$ if binary '0'

→ $x(t) = x_{01}(t)$ if $x(t) = x_1(t)$

→ $x(t) = x_{02}(t)$ if $x(t) = x_2(t)$.



- If $x(T) = x_{01}(T)$ when $x(t) = x_1(T)$
  $x(T) = x_{02}(T)$ when $x(T) = x_2(T)$
- The noise in the $x_2(t)$ & in $x_1(t)$ is denoted as
  $\frac{x_{01}(T) + x_{02}(T)}{2}$

Probability of error in optimum filter

- If $x_2(t)$ is transmitted ~~but~~ $x_1(t)$ is greater than $x_2(t)$ then the noise ~~occured~~, they noise is denoted as

→ $n_0(t) = \frac{x_{01}(T) + x_{02}(T)}{2} - x_{02}(T)$

→ $n_0(T) \geq \frac{x_{01}(T) - x_{02}(T)}{2}$ —(1)

- Thus the noise occured in $x_{02}(t)$ then we use the probability distribution function

- $$f_X(x) = \frac{1}{\sigma\sqrt{2\pi}} \int_{-\infty}^{\infty} e^{-\frac{(x-m)^2}{2\sigma^2}} \, dx.$$

- If $x = n_0(t)$ & $m=0$ then

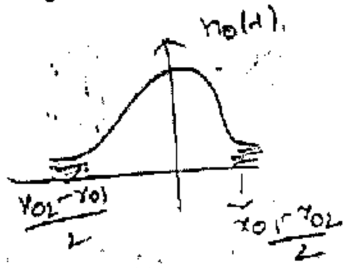
$$\therefore f_X(x) = \frac{1}{\sigma\sqrt{2\pi}} \int_{-\infty}^{\infty} e^{-\frac{n_0^2(t)}{2\sigma^2}} \, dx$$

- then $P_e = P\left[n_0(t) \geq \frac{x_{01}(T) - x_{02}(T)}{2} \right]$.

- $$P_e = P \int_{-\infty}^{\infty} f_X(n_0(t)) \, d(n_0(t)).$$

$$f_Y(n_0(t)) = \frac{1}{\sigma\sqrt{2\pi}} \int_{-\infty}^{\infty} e^{-\frac{n_0^2(t)}{2\sigma^2}} \, dx.$$

- $$\therefore P_e = \int_{\frac{x_{01}(T)-x_{02}(T)}{2}}^{\infty} \frac{1}{\sigma\sqrt{2\pi}} \left[e^{-\frac{n_0^2(t)}{2\sigma^2}} \right] d(n_0(t)).$$



- Consider $\frac{n_0^2(t)}{2\sigma^2} = y^2$

$$y = \frac{n_0(t)}{\sqrt{2}\sigma}$$

$$y\sqrt{2}\sigma = n_0(t)$$

$$d(n_0(t)) = \sqrt{2}\,dy\,\sigma.$$

$y = \infty$ $n_0(t) = \infty$

$$n_0(t) = \frac{x_{01}(T) - x_{02}(T)}{2}$$

$$y = \frac{x_{01}(T) - x_{02}(T)}{2\sqrt{2}\sigma}$$

- $$\therefore P_e = \int_{\frac{x_{01}(T)-x_{02}(T)}{2\sqrt{2}\sigma}}^{\infty} \frac{1}{\cancel{\sigma}\sqrt{2}\sqrt{\pi}} e^{-y^2} \cancel{\sqrt{2}\sigma} \, dy$$

- $$P_e = \frac{1}{\sqrt{\pi}} \int_{\frac{x_{01}(T)-x_{02}(T)}{2\sqrt{2}\sigma}}^{\infty} e^{-y^2} \, dy.$$

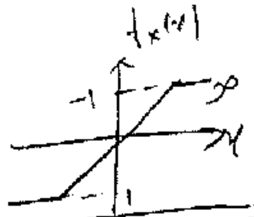
$$P_e = \frac{1}{2}\left\{\frac{2}{\pi}\int_{\frac{x_{01}(T)-x_{02}(T)}{2\sqrt{2}\sigma}}^{\infty} e^{-y^2}\,dy\right\}$$

- Consider $\frac{2}{\pi}\int_{\frac{x_{01}(T)-x_{02}(T)}{2\sqrt{2}\sigma}}^{\infty} e^{-y^2}dy$ (or) $\frac{2}{\pi}\int_{u}^{\infty} e^{-y^2}dy = \text{Erfc}(u)$.

$$\therefore P_e = \frac{1}{2}\,\text{Erfc}\left[\frac{x_{01}(T)-x_{02}(T)}{2\sqrt{2}\,\sigma}\right].$$

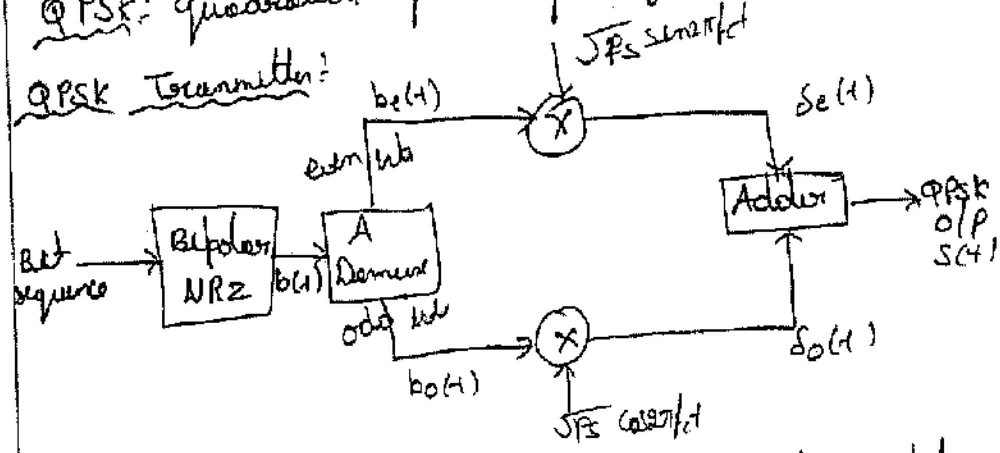
- $\therefore$ The probability of error in optimum filter is

$$\boxed{P_e = \frac{1}{2}\,\text{Erfc}\left[\frac{x_{01}(T)-x_{02}(T)}{2\sqrt{2}\,\sigma}\right]}$$



2A) QPSK: quadrature phase shift keying.

- QPSK Transmitter:



- Here the input bit sequence is given to the Bipolar NRZ. Then it selects the inputs. is given to the
- Then the o/p of bipolar NRZ is $b(t)$, is given to the demultiplexer.
- It selects the bit sequences by even & odd then bit '1' select (or) even bit select after the odd bit.
- There is a one bit time delay in even bit then a carrier is added to those bits.

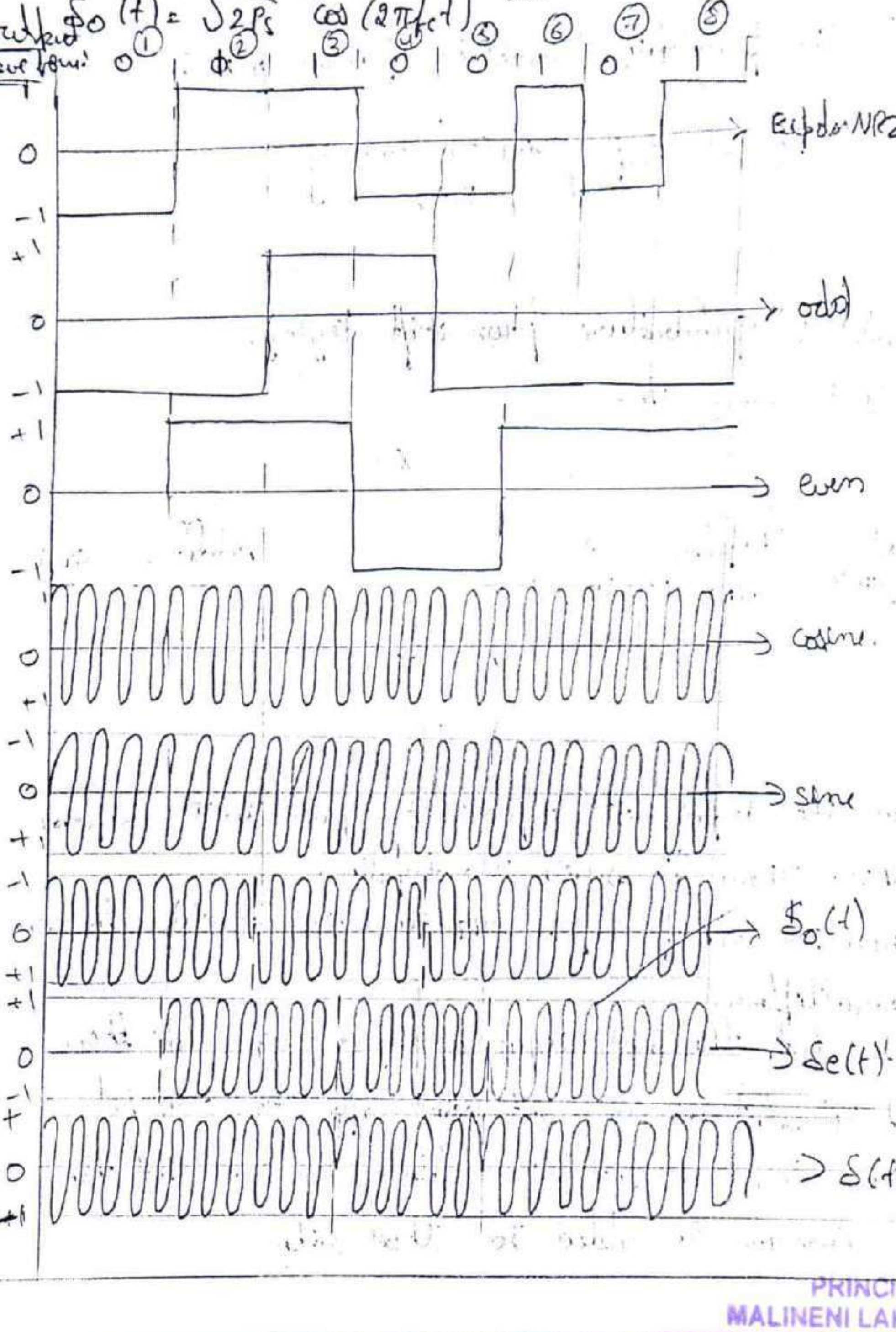
- $b_e(t)$ with the carrier $\sqrt{P_s}\sin(2\pi f_c t)$
- $b_o(t)$ with the carrier $\sqrt{P_s}\cos(2\pi f_c t)$.
- then the sampled o/p is given to the Adder.
- The adder adds the both even & odd bits & gives the QPSK output.

→ $S(t) = S_e(t) + S_o(t)$

$S_e(t) = \sqrt{2P_s}\,\sin(2\pi f_c t)\, b_e(t)$

$S_o(t) = \sqrt{2P_s}\,\cos(2\pi f_c t)\, b_o(t)$

output waveform:



1

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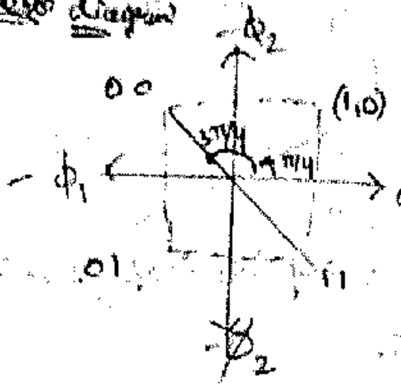
Regd. No. 20KE1A0464 ADDITIONAL SHEET

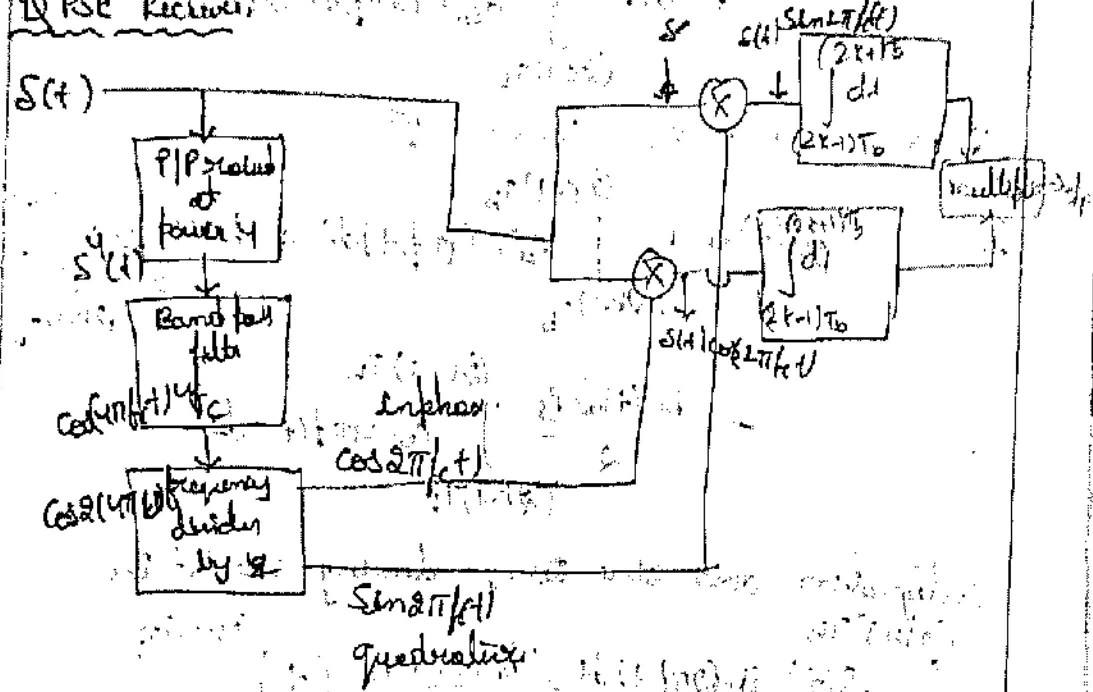
Sign of the Invigilator

- Phase diagram



1. (0-ve)(A-ve) S_1 $\pi/4$
2. (0-ve)(a-ve) S_2 $3\pi/4$
3. (a-ve)1(+ve) S_3 $5\pi/4$
4. (A-ve)1(+ve) S_4 $7\pi/4$

- QPSK Reciever:



- $S(t)$ is given to the raised power 4 then it becomes $S^4(t)$.
- Then it is given to B.P.F then o/p of BPF is $\cos(4\pi f_c t)$
- Then it is given to the freq divider by 2 then the output having two components
- They are $\cos(2\pi f_c t)$ & $\sin(2\pi f_c t)$.
- These are given to the product modulator

- Then given to the integrator then it integrates & get the demodulated output
- The output of multiplier is
$$s(t)\sin 2\pi f_c t = b_o(t)\sqrt{2P_s}\cos 2\pi f_c t \sin 2\pi f_c t + b_e(t)\sqrt{2P_s}\sin^2(2\pi f_c t).$$

where $s(t) = b_o(t)\sqrt{2P_s}\cos 2\pi f_c t + b_e(t)\sqrt{2P_s}\sin 2\pi f_c t$

$$\int_{(2k-1)T_b}^{(2k+1)T_b} s(t)\sin(2\pi f_c t)\,dt = b_o(t)\sqrt{2P_s}\int_{(2k-1)T_b}^{(2k+1)T_b}\cos(2\pi f_c t)\sin(2\pi f_c t)\,dt + b_e(t)\sqrt{2P_s}\int_{(2k-1)T_b}^{(2k+1)T_b}\sin^2(2\pi f_c t)\,dt.$$

$\sin 2x = 2\cos x \sin x$, $\sin^2 x = \frac{1-\cos 2x}{2}$

$$\therefore \quad = \frac{b_o(t)\sqrt{2P_s}}{2}\int_{(2k-1)T_b}^{(2k+1)T_b}\underbrace{\sin(4\pi f_c t)\,dt}_{0} + \frac{b_e(t)\sqrt{2P_s}}{2}\int_{(2k-1)T_b}^{(2k+1)T_b} 1\,dt$$
$$- \frac{b_e(t)\sqrt{2P_s}}{2}\underbrace{\int_{(2k-1)T_b}^{(2k+1)T_b}\cos 4\pi f_c t\,dt}_{0}$$

Integration over sine terms during one bit is 0

$$\int_{(2k-1)T_b}^{(2k+1)T_b} s(t)\sin(2\pi f_c t)\,dt = \frac{b_e(t)\sqrt{2P_s}}{2}\left(t\right)_{(2k-1)T_b}^{(2k+1)T_b}$$

$$= \frac{b_e(t)\sqrt{2P_s}}{2}\left((2k+1)T_b - (2k-1)T_b\right)$$

$$= \frac{b_e(t)\sqrt{2P_s}}{2}\left(\cancel{2kT_b} + T_b - \cancel{2kT_b} + T_b\right)$$

$$= \frac{b_e(t)\sqrt{2P_s}}{\cancel{2}}\,\cancel{2}T_b$$

$$= b_e(t)\sqrt{2P_s}\,T_b.$$

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Regd. No. 20KE1A0464 Sign of the Invigilator

Hly

- $s(t)\cos 2\pi f_c t = b_o(t)\sqrt{2P_s}\cos^2 2\pi f_c t + b_e(t)\sqrt{2P_s}\sin 2\pi f_c t \cos 2\pi f_c t$

$$\int_{(2k-1)T_b}^{(2k+1)T_b} s(t)\cos 2\pi f_c t = b_o(t)\sqrt{2P_s}\int_{(2k-1)T_b}^{(2k+1)T_b} \cos^2(2\pi f_c t)\,dt + b_e(t)\sqrt{2P_s}\int_{(2k-1)T_b}^{(2k+1)T_b} \sin 2\pi f_c t \cos 2\pi f_c t\,dt$$

$$= \frac{b_o(t)\sqrt{2P_s}}{2}\int_{(2k-1)T_b}^{(2k+1)T_b} 1\,dt + \frac{b_o(t)\sqrt{2P_s}}{2}\int_{(2k-1)T_b}^{(2k+1)T_b} \cos(4\pi f_c t)\,dt + \frac{b_e(t)\sqrt{2P_s}}{2}\int_{(2k-1)T_b}^{(2k+1)T_b} \sin(4\pi f_c t)\,dt$$

$$= \frac{b_o(t)\sqrt{2P_s}}{2}\left(t\right)_{(2k-1)T_b}^{(2k+1)T_b}$$

$$= \frac{b_o(t)\sqrt{2P_s}}{2}\left(\cancel{2kT_b} + T_b \cancel{- 2kT_b} + T_b\right)$$

$$= \frac{b_o(t)\sqrt{2P_s}}{\cancel{2}}\cancel{2}T_b$$

$$= b_o(t)\sqrt{2P_s}\,T_b.$$

- B.W $\Rightarrow f_b$.
- Spectral of QPSK

$$S(f) = 2P_sT_s \cancel{\sin} \left(\frac{\sin \pi f T}{\pi f T}\right)^2$$

- Advantages:

To transform the information quickly.

Q.1)

(a) quantization error/noise

These are expressed in 4 steps.

1. quantization error.
2. Step size
3. Pdf of quantization error.
4. Signal to Noise ratio.

1. quantization error:

→ The error occured in the quantization process is called quantization error.

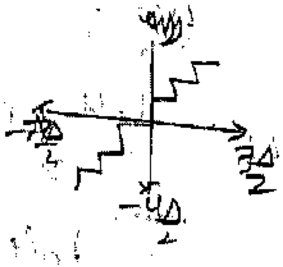
- It is denoted as 'ε'

$\therefore \epsilon = x_q(nT_s) - x(nT_s)$.

2. Step size:

→ step size is defined as the amplitude of the signal "from $-x_{max}$ to $+x_{max}$"

- Ex: If input is 4Δ & output is $\frac{7\Delta}{2}$
input is -4Δ then output is $-\frac{7\Delta}{2}$



$+x_{max}$ is 4Δ

& $-x_{max}$ is -4Δ

- The amplitude of the steps are

$$+x_{max} - (-x_{max}) = 2x_{max}$$

- In q-levels the step size is

$$\Delta = \frac{2x_{max}}{q}$$

- If it is normalised $x_{max} = 1$

$$\therefore \Delta = \frac{+1-(-1)}{q}$$

$$\Delta = \frac{2}{q} \text{ for normalized}$$

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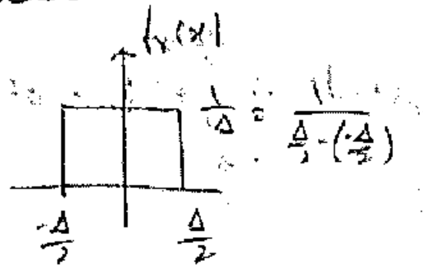
3. Pdf of quantization error: Probability density function of q.e



$$f_X(x) = \begin{cases} 0 & x \leq -\frac{\Delta}{2} \\ \frac{1}{\Delta} & -\frac{\Delta}{2} < x < \frac{\Delta}{2} \\ 0 & x > \frac{\Delta}{2} \end{cases}$$

- when the interval from $(-\frac{\Delta}{2}, \frac{\Delta}{2})$ then from the probability distribution function then we get the above equation.

4. Signal to Noise ratio:

$$\frac{S}{N} = \frac{\text{Normalised signal power}}{\text{Normalised noise power}}$$

∴ Noise power

$$P_{noise} = V \times I$$
$$= V \times \frac{V}{R}$$
$$P_{noise} = \frac{V^2_{noise}}{R} \qquad P_{noise} = \frac{V^2}{R} =$$

$$\epsilon\, E(x^2) = \int_{-\infty}^{\infty} x^2 f_X(x)\, dx$$

$$E(x^2) = (V^2) = \int_{-\infty}^{\infty} x^2 f_X(x)\, dx$$

$$E(\epsilon^2) = \int_{-\infty}^{\infty} \epsilon^2 f_\epsilon(\epsilon)\, d\epsilon$$

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- Signal to Noise ratio for linear quantization

$$\frac{S}{N} = \frac{\text{Normalized signal power}}{\text{Normalized Noise power}}$$

$$\text{Noise power} = \frac{\Delta^2}{12}$$

$$\Delta = \frac{2x_{max}}{q}, \quad q = 2^V$$

$$\therefore \frac{S}{N} = \frac{N.S.P}{\Delta^2/12}$$

$$= \frac{NSP}{\frac{\left(\frac{2x_{max}}{q}\right)^2}{12}} = \frac{NSP}{\frac{4x^2_{max}}{2^{2V}\cdot 12_3}}$$

$$= \frac{N.S.P}{x^2_{max}} 3 \cdot 2^{2V}$$

V. Good

$$\frac{S}{N} = \frac{3\,N.S.P}{x^2_{max}} 2^{2V}$$

- Consider $N.S.P = P$.

$$\therefore \frac{S}{N} = \frac{3P}{x^2_{max}} 2^{2V}$$

$x^2_{max} = 1$

$$\frac{S}{N} = 3P \cdot 2^{2V}$$

$P << 1$

$P \leq 1$, then we get

$$\therefore \frac{S}{N} \leq 3 \cdot 2^{2V}$$

$P = 1$

$$\therefore \frac{S}{N} = 3 \times 2^{2V}$$

Scanned with CamScanner

x_i	$P(x_i)$	step 1	Step 2	step 3	Step 4	step 5	code	n_i
x_7	0.35	0.35	0.35	0.38	0.55	0.73	0.1	2
x_6	0.3	0.3	0.3	0.35	0.38	0.55	10	2
x_3	0.25	0.25	0.25	0.3	0.35		11	2
x_2	0.15	0.15	0.23	0.25			001	3
x_5	0.15	0.15	0.15				0000	4
x_1	0.05	0.08					00010	5
x_4	0.03						00011	5

$$L = \sum_{i=1}^{n} P(x_i)\cdot n_i$$

$$= P(x_1)\cdot n_1 + P(x_2)n_2 + P(x_3)(n_3) + P(x_4)n_4 + P(x_5)n_5 + P(x_6)n_6 + P(x_7)n_7$$

$$= 0.35\times2 + 0.3\times2 + 0.25\times2 + 0.15\times3 + 0.15\times4 + 0.05\times5 + 0.03\times5$$

$$= 1.4 + 0.95 + 0.6 + 0.25 + 0.15$$

$$\boxed{L = 3.35 \text{ bits}}$$

$$H(x) = -\sum_{i=1}^{n} P(x_i)\log_2 P(x_i)$$

$$= -[0.35\log_2(0.5) + 0.3\cdot\log_2(0.3) + 0.25\cdot\log_2(0.25) + 0.15\log_2 0.15 + 0.15\log_2 0.15 + 0.05\log_2 0.05 + 0.03\log_2 0.03]$$

$$= 2.739 \text{ bits/symbols}$$

$$\eta = \frac{H(x)}{L} = 0.81 \Rightarrow \%\eta = 81.7\,\%$$

b) <u>shannon-Fano code</u>

<u>step-1</u>:- list the source symbols in order of decreasing probability

<u>step 2</u>:- partition the set into 2 sets that are as close to equii probables as possible and assign zero to the upper set and one to the lower set.

<u>step 3</u>:- continuey this process each time partioning the set as nearly equal probabilities as possible until further partitioning is not possible.

we get; $H(x) = \frac{1}{8}\log_2 8 + \frac{3}{8}\log_2(8/3) + \frac{1}{8}\log_2(8)$

$H(x) = 1.8$ bits/symbol.

→ it is given that the signal is sampled at Nyquist rate

Nyquist rate = $2f_m$ samples/sec. ($r = 2f_m$)

information rate is given by $R = rH(x)$

Putting values of r and H(x) in this eqn;

$R = 2f_m$ symbol/sec × 1.8 bits/symbols

$= 3.6 f_m$ bits/sec

in this ex: There are four levels. Those levels may be coded using binary PCM as shown in fig

S.NO	symbol or level	probability	Binary digits
1.	Q_1	$\frac{1}{8}$	00
2.	Q_2	$\frac{3}{8}$	01
3.	Q_3	$\frac{3}{8}$	10
4.	Q_4	$\frac{1}{8}$	11

two binary digits are required to send each symbol. we know that symbols are sent at the rate of $2f_m$ symbols/sec

Binary digits rate = 2 bits/symbol × $2f_m$ symbol/sec

$= 4 f_m$ bits/sec

Because one unit is capable of conveying 1 bit of information therefore, the above coding scheme is capable of conveying $4f_m$ bits of information per second. we have obtained that we are transmitting $9.6 f_m$ bits of information per second

3. Given a telegraph source having two symbols, dot and dash. The dot duration is 0.2s The dash duration is 3 times the dot duration. The probability of the dots occuring is twice that of the dash, and the time between symbols is 0.2s calculate the information rate of telegraph source.

sub in the value in $Pe = 1/2\, Erfc \left\{ \frac{1}{2\sqrt{2}} \sqrt{\frac{8Eb}{N0}} \right\}$

$$\therefore Pe = 1/2\, Erfc \sqrt{\frac{Eb}{N0}} \quad Pe = 2\sqrt{\frac{2E}{N0}}$$

This is because of the relation between erfc → Q function is given by

$$Q(x) = 1/2\, Erfc(x/\sqrt{2}) \text{ and } Erfc(x) = 2Q(x/\sqrt{2}).$$

Calculation of probability error of BFSK

In FSK two different carrier frequencies are used to transmit two binary levels.

for binary '1' $x_1(t) = \sqrt{2Ps}\cos(2\pi fc t + \Omega)t$

for binary '0' $x_2(t) = \sqrt{2Ps}\cos(2\pi fct - \Omega)t$

→ In general $Pe = 1/2\, Erfc\left(\frac{x_{01}(T) - x_{02}(T)}{2\sqrt{2}\,\sigma}\right) \rightarrow ①$

→ The detector which maximizes the ratio $h = \frac{Po(T)}{\sigma}$

i.e; $\frac{x_{01}(T) - x_{02}(T)}{\sigma}$ is the matched filter detector

→ now; output $(SNR)_0$ i.e; γ^2, can be obtained as

$$\left(\frac{x_{01}(T) - x_{02}(T)}{\sigma}\right)^2_{max} = \int_{-\infty}^{\infty} \frac{|x(f)|^2}{Sni(f)}\, dt \rightarrow ②$$

w.k.T; $Sni(f) = \frac{N0}{2}$

from the Parsevals' Theorem;

$$\int_{-\infty}^{\infty} |x(f)|^2 dt = \int_{-\infty}^{\infty} x^2(t)\, dt = \int_0^T x^2(t)\, dt$$

from eqn ② : $$\left[\frac{x_{01}(T) - x_{02}(T)}{\sigma}\right]^2_{max} = \int_0^T \frac{x^2(t)}{\frac{N0}{2}}\, dt \rightarrow ③$$

$$= \frac{2}{N0}\int_0^T x^2(t)\, dt$$

$$\therefore x(t) = x_1(t) - x_2(t)$$

$$= \sqrt{2Ps}\cos(\omega_0 + \Omega)t - \sqrt{2Ps}\cos(\omega_0 - \Omega)t$$

sub in eqn ③

$$\left[\frac{x_{01}(T) - x_{02}(T)}{\sigma}\right]^2_{max} = \frac{2}{N0}\int_0^T \left[\sqrt{2Ps}\cos(\omega_0 + \Omega)t - \sqrt{2Ps}\cos(\omega_0 - \Omega)t\right]^2 dt$$

$$= \frac{2}{N0}\left[\int_0^T (\sqrt{2Ps}\cos(\omega_0 + \Omega)t)^2 + \int_0^T (\sqrt{2Ps}\cos(\omega_0 - \Omega)t)^2 - 2\int_0^T \sqrt{2Ps}\cos(\omega_0 + \Omega) + \sqrt{2Ps}\cos(\omega_0 - \Omega)t\, dt\right]$$

$$= \frac{2}{N0}\, 2Ps\left[\int_0^T \cos^2(\omega_0 + \Omega)t\, dt + \int_0^T \cos^2(\omega_0 - \Omega)t\, dt - 2\int_0^T \cos(\omega_0 + \Omega)t \cdot \cos(\omega_0 - \Omega)t\, dt\right]$$

$$= 2P_s \int_0^T \cos^2 (2\pi f_c t)\, dt$$

$$= 2P_s \int_0^T \frac{1+\cos 2(2\pi f_c t)}{2}\, dt$$

$$= P_s \int_0^T 1.dt + P_s \int_0^T \cos (2\pi f_c t)\, 2\, dt$$

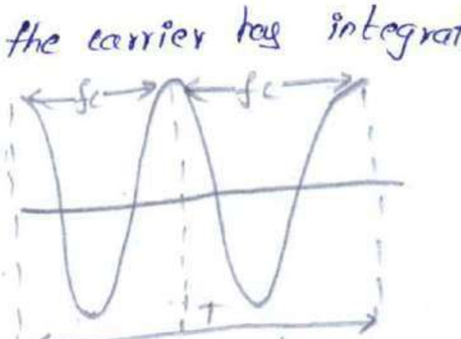
$$= P_s (t)_0^T + P_s \left(\frac{\sin 4\pi f_c t}{4\pi f_c} \right)_0^T$$

$$= P_s T + P_s \left[\frac{\sin 4\pi f_c t}{4\pi f_c} \right]$$

$$\therefore \left[\frac{x_{01}(T) - x_{02}(T)}{\sigma} \right]^2_{max} = \frac{2P_s}{N_0} \left[1 + \frac{\sin 4\pi f_c t}{4\pi f_c} \right] \rightarrow (5)$$

where 'T' is bit Period. in This '1' bit Period the carrier has integrator no. of $T = \frac{1}{f_c} + \frac{1}{f_c} = \frac{2}{f_c}$

$\boxed{f_c T = 2}$



→ In general carrier completes 'k' no. of cycles

Then: $f_c T = k$; here k = Integer

→ from eq(5) becomes $\sin 4\pi k$, for all integer values of k

$\boxed{\sin 4\pi k \geq 0}$

$$\therefore \left[\frac{x_{01}(T) - x_{02}(T)}{\sigma} \right]^2_{max} = \frac{2P_s T}{N_0}$$

squaring on both sides

$$\left[\frac{x_{01}(T) - x_{02}(T)}{\sigma} \right]_{max} = \sqrt{\frac{2P_s}{N_0}}$$

sub in $P_e = \frac{1}{2} \mathrm{Erfc} \left[\frac{x_{01}(T) - x_{02}(T)}{2\sqrt{2}\, \sigma} \right]_{max} = \frac{1}{2} \mathrm{Erfc} \left(\frac{1}{2\sqrt{2}} \sqrt{\frac{2P_s T}{N_0}} \right)$

$$= \frac{1}{2} \mathrm{Erfc} \sqrt{\frac{P_s T}{4N_0}}$$

$P_s T = E$ i.e; energy of '1 bit

$$\boxed{P_e = \frac{1}{2} \mathrm{Erfc} \sqrt{\frac{E}{4N_0}}} \quad . \quad E_b = E/2$$

The modified expression for P_e for ASK is

$$P_e = \frac{1}{2} \mathrm{Erfc} \sqrt{\frac{E_b}{2N_0}}$$

$$\boxed{P_e = \hat{Q} \sqrt{\frac{E_b}{n}}}$$

→ This resets the integrator voltage to zero. The integrator then integrates next bit.

let T_b = one bit Period.

The Phase change occurs in the carrier only at zero crossing.

→ At k^{th} bit interval, the o/P signal can be written as

$$S_o(kT_b) = b(kT_b)\sqrt{P/2} \int_{(k-1)T_b}^{kT_b} 1 + \cos(2\pi f_c t + \theta)\, dt$$

The integration is Performed from $(k-1)T_b$ to kT_b

$$= b(kT_b)\sqrt{P/2} \left[\int_{(k-1)T_b}^{kT_b} 1 \cdot dt + \int_{(k-1)T_b}^{kT_b} \cos(2\pi f_c t) dt \right]$$

where $\int_{(k-1)T_b}^{kT_b} \cos(2\pi f_c t + \theta) dt = 0$; since average of sinusoidal w/f is '0'.

If integration is done over full cycle

$$\therefore S_o(kT_b) = b(kT_b)\sqrt{P/2} \int_{(k-1)T_b}^{kT_b} 1 \cdot dt + 0$$

$$= b(kT_b)\sqrt{P/2} \left[t \right]_{(k-1)T_b}^{kT_b}$$

$$= b(kT_b)\sqrt{P/2} \left[kT_b - (k-1)T_b \right]$$

$$= b(kT_b)\sqrt{P/2} \cdot T_b$$

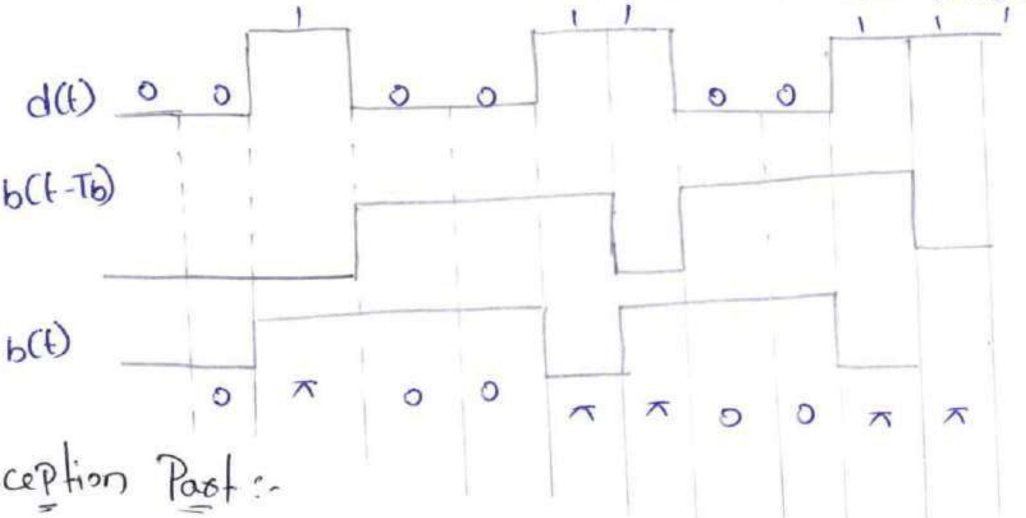
$$S_o(kT_b) = b(kT_b)\sqrt{P/2} \cdot T_b$$

$$S_o(kT_b) \propto b(kT_b)$$

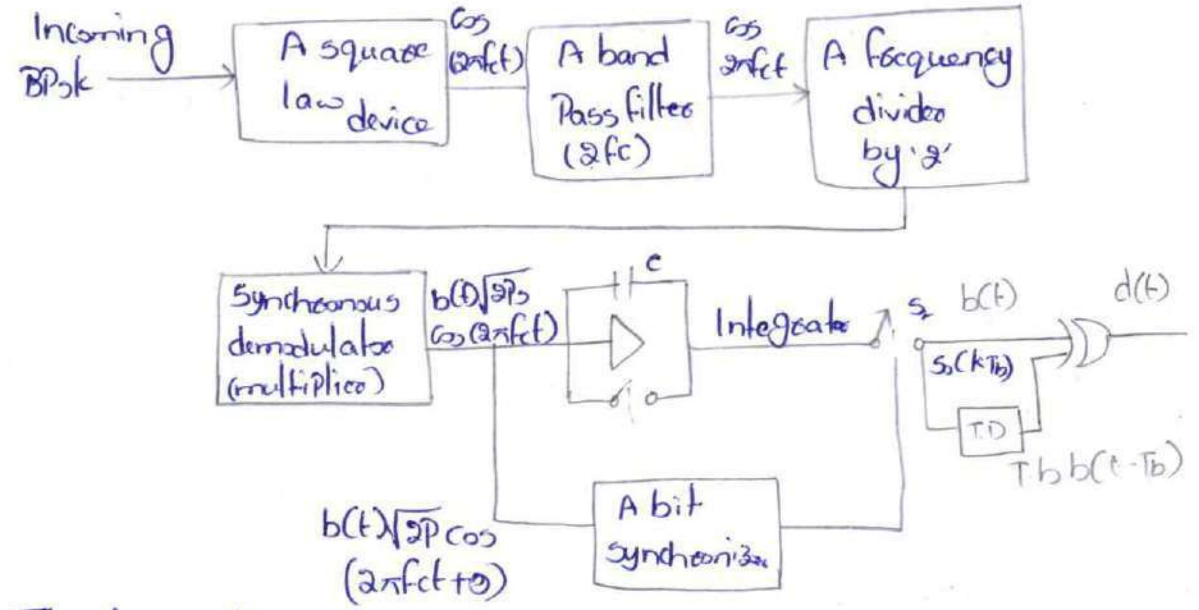
→ Depending upon the values of $b(kT_b)$. The o/P $S_o(kT_b)$ is generated in the receiver.

→ Finally this signal is applied to decision device which decides whether the transmitted symbol was zero (or) one

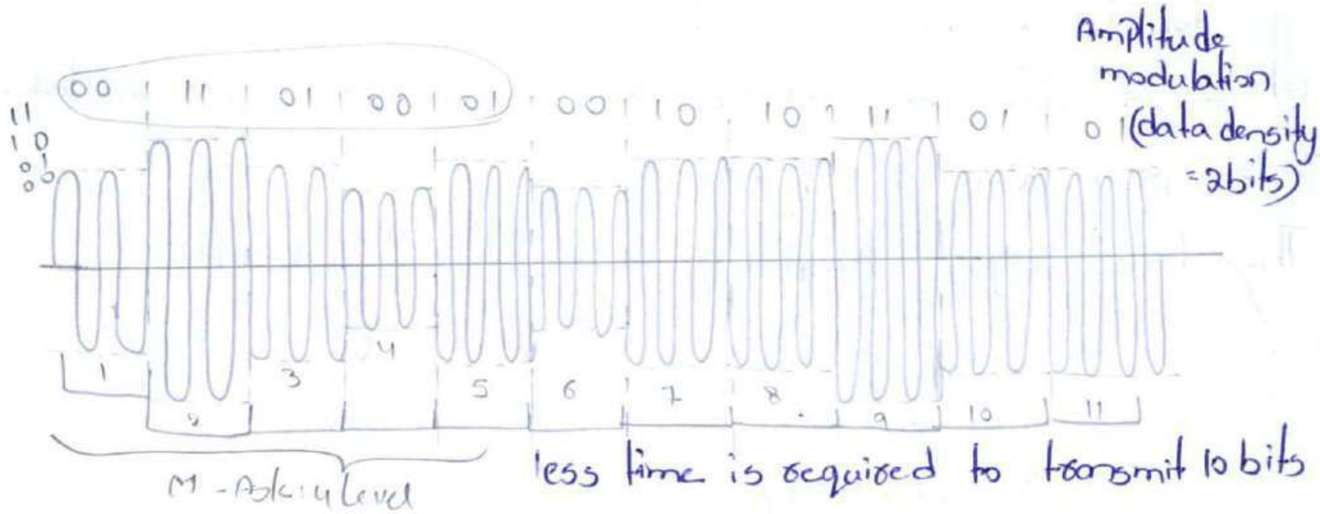
let $b(t) = 0$ assume initially
$b(t-T_b)$ is delayed version of $b(t)$
Phase shift at the carrier signal (observe $d(t)$)
$d(t) = 1 \Rightarrow$ Phase shift $d(t) = 0 \rightarrow$ No Phase shift.



Reception Part :-

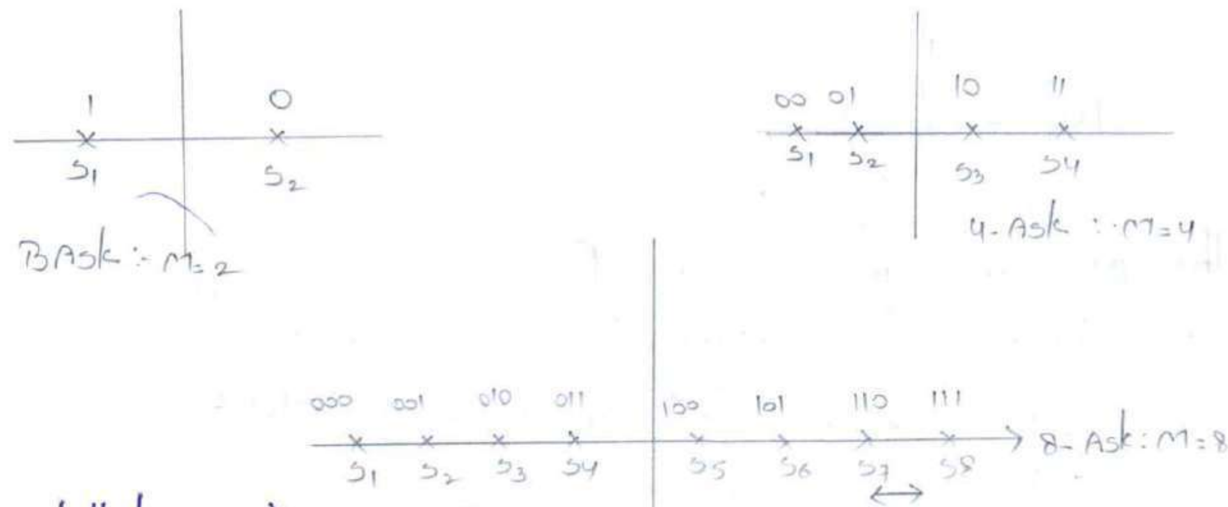


1. The transmitted BPSK signal is given as
$$S(t) = b(t)\sqrt{2P}\cos(2\pi f_c t)$$
2. This signal undergoes the phase change depending upon the time delay from transmitter end to receiver end it is usually a phase shift in transmitted signal.
3. let Phase shift $= \theta$
The signal at the i/p of the receiver is $S(t) = b(t)\sqrt{2P}\cos(2\pi f_c t + \theta)$



less time is required to transmit 10 bits

Two bits are Combined for 1 symbol levels are divided as 4 levels to t = 5 sec For bits transmission



Constallation diagram of BASK and M-ary Ask signal
As No. of levels increases the seperation between two adjacent symbols decreases it means demodulation is difficult for higher level techniques

Applications:-

1. M-ary is also used in PAM
2. Implementation is simple
3. Drawback :- It is easily susceptable to Noise.

Binary level $M = 2$

Bit rate $= 8$ bps $m(t) = 10110001 = 8$ bits

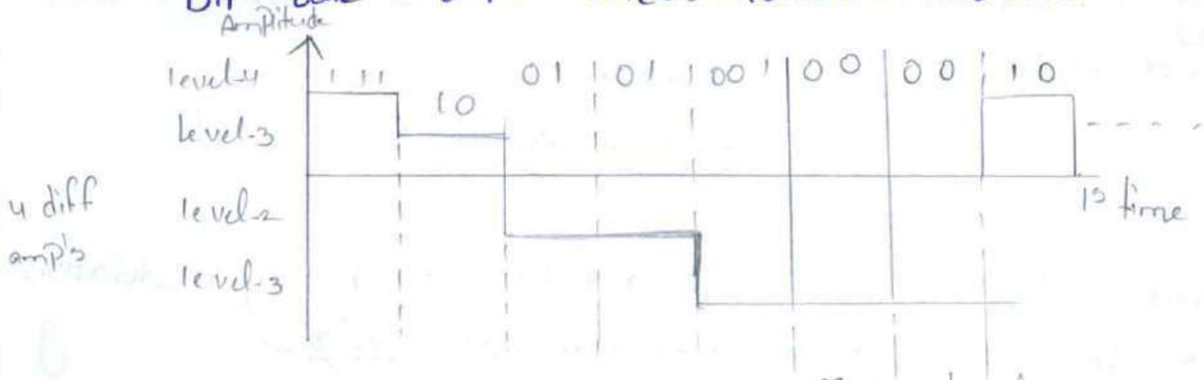


fig:. Digital signal with 4 levels   M-ary level $m = 4$

In this signal representation 16 bits are sent in 1s

$\therefore$ Bit rate $= 16$ BPS (bits per second)

fig:. Binary and M-ary digital signal representation

8. M-level signal is used to modulate the carrier then this technique is known as M-ary digital modulation technique.
9. In this, one of the M-possible signal is transmitted during each symbol duration, T_s

$$T_s = T_b \log_2 m$$
$$= T_b \log_2 2^n = nT_b$$

where T_b = bit duration; $\boxed{T_s = nT_b}$

10. Based on the type of modulation used, They are classified as
    1. M-ary ASK
    2. M-ary FSK
    3. M-ary PSK
    4. M-ary Amplitude & Phase shift keying.

M-ary ASK modulation Technique :-

1. In M-ary Amplitude shift keying (M-ary ASK), there are M - different amplitude levels of the carrier are used.
2. The signal is represented by.

$$s_i(t) = A_i \cos(2\pi f_c t), \quad 0 \le t \le T_s \quad - (1)$$

In logarithmic (or) in decibels

$$\left(\frac{S}{N}\right)_{dB} = \log(3\times 2^{2V})$$

$$= \left(\log_{10} 3 + \log_{10} 2^{2V}\right) dB$$

$$= 4.8 + 2V \log_{10} 2$$

$$\left(\frac{S}{N}\right)_{dB} = (4.8 + 6V)\ dB.$$

1A) 6A) Given that.

$x_{max} = \pm 0.1\%$ $+x_{max}$

$-x$ ~~to~~ $+x \Rightarrow -10$ to $10V$

$x_{max} = \pm 0.001$

$f_m = 100Hz.$

$$x_{max} = \frac{\Delta}{2}$$

$$\Delta = x_{max} \times 2$$

$$= 0.001 \times 2.$$

$$\Delta = 0.002$$

$$\Delta = \frac{2x_{max}}{q}$$

$$q = \frac{2 \cdot x_{max}}{\Delta}$$

$$q = \frac{2\times 10}{\Delta} = \frac{2\times 10}{0.002} = 10{,}000\ \cancel{kb}$$

i) $f_s = 2f_m$ $f_m = 100Hz$

$f_s = 2\times 100Hz$

$\boxed{f_s = 200Hz}$

ii) $q = 2^V$

$10000 = 2^V$

apply log on both sides

$\log 10000 = \log 2^V.$

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ADDITIONAL SHEET

Sign of the Invigilator : ....

Regd. No. ...20KE1A0464...

$\log 10{,}000 = v \log 2$

$v = \frac{\log 10{,}000}{\log 2} = 13.282$

$\boxed{v = 14 \text{ bits}}$

iii) $r = v f_s$

$r = 14 \times 200 \text{ Hz}$

$\boxed{r = 2800 \text{ bits/sec}}$

iv) $B.W = \frac{r}{2}$ (or) $v f_m$

$= \frac{2{,}800}{2}$ (or) 14×100

$\boxed{B.W = 14{,}00 \text{ Hz}}$ $= 1400 \text{ Hz}$

3

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10 Bh.Suneetha

Name of the Student : Bh. Suneetha Regd. No. 20KE1A0408 Branch ECE

B.Tech / M.Tech / MBA Year : IV Sem : I Subject : DC Sign of the Invigilator :

Date 28-09-22

1d) minimum sampling rate required

$f_m = 100Hz$

then

$q = 10,000$

(i) $f_m : 100Hz$

$f_s \geq 2 \times f_m$

$f_s \geq 2 \times 100$

$f_s \geq 200$

(ii)

$q = 2^V$

$10000 = 2^V$

$\log_{10} 10,000 = V \log_{10} 2$

$$V = \frac{\log_{10} 10,000}{\log_{10} 2}$$

$= 14 bits$

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(iii) minimum bit rate required in the signal

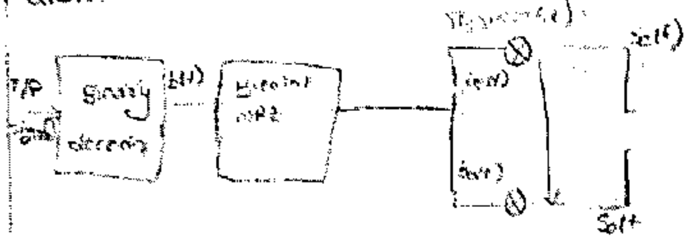
when

$R_b = 2 \times 14 \times 20023800$ VXfs 13800.

(iv) minimum absolute channel bandwidth required the transmission the signal

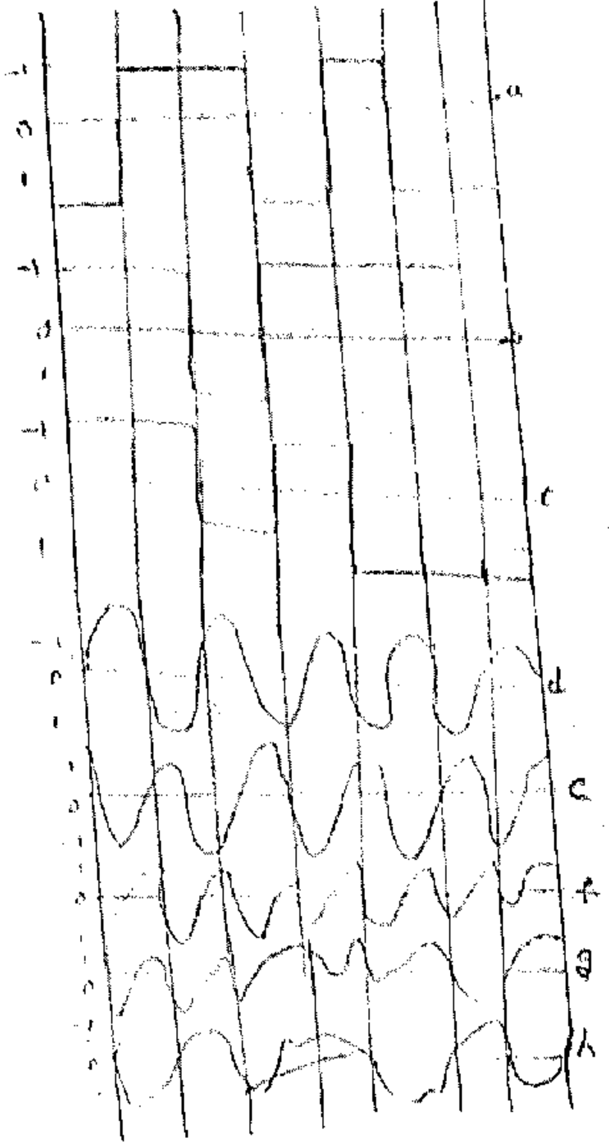
$B_{abs} = \frac{1}{2} \times 2 \cdot \frac{1}{T_b}$ 28002400

(9) QPSK = quantization pulse shift keying



input signal is connected to Binary decoder & it based to the b(t)

Binary decoder connected Bipolar NRZ it is connected to two terminal bo(t) and be(t) when one is even and another is odd first even is come and second odd is come the bo(t) $\sqrt{P_s}\cos(\omega t)$ and be(t) $\sqrt{P_s}\sin(\omega t)$



wave form of QPSK.

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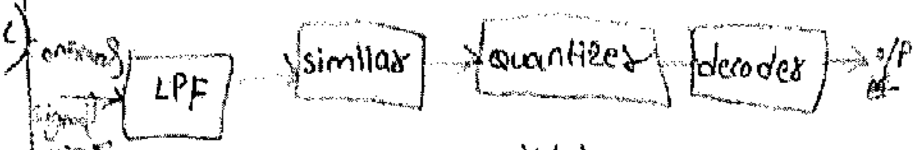
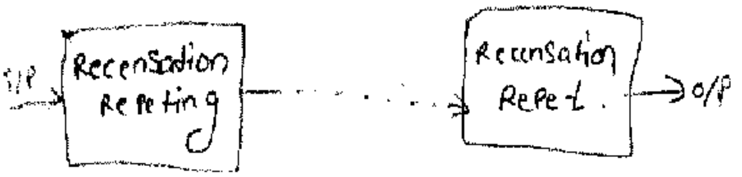
Regd. No. ...Shk Mouls... Sign of the Invigilator :.......

1 c)

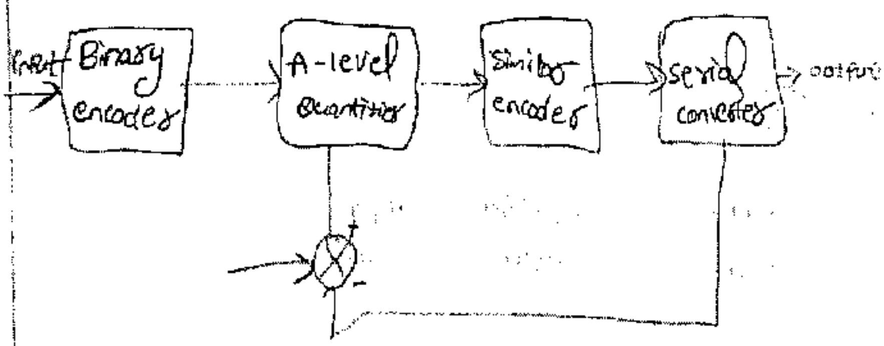


Pcm transmitter



Pcm transmiter path

Pcm generation



Binary encoder is connected into A-level quantization

The pcm generation is main part of pcm signal it is converted

analog to digital converter.

Then quantizer is connected to positive and nagitive

parts then it conneted serial converter.

$$= \frac{1}{\sigma\sqrt{2\pi}} \int_{\frac{x_{01}(T)-x_{02}(T)}{2\sqrt{2}}}^{\infty} e^{-y^2} \sigma\sqrt{2}\, dy$$

Then final equation is.

$$= \int_{\frac{x_{01}(T)-x_{02}(T)}{2}}^{\infty} e^{-y^2}$$ error probability

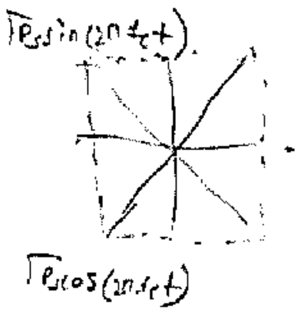
$$= \int_{\frac{x_{01}(T)-x_{02}(T)}{2}}^{\infty} \cancel{\frac{1}{\sigma\sqrt{2\pi}} e^{-y^2}} \sigma\sqrt{2}\, dy$$

then

$$s_o(t) = b_o(t)\sqrt{P_s}\sin(2\pi f_c t)$$

even is

$$s_e(t) = b_e(t)\sqrt{P_s}\cos(2\pi f_c t)$$



$s_o(t) = b_o(t)\sqrt{P_s}\sin(2\pi f_c t) - \sqrt{P_s}\cos(2\pi f_c t)$

$b_o(t) = -1$

$b_e(t) = -1$

$s_o(t) = b_o(t)\sqrt{P_s}\cos(2\pi f_c t) - \sqrt{P_s}\sin(2\pi f_c t)$

$b_o(t) = -1$

$b_e(t) = 1$

$s_e(t) = b_e(t)\sqrt{P_s}\cos(2\pi f_c t) + \sqrt{P_s}\sin(2\pi f_c (t))$

$b_o(t) = 1 \quad b_e(t) = 1$

$s_e(t) = b_e(t)\sqrt{P_s}\cos(2\pi f_c t + \sqrt{P_s}\sin(2\pi f_c t))$

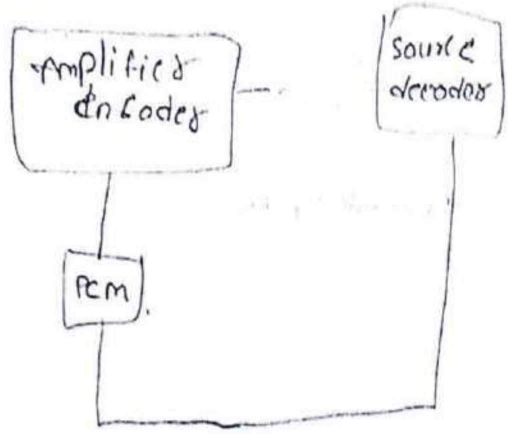
$b_o(t) = 1 \quad b_e(t) = -1$

$s(t) = \sqrt{P_s}\cos(2\pi f_c t) \; \overset{\pi s}{-} \sin(2\pi f_c t)$

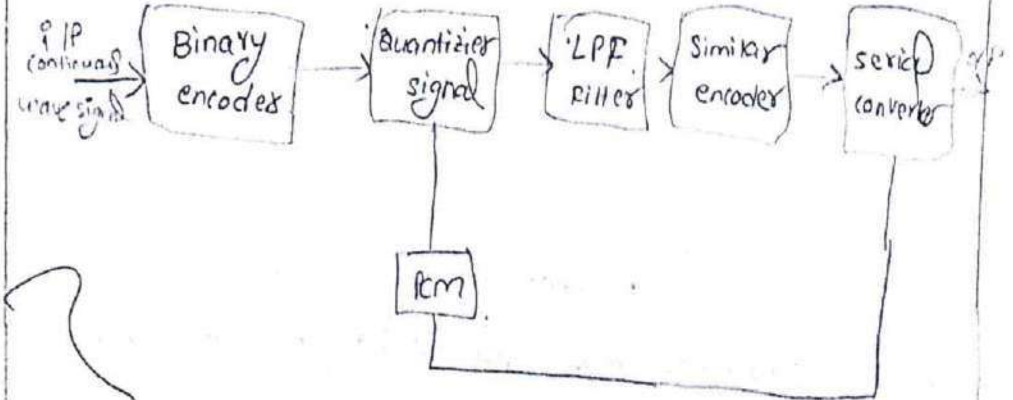
$\sqrt{P_s}\left(\cos(2\pi f_c t) - \sin(2\pi f_c t)\right)$

Pcm transmition. Path

Repeating Path.



Pcm receiver



Pcm receiver is i/p is connected to Binary encoder it is conneted quantizer signal Then conneted LPF filter. pcm receveris quantization noise and signal-to noise ration in Pcm.

Scheme of Evaluation of MID

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DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

A.Y.: 2022-23

Date: 17-12-2022

Subject Code	C304
Subject Name	Digital Communications
Regulation	R20
Year & Sem	III & I
Academic Year	2022-23

SCHEME OF EVALUATION – MID I EXAMINATION

Q.No.	Assignment Question	Marks Allotted	Course Outcome mapping	Taxonomy level
1	a. Derive the expression for quantization noise and signal to noise ratio in PCM? b. The information in an analog signal voltage waveform is to be transmitted over a PCM system with an accuracy of ±0.1% (full scale). The analog voltage waveform has a bandwidth of 100 Hz and an amplitude range of -10 to +10 volts. i. Find the minimum sampling rate required ii. Find the no of bits in each PCM word. iii. Find minimum bit rate required in the PCM signal. iv. Find the minimum absolute channel bandwidth required for the transmission of the PCM signal.	5 4	C304.1	Level 3 (Apply), Level 4 (Analyze)
2	With neat diagrams, discuss the DEPSK Transmitter and receiver Sketch and draw the waveforms?	3	C304.2, C304.3	Level 4 (Analyze)
3	Explain the probability of error calculation in optimum filter? Define optimum filter?	3	C304.3	Level 4 (Analyze)

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Academic Year	2022-23

SCHEME OF EVALUATION – MID II EXAMINATION

Q.No.	Assignment Question	Marks Allotted	Course Outcome mapping	Taxonomy level
1	a) Define the mutual information? State and prove the properties of mutual information. b) A source is transmitting the symbols A and B with probabilities 1/16 and 15/16 respectively. Calculate the Entropy of the source and the required channel capacity using the simplest code and also coding efficiency?	3 5	C303.3,C303.4	Level 2 (Understand
2	Apply Shannon-Fano Coding For The 5 Messages With Probabilities 0.4, 0.15, 0.15, 0.15, 0.15 and Find The coding Efficiency?	3	C303.4	Level 4 (Analyze)
3	Write Error Detection And Error Correction Capabilities Of Linear Block Codes?	4	C303.5	Level 3 (Apply)

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CO & BL EVALUATION – MID I EXAMINATION

Date: 17-12-2022

Subject Name : Digital Communications
Year / Semester : III/ I
Degree / Branch : B.Tech / ECE
Academic Year : 2022-2023

Course Outcome Number	Marks Allotted	CO %
C304.1	9	60
C304.2	3	20
C304.3	3	20
Total Marks	15	100

Taxonomy level	Marks Allotted	Taxonomy Level %
Remember	0	0.00
Understand	0	0.00
Apply	5	33.33
Analyze	10	66.67
Evaluate	0	0
Create	0	0
Total Marks	15	100

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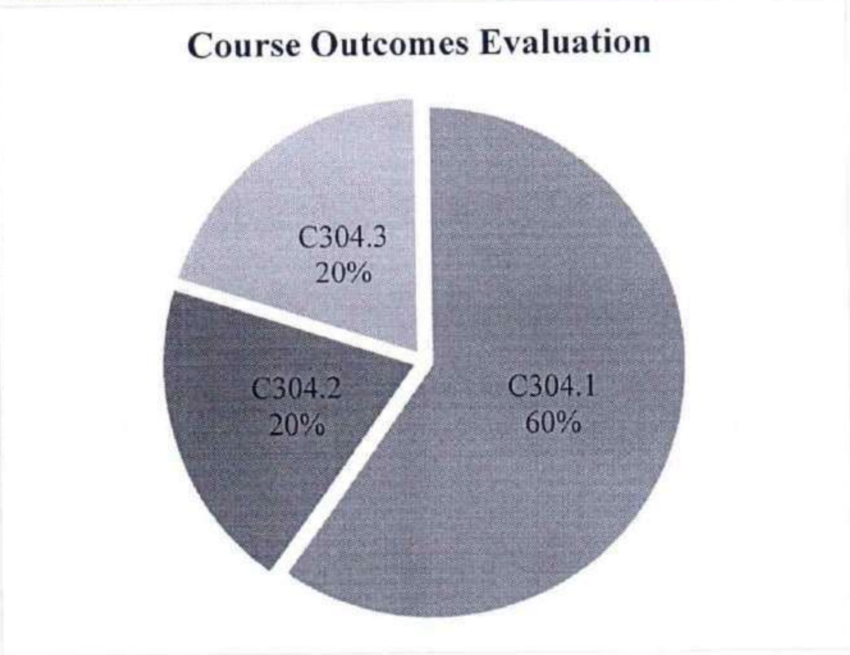

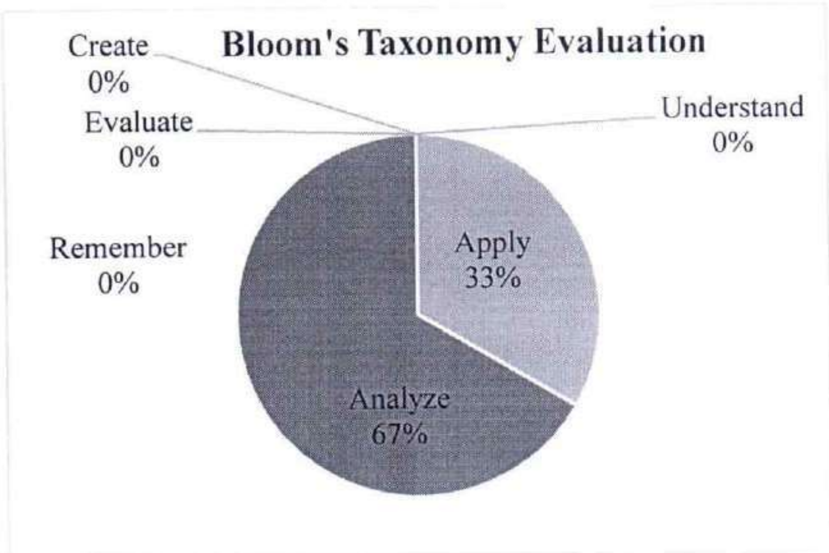

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CO & BL EVALUATION – MID II EXAMINATION

Date: 17-12-2022

Subject Name : Digital Communications
Year / Semester : III/ I
Degree / Branch : B.Tech / ECE
Academic Year : 2022-2023

Course Outcome Number	Marks Allotted	CO %	Taxonomy level	Marks Allotted	Taxonomy Level %
C304.3	3	20.00	Remember	0	0
C304.4	8	53.33	Understand	8	53
C304.5	4	26.67	Apply	4	26.67
Total Marks	15	100	Analyze	3	20.00
			Evaluate	0	0.00
			Create	0	0.00
			Total Marks	15	100

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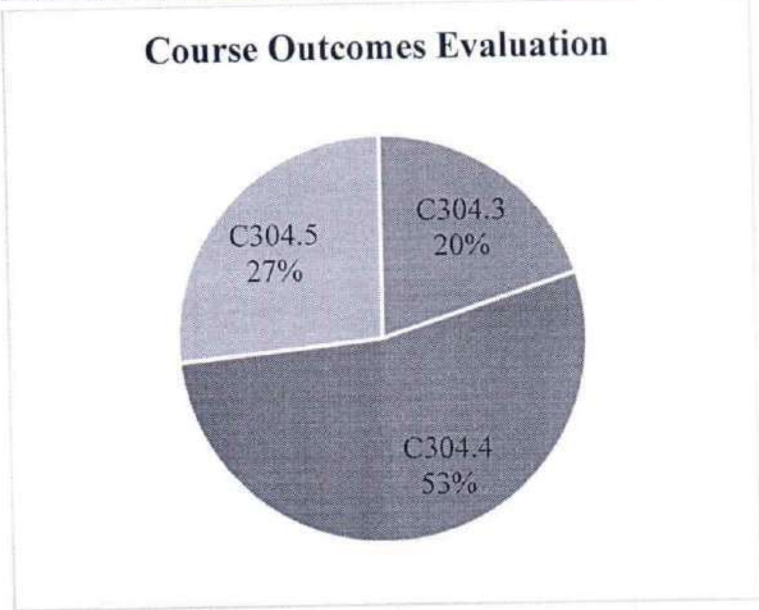

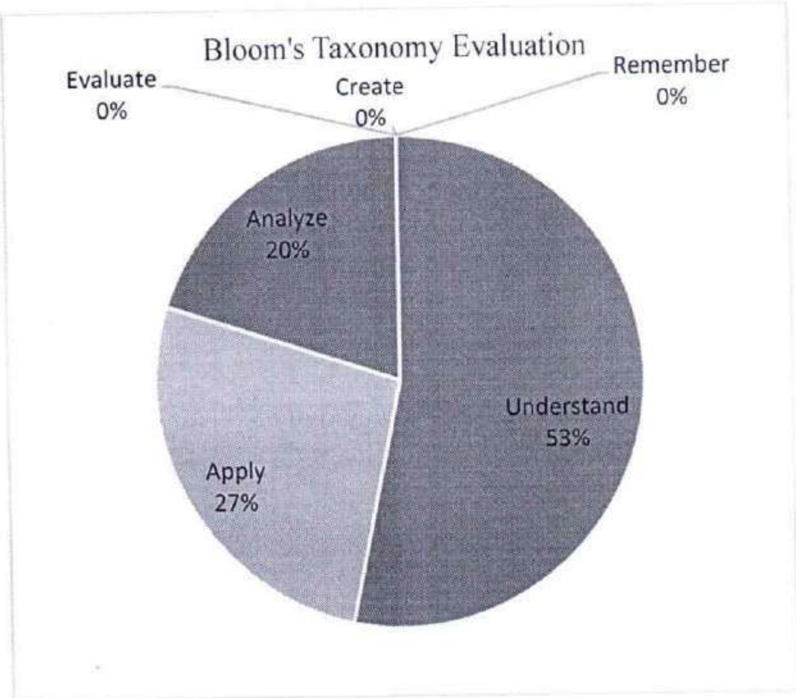

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CO & BL EVALUATION – MID I & II EXAMINATION

Date: 17-12-2022

Subject Name : Digital Communications
Year / Semester : III/ I
Degree / Branch : B.Tech / ECE
Academic Year : 2022-2023

Course Outcome Number	Marks Allotted	CO %		Taxonomy level	Marks Allotted	Taxonomy Level %
C304.1	9	30.00		Remember	0	0
C304.2	3	10.00		Understand	8	27
C304.3	6	20.00		Apply	9	30.00
C304.4	8	26.67		Analyze	13	43.33
C304.5	8	26.67		Evaluate	0	0.00
				Create	0	0.00
Total Marks	30	100		Total Marks	30	100

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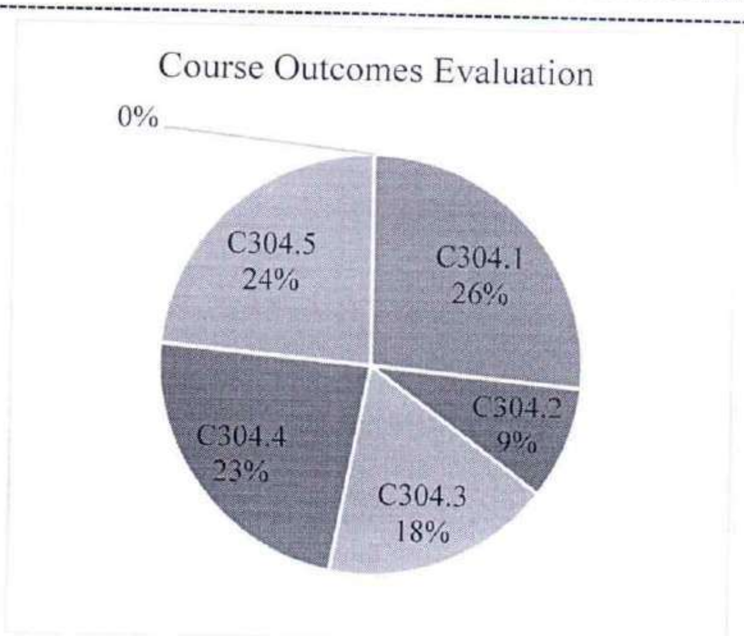

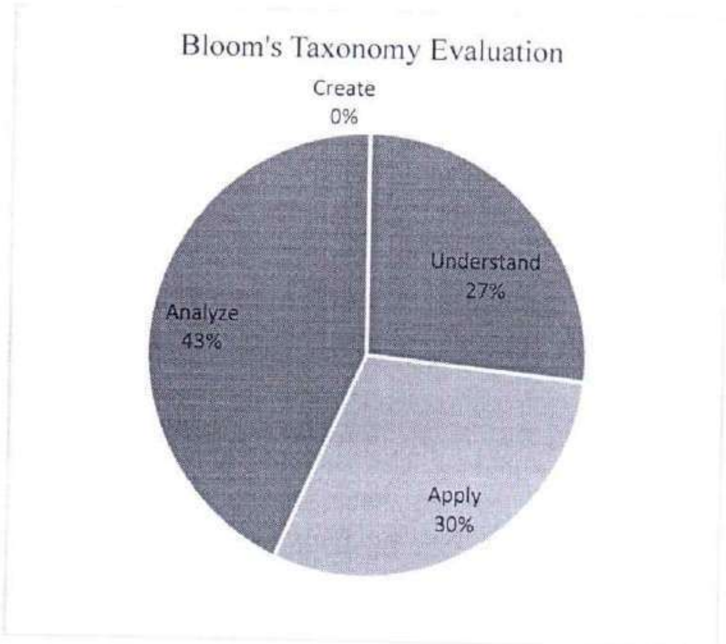

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Subject Code	C304
Subject Name	Digital Communications
Regulation	R20
Year & Sem	III & I
Academic Year	2022-23

ATTENDANCE RECORD

PRINCIPAL
MALINENI LAKSHMAIAH
WOMEN'S ENGINEERING COLLEGE
PULLADIGUNTA, GUNTUR-17

MALINENI LAKSHMAIAH WOMEN'S ENGINEERING COLLEGE
PULLADIGUNTA, GUNTUR - 522017
APPROVED BY AICTE AFFILIATED TO JNTU KAKINADA
III B. TECH 2022- 2023 - I SEMESTER

DEPARTMENT OF ELECTRONICS AND COMMUNICATIONS ENGINEERING

ATTENDANCE		BRANCH :III ECE-A						As on: 17-11-2022			
S. No.	Roll No.	AICA	EMTL	DC	EMI	COA	AICA LAB	DC LAB	DS with JAVA LAB	TOT	%
No. of Classes conducted		66	65	64	65	64	36	36	36	432	
1	20KE1A0401	60	57	58	59	59	36	36	36	401	92.82
2	20KE1A0402	58	60	59	58	58	36	36	36	401	92.82
3	20KE1A0403	59	58	60	57	60	36	36	33	399	92.36
4	20KE1A0404	61	59	58	63	59	36	36	36	408	94.44
5	20KE1A0405	60	58	59	59	57	36	36	36	401	92.82
6	20KE1A0406	60	57	61	60	60	36	36	30	400	92.59
7	20KE1A0407	58	59	60	60	60	36	33	36	402	93.06
8	20KE1A0408	62	59	58	61	58	36	36	33	403	93.29
9	20KE1A0409	61	60	57	58	59	36	36	36	403	93.29
10	20KE1A0410	59	58	61	62	60	36	36	36	408	94.44
11	20KE1A0411	58	57	60	60	61	33	36	36	401	92.82
12	20KE1A0412	61	59	58	63	59	36	36	36	408	94.44
13	20KE1A0413	60	58	59	59	57	36	36	36	401	92.82
14	20KE1A0414	60	57	61	60	60	36	36	30	400	92.59
15	20KE1A0415	62	59	58	61	58	36	36	33	403	93.29
16	20KE1A0416	61	60	57	58	59	36	36	36	403	93.29
17	20KE1A0417	59	58	61	62	60	36	36	36	408	94.44
18	20KE1A0418	58	57	60	60	61	33	36	36	401	92.82
19	20KE1A0420	60	58	59	58	58	36	36	36	401	92.82
20	20KE1A0421	61	60	58	60	57	30	36	36	398	92.13
21	20KE1A0422	58	58	61	59	62	36	36	36	406	93.98
22	20KE1A0423	59	57	60	58	62	36	36	36	404	93.52
23	20KE1A0424	57	58	55	56	54	33	30	30	373	86.34
24	20KE1A0425	58	59	61	62	60	36	36	36	408	94.44
25	20KE1A0426	59	60	60	61	58	36	36	36	406	93.98
26	20KE1A0427	60	59	58	58	60	36	36	36	403	93.29
27	20KE1A0428	61	59	61	60	59	36	36	36	408	94.44
28	20KE1A0429	62	58	63	62	61	36	36	36	414	95.83
29	20KE1A0430	58	60	59	62	58	36	36	30	399	92.36
30	20KE1A0431	59	59	58	60	61	36	36	36	405	93.75
31	20KE1A0432	60	57	59	60	61	36	36	33	402	93.06
32	20KE1A0433	60	58	60	61	59	36	36	30	400	92.59
33	20KE1A0434	58	60	58	61	59	36	36	36	404	93.52
34	20KE1A0435	61	58	59	60	60	36	33	30	397	91.9

MALINENI LAKSHMAIAH WOMEN'S ENGINEERING COLLEGE
PULLADIGUNTA, GUNTUR - 522017
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III B. TECH 2022- 2023 - I SEMESTER

S. No.	Roll No.	AICA	EMTL	DC	EMI	COA	AICA LAB	DC LAB	DS with JAVA LAB	TOT	%
No. of Classes conducted		66	65	64	65	64	36	36	36	432	
35	20KE1A0436	61	62	58	60	61	33	36	33	404	93.52
36	20KE1A0437	60	60	59	59	58	36	36	30	398	92.13
37	20KE1A0438	58	61	60	61	60	36	36	33	405	93.75
38	20KE1A0439	59	59	61	57	59	36	36	30	397	91.9
39	20KE1A0440	58	58	59	58	60	36	36	30	395	91.44
40	20KE1A0441	60	58	58	59	59	33	36	33	396	91.67
41	20KE1A0442	61	58	60	60	59	36	36	36	406	93.98
42	20KE1A0443	58	60	59	61	60	36	33	36	403	93.29
43	20KE1A0444	59	58	57	59	58	36	30	36	393	90.97
44	20KE1A0445	60	58	62	58	60	36	36	36	406	93.98
45	20KE1A0446	59	60	58	59	62	36	36	36	406	93.98
46	20KE1A0447	61	58	62	60	60	36	36	36	409	94.68
47	20KE1A0448	58	57	60	61	59	36	36	36	403	93.29
48	20KE1A0449	59	58	59	58	58	36	36	36	400	92.59
49	20KE1A0450	61	58	58	59	57	36	36	36	401	92.82
50	20KE1A0451	60	59	59	57	59	36	36	36	402	93.06
51	20KE1A0452	58	60	58	60	60	36	36	30	398	92.13
52	20KE1A0453	57	59	57	61	61	36	36	36	403	93.29
53	20KE1A0454	61	58	62	59	59	36	36	36	407	94.21
54	20KE1A0455	59	61	61	58	60	36	36	30	401	92.82
55	20KE1A0456	60	58	60	59	59	36	33	33	398	92.13
56	20KE1A0457	57	59	59	60	57	36	36	36	400	92.59
57	20KE1A0458	59	61	61	58	60	36	36	30	401	92.82
58	20KE1A0459	59	61	61	58	60	36	36	30	401	92.82
59	20KE1A0460	57	59	59	60	57	36	36	36	400	92.59

PRINCIPAL
MALINENI LAKSHMAIAH
WOMEN'S ENGINEERING COLLEGE
PULLADIGUNTA, GUNTUR-17.

MALINENI LAKSHMAIAH WOMEN'S ENGINEERING COLLEGE
PULLADIGUNTA, GUNTUR - 522017
APPROVED BY AICTE AFFILIATED TO JNTU KAKINADA
III B. TECH 2022- 2023 - I SEMESTER

DEPARTMENT OF ELECTRONICS AND COMMUNICATIONS ENGINEERING

ATTENDANCE		BRANCH : III ECE-B						As on: 17-11-2022			
S. No.	Roll No.	AICA	EMTL	DC	EMI	COA	AICA LAB	DC LAB	DS with JAVA LAB	TOT	%
No. of Classes conducted		66	65	64	65	64	36	36	36	432	
1	20KE1A0461	59	60	58	59	62	36	36	36	406	93.98
2	20KE1A0462	58	57	60	61	59	36	36	36	403	93.29
3	20KE1A0463	59	58	59	58	58	36	36	36	400	92.59
4	20KE1A0464	61	58	58	59	57	36	36	36	401	92.82
5	20KE1A0465	60	59	59	57	59	33	36	36	399	92.36
6	20KE1A0466	58	60	58	60	60	36	36	36	404	93.52
7	20KE1A0467	57	59	57	61	61	36	33	36	400	92.59
8	20KE1A0468	61	58	62	59	59	36	33	36	404	93.52
9	20KE1A0469	58	60	59	61	60	36	36	36	406	93.98
10	20KE1A0470	59	58	57	59	58	36	36	36	399	92.36
11	20KE1A0471	57	59	58	56	57	33	30	30	380	87.96
12	20KE1A0472	59	60	58	59	62	36	36	36	406	93.98
13	20KE1A0474	58	59	58	59	57	36	36	30	393	90.97
14	20KE1A0475	60	60	59	59	58	36	36	36	404	93.52
15	20KE1A0476	58	61	60	61	60	36	36	36	408	94.44
16	20KE1A0477	60	59	59	57	59	33	36	36	399	92.36
17	20KE1A0478	58	60	58	60	60	36	36	36	404	93.52
18	20KE1A0479	57	59	57	61	61	36	33	36	400	92.59
19	20KE1A0480	61	58	62	59	59	36	33	36	404	93.52
20	20KE1A0481	59	61	61	58	60	36	36	33	404	93.52
21	20KE1A0482	60	58	60	59	59	36	36	33	401	92.82
22	20KE1A0483	57	59	59	60	57	36	33	36	397	91.9
23	20KE1A0484	60	58	59	58	58	36	36	33	398	92.13
24	20KE1A0485	61	60	58	60	57	36	36	36	404	93.52
25	20KE1A0486	58	58	61	59	62	36	36	36	406	93.98
26	20KE1A0487	59	57	60	58	62	36	36	36	404	93.52
27	20KE1A0488	60	59	58	60	61	36	36	36	406	93.98
28	20KE1A0489	58	56	59	58	60	33	33	30	387	89.58
29	20KE1A0490	59	60	60	61	58	36	36	36	406	93.98
30	20KE1A0491	60	58	59	58	58	36	36	36	401	92.82
31	20KE1A0492	61	60	58	60	57	33	36	36	401	92.82
32	20KE1A0493	58	58	61	59	62	36	36	36	406	93.98
33	20KE1A0494	61	58	58	59	61	36	36	33	402	93.06
34	20KE1A0495	60	59	59	57	59	36	33	36	399	92.36

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III B. TECH 2022- 2023 - I SEMESTER

S. No.	Roll No.	AICA	EMTL	DC	EMI	COA	AICA LAB	DC LAB	DS with JAVA LAB	432	
No. of Classes conducted		66	65	64	65	64	36	36	36		
										399	92.36
35	19KE1A0496	60	59	59	57	59	36	33	36	401	92.82
36	19KE1A0497	58	60	58	60	60	36	36	33	403	93.29
37	19KE1A0498	57	59	57	61	61	36	36	36	404	93.52
38	19KE1A0499	61	58	62	59	59	33	36	36	398	92.13
39	20KE1A04A0	59	61	61	58	60	33	36	30	398	92.13
40	20KE1A04A1	60	58	59	58	58	36	36	33	401	92.82
41	20KE1A04A2	61	60	58	60	57	33	36	36	403	93.29
42	20KE1A04A3	58	58	61	59	62	36	33	36	401	92.82
43	21KE5A0401	59	57	60	58	62	36	36	33	406	93.98
44	21KE5A0402	60	59	58	60	61	36	36	36	408	94.44
45	21KE5A0403	58	59	61	62	60	36	36	36	400	92.59
46	21KE5A0404	59	60	60	61	58	30	36	36	402	93.06
47	21KE5A0405	58	59	60	60	60	33	36	36	407	94.21
48	21KE5A0406	62	58	60	58	61	36	36	36	402	93.06
49	21KE5A0407	60	58	58	59	59	36	36	36	412	95.37
50	21KE5A0408	61	60	59	62	62	36	36	36	407	94.21
51	21KE5A0409	59	59	60	61	60	36	36	36	407	94.21
52	21KE5A0410	62	58	60	58	61	36	36	36	402	93.06
53	21KE5A0411	60	58	58	59	59	36	36	36	412	95.37
54	21KE5A0412	61	60	59	62	62	36	36	36	402	93.06
55	21KE5A0413	60	58	58	59	59	36	36	36		

PRINCIPAL

PRINCIPAL
MALINENI LAKSHMAIAH
WOMEN'S ENGINEERING COLLEGE
PULLADIGUNTA, GUNTUR-17.

List of
Slow learners
in the course

MALINENI LAKSHMAIAH WOMEN'S ENGINE[ERING COLLEGE]
Approved by AICTE, New Delhi & Affiliat[ed to JNTUK], Kakinada
(An ISO9001:2008 Certified Institution)
Pulladigunta (Vil), Vatticherukuru (Md), Prathipadu Road, Guntur – 522 017 A.P.

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

A.Y.: 2022-23

Date: 17-12-2022

Subject Code	C304
Subject Name	Digital Communications
Regulation	R20
Year & Sem	III & I
Academic Year	2022-23

LIST OF SLOW LEARNERS IN THE COURSE

S.No.	ROLL NUMBER	No. OF BACKLOGS
1	20KE1A0403	1
2	20KE1A0404	3
3	20KE1A0407	1
4	20KE1A0408	2
5	20KE1A0414	4
6	20KE1A0416	1
7	20KE1A0420	1
8	20KE1A0427	2
9	20KE1A0429	3
10	20KE1A0430	1
11	20KE1A0431	4
12	20KE1A0433	2
13	20KE1A0435	1
14	20KE1A0439	1
15	20KE1A0441	2
16	20KE1A0445	1
17	20KE1A0447	1
18	20KE1A0450	1
19	20KE1A0451	1
20	20KE1A0453	1
21	20KE1A0454	1
22	20KE1A0457	1
23	20KE1A0459	4
24	20KE1A0461	1
25	20KE1A0470	2
26	20KE1A0475	2
27	20KE1A0476	1
28	20KE1A0478	3

29	20KE1A0482	2
30	20KE1A0486	2
31	20KE1A0489	2
32	20KE1A0491	1
33	20KE1A0492	3
34	20KE1A0493	2
35	20KE1A0494	2
36	20KE1A0498	1
37	20KE1A04A0	3
38	20KE1A04A2	4
39	21KE5A0405	1
40	21KE5A0411	4

Signature of Faculty

PRINCIPAL
MALINENI LAKSHMAIAH
WOMEN'S ENGINEERING COLLEGE
PULLADIGUNTA, GUNTUR-17

Slow learners
Based on No.of
Back Logs

MALINENI LAKSHMAIAH WOMEN'S ENGINEERING COLLEGE

Pulladigunta, Vatticherukuru Mandal, Guntur, Andhra Pradesh-522017.

Approved by AICTE, New Delhi, Affiliated to JNTUK.

ESTD : 2008

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

REGULAR EXAMINATIONS RESULTS ANALYSIS (SEPT-2022)

YEAR/SEM: II/II (20-09-2022) **BATCH: 2020-24**

S.No.	ROLL NUMBER	ECA	DICD	AC	LCS	MOB	ECA LAB	AC LAB	DICD LAB	SS LAB	P / F	No. OF BACK LOGS
		R2022041	R2022042	R2022043	R2022044	R2022045	R2022046	R2022047	R2022048	R2022049		
1	20KE1A0401	E	D	E	D	D	A+	A+	A+	A+	P	0
2	20KE1A0402	C	C	C	D	D	A+	A+	A+	A+	P	0
3	20KE1A0403	C	F	C	C	C	A+	A+	A+	A+	F	1
4	20KE1A0404	E	E	F	F	F	A+	A+	A+	A+	F	3
5	20KE1A0405	D	C	D	C	C	A+	A+	A+	A+	P	0
6	20KE1A0406	D	C	C	D	C	A+	A+	A+	A+	P	0
7	20KE1A0407	D	F	E	C	D	A+	A+	A+	A+	F	1
8	20KE1A0408	E	E	E	F	F	A+	A+	A+	A+	F	2
9	20KE1A0409	D	C	D	C	D	A+	A+	A+	A+	P	0
10	20KE1A0410	C	E	D	C	C	A+	A+	A+	A+	P	0
11	20KE1A0411	E	D	D	D	D	A+	A+	A+	A+	P	0
12	20KE1A0412	D	C	D	E	C	A+	A+	A+	A+	P	0
13	20KE1A0413	C	D	E	D	C	A+	A+	A+	A+	P	0
14	20KE1A0414	F	F	F	D	F	A	A	A	A	F	4
15	20KE1A0415	D	D	E	C	D	A+	A+	A+	A+	P	0
16	20KE1A0416	D	C	C	F	D	A+	A+	A+	A+	F	1
17	20KE1A0417	E	E	E	D	C	A+	A+	A+	A+	P	0
18	20KE1A0418	D	D	D	D	D	A+	A+	A+	A+	P	0
19	20KE1A0420	D	F	E	C	D	A+	A+	A+	A+	F	1
20	20KE1A0421	C	D	D	E	D	A+	A+	A+	A+	P	0
21	20KE1A0422	C	C	D	C	C	A+	A+	A+	A+	P	0
22	20KE1A0423	B	C	D	D	D	A+	A+	A+	A+	p	0
23	20KE1A0424	D	E	C	D	D	A+	A+	A+	A+	p	0

24	20KE1A0425	C	D	D	E	C	A+	A+	A+	A+	p	0
25	20KE1A0426	B	B	C	B	D	A+	A+	A+	A+	p	0
26	20KE1A0427	E	F	D	E	F	A+	A+	A+	A+	F	2
27	20KE1A0428	D	C	D	D	D	A+	A+	A+	A+	p	0
28	20KE1A0429	D	D	F	F	F	A+	A+	A+	A+	F	3
29	20KE1A0430	D	D	D	F	D	A+	A+	A+	A+	F	1
30	20KE1A0431	F	F	E	F	F	A+	A+	A+	A+	F	4
31	20KE1A0432	C	D	B	C	D	A+	A+	A+	A+	P	0
32	20KE1A0433	D	C	F	F	D	A+	A+	A+	A+	F	2
33	20KE1A0434	D	D	D	E	D	A+	A+	A+	A+	P	0
34	20KE1A0435	E	F	D	D	D	A+	A+	A+	A+	F	1
35	20KE1A0436	E	E	E	D	D	A+	A+	A+	A+	P	0
36	20KE1A0437	C	C	B	A	C	A+	A+	A+	A+	P	0
37	20KE1A0438	C	B	D	C	D	A+	A+	A+	A+	P	0
38	20KE1A0439	E	F	C	D	D	A+	A+	A+	A+	F	1
39	20KE1A0440	E	D	D	D	D	A+	A+	A+	A+	P	0
40	20KE1A0441	D	C	F	F	D	A+	A+	A+	A+	F	2
41	20KE1A0442	C	C	C	D	C	A+	A+	A+	A+	P	0
42	20KE1A0443	E	D	C	D	D	A+	A+	A+	A+	P	0
43	20KE1A0444	C	D	C	D	D	A+	A+	A+	A+	P	0
44	20KE1A0445	D	D	D	F	E	A+	A+	A+	A+	F	1
45	20KE1A0446	E	D	D	E	D	A+	A+	A+	A+	P	0
46	20KE1A0447	E	D	F	C	D	A+	A+	A+	A+	F	1
47	20KE1A0448	B	A	B	C	C	A+	A+	A+	A+	P	0
48	20KE1A0449	D	C	D	C	D	A+	A+	A+	A+	P	0
49	20KE1A0450	D	E	E	F	E	A+	A+	A+	A+	F	1
50	20KE1A0451	D	F	E	E	E	A+	A+	A+	A+	F	1
51	20KE1A0452	E	E	D	D	D	A+	A+	A+	A+	P	0
52	20KE1A0453	E	D	E	F	E	A+	A+	A+	A+	F	1
53	20KE1A0454	C	E	E	F	D	A+	A+	A+	A+	F	1
54	20KE1A0455	B	C	C	B	D	A+	A+	A+	A+	P	0
55	20KE1A0456	D	C	E	C	D	A+	A+	A+	A+	P	0

56	20KE1A0457	C	D	E	E	F	A+	A+	A+	A+	F	1
57	20KE1A0458	D	D	E	E	D	A+	A+	A+	A+	P	0
58	20KE1A0459	D	F	F	F	F	A+	A+	A+	A+	F	4
59	20KE1A0460	D	E	D	E	D	A	A+	A+	A+	P	0
60	20KE1A0461	E	D	E	F	C	A+	A+	A+	A+	F	1
61	20KE1A0462	D	D	D	E	C	A+	A+	A+	A+	P	0
62	20KE1A0463	C	D	D	D	D	A+	A+	A+	A+	P	0
63	20KE1A0464	C	C	B	C	C	A+	A+	A+	A+	P	0
64	20KE1A0465	D	D	D	D	D	A+	A+	A+	A+	P	0
65	20KE1A0466	D	D	C	D	D	A+	A+	A+	A+	P	0
66	20KE1A0467	D	C	D	D	C	A+	A+	A+	A+	P	0
67	20KE1A0468	C	D	C	C	D	A+	A+	A+	A+	P	0
68	20KE1A0469	D	C	D	C	E	A+	A+	A+	A+	P	0
69	20KE1A0470	E	F	E	F	E	A	A+	A+	A+	F	2
70	20KE1A0471	D	C	C	D	C	A+	A+	A+	A+	P	0
71	20KE1A0472	E	D	D	D	E	A+	A+	A+	A+	P	0
72	20KE1A0474	D	D	D	C	E	A+	A+	A+	A+	P	0
73	20KE1A0475	D	F	D	D	D	A+	A+	A+	A+	F	2
74	20KE1A0476	E	F	D	E	C	A+	A+	A+	A+	F	1
75	20KE1A0477	E	E	E	D	D	A+	A+	A+	A+	P	0
76	20KE1A0478	E	C	F	F	F	A+	A+	A+	A+	F	3
77	20KE1A0479	E	E	E	D	D	A+	A+	A+	A+	P	0
78	20KE1A0480	C	E	B	D	D	A+	A+	A+	A+	P	0
79	20KE1A0481	C	B	D	C	D	A+	A+	A+	A+	P	0
80	20KE1A0482	C	C	D	F	F	A+	A+	A+	A+	F	2
81	20KE1A0483	E	D	D	C	D	A+	A+	A+	A+	P	0
82	20KE1A0484	D	E	C	D	D	A+	A+	A+	A+	P	0
83	20KE1A0485	C	C	C	C	D	A+	A+	A+	A+	P	0
84	20KE1A0486	D	C	F	F	E	A+	A+	A+	A+	F	2
85	20KE1A0487	E	E	C	D	D	A+	A+	A+	A+	P	0
86	20KE1A0488	C	D	C	C	C	A+	A+	A+	A+	P	0
87	20KE1A0489	D	E	F	F	E	A+	A+	A+	A+	F	2

88	20KE1A0490	C	C	C	D	D	A+	A+	A+	A+	P	0
89	20KE1A0491	E	F	D	D	D	A+	A+	A+	A+	F	1
90	20KE1A0492	E	F	F	F	D	A+	A+	A+	A+	F	3
91	20KE1A0493	E	D	F	D	F	A+	A+	A+	A+	F	2
92	20KE1A0494	D	D	E	F	F	A+	A+	A+	A+	F	2
93	20KE1A0495	E	D	D	D	D	A+	A+	A+	A+	P	0
94	20KE1A0496	E	E	C	D	D	A+	A+	A+	A+	P	0
95	20KE1A0497	C	D	E	E	D	A+	A+	A+	A+	P	0
96	20KE1A0498	C	C	D	F	D	A+	A+	A+	A+	F	1
97	20KE1A0499	D	C	C	C	D	A+	A+	A+	A+	P	0
98	20KE1A04A0	E	F	F	F	E	A	A+	A+	A+	F	3
99	20KE1A04A1	D	D	E	F	D	A	A+	A+	A	P	0
100	20KE1A04A2	F	E	F	F	F	A+	A+	A+	A+	F	4
101	20KE1A04A3	E	D	D	D	D	A+	A+	A+	A+	P	0
102	21KE5A0401	D	D	D	D	D	A+	A+	A+	A+	P	0
103	21KE5A0402	D	C	C	C	C	A+	A+	A+	A+	P	0
104	21KE5A0403	C	C	C	E	D	A+	A+	A+	A+	P	0
105	21KE5A0404	D	D	D	D	D	A+	A+	A+	A+	P	0
106	21KE5A0405	D	D	D	F	D	A+	A+	A+	A+	F	1
107	21KE5A0406	D	D	D	C	D	A+	A+	A+	A+	P	0
108	21KE5A0407	E	D	D	E	D	A+	A+	A+	A+	P	0
109	21KE5A0408	C	B	C	C	C	A+	A+	A+	A+	P	0
110	21KE5A0409	D	C	D	D	D	A+	A+	A+	A+	P	0
111	21KE5A0410	C	B	D	B	D	A+	A+	A+	A+	P	0
112	21KE5A0411	F	E	F	F	F	A+	A+	A+	A+	F	4
113	21KE5A0412	C	C	C	C	C	A+	A+	A+	A+	P	0
114	21KE5A0413	D	C	D	D	D	A+	A+	A+	A+	P	0

PASS	110	98	99	87	100	114	114	114	74
FAIL	4	16	15	27	14	0	0	0	40
%	96.49	85.96	86.84	76.32	87.72	100.00	100.00	100.00	64.91

PRINCIPAL
MALINENI LAKSHMAIAH
WOMEN'S ENGINEERING COLLEGE
PULLADIGUNTA, GUNTUR-17

MALINENI LAKSHMAIAH WOMEN'S ENGINEERING COLLEGE

Pulladigunta, Vatticherukuru Mandal, Guntur, Andhra Pradesh-522017.

Approved by AICTE, New Delhi, Affiliated to JNTUK.

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

REGULAR EXAMINATIONS RESULTS ANALYSIS (SEPT-2022)

YEAR/SEM: II/II (20-09-2022)

BATCH: 2020-24

S.No	ROLL NUMBER	ECA	DICD	AC	LCS	MOB	ECA LAB	AC LAB	DICD LAB	SS LAB	P / F	No. OF BACKLOGS	SGPA	%
		R2022041	R2022042	R2022043	R2022044	R2022045	R2022046	R2022047	R2022048	R2022049				
1	20KE1A0401	5	6	5	6	6	10	10	10	10	P	0	6.930	61.80
2	20KE1A0402	7	7	7	6	6	10	10	10	10	P	0	7.628	68.78
3	20KE1A0403	7	4	7	7	7	10	10	10	10	F	1	7.488	67.38
4	20KE1A0404	5	5	4	4	4	10	10	10	10	F	3	6.093	53.43
5	20KE1A0405	6	7	6	7	7	10	10	10	10	P	0	7.628	68.78
6	20KE1A0406	6	7	7	6	7	10	10	10	10	P	0	7.628	68.78
7	20KE1A0407	6	4	5	7	6	10	10	10	10	F	1	6.930	61.80
8	20KE1A0408	5	5	5	4	4	10	10	10	10	F	2	6.233	54.83
9	20KE1A0409	6	7	6	7	6	10	10	10	10	P	0	7.488	67.38
10	20KE1A0410	7	5	6	7	7	10	10	10	10	P	0	7.488	67.38
11	20KE1A0411	5	6	6	6	6	10	10	10	10	P	0	7.070	63.20
12	20KE1A0412	6	7	6	5	7	10	10	10	10	P	0	7.349	65.99
13	20KE1A0413	7	6	5	6	7	10	10	10	10	P	0	7.349	65.99
14	20KE1A0414	4	4	4	6	4	9	9	9	9	F	4	5.791	50.41
15	20KE1A0415	6	6	5	7	6	10	10	10	10	P	0	7.209	64.59
16	20KE1A0416	6	7	7	4	6	10	10	10	10	F	1	7.209	64.59
17	20KE1A0417	5	5	5	6	7	10	10	10	10	P	0	6.930	61.80
18	20KE1A0418	6	6	6	6	6	10	10	10	10	P	0	7.209	64.59
19	20KE1A0420	6	4	5	7	6	10	10	10	10	F	1	6.930	61.80
20	20KE1A0421	7	6	6	5	6	10	10	10	10	P	0	7.209	64.59
21	20KE1A0422	7	7	6	7	7	10	10	10	10	P	0	7.767	70.17
22	20KE1A0423	8	7	6	6	6	10	10	10	10	P	0	7.628	68.78

23	20KE1A0424	6	5	7	6	6	10	10	10	10	p	0	7.209	64.59
24	20KE1A0425	7	6	6	5	7	10	10	10	10	p	0	7.349	65.99
25	20KE1A0426	8	8	7	8	6	10	10	10	10	p	0	8.186	74.36
26	20KE1A0427	5	4	6	5	4	10	10	10	10	F	2	6.372	56.22
27	20KE1A0428	6	7	6	6	6	10	10	10	10	p	0	7.349	65.99
28	20KE1A0429	6	6	4	4	4	10	10	10	10	F	3	6.372	56.22
29	20KE1A0430	6	6	6	4	6	10	10	10	10	F	1	6.930	61.80
30	20KE1A0431	4	4	5	4	4	10	10	10	10	F	4	5.953	52.03
31	20KE1A0432	7	6	8	7	6	10	10	10	10	P	0	7.767	70.17
32	20KE1A0433	6	7	4	4	6	10	10	10	10	F	2	6.791	60.41
33	20KE1A0434	6	6	6	5	6	10	10	10	10	P	0	7.070	63.20
34	20KE1A0435	5	4	6	6	6	10	10	10	10	F	1	6.791	60.41
35	20KE1A0436	5	5	5	6	6	10	10	10	10	P	0	6.791	60.41
36	20KE1A0437	7	7	8	9	7	10	10	10	10	P	0	8.326	75.76
37	20KE1A0438	7	8	6	7	6	10	10	10	10	P	0	7.767	70.17
38	20KE1A0439	5	4	7	6	6	10	10	10	10	F	1	6.930	61.80
39	20KE1A0440	5	6	6	6	6	10	10	10	10	P	0	7.070	63.20
40	20KE1A0441	6	7	4	4	6	10	10	10	10	F	2	6.791	60.41
41	20KE1A0442	7	7	7	6	7	10	10	10	10	P	0	7.767	70.17
42	20KE1A0443	5	6	7	6	6	10	10	10	10	P	0	7.209	64.59
43	20KE1A0444	7	6	7	6	6	10	10	10	10	P	0	7.488	67.38
44	20KE1A0445	6	6	6	4	5	10	10	10	10	F	1	6.791	60.41
45	20KE1A0446	5	6	6	5	6	10	10	10	10	P	0	6.930	61.80
46	20KE1A0447	5	6	4	7	6	10	10	10	10	F	1	6.930	61.80
47	20KE1A0448	8	9	8	7	7	10	10	10	10	P	0	8.465	77.15
48	20KE1A0449	6	7	6	7	6	10	10	10	10	P	0	7.488	67.38
49	20KE1A0450	6	5	5	4	5	10	10	10	10	F	1	6.512	57.62
50	20KE1A0451	6	4	5	5	5	10	10	10	10	F	1	6.512	57.62
51	20KE1A0452	5	5	6	6	6	10	10	10	10	P	0	6.930	61.80
52	20KE1A0453	5	6	5	4	5	10	10	10	10	F	1	6.512	57.62
53	20KE1A0454	7	5	5	4	6	10	10	10	10	F	1	6.791	60.41
54	20KE1A0455	8	7	7	8	6	10	10	10	10	P	0	8.047	72.97
55	20KE1A0456	6	7	5	7	6	10	10	10	10	P	0	7.349	65.99

56	20KE1A0457	7	6	5	5	4	10	10	10	10	**F**	1	6.791	60.41
57	20KE1A0458	6	6	5	5	6	10	10	10	10	**P**	0	6.930	61.80
58	20KE1A0459	6	4	4	4	4	10	10	10	10	**F**	4	6.093	53.43
59	20KE1A0460	6	5	6	5	6	9	10	10	10	**P**	0	6.860	61.10
60	20KE1A0461	5	6	5	4	7	10	10	10	10	**F**	1	6.791	60.41
61	20KE1A0462	6	6	6	5	7	10	10	10	10	P	0	7.209	64.59
62	20KE1A0463	7	6	6	6	6	10	10	10	10	P	0	7.349	65.99
63	20KE1A0464	7	7	8	7	7	10	10	10	10	P	0	8.047	72.97
64	20KE1A0465	6	6	6	6	6	10	10	10	10	P	0	7.209	64.59
65	20KE1A0466	6	6	7	6	6	10	10	10	10	P	0	7.349	65.99
66	20KE1A0467	6	7	6	6	7	10	10	10	10	P	0	7.488	67.38
67	20KE1A0468	7	6	7	7	6	10	10	10	10	P	0	7.628	68.78
68	20KE1A0469	6	7	6	7	5	10	10	10	10	P	0	7.349	65.99
69	20KE1A0470	5	4	5	4	5	9	10	10	10	F	2	6.163	54.13
70	20KE1A0471	6	7	7	6	7	10	10	10	10	P	0	7.628	68.78
71	20KE1A0472	5	6	6	6	5	10	10	10	10	P	0	6.930	61.80
72	20KE1A0474	6	6	6	7	5	10	10	10	10	P	0	7.209	64.59
73	20KE1A0475	6	4	6	6	6	10	10	10	10	F	2	6.930	61.80
74	20KE1A0476	5	4	6	5	7	10	10	10	10	F	1	6.791	60.41
75	20KE1A0477	5	5	5	6	6	10	10	10	10	P	0	6.791	60.41
76	20KE1A0478	5	7	4	4	4	10	10	10	10	F	3	6.372	56.22
77	20KE1A0479	5	5	5	6	6	10	10	10	10	P	0	6.791	60.41
78	20KE1A0480	7	5	8	6	6	10	10	10	10	P	0	7.488	67.38
79	20KE1A0481	7	8	6	7	6	10	10	10	10	P	0	7.767	70.17
80	20KE1A0482	7	7	6	4	4	10	10	10	10	F	2	6.930	61.80
81	20KE1A0483	5	6	6	7	6	10	10	10	10	P	0	7.209	64.59
82	20KE1A0484	6	5	7	6	6	10	10	10	10	P	0	7.209	64.59
83	20KE1A0485	7	7	7	7	6	10	10	10	10	P	0	7.767	70.17
84	20KE1A0486	6	7	4	4	5	10	10	10	10	F	2	6.651	59.01
85	20KE1A0487	5	5	7	6	6	10	10	10	10	P	0	7.070	63.20
86	20KE1A0488	7	6	7	7	7	10	10	10	10	P	0	7.767	70.17
87	20KE1A0489	6	5	4	4	5	10	10	10	10	F	2	6.372	56.22
88	20KE1A0490	7	7	7	6	6	10	10	10	10	P	0	7.628	68.78

89	20KE1A0491	5	4	6	6	6	10	10	10	10	F	1	6.791	60.41
90	20KE1A0492	5	4	4	4	6	10	10	10	10	F	3	6.233	54.83
91	20KE1A0493	5	6	4	6	4	10	10	10	10	F	2	6.512	57.62
92	20KE1A0494	6	6	5	4	4	10	10	10	10	F	2	6.512	57.62
93	20KE1A0495	5	6	6	6	6	10	10	10	10	P	0	7.070	63.20
94	20KE1A0496	5	5	7	6	6	10	10	10	10	P	0	7.070	63.20
95	20KE1A0497	7	6	5	5	6	10	10	10	10	P	0	7.070	63.20
96	20KE1A0498	7	7	6	4	6	10	10	10	10	F	1	7.209	64.59
97	20KE1A0499	6	7	7	7	6	10	10	10	10	P	0	7.628	68.78
98	20KE1A04A0	5	4	4	4	5	9	10	10	10	F	3	6.023	52.73
99	20KE1A04A1	6	6	5	4	6	9	10	10	9	P	0	6.628	58.78
100	20KE1A04A2	4	5	4	4	4	10	10	10	10	F	4	5.953	52.03
101	20KE1A04A3	5	6	6	6	6	10	10	10	10	P	0	7.070	63.20
102	21KE5A0401	6	6	6	6	6	10	10	10	10	P	0	7.209	64.59
103	21KE5A0402	6	7	7	7	7	10	10	10	10	P	0	7.767	70.17
104	21KE5A0403	7	7	7	5	6	10	10	10	10	P	0	7.488	67.38
105	21KE5A0404	6	6	6	6	6	10	10	10	10	P	0	7.209	64.59
106	21KE5A0405	6	6	6	4	6	10	10	10	10	F	1	6.930	61.80
107	21KE5A0406	6	6	6	7	6	10	10	10	10	P	0	7.349	65.99
108	21KE5A0407	5	6	6	5	6	10	10	10	10	P	0	6.930	61.80
109	21KE5A0408	7	8	7	7	7	10	10	10	10	P	0	8.047	72.97
110	21KE5A0409	6	7	6	6	6	10	10	10	10	P	0	7.349	65.99
111	21KE5A0410	7	8	6	8	6	10	10	10	10	P	0	7.907	71.57
112	21KE5A0411	4	5	4	4	4	10	10	10	10	F	4	5.953	52.03
113	21KE5A0412	7	7	7	7	7	10	10	10	10	P	0	7.907	71.57
114	21KE5A0413	6	7	6	6	6	10	10	10	10	P	0	7.349	65.99

PASS	110	98	99	87	100	114	114	114	74
FAIL	4	16	15	27	14	0	0	0	40
%	96.49	85.96	86.84	76.32	87.72	100.00	100.00	100.00	64.91

PRINCIPAL
MALINENI LAKSHMAIAH
WOMEN'S ENGINEERING COLLEGE
PULLADIGUNTA, GUNTUR-17.

MALINENI LAKSHMAIAH WOMEN'S ENGINEERING COLLEGE

Pulladigunta, Vatticherukuru Mandal, Guntur, Andhra Pradesh-522017.

Approved by AICTE, New Delhi, Affiliated to JNTUK.

ESTD : 2008

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

REGULAR EXAMINATIONS RESULTS ANALYSIS (SEPT-2022)

YEAR/SEM: II/II (20-09-2022) BATCH: 2020-24

S.No.	ROLL NUMBER	No. OF BACKLOGS
1	20KE1A0403	1
2	20KE1A0404	3
3	20KE1A0407	1
4	20KE1A0408	2
5	20KE1A0414	4
6	20KE1A0416	1
7	20KE1A0420	1
8	20KE1A0427	2
9	20KE1A0429	3
10	20KE1A0430	1
11	20KE1A0431	4
12	20KE1A0433	2
13	20KE1A0435	1
14	20KE1A0439	1
15	20KE1A0441	2
16	20KE1A0445	1
17	20KE1A0447	1
18	20KE1A0450	1
19	20KE1A0451	1
20	20KE1A0453	1
21	20KE1A0454	1
22	20KE1A0457	1
23	20KE1A0459	4
24	20KE1A0461	1
25	20KE1A0470	2
26	20KE1A0475	2
27	20KE1A0476	1
28	20KE1A0478	3
29	20KE1A0482	2
30	20KE1A0486	2
31	20KE1A0489	2
32	20KE1A0491	1
33	20KE1A0492	3
34	20KE1A0493	2
35	20KE1A0494	2
36	20KE1A0498	1
37	20KE1A04A0	3
38	20KE1A04A2	4
39	21KE5A0405	1
40	21KE5A0411	4

PRINCIPAL
MALINENI LAKSHMAIAH
WOMEN'S ENGINEERING COLLEG
PULLADIGUNTA, GUNTUR-17

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY KAKINADA

Result of II B.TECH II SEMESTER (R20) REG. EXAMINATIONS, July-2022

College name: MALINENI LAKSHMAIAH WOMEN'S ENGG COLL.,PULLADIGUNTA,GUNTUR:KE

Sl.No	ROOL NO	ECA	DICD	AC	LCS	MOB	ECA LAB	AC LAB	DICD LAB	SS LAB	P / F
		G	G	G	G	G	G	G	G	G	
1	20KE1A0401	E	D	E	D	D	A+	A+	A+	A+	P
2	20KE1A0402	C	C	C	D	D	A+	A+	A+	A+	P
3	20KE1A0403	C	F	C	C	C	A+	A+	A+	A+	F
4	20KE1A0404	E	E	F	F	F	A+	A+	A+	A+	F
5	20KE1A0405	D	C	D	C	C	A+	A+	A+	A+	P
6	20KE1A0406	D	C	C	D	C	A+	A+	A+	A+	P
7	20KE1A0407	D	F	E	C	D	A+	A+	A+	A+	F
8	20KE1A0408	E	E	E	F	F	A+	A+	A+	A+	F
9	20KE1A0409	D	C	D	C	D	A+	A+	A+	A+	P
10	20KE1A0410	C	E	D	C	C	A+	A+	A+	A+	P
11	20KE1A0411	E	D	D	D	D	A+	A+	A+	A+	P
12	20KE1A0412	D	C	D	E	C	A+	A+	A+	A+	P
13	20KE1A0413	C	D	E	D	C	A+	A+	A+	A+	P
14	20KE1A0414	F	F	F	D	F	A	A	A	A	F
15	20KE1A0415	D	D	E	C	D	A+	A+	A+	A+	P
16	20KE1A0416	D	C	C	F	D	A+	A+	A+	A+	F
17	20KE1A0417	E	E	E	D	C	A+	A+	A+	A+	P
18	20KE1A0418	D	D	D	D	D	A+	A+	A+	A+	P
19	20KE1A0420	D	F	E	C	D	A+	A+	A+	A+	F
20	20KE1A0421	C	D	D	E	D	A+	A+	A+	A+	P
21	20KE1A0422	C	C	D	C	C	A+	A+	A+	A+	P
22	20KE1A0423	B	C	D	D	D	A+	A+	A+	A+	p
23	20KE1A0424	D	E	C	D	D	A+	A+	A+	A+	p
24	20KE1A0425	C	D	D	E	C	A+	A+	A+	A+	p
25	20KE1A0426	B	B	C	B	D	A+	A+	A+	A+	p
26	20KE1A0427	E	F	D	E	F	A+	A+	A+	A+	F
27	20KE1A0428	D	C	D	D	D	A+	A+	A+	A+	p
28	20KE1A0429	D	D	F	F	F	A+	A+	A+	A+	F
29	20KE1A0430	D	D	D	F	D	A+	A+	A+	A+	F
30	20KE1A0431	F	F	E	F	F	A+	A+	A+	A+	F

31	20KE1A0432	C	D	B	C	D	A+	A+	A+	A+	P
32	20KE1A0433	D	C	F	F	D	A+	A+	A+	A+	F
33	20KE1A0434	D	D	D	E	D	A+	A+	A+	A+	P
34	20KE1A0435	E	F	D	D	D	A+	A+	A+	A+	F
35	20KE1A0436	E	E	E	D	D	A+	A+	A+	A+	P
36	20KE1A0437	C	C	B	A	C	A+	A+	A+	A+	P
37	20KE1A0438	C	B	D	C	D	A+	A+	A+	A+	P
38	20KE1A0439	E	F	C	D	D	A+	A+	A+	A+	F
39	20KE1A0440	E	D	D	D	D	A+	A+	A+	A+	P
40	20KE1A0441	D	C	F	F	D	A+	A+	A+	A+	F
41	20KE1A0442	C	C	C	D	C	A+	A+	A+	A+	P
42	20KE1A0443	E	D	C	D	D	A+	A+	A+	A+	P
43	20KE1A0444	C	D	C	D	D	A+	A+	A+	A+	P
44	20KE1A0445	D	D	D	F	E	A+	A+	A+	A+	F
45	20KE1A0446	E	D	D	E	D	A+	A+	A+	A+	P
46	20KE1A0447	E	D	F	C	D	A+	A+	A+	A+	F
47	20KE1A0448	B	A	B	C	C	A+	A+	A+	A+	P
48	20KE1A0449	D	C	D	C	D	A+	A+	A+	A+	P
49	20KE1A0450	D	E	E	F	E	A+	A+	A+	A+	F
50	20KE1A0451	D	F	E	E	E	A+	A+	A+	A+	F
51	20KE1A0452	E	E	D	D	D	A+	A+	A+	A+	P
52	20KE1A0453	E	D	E	F	E	A+	A+	A+	A+	F
53	20KE1A0454	C	E	E	F	D	A+	A+	A+	A+	F
54	20KE1A0455	B	C	C	B	D	A+	A+	A+	A+	P
55	20KE1A0456	D	C	E	C	D	A+	A+	A+	A+	P
56	20KE1A0457	C	D	E	E	F	A+	A+	A+	A+	F
57	20KE1A0458	D	D	E	E	D	A+	A+	A+	A+	P
58	20KE1A0459	D	F	F	F	F	A+	A+	A+	A+	F
59	20KE1A0460	D	E	D	E	D	A	A+	A+	A+	P
	PASS	57	49	52	46	51	59	59	59	59	APPEARED:59
	FAIL	2	10	7	13	8	59	59	59	59	PASS:36
	PASS%	96.61%	83.05%	88.14%	77.97%	86.44%	100.00%	100.00%	100.00%	100.00%	PASS % :61.01%
	FACULTY	K.Sarada	K.Rajitha	DR CH. Ramesh	Deepa	M.Kalyani	K.Sarada	DR.Syed Parveen	DR CH. Ramesh	DR Subba Rao	One Subject Fail:13

PRINCIPAL
MALINENI LAKSHMAIAH
WOMEN'S ENGINEERING COLLEGE
PULLADIGUNTA, GUNTUR-17.

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY KAKINADA

Result of II B.TECH II SEMESTER (R20) REG. EXAMINATIONS, July.-2022

College name: MALINENI LAKSHMAIAH WOMEN'S ENGG COLL.,PULLADIGUNTA,GUNTUR:KE

Sl.No	ROOL NO	ECA	DICD	AC	LCS	MOB	ECA LAB	AC LAB	DICD LAB	SS LAB	P / F
		G	G	G	G	G	G	G	G	G	
1	20KE1A0461	E	D	E	F	C	A+	A+	A+	A+	F
2	20KE1A0462	D	D	D	E	C	A+	A+	A+	A+	P
3	20KE1A0463	C	D	D	D	D	A+	A+	A+	A+	P
4	20KE1A0464	C	C	B	C	C	A+	A+	A+	A+	P
5	20KE1A0465	D	D	D	D	D	A+	A+	A+	A+	P
6	20KE1A0466	D	D	C	D	D	A+	A+	A+	A+	P
7	20KE1A0467	D	C	D	D	C	A+	A+	A+	A+	P
8	20KE1A0468	C	D	C	C	D	A+	A+	A+	A+	P
9	20KE1A0469	D	C	D	C	E	A+	A+	A+	A+	P
10	20KE1A0470	E	F	E	F	E	A	A+	A+	A+	F
11	20KE1A0471	D	C	C	D	C	A+	A+	A+	A+	P
12	20KE1A0472	E	D	D	D	E	A+	A+	A+	A+	P
13	20KE1A0474	D	D	D	C	E	A+	A+	A+	A+	P
14	20KE1A0475	D	F	D	D	D	A+	A+	A+	A+	F
15	20KE1A0476	E	F	D	E	C	A+	A+	A+	A+	F
16	20KE1A0477	E	E	E	D	D	A+	A+	A+	A+	P
17	20KE1A0478	E	C	F	F	F	A+	A+	A+	A+	F
18	20KE1A0479	E	E	E	D	D	A+	A+	A+	A+	P
19	20KE1A0480	C	E	B	D	D	A+	A+	A+	A+	P
20	20KE1A0481	C	B	D	C	D	A+	A+	A+	A+	P
21	20KE1A0482	C	C	D	F	F	A+	A+	A+	A+	F
22	20KE1A0483	E	D	D	C	D	A+	A+	A+	A+	P
23	20KE1A0484	D	E	C	D	D	A+	A+	A+	A+	P
24	20KE1A0485	C	C	C	C	D	A+	A+	A+	A+	P
25	20KE1A0486	D	C	F	F	E	A+	A+	A+	A+	P
26	20KE1A0487	E	E	C	D	D	A+	A+	A+	A+	P
27	20KE1A0488	C	D	C	C	C	A+	A+	A+	A+	P
28	20KE1A0489	D	E	F	F	E	A+	A+	A+	A+	F
29	20KE1A0490	C	C	C	D	D	A+	A+	A+	A+	P
30	20KE1A0491	E	F	D	D	D	A+	A+	A+	A+	F

31	20KE1A0492	E	F	F	F	D	A+	A+	A+	A+	F
32	20KE1A0493	E	D	F	D	F	A+	A+	A+	A+	F
33	20KE1A0494	D	D	E	F	F	A+	A+	A+	A+	F
34	20KE1A0495	E	D	D	D	D	A+	A+	A+	A+	P
35	20KE1A0496	E	E	C	D	D	A+	A+	A+	A+	P
36	20KE1A0497	C	D	E	E	D	A+	A+	A+	A+	P
37	20KE1A0498	C	C	D	F	D	A+	A+	A+	A+	F
38	20KE1A0499	D	C	C	C	D	A+	A+	A+	A+	P
39	20KE1A04A0	E	F	F	F	E	A	A+	A+	A+	F
40	20KE1A04A1	D	D	E	F	D	A	A+	A+	A	P
41	20KE1A04A2	F	E	F	F	F	A+	A+	A+	A+	F
42	20KE1A04A3	E	D	D	D	D	A+	A+	A+	A+	P
43	21KE5A0401	D	D	D	D	D	A+	A+	A+	A+	P
44	21KE5A0402	D	C	C	C	C	A+	A+	A+	A+	P
45	21KE5A0403	C	C	C	E	D	A+	A+	A+	A+	P
46	21KE5A0404	D	D	D	D	D	A+	A+	A+	A+	P
47	21KE5A0405	D	D	D	F	D	A+	A+	A+	A+	F
48	21KE5A0406	D	D	D	C	D	A+	A+	A+	A+	P
49	21KE5A0407	E	D	D	E	D	A+	A+	A+	A+	P
50	21KE5A0408	C	B	C	C	C	A+	A+	A+	A+	P
51	21KE5A0409	D	C	D	D	D	A+	A+	A+	A+	P
52	21KE5A0410	C	B	D	B	D	A+	A+	A+	A+	P
53	21KE5A0411	F	E	F	F	F	A+	A+	A+	A+	F
54	21KE5A0412	C	C	C	C	C	A+	A+	A+	A+	P
55	21KE5A0413	D	C	D	D	D	A+	A+	A+	A+	P
	PASS	53	49	47	41	49	55	55	55	55	APPEARED:55
	FAIL	2	6	8	14	6	55	55	55	55	PASS:39
	PASS%	96.36%	89.09%	85.45%	74.55%	89.09%	100.00%	100.00%	100.00%	100.00%	PASS % :70.90
	FACULTY	K.Sarada	K.Rajitha	DR CH. Ramesh	Deepa	M.Kalyani	K.Sarada	DR.Syed Parveen	DR CH. Ramesh	DR Subba Rao	One Subject Fail:6

PRINCIPAL
MALINENI LAKSHMAIAH
WOMEN'S ENGINEERING COLLEGE
PULLADIGUNTA, GUNTUR-17

MALINENI LAKSHMAIAH WOMEN'S ENGINEERING COLLEGE

PULLADIGUNTA, GUNTUR - 52201

III B.TECH I - SEMESTER INTERNAL ~~LAB~~ EXA

Internal marks 20KE MID-I & II

Subject : DC

Sl.No	REGD No	Q1 b (3M)	Q1a (5M)	Q2 (3M)	Q3 (4M)	MID Total (15)	QUIZ (10M)	Assisgment-I (5M)	Total (30M)
1	20KE1A0401	3	5	3	4	14	3	5	22
2	20KE1A0402	3	4	3	4	14	5	5	24
3	20KE1A0403	3	5	3	3	14	3	5	22
4	20KE1A0404	3	3	3	4	13	3	5	21
5	20KE1A0405	3	2	3	4	13	2	5	20
6	20KE1A0406	3	4	3	4	14	4	5	23
7	20KE1A0407	3	2	3	4	13	3	5	21
8	20KE1A0408	3	2	3	4	13	2	5	20
9	20KE1A0409	3	4	3	4	14	3	5	22
10	20KE1A0410	3	4	3	4	14	1	5	20
11	20KE1A0411	3	4	3	4	14	2	5	21
12	20KE1A0412	3	4	3	4	14	4	5	23
13	20KE1A0413	3	4	3	4	14	4	5	23
14	20KE1A0414	2	4	2	3	12	2	5	19
15	20KE1A0415	3	2	3	4	13	3	5	21
16	20KE1A0416	3	2	3	4	13	5	5	23
17	20KE1A0417	3	2	3	4	13	3	5	21
18	20KE1A0418	3	4	3	4	14	3	5	22
19	20KE1A0420	2	4	2	3	12	4	5	21
20	20KE1A0421	3	2	3	4	13	3	5	21
21	20KE1A0422	3	5	3	4	15	2	5	22
22	20KE1A0423	3	4	3	4	14	4	5	23
23	20KE1A0424	3	4	3	4	14	3	5	22
24	20KE1A0425	3	4	3	4	14	3	5	22
25	20KE1A0426	3	4	3	4	14	5	5	24
26	20KE1A0427	3	2	3	4	13	6	5	24
27	20KE1A0428	3	2	3	4	13	4	5	22
28	20KE1A0429	3	2	3	4	13	4	5	22
29	20KE1A0430	3	4	3	4	14	4	5	23
30	20KE1A0431	3	4	3	4	14	2	5	21
31	20KE1A0432	3	4	3	4	14	6	5	25
32	20KE1A0433	3	2	3	4	13	4	5	22
33	20KE1A0434	3	2	3	4	13	4	5	22
34	20KE1A0435	3	2	3	4	13	5	5	23
35	20KE1A0436	3	4	3	4	14	4	5	23
36	20KE1A0437	3	5	3	4	15	4	5	24

37	20KE1A0438	3	5	3	4	15	3	5	23
38	20KE1A0439	3	4	3	3	14	4	5	23
39	20KE1A0440	3	4	3	3	14	3	5	22
40	20KE1A0441	3	4	3	3	14	3	5	22
41	20KE1A0442	3	4	3	3	14	3	5	22
42	20KE1A0443	3	4	3	3	14	1	5	20
43	20KE1A0444	3	2	3	3	13	3	5	21
44	20KE1A0445	3	2	3	3	13	2	5	20
45	20KE1A0446	3	2	3	3	13	3	5	21
46	20KE1A0447	3	2	3	3	13	6	5	24
47	20KE1A0448	3	5	3	4	15	4	5	24
48	20KE1A0449	3	4	3	3	14	5	5	24
49	20KE1A0450	3	2	3	3	13	4	5	22
50	20KE1A0451	3	2	3	3	13	4	5	22
51	20KE1A0452	3	2	3	3	13	2	5	20
52	20KE1A0453	3	2	3	3	13	3	5	21
53	20KE1A0454	3	4	3	3	14	3	5	22
54	20KE1A0455	3	5	3	4	15	4	5	24
55	20KE1A0456	3	4	3	3	14	6	5	25
56	20KE1A0457	3	4	3	3	14	2	5	21
57	20KE1A0458	3	4	3	3	14	2	5	21
58	20KE1A0459	3	4	3	3	14	2	5	21
59	20KE1A0460	3	4	3	3	14	4	5	23
60	20KE1A0461	3	4	3	3	14	5	5	24
61	20KE1A0462	3	4	3	3	14	0	5	19
62	20KE1A0463	3	4	3	3	14	5	5	24
63	20KE1A0464	3	4	3	3	14	4	5	23
64	20KE1A0465	3	5	3	4	15	3	5	23
65	20KE1A0466	3	4	3	3	14	2	5	21
66	20KE1A0467	3	4	3	3	14	2	5	21
67	20KE1A0468	3	4	3	3	14	3	5	22
68	20KE1A0469	3	5	3	4	15	6	5	26
69	20KE1A0470	2	4	2	3	12	2	5	19
70	20KE1A0471	3	2	3	3	13	4	5	22
71	20KE1A0472	3	2	3	3	13	3	5	21
72	20KE1A0474	3	2	3	3	13	5	5	23
73	20KE1A0475	3	4	3	3	14	4	5	23
74	20KE1A0476	3	2	3	3	13	4	5	22
75	20KE1A0477		5	3	4	12	4	5	21
76	20KE1A0478	2	4	3	4	13	4	5	22
77	20KE1A0479	2	4	3	4	13	4	5	22
78	20KE1A0480	3	4	3	2	14	2	5	21

79	20KE1A0481	3	4	3	3	14	4	5	23
80	20KE1A0482	3	4	3	3	14	3	5	22
81	20KE1A0483	3	2	3	3	13	2	5	20
82	20KE1A0484	3	4	3	3	14	3	5	22
83	20KE1A0485	3	5	3	3	15	3	5	23
84	20KE1A0486	3	4	3	3	14	3	5	22
85	20KE1A0487	3	4	3	3	14	3	5	22
86	20KE1A0488	3	4	3	3	14	3	5	22
87	20KE1A0489	3	2	3	3	13	3	5	21
88	20KE1A0490	3	4	3	3	14	5	5	24
89	20KE1A0491	3	2	3	3	13	4	5	22
90	20KE1A0492	3	2	3	3	13	1	5	19
91	20KE1A0493	3	2	3	3	13	2	5	20
92	20KE1A0494	3	2	3	3	13	3	5	21
93	20KE1A0495	3	2	3	3	13	5	5	23
94	20KE1A0496	3	4	3	3	14	3	5	22
95	20KE1A0497	3	4	3	3	14	2	5	21
96	20KE1A0498	3	2	3	3	13	3	5	21
97	20KE1A0499	3	4	3	3	14	3	5	22
98	20KE1A04A0	3	2	3	3	13	2	5	20
99	20KE1A04A1	3	5		4	12	3	5	20
100	20KE1A04A2		5	3	4	12	2	5	19
101	20KE1A04A3	3	4	3	3	14	4	5	23
102	21KE5A0401	3	2	3	3	13	3	5	21
103	21KE5A0402	3	5	3	3	15	2	5	22
104	21KE5A0403	3	5	3	3	15	4	5	24
105	21KE5A0404	3	5	3	3	15	3	5	23
106	21KE5A0405	3	4	3	3	14	3	5	22
107	21KE5A0406	3	4	3	3	14	2	5	21
108	21KE5A0407	3	4	3	3	14	4	5	23
109	21KE5A0408	3	4	3	3	14	3	5	22
110	21KE5A0409	3	2	3	3	13	4	5	22
111	21KE5A0410	3	4	3	3	14	5	5	24
112	21KE5A0411	3	4	3	3	14	2	5	21
113	21KE5A0412	3	5	3	3	15	1	5	21
114	21KE5A0413	3	4	3	3	14	2	5	21

Signature of the Faculty

PRINCIPAL
MALINENI LAKSHMAIAH
WOMEN'S ENGINEERING COLLEGE
PULLADIGUNTA, GUNTUR-17.

MALINENI LAKSHMAIAH WOMEN'S ENGINEERING COLLEGE

PULLADIGUNTA, GUNTUR - 522017

III B.TECH I - SEMESTER INTERNAL ~~LAB~~ EXAM MARKS

Subject : DC

Sl.No	REGD No	Q1a (5M)	Q1 b (3M)	Q2 (3M)	Q3 (4M)	Total (15)	QUIZ (10M)	Assisgment-I (5M)	Total (30)
1	20KE1A0401	4	3	3	4	14	1	5	20
2	20KE1A0402	4	3	3	4	11	4	5	20
3	20KE1A0403	5	2	3	4	14	6	5	25
4	20KE1A0404	2	3	3	4	12	3	5	20
5	20KE1A0405	2	3	3	4	12	4	5	21
6	20KE1A0406	2	3	3	4	12	3	5	20
7	20KE1A0407	4.5	2.5	2	4	12	6	5	23
8	20KE1A0408	2	2	3	4	10	4	5	19
9	20KE1A0409	2	3	3	4	12	5	5	22
10	20KE1A0410	2	2	3	4	10	4	5	19
11	20KE1A0411	2	3	3	4	12	5	5	22
12	20KE1A0412	4	3	3	4	14	3	5	22
13	20KE1A0413	3	3	3	4	13	3	5	21
14	20KE1A0414	2	2	2	3	8	5	5	18
15	20KE1A0415	5	3	3	4	15	2	5	22
16	20KE1A0416	4	3	3	4	14	4	5	23
17	20KE1A0417	5	2	2	3	13	4	5	22
18	20KE1A0418	4	2	3	4	13	5	5	23
19	20KE1A0420	3	3	3	3	11	5	5	21
20	20KE1A0421	4	3	3	4	14	4	5	23
21	20KE1A0422	5	3	3	4	15	2	5	22
22	20KE1A0423	5	3	3	4	15	1	5	21
23	20KE1A0424	4	3	2	4	13	3	5	21
24	20KE1A0425	4	3	2	4	13	4	5	22
25	20KE1A0426	3	3	3	4	12	4	5	21
26	20KE1A0427	3	2	3	4	11	3	5	19
27	20KE1A0428	4	3	2	4	12	4	5	21
28	20KE1A0429	4	3	2	4	12	3	5	20
29	20KE1A0430	3	2	3	4	11	4	5	20
30	20KE1A0431	4	1	3	3	10	2	5	17
31	20KE1A0432	4	2	3	3	11	3	5	19
32	20KE1A0433	5	3	2	3	12	3	5	20
33	20KE1A0434	5	3	3	2	13	3	5	21
34	20KE1A0435	4	3	3	3	12	2	5	19
35	20KE1A0436	4	3	3	3	12	3	5	20
36	20KE1A0437	5	3	3	4	15	7	5	27

37	20KE1A0438	4	3	3	4	14	3	5	22
38	20KE1A0439	4	3	3	4	14	5	5	24
39	20KE1A0440	2	3	3	4	13	3	5	21
40	20KE1A0441	2	3	3	4	13	5	5	23
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46	20KE1A0447	5	3	3	4	15	8	5	28
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67	20KE1A0468	5	3	3	4	15	3	5	23
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84	20KE1A0486	5	2	2	4	13	4	5	22
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97	20KE1A0499	2	3	3	4	12	4	5	21
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103	21KE5A0402	2	3	3	4	12	2	5	19
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108	21KE5A0407	5	2	2	4	13	2	5	20
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110	21KE5A0409	5	3	3	4	15	5	5	25
111	21KE5A0410	5	3	3	4	15	4	5	24
112	21KE5A0411	2	3	3	4	12	3	5	20
113	21KE5A0412	4	3	3	4	14	2	5	21
114	21KE5A0413	5	2	2	4	13	4	5	22

Signature of the Faculty

PRINCIPAL
MALINENI LAKSHMAIAH
WOMEN'S ENGINEERING COLLEGE
PULLADIGUNTA, GUNTUR-17

MALINENI LAKSHMAIAH WOMEN'S ENGINEERING COLLEGE

PULLADIGUNTA, GUNTUR - 522017

III B.TECH I - SEMESTER MID I EXAMINATIONS

Award List

Subject : DC

Section : B

Sl.No	REGD No	Total (15M)
1	20KE1A0461	12
2	20KE1A0462	13
3	20KE1A0463	12
4	20KE1A0464	15
5	20KE1A0465	15
6	20KE1A0466	14
7	20KE1A0467	15
8	20KE1A0468	15
9	20KE1A0469	13
10	20KE1A0470	12
11	20KE1A0471	15
12	20KE1A0472	14
13	20KE1A0474	15
14	20KE1A0475	12
15	20KE1A0476	11
16	20KE1A0477	14
17	20KE1A0478	12
18	20KE1A0479	13
19	20KE1A0480	10
20	20KE1A0481	15
21	20KE1A0482	14
22	20KE1A0483	12
23	20KE1A0484	14
24	20KE1A0485	15
25	20KE1A0486	13
26	20KE1A0487	12
27	20KE1A0488	14
28	20KE1A0489	14

Sl.No	REGD No	Total (15M)
29	20KE1A0490	15
30	20KE1A0491	12
31	20KE1A0492	11
32	20KE1A0493	13
33	20KE1A0494	12
34	20KE1A0495	15
35	20KE1A0496	12
36	20KE1A0497	14
37	20KE1A0498	14
38	20KE1A0499	12
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41	20KE1A04A2	11
42	20KE1A04A3	14
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49	21KE5A0407	13
50	21KE5A0408	15
51	21KE5A0409	15
52	21KE5A0410	15
53	21KE5A0411	12
54	21KE5A0412	14
55	21KE5A0413	13

Signatures :

Faculty : Dr. S.D. [signature]

HOD HOD

Principal: Dept. of Electronics & Communication Engineering
Malineni Lakshmaiah Women's Engineering College
Pulladigunta, GUNTUR-522017

PRINCIPAL
MALINENI LAKSHMAIAH
WOMEN'S ENGINEERING COLLEGE
PULLADIGUNTA. GUNTUR-17

MALINENI LAKSHMAIAH WOMEN'S ENGINEERING COLLEGE

R20-III-I ONLINE QUIZ MARKS BRANCH:ECE

R2031041			R2031042			R2031043			R203104B			R203105K		
A IC A			EWTM			DC			EMI			COA		
SNO	Hallticket	Marks	SNO	Hallticket	Marks	SNO	Hallticket	Marks	SNO	Hallticket	Marks	SNO	Hallticket	Marks
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2	20KE1A0402	8	2	20KE1A0402	6	2	20KE1A0402	8	2	20KE1A0402	6	2	20KE1A0402	11
3	20KE1A0403	5	3	20KE1A0403	5	3	20KE1A0403	11	3	20KE1A0403	5	3	20KE1A0403	9
4	20KE1A0404	8	4	20KE1A0404	5	4	20KE1A0404	5	4	20KE1A0404	5	4	20KE1A0404	9
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Quiz Marks

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90	20KE1A0492	8	90	20KE1A0492	5	90	20KE1A0492	10	90	20KE1A0493	4	90	20KE1A0492	5
91	20KE1A0493	8	91	20KE1A0493	9	91	20KE1A0493	4	91	20KE1A0494	10	91	20KE1A0493	11
92	20KE1A0494	7	92	20KE1A0494	7	92	20KE1A0494	7	92	20KE1A0495	4	92	20KE1A0494	10
93	20KE1A0495	7	93	20KE1A0495	4	93	20KE1A0495	9	93	20KE1A0496	4	93	20KE1A0495	11
94	20KE1A0496	4	94	20KE1A0496	5	94	20KE1A0496	12	94	20KE1A0497	5	94	20KE1A0496	3
95	20KE1A0497	10	95	20KE1A0497	10	95	20KE1A0497	10	95	20KE1A0498	2	95	20KE1A0497	10
96	20KE1A0498	9	96	20KE1A0498	9	96	20KE1A0498	9	96	20KE1A0499	6	96	20KE1A0498	4
97	20KE1A0499	8	97	20KE1A0499	8	97	20KE1A0499	7	97	20KE1A04A0	6	97	20KE1A0499	7
98	20KE1A04A0	5	98	20KE1A04A0	3	98	20KE1A04A0	7	98	20KE1A04A2	6	98	20KE1A04A0	6
99	20KE1A04A1	8	99	20KE1A04A1	8	99	20KE1A04A1	13	99	20KE1A04A3	7	99	20KE1A04A1	4
100	20KE1A04A2	7	100	20KE1A04A2	5	100	20KE1A04A2	2	100	21KE5A0401	7	100	20KE1A04A2	3
101	20KE1A04A3	8	101	20KE1A04A3	12	101	20KE1A04A3	11	101	21KE5A0402	4	101	20KE1A04A3	5
102	21KE5A0401	8	102	21KE5A0401	6	102	21KE5A0401	8	102	21KE5A0403	11	102	21KE5A0401	11
103	21KE5A0402	12	103	21KE5A0402	6	103	21KE5A0402	4	103	21KE5A0404	4	103	21KE5A0402	12
104	21KE5A0403	15	104	21KE5A0403	8	104	21KE5A0403	8	104	21KE5A0405	9	104	21KE5A0403	17
105	21KE5A0404	7	105	21KE5A0404	3	105	21KE5A0404	5	105	21KE5A0406	5	105	21KE5A0404	10
106	21KE5A0405	7	106	21KE5A0405	6	106	21KE5A0405	2	106	21KE5A0407	4	106	21KE5A0405	11
107	21KE5A0406	9	107	21KE5A0406	9	107	21KE5A0406	6	107	21KE5A0408	3	107	21KE5A0406	6
108	21KE5A0407	5	108	21KE5A0407	7	108	21KE5A0407	4	108	21KE5A0409	4	108	21KE5A0407	5
109	21KE5A0408	6	109	21KE5A0408	7	109	21KE5A0408	7	109	21KE5A0410	10	109	21KE5A0408	10
110	21KE5A0409	5	110	21KE5A0409	5	110	21KE5A0409	9	110	21KE5A0411	7	110	21KE5A0409	8
111	21KE5A0410	8	111	21KE5A0410	5	111	21KE5A0410	8	111	21KE5A0412	8	111	21KE5A0410	14
112	21KE5A0411	9	112	21KE5A0411	8	112	21KE5A0411	6	112	21KE5A0413	7	112	21KE5A0411	8
113	21KE5A0412	10	113	21KE5A0412	8	113	21KE5A0412	4				113	21KE5A0412	11
114	21KE5A0413	10	114	21KE5A0413	7	114	21KE5A0413	7				114	21KE5A0413	7

MALINENI LAKSHMAIAH WOMEN'S ENGINEERING COLLEGE

III-I MID-2 ONLINE QUIZ MARKS — BRANCH: ECE

A ICS A			EWTL			DC			EMI			COA		
R2031041			R2031042			R2031043			R203104B			R203105K		
SNO	Hallticket	Marks	SNO	Hallticket	Marks	SNO	Hallticket	Marks	SNO	Hallticket	Marks	SNO	Hallticket	Marks
1	20KE1A0401	8	1	20KE1A0401	2	1	20KE1A0401	5	1	20KE1A0401	4	1	20KE1A0401	6
2	20KE1A0402	11	2	20KE1A0402	7	2	20KE1A0402	9	2	20KE1A0402	3	2	20KE1A0402	7
3	20KE1A0403	8	3	20KE1A0403	4	3	20KE1A0403	5	3	20KE1A0403	1	3	20KE1A0403	10
4	20KE1A0404	3	4	20KE1A0404	5	4	20KE1A0404	6	4	20KE1A0404	8	4	20KE1A0404	4
5	20KE1A0405	9	5	20KE1A0405	4	5	20KE1A0405	3	5	20KE1A0405	5	5	20KE1A0405	6
6	20KE1A0406	8	6	20KE1A0406	10	6	20KE1A0406	7	6	20KE1A0406	5	6	20KE1A0406	7
7	20KE1A0407	7	7	20KE1A0407	8	7	20KE1A0407	6	7	20KE1A0407	7	7	20KE1A0407	8
8	20KE1A0408	6	8	20KE1A0408	9	8	20KE1A0408	4	8	20KE1A0408	6	8	20KE1A0408	7
9	20KE1A0409	5	9	20KE1A0409	6	9	20KE1A0409	6	9	20KE1A0409	4	9	20KE1A0409	3
10	20KE1A0410	7	10	20KE1A0410	2	10	20KE1A0410	2	10	20KE1A0410	3	10	20KE1A0410	1
11	20KE1A0411	9	11	20KE1A0411	2	11	20KE1A0411	3	11	20KE1A0411	4	11	20KE1A0411	1
12	20KE1A0412	2	12	20KE1A0412	6	12	20KE1A0412	7	12	20KE1A0412	7	12	20KE1A0412	8
13	20KE1A0413	8	13	20KE1A0413	6	13	20KE1A0413	8	13	20KE1A0413	11	13	20KE1A0413	8
14	20KE1A0414	7	14	20KE1A0414	4	14	20KE1A0414	4	14	20KE1A0414	6	14	20KE1A0414	6
15	20KE1A0415	6	15	20KE1A0415	3	15	20KE1A0415	5	15	20KE1A0415	5	15	20KE1A0415	5
16	20KE1A0416	4	16	20KE1A0416	7	16	20KE1A0416	10	16	20KE1A0416	6	16	20KE1A0416	8
17	20KE1A0417	3	17	20KE1A0417	5	17	20KE1A0417	6	17	20KE1A0417	7	17	20KE1A0417	4
18	20KE1A0418	9	18	20KE1A0418	5	18	20KE1A0418	5	18	20KE1A0418	3	18	20KE1A0418	9
19	20KE1A0420	10	19	20KE1A0420	6	19	20KE1A0420	8	19	20KE1A0420	5	19	20KE1A0420	6
20	20KE1A0421	8	20	20KE1A0421	5	20	20KE1A0421	5	20	20KE1A0421	5	20	20KE1A0421	7
21	20KE1A0422	11	21	20KE1A0422	5	21	20KE1A0422	4	21	20KE1A0422	6	21	20KE1A0422	6
22	20KE1A0423	12	22	20KE1A0423	10	22	20KE1A0423	8	22	20KE1A0423	8	22	20KE1A0423	8
23	20KE1A0424	9	23	20KE1A0424	6	23	20KE1A0424	6	23	20KE1A0424	7	23	20KE1A0424	8
24	20KE1A0425	4	24	20KE1A0425	2	24	20KE1A0425	6	24	20KE1A0425	4	24	20KE1A0425	3
25	20KE1A0426	8	25	20KE1A0426	6	25	20KE1A0426	9	25	20KE1A0426	7	25	20KE1A0426	5
26	20KE1A0427	11	26	20KE1A0427	10	26	20KE1A0427	12	26	20KE1A0427	11	26	20KE1A0427	7

27	20KE1A0428	7	27	20KE1A0428	7	27	20KE1A0428	8	27	20KE1A0428	2	27	20KE1A0428	9
28	20KE1A0429	4	28	20KE1A0429	10	28	20KE1A0429	7	28	20KE1A0429	5	28	20KE1A0429	2
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30	20KE1A0431	7	30	20KE1A0431	5	30	20KE1A0431	4	30	20KE1A0431	10	30	20KE1A0431	5
31	20KE1A0432	9	31	20KE1A0432	6	31	20KE1A0432	11	31	20KE1A0432	8	31	20KE1A0432	4
32	20KE1A0433	4	32	20KE1A0433	5	32	20KE1A0433	7	32	20KE1A0433	6	32	20KE1A0433	5
33	20KE1A0434	7	33	20KE1A0434	4	33	20KE1A0434	8	33	20KE1A0434	3	33	20KE1A0434	9
34	20KE1A0435	8	34	20KE1A0435	4	34	20KE1A0435	10	34	20KE1A0435	4	34	20KE1A0435	5
35	20KE1A0436	7	35	20KE1A0436	5	35	20KE1A0436	7	35	20KE1A0436	3	35	20KE1A0436	5
36	20KE1A0437	15	36	20KE1A0437	11	36	20KE1A0437	7	36	20KE1A0437	6	36	20KE1A0437	9
37	20KE1A0438	10	37	20KE1A0438	11	37	20KE1A0438	5	37	20KE1A0438	6	37	20KE1A0438	8
38	20KE1A0439	1	38	20KE1A0439	8	38	20KE1A0439	7	38	20KE1A0439	6	38	20KE1A0439	6
39	20KE1A0440	4	39	20KE1A0440	5	39	20KE1A0440	6	39	20KE1A0440	4	39	20KE1A0440	5
40	20KE1A0441	5	40	20KE1A0441	3	40	20KE1A0441	6	40	20KE1A0441	11	40	20KE1A0441	5
41	20KE1A0442	6	41	20KE1A0442	5	41	20KE1A0442	5	41	20KE1A0442	4	41	20KE1A0442	5
42	20KE1A0443	7	42	20KE1A0443	8	42	20KE1A0443	2	42	20KE1A0443	4	42	20KE1A0443	3
43	20KE1A0444	10	43	20KE1A0444	7	43	20KE1A0444	6	43	20KE1A0444	5	43	20KE1A0444	9
44	20KE1A0445	5	44	20KE1A0445	4	44	20KE1A0445	4	44	20KE1A0445	5	44	20KE1A0445	4
45	20KE1A0446	7	45	20KE1A0446	1	45	20KE1A0446	6	45	20KE1A0446	7	45	20KE1A0446	8
46	20KE1A0447	6	46	20KE1A0447	5	46	20KE1A0447	12	46	20KE1A0447	9	46	20KE1A0447	5
47	20KE1A0448	13	47	20KE1A0448	3	47	20KE1A0448	8	47	20KE1A0448	5	47	20KE1A0448	12
48	20KE1A0449	7	48	20KE1A0449	8	48	20KE1A0449	9	48	20KE1A0449	5	48	20KE1A0449	9
49	20KE1A0450	9	49	20KE1A0450	7	49	20KE1A0450	8	49	20KE1A0450	5	49	20KE1A0450	5
50	20KE1A0451	5	50	20KE1A0451	2	50	20KE1A0451	8	50	20KE1A0451	4	50	20KE1A0451	4
51	20KE1A0452	9	51	20KE1A0452	3	51	20KE1A0452	3	51	20KE1A0452	9	51	20KE1A0452	11
52	20KE1A0453	2	52	20KE1A0453	3	52	20KE1A0453	6	52	20KE1A0453	5	52	20KE1A0453	4
53	20KE1A0454	3	53	20KE1A0454	1	53	20KE1A0454	5	53	20KE1A0454	5	53	20KE1A0454	4
54	20KE1A0455	7	54	20KE1A0455	9	54	20KE1A0455	8	54	20KE1A0455	4	54	20KE1A0455	11
55	20KE1A0456	7	55	20KE1A0456	8	55	20KE1A0456	11	55	20KE1A0456	8	55	20KE1A0456	9
56	20KE1A0457	2	56	20KE1A0457	3	56	20KE1A0457	4	56	20KE1A0457	7	56	20KE1A0457	4
57	20KE1A0458	8	57	20KE1A0458	5	57	20KE1A0458	4	57	20KE1A0458	5	57	20KE1A0458	7
58	20KE1A0459	8	58	20KE1A0459	7	58	20KE1A0459	3	58	20KE1A0459	7	58	20KE1A0459	7

59	20KE1A0460	9	59	20KE1A0460	8	59	20KE1A0460	7	59	20KE1A0460	5	59	20KE1A0460	6
60	20KE1A0461	12	60	20KE1A0461	8	60	20KE1A0461	9	60	20KE1A0461	9	60	20KE1A0461	5
61	20KE1A0462	3	61	20KE1A0462	5	61	20KE1A0462	0	61	20KE1A0462	8	61	20KE1A0462	4
62	20KE1A0463	5	62	20KE1A0463	3	62	20KE1A0463	10	62	20KE1A0463	6	62	20KE1A0463	6
63	20KE1A0464	9	63	20KE1A0464	7	63	20KE1A0464	7	63	20KE1A0464	7	63	20KE1A0464	7
64	20KE1A0465	7	64	20KE1A0465	6	64	20KE1A0465	6	64	20KE1A0465	4	64	20KE1A0465	8
65	20KE1A0466	9	65	20KE1A0466	4	65	20KE1A0466	3	65	20KE1A0466	3	65	20KE1A0466	3
66	20KE1A0467	11	66	20KE1A0467	2	66	20KE1A0467	3	66	20KE1A0467	9	66	20KE1A0467	5
67	20KE1A0468	5	67	20KE1A0468	3	67	20KE1A0468	5	67	20KE1A0468	9	67	20KE1A0468	6
68	20KE1A0469	14	68	20KE1A0469	6	68	20KE1A0469	12	68	20KE1A0469	6	68	20KE1A0469	6
69	20KE1A0470	7	69	20KE1A0470	3	69	20KE1A0470	3	69	20KE1A0470	7	69	20KE1A0470	2
70	20KE1A0471	11	70	20KE1A0471	5	70	20KE1A0471	8	70	20KE1A0471	7	70	20KE1A0471	8
71	20KE1A0472	6	71	20KE1A0472	6	71	20KE1A0472	6	71	20KE1A0472	6	71	20KE1A0472	4
72	20KE1A0474	7	72	20KE1A0474	4	72	20KE1A0474	9	72	20KE1A0474	4	72	20KE1A0474	6
73	20KE1A0475	8	73	20KE1A0475	3	73	20KE1A0475	7	73	20KE1A0475	10	73	20KE1A0475	7
74	20KE1A0476	6	74	20KE1A0476	9	74	20KE1A0476	7	74	20KE1A0476	6	74	20KE1A0476	2
75	20KE1A0477	6	75	20KE1A0477	3	75	20KE1A0477	7	75	20KE1A0477	6	75	20KE1A0477	6
76	20KE1A0478	4	76	20KE1A0478	5	76	20KE1A0478	7	76	20KE1A0478	6	76	20KE1A0478	9
77	20KE1A0479	3	77	20KE1A0479	6	77	20KE1A0479	7	77	20KE1A0479	6	77	20KE1A0479	4
78	20KE1A0480	3	78	20KE1A0480	4	78	20KE1A0480	4	78	20KE1A0480	6	78	20KE1A0480	5
79	20KE1A0481	12	79	20KE1A0481	2	79	20KE1A0481	7	79	20KE1A0481	7	79	20KE1A0481	3
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81	20KE1A0483	5	81	20KE1A0483	7	81	20KE1A0483	4	81	20KE1A0483	4	81	20KE1A0483	7
82	20KE1A0484	4	82	20KE1A0484	4	82	20KE1A0484	5	82	20KE1A0484	4	82	20KE1A0484	6
83	20KE1A0485	10	83	20KE1A0485	8	83	20KE1A0485	6	83	20KE1A0485	6	83	20KE1A0485	11
84	20KE1A0486	3	84	20KE1A0486	6	84	20KE1A0486	5	84	20KE1A0486	4	84	20KE1A0486	5
85	20KE1A0487	9	85	20KE1A0487	6	85	20KE1A0487	6	85	20KE1A0487	4	85	20KE1A0487	6
86	20KE1A0488	10	86	20KE1A0488	7	86	20KE1A0488	5	86	20KE1A0488	5	86	20KE1A0488	4
87	20KE1A0489	5	87	20KE1A0489	3	87	20KE1A0489	5	87	20KE1A0489	6	87	20KE1A0489	11
88	20KE1A0490	8	88	20KE1A0490	3	88	20KE1A0490	10	88	20KE1A0490	9	88	20KE1A0490	8
89	20KE1A0491	8	89	20KE1A0491	10	89	20KE1A0491	8	89	20KE1A0491	5	89	20KE1A0491	11
90	20KE1A0492	7	90	20KE1A0492	5	90	20KE1A0492	2	90	20KE1A0492	5	90	20KE1A0492	7

91	20KE1A0493	6	91	20KE1A0493	6	91	20KE1A0493	4	91	20KE1A0493	1	91	20KE1A0493	8
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93	20KE1A0495	9	93	20KE1A0495	4	93	20KE1A0495	10	93	20KE1A0495	6	93	20KE1A0495	7
94	20KE1A0496	6	94	20KE1A0496	7	94	20KE1A0496	6	94	20KE1A0496	8	94	20KE1A0496	3
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96	20KE1A0498	8	96	20KE1A0498	1	96	20KE1A0498	6	96	20KE1A0498	3	96	20KE1A0498	8
97	20KE1A0499	9	97	20KE1A0499	3	97	20KE1A0499	6	97	20KE1A0499	4	97	20KE1A0499	8
98	20KE1A04A0	6	98	20KE1A04A0	3	98	20KE1A04A0	3	98	20KE1A04A0	3	98	20KE1A04A0	3
99	20KE1A04A1	6	99	20KE1A04A1	7	99	20KE1A04A1	6	99	20KE1A04A1	6	99	20KE1A04A1	4
100	20KE1A04A2	6	100	20KE1A04A2	4	100	20KE1A04A2	3	100	20KE1A04A2	8	100	20KE1A04A2	6
101	20KE1A04A3	11	101	20KE1A04A3	6	101	20KE1A04A3	8	101	20KE1A04A3	6	101	20KE1A04A3	6
102	21KE5A0401	11	102	21KE5A0401	4	102	21KE5A0401	5	102	21KE5A0401	5	102	21KE5A0401	7
103	21KE5A0402	8	103	21KE5A0402	10	103	21KE5A0402	4	103	21KE5A0402	6	103	21KE5A0402	9
104	21KE5A0403	13	104	21KE5A0403	3	104	21KE5A0403	8	104	21KE5A0403	7	104	21KE5A0403	8
105	21KE5A0404	5	105	21KE5A0404	4	105	21KE5A0404	5	105	21KE5A0404	3	105	21KE5A0404	5
106	21KE5A0405	11	106	21KE5A0405	5	106	21KE5A0405	6	106	21KE5A0405	5	106	21KE5A0405	6
107	21KE5A0406	11	107	21KE5A0406	4	107	21KE5A0406	3	107	21KE5A0406	7	107	21KE5A0406	11
108	21KE5A0407	8	108	21KE5A0407	4	108	21KE5A0407	7	108	21KE5A0407	2	108	21KE5A0407	6
109	21KE5A0408	1	109	21KE5A0408	6	109	21KE5A0408	5	109	21KE5A0408	8	109	21KE5A0408	8
110	21KE5A0409	12	110	21KE5A0409	8	110	21KE5A0409	8	110	21KE5A0409	4	110	21KE5A0409	6
111	21KE5A0410	9	111	21KE5A0410	8	111	21KE5A0410	10	111	21KE5A0410	7	111	21KE5A0410	5
112	21KE5A0411	6	112	21KE5A0411	8	112	21KE5A0411	4	112	21KE5A0411	7	112	21KE5A0411	7
113	21KE5A0412	9	113	21KE5A0412	5	113	21KE5A0412	2	113	21KE5A0412	7	113	21KE5A0412	8
114	21KE5A0413	7	114	21KE5A0413	9	114	21KE5A0413	3	114	21KE5A0413	4	114	21KE5A0413	10

PRINCIPAL
MALINENI LAKSHMAIAH
WOMEN'S ENGINEERING COLLEGE
PULLADIGUNTA, GUNTUR-17.

MALINENI LAKSHMAIAH WOMEN'S ENGINEERING COLLEGE

PULLADIGUNTA, GUNTUR - 522017

II-B.TECH II - SEMESTER MID I EXAMINATIONS

Award List

Subject : DC

Section : A

Sl.No	REGD No	Total (15M)
1	20KE1A0401	14
2	20KE1A0402	11
3	20KE1A0403	14
4	20KE1A0404	12
5	20KE1A0405	12
6	20KE1A0406	12
7	20KE1A0407	12
8	20KE1A0408	10
9	20KE1A0409	12
10	20KE1A0410	10
11	20KE1A0411	12
12	20KE1A0412	14
13	20KE1A0413	13
14	20KE1A0414	8
15	20KE1A0415	15
16	20KE1A0416	14
17	20KE1A0417	13
18	20KE1A0418	13
19	20KE1A0420	11
20	20KE1A0421	14
21	20KE1A0422	15
22	20KE1A0423	15
23	20KE1A0424	13
24	20KE1A0425	13
25	20KE1A0426	12
26	20KE1A0427	11
27	20KE1A0428	12
28	20KE1A0429	12
29	20KE1A0430	11
30	20KE1A0431	10
31	20KE1A0432	11
32	20KE1A0433	12
33	20KE1A0434	13
34	20KE1A0435	12
35	20KE1A0436	12
36	20KE1A0437	15
37	20KE1A0438	14
38	20KE1A0439	14
39	20KE1A0440	13
40	20KE1A0441	13
41	20KE1A0442	15
42	20KE1A0443	11
43	20KE1A0444	13
44	20KE1A0445	13
45	20KE1A0446	10
46	20KE1A0447	15
47	20KE1A0448	15
48	20KE1A0449	12
49	20KE1A0450	14
50	20KE1A0451	12
51	20KE1A0452	13
52	20KE1A0453	13
53	20KE1A0454	12
54	20KE1A0455	15
55	20KE1A0456	15
56	20KE1A0457	11
57	20KE1A0458	11
58	20KE1A0459	12
59	20KE1A0460	12

Signatures :

Faculty : Dr.SD.N.Praveen.

HOD :

Principal:

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Advanced Learners

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ESTD : 2008

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

A.Y.: 2022-23

Date: 17-12-2022

Subject Code	C304
Subject Name	Digital Communications
Regulation	R20
Year & Sem	III & I
Academic Year	2022-23

LIST OF ADVANCED LEARNERS IN THE COURSE

Bright Students: more than 75% (23) in Mid-1(30M) marks

SECTION-A

S.NO	ROLL NO	M1	QUIZ	Assig	T1
		15M	10 M	5M	30
1	20KE1A0403	14	6	5	25
2	20KE1A0416	14	4	5	23
3	20KE1A0418	13	5	5	23
4	20KE1A0439	14	5	5	24
5	20KE1A0442	15	3	5	23
6	20KE1A0447	15	8	5	28
7	20KE1A0448	15	4	5	24
8	20KE1A0450	14	5	5	24
9	20KE1A0456	15	4	5	24

Section-B

S.NO	ROLL NO	M1	Quiz	Assig	T1
		15M	10M	5M	
1	20KE1A0464	15	6	5	26
2	20KE1A0465	15	4	5	24
5	20KE1A0472	14	7	5	26
7	20KE1A0479	13	6	5	24

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17	20KE1A0497	14	5	5	24
18	20KE1A0498	14	5	5	24
19	20KE1A04A3	14	6	5	25
20	21KE5A0401	14	4	5	23
21	21KE5A0403	15	4	5	24
22	21KE5A0406	15	3	5	23
23	21KE5A0408	15	4	5	24
24	21KE5A0409	15	5	5	25
25	21KE5A0410	15	4	5	24

Facilities for Advanced Learners

a) NPTEL – e-learning / web learning
b) Association activities
c) Group discussions & role play / peer discussion
d) Paper presentations & seminars
e) Brain storming sessions
f) GATE training
g) EFY magazine (department magazine)
h) IETE journals
i) Professional society activities(IETE,ISTE)
j) Digital library
k) Central library, Dept. library

Signature of Faculty

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BRight Students Engagement

ESTD : 2008

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

A.Y.: 2022-23

Date: 17-12-2022

Subject Code	C304
Subject Name	Digital Communications
Regulation	R20
Year & Sem	III & I
Academic Year	2022-23

BRIGHT STUDENTS ENGAGEMENT QUESTIONS

1. In a baseband communications link, frequencies up to 3500 Hz are used for signalling. Using a raised cosine pulse with 75% excess bandwidth and for no inter-symbol interference, the maximum possible signalling rate in symbols per second is

   (A) 1750 (B) 2625
   (C) 4000 (D) 5250

2. A source alphabet consists of N symbols with the probability of the first two symbols being the same. A source encoder increases the probability of the first symbol by a small amount ε and decreases that of the second by ε. After encoding, the entropy of the source

   (A) increases (B) remains the same
   (C) increases only if $N = 2$ (D) decreases

3. A BPSK scheme operating over an AWGN channel with noise power spectral density of $N0/2$, uses equiprobable signals $s_1(t) = \sqrt{\frac{2E}{T}}Sin(W_C t)$ and $s_2(t) = -\sqrt{\frac{2E}{T}}Sin(W_C t)$ over the symbol interval $(0,T)$. If the local oscillator in a coherent receiver is ahead in phase by 45c with respect to the received signal, the probability of error in the resulting system is

   (A) $Q(\sqrt{\frac{2E}{N_0}})$ (B) $Q(\sqrt{\frac{E}{N_0}})$
   (C) $Q(\sqrt{\frac{E}{2N_0}})$ (D) $Q(\sqrt{\frac{E}{4N_0}})$

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4. A binary symmetric channel (BSC) has a transition probability of 1/8. If the binary symbol X is such that $P(X = 0) = 9/10$, then the probability of error for an optimum receiver will be

   (A) 7/80 (B) 63/80
   (C) 9/10 (D) 1/10

5. An analog signal is sampled at 36 kHz and quantized into 256 levels. The time duration of a bit of the binary coded signal is
   (A) 5.78 s (B) 3.47 s
   (C) 6.43 ms (D) 7.86 ms

6. An analog signal is quantized and transmitted using a PCM system. The tolerable error in sample amplitude is 0.5% of the peak-to-peak full scale value. The minimum binary digits required to encode a sample is

   (A) 5 (B) 6
   (C) 7 (D) 8

7. Television signal is sampled at a rate of 20% above the Nyquist rate. The signal has a bandwidth of 6 MHz. The samples are quantized into 1024 levels. The minimum bandwidth required to transmit this signal would be

   (A) 72 M bits/sec (B) 144 M bits/sec
   (C) 72 k bits/sec (D) 144 k bits/sec

8. A CD record audio signals digitally using PCM. The audio signal bandwidth is 15 kHz. The Nyquist samples are quantized into 32678 levels and then binary coded. The minimum number of binary digits required to encode the audio signal

   (A) 450 k bits/sec (B) 900 k bits/sec
   (C) 980 340 k bits/sec (D) 490 170, k bits/sec

9. The American Standard Code for Information Interchange has 128 characters, which are binary coded. If a certain computer generates 1,000,000 character per second, the minimum bandwidth required to transmit this signal will be

   (A) 1.4 M bits/sec (B) 14 M bits/sec
   (C) 7 M bits/sec (D) 0.7 M bits/sec

10. A binary channel with capacity 36 k bits/sec is available for PCM voice transmission. If signal is band limited to 3.2 kHz, then the appropriate values of quantizing level L and the sampling frequency will be

(A) 32, 3.6 kHz (B) 64, 7.2 kHz
(C) 64, 3.6 kHz (D) 32, 7.2 kHz

11. A PCM system uses a uniform quantizer followed by a 8-bit encoder. The bit rate of the system is equal to 108 bits/s. The maximum message bandwidth for which the system operates satisfactorily is
(A) 25 MHz (B) 6.25 MHz
(C) 12.5 MHz (D) 50 MHz

12. A linear delta modulator is designed to operate on speech signals limited to 3.4 kHz. The sampling rate is 10 time the Nyquist rate of the speech signal. The step size is 100 m V. The modulator is tested with a this test signal required to avoid slope overload is

(A) 2.04 V (B) 1.08 V
(C) 4.08 V (D) 2.16 V

Statement to Question 13-15 :

Consider a linear DM system designed to accommodate analog message signals limited to bandwidth of 3.5 kHz. A sinusoidal test signals of amplitude A_{max} =1V and frequency f_m =800 Hz is applied to system. The sampling rate of the system is 64 kHz.

13. The minimum value of the step size to avoid overload is

(A) 240 mV (B) 120 mV
(C) 670 mV (D) 78.5 mV

14. The granular-noise power would be

(A) 1.68mW (B) 28.6 mW
(C) 2.48mW (D) 11.2mW

15. The SNR will be
(A) 298 (B) 1.75 x 10^{-3}

(C) $4.46x\ 10^3$ (D) 201

16. The output signal-to-quantization-noise ratio of a 10-bit PCM was found to be 30 dB. The desired SNR is 42 dB. It can be increased by increasing the number of quantization level.In this way the fractional increase in the transmission bandwidth would be

(A) 20% (B) 30%
(C) 40% (D) 50%

Statement for Question 17-18.

A signal has a bandwidth of 1 MHz. It is sampled at a rate 50% higher than the Nyquist rate and quantized into 256 level using a μ -law quantizer with μ=225.

17. The signal-to-quantization-noise ratio is

(A) 34.91 dB (B) 38.06 dB
(C) 42.05 dB (D) 48.76 dB

18. It was found that a sampling rate 20% above the rate wou7ld be adequate. So the maximum SNR, that can be realized without increasing the transmission bandwidth, would be

(A) 60.4 dB (B) 70.3 dB
(C) 50.1 dB (D) None of the above

19. For a PCM signal the compression parameter μ = 100 and the minimum signal to quantization-noise ratio is 50 dB. The number of bits per sample would be.

(A) 8 (B) 10
(C) 12 (D) 14.

20. A sinusoid massage signal $m(t)$ is transmitted by binary PCM without compression. If the signal to-quantization-noise ratio is required to be at least 48 dB, the minimum number of bits per sample will be

(A) 8 (B) 10
(C) 12 (D) 14

21. A speech signal has a total duration of 20 sec. It is sampled at the rate of 8 kHz and then PCM encoded. The signal-to-quantization noise ratio is required to be 40 dB. The minimum storage capacity needed to accommodate this signal is

(A) 1.12 KBytes
(B) 140 KBytes
(C) 168 KBytes
(D) None of the above

Statement for Question 22-23.

Ten telemetry signals, each of bandwidth 2kHz, are to be transmitted simultaneously by binary PCM. The maximum tolerable error in sample amplitudes is 0.2% of the peak signal amplitude. The signals must be sampled at least 20% above the Nyquist rate. Framing and synchronizing requires an additional 1% extra bits.

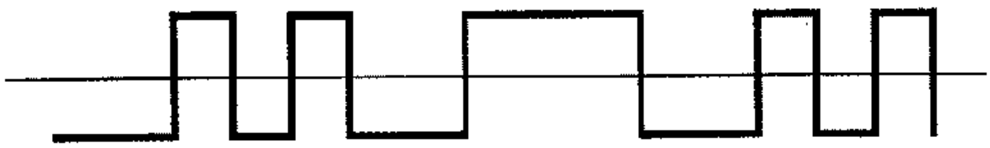
22. The minimum possible data rate must be

(A) 272.64 k bits/sec
(B) 436.32 k bits/sec
(C) 936.32 k bits/sec
(D) None of the above

23. The minimum transmission bandwidth is

(A) 218.16 kHz
(B) 468.32 kHz
(C) 136.32 kHz
(D) None of the above

24. Fig. shows a PCM signals in which amplitude level of + 1 volt and - 1 volt are used to represent binary symbol 1 and 0 respectively. The code word used consists of three bits. The sampled version of analog signal from which this PCM signal is derived is



(A) 4 5 1 2 1 3
(B) 8 4 3 1 2
(C) 6 4 3 1 7
(D) 1 2 3 4 5

25. Twenty-four voice signals are sampled uniformly at a rate of 8 kHz and then time-division multiplexed. The sampling process uses flat-top samples with 1 μs duration. The

multiplexing operating includes provision for synchronization by adding and extra pulse of 1 μs duration. The spacing between successive pulses of the multiplexed signal is

(A) 4μ s (B) 6μ s
(C) 7.2μ s (D) 8.4 μs

26. The input to a linear delta modulator having a step-size Δ=0.628 is a sine wave with frequency fm and peak amplitude E_m. If the sampling frequency f_s =40 kHz, the combination of the sine-wave frequency and the peak amplitude, where slope overload will take place is

E_m	f_m
(A) 0.3 V	8 kHz
(B) 1.5 V	4 kHz
(C) 1.5 V	2 kHz
(D) 3.0 V	1 kHz

27. A sinusoidal signal with peak-to-peak amplitude of 1.536 V is quantized into 128 levels using a mid-rise uniform quantizer. The quantization-noise power is

(A) 0.768 V (B) 48 x 10^{-6} V^2
(C) 12 x10^{-6} V^2 (D) 3.072 V

28. A signal is sampled at 8 kHz and is quantized using 8 bit uniform quantizer. Assuming SNR_q for a sinusoidal signal, the correct statement for PCM signal with a bit rate of R is

(A) R = 32 kbps, SNR_q = 25.8 dB
(B) R = 64 kbps, SNR_q = 49.8 dB
(C) R = 64 kbps, SNR_q = 55.8 dB
(D) R = 32 kbps, SNR_q = 49.8 dB

29. A 1.0 kHz signal is flat-top sampled at the rate of 180 samples sec and the samples are applied to an ideal rectangular LPF with cat-off frequency of 1100 Hz, then the output of the filter contains

(A) only 800 Hz component
(B) 800 and 900 Hz components
(C) 800 Hz and 1000 Hz components
(D) 800 Hz, 900 and 1000 Hz components

30. The Nyquist sampling interval, for the signal sinc($700t$) + sinc($500t$) is

(A)1/350sec (B)π/350sec
(C)1/700sec (D) π/175sec

31. A signal $x(t) = 100\cos(24\pi \times 10^3)\, t$ is ideally sampled with a sampling period of 50 sec and then passed through an ideal lowpass filter with cutoff frequency of 15 KHz. Which of the following frequencies is/are present at the filter output

(A) 12 KHz only (B) 8 KHz only
(C) 12 KHz and 9 KHz (D) 12 KHz & 8 KHz

32. In a PCM system, if the code word length is increased from 6 to 8 bits, the signal to quantization noise ratio improves by the factor.

(A) 8/6 (B) 12
(C) 16 (D) 8

33. Four signals $g_1(t)$, $g_2(t)$, $g_3(t)$ and $g_4(t)$ are to be multiplexed and transmitted. $g_1(t)$ and $g_4(t)$ have a bandwidth of 4 kHz, and the remaining two signals have bandwidth of 8 kHz,. Each sample requires 8 bit for encoding. What is the minimum transmission bit rate of the system.

(A) 512 kbps (B) 16 kbps
(C) 192 kbps (D) 384 kbps

34. Three analog signals, having bandwidths 1200 Hz, 600 Hz and 600 Hz, are sampled at their respective Nyquist rates, encoded with 12 bit words, and time division multiplexed. The bit rate for the multiplexed signal is

(A) 115.2 kbps (B) 28.8 kbps
(C) 57.6 kbps (D) 38.4 kbps

35. The minimum sampling frequency (in samples/sec) required to reconstruct the following signal form its samples without distortion would be

$$x(t) = 5\left(\frac{\sin 2\pi 1000t}{\pi t}\right)^3 + 7\left(\frac{\sin 2\pi 1000t}{\pi t}\right)^2$$

(A) 2×10^3 (C) 6×10^3
(B) 4×10^3 (D) 8×10^3

36. The minimum step-size required for a Delta-Modulator operating at32 K samples/sec to track the signal (here $u(t)$ is the nuit function) $x(t)$ =125t* ($u(t)$-$u(t$-1)) (250-125t)($u(t$-1)-$u(t$-2)s so that slope overload is avoided, would be

(A) 2^{-10} (B) 2^{-8}
(C) 2^{-6} (D)2^{-4}

37. Four signals each band limited to 5 kHz are sampled at twice the Nyquist rate. The resulting PAM samples are transmitted over a single channel after time division multiplexing. The theoretical minimum transmissions bandwidth of the channel should be equal to.

(A) 5 kHz (B) 20 kHz
(C) 40 kHz (D) 80 kHz

38. Four independent messages have bandwidths of 100 Hz, 100 Hz, 200 Hz and 400 Hz respectively. Each is sampled at the Nyquist rate, time division multiplexed and transmitted. The transmitted sample rate, in Hz, is given by

(A) 200 (B) 400
(C) 800 (D) 1600

39. The Nyquist sampling rate for the signal $g(t)$= 10* cos(50π t) cos ^{2}(150π t) . Where ' t' is in seconds, is

(A) 150 samples per second
(B) 200 samples per second
(C) 300 samples per second
(D) 350 samples per second

40. A TDM link has 20 signal channels and each channel is sampled 8000 times/sec. Each sample is represented by seven binary bits and contains an additional bit for synchronization. The total bit rate for the TDM link is
(A) 1180 K bits/sec (B) 1280 K bits/sec
(C) 1180 M bits/sec (D) 1280 M bits/sec

41. In a CD player, the sampling rate is 44.1 kHz and the samples are quantized using a 16-bit/sample quantizer. The resulting number of bits for a piece of music with a duration of 50 minutes is
(A) 1.39 x 10^9 (B) 4.23 x 10^9
(C) 8.46 x 10^9 (D) 12.23 10^9

42. Four voice signals. each limited to 4 kHz and sampled at Nyquist rate are converted into binary PCM signal using 256 quantization levels. The bit transmission rate for the time-division multiplexed signal will be

(A) 8 kbps (B) 64 kbps
(C) 256 kbps (D) 512 kbps

43. Analog data having highest harmonic at 30 kHz generated by a sensor has been digitized using 6 level PCM. What will be the rate of digital signal generated?

(A) 120 kbps (B) 200 kbps
(C) 240 kbps (D) 180 kbps

44. In a PCM system, the number of quantization levels is 16 and the maximum lsignal frequency is 4 kHz.; the bit transmission rate is

(A) 32 bits/s (B) 16 bits/s
(C) 32 kbits/s (D) 64 dbits/s

45. A speech signal occupying the bandwidth of 300 Hz to 3 kHz is converted into PCM format for use in digital communication. If the sampling frequency is8 kHz and each sample is quantized into 256 levels, then the output bit the rate will be

(A) 3 kb/s (B) 8 kb/s
(C) 64 kb/s (D) 256 kb/s

46. If the number of bits in a PCM system is increased from n to n _ 1, the signal-to-quantization noise ratio will increase by a factor.

(A) $\frac{n+1}{n}$ (B) $\frac{(n+1)^2}{n^2}$
(C) 2 (D) 4

47. In PCM system, if the quantization levels are increased from 2 to 8, the relative bandwidth requirement will.

(A) remain same (B) be doubled
(C) be tripled (D) become four times

48. Assuming that the signal is quantized to satisfy the condition of previous question and assuming the approximate bandwidth of the signal is W. The minimum required bandwidth for transmission of a binary PCM signal based on this quantization scheme will be.

(A) 5 W (B) 10 W
(C) 20 W (D) None of the above

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circular Remedial classes to the slow learners Time Table

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DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

MLWEC/ECE/ TIMETABLES /22-23/CT/01 Dates: 10-10-2022

CIRCULAR

It is observed that after mid-1 the Students who are the slow learners in III ECE (I-Sem) in Respective Subject course. Remedial classes are scheduled for the weak learners from 10-10-2022 to 26-11-2022.Hence the students should Follow the time table and attend the remedial classes regularly.

REMEDIAL CLASS TIME TABLE

Class: III-B.Tech ECE **Semester: I** **Section: A** **W.E.F.: 10-10-22**

2-Period / Day	1 9:00-09:50	2 09:50-10:40	10:40 – 10:50	3 10:50 – 11:40	4 11:40-12:30	12:30-1:20	5 01:20-02:10	6 02:10-03:00	7 03:00-03:50	8 4:00-5:00
Mond			B							AICA
Tuesd			R							EMTL
Wednesday										DC
Thursday			E			LUNCH BREAK				EMI
Friday			A							COA
Saturday			K							TEST

CLASS INCHARGE TIME TABLE INCHARGE HOD

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DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

Class: III-B.Tech ECE **Semester: I** **Section: B** **W.E.F.:10-10-22**

2- Period / Day	1 9:00-09:50	2 09:50-10:40	10:40 – 10:50	3 10:50 – 11:40	4 11:40-12:30	12:30-1:2	5 01:20-02:10	6 02:10-03:00	7 03:00-03:50	8 4:00-5:00
Mond			B							**EMTL**
Tuesd			R							**AICA**
Wednesday										**EMI**
Thursday			E			LUNCH BREAK				**COA**
Friday			A							**DC**
Saturday			K							**TEST**

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Remedial class
Time Table

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DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

Subject Code	C304
Subject Name	Digital Communications
Regulation	R20
Year & Semester	III & I
Academic Year	2022-23

REMEDIAL CLASS TIME TABLE MLWEC/ECE/ TIMETABLES /22-23/CT/01

Class: III-B.Tech ECE **Semester: I** **Section: A** W.E.F.: **10-10-22**

2-Period /	1 9:00-09:50	2 09:50-10:40	10:40 – 10:50	3 10:50 – 11:40	4 11:40-12:30	12:30-1:20	5 01:20-02:10	6 02:10-03:00	7 03:00-03:50	8 4:00-5:00
Monday			B							AICA
Tuesday			R							EMTL
Wednesday										DC
Thursday			E			LUNCH BREAK				EMI
Friday			A							COA
Saturday			K							TEST

CLASS INCHARGE **TIME TABLE INCHARGE** **HOD**

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Class: III-B.Tech ECE | **Semester: I** | **Section: B** | **W.E.F.:10-10-22**

2-Period /	1	2	10:40 – 10:5	3	4	12:30-1:2	5	6	7	8
	9:00-09:50	09:50-10:40		10:50 – 11:40	11:40-12:30		01:20-02:10	02:10-03:00	03:00-03:50	4:00-5:00
Monday			B							EMTL
Tuesday			R							AICA
Wednesday										EMI
Thursday			E			LUNCH BREAK				COA
Friday			A							DC
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PRINCIPAL
MALINENI LAKSHMAIAH
WOMEN'S ENGINEERING COLLEGE
PULLADIGUNTA, GUNTUR-17.

Remedial classes Attendance Report

MALINENI LAKSHMAIAH WOMEN'S ENGIN
Approved by AICTE, New Delhi & Affiliated to JNTUK, Kakinada
(An ISO9001:2008 Certified Institution)
Pulladigunta (Vil), Vatticherukuru (Md), Prathipadu Road, Guntur – 522 017 A.P.
ESTD : 2008

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

A.Y.: 2022-23

Date: 17-12-2022

Subject Code	C304
Subject Name	Digital Communications
Regulation	R20
Year & Sem	III & I
Academic Year	2022-23

REMEDIAL CLASSES ATTENDANCE REPORT

Section A

SNO	REGDNO	12-10-2022	19-10-2022	26-10-2022	02-11-2022	08-11-2022	15-11-2022	22-11-2022
1	20KE1A0403	1	2	3	4	5	6	7
2	20KE1A0404	1	2	3	4	5	6	7
3	20KE1A0407	1	AB	2	3	4	5	6
4	20KE1A0408	1	2	3	4	5	6	7
5	20KE1A0414	1	2	3	AB	4	5	6
6	20KE1A0416	1	2	3	4	5	6	7
7	20KE1A0420	1	2	3	4	5	6	7
8	20KE1A0427	1	2	3	4	5	6	AB
9	20KE1A0429	1	2	3	4	5	6	7
10	20KE1A0430	1	2	3	4	5	6	7
11	20KE1A0431	1	2	3	4	5	6	7
12	20KE1A0433	1	2	3	4	5	6	7
13	20KE1A0435	1	2	3	4	AB	5	6
14	20KE1A0439	1	2	3	4	5	6	7
15	20KE1A0441	1	AB	2	3	4	5	6
16	20KE1A0445	1	2	3	4	5	6	7
17	20KE1A0447	1	2	3	4	AB	5	6
18	20KE1A0450	1	2	3	4	5	6	7
19	20KE1A0451	1	AB	2	3	4	5	6
20	20KE1A0453	1	2	3	4	5	6	7
21	20KE1A0454	1	2	3	4	5	6	7
22	20KE1A0457	1	2	3	4	5	6	7
23	20KE1A0459	1	2	3	4	AB	5	6

PRINCIPAL
MALINENI LAKSHMAIAH
WOMEN'S ENGINEERING COLLEGE
PULLADIGUNTA. GUNTUR-17.

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

Section B

SNO	REGDNO	14-10-2022	21-10-2022	28-10-2022	04-11-2022	11-11-2022	18-11-2022	25-11-2022
1	20KE1A0461	1	2	3	4	5	6	AB
2	20KE1A0470	1	2	3	4	5	6	7
3	20KE1A0475	1	2	3	4	5	6	AB
4	20KE1A0476	1	2	3	AB	5	AB	7
5	20KE1A0478	1	2	3	4	5	6	7
6	20KE1A0482	1	2	3	4	AB	6	7
7	20KE1A0486	1	2	3	4	AB	6	7
8	20KE1A0489	AB	1	2	3	4	5	7
9	20KE1A0491	1	AB	AB	2	3	4	7
10	20KE1A0492	1	2	3	4	5	6	7
11	20KE1A0493	1	2	3	4	5	6	7
12	20KE1A0494	1	2	3	4	5	6	7
13	20KE1A0498	1	2	3	AB	4	5	6
14	20KE1A04A0	1	2	3	4	5	6	7
15	20KE1A04A2	1	2	3	4	5	6	7.
16	21KE5A0405	1	AB	2	3	4	5	6
17	21KE5A0411	1	2	3	4	5	6	AB

Signature of Faculty

PRINCIPAL
MALINENI LAKSHMAIAH
WOMEN'S ENGINEERING COLLEGE
PULLADIGUNTA. GUNTUR-17.

Evaluation Record
Internal-Quiz & Assignment

MALINENI LAKSHMAIAH WOMEN'S ENGINEERING COLLEGE, GUNTUR
Approved by AICTE, New Delhi & Affiliated to JNTUK, Kakinada
(An ISO9001:2008 Certified Institution)
Pulladigunta (Vil), Vatticherukuru (Md), Prathipadu Road, Guntur – 522 017 A.P.

ESTD : 2008

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

A.Y.: 2022-23

Date: 17-12-2022

Subject Code	C304
Subject Name	Digital Communications
Regulation	R20
Year & Sem	III & I
Academic Year	2022-23

I INTERNAL MARKS

SECTION-A

Sl.No	REGD No	Q1a (5M)	Q1 b (3M)	Q2 (3M)	Q3 (4M)	Total (15)	QUIZ (10M)	Assisgment-I (5M)	Total (30)
1	20KE1A0401	4	3	3	4	14	1	5	20
2	20KE1A0402	4	3	3	4	11	4	5	20
3	20KE1A0403	5	2	3	4	14	6	5	25
4	20KE1A0404	2	3	3	4	12	3	5	20
5	20KE1A0405	2	3	3	4	12	4	5	21
6	20KE1A0406	2	3	3	4	12	3	5	20
7	20KE1A0407	4.5	2.5	2	4	12	6	5	23
8	20KE1A0408	2	2	3	4	10	4	5	19
9	20KE1A0409	2	3	3	4	12	5	5	22
10	20KE1A0410	2	2	3	4	10	4	5	19
11	20KE1A0411	2	3	3	4	12	5	5	22
12	20KE1A0412	4	3	3	4	14	3	5	22
13	20KE1A0413	3	3	3	4	13	3	5	21
14	20KE1A0414	2	2	2	3	8	5	5	18
15	20KE1A0415	5	3	3	4	15	2	5	22
16	20KE1A0416	4	3	3	4	14	4	5	23
17	20KE1A0417	5	2	2	3	13	4	5	22
18	20KE1A0418	4	2	3	4	13	5	5	23
19	20KE1A0420	3	3	3	3	11	5	5	21

20	20KE1A0421	4	3	3	4	14	4	5	23
21	20KE1A0422	5	3	3	4	15	2	5	22
22	20KE1A0423	5	3	3	4	15	1	5	21
23	20KE1A0424	4	3	2	4	13	3	5	21
24	20KE1A0425	4	3	2	4	13	4	5	22
25	20KE1A0426	3	3	3	4	12	4	5	21
26	20KE1A0427	3	2	3	4	11	3	5	19
27	20KE1A0428	4	3	2	4	12	4	5	21
28	20KE1A0429	4	3	2	4	12	3	5	20
29	20KE1A0430	3	2	3	4	11	4	5	20
30	20KE1A0431	4	1	3	3	10	2	5	17
31	20KE1A0432	4	2	3	3	11	3	5	19
32	20KE1A0433	5	3	2	3	12	3	5	20
33	20KE1A0434	5	3	3	2	13	3	5	21
34	20KE1A0435	4	3	3	3	12	2	5	19
35	20KE1A0436	4	3	3	3	12	3	5	20
36	20KE1A0437	5	3	3	4	15	7	5	27
37	20KE1A0438	4	3	3	4	14	3	5	22
38	20KE1A0439	4	3	3	4	14	5	5	24
39	20KE1A0440	2	3	3	4	13	3	5	21
40	20KE1A0441	2	3	3	4	13	5	5	23
41	20KE1A0442	5	3	3	4	15	3	5	23
42	20KE1A0443	2	3	3	4	11	4	5	20
43	20KE1A0444	5	2	2	4	13	4	5	22
44	20KE1A0445	5	2	2	4	13	3	5	21
45	20KE1A0446	4	2	2	3	10	3	5	18
46	20KE1A0447	5	3	3	4	15	8	5	28
47	20KE1A0448	5	3	3	4	15	4	5	24
48	20KE1A0449	2	3	3	4	12	4	5	21
49	20KE1A0450	4	3	3	4	14	5	5	24
50	20KE1A0451	3	3	3	4	12	3	5	20
51	20KE1A0452	5	2	2	4	13	3	5	21
52	20KE1A0453	5	2	2	4	13	4	5	22
53	20KE1A0454	3	3	3	4	12	4	5	21
54	20KE1A0455	5	3	3	4	15	6	5	26
55	20KE1A0456	5	3	3	4	15	4	5	24

56	20KE1A0457	3	2	3	4	11	2	5	18
57	20KE1A0458	3	2	3	4	11	3	5	19
58	20KE1A0459	2	3	3	4	12	2	5	19
59	20KE1A0460	4	3	2	4	12	3	5	20

I INTERNAL MARKS

Section-B

S.NO	REGD No	Q1a (5M)	Q1 b (3M)	Q2 (3M)	Q3 (4M)	Total (15)	QUIZ (10M)	Assisg ment-I (5M)	Total (30)
1	20KE1A0461	4	3	2	4	12	3	5	20
2	20KE1A0462	5	2	2	4	13	2	5	20
3	20KE1A0463	4	3	2	4	12	2	5	19
4	20KE1A0464	5	3	3	4	15	6	5	26
5	20KE1A0465	5	3	3	4	15	4	5	24
6	20KE1A0466	4	3	3	4	14	3	5	22
7	20KE1A0467	5	3	3	4	15	2	5	22
8	20KE1A0468	5	3	3	4	15	3	5	23
9	20KE1A0469	5	2	2	4	13	2	5	20
10	20KE1A0470	2	3	3	4	12	3	5	20
11	20KE1A0471	5	3	3	4	15	8	5	28
12	20KE1A0472	4	3	3	4	14	7	5	26
13	20KE1A0474	5	3	3	4	15	1	5	21
14	20KE1A0475	2	3	3	4	12	4	5	21
15	20KE1A0476	2	3	3	4	11	2	5	18

16	20KE1A0477	4	3	3	4	14	5	5	24
17	20KE1A0478	2	3	3	4	12	4	5	21
18	20KE1A0479	5	2	2	4	13	6	5	24
19	20KE1A0480	1	3	3	4	10	3	5	18
20	20KE1A0481	5	3	3	4	15	2	5	22
21	20KE1A0482	4	3	3	4	14	4	5	23
22	20KE1A0483	2	3	3	4	12	5	5	22
23	20KE1A0484	4	3	3	4	14	2	5	21
24	20KE1A0485	5	3	3	4	15	5	5	25
25	20KE1A0486	5	2	2	4	13	4	5	22
26	20KE1A0487	2	3	3	4	12	2	5	19
27	20KE1A0488	4	3	3	4	14	6	5	25
28	20KE1A0489	4	3	3	4	14	4	5	23
29	20KE1A0490	5	3	3	4	15	4	5	24
30	20KE1A0491	2	3	3	4	12	5	5	22
31	20KE1A0492	2	3	3	4	11	5	5	21
32	20KE1A0493	5	2	2	4	13	2	5	20
33	20KE1A0494	2	3	3	4	12	4	5	21
34	20KE1A0495	5	3	3	4	15	5	5	25
35	20KE1A0496	2	3	3	4	12	6	5	23
36	20KE1A0497	4	3	3	4	14	5	5	24
37	20KE1A0498	4	3	3	4	14	5	5	24

ESTD : 2008

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

38	20KE1A0499	2	3	3	4	12	4	5	21
39	20KE1A04A0	5	3	3	0	11	4	5	20
40	20KE1A04A1	5	2	3	0	10	7	5	22
41	20KE1A04A2	5	3	3	0	11	1	5	17
42	20KE1A04A3	4	3	3	4	14	6	5	25
43	21KE5A0401	4	3	3	4	14	4	5	23
44	21KE5A0402	2	3	3	4	12	2	5	19
45	21KE5A0403	5	3	3	4	15	4	5	24
46	21KE5A0404	5	3	3	0	11	3	5	19
47	21KE5A0405	5	3	3	4	15	1	5	21
48	21KE5A0406	5	3	3	4	15	3	5	23
49	21KE5A0407	5	2	2	4	13	2	5	20
50	21KE5A0408	5	3	3	4	15	4	5	24
51	21KE5A0409	5	3	3	4	15	5	5	25
52	21KE5A0410	5	3	3	4	15	4	5	24
53	21KE5A0411	2	3	3	4	12	3	5	20
54	21KE5A0412	4	3	3	4	14	2	5	21
55	21KE5A0413	5	2	2	4	13	4	5	22

PRINCIPAL
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Pulladigunta (Vil), Vatticherukuru (Md), Prathipadu Road, Guntur – 522 017 A.P.

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

II INTERNAL MARKS

Section-A

Sl.No	REGD No	Q1 b (3M)	Q1a (5M)	Q2 (3M)	Q3 (4M)	MID Total (15)	QUIZ (10M)	Assisgment-I (5M)	Total (30M)
1	20KE1A0401	3	5	3	4	14	3	5	22
2	20KE1A0402	3	4	3	4	14	5	5	24
3	20KE1A0403	3	5	3	3	14	3	5	22
4	20KE1A0404	3	3	3	4	13	3	5	21
5	20KE1A0405	3	2	3	4	13	2	5	20
6	20KE1A0406	3	4	3	4	14	4	5	23
7	20KE1A0407	3	2	3	4	13	3	5	21
8	20KE1A0408	3	2	3	4	13	2	5	20
9	20KE1A0409	3	4	3	4	14	3	5	22
10	20KE1A0410	3	4	3	4	14	1	5	20
11	20KE1A0411	3	4	3	4	14	2	5	21
12	20KE1A0412	3	4	3	4	14	4	5	23
13	20KE1A0413	3	4	3	4	14	4	5	23
14	20KE1A0414	2	4	2	3	12	2	5	19
15	20KE1A0415	3	2	3	4	13	3	5	21
16	20KE1A0416	3	2	3	4	13	5	5	23
17	20KE1A0417	3	2	3	4	13	3	5	21
18	20KE1A0418	3	4	3	4	14	3	5	22
19	20KE1A0420	2	4	2	3	12	4	5	21
20	20KE1A0421	3	2	3	4	13	3	5	21
21	20KE1A0422	3	5	3	4	15	2	5	22
22	20KE1A0423	3	4	3	4	14	4	5	23
23	20KE1A0424	3	4	3	4	14	3	5	22
24	20KE1A0425	3	4	3	4	14	3	5	22
25	20KE1A0426	3	4	3	4	14	5	5	24
26	20KE1A0427	3	2	3	4	13	6	5	24
27	20KE1A0428	3	2	3	4	13	4	5	22
28	20KE1A0429	3	2	3	4	13	4	5	22
29	20KE1A0430	3	4	3	4	14	4	5	23
30	20KE1A0431	3	4	3	4	14	2	5	21
31	20KE1A0432	3	4	3	4	14	6	5	25
32	20KE1A0433	3	2	3	4	13	4	5	22

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

33	20KE1A0434	3	2	3	4	13	4	5	22
34	20KE1A0435	3	2	3	4	13	5	5	23
35	20KE1A0436	3	4	3	4	14	4	5	23
36	20KE1A0437	3	5	3	4	15	4	5	24
37	20KE1A0438	3	5	3	4	15	3	5	23
38	20KE1A0439	3	4	3	3	14	4	5	23
39	20KE1A0440	3	4	3	3	14	3	5	22
40	20KE1A0441	3	4	3	3	14	3	5	22
41	20KE1A0442	3	4	3	3	14	3	5	22
42	20KE1A0443	3	4	3	3	14	1	5	20
43	20KE1A0444	3	2	3	3	13	3	5	21
44	20KE1A0445	3	2	3	3	13	2	5	20
45	20KE1A0446	3	2	3	3	13	3	5	21
46	20KE1A0447	3	2	3	3	13	6	5	24
47	20KE1A0448	3	5	3	4	15	4	5	24
48	20KE1A0449	3	4	3	3	14	5	5	24
49	20KE1A0450	3	2	3	3	13	4	5	22
50	20KE1A0451	3	2	3	3	13	4	5	22
51	20KE1A0452	3	2	3	3	13	2	5	20
52	20KE1A0453	3	2	3	3	13	3	5	21
53	20KE1A0454	3	4	3	3	14	3	5	22
54	20KE1A0455	3	5	3	4	15	4	5	24
55	20KE1A0456	3	4	3	3	14	6	5	25
56	20KE1A0457	3	4	3	3	14	2	5	21
57	20KE1A0458	3	4	3	3	14	2	5	21
58	20KE1A0459	3	4	3	3	14	2	5	21
59	20KE1A0460	3	4	3	3	14	4	5	23

PRINCIPAL
MALINENI LAKSHMAIAH
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DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

II INTERNAL MARKS

Section-B

Sl.No	REGD No	Q1 b (3M)	Q1a (5M)	Q2 (3M)	Q3 (4M)	MID Total (15)	QUIZ (10M)	Assisgment-I (5M)	Total (30M)
1	20KE1A0461	3	4	3	3	14	5	5	24
2	20KE1A0462	3	4	3	3	14	0	5	19
3	20KE1A0463	3	4	3	3	14	5	5	24
4	20KE1A0464	3	4	3	3	14	4	5	23
5	20KE1A0465	3	5	3	4	15	3	5	23
6	20KE1A0466	3	4	3	3	14	2	5	21
7	20KE1A0467	3	4	3	3	14	2	5	21
8	20KE1A0468	3	4	3	3	14	3	5	22
9	20KE1A0469	3	5	3	4	15	6	5	26
10	20KE1A0470	2	4	2	3	12	2	5	19
11	20KE1A0471	3	2	3	3	13	4	5	22
12	20KE1A0472	3	2	3	3	13	3	5	21
13	20KE1A0474	3	2	3	3	13	5	5	23
14	20KE1A0475	3	4	3	3	14	4	5	23
15	20KE1A0476	3	2	3	3	13	4	5	22
16	20KE1A0477		5	3	4	12	4	5	21
17	20KE1A0478	2	4	3	4	13	4	5	22
18	20KE1A0479	2	4	3	4	13	4	5	22

19	20KE1A0480	3	4	3	2	14	2	5	21
20	20KE1A0481	3	4	3	3	14	4	5	23
21	20KE1A0482	3	4	3	3	14	3	5	22
22	20KE1A0483	3	2	3	3	13	2	5	20
23	20KE1A0484	3	4	3	3	14	3	5	22
24	20KE1A0485	3	5	3	3	15	3	5	23
25	20KE1A0486	3	4	3	3	14	3	5	22
26	20KE1A0487	3	4	3	3	14	3	5	22
27	20KE1A0488	3	4	3	3	14	3	5	22
28	20KE1A0489	3	2	3	3	13	3	5	21
29	20KE1A0490	3	4	3	3	14	5	5	24
30	20KE1A0491	3	2	3	3	13	4	5	22
31	20KE1A0492	3	2	3	3	13	1	5	19
32	20KE1A0493	3	2	3	3	13	2	5	20
33	20KE1A0494	3	2	3	3	13	3	5	21
34	20KE1A0495	3	2	3	3	13	5	5	23
35	20KE1A0496	3	4	3	3	14	3	5	22
36	20KE1A0497	3	4	3	3	14	2	5	21
37	20KE1A0498	3	2	3	3	13	3	5	21
38	20KE1A0499	3	4	3	3	14	3	5	22
39	20KE1A04A0	3	2	3	3	13	2	5	20
40	20KE1A04A1	3	5		4	12	3	5	20

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

41	20KE1A04A2		5	3	4	12	2	5	19
42	20KE1A04A3	3	4	3	3	14	4	5	23
43	21KE5A0401	3	2	3	3	13	3	5	21
44	21KE5A0402	3	5	3	3	15	2	5	22
45	21KE5A0403	3	5	3	3	15	4	5	24
46	21KE5A0404	3	5	3	3	15	3	5	23
47	21KE5A0405	3	4	3	3	14	3	5	22
48	21KE5A0406	3	4	3	3	14	2	5	21
49	21KE5A0407	3	4	3	3	14	4	5	23
50	21KE5A0408	3	4	3	3	14	3	5	22
51	21KE5A0409	3	2	3	3	13	4	5	22
52	21KE5A0410	3	4	3	3	14	5	5	24
53	21KE5A0411	3	4	3	3	14	2	5	21
54	21KE5A0412	3	5	3	3	15	1	5	21
55	21KE5A0413	3	4	3	3	14	2	5	21

Signature of the Faculty

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① Define M-ary modulation Technique and explain the M-ary -ASK?

In any communication system, the 2 major resources that are used efficiently are
1. Transmit power
2. Bandwidth of the channel

M-ary (multilevel) signalling scheme

① IN W.K.T BASK, BFSK, BPSK and DPSK are Binary modulation Technique. In these techniques signals are Represented using only 2 symbols consisting of single Bit either '1' or '0'

② It means either 2 amplitude, 2 frequencies (or) 2 phases are used to represent 2 symbol respectively

③ The maximum Bandwidth requirement of BASK $= 2f_b$

BFSK $= 4f_b$

BPSK $= 2f_b$

DPSK $= f_b$

④ Hence to reduce the Bandwidth requirement 2 (or) more bits are combined to form one symbol

⑤ Thus the symbol is always greater than 2 and is given by $M = 2^n$ where n = no. of Bits combined ($n = 2, 3, 4 \dots$)

M = total No. of symbols (or) levels

⑥ The signal representation which uses the combination of 2 (or) Bits to represent which a single symbol is known as M-ary (multi-level signaling scheme)

7. fig shows the Binary and M-ary digital signal representation in fig (a): only 2 amplitude levels are used to represent the signal

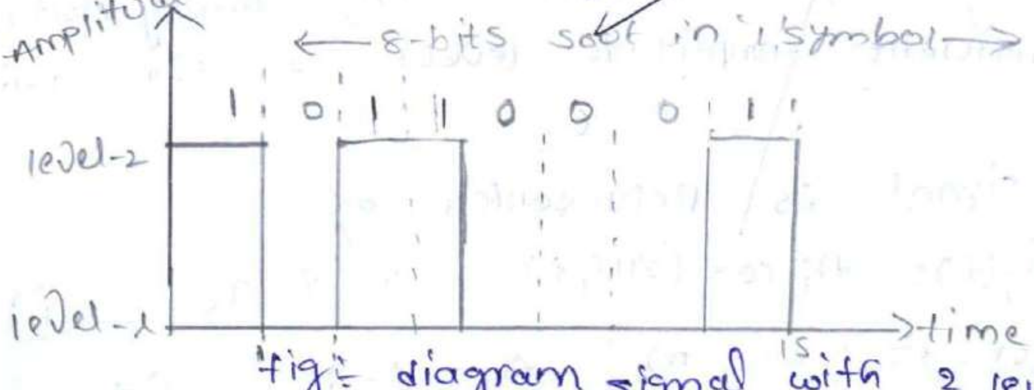
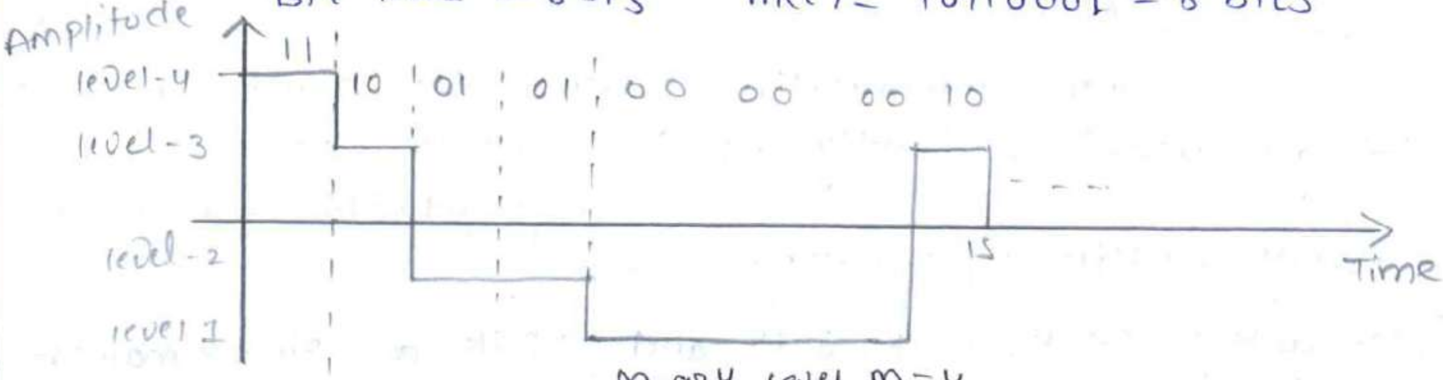


fig: diagram signal with 2 level

Binary level $m=2$

Bit Rate $= 8\,bP_s$ $m(t) = 1011000l = 8$ bits



M-ary level $M=4$

fig: Digital signal with 4 levels

In this signal representation 16 bits are sent in 1's

$\therefore$ Bit rate $= 16\,BP_s$ (Bits per second)

fig: Binary and m-ary digital signal representation

(8) m-level signal is used to modulate the carrier then this technique is known as m-ary digital modulation Technique

(9) In this, one of the m- possible signal is transmitted during each symbol duration, T_s

$$T_s = T_b \log_2 m$$
$$= T_b \log_2 2^n = nT_b$$

where T_b = Bit duration; $T_s = nT_b$

(10) Based on the type of modulation used, They are classified as

1. m-ary ASK
2. m-ary FSK
3. m-ary PSK
4. m-ary Amplitude & phase shift keying

M-ary ASK Modulation Technique

(1) In m-ary Amplitude shift keying (m-ary ASK), there are M - different amplitude levels of the carrier are used

(2) The signal is Represented by

$$S_i(t) = A_i \cos(2\pi f_c t), \quad 0 \le t \le T_s \quad \text{—(1)}$$

for $i = 1, 2 \ldots m$ $\quad A_i = (2i - 1 - m)d$

where $2d$ = difference b/w 2 consecutive signal Amplitudes

(3) Let $m=4$ and $\alpha=1$; $i=1,2,3,4$.

The 4 signal Amplitudes will be $A_1 = (2\cdot 1-4)\cdot 1$
$= 2-5$
$= -3$

$A_2 = (2\cdot 2-1-4)\cdot 1$
$= -1$

$A_3 = (2\cdot 3 - 1\cdot 4)\cdot 1$
$= (6\cdot 5)\cdot 1$
$= 1$

$A_4 = (2\cdot 4 - 1\cdot 4)\cdot 1 = (8-5) = 3$

$A_i = -3, -1, 1, 3V$

The m-ASK signal will be for $0 \le t \le T_s$

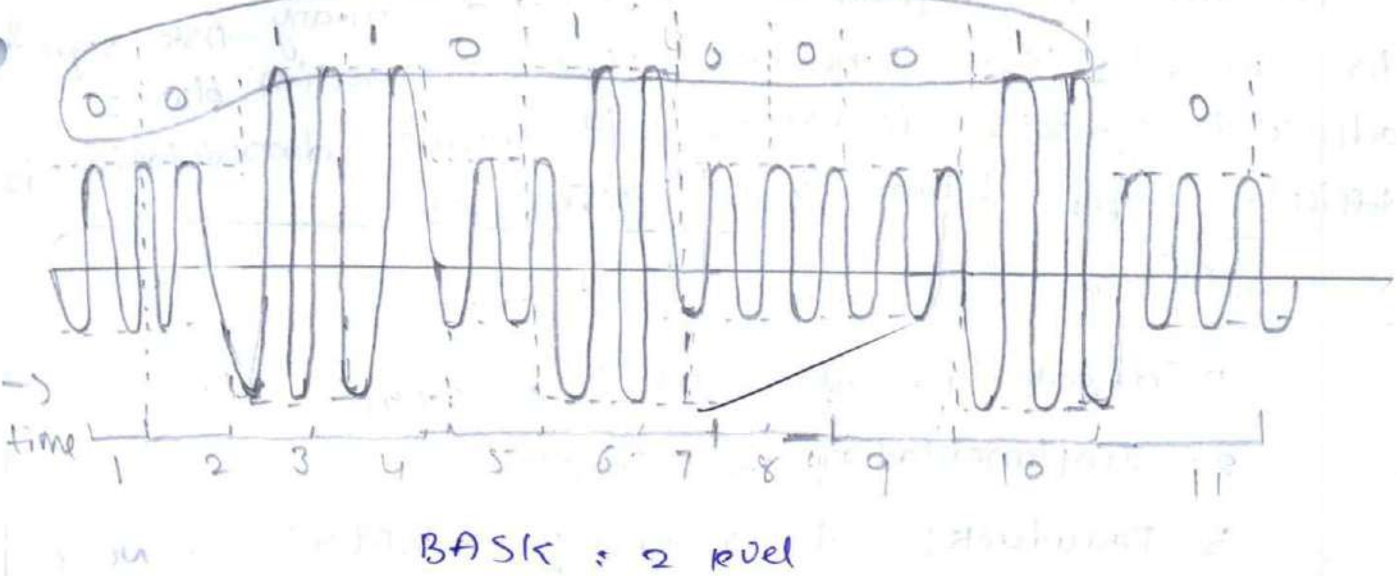
$s_1(t) = -3\cos(2\pi f_c t)$; $s_2(t) = -\cos(2\pi f_c t)$

$s_3(t) = \cos(2\pi f_c t)$; $s_4(t) = 3\cos(2\pi f_c t)$

sub $A_i = -3, -1, 1, 3$ in (1)

w.k.T in BASK, 2 level

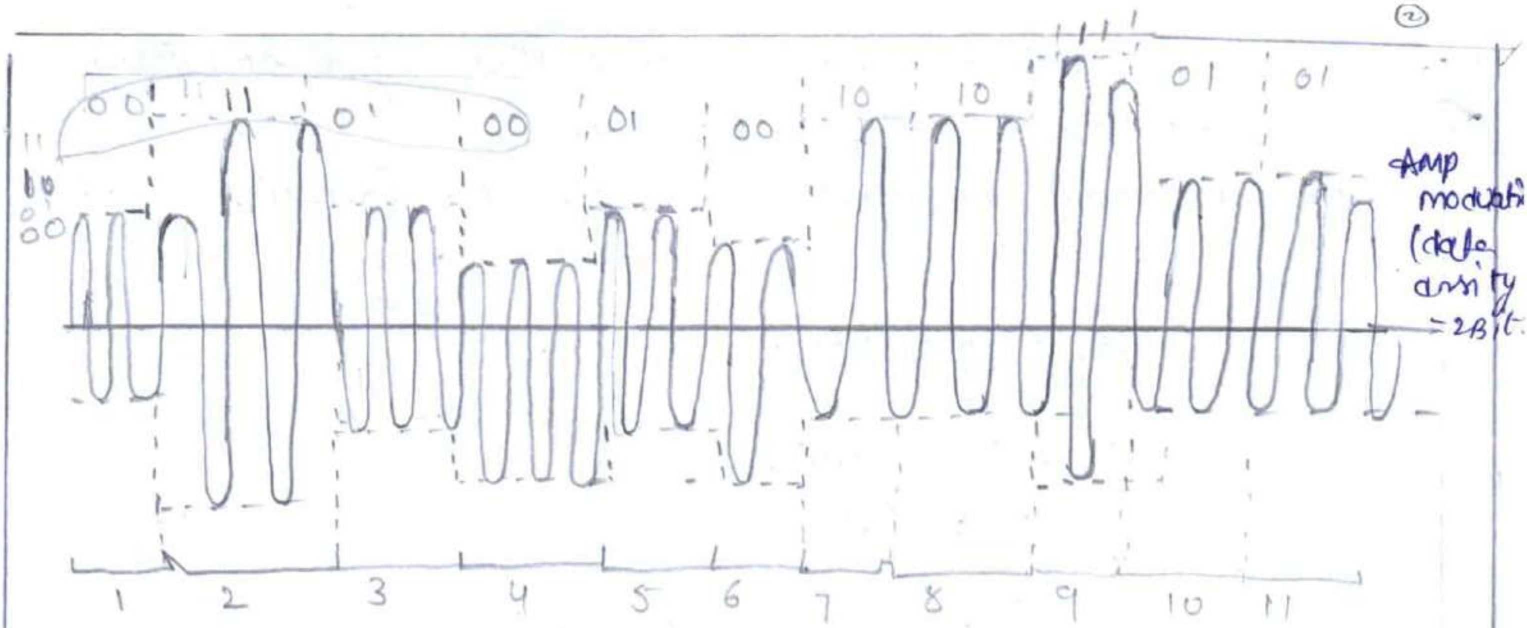
1 Bit in '1' symbol duration



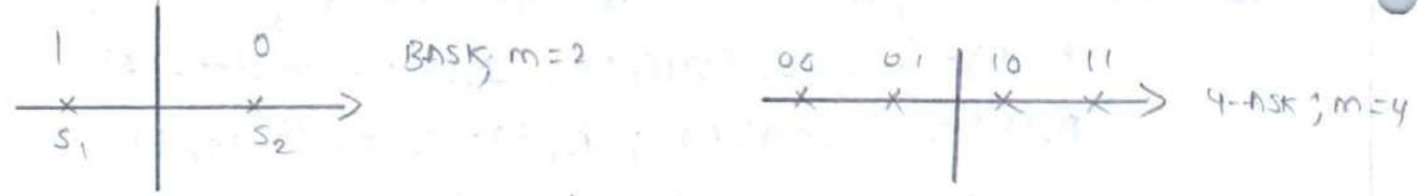
BASK : 2 level

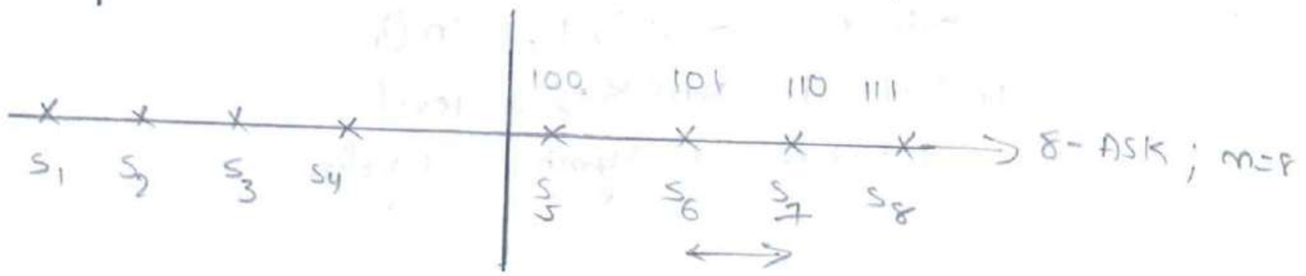
more time is

Required to transmit 10 Bits $t = 10$ sec



Two bits are combined for '1' symbol levels are divided as 4 levels to t = 5 sec for bits transmission





constallation digram of BASK and m-ary ASK signal. As no.of levels increases the separation b/w 2 adjacent symbols decreases it means demodulation is difficult for higher level techniques

— Applications

1. m-ary is also used in PAM
2. Implementation is simple
3. Drawback :- It is easily suseptable to Noise

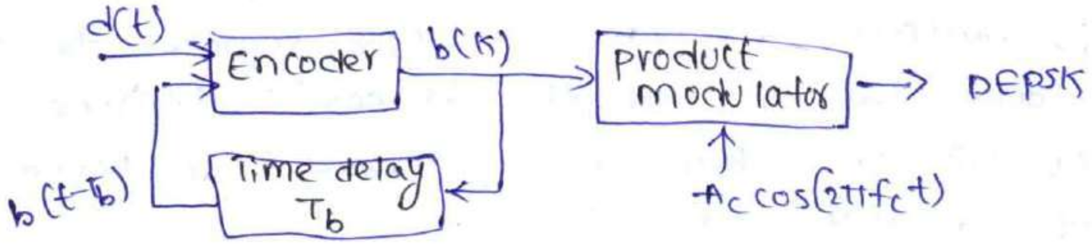
(2) With a neat sketch analyzer Differentially Encoder phase shift keying (DEPSK)

A. DEPSK is a non-cohrent modulation Technique

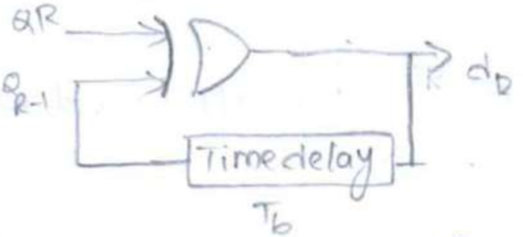
Differential :- procedure of encoding the data differentially, in the receiver, previously received Bits are used to detect the present bits

=) There is no need of synchronization

Transmitter part



$$b(t) = d(t) \oplus b(t - T_b)$$



0	0	0
0	1	1
1	0	1
1	1	0

next Bit = 0 Nochange
next Bit = 1 change

(1) The eliminate the need for phase synchronization of cohrent Receiver with PSK, a differential encoding system can be used with PSK

(2) The digital information content of the Binary data is encoded in terms of signal transistions

Ex: The symbol '0' may be used to represent transistion in a given binary sequence and symbol '1' to indicate no transistion

(3) This " new signaling Technique" which combines "differentially encoding with psk" is known as "DEPSK"!

→ The data stream b(t) is applied to the i/p of the encoder The o/p of encoder is applied to one i/p of the produce modulator. other i/p is sinusoidal carrier of fixed amplitude & frequency

(4) Now from this received signal a carrier is separated Because this is cohrent detection

square law device ÷ The received signal is pass through a square law device and the o/p of this device is $\cos^2(2\pi f_c t+\theta)$

Amplitude = neglected

$$\text{w.k.T} = \cos^2\theta = \frac{1+\cos 2\theta}{2}$$

$$\cos^2(2\pi f_c t+\theta) = \frac{1+\cos(2\pi f_c t+\theta)}{2}$$

$$= \frac{1}{2}+\frac{1}{2}\cos(2\pi f_c t+\theta) \quad \text{—} (1)$$

where $1/2$ is DC Level

(5) This signal is passed through a Band pass filter whose pass Band is centred around $2f_c$. BPF removes the DC level of $1/2$ and the o/p of BPF is $\cos(2\pi f_c t+\theta)$. Now the signal freq of o/p of BPF is $2f_c$. Now it is passed through a freq divided by two

(6) The o/p of frequency divider we get carrier signal whose freq is f_c i.e; $\cos(2\pi f_c t+\theta)$

(7) The synchronous demodulator multiplies the i/p signal whose and the recovered carrier

The o/p of multiplier

$$b(t)\sqrt{2P}\cos(2\pi f_c t+\theta)\times\cos(2\pi f_c t+\theta) = b(t)\cos^2(2\pi f_c t+\theta)\sqrt{2P}$$

$$= b(t)\sqrt{2P}\times\frac{1}{2}\left[1+\cos 2(2\pi f_c t+\theta)\right]$$

$$= b(t)\sqrt{P/2}\left[1+\cos 2(2\pi f_c t+\theta)\right] \quad \text{—} (2)$$

Integrator ÷ It integrates the signal over one Bit period $\int_0^{T_b}$

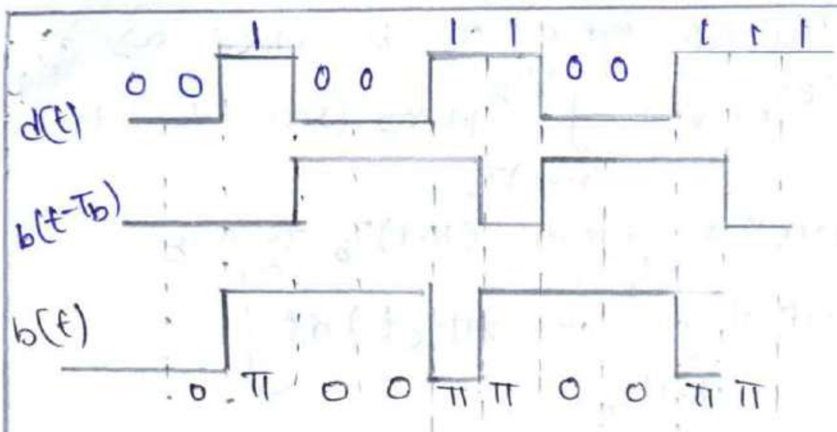
Bit synchronizer ÷ It takes case of starting and ending times of a bit; at the end of time bit duration T_b, the Bit synchronizer close switch

let $b(t)=0$ assume initially

$b(t-T_b)$ is delayed version of $b(t)$

phase shift at the carrier signal (observe $d(t)$)

$d(t)=1 \rightarrow$ phase shift $d(t)=0 \rightarrow$ No phase shift



Reception part

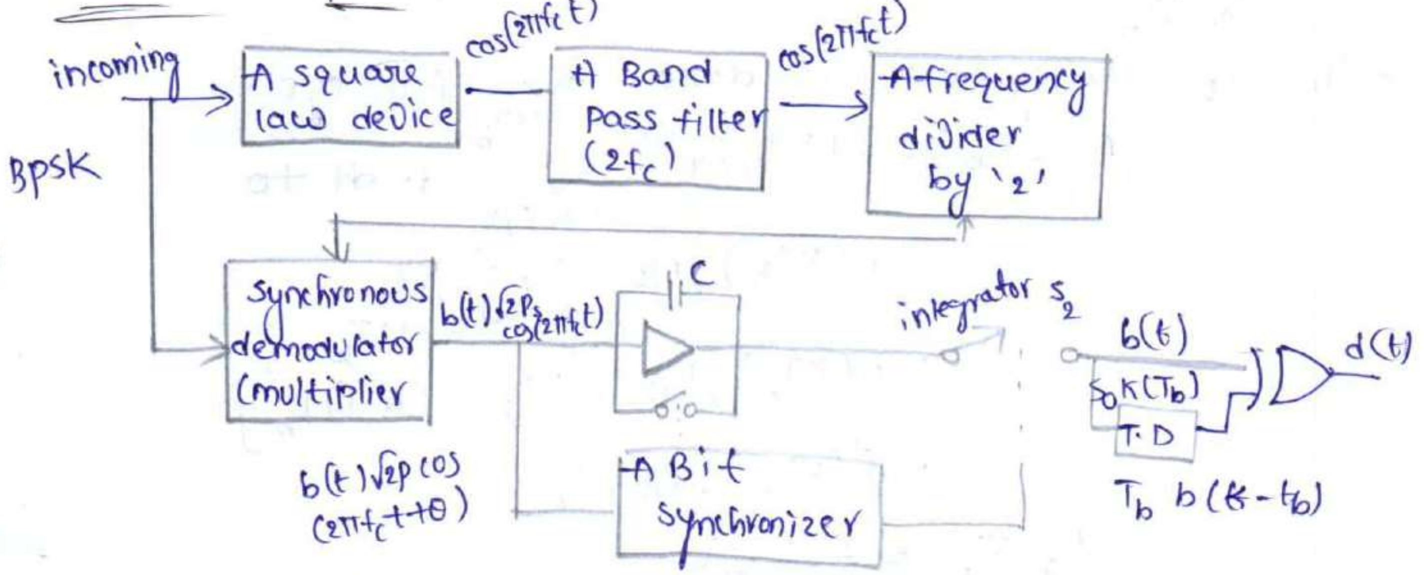


fig:- Receiver part of DEPSK

1. The transmitted BPSK signal is given as

$$s(t) = b(t)\sqrt{2p}\cos(2\pi f_c t)$$

2. The signal undergoes the phase change depending upon the Time delay from Transmitter end to Receiver and it is usually a phase shift in Transmitted signal

3. Let phase shift $= \theta$

The signal at the i/p of the receiver is

$$s(t) = b(t)\sqrt{2p}\cos(2\pi f_c t+\theta)$$

s_2 temporarily

=) This connects the o/p ~~of an~~ integrator to the Decision device. The synchronizer then opens switch s_2 & S_1 is closed temporarily

=) This Resets the integrator voltage to zero. The integrator then integrates next Bit.

Let T_b = one Bit period

The phase change occurs in the carrier only at zero crossing

⇒ At k^{th} bit interval, the o/p signal can be written as

$$s_0(kT_b) = b(kT_b)\sqrt{P/2}\int_{(k-1)T_b}^{kT_b} 1+\cos(2\pi f_c t+\theta)\,dt$$

The integration is performed from $(k-1)T_b$ to kT_b

$$= b(kT_b)\sqrt{P/2}\left[\int_{(k-1)T_b}^{kT_b} 1\cdot dt + \int_{(k-1)T_b}^{kT_b}\cos(2\pi f_c t)\,dt\right]$$

where $\int_{(k-1)T_b}^{kT_b}\cos(2\pi f_c t+\theta)\,dt = 0$; since avg of sinusoidal w/f is 'b' if integration is done over full cycle

$$s_0(kT_b) = b(kT_b)\sqrt{P/2}\int_{(k-1)T_b}^{kT_b} 1\cdot dt + 0$$

$$= b(kT_b)\sqrt{P/2}\,\left[t\right]_{(k-1)T_b}^{kT_b}$$

$$= b(kT_b)\sqrt{P/2}\,\left[kT_b-(k-1)T_b\right]$$

$$= b(kT_b)\sqrt{P/2}\cdot T_b$$

$$s_0(kT_b) \propto b(kT_b)$$

⇒ Depending upon the value of $b(kT_b)$. The o/p of $s_0(kT_b)$ is generated in the receiver

⇒ Finally this signal is applied to decision device which decides whether the transmitted symbol was '0' (or) 'one'

Advantages of DEPSK

- The DEPSK eliminates the probability of error occurance

Disadvantages of DEPSK

- The disadvantage of DEPSK it requires synchronization modulation

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ESTD : 2008

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DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

COURSE: **CloudComputing**	DEGREE: **B.Tech**
COURSE CODE: R194105G	YEAR: **IV** SEMESTER: **I**
REGULATION: **R19**	COURSE TYPE: **REGULAR**
ACADEMIC YEAR: **2022-2023**	CREDITS: **3**

Teaching/Instructional Plan

S.No	Topic(s)	No. of Hours	Reference Book	Teaching Methodology
	UNIT-I : Introduction			
1	Network centric computing, Network centric content	1	T1	Chalk & talk
2	peer-to -peer systems architecture	1	T1	Chalk & talk
3	cloud computing delivery models and services	2	T1	PPT1
4	Ethical issues, Vulnerabilities	1	T1	Chalk & talk
5	Major challenges for cloud computing	1	T1	Chalk & talk
6	Parallel and Distributed Systems introduction	1	T1	Chalk & talk
7	Architecture of Parallel Systems	1	T1	Chalk & talk
8	Communication protocols	1	T1	Chalk & talk
9	Logical clocks,Message delivery rules	1	T1	Assignment
10	Concurrency,and model concurrency with Petri Nets.	1	T1	Chalk & talk
		10		
	UNIT-II : : Cloud Infrastructure			
11	Cloud Infrastructure At Amazon	1	T1	Chalk & talk
12	The Google Perspective,	1	T1	Chalk & talk
13	Microsoft Windows Azure,	1	T1	Chalk & talk
14	Open Source Software Platforms,	1	T1	Chalk & talk
15	Cloud storage diversity, Inter cloud,	1	T1	Chalk & talk
16	energy use and ecological impact, responsibility sharing,	1	T1	Chalk & talk
17	Software licensing	1	T1	Chalk & talk
18	Challenges for cloud,	1	T1	Chalk & talk
19	existing cloud applications and new opportunities	1	T1	Chalk & talk

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20	architectural styles, workflows	1	T1	Chalk & talk
21	The Zookeeper, HPC on cloud	1	T1	Chalk & talk
		11		
	UNIT III: Cloud Resource virtualization			
22	Virtualization and layering	1	T1	Chalk & talk
23	virtual machine monitors, virtual machines	1	T1	Chalk & talk
24	virtualization- full and para, performance	1	T1	Chalk & talk
25	security isolation, hardware support for virtualization	1	T1	Chalk & talk
26	Case Study: Xen, vBlades Policies and Mechanisms	1	T1	Chalk & talk
27	Applications of control theory to task scheduling	1	T1	Chalk & talk
28	Stability of a two-level resource allocation architecture	1	T1	Chalk & talk
29	feedback control based on dynamic thresholds	1	T1	Chalk & talk
30	coordination, resource bundling, scheduling algorithms	1	T1	Chalk & talk
31	fair queuing, start time fair queuing, ,	1	T1	Chalk & talk
32	cloud scheduling subject to deadlines	1	T1	Chalk & talk
33	Scheduling Map Reduce applications	1	T1	Chalk & talk
34	Resource management and dynamic application scaling	1	T1	Seminar
		13		
	UNIT-IV: Storage Systems			
35	Evolution of storage technology, storage models, file systems,	1	T1	Chalk & talk
36	database, distributed file systems,	1	T1	Chalk & talk
37	general parallel file systems.	1	T1	Chalk & talk
38	Apache Hadoop file system	1	T1	Chalk & talk
39	Amazon Simple Storage Service(S3)	1	T2	Chalk & talk
40	Google file systemBig Table, Megastore	1	T1	Chalk & talk

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41	Cloud security risks, security – a top concern for cloud users,	1	T1	Chalk & talk
42	privacy and privacy impact assessment	1	T1	Chalk & talk
43	*trust, OS security,*	1	T1	Seminar
44	Virtual machine security, Security risks.	1	T1	Chalk & talk
		10		
	UNIT V:Cloud Application Development			
45	**Amazon Web Services : EC2 – instances**	1	T1	PPT
46	connecting clients, security rules, launching, usage of S3 in Java,	1	T1	PPT
47	Cloud based simulation of a Distributed trust algorithm,	1	T1	Chalk & talk
48	Cloud service for adaptive data streaming	1	T1	Chalk & talk
49	Google: Google App Engine,	1	T2	Chalk & talk
50	Google Web Toolkit	1	T2	Chalk & talk
51	**Azure Services Platform, Windows live, Exchange Online**	1	T2	Chalk & talk
52	SharePoint Services,Dynamics CRM (Text Book 2)	1	T2	Chalk & talk
		8		
TOTAL NO.OF CLASSES =10+11+13+10+8=52				

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TEXT BOOKS:

T1	Cloud Computing, Theory and Practice,1st Edition, Dan C Marinescu, MK Elsevier publisher ,2013
T2	Cloud Computing, A Practical Approach, 1st Edition, Anthony T Velte, Toby J Velte, Robert Elsenpeter, TMH,2017

REFERENCE BOOKS:

R1	Mastering Cloud Computing, Foundations and Application Programming,1st Edition, Raj Kumar Buyya, Christen vecctiola, S Tammarai selvi, TMH,2013
R2	Essential of Cloud Computing, 1st Edition, K Chandrasekharan, CRC Press, 2014.
R3	Cloud Computing, A Hands on Approach, Arshdeep Bahga, Vijay Madisetti, Universities Press, 2014.

WebReferences:

https://www.javatpoint.com/cloud-computing-tutorial
https://aws.amazon.com/getting-started/
https://www.techtarget.com/searchcloudcomputing/definition/Windows-Azure
https://www.jigsawacademy.com/blogs/cloud-computing/open-source-cloud-software

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Instructional Methods and Pedagogies

The following methods are some of the appropriate and efficient methodologies according to the characteristic of the learner.

S.No.	INSTRUCTIONALMETHODOLOGY	YES/NO
1.	Chalk & Talk	YES
2	PPT	YES
3	NPTEL Videos	
4	Guest Lectures & Workshops	
5	Learning from Industrial visits	
6	Student centric Learning:	
	i. Seminar Method	YES
	ii. Group discussions	YES
	iii. Assignment	YES
	iv. Quiz	YES
	v. Learning from Industrial visits	
	vi. Brain Storming	
	vii. Minutes of paper	YES
	viii. Puzzles	YES
	ix. TPS(Think Pair Share)	YES

Course Instructor:

Program Coordinator

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COURSE CODE: R194105G	YEAR: **IV** SEMESTER: **I**
REGULATION: **R19**	COURSE TYPE: **REGULAR**
ACADEMIC YEAR: **2022-2023**	CREDITS: **3**

COURSE OBJECTIVES & OUTCOMES

COURSE OBJECTIVE:

Students will demonstrate a mastery of the course materials and concepts within in class discussions

1	The Ability to Implement Task Scheduling Algorithms in Cloud.
2	The Ability To implement Virtualization mechanisam
3	Apply Map-Reduce concept to applications
4	Familiar with Private and Public and Hybrid and Community Clouds .
5	Broadly educate to know the impact of engineering on legal and societal issues involved.

COURSE OUTCOME:

By the end of the course student will be able to:

CO.NO	Description
C405.1	Ability To Understand Various Service Delivery Models And Parallel&Distributed Computing.
C405.2	Analyze The Economics, Financial, And Technological Implications For Selecting Cloud Computing For Own Organization .
C405.3	Implement Different Types Of Virtualization Technologies For Data-Center Automation.
C405.4	Analyze Various Scheduling Algorithms For Resource Management And Identify Security Implications In Cloud Computing
C405.5	Illustrate The Fundamental Concepts Of Cloud Storage And Demonstrate Their Use In Storage Systems Such As S3 ,HDFS,Megastore,Bigtable.
C405.6	Choose Among Various Cloud Technologies For Implementing Applications

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Guntur-522017, Andhra Pradesh, India

Department of Computer Science and Engineering

INSTITUTE VISION AND MISSION

Vision:

To be a pioneer institute in engineering education, fostering academic excellence, and producing empowered women engineers, blended with ethics and values, to serve the society.

Mission:

M1	To achieve academic excellence through innovative teaching-learning practices.
M2	To inculcate self-discipline, ethics and values amongst the learners.
M3	To bridge the gap between industry and academia through the industry-institute interface.
M4	To promote higher education, research and inculcate entrepreneurial attitude amongst the learners.

DEPARTMENT VISION AND MISSION

Vision:

To emerge as the center of quality education in Computer Science and Engineering by promoting competent and woman engineers with ethical values to serve the society.

Mission:

M1	To impart quality education through innovative teaching and learning methods.
M2	To inculcate ethical and social values among the students for improving their life skills.
M3	To facilitate knowledge on updating technologies to meet industry requirements.
M4	To prepare students for software development, higher education entrepreneurship and lifelong learning careers.

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Pulladigunta (Village), Vatticherukuru (Mandal),

Guntur-522017, Andhra Pradesh, India

Department of Computer Science and Engineering

PROGRAM OUTCOMES (POs) PRESCRIBED BY NBA:

PO No	Description
PO1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of Mathematics, Natural Sciences, And Engineering Sciences
PO3	**Design&development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations
PO4	**Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5	**Modern tools usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.
PO6	**The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply the set one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO12	**Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

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COURSE SYLLABUS INCLUDING COURSE STRUCTURE

IV Year –I Semester		L	T	P	C
		3	0	0	3
CLOUD COMPUTING					

UNIT I

Introduction: Network centric computing, Network centric content, peer-to –peer systems, cloud computing delivery models and services, Ethical issues, Vulnerabilities, Major challenges for cloud computing. Parallel and Distributed Systems: introduction, architecture, distributed systems, communication protocols, logical clocks, message delivery rules, concurrency, and model concurrency with Petri Nets.

UNIT II

Cloud Infrastructure: At Amazon, The Google Perspective, Microsoft Windows Azure, Open Source Software Platforms, Cloud storage diversity, Inter cloud, energy use and ecological impact, responsibility sharing, user experience, Software licensing, Cloud Computing : Applications and Paradigms: Challenges for cloud, existing cloud applications and new opportunities, architectural styles, workflows, The Zookeeper, HPC on cloud.

UNIT III

Cloud Resource virtualization: Virtualization, layering and virtualization, virtual machine monitors, virtual machines, virtualization- full and para, performance and security isolation, hardware support for virtualization, Case Study: Xen, vBlades, Cloud Resource Management and Scheduling: Policies and Mechanisms, Applications of control theory to task scheduling, Stability of a two-level resource allocation architecture, feedback control based on dynamic thresholds, coordination, resource bundling, scheduling algorithms, fair queuing, start time fair queuing, cloud scheduling subject to deadlines, Scheduling Map Reduce applications, Resource management and dynamic application scaling.

UNIT IV

Storage Systems: Evolution of storage technology, storage models, file systems and database, distributed file systems, general parallel file systems. Google file system. Apache Hadoop, Big Table, Megastore (text book 1), Amazon Simple Storage Service(S3) (Text book 2), Cloud Security: Cloud security risks, security – a top concern for cloud users, privacy and privacy impact assessment, trust, OS security, Virtual machine security, Security risks.

UNIT V

Cloud Application Development: Amazon Web Services : EC2 – instances, connecting clients, security rules, launching, usage of S3 in Java, Cloud based simulation of a Distributed trust algorithm, Cloud service for adaptive data streaming (Text Book 1), Google: Google App Engine, Google Web Toolkit (Text Book 2), Microsoft: Azure Services Platform, Windows live, Exchange Online, Share Point Services, Microsoft Dynamics CRM (Text Book 2)

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Text Books:

1) Cloud Computing, Theory and Practice,1st Edition, Dan C Marinescu, MK Elsevier publisher ,2013
2) Cloud Computing, A Practical Approach, 1st Edition, Anthony T Velte, Toby J Velte, Robert Elsenpeter, TMH,2017

Reference Books:

1) Mastering Cloud Computing, Foundations and Application Programming,1st Edition, Raj Kumar Buyya, Christen vecctiola, S Tammarai selvi, TMH,2013
2) Essential of Cloud Computing, 1st Edition, K Chandrasekharan, CRC Press, 2014.
3) Cloud Computing, A Hands on Approach, Arshdeep Bahga, Vijay Madisetti, Universities Press, 2014.

CourseStructure

IV Year – I SEMESTER(R19)

S.No	Course Code	Courses	L	T	P	Credits
1	CS4101	Cryptography and Network Security	3	0	0	3
2	CS4102	UML & Design Patterns	3	0	0	3
3	CS4103	Machine Learning	3	0	0	3
4	OE4101	**Open Elective -II** (Inter Disciplinary)	3	0	0	3
5	PE4101	**Professional Elective- III** 1. Mobile Computing 2. Data Science 3. NoSQL Databases 4. Internet of Things 5. Software Project Management	3	0	0	3
6	PE4102	**Professional Elective- IV** 1. Web Services 2. Cloud Computing 3. Mean Stack Technologies 4. Ad-hoc and Sensor Networks 5. Cyber Security & Forensics	3	0	0	3
7	CS4104	UML Lab #	0	0	2	1
8	PR4101	Project- I	0	0	0	2
9	MC4101	IPR & Patents	3	0	0	0
		Total	21	0	2	21

Relevant theory to be taught in the lab

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DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

COURSE: **CloudComputing**	DEGREE: **B.Tech**
COURSE CODE: R194105G	YEAR: **IV** SEMESTER: **I**
REGULATION: **R19**	COURSE TYPE: **REGULAR**
ACADEMIC YEAR: **2022-2023**	CREDITS: **3**

COURSE OBJECTIVES & OUTCOMES

COURSE OBJECTIVE:

Students will demonstrate a mastery of the course materials and concepts within in class discussions

1	The Ability to Implement Task Scheduling Algorithms in Cloud.
2	The Ability To implement Virtualization mechanisam
3	Apply Map-Reduce concept to applications
4	Familiar with Private and Public and Hybrid and Community Clouds .
5	. Broadly educate to know the impact of engineering on legal and societal issues involved.

COURSE OUTCOME:

By the end of the course student will be able to:

CO.NO	Description
C405.1	Ability To Understand Various Service Delivery Models And Parallel&Distributed Computing.
C405.2	Analyze The Economics, Financial, And Technological Implications For Selecting Cloud Computing For Own Organization .
C405.3	Implement Different Types Of Virtualization Technologies For Data-Center Automation.
C405.4	Analyze Various Scheduling Algorithms For Resource Management And Identify Security Implications In Cloud Computing
C405.5	Illustrate The Fundamental Concepts Of Cloud Storage And Demonstrate Their Use In Storage Systems Such As S3 ,HDFS,Megastore,Bigtable.
C405.6	Choose Among Various Cloud Technologies For Implementing Applications

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Course Instructor

HOD

Program Coordinator

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COURSE OUTCOMES WITH PO & PSO MAPPING

COURSE:CloudComputing	DEGREE: **B.Tech**
COURSE CODE: R194105G	YEAR: **IV** SEMESTER: **I**
REGULATION: **R19**	COURSE TYPE: **REGULAR**
ACADEMIC YEAR : **2022-2023**	CREDITS: **3**

By the end of the course student will be able to:

CO No.	Course Outcome Statement	Taxonomy Level
C405.1	Ability To Understand Various Service Delivery Models And Parallel&Distributed Computing.	**2(Understand)**
C405.2	Analyze The Economics, Financial, And Technological Implications For Selecting Cloud Computing For Own Organization .	**4 (Analyze)**
C405.3	Implement Different Types Of Virtualization Technologies For Data-Center Automation.	**3(Apply)**
C405.4	Analyze Various Scheduling Algorithms For Resource Management And Identify Security Implications In Cloud Computing	**4(Analyze)**
C405.5	Illustrate The Fundamental Concepts Of Cloud Storage And Demonstrate Their Use In Storage Systems Such As S3 ,HDFS,Megastore,Bigtable.	**3(Apply)**
C405.6	Choose Among Various Cloud Technologies For Implementing Applications	**3(Apply)**

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CO: PO and PSO Mapping

Mapping of Course Outcomes with Program Outcomes:

Strong -3 Moderate -2 Slight -1

PO / CO	CC	2022-2023	3	0	0	3	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
C405.1	Ability To Understand Various Service Delivery Models And Parallel&Distributed Computing.						3	-	-	-	-									
C405.2	Analyze The Economics, Financial, And Technological Implications For Selecting Cloud Computing For Own Organization .						2	2	3	1	-									2
C405.3	Implement Different Types Of Virtualization Technologies For Data-Center Automation.						2	2	3	2	-									3
C405.4	Analyze Various Scheduling Algorithms For Resource Management And Identify Security Implications In Cloud Computing						2	2	3	3	-									3
C405.5	Illustrate The Fundamental Concepts Of Cloud Storage And Demonstrate Their Use In Storage Systems Such As S3 ,HDFS,Megastore,Bigtable.						3	2	2		-									3
C405.6	Choose Among Various Cloud Technologies For Implementing Applications						3	2	2	2	-									
TOTAL							15	10	13	8	-									11
No of Co's Mapping with Po/Pso							6	5	5	4										4
Average							2.5	2	2.6	2										2.75

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Directorate of Academic Planning

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY KAKINADA
KAKINADA-533003, Andhra Pradesh, INDIA
(Established by AP Government Act No. 30 of 2008)

Lr. No. DAP/AC/IV Year /B. Tech/B. Pharmacy/2022 *Date 25.06.2022*

Dr. KVSG Murali Krishna,
M.E. Ph.D.,
Director, Academic Planning
JNTUK, Kakinada

To
All the Principals of Affiliated Colleges,
JNTUK, Kakinada.

Academic Calendar for IV Year - B. Tech/B. Pharmacy for the AY 2022-23

I SEMESTER			
Description	**From**	**To**	**Weeks**
Commencement of Class Work	**04.07.2022**		
I Unit of Instruction	04.07.2022	27.08.2022	8W
I Mid Examinations	29.08.2022	03.09.2022	1W
II Unit of Instructions	05.09.2022	29.10.2022	8W
II Mid Examinations	31.10.2022	05.11.2022	1W
Preparation & Practicals	07.11.2022	12.11.2022	1W
End Examinations	14.11.2022	26.11.2022	2W
Commencement of II Semester Class Work	**05.12.2022**		
II SEMESTER			
I Unit of Instructions	**05.12.2022**	28.01.2023	8W
I Mid Examinations	30.01.2023	04.01.2023	1W
II Unit of Instructions	06.01.2023	01.04.2023	8W
II Mid Examinations	03.04.2023	08.04.2023	1W
Preparation & Practicals	10.04.2023	15.04.2023	1W
End Examinations	17.04.2023	29.04.2023	2W

KVSG 25/6/22
Director,
Academics & Planning,
JNTUK

Director
Academic Planning
JNTUK Kakinada

Copy to the Secretary to the Hon'ble Vice Chancellor, JNTUK
Copy to Rector, Registrar, JNTUK
Copy to Director Academic Audit, JNTUK
Copy to Director of Evaluation, JNTUK

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DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

COURSE: **CloudComputing**	DEGREE: **B.Tech**
COURSE CODE: **R194105G**	YEAR: **IV** SEMESTER: **I**
REGULATION: **R19**	COURSE TYPE: **REGULAR**
ACADEMIC YEAR: **2022-2023**	CREDITS: **3**

LESSON PLAN FOR TUTORIAL CLASSES

T.No	Name of the Topic	Teaching Aid	Books
1	Explain the Cloudcomputing delivery Models? Define Logical Clocks?	Chalk & Talk	T1
2	Explain Architecture of Parallel Systems? Define Communication Protocols?	Chalk & Talk	T1
3	Define Concurrency and Model Concurrency with Petri Nets? Ethical Issues of CloudComputing	Chalk & Talk	T1
4	Examine the Cloud Infrastructure at Amazon AWS?	Chalk & Talk	T2
5	Define The following terms. i)CloudStorage diversity ii)Intercloud iii)Challenges	Chalk & Talk	T1
6	Examine the Infrastructure of Microsoft Azure Explain OpenSource Software platforms?	Chalk & Talk	T1
7	Explain Zookeeper at amazon? Explain HPC(High Performance computing) on cloud?	Chalk & Talk	T2
8	What is Virtualization and explain Full and Para Virtualization Define the Terms i)VMM ii)VM	Chalk & Talk	T1
9	Case study on XEN? Explain Scheduling Algorithms?	Chalk & Talk	T1
10	Define the Following terms i)StorageModels ii)FileSystem iii)Databases	Chalk & Talk	T1

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11	Explain the Storage system of Amazon S3(Simple storage service) Explain the Storage system of Bigtable?	Chalk & Talk	T2
12	Explain the Storage system of ApacheHadoop?	Chalk & Talk	T1
13	Steps for create EC2 Instances and connecting clients through firewalls How to use S3 in java	Chalk & Talk	T2
14	Explain Microsoft Cloud services i)Microsoft Azure ii)Sharepoint services iii)Microsoft CRM iv)ExchangeOnline v)Windows Live	Chalk & Talk	T2
15	Explain the architecture of Google App engine ?	Chalk & Talk	T2

TEXT BOOKS:

T1	Cloud Computing, Theory and Practice,1st Edition, Dan C Marinescu, MK Elsevier publisher ,2013
T2	Cloud Computing, A Practical Approach, 1st Edition, Anthony T Velte, Toby J Velte, Robert Elsenpeter, TMH,2017

REFERENCE BOOKS:

R1	Mastering Cloud Computing, Foundations and Application Programming,1st Edition, Raj Kumar Buyya, Christen vecctiola, S Tammarai selvi, TMH,2013
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R3	Cloud Computing, A Hands on Approach, Arshdeep Bahga, Vijay Madisetti, Universities Press, 2014.

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Course Instructor:

Program Coordinator

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SUBJECT CODE: R194105G	YEAR: **IV** SEMESTER: **I**
REGULATION: **R19**	COURSE TYPE: **REGULAR**
ACADEMIC YEAR : **2022-2023**	CREDITS: **3**

TUTORIAL QUESTIONS

1.Explain the Cloudcomputing delivery Models?
2.Define Logical Clocks?

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TUTORIAL QUESTIONS

1.Explain Architecture of Parallel Systems?
2.Define Communication Protocols?

Course Instructor:

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TUTORIAL QUESTIONS

1.Define Concurrency and Model Concurrency with Petri Nets?
2.Ethical Issues of CloudComputing?

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TUTORIAL QUESTIONS

1.Examine the Cloud Infrastructure at Amazon AWS?

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TUTORIAL QUESTIONS

1.Define The following terms.
i)CloudStorage diversity
ii)Intercloud
iii)Challenges

Course Instructor:

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TUTORIAL QUESTIONS

1.Examine the Infrastructure of Microsoft Azure?
2.Explain OpenSource Software platforms?

Course Instructor:

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TUTORIAL QUESTIONS

1.Explain Zookeeper at amazon?
2.Explain HPC(High Performance computing) on cloud?

Course Instructor:

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TUTORIAL QUESTIONS

1.What is Virtualization and explain Full and Para Virtualization?
2.Define the Terms
i)VMM ii)VM

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TUTORIAL QUESTIONS

1.Case study on XEN?
2.Explain Scheduling Algorithms?

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TUTORIAL QUESTIONS

1.Define the Following terms
i)StorageModels
ii)FileSystem
iii)Databases

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Department of Computer Science & Engineering

Department Calendar Year: 2022-2023(Odd Semester)

Month	Activity	Activity dates
July	Date of Commencement of class work I unit Instructions for IV B.Tech	4-07-2022
July	Community Service Project for III B.Tech	15-7-2022 to 30-7-2022
August	Date of Commencement of class work I unit Instructions for III B.Tech	1-8-2022
August	Blood donation awareness Program	1-8-2022
August	Pre-Independence Celebrations	12-8-2022
August	Community Service Project for II B.Tech	22-8-2022 to 3-9-2022
August	Commencement of I mid Examination for IV B. Tech	29-8-2022 to 3-9-2022
September	Date of Commencement of class work I unit Instructions for II B.Tech	5-9-2022
September	Teacher's day	5-9-2022
September	Engineers day	15-9-2022
September	Commencement of I mid Examination for III B. Tech	26-9-2022 to 1-10-2022
October	A Three day workshop for II B.Tech on Django	25-10-2022 to 27-10-2022
October	Commencement of II mid Examination for IV B. Tech	31-10-2022 to 5-11-2022
November	Commencement of University Practical Examination	7-11-2022 to 12-11-2022
November	Culture club activities	12-112022
November	Commencement of University Theory End Examination	14-11-2022 to 26-11-2022
November	Literature club activities	19-112022
November	Fresher's Day	24-11-2022
November	Commencement of II mid Examination for III B. Tech	28-11-2022 to 3-12-2022
December	Commencement of University Practical Examination for III B.Tech	5-12-2022 to 10-12-2022
December	Commencement of University Theory End Examination for III B.Tech	12-12-2022 to 25-12-2022

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Department of Computer Science & Engineering

December	Commencement of II mid Examination for II B. Tech	19-12-2022 to 24-12-2022
December	Commencement of University Practical Examination for II B.Tech	26-12-2022 to 31-12-2022
January	Commencement of University Theory End Examination for II B.Tech	2-1-2023 to 14-1-2023

HOD

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DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

COURSE: **CloudComputing**	DEGREE: **B.Tech**
COURSE CODE: R194105G	YEAR: **IV** SEMESTER: **I**
REGULATION: **R19**	COURSE TYPE: **REGULAR**
ACADEMIC YEAR: **2022-2023**	CREDITS: **3**

Teaching/Instructional Plan

S.No	Topic(s)	No. of Hours	Reference Book	Teaching Methodology
	UNIT-I : Introduction			
1	Network centric computing, Network centric content	1	T1	Chalk & talk
2	peer-to –peer systems architecture	1	T1	Chalk & talk
3	cloud computing delivery models and services	2	T1	PPT1
4	Ethical issues, Vulnerabilities	1	T1	Chalk & talk
5	Major challenges for cloud computing	1	T1	Chalk & talk
6	Parallel and Distributed Systems introduction	1	T1	Chalk & talk
7	Architecture of Parallel Systems	1	T1	Chalk & talk
8	Communication protocols	1	T1	Chalk & talk
9	Logical clocks,Message delivery rules	1	T1	Assignment
10	Concurrency,and model concurrency with Petri Nets.	1	T1	Chalk & talk
		10		
	UNIT-II : : Cloud Infrastructure			
11	Cloud Infrastructure At Amazon	1	T1	Chalk & talk
12	The Google Perspective,	1	T1	Chalk & talk
13	Microsoft Windows Azure,	1	T1	Chalk & talk
14	Open Source Software Platforms,	1	T1	Chalk & talk
15	Cloud storage diversity, Inter cloud,	1	T1	Chalk & talk
16	energy use and ecological impact, responsibility sharing,	1	T1	Chalk & talk
17	Software licensing	1	T1	Chalk & talk
18	Challenges for cloud,	1	T1	Chalk & talk

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40	Google file systemBig Table, Megastore	1	T1	Chalk & talk
41	Cloud security risks, security – a top concern for cloud users,	1	T1	Chalk & talk
42	privacy and privacy impact assessment	1	T1	Chalk & talk
43	*trust, OS security,*	1	T1	Seminar
44	Virtual machine security, Security risks.	1	T1	Chalk & talk
		10		
	UNIT V: Cloud Application Development			
45	Amazon Web Services : EC2 – instances	1	T1	PPT
46	connecting clients, security rules, launching, usage of S3 in Java,	1	T1	PPT
47	Cloud based simulation of a Distributed trust algorithm,	1	T1	Chalk & talk
48	Cloud service for adaptive data streaming	1	T1	Chalk & talk
49	Google: Google App Engine,	1	T2	Chalk & talk
50	Google Web Toolkit	1	T2	Chalk & talk
51	Azure Services Platform, Windows live, Exchange Online	1	T2	Chalk & talk
52	SharePoint Services,Dynamics CRM (Text Book 2)	1	T2	Chalk & talk
		8		
TOTAL NO.OF CLASSES	=10+11+13+10+8=52			

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ASSIGNMENT-I

COURSE : CloudComputing	DEGREE: **B.Tech**
COURSE CODE: R194105G	YEAR: **IV** SEMESTER: **I**
REGULATION: **R19**	COURSE TYPE: **REGULAR**
ACADEMIC YEAR : **2022-2023**	CREDITS: **3**

Q.No.	QUESTION	Marks Allotted	Course Outcome mapping	Taxonomy level
1.	Explain Cloud Service Delivery Models.	5M	C405.1	Understand
2	Discuss AWS Storage Services In Detail	5M	C405.2	Analyze
3.	Apply Virualization in datacentertechniques in details	5M	C405.3	Apply

1.Explain Cloud Service Delivery Models?
Def:1M
Explanation:3M
DiagramRepresentation:1M

2. Discuss AWS Storage Services In Detail
Def:1M
Explanation:3M
Usage:1M

3. Apply Virualization in datacenter techniques in details
Def:1M
Explanation:3M
DiagramRepresentation:1M

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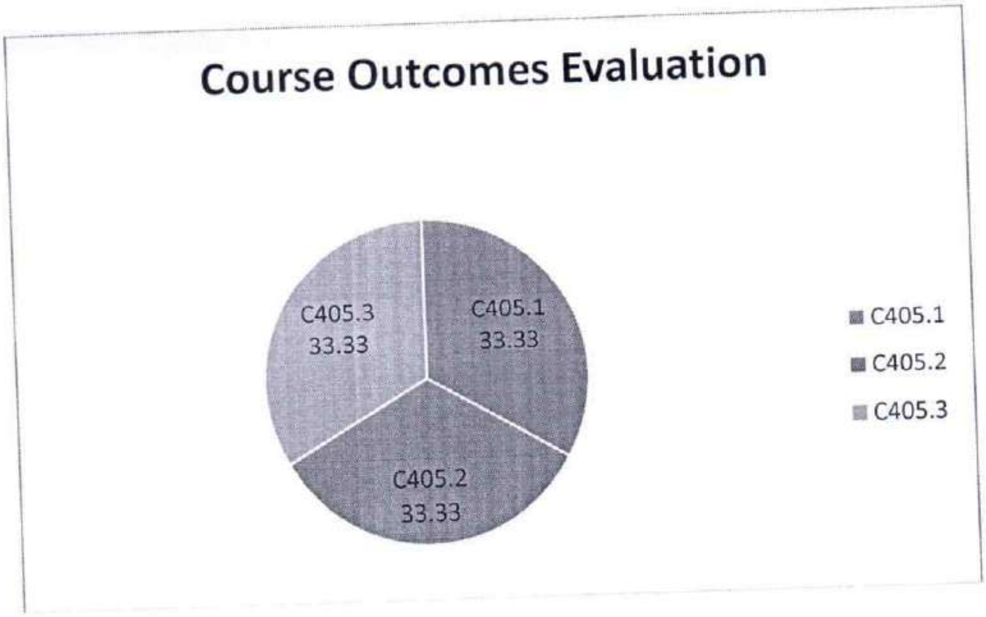
Course Outcomes& Bloom's TaxonomyEvaluation:

Course Outcome Number	Marks Allotted	Percentage of Marks
C405.1	5	33.33
C405.2	5	33.33
C405.3	5	33.33
Total Marks	15	100.00

Taxonomy level	Marks Allotted	Percentage of Marks
Remember		
Understand	5	100.00
Apply	5	100.00
Analyze	5	100.00
Evaluate		
Create		
Total Marks	15	100.00



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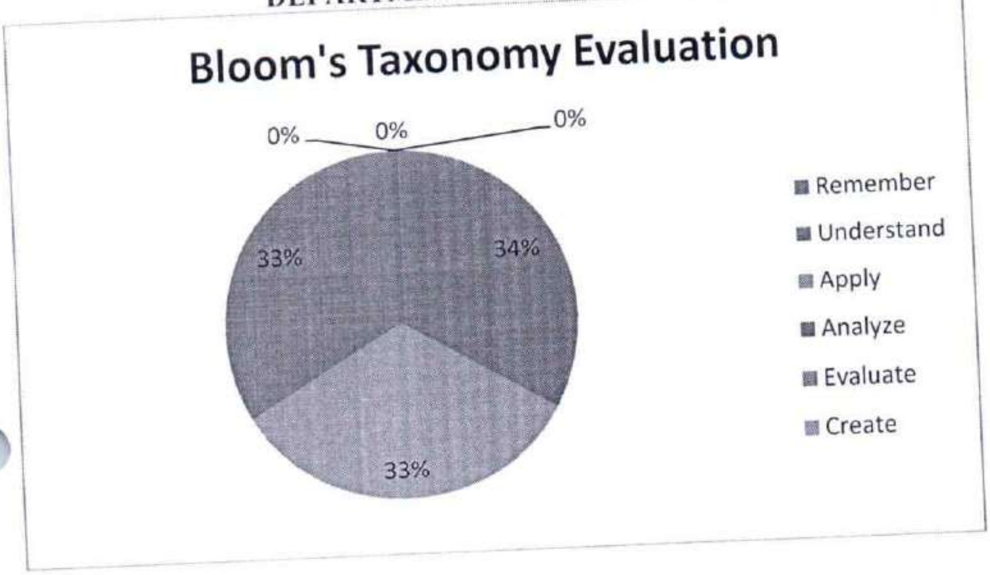

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ASSIGNMENT-II

COURSE : **CloudComputing**	DEGREE: **B.Tech**
COURSE CODE: **R194105G**	YEAR: **IV** SEMESTER: **I**
REGULATION: **R19**	COURSE TYPE: **REGULAR**
ACADEMIC YEAR : **2022-2023**	CREDITS: **3**

Q.No.	QUESTION	Marks Allotted	Course Outcome mapping	Taxonomy level
1.	Explain Two-Level Resource Allocation Architecture	2M	C405.4	Analyze
2	Define the scheduling algorithms i)fair queuing ii)short-time fair	3M	C405.4	Analyze
3.	Define Architecture of GoogleFileSystem	3M	C405.5	Apply
4.	Explain Apache Hadoop Storage System	2M	C405.5	Apply
5.	Steps for create and launching Ec2 instances.	5M	C405.6	Apply

1. Explain Two-Level Resource Allocation Architecture
   Explanation:1M
   Diagram:1M

2. Define the scheduling algorithms i)fair queuing ii)short-time fair
   Explanation:3M

3. Define Architecture of GoogleFileSystem
   Def:1
   Explanation:1M
   Digram:1M

4. Explain Apache Hadoop Storage System
   Explanation:1M
   Diagram:1M

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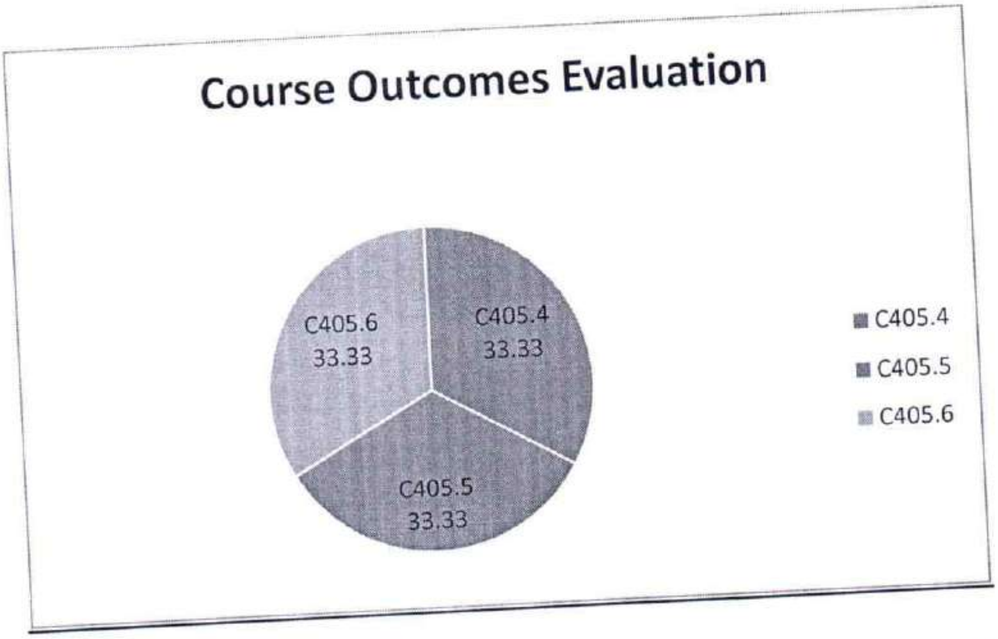
5. Steps for create and launching Ec2 instances.
   Procedure:3M
   Implementation:2M

Course Outcomes& Bloom's TaxonomyEvaluation

Course Outcome Number	Marks Allotted	Percentage of Marks
C405.4	5	33.33
C405.5	5	33.33
C405.6	5	33.33
Total Marks	15	100.00

Taxonomy level	Marks Allotted	Percentage of Marks
Remember		
Understand		
Apply	10	66.67
Analyze	5	33.33
Evaluate		
Create		
Total Marks	15	100.00



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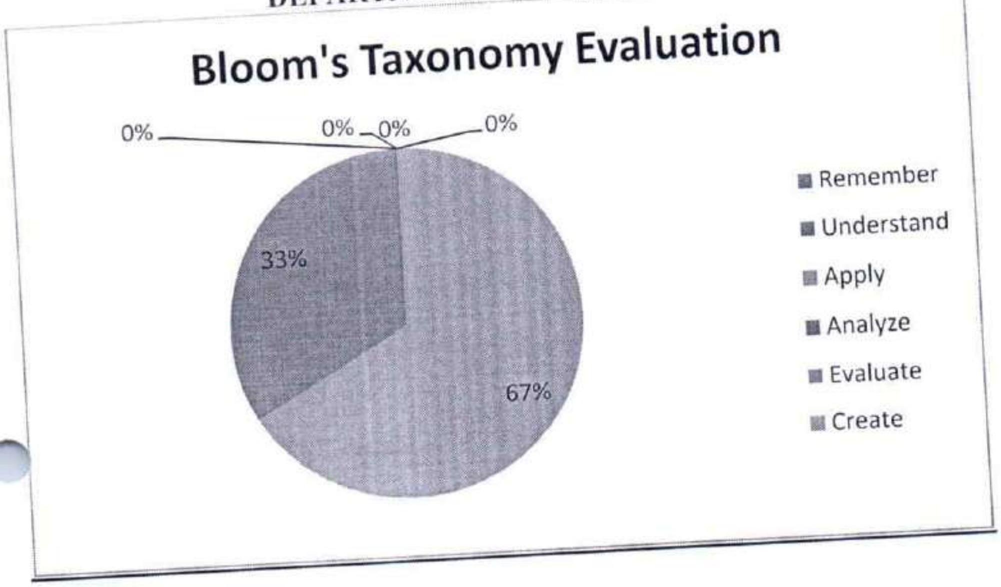

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DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

IV-BTECH I SEMESTER MID-I QUESTION PAPER

COURSE: CloudComputing **Date:09/09/2022**

Max. Marks: 10 **Time: 90 min**

Branches: CSE&IT (UNIVERSITY CODE: R194105G) **REG.NO:**

Answer all the questions

Q.N0			Marks
1(a)	Explain CloudComputing and its delivery models?	[BT:2] [Understand]	2M
1(b)	Explain the challenges for cloud computing?	[BT:2] [Understand]	1.5M
2(a)	Examine the Storage resources in AWS?	[BT:4][Analyze]	2M
2(b)	Classify the following terms i)Ec2 ii)SQS iii)CloudWatch	[BT:4][Analyze]	2M
3	Develop Virtualization in CloudComputing?	[BT:3][Apply]	2.5M

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SCHEME OF EVALUATION – MID-1 EXAMINATION

COURSE : CloudComputing	DEGREE: **B.Tech**
COURSE CODE: R194105G	YEAR: **IV** SEMESTER: **I**
REGULATION: **R19**	COURSE TYPE: **REGULAR**
ACADEMIC YEAR: **2022-2023**	CREDITS: **3**

Q.No.	Solution	Marks Allotted	Course Outcome mapping	Taxonomy level
1	a)Explain CloudComputing and its delivery models?	2M	C405.1	Understand
	b)Explain the challenges for cloud computing?	1.5M		
2	a)Examine the Storage resources in AWS?	2M	C405.2	Analyze
	b)Classify the following terms i)Ec2 ii)SQS iii)CloudWatch	2M		
3	Develop Virtualization in CloudComputing?	2.5M	C405.3	Apply

Course Outcome Number	Marks Allotted	Percentage of Marks
C405.1	3.5	35.00
C405.2	4	40.00
C405.3	2.5	33.33
Total Marks	10	100

Taxonomy level	Marks Allotted	Percentage of Marks
Remember	0	0.00
Understand	3.5	35.00
Apply	2.5	25.00
Analyze	4	40.00
Evaluate	0	0.00
Create	0	0.00
Total Marks	10	100

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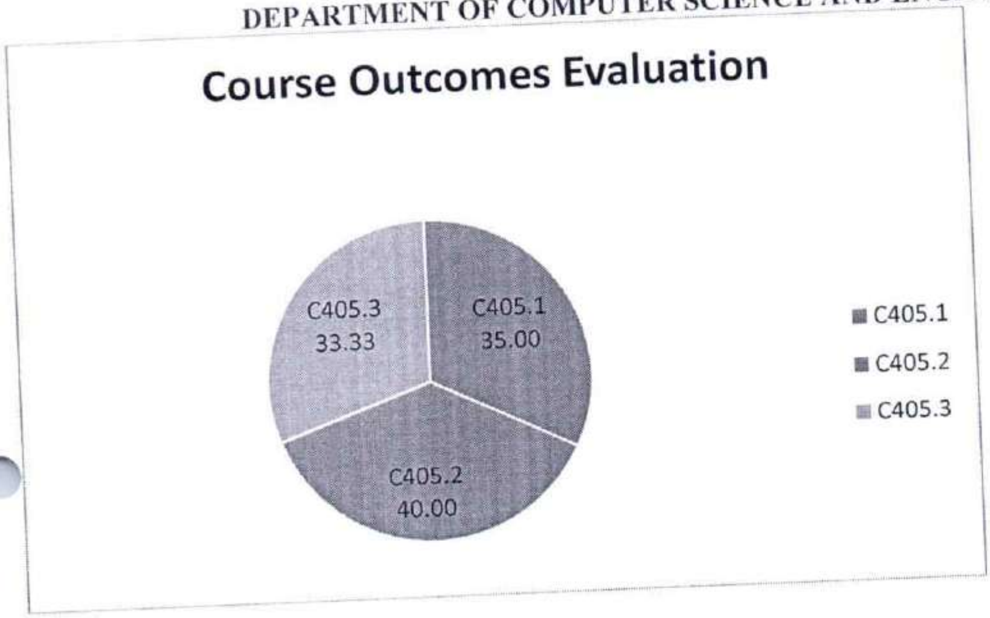

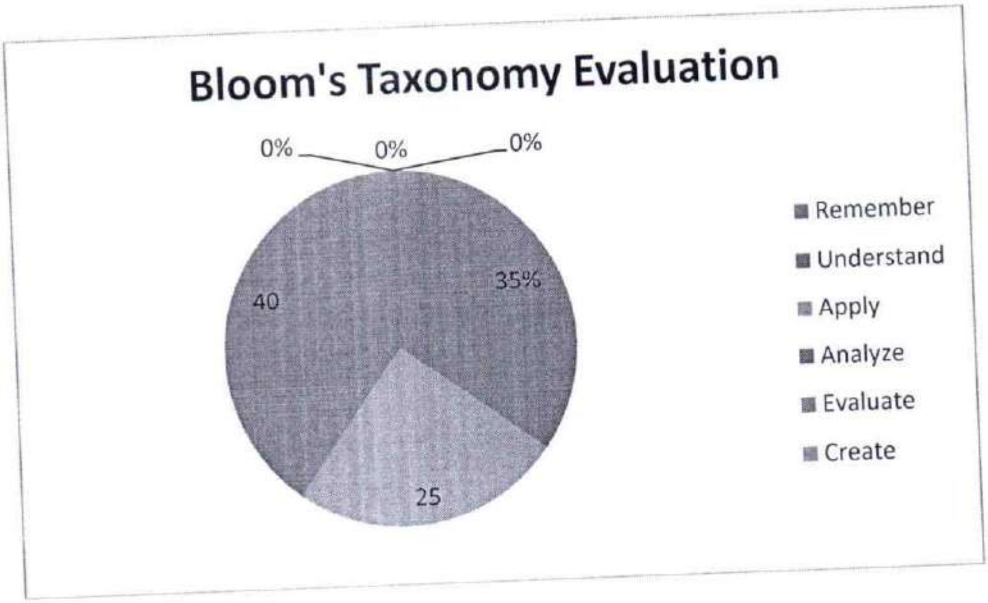

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IV-BTECH I SEMESTER MID-II QUESTION PAPER

COURSE: CloudComputing

Date:04/11/2022

Max. Marks: 10

Time: 90 min

Branches: CSE&IT (UNIVERSITY CODE: R194105G)

REG.NO:

Answer all the questions

Q.N0			Marks
1.	Develop Sheduling Algorithms in Cloud Computing	[BL:3][Apply]	2.5M
2.	Examine the Storage System of Apache Hadoop	[BL:4][Analyze]	2.5M
3.	Explain how to provide Security to VirtualMachine	[BL:4][Analyze]	2.5M
4	Build EC2 and Steps for Create and Launching Instances in AWS	[BL:3][Apply]	2.5M

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SCHEME OF EVALUATION – MID-II EXAMINATION

COURSE : CloudComputing	DEGREE: **B.Tech**
COURSE CODE: R194105G	YEAR: **IV** SEMESTER: **I**
REGULATION: **R19**	COURSE TYPE: **REGULAR**
ACADEMIC YEAR: **2022-2023**	CREDITS: **3**

Q.No.	**Solution**	**Marks Allotted**	**Course Outcome mapping**	**Taxonomy level**
1	Develop Sheduling Algorithms in Cloud Computing	2.5M	C405.4	**Analyze**
2	Examine the Storage System of Apache Hadoop	2.5M	C405.5	**Apply**
3	Explain how to provide Security to VirtualMachine	2.5M	C405.4	**Analyze**
4	Build EC2 and Steps for Create and Launching Instances in AWS	2.5M	C405.6	**Apply**

Course Outcome Number	**Marks Allotted**	**Percentage of Marks**
C405.4	5	50.00
C405.5	2.5	25.00
C405.6	2.5	25.00
Total Marks	10	100

Taxonomy level	**Marks Allotted**	**Percentage of Marks**
Remember	0	0.00
Understand	0	0.00
Apply	5	50.00
Analyze	5	50.00
Evaluate	0	0.00
Create	0	0.00
Total Marks	10	100

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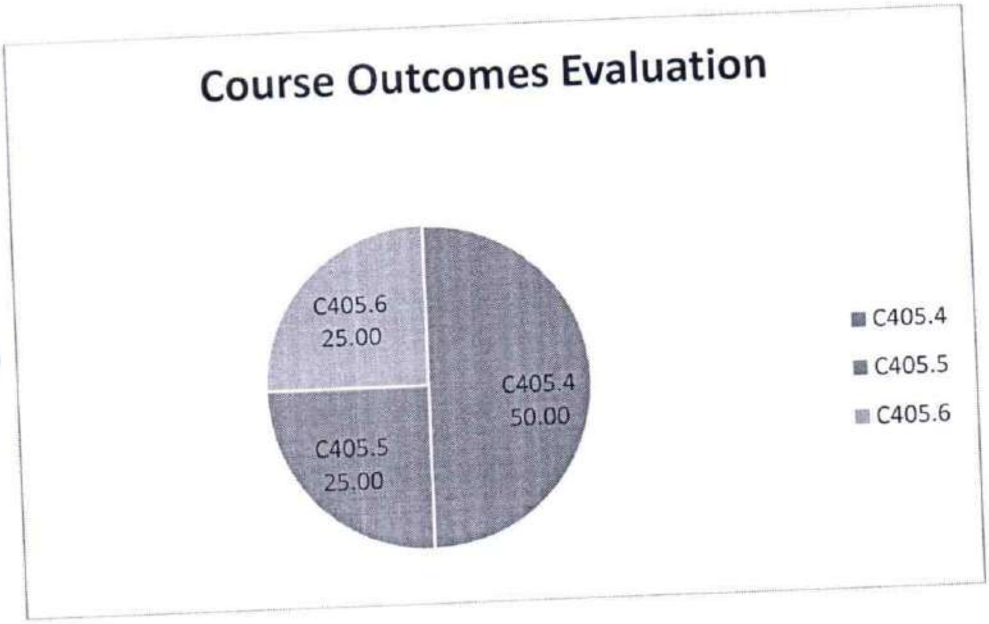

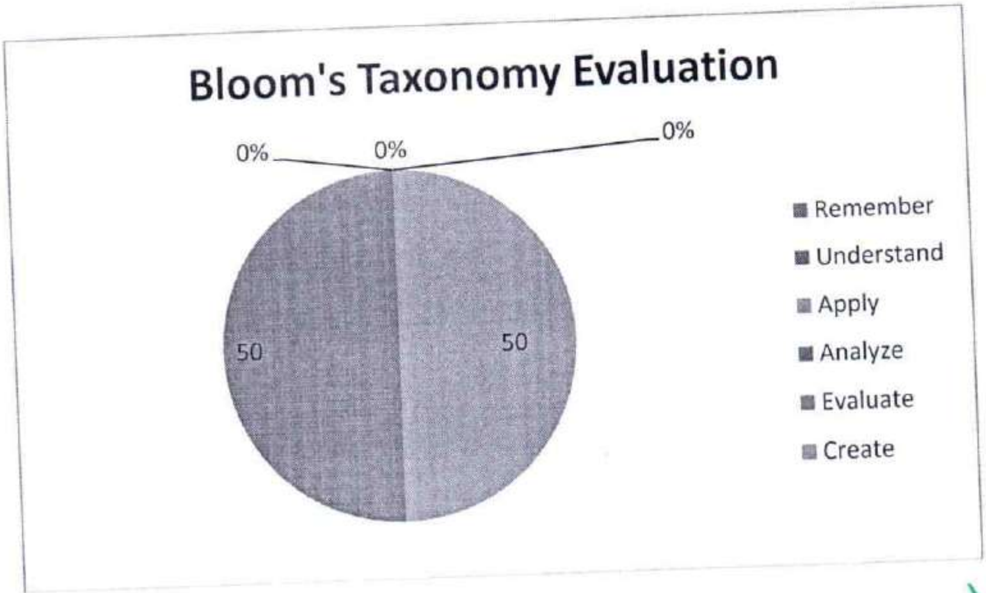

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REGULATION: **R19**	COURSE TYPE: **REGULAR**
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STUDENT RESULT ANALYSIS FOR MID-I

S.NO	ROLL.NO	NAME OF THE STUDENT	DESCRIPTIVE	OBJECTIVE	ASSIGNMENT	TOTAL
1	19KE1A0501	AASRITHA JASTY	10	5	5	20
2	19KE1A0502	ADAPALA SRAVANI	7	3	5	15
3	19KE1A0503	ADDAGADA KEERTHI	7	4	5	16
4	19KE1A0504	ADIGOPPULA SATHVIKA	7	4	5	16
5	19KE1A0505	ALAPATI MENAKA	7	2	5	14
6	19KE1A0506	ALLA DEVI PRASANTHI	8	1	5	14
7	19KE1A0507	ALLA HAREESHA	8	4	5	17
8	19KE1A0508	ANNAM SRAVANI	7	4	5	16
9	19KE1A0509	ANUSHA VEJANDLA	7	3	5	15
10	19KE1A0510	AREPALLI NANDITHA	9	4	5	18
11	19KE1A0511	ATUKURI SUPRIYA	7	3	5	15
12	19KE1A0512	BANDARU VENKATA SUDHISHANA	8	2	5	15
13	19KE1A0513	B. PRAVALLIKA	8	3	5	16
14	19KE1A0515	BATTULA PRIYANKA	7	3	5	15
15	19KE1A0516	BHAVANAM SRAVANTHI	7	4	5	16
16	19KE1A0517	BHOGYAM PAVANI	7	3	5	15
17	19KE1A0518	BHUMIREDDY DEEPTHI	8	2	5	15
18	19KE1A0519	BHUMIREDDY SUPRIYA	9	5	5	19
19	19KE1A0520	BOLLAM LAKSHMI DEVI	9	5	5	19
20	19KE1A0521	BOLLINENI PAVANI LAKSHMI	8	5	5	18
21	19KE1A0522	BOPPUDI JYOTHI	6	5	5	16
22	19KE1A0523	CHANDU NEERAJA	8	4	5	17
23	19KE1A0524	CHERUKURI JOSHITHA	7	2	5	14
24	19KE1A0525	CHIDELLA LAKSHMI VENKATA SOWMYA	9	5	5	1
25	19KE1A0526	CHILAKA KUMARI	8	4	5	1
26	19KE1A0527	CHINNAM BINDHU MADHURI	8	3	5	1
27	19KE1A0528	CHINNAM NAGA NISCHALA	9	4	5	1
28	19KE1A0530	CHIRUMAMILLA VIJAYA SRI	8	2	5	1
29	19KE1A0531	DANABOYINA PAVANI	6	4	5	1

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30	19KE1A0532	DARA ABHINETHRI	9	3	5	17
31	19KE1A0533	DERANGULA SWATHI	9	1	5	15
32	19KE1A0534	EKKURTHI DEVIKALYANI	8	3	5	16
33	19KE1A0535	DHADI NAGA POOJITHA	8	1	5	14
34	19KE1A0536	DODDA SATHVIKA	8	3	5	16
35	19KE1A0537	DOREDLA SARANYA	8	2	5	15
36	19KE1A0538	GADDIPATI NAGASINDHU	10	3	5	18
37	19KE1A0539	GADE NAGA PREETHI REDDY	10	4	5	19
38	19KE1A0540	GALLA HEMASREE	7	2	5	14
39	19KE1A0541	G. KEERTHI	6	4	5	15
40	19KE1A0542	GANGISETTY SRI LAKSHMI	8	2	5	15
41	19KE1A0543	GERA SUGANDHA SRI	8	4	5	17
42	19KE1A0544	GOPIDESI SAI ARSHITHA	6	3	5	14
43	19KE1A0545	GORAPALLI MANASA	8	3	5	16
44	19KE1A0546	GORIPARTHI NAGA LALITHA DEVI	7	4	5	16
45	19KE1A0547	GUDDETI AMRUTHAVALLI	9	5	5	19
46	19KE1A0548	GUNDA PRAVALLIKA	6	3	5	14
47	19KE1A0549	GUNTI KALYANI	7	3	5	15
48	19KE1A0550	JARIPALLI DIVYA	8	3	5	16
49	19KE1A0551	KADIYAM UMAMAHESWARI	9	3	5	17
50	19KE1A0553	KAMATHAM BALA BHARATHI	6	3	5	14
51	19KE1A0554	KANDULA SINDHUJA	10	3	5	18
52	19KE1A0555	KATTA MAHITHA	9	1	5	15
53	19KE1A0556	YECHURI KAVYA	8	5	5	18
54	19KE1A0557	KILARU VASAVI	8	4	5	17
55	19KE1A0558	KOLA ANUHYA	9	3	5	17
56	19KE1A0559	KOLLA ALEKHYA	8	4	5	17
57	19KE1A0560	KOMATINENI YAKSHITHA	9	2	5	16
58	19KE1A0561	KONIKI BHARGAVI	7	4	5	16
59	19KE1A0562	KOTAGIRI PRIYANKA	8	6	5	19
60	19KE1A0563	KOTTAPALLI SRAVANI	9	5	5	19
61	19KE1A0564	LAGHUVARAPU PRAVALLIKA	9	3	5	17
62	19KE1A0565	LAKSHMI PRAVALLIKA KODAVATI	5	5	5	15
63	19KE1A0566	MADALA SOUMITHRI	5	4	5	14
64	19KE1A0567	MAKKENA APARNA	5	4 .	5	14
65	19KE1A0568	MANDAVA AKANKSHA	0	0	5	5
66	19KE1A0570	MARRIVADA NAGA VENKATA SAI RUKMINI	7	3	5	1[illegible]
67	19KE1A0571	MEDARAMETLA RENUKA CHOWDARY	7	0	5	1[illegible]
68	19KE1A0572	MEDATATI HARIPRIYA	7	2	5	1[illegible]
69	19KE1A0573	MOHAMMED TASNEEM SULTANA	8	0	5	1[illegible]

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70	19KE1A0574	MORAM NAVYA	7	5	5	17
71	19KE1A0575	MURTHI SUSHMITHA	6	3	5	14
72	19KE1A0576	MUTTHIREDDY SWAROOPA	7	0	5	12
73	19KE1A0577	NAGENDLA LAKSHMI PRIYA	10	4	5	19
74	19KE1A0578	NALABOTHULA NAVYA	7	2	5	14
75	19KE1A0579	NALLAMOTHU DIVYA SREE	7	3	5	15
76	19KE1A0580	NANGINENI ASWANI	6	2	5	13
77	19KE1A0581	NARABOYINA YAMUNA	7	2	5	14
78	19KE1A0582	NARRA VIJAYA LAKSHMI	5	4	5	14
79	19KE1A0583	NUKALA RAJYA LAKSHMI	5	4	5	14
80	19KE1A0584	NUTHALAPATI VENKATA PRASANNALAKSHMI	6	4	5	15
81	19KE1A0585	PADALA RUPADEVI	7	4	5	16
82	19KE1A0586	PALCHURI MADHU HARIKA	7	3	5	15
83	19KE1A0587	PALETI DHANALAKSHMI	7	2	5	14
84	19KE1A0588	PALLA HEMA SARIKA	7	2	5	14
85	19KE1A0589	PALUCHURI MOUNIKA	5	4	5	14
86	19KE1A0590	PANDILLA PRIYANKA	6	2	5	13
87	19KE1A0591	PAREPALLI SUSHMA	6	2	5	13
88	19KE1A0592	PEDDI UMADEVI	6	4	5	15
89	19KE1A0593	PERAM SNEHALATHA	7	2	5	14
90	19KE1A0594	POLISETTY AMALA MARY	7	4	5	16
91	19KE1A0595	POLU ANUHYA	7	4	5	16
92	19KE1A0596	PERNI RUCHITHA	6	2	5	13
93	19KE1A0597	PRODDUTURI SATHVIKA	6	4	5	15
94	19KE1A0598	PULUKURI NAVYA TEJA	7	3	5	15
95	19KE1A0599	RONDI PADMASRI	6	4	5	15
96	19KE1A5A1	SANAMPUDI SAI LAKSHMI	6	4	5	15
97	19KE1A5A2	SANKA NAGA GOWTHAMI	6	3	5	14
98	19KE1A5A3	SESHADRI MADHUVIKA	5	6	5	16
99	19KE1A5A4	SHAIK BHASHEERA	5	2	5	12
100	19KE1A5A5	SHAIK HASMATHUNNISA	6	4	5	15
101	19KE1A5A6	SHAIK VINEESHA	7	3	5	15
102	19KE1A5A7	SRIRAM SINDHU	6	3	5	14
103	19KE1A5A8	SUDULA SIREESHA	6	4	5	15
104	19KE1A5A9	SUNDARAGIRI AYESHA	6	4	5	15
105	19KE1A5B0	SYAMALA TRIVENI	5	3	5	13
106	19KE1A5B1	SYAMALA YASHASRI	7	5	5	17
107	19KE1A5B2	TAMTAM SANDHYA RANI	7	7	5	19
108	19KE1A5B3	TATA GOWRI SAI TEJASWI	7	4	5	1
109	19KE1A5B4	TELANAKULA MRULAALINI	7	3	5	1
110	19KE1A5B5	THAMMINENI LIKHITHA	5	6	5	1

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111	19KE1A5B6	THATAVARTHI BHAVANA	9	4	5	18
112	19KE1A5B7	THOLUSURI BHUVANESWARI	8	0	5	13
113	19KE1A5B8	THOTA GOWTHAMI	0	0	5	5
114	19KE1A5B9	UPPALA NAGAMANI	7	0	5	12
115	19KE1A5C0	VADDE POOJITHA	6	3	5	14
116	19KE1A5C1	VAKA SUDHA RANI	6	3	5	14
117	19KE1A5C2	VEERAGANDHAM RAMYA KRISHNA	7	3	5	15
118	19KE1A5C3	VINAKALLU SRIHITHA	6	5	5	16
119	19KE1A5C4	VUNADI SRI LATHA	6	3	5	14
120	19KE1A5C5	YASAM KALYANI	7	4	5	16
121	20KE5A0501	j. vani	8	5	5	18
122	20KE5A0502	R. kalyani	6	5	5	16
123	20KE5A0503	R. radha Byi	7	5	5	17

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COURSE : **CloudComputing**	DEGREE: **B.Tech**
COURSE CODE: **R194105G**	YEAR: **IV** SEMESTER: **I**
REGULATION: **R19**	COURSE TYPE: **REGULAR**
ACADEMIC YEAR : **2022-2023**	CREDITS: **3**

ADVANCED LEARNERS FOR MID-I EXAMINATION

S.NO	ROLL.NO	NAME OF THE STUDENT	Grade
1	19KE1A0501	AASRITHA JASTY	AL
2	19KE1A0502	ADAPALA SRAVANI	AL
3	19KE1A0503	ADDAGADA KEERTHI	AL
4	19KE1A0504	ADIGOPPULA SATHVIKA	AL
5	19KE1A0507	ALLA HAREESHA	AL
6	19KE1A0508	ANNAM SRAVANI	AL
7	19KE1A0509	ANUSHA VEJANDLA	AL
8	19KE1A0510	AREPALLI NANDITHA	AL
9	19KE1A0511	ATUKURI SUPRIYA	AL
10	19KE1A0512	BANDARU VENKATA SUDHISHANA	AL
11	19KE1A0513	B. PRAVALLIKA	AL
12	19KE1A0515	BATTULA PRIYANKA	AL
13	19KE1A0516	BHAVANAM SRAVANTHI	AL
14	19KE1A0517	BHOGYAM PAVANI	AL
15	19KE1A0518	BHUMIREDDY DEEPTHI	AL
16	19KE1A0519	BHUMIREDDY SUPRIYA	AL
17	19KE1A0520	BOLLAM LAKSHMI DEVI	AL
18	19KE1A0521	BOLLINENI PAVANI LAKSHMI	AL
19	19KE1A0522	BOPPUDI JYOTHI	AL
20	19KE1A0523	CHANDU NEERAJA	AL
21	19KE1A0525	CHIDELLA LAKSHMI VENKATA SOWMYA	AL
22	19KE1A0526	CHILAKA KUMARI	AL
23	19KE1A0527	CHINNAM BINDHU MADHURI	AL
24	19KE1A0528	CHINNAM NAGA NISCHALA	AL
25	19KE1A0530	CHIRUMAMILLA VIJAYA SRI	AL
26	19KE1A0531	DANABOYINA PAVANI	AL
27	19KE1A0532	DARA ABHINETHRI	AL
28	19KE1A0533	DERANGULA SWATHI	AL

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29	19KE1A0534	EKKURTHI DEVIKALYANI	AL
30	19KE1A0536	DODDA SATHVIKA	AL
31	19KE1A0537	DOREDLA SARANYA	AL
32	19KE1A0538	GADDIPATI NAGASINDHU	AL
33	19KE1A0539	GADE NAGA PREETHI REDDY	AL
34	19KE1A0541	G. KEERTHI	AL
35	19KE1A0542	GANGISETTY SRI LAKSHMI	AL
36	19KE1A0543	GERA SUGANDHA SRI	AL
37	19KE1A0545	GORAPALLI MANASA	AL
38	19KE1A0546	GORIPARTHI NAGA LALITHA DEVI	AL
39	19KE1A0547	GUDDETI AMRUTHAVALLI	AL
40	19KE1A0549	GUNTI KALYANI	AL
41	19KE1A0550	JARIPALLI DIVYA	AL
42	19KE1A0551	KADIYAM UMAMAHESWARI	AL
43	19KE1A0554	KANDULA SINDHUJA	AL
44	19KE1A0555	KATTA MAHITHA	AL
45	19KE1A0556	YECHURI KAVYA	AL
46	19KE1A0557	KILARU VASAVI	AL
47	19KE1A0558	KOLA ANUHYA	AL
48	19KE1A0559	KOLLA ALEKHYA	AL
49	19KE1A0560	KOMATINENI YAKSHITHA	AL
50	19KE1A0561	KONIKI BHARGAVI	AL
51	19KE1A0562	KOTAGIRI PRIYANKA	AL
52	19KE1A0563	KOTTAPALLI SRAVANI	AL
53	19KE1A0564	LAGHUVARAPU PRAVALLIKA	AL
54	19KE1A0565	LAKSHMI PRAVALLIKA KODAVATI	AL
55	19KE1A0570	MARRIVADA NAGA VENKATA SAI RUKMINI	AL
56	19KE1A0574	MORAM NAVYA	AL
57	19KE1A0577	NAGENDLA LAKSHMI PRIYA	AL
58	19KE1A0579	NALLAMOTHU DIVYA SREE	AL
59	19KE1A0584	NUTHALAPATI VENKATA PRASANNALAKSHMI	AL
60	19KE1A0585	PADALA RUPADEVI	AL
61	19KE1A0586	PALCHURI MADHU HARIKA	AL
62	19KE1A0592	PEDDI UMADEVI	AL
63	19KE1A0594	POLISETTY AMALA MARY	AL
64	19KE1A0595	POLU ANUHYA	AL
65	19KE1A0597	PRODDUTURI SATHVIKA	AL
66	19KE1A0598	PULUKURI NAVYA TEJA	AL
67	19KE1A0599	RONDI PADMASRI	AL
68	19KE1A5A1	SANAMPUDI SAI LAKSHMI	AL
69	19KE1A5A3		AL

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		SESHADRI MADHUVIKA	
70	19KE1A5A5	SHAIK HASMATHUNNISA	AL
71	19KE1A5A6	SHAIK VINEESHA	AL
72	19KE1A5A8	SUDULA SIREESHA	AL
73	19KE1A5A9	SUNDARAGIRI AYESHA	AL
74	19KE1A5B1	SYAMALA YASHASRI	AL
75	19KE1A5B2	TAMTAM SANDHYA RANI	AL
76	19KE1A5B3	TATA GOWRI SAI TEJASWI	AL
77	19KE1A5B4	TELANAKULA MRULAALINI	AL
78	19KE1A5B5	THAMMINENI LIKHITHA	AL
79	19KE1A5B6	THATAVARTHI BHAVANA	AL
80	19KE1A5C2	VEERAGANDHAM RAMYA KRISHNA	AL
81	19KE1A5C3	VINAKALLU SRIHITHA	AL
82	19KE1A5C5	YASAM KALYANI	AL
83	20KE5A0501	j. vani	AL
84	20KE5A0502	R. kalyani	AL
85	20KE5A0503	R. radha Byi	AL

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COURSE : **CloudComputing**	DEGREE: **B.Tech**
COURSE CODE: **R194105G**	YEAR: **IV** SEMESTER: **I**
REGULATION: **R19**	COURSE TYPE: **REGULAR**
ACADEMIC YEAR : **2022-2023**	CREDITS: **3**

SLOW LEARNERS FOR MID-I EXAMINATION

S.NO	ROLL.NO	NAME OF THE STUDENT	Grade
1	19KE1A0505	ALAPATI MENAKA	SL
2	19KE1A0506	ALLA DEVI PRASANTHI	SL
3	19KE1A0524	CHERUKURI JOSHITHA	SL
4	19KE1A0535	DHADI NAGA POOJITHA	SL
5	19KE1A0540	GALLA HEMASREE	SL
6	19KE1A0544	GOPIDESI SAI ARSHITHA	SL
7	19KE1A0548	GUNDA PRAVALLIKA	SL
8	19KE1A0553	KAMATHAM BALA BHARATHI	SL
9	19KE1A0566	MADALA SOUMITHRI	SL
10	19KE1A0567	MAKKENA APARNA	SL
11	19KE1A0568	MANDAVA AKANKSHA	SL
12	19KE1A0571	MEDARAMETLA RENUKA CHOWDARY	SL
13	19KE1A0572	MEDATATI HARIPRIYA	SL
14	19KE1A0573	MOHAMMED TASNEEM SULTANA	SL
15	19KE1A0575	MURTHI SUSHMITHA	SL
16	19KE1A0576	MUTTHIREDDY SWAROOPA	SL
17	19KE1A0578	NALABOTHULA NAVYA	SL
18	19KE1A0580	NANGINENI ASWANI	SL
19	19KE1A0581	NARABOYINA YAMUNA	SL
20	19KE1A0582	NARRA VIJAYA LAKSHMI	SL
21	19KE1A0583	NUKALA RAJYA LAKSHMI	SL
22	19KE1A0587	PALETI DHANALAKSHMI	SL
23	19KE1A0588	PALLA HEMA SARIKA	SL
24	19KE1A0589	PALUCHURI MOUNIKA	SL
25	19KE1A0590	PANDILLA PRIYANKA	SL
26	19KE1A0591	PAREPALLI SUSHMA	SL
27	19KE1A0593	PERAM SNEHALATHA	SL
28	19KE1A0596	PERNI RUCHITHA	SL
29	19KE1A5A2	SANKA NAGA GOWTHAMI	SL

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30	19KE1A5A4	SHAIK BHASHEERA	SL
31	19KE1A5A7	SRIRAM SINDHU	SL
32	19KE1A5B0	SYAMALA TRIVENI	SL
33	19KE1A5B7	THOLUSURI BHUVANESWARI	SL
34	19KE1A5B8	THOTA GOWTHAMI	SL
35	19KE1A5B9	UPPALA NAGAMANI	SL
36	19KE1A5C0	VADDE POOJITHA	SL
37	19KE1A5C1	VAKA SUDHA RANI	SL
38	19KE1A5C4	VUNADI SRI LATHA	SL

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COURSE CODE: **R194105G**	YEAR: **IV** SEMESTER: **I**
REGULATION: **R19**	COURSE TYPE: **REGULAR**
ACADEMIC YEAR : **2022-2023**	CREDITS: **3**

STUDENT RESULT ANALYSIS FOR MID-II

S.NO	ROLL.NO	NAME OF THE STUDENT	DESCRIPTIVE	OBJECTIVE	ASSIGNMENT	TOTAL
1	19KE1A0501	AASRITHA JASTY	9	3	5	17
2	19KE1A0502	ADAPALA SRAVANI	9	4	5	18
3	19KE1A0503	ADDAGADA KEERTHI	9	3	5	17
4	19KE1A0504	ADIGOPPULA SATHVIKA	9	7	5	21
5	19KE1A0505	ALAPATI MENAKA	7	5	5	17
6	19KE1A0506	ALLA DEVI PRASANTHI	10	5	5	20
7	19KE1A0507	ALLA HAREESHA	8	5	5	18
8	19KE1A0508	ANNAM SRAVANI	10	4	5	19
9	19KE1A0509	ANUSHA VEJANDLA	7	3	5	15
10	19KE1A0510	AREPALLI NANDITHA	9	4	5	18
11	19KE1A0511	ATUKURI SUPRIYA	6	4	5	15
12	19KE1A0512	BANDARU VENKATA SUDHISHANA	7	2	5	14
13	19KE1A0513	B. PRAVALLIKA	10	4	5	19
14	19KE1A0515	BATTULA PRIYANKA	9	3	5	17
15	19KE1A0516	BHAVANAM SRAVANTHI	8	4	5	17
16	19KE1A0517	BHOGYAM PAVANI	9	4	5	18
17	19KE1A0518	BHUMIREDDY DEEPTHI	10	4	5	19
18	19KE1A0519	BHUMIREDDY SUPRIYA	10	7	5	22
19	19KE1A0520	BOLLAM LAKSHMI DEVI	10	7	5	22
20	19KE1A0521	BOLLINENI PAVANI LAKSHMI	9	7	5	21
21	19KE1A0522	BOPPUDI JYOTHI	8	6	5	19
22	19KE1A0523	CHANDU NEERAJA	8	4	5	17
23	19KE1A0524	CHERUKURI JOSHITHA	10	3	5	18
24	19KE1A0525	CHIDELLA LAKSHMI VENKATA SOWMYA	9	5	5	19
25	19KE1A0526	CHILAKA KUMARI	7	2	5	14
26	19KE1A0527	CHINNAM BINDHU MADHURI	8	5	5	18
27	19KE1A0528	CHINNAM NAGA NISCHALA	9	5	5	19
28	19KE1A0530	CHIRUMAMILLA VIJAYA SRI	8	2	5	15
29	19KE1A0531	DANABOYINA PAVANI	8	1	5	14
30	19KE1A0532	DARA ABHINETHRI	8	2	5	15

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31	19KE1A0533	DERANGULA SWATHI	8	5	5	18
32	19KE1A0534	EKKURTHI DEVIKALYANI	9	4	5	18
33	19KE1A0535	DHADI NAGA POOJITHA	7	2	5	14
34	19KE1A0536	DODDA SATHVIKA	8	4	5	17
35	19KE1A0537	DOREDLA SARANYA	8	7	5	20
36	19KE1A0538	GADDIPATI NAGASINDHU	9	4	5	18
37	19KE1A0539	GADE NAGA PREETHI REDDY	7	3	5	15
38	19KE1A0540	GALLA HEMASREE	7	4	5	16
39	19KE1A0541	G. KEERTHI	8	2	5	15
40	19KE1A0542	GANGISETTY SRI LAKSHMI	6	3	5	14
41	19KE1A0543	GERA SUGANDHA SRI	8	3	5	16
42	19KE1A0544	GOPIDESI SAI ARSHITHA	7	6	5	18
43	19KE1A0545	GORAPALLI MANASA	8	3	5	16
44	19KE1A0546	GORIPARTHI NAGA LALITHA DEVI	8	4	5	17
45	19KE1A0547	GUDDETI AMRUTHAVALLI	9	5	5	19
46	19KE1A0548	GUNDA PRAVALLIKA	6	3	5	14
47	19KE1A0549	GUNTI KALYANI	5	2	5	12
48	19KE1A0550	JARIPALLI DIVYA	7	3	5	15
49	19KE1A0551	KADIYAM UMAMAHESWARI	8	5	5	18
50	19KE1A0553	KAMATHAM BALA BHARATHI	9	7	5	21
51	19KE1A0554	KANDULA SINDHUJA	9	3	5	17
52	19KE1A0555	KATTA MAHITHA	8	3	5	16
53	19KE1A0556	YECHURI KAVYA	10	3	5	18
54	19KE1A0557	KILARU VASAVI	8	6	5	19
55	19KE1A0558	KOLA ANUHYA	10	3	5	18
56	19KE1A0559	KOLLA ALEKHYA	9	5	5	19
57	19KE1A0560	KOMATINENI YAKSHITHA	8	3	5	16
58	19KE1A0561	KONIKI BHARGAVI	5	3	5	13
59	19KE1A0562	KOTAGIRI PRIYANKA	10	3	5	18
60	19KE1A0563	KOTTAPALLI SRAVANI	8	5	5	18
61	19KE1A0564	LAGHUVARAPU PRAVALLIKA	9	5	5	19
62	19KE1A0565	LAKSHMI PRAVALLIKA KODAVATI	9	5	5	19
63	19KE1A0566	MADALA SOUMITHRI	9	6	5	20
64	19KE1A0567	MAKKENA APARNA	8	5	5	18
65	19KE1A0568	MANDAVA AKANKSHA	8	3	5	16
66	19KE1A0570	MARRIVADA NAGA VENKATA SAI RUKMINI	9	3	5	17
67	19KE1A0571	MEDARAMETLA RENUKA CHOWDARY		2	5	7
68	19KE1A0572	MEDATATI HARIPRIYA	9	4	5	18
69	19KE1A0573	MOHAMMED TASNEEM SULTANA	9	4	5	18
70	19KE1A0574	MORAM NAVYA	9	5	5	[illegible]

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71	19KE1A0575	MURTHI SUSHMITHA	8	3	5	16
72	19KE1A0576	MUTTHIREDDY SWAROOPA	9	4	5	18
73	19KE1A0577	NAGENDLA LAKSHMI PRIYA	9	6	5	20
74	19KE1A0578	NALABOTHULA NAVYA	8	2	5	15
75	19KE1A0579	NALLAMOTHU DIVYA SREE	10	3	5	18
76	19KE1A0580	NANGINENI ASWANI	6	5	5	16
77	19KE1A0581	NARABOYINA YAMUNA	8	3	5	16
78	19KE1A0582	NARRA VIJAYA LAKSHMI	6	4	5	15
79	19KE1A0583	NUKALA RAJYA LAKSHMI	7	5	5	17
80	19KE1A0584	NUTHALAPATI VENKATA PRASANNALAKSHMI	8	3	5	16
81	19KE1A0585	PADALA RUPADEVI	8	3	5	16
82	19KE1A0586	PALCHURI MADHU HARIKA	6	2	5	13
83	19KE1A0587	PALETI DHANALAKSHMI	9	6	5	20
84	19KE1A0588	PALLA HEMA SARIKA	8	5	5	18
85	19KE1A0589	PALUCHURI MOUNIKA	8	3	5	16
86	19KE1A0590	PANDILLA PRIYANKA	8	2	5	15
87	19KE1A0591	PAREPALLI SUSHMA	7	2	5	14
88	19KE1A0592	PEDDI UMADEVI	9	3	5	17
89	19KE1A0593	PERAM SNEHALATHA	8	3	5	16
90	19KE1A0594	POLISETTY AMALA MARY	9	1	5	15
91	19KE1A0595	POLU ANUHYA	7	1	5	13
92	19KE1A0596	PERNI RUCHITHA	9	2	5	16
93	19KE1A0597	PRODDUTURI SATHVIKA	7	2	5	14
94	19KE1A0598	PULUKURI NAVYA TEJA	9	4	5	18
95	19KE1A0599	RONDI PADMASRI	10	4	5	19
96	19KE1A5A1	SANAMPUDI SAI LAKSHMI	8	5	5	18
97	19KE1A5A2	SANKA NAGA GOWTHAMI	8	2	5	15
98	19KE1A5A3	SESHADRI MADHUVIKA	8	3	5	16
99	19KE1A5A4	SHAIK BHASHEERA	9	2	5	16
100	19KE1A5A5	SHAIK HASMATHUNNISA	9	4	5	18
101	19KE1A5A6	SHAIK VINEESHA	8	3	5	16
102	19KE1A5A7	SRIRAM SINDHU	8	2	5	15
103	19KE1A5A8	SUDULA SIREESHA	8	3	5	16
104	19KE1A5A9	SUNDARAGIRI AYESHA	8	4	5	17
105	19KE1A5B0	SYAMALA TRIVENI	9	4	5	18
106	19KE1A5B1	SYAMALA YASHASRI	8	3	5	16
107	19KE1A5B2	TAMTAM SANDHYA RANI	8	3	5	16
108	19KE1A5B3	TATA GOWRI SAI TEJASWI	8	4	5	17
109	19KE1A5B4	TELANAKULA MRULAALINI	8	3	5	16
110	19KE1A5B5	THAMMINENI LIKHITHA	8	5	5	18
111	19KE1A5B6	THATAVARTHI BHAVANA	9	3	5	17

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112	19KE1A5B7	THOLUSURI BHUVANESWARI	0	2	5	7
113	19KE1A5B8	THOTA GOWTHAMI	0	0	5	5
114	19KE1A5B9	UPPALA NAGAMANI	8	2	5	15
115	19KE1A5C0	VADDE POOJITHA	8	3	5	16
116	19KE1A5C1	VAKA SUDHA RANI	8	3	5	16
117	19KE1A5C2	VEERAGANDHAM RAMYA KRISHNA	8	3	5	16
118	19KE1A5C3	VINAKALLU SRIHITHA	9	4	5	18
119	19KE1A5C4	VUNADI SRI LATHA	9	4	5	18
120	19KE1A5C5	YASAM KALYANI	9	5	5	19
121	20KE5A0501	j. vani	8	4	5	17
122	20KE5A0502	R. kalyani	9	7	5	21
123	20KE5A0503	R. radha Byi	9	5	5	19

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COURSE : **CloudComputing**	DEGREE: **B.Tech**
COURSE CODE: **R194105G**	YEAR: **IV** SEMESTER: **I**
REGULATION: **R19**	COURSE TYPE: **REGULAR**
ACADEMIC YEAR : **2022-2023**	CREDITS: **3**

ADVANCED LEARNERS FOR MID-II EXAMINATION

S.NO	ROLL.NO	NAME OF THE STUDENT	Grade
1	19KE1A0501	AASRITHA JASTY	AL
2	19KE1A0502	ADAPALA SRAVANI	AL
3	19KE1A0503	ADDAGADA KEERTHI	AL
4	19KE1A0504	ADIGOPPULA SATHVIKA	AL
5	19KE1A0505	ALAPATI MENAKA	AL
6	19KE1A0506	ALLA DEVI PRASANTHI	AL
7	19KE1A0507	ALLA HAREESHA	AL
8	19KE1A0508	ANNAM SRAVANI	AL
9	19KE1A0509	ANUSHA VEJANDLA	AL
10	19KE1A0510	AREPALLI NANDITHA	AL
11	19KE1A0511	ATUKURI SUPRIYA	AL
12	19KE1A0513	B. PRAVALLIKA	AL
13	19KE1A0515	BATTULA PRIYANKA	AL
14	19KE1A0516	BHAVANAM SRAVANTHI	AL
15	19KE1A0517	BHOGYAM PAVANI	AL
16	19KE1A0518	BHUMIREDDY DEEPTHI	AL
17	19KE1A0519	BHUMIREDDY SUPRIYA	AL
18	19KE1A0520	BOLLAM LAKSHMI DEVI	AL
19	19KE1A0521	BOLLINENI PAVANI LAKSHMI	AL
20	19KE1A0522	BOPPUDI JYOTHI	AL
21	19KE1A0523	CHANDU NEERAJA	AL
22	19KE1A0524	CHERUKURI JOSHITHA	AL
23	19KE1A0525	CHIDELLA LAKSHMI VENKATA SOWMYA	AL
24	19KE1A0527	CHINNAM BINDHU MADHURI	AL
25	19KE1A0528	CHINNAM NAGA NISCHALA	AL
26	19KE1A0530	CHIRUMAMILLA VIJAYA SRI	AL
27	19KE1A0532	DARA ABHINETHRI	AL
28	19KE1A0533	DERANGULA SWATHI	AL
29	19KE1A0534	EKKURTHI DEVIKALYANI	AL

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30	19KE1A0536	DODDA SATHVIKA	AL
31	19KE1A0537	DOREDLA SARANYA	AL
32	19KE1A0538	GADDIPATI NAGASINDHU	AL
33	19KE1A0539	GADE NAGA PREETHI REDDY	AL
34	19KE1A0540	GALLA HEMASREE	AL
35	19KE1A0541	G. KEERTHI	AL
36	19KE1A0543	GERA SUGANDHA SRI	AL
37	19KE1A0544	GOPIDESI SAI ARSHITHA	AL
38	19KE1A0545	GORAPALLI MANASA	AL
39	19KE1A0546	GORIPARTHI NAGA LALITHA DEVI	AL
40	19KE1A0547	GUDDETI AMRUTHAVALLI	AL
41	19KE1A0550	JARIPALLI DIVYA	AL
42	19KE1A0551	KADIYAM UMAMAHESWARI	AL
43	19KE1A0553	KAMATHAM BALA BHARATHI	AL
44	19KE1A0554	KANDULA SINDHUJA	AL
45	19KE1A0555	KATTA MAHITHA	AL
46	19KE1A0556	YECHURI KAVYA	AL
47	19KE1A0557	KILARU VASAVI	AL
48	19KE1A0558	KOLA ANUHYA	AL
49	19KE1A0559	KOLLA ALEKHYA	AL
50	19KE1A0560	KOMATINENI YAKSHITHA	AL
51	19KE1A0562	KOTAGIRI PRIYANKA	AL
52	19KE1A0563	KOTTAPALLI SRAVANI	AL
53	19KE1A0564	LAGHUVARAPU PRAVALLIKA	AL
54	19KE1A0565	LAKSHMI PRAVALLIKA KODAVATI	AL
55	19KE1A0566	MADALA SOUMITHRI	AL
56	19KE1A0567	MAKKENA APARNA	AL
57	19KE1A0568	MANDAVA AKANKSHA	AL
58	19KE1A0570	MARRIVADA NAGA VENKATA SAI RUKMINI	AL
59	19KE1A0572	MEDATATI HARIPRIYA	AL
60	19KE1A0573	MOHAMMED TASNEEM SULTANA	AL
61	19KE1A0574	MORAM NAVYA	AL
62	19KE1A0575	MURTHI SUSHMITHA	AL
63	19KE1A0576	MUTTHIREDDY SWAROOPA	AL
64	19KE1A0577	NAGENDLA LAKSHMI PRIYA	AL
65	19KE1A0578	NALABOTHULA NAVYA	AL
66	19KE1A0579	NALLAMOTHU DIVYA SREE	AL
67	19KE1A0580	NANGINENI ASWANI	AL
68	19KE1A0581	NARABOYINA YAMUNA	AL
69	19KE1A0582		

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		NARRA VIJAYA LAKSHMI	
70	19KE1A0583	NUKALA RAJYA LAKSHMI	AL
71	19KE1A0584	NUTHALAPATI VENKATA PRASANNALAKSHMI	AL
72	19KE1A0585	PADALA RUPADEVI	AL
73	19KE1A0587	PALETI DHANALAKSHMI	AL
74	19KE1A0588	PALLA HEMA SARIKA	AL
75	19KE1A0589	PALUCHURI MOUNIKA	AL
76	19KE1A0590	PANDILLA PRIYANKA	AL
77	19KE1A0592	PEDDI UMADEVI	AL
78	19KE1A0593	PERAM SNEHALATHA	AL
79	19KE1A0594	POLISETTY AMALA MARY	AL
80	19KE1A0596	PERNI RUCHITHA	AL
81	19KE1A0598	PULUKURI NAVYA TEJA	AL
82	19KE1A0599	RONDI PADMASRI	AL
83	19KE1A5A1	SANAMPUDI SAI LAKSHMI	AL
84	19KE1A5A2	SANKA NAGA GOWTHAMI	AL
85	19KE1A5A3	SESHADRI MADHUVIKA	AL
86	19KE1A5A4	SHAIK BHASHEERA	AL
87	19KE1A5A5	SHAIK HASMATHUNNISA	AL
88	19KE1A5A6	SHAIK VINEESHA	AL
89	19KE1A5A7	SRIRAM SINDHU	AL
90	19KE1A5A8	SUDULA SIREESHA	AL
91	19KE1A5A9	SUNDARAGIRI AYESHA	AL
92	19KE1A5B0	SYAMALA TRIVENI	AL
93	19KE1A5B1	SYAMALA YASHASRI	AL
94	19KE1A5B2	TAMTAM SANDHYA RANI	AL
95	19KE1A5B3	TATA GOWRI SAI TEJASWI	AL
96	19KE1A5B4	TELANAKULA MRULAALINI	AL
97	19KE1A5B5	THAMMINENI LIKHITHA	AL
98	19KE1A5B6	THATAVARTHI BHAVANA	AL
99	19KE1A5B9	UPPALA NAGAMANI	AL
100	19KE1A5C0	VADDE POOJITHA	AL
101	19KE1A5C1	VAKA SUDHA RANI	AL
102	19KE1A5C2	VEERAGANDHAM RAMYA KRISHNA	AL
103	19KE1A5C3	VINAKALLU SRIHITHA	AL
104	19KE1A5C4	VUNADI SRI LATHA	AL
105	19KE1A5C5	YASAM KALYANI	AL
106	20KE5A0501	j. vani	AL
107	20KE5A0502	R. kalyani	AL
108	20KE5A0503	R. radha Byi	AL

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DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

COURSE : **CloudComputing**	DEGREE: **B.Tech**
COURSE CODE: **R194105G**	YEAR: **IV** SEMESTER: **I**
REGULATION: **R19**	COURSE TYPE: **REGULAR**
ACADEMIC YEAR : **2022-2023**	CREDITS: **3**

SLOW LEARNERS FOR MID-II EXAMINATION

S.NO	ROLL.NO	NAME OF THE STUDENT	Grade
1	19KE1A0512	BANDARU VENKATA SUDHISHANA	SL
2	19KE1A0526	CHILAKA KUMARI	SL
3	19KE1A0531	DANABOYINA PAVANI	SL
4	19KE1A0535	DHADI NAGA POOJITHA	SL
5	19KE1A0542	GANGISETTY SRI LAKSHMI	SL
6	19KE1A0548	GUNDA PRAVALLIKA	SL
7	19KE1A0549	GUNTI KALYANI	SL
8	19KE1A0561	KONIKI BHARGAVI	SL
9	19KE1A0571	MEDARAMETLA RENUKA CHOWDARY	SL
10	19KE1A0586	PALCHURI MADHU HARIKA	SL
11	19KE1A0591	PAREPALLI SUSHMA	SL
12	19KE1A0595	POLU ANUHYA	SL
13	19KE1A0597	PRODDUTURI SATHVIKA	SL
14	19KE1A5B7	THOLUSURI BHUVANESWARI	SL
15	19KE1A5B8	THOTA GOWTHAMI	SL

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SUBJECT CODE: **R194105G**	YEAR: **IV** SEMESTER: **I**
REGULATION: **R19**	COURSE TYPE: **REGULAR**
ACADEMIC YEAR : **2022-2023**	CREDITS: **3**

TUTORIAL QUESTIONS

1.Explain the Storage system of Amazon S3(Simple storage service)
2.Explain the Storage system of Bigtable?

Course Instructor:

Program Coordinator

HOD

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TUTORIAL QUESTIONS

1.Explain the Storage system of ApacheHadoop?

Course Instructor:

Program Coordinator

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TUTORIAL QUESTIONS

1.Steps for create EC2 Instances and connecting clients through firewalls
2.How to use S3 in java

Course Instructor:

Program Coordinator

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SUBJECT CODE: **R194105G**	YEAR: **IV** SEMESTER: **I**
REGULATION: **R19**	COURSE TYPE: **REGULAR**
ACADEMIC YEAR : **2022-2023**	CREDITS: **3**

TUTORIAL QUESTIONS

1.Explain Microsoft Cloud services
- i)Microsoft Azure
- ii)Sharepoint services
- iii)Microsoft CRM
- iv)ExchangeOnline
- v)Windows Live

Course Instructor:

Program Coordinator

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REGULATION: **R19**	COURSE TYPE: **REGULAR**
ACADEMIC YEAR : **2022-2023**	CREDITS: **3**

TUTORIAL QUESTIONS

1.Explain the architecture of Google App engine ?

Course Instructor:

Program Coordinator **HOD**

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COURSE ASSESSMENT TOOLS AND WEIGHTAGES

Direct Assessment (DA)			**Indirect Assessment (IA)**	
Assessment Tool		**Weightage**	**Assessment Tool**	**Weightage**
Continuous Internal Evaluation (CIE)	MID-I	30%	Course End Survey - CES (Feedback on course outcomes collected from students)	100%
	Objective-I			
	Assignment-I			
	MID-II			
	Objective-II			
	Assignment-II			
Semester End Examination (SEE)		70%	Total (CES)	100%
Total (CIE + SEE)		100%		
Weightage of Direct Assessment(DA) is 80%			Weightage of Indirect Assessment(IA) is 20%	
TOTAL = DA + IA = 100%				

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COURSE OUTCOMES

After the completion of the course, the student will be able to

#	STATEMENT
C415.1	Ability To Understand Various Service Delivery Models And Parallel&Distributed Computing
C415.2	Analyze The Economics, Financial, And Technological Implications For Selecting Cloud Computing For Own Organization .
C415.3	Implement Different Types Of Virtualization Technologies For Data-Center Automation.
C415.4	Analyze Various Scheduling Algorithms For Resource Management And Identify Security Implications In Cloud Computing
C415.5	Illustrate The Fundamental Concepts Of Cloud Storage And Demonstrate Their Use In Storage Systems Such As S3 ,HDFS,Megastore,Bigtable.
C415.6	Choose Among Various Cloud Technologies For Implementing Applications

Course Articulation Matrix: Mapping Course Outcomes (COs) with Program Outcomes (POs)

COs/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
C415.1														
C415.2		2		1									2	3
C415.3	3	3		2									2	2
C415.4		3	1	2									2	2
C415.5	3	2		2									2	2
C415.6	3	2	1	2									2	2

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Program Outcomes & Program Specific Outcomes

PO1	**Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems
PO2	**Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations
PO4	**Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5	**Modern tool usage:** Create, select, and apply appropriate techniques, resources ,and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
PSO 2	Design and develop computer programs/computer-based systems in the areas related to algorithms, networking, cloud computing, AI, and data analytics of varying complexity.

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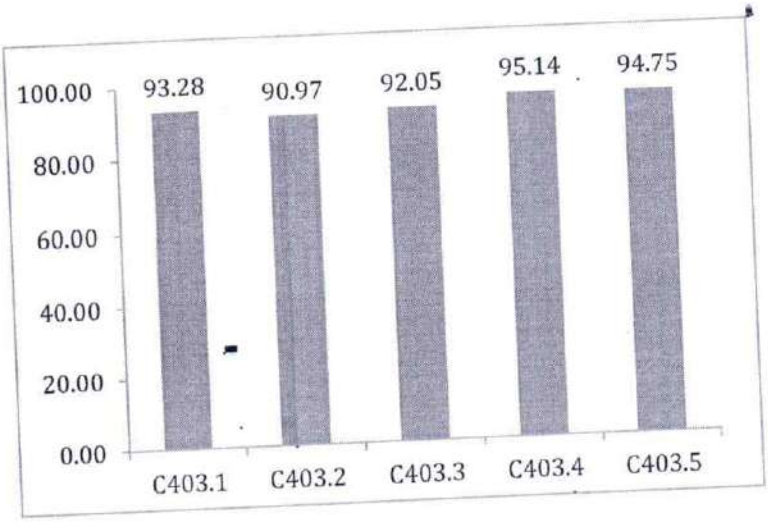
DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

OVERALL ATTAINMENT OF COURSE OUTCOMES (CO) THROUGH DIRECT AND INDIRECT ASSESSMENT TOOLS

CO No	DIRECT ASSESSMENT					INDIRECT ASSESSMENT	TOTAL AT% THROUGH (80% DA + 20% IDA)	TARGET	AT LEVEL	YES/ NO
	CIE (100%)	SEE (100 %)	30% of CIE	70% of SEE	TOTAl (30% CIE +70% SEE)					
C403.1	85	97	42.69	48.30	91.0	93.50	93.28	60.00	3	YES
C403.2	76	97	38.21	48.30	86.5	92.68	90.97	60.00	3	YES
C403.3	83	97	41.47	48.30	89.8	90.24	92.05	60.00	3	YES
C403.4	95	97	47.56	48.30	95.9	91.06	95.14	60.00	3	YES
C403.5	95	97	47.44	48.30	95.7	89.43	94.75	60.00	3	YES
C403.6	97	97	29.10	67.90	97.0	90.24	95.65	60.00	3	YES



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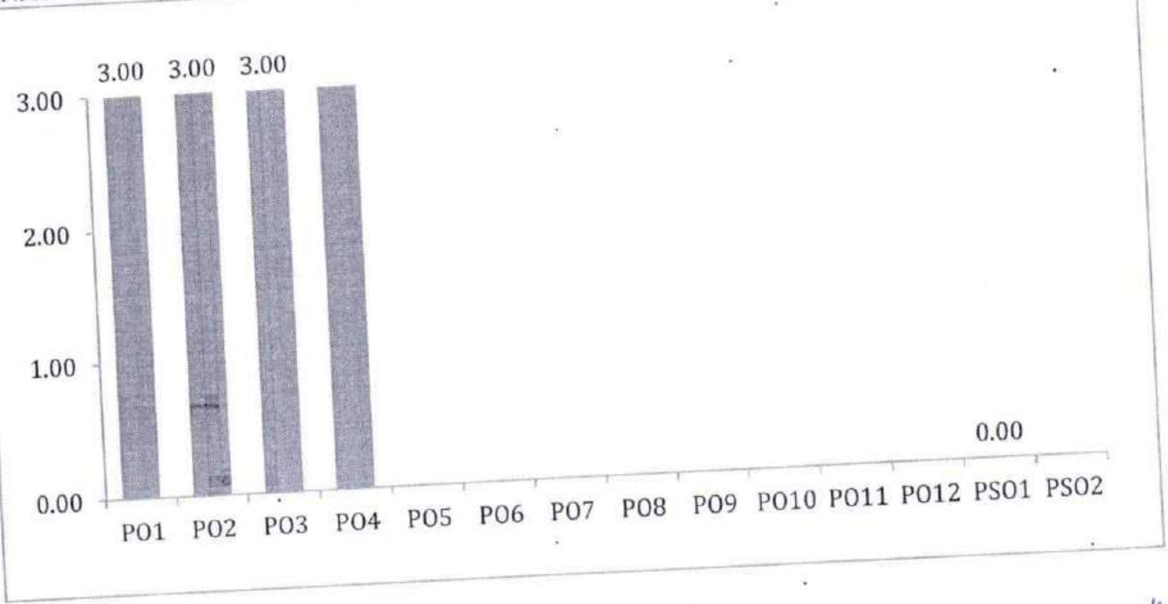
OVERALL ATTAINMENT OF PO&PSO THROUGH DIRECT ASSESSMENT TOOL

CO #	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
C403.1														
C403.2		0.60		0.43										
C403.3	1.50	0.90		0.86										
C403.4		0.90	3.00	0.86										
C403.5	1.50	0.60		0.86										
PO AT	3.00	3.00	3.00	3.00										

FINAL PO ATTAINMENT



HOD

COURSE COORDINATOR

NBA CO-ORDINATOR

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DEPARTMENT OF COMPUTER SCIENCE ANI

REMEDIAL CLASS SCHEDUL

COURSE: **CloudComputing**	DEGREE: **B.**
COURSE CODE: **R194105G**	YEAR: **IV**
REGULATION: **R19**	COURSE TY
ACADEMIC YEAR: **2022-2023**	CREDITS: .**3**

Class: IV-B.Tech CSE **Semester: I** **LH. NO.318**

Day	9:00--12:30					01:20-03:30	03:30-04:30
Monday					L		CNS
Tuesday					U		ML
Wednesday					N		UML&DP
Thursday					C		SPM
Friday					H		CC
Saturday							ES

Subject Code	Subject	Name of the Faculty
R1941051	Cryptography and Network Security	
R1941052	UML & Design Patterns	
R1941053	Machine Learning	
R194105E	Software Project Management	
R194105G	**CloudComputing**	
R194104K	Embedded systems	

Course Instructor

Program Coordinator

HOD

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DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

Attendence Sheet For Remedial Classes

COURSE: **CloudComputing**	DEGREE: **B.Tech**
COURSE CODE: **R194105G**	YEAR: **IV** SEMESTER: **I**
REGULATION: **R19**	COURSE TYPE: **REGULAR**
ACADEMIC YEAR: **2022-2023**	CREDITS: **3**

S.NO	ROLL.NO	Date 09-09-22	Date 16-09-22	Date 23-09-22	Date 7-10-22	Date 14-10-22	Date 28-10-22
1	19KE1A0505	Menaka	Menaka	Menaka	Menaka	Menaka	Menaka
2	19KE1A0506	Prasanthi	Prasanthi	Prasanthi	Prasanthi	Prasanthi	Prasanthi
3	19KE1A0524	Joshitha	Joshitha	Joshitha	Joshitha	Joshitha	Joshitha
4	19KE1A0535	Poojitha	Poojitha	Poojitha	Poojitha	Poojitha	Poojitha
5	19KE1A0540	Heena	Heena	Heena	Heena	Heena	Heena
6	19KE1A0544	Ashritha	Ashritha	Ashritha	Ashritha	Ashritha	Ashritha
7	19KE1A0548	Pravallika	Pravallika	Pravallika	Pravallika	Pravallika	Pravallika
8	19KE1A0553	Bhar	Bhar	Bhar	Bhar	Bhar	Bhar
9	19KE1A0566	Soumithri	Soumithri	Soumithri	Soumithri	Soumithri	Soumithri
10	19KE1A0567	Aparna	Aparna	Aparna	Aparna	Aparna	Aparna
11	19KE1A0568	Akanksha	Akanksha	Akanksha	Akanksha	Akanksha	Akanksha
12	19KE1A0571	Remlara	Remlara	Remlara	Remlara	Remlara	Remlara
13	19KE1A0572	Haripriya	Haripriya	Haripriya	Haripriya	Haripriya	Haripriya
14	19KE1A0573	Sulthana	Sulthana	Sulthana	Sulthana	Sulthana	Sulthana
15	19KE1A0575	Sushmitha	Sushmitha	Sushmitha	Sushmitha	Sushmitha	Sushmitha
16	19KE1A0576	Swaroopa	Swaroopa	Swaroopa	Swaroopa	Swaroopa	Swaroopa
17	19KE1A0578	Navya	Navya	Navya	Navya	Navya	Navya
18	19KE1A0580	AS	AS	AS	AS	AS	AS
19	19KE1A0581	Yamuna	Yamuna	Yamuna	Yamuna	Yamuna	Yamuna
20	19KE1A0582	KJ	KJ	KJ	KJ	KJ	KJ
21	19KE1A0583	Lakky	Lakky	Lakky	Lakky	Lakky	Lakky
22	19KE1A0587	Dhana	Dhana	Dhana	Dhana	Dhana	Dhana
23	19KE1A0588	Sarika	Sarika	Sarika	Sarika	Sarika	Sarika
24	19KE1A0589	NY	NY	NY	NY	NY	NY
25	19KE1A0590	Vaiyanka	Vaiyanka	Vaiyanka	Vaiyanka	Vaiyanka	Vaiyanka
26	19KE1A0591	Sush	Sush	Sush	Sush	Sush	Sush
27	19KE1A0593	Sneha	Sneha	Sneha	Sneha	Sneha	Sneha
28	19KE1A0596	Ruchitha	Ruchitha	Ruchitha	Ruchitha	Ruchitha	Ruchitha
29	19KE1A5A2	SG	SG	SG	SG	SG	SG
30	19KE1A5A4	SK.Rasi	SK.Rasi	SK.Rasi	SK.Rasi	SK.Rasi	SK.Rasi
31	19KE1A5A7	Sindhu	Sindhu	Sindhu	Sindhu	Sindhu	Sindhu
32	19KE1A5B0	Jeevani	Jeevani	Jeevani	Jeevani	Jeevani	Jeevani
33	19KE1A5B7	Bhuva	Bhuva	Bhuva	Bhuva	Bhuva	Bhuva
	19KE1A5B8	Gouthami	Gouthami	Gouthami	Gouthami	Gouthami	Gouthami

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34							
35	19KE1A5B9	naga mani	naga mani	naga mani	naga mani	naga mani	naga mani
36	19KE1A5C0	Pooja	Pooja	Pooja	Pooja	Pooja	Pooja
37	19KE1A5C1	Rani	Rani	Rani	Rani	Rani	Rani
38	19KE1A5C4	Latha	Latha	Latha	Latha	Latha	Latha

Topics Covered:

1. cloud delivery Models
2. Architecture of distributed System.
3. cloud Infrastructure at Amazon.
4. The Zookeeper in Amazon.
5. Virtualization & Types of virtualization.
6. scheduling algorithms
7. scheduling Map-Reduce applications
8. Two Level Resource allocation architecture.
9. Amazon Simple Storage Service
10. Virtual machine Security
11. cloud-based Simulation of a Distributed -tr algorithm.

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IMPACT ANALYSIS ON SLOW LEARNERS

S.NO	ROLL.NO	NAME OF THE STUDENT	MID -1 MARKS	MID-2 MARKS	REMARKS
1	19KE1A0505	ALAPATI MENAKA	14	17	IMPROVED
2	19KE1A0506	ALLA DEVI PRASANTHI	14	20	IMPROVED
3	19KE1A0524	CHERUKURI JOSHITHA	14	18	IMPROVED
4	19KE1A0535	DHADI NAGA POOJITHA	14	14	------------
5	19KE1A0540	GALLA HEMASREE	14	16	IMPROVED
6	19KE1A0544	GOPIDESI SAI ARSHITHA	14	18	IMPROVED
7	19KE1A0548	GUNDA PRAVALLIKA	14	14	-----------
8	19KE1A0553	KAMATHAM BALA BHARATHI	14	21	IMPROVED
9	19KE1A0566	MADALA SOUMITHRI	14	20	IMPROVED
10	19KE1A0567	MAKKENA APARNA	14	18	IMPROVED
11	19KE1A0568	MANDAVA AKANKSHA	5	16	IMPROVED
12	19KE1A0571	MEDARAMETLA RENUKA CHOWDARY	12	7	-------------
13	19KE1A0572	MEDATATI HARIPRIYA	14	18	IMPROVED
14	19KE1A0573	MOHAMMED TASNEEM SULTANA	13	18	IMPROVED
15	19KE1A0575	MURTHI SUSHMITHA	14	16	IMPROVED
16	19KE1A0576	MUTTHIREDDY SWAROOPA	12	18	IMPROVED
17	19KE1A0578	NALABOTHULA NAVYA	14	15	------------
18	19KE1A0580	NANGINENI ASWANI	13	16	IMPROVED
19	19KE1A0581	NARABOYINA YAMUNA	14	16	IMPROVED
20	19KE1A0582	NARRA VIJAYA LAKSHMI	14	15	-----------
21	19KE1A0583	NUKALA RAJYA LAKSHMI	14	17	IMPROVED
22	19KE1A0587	PALETI DHANALAKSHMI	14	20	IMPROVED
23	19KE1A0588	PALLA HEMA SARIKA	14	18	IMPROVED

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24	19KE1A058 9	PALUCHURI MOUNIKA	14	16	IMPROVED
25	19KE1A059 0	PANDILLA PRIYANKA	13	15	------------
26	19KE1A059 1	PAREPALLI SUSHMA	13	14	------------
27	19KE1A059 3	PERAM SNEHALATHA	14	16	IMPROVED
28	19KE1A059 6	PERNI RUCHITHA	13	16	IMPROVED
29	19KE1A5A2	SANKA NAGA GOWTHAMI	14	15	------------
30	19KE1A5A4	SHAIK BHASHEERA	12	16	IMPROVED
31	19KE1A5A7	SRIRAM SINDHU	14	15	-
32	19KE1A5B0	SYAMALA TRIVENI	13	18	IMPROVED
33	19KE1A5B7	THOLUSURI BHUVANESWARI	13	7	-----------
34	19KE1A5B8	THOTA GOWTHAMI	5	5	------------
35	19KE1A5B9	UPPALA NAGAMANI	12	15	IMPROVED
36	19KE1A5C0	VADDE POOJITHA	14	16	IMPROVED
37	19KE1A5C1	VAKA SUDHA RANI	14	16	IMPROVED
38	19KE1A5C4	VUNADI SRI LATHA	14	18	IMPROVED

IMPACT EFFECT:

Slow Learners identified based on Mid-1 Marks, 70% of them are improved in the Mid-2 Marks.

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DEPARTMENT OF INFORMATION TECHNOLOGY

CONTENTS OF COURSE FILE

S.NO	CONTENTS	AVAILABLE/ NOT AVAILABLE
1	V/M/PEO/PO/PSO	Available
2	Course syllabus including course structure	Available
3	Course outcomes	Available
4	Mapping co with po/pso	Available
5	Academic calendar	Available
6	Timetable	Available
7	Lesson plan	Available
8	Gaps beyond syllabus	Available
9	Gaps with-in syllabus	Available
10	Gaps addressed by a resource person	Available
11	Gaps addressed by other methodology	Available
12	Web references	Available
13	Lecture notes	Available
14	List of ppt's & videos	Available
15	CD with ppt & videos	Available
16	End exam question papers	Available
17	Internal question paper with key	Available
18	Assignment question papers	Available
19	Scheme of evaluation (university, mid, assignment)	Available
20	Tutorial topics with evidence	Available
21	Result analysis to identify weak & advanced learners	Available
22	Result analysis at the end of course	Available
23	Remedial class schedule & evidences	Available
24	Bright student engagement documentation	Available
25	Course assessment	Available
26	CO PO attainment	Available
27	Observation for not attaining co or for improvement	Available
28	Plan of action for improve co attainment	Available
29	Attendance register	Available
30	Course file digital form	Available

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Information Technology Dept
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DEPARTMENT OF INFORMATION TECHNOLOGY

INSTITUTE VISION AND MISSION

Vision:

To be a pioneer institute in engineering education, fostering academic excellence, and producing empowered women engineers, blended with ethics and values, to serve the society.

Mission:

M1	To achieve academic excellence through innovative teaching-learning practices.
M2	To inculcate self-discipline, ethics and values amongst the learners.
M3	To bridge the gap between industry and academia through the industry-institute interface.
M4	To promote higher education, research and inculcate entrepreneurial attitude amongst the learners.

DEPARTMENT VISION AND MISSION

Department Vision:

To emerge as center of excellence in IT education, research and innovation by promoting competent and woman engineers with ethical values for development of the society

Department Mission:

M1	Bringing innovative approach in teaching-learning process competent Information Technology engineers.
M2	To inculcate ethical and social values among the students for improving their life skills.
M3	To promote research and development in the domain of Information Technology to meet the emerging needs of the Society.
M4	To promote higher education, technological innovation and entrepreneurship in the areas of IT with interdisciplinary connection.

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DEPARTMENT OF INFORMATION TECHNOLOGY

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

PEO 1	Graduates will be able to apply foundational knowledge to solve challenges in Information Technology
PEO 2	Graduates will be able to become quality engineers and succeed in the programming skills.
PEO 3	Graduates will be able to deliver realistic and innovative solutions to real-world challenges in the fields of Information Technology.
PEO 4	Graduates will be able to acquire technical knowledge though demonstrating leadership abilities, social awareness.

DEPARTMENT PROGRAM SPECIFIC OUTCOMES (PSOs):

PSO 1	To design software applications, providing with open-ended programming environments.
PSO 2	To demonstrate and interpretation of computer programs and computer support systems in the areas of data analysis and the latest trending technologies.

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Program Outcomes:

PO No	Description
1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of Mathematics, Natural Sciences, And Engineering Sciences
3	**Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations
4	**Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5	**Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.
6	**The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply the set one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
12	**Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

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COURSE SYLLABUS INCLUDING COURSE STRUCTURE

IV Year –I Semester		L	T	P	C
		3	0	0	3
CLOUD COMPUTING					

UNIT I

Introduction: Network centric computing, Network centric content, peer-to –peer systems, cloud computing delivery models and services, Ethical issues, Vulnerabilities, Major challenges for cloud computing. Parallel and Distributed Systems: introduction, architecture, distributed systems, communication protocols, logical clocks, message delivery rules, concurrency, and model concurrency with Petri Nets.

UNIT II

Cloud Infrastructure: At Amazon, The Google Perspective, Microsoft Windows Azure, Open Source Software Platforms, Cloud storage diversity, Inter cloud, energy use and ecological impact, responsibility sharing, user experience, Software licensing, Cloud Computing : Applications and Paradigms: Challenges for cloud, existing cloud applications and new opportunities, architectural styles, workflows, The Zookeeper, HPC on cloud.

UNIT III

Cloud Resource virtualization: Virtualization, layering and virtualization, virtual machine monitors, virtual machines, virtualization- full and para, performance and security isolation, hardware support for virtualization, Case Study: Xen, vBlades, Cloud Resource Management and Scheduling: Policies and Mechanisms, Applications of control theory to task scheduling, Stability of a two-level resource allocation architecture, feedback control based on dynamic thresholds, coordination, resource bundling, scheduling algorithms, fair queuing, start time fair queuing, cloud scheduling subject to deadlines, Scheduling Map Reduce applications, Resource management and dynamic application scaling.

UNIT IV

Storage Systems: Evolution of storage technology, storage models, file systems and database, distributed file systems, general parallel file systems. Google file system. Apache Hadoop, Big Table, Megastore (text book 1), Amazon Simple Storage Service(S3) (Text book 2), Cloud Security: Cloud security risks, security – a top concern for cloud users, privacy and privacy impact assessment, trust, OS security, Virtual machine security, Security risks.

UNIT V

Cloud Application Development: Amazon Web Services : EC2 – instances, connecting clients, security rules, launching, usage of S3 in Java, Cloud based simulation of a Distributed trust algorithm, Cloud service for adaptive data streaming (Text Book 1), Google: Google App Engine, Google Web Toolkit (Text Book 2), Microsoft: Azure Services Platform, Windows live, Exchange Online, Share Point Services, Microsoft Dynamics CRM

DEPARTMENT OF INFORMATION TECHNOLOGY

8	PR4101	Project –I	0	0	0	2
9	MC4101	IPR & Patents	3	0	0	0
		Total	21	1	2	22
*Relevant theory to be taught in the lab						

(Text Book 2)

Text Books:

1) Cloud Computing, Theory and Practice,1st Edition, Dan C Marinescu, MK Elsevier publisher ,2013
2) Cloud Computing, A Practical Approach, 1st Edition, Anthony T Velte, Toby J Velte, Robert Elsenpeter, TMH,2017

Reference Books:

1) Mastering Cloud Computing, Foundations and Application Programming,1st Edition, Raj Kumar Buyya, Christen vecctiola, S Tammarai selvi, TMH,2013
2) Essential of Cloud Computing, 1st Edition, K Chandrasekharan, CRC Press, 2014.
3) Cloud Computing, A Hands on Approach, Arshdeep Bahga, Vijay Madisetti, Universities Press, 2014.

CourseStructure

IV Year – I SEMESTER(R19)

S.No	Course Code	Courses	L	T	P	Credits
1	IT4101	Cryptography and Network Security	3	0	0	3
2	IT4102	Machine Learning	3	1	0	4
3	IT4103	Advanced Computer Networks	3	0	0	3
4	OE4101	**Open Elective II (Inter Disciplinary)**	3	0	0	3
5	PE4101	**Professional Elective III** 1. Big Data Analytics 2. Social Networking 3. Ad-hoc and Sensor Networks 4. Cloud Computing 5. Design Patterns	3	0	0	3
6	PE4102	**Professional Elective IV** 1. Distributed Systems 2. DevOps 3. Internet of Things 4. Data Science 5. Biometrics	3	0	0	3
7	IT4104	Unified Modeling Language (UML) Lab *	0	0	2	1

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DEPARTMENT OF INFORMATION TECHNOLOGY

COURSE: **CloudComputing**	DEGREE: **B.Tech**
COURSE CODE: **R194105G**	YEAR: **IV** SEMESTER: **I**
REGULATION: **R19**	COURSE TYPE: **REGULAR**
ACADEMIC YEAR: **2022-23**	CREDITS: **3**

COURSE OBJECTIVES & OUTCOMES

COURSE OBJECTIVE:

Students will demonstrate a mastery of the course materials and concepts within in class discussions

1	The Ability to Implement Task Scheduling Algorithms in Cloud.
2	The Ability To implement Virtualization mechanisam
3	Apply Map-Reduce concept to applications
4	Familiar with Private and Public and Hybrid and Community Clouds .
5	Broadly educate to know the impact of engineering on legal and societal issues involved.

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DEPARTMENT OF INFORMATION TECHNOLOGY

COURSE OUTCOME:

By the end of the course student will be able to:

CO.NO	Description
C405.1	Ability To Understand Various Service Delivery Models And Parallel&Distributed Computing.
C405.2	Analyze The Economics, Financial, And Technological Implications For Selecting Cloud Computing For Own Organization .
C405.3	Implement Different Types Of Virtualization Technologies For Data-Center Automation.
C405.4	Analyze Various Scheduling Algorithms For Resource Management And Identify Security Implications In Cloud Computing
C405.5	Illustrate The Fundamental Concepts Of Cloud Storage And Demonstrate Their Use In Storage Systems Such As S3 ,HDFS,Megastore,Bigtable.
C405.6	Choose Among Various Cloud Technologies For Implementing Applications

Course Instructor

Program Coordinator

HOD

PRINCIPAL
MALINENI LAKSHMAIAH
WOMEN'S ENGINEERING COLLEGE
PULLADIGUNTA, GUNTUR-17.

HOD
Information Technology Dept
Malineni Lakshmaiah Women's Engg. Colle
Pulladigunta, Guntur - 52

MALINENI LAKSHMAIAH WOMEN'S ENGINEERING COLLEGE

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Pulladigunta (V), Vatticherukuru(M), Guntur-522017

DEPARTMENT OF INFORMATION TECHNOLOGY

COURSE OUTCOMES WITH PO & PSO MAPPING

COURSE:CloudComputing	DEGREE: **B.Tech**
COURSE CODE: **R194105G**	YEAR: **IV** SEMESTER: **I**
REGULATION: **R19**	COURSE TYPE: **REGULAR**
ACADEMIC YEAR : **2022-23**	CREDITS: **3**

By the end of the course student will be able to:

CO No.	Course Outcome Statement	Taxonomy Level
C405.1	Ability To Understand Various Service Delivery Models And Parallel&Distributed Computing.	**2(Understand)**
C405.2	Analyze The Economics, Financial, And Technological Implications For Selecting Cloud Computing For Own Organization .	**4 (Analyze)**
C405.3	Implement Different Types Of Virtualization Technologies For Data-Center Automation.	**3(Apply)**
C405.4	Analyze Various Scheduling Algorithms For Resource Management And Identify Security Implications In Cloud Computing	**4(Analyze)**
C405.5	Illustrate The Fundamental Concepts Of Cloud Storage And Demonstrate Their Use In Storage Systems Such As S3 ,HDFS,Megastore,Bigtable.	**3(Apply)**
C405.6	Choose Among Various Cloud Technologies For Implementing Applications	**3(Apply)**

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CO: PO and PSO Mapping

Mapping of Course Outcomes with Program Outcomes:

Strong -3 Moderate -2 Slight -1

PO / CO	CC	2022-2023	3	0	0	3	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
C405.1	Ability To Understand Various Service Delivery Models And Parallel&Distributed Computing.						3	-	-	-	-									
C405.2	Analyze The Economics, Financial, And Technological Implications For Selecting Cloud Computing For Own Organization .						2	2	3	1	-									2
C405.3	Implement Different Types Of Virtualization Technologies For Data-Center Automation.						2	2	3	2	-									3
C405.4	Analyze Various Scheduling Algorithms For Resource Management And Identify Security Implications In Cloud Computing						2	2	3	3	-									3
C405.5	Illustrate The Fundamental Concepts Of Cloud Storage And Demonstrate Their Use In Storage Systems Such As S3 ,HDFS,Megastore,Bigtable.						3	2	2		-									3
C405.6	Choose Among Various Cloud Technologies For Implementing Applications						3	2	2	2	-									
TOTAL							15	10	13	8	-									11
No of Co's Mapping with Po/Pso							6	5	5	4										4
Average							2.5	2	2.6	2										2.75

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JUSTIFICATION FOR CO-PO MAPPING

MAPPING	Slight 1 / Moderate-2 / Strong-3	JUSTIFICATION
C405.1-PO1	3	Strongly mapped as the students will be able to Apply the knowledge of engineering fundamentals in Service Delivery Models of Cloud And Parallel&Distributed Computing Environment.
C405.2-PO1	2	Moderately mapped as the students will be able to Apply the knowledge of engineering fundamentals in selecting cloud computing for an organizations.
C405.2-PO2	2	Moderately mapped as the students will be able to Analyze the Economics, Financial, And Technological Implications For Selecting Cloud Computing For Own Organization .
C405.2-PO3	3	Strongly mapped as the students will be able to Design the Economics, Financial, And Technological Implications .
C405.2-PO4	1	Slightly mapped as the students will be able to Use research-based knowledge in selecting cloud computing for own organization
C405.2-PSO2	2	Moderately mapped as the students will be able to Design and develop computer programs and computer-based systems in the areas related to Cloud Computing, AI and latest trending technologies in Selecting Cloud Computing For Own Organization
C405.3-PO1	2	Moderately mapped as the students will be able to Apply the knowledge of engineering fundamentals in Virtualization technologies for Data-Center automation.
C405.3-PO2	2	Moderately mapped as the students will be able to Analyze the types of virtualization techniques for data-center automation..
C405.3-PO3	3	Strongly mapped as the students will be able to Design the different types of virtualization for data-center automation.
C405.3-PO4	2	Moderately mapped as the students will be able to Use research-based knowledge in Data-center automation.
C405.3-PSO2	3	Strongly mapped as the students will be able to Design and develop computer programs and computer-based systems in the areas related to Cloud Computing, AI and latest trending technologies in virtualization for data-center automation.
C405.4-PO1	2	Moderately mapped as the students will be able to Apply the knowledge of engineering fundamentals in selecting Scheduling Algorithms For Resource Management.
C405.4-PO2	2	Moderately mapped as the students will be able to Analyze the Scheduling Algorithms For Resource Management And Identify

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		Security Implications In Cloud Computing
C405.4-PO3	3	Strongly mapped as the students will be able to Design the Scheduling Algorithms For Resource Management
C405.4-PO4	3	Strongly mapped as the students will be able to Use research-based knowledge in Security Implications In Cloud Computing
C405.4-PSO2	3	Strongly mapped as the students will be able to Design and develop computer programs and computer-based systems in the areas related to Cloud Computing, AI and latest trending technologies for selecting scheduling algorithms.
C405.5-PO1	3	Strongly mapped as the students will be able to Apply the knowledge of engineering fundamentals in the Fundamental Concepts Of Cloud Storage And Demonstrate Their Use In Storage Systems
C405.5-PO2	2	Moderately mapped as the students will be able to Analyze the various cloud storage techniques.
C405.5-PO3	2	Moderately mapped as the students will be able to Design the cloud storage systems.
C405.5-PSO2	3	Strongly mapped as the students will be able to Design and develop computer programs and computer-based systems in the areas related to Cloud Computing, AI and latest trending technologies in cloud storage in different vendors.
C405.6-PO1	3	Strongly mapped as the students will be able to Apply the knowledge of engineering fundamentals in Various Cloud Technologies For Implementing Applications
C405.6-PO2	2	Moderately mapped as the students will be able to Analyze the various Cloud Vendors for developing applications in cloud
C405.6-PO3	2	Moderately mapped as the students will be able to Design the model for implementing applications in Cloud
C405.6-PO4	2	Moderately mapped as the students will be able to Use research-based knowledge for implementing applications in Cloud Computing.

Website: www.jntuk.edu.in
Email: dap@jntuk.edu.in

Phone: 0884-2300991

Directorate of Academic Planning

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY KAKINADA
KAKINADA-533003, Andhra Pradesh, INDIA
(Established by AP Government Act No. 30 of 2008)

Lr. No. DAP/AC/IV Year /B. Tech/B. Pharmacy/2022 *Date 25.06.2022*

Dr. KVSG Murali Krishna,
M.E, Ph.D.,
Director, Academic Planning
JNTUK, Kakinada

To
All the Principals of Affiliated Colleges.
JNTUK, Kakinada.

Academic Calendar for IV Year - B. Tech/B. Pharmacy for the AY 2022-23

I SEMESTER			
Description	**From**	**To**	**Weeks**
Commencement of Class Work	**04.07.2022**		
I Unit of Instruction	04.07.2022	27.08.2022	8W
I Mid Examinations	29.08.2022	03.09.2022	1W
II Unit of Instructions	05.09.2022	29.10.2022	8W
II Mid Examinations	31.10.2022	05.11.2022	1W
Preparation & Practicals	07.11.2022	12.11.2022	1W
End Examinations	14.11.2022	26.11.2022	2W
Commencement of II Semester Class Work	**05.12.2022**		
II SEMESTER			
I Unit of Instructions	**05.12.2022**	28.01.2023	8W
I Mid Examinations	30.01.2023	04.01.2023	1W
II Unit of Instructions	06.01.2023	01.04.2023	8W
II Mid Examinations	03.04.2023	08.04.2023	1W
Preparation & Practicals	10.04.2023	15.04.2023	1W
End Examinations	17.04.2023	29.04.2023	2W

KVSG 25/6/22

Director,
Academics & Planning,
JNTUK

Director
Academic Planning
JNTUK Kakinada

Copy to the Secretary to the Hon'ble Vice Chancellor, JNTUK
Copy to Rector, Registrar, JNTUK
Copy to Director Academic Audit, JNTUK
Copy to Director of Evaluation, JNTUK

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Pulladigunta (Village), Vatticherukuru (Mandal), Guntur-522017, Andhra Pradesh, India
Department of Information Technology

Department Calendar Year: 2022-2023(Odd Semester)

Month	Activity	Activity dates
July	Date of Commencement of class work I unit Instructions for IV B.Tech	4-07-2022
July	Community Service Project for III B.Tech	15-7-2022 to 30-7-2022
August	Date of Commencement of class work I unit Instructions for III B.Tech	1-8-2022
August	Blood donation awareness seminar	1-8-2022
August	Pre-Independence Celebrations	12-8-2022
August	Community Service Project for II B.Tech	22-8-2022 to 3-9-2022
August	Commencement of I mid Examination for IV B. Tech	29-8-2022 to 3-9-2022
September	Teacher's day	5-9-2022
September	Date of Commencement of class work I unit Instructions for II B.Tech	5-9-2022
September	Engineers day	15-9-2022
September	Commencement of I mid Examination for III B. Tech	26-9-2022 to 1-10-2022
October	Commencement of II mid Examination for II, III & IV B. Tech	31-10-2022 to 5-11-2022
November	Commencement of University Practical Examination	7-11-2022 to 12-11-2022
November	Culture club activities	12-112022
November	Commencement of University Theory End Examination	14-11-2022 to 26-11-2022
November	Literature club activities	19-112022
November	Fresher's Day	24-11-2022
November	Commencement of II mid Examination for III B. Tech	28-11-2022 to 3-12-2022
December	Commencement of University Practical Examination for III B.Tech	5-12-2022 to 10-12-2022
December	Commencement of University Theory End Examination for III B.Tech	12-12-2022 to 25-12-2022
December	Commencement of II mid Examination for II B. Tech	19-12-2022 to 24-12-2022
December	Commencement of University Practical Examination for II B.Tech	26-12-2022 to 31-12-2022
January	Commencement of University Theory End Examination for II B.Tech	2-1-2023 to 14-1-2023

HOD

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DEPARTMENT OF INFORMATION TECHNOLOGY

COURSE: **CloudComputing**	DEGREE: **B.Tech**
COURSE CODE: **R194105G**	YEAR: **IV** SEMESTER: **I**
REGULATION: **R19**	COURSE TYPE: **REGULAR**
ACADEMIC YEAR: **2022-23**	CREDITS: **3**

Teaching/Instructional Plan

S.No	Topic(s)	No of Hours	Reference Book	Teaching Methodology
	UNIT-I : Introduction			
1	Network centric computing, Network centric content	1	T1	Chalk & talk
2	peer-to –peer systems architecture	1	T1	Chalk & talk
3	cloud computing delivery models and services	2	T1	PPT1
4	Ethical issues, Vulnerabilities	1	T1	Chalk & talk
5	Major challenges for cloud computing	1	T1	Chalk & talk
6	Parallel and Distributed Systems introduction	1	T1	Chalk & talk
7	Architecture of Parallel Systems	1	T1	Chalk & talk
8	Communication protocols	1	T1	Chalk & talk
9	Logical clocks,Message delivery rules	1	T1	Assignment
10	Concurrency,and model concurrency with Petri Nets.	1	T1	Chalk & talk
		10		
	UNIT-II : : Cloud Infrastructure			
11	Cloud Infrastructure At Amazon	1	T1	Chalk & talk
12	The Google Perspective,	1	T1	Chalk & talk
13	Microsoft Windows Azure,	1	T1	Chalk & talk
14	Open Source Software Platforms,	1	T1	Chalk & talk
15	Cloud storage diversity, Inter cloud,	1	T1	Chalk & talk
16	energy use and ecological impact, responsibility sharing,	1	T1	Chalk & talk
17	Software licensing	1	T1	Chalk & talk
18	Challenges for cloud,	1	T1	Chalk & talk
19	existing cloud applications and new opportunities	1	T1	Chalk & talk

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41	Cloud security risks, security – a top concern for cloud users,	1	T1	Chalk & talk
42	privacy and privacy impact assessment	1	T1	Chalk & talk
43	*trust, OS security,*	1	T1	Seminar
44	Virtual machine security, Security risks.	1	T1	Chalk & talk
		10		
UNIT V:Cloud Application Development				
45	**Amazon Web Services : EC2 – instances**	1	T1	PPT
46	connecting clients, security rules, launching, usage of S3 in Java,	1	T1	PPT
47	Cloud based simulation of a Distributed trust algorithm,	1	T1	Chalk & talk
48	Cloud service for adaptive data streaming	1	T1	Chalk & talk
49	Google: Google App Engine,	1	T2	Chalk & talk
50	Google Web Toolkit	1	T2	Chalk & talk
51	**Azure Services Platform, Windows live, Exchange Online**	1	T2	Chalk & talk
52	SharePoint Services,Dynamics CRM (Text Book 2)	1	T2	Chalk & talk
		8		
TOTAL NO.OF CLASSES =10+11+13+10+8=52				

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Instructional Methods and Pedagogies

The following methods are some of the appropriate and efficient methodologies according to the characteristic of the learner.

S.No.	INSTRUCTIONALMETHODOLOGY	YES/NO
1.	Chalk & Talk	YES
2	PPT	YES
3	NPTEL Videos	
4	Guest Lectures & Workshops	
5	Learning from Industrial visits	
6	Student centric Learning:	
	i. Seminar Method	YES
	ii. Group discussions	YES
	iii. Assignment	YES
	iv. Quiz	YES
	v. Learning from Industrial visits	
	vi. Brain Storming	
	vii. Minutes of paper	
	viii. Puzzles	YES
	ix. TPS(Think Pair Share)	YES

Course Instructor

Program Coordinator

K. Smitha

HOD

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Information Technology Dept
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Pulladigunta, Guntur - 522 017

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ASSIGNMENT-I

COURSE : **CloudComputing**	DEGREE: **B.Tech**
COURSE CODE: **R194105G**	YEAR: **IV** SEMESTER: **I**
REGULATION: **R19**	COURSE TYPE: **REGULAR**
ACADEMIC YEAR : **2022-23**	CREDITS: **3**

Q.No.	QUESTION	Marks Allotted	Course Outcome mapping	Taxonomy level
1.	Explain Cloud Service Delivery Models.	5M	C405.1	Understand
2	Discuss AWS Storage Services In Detail	5M	C405.2	Analyze
3.	Apply Virualization in datacentertechniques in details	5M	C405.3	Apply

1.Explain Cloud Service Delivery Models?
Def:1M
Explanation:3M
DiagramRepresentation:1M

2. Discuss AWS Storage Services In Detail
Def:1M
Explanation:3M
Usage:1M

3. Apply Virualization in datacenter techniques in details
Def:1M
Explanation:3M
DiagramRepresentation:1M

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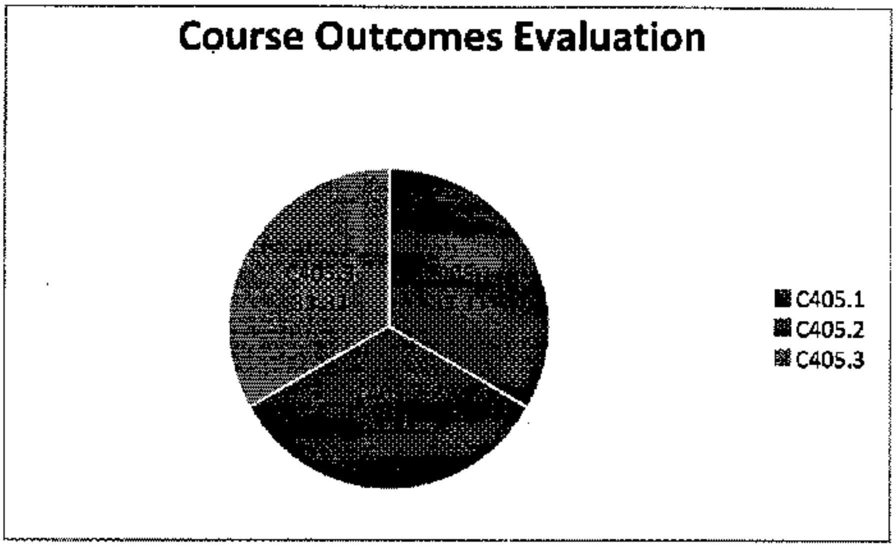
Course Outcomes& Bloom's TaxonomyEvaluation:

Course Outcome Number	Marks Allotted	Percentage of Marks		Taxonomy level	Marks Allotted	Percentage of Marks
C405.1	5	33.33		Remember		
C405.2	5	33.33		Understand	5	100.00
C405.3	5	33.33		Apply	5	100.00
Total Marks	15	100.00		Analyze	5	100.00
				Evaluate		
				Create		
				Total Marks	15	100.00



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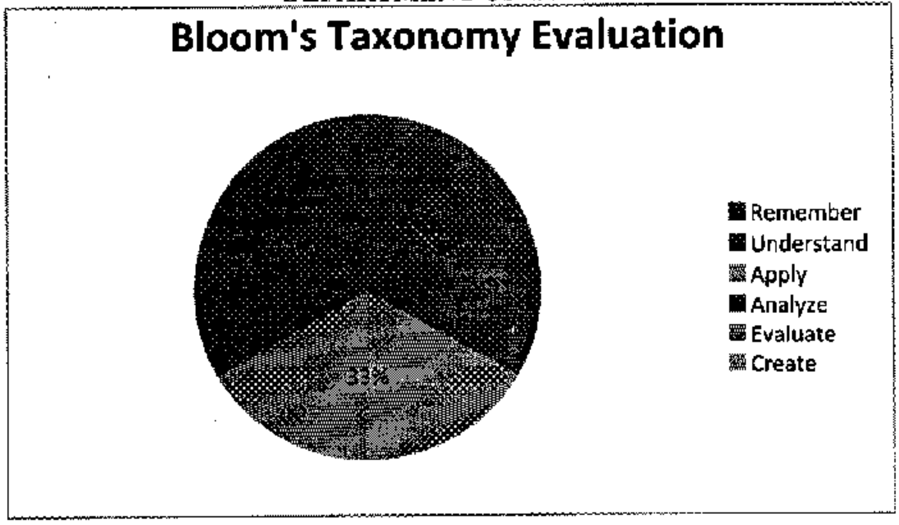

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ASSIGNMENT-II

COURSE : **CloudComputing**	DEGREE: **B.Tech**
COURSE CODE: **R194105G**	YEAR: **IV** SEMESTER: **I**
REGULATION: **R19**	COURSE TYPE: **REGULAR**
ACADEMIC YEAR : **2022-23**	CREDITS: **3**

Q.No.	QUESTION	Marks Allotted	Course Outcome mapping	Taxonomy level
1.	Explain Two-Level Resource Allocation Architecture	2M	C405.4	Analyze
2	Define the scheduling algorithms i)fair queuing ii)short-time fair	3M	C405.4	Analyze
3.	Define Architecture of GoogleFileSystem	3M	C405.5	Apply
4.	Explain Apache Hadoop Storage System	2M	C405.5	Apply
5.	Steps for create and launching Ec2 instances.	5M	C405.6	Apply

1. Explain Two-Level Resource Allocation Architecture
   Explanation:1M
   Diagram:1M

2. Define the scheduling algorithms i)fair queuing ii)short-time fair
   Explanation:3M

3. Define Architecture of GoogleFileSystem
   Def:1
   Explanation:1M
   Digram:1M

4. Explain Apache Hadoop Storage System
   Explanation:1M
   Diagram:1M

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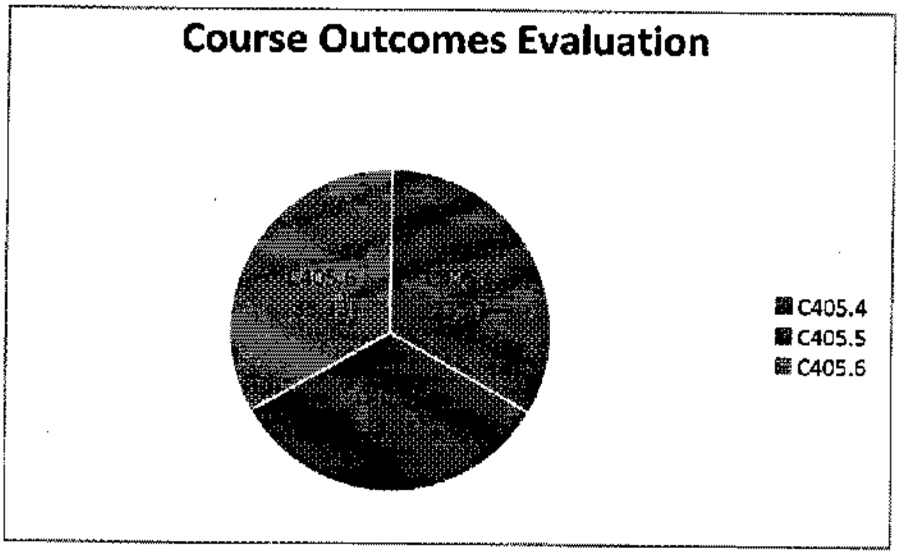
5. Steps for create and launching Ec2 instances.
   Procedure:3M
   Implementation:2M

Course Outcomes& Bloom's TaxonomyEvaluation

Course Outcome Number	Marks Allotted	Percentage of Marks
C405.4	5	33.33
C405.5	5	33.33
C405.6	5	33.33
Total Marks	15	100.00

Taxonomy level	Marks Allotted	Percentage of Marks
Remember		
Understand		
Apply	10	66.67
Analyze	5	33.33
Evaluate		
Create		
Total Marks	15	100.00



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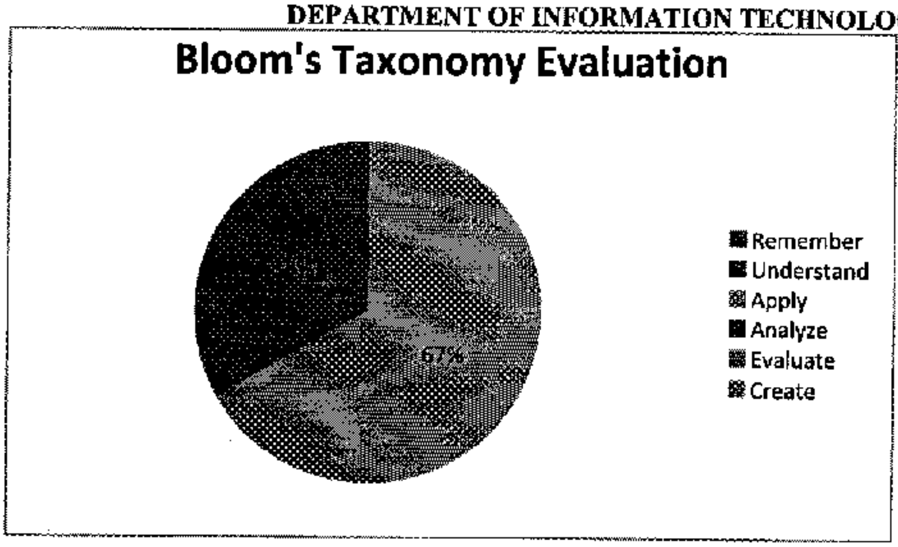

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IV-BTECH I SEMESTER MID-I QUESTION PAPER

COURSE: CloudComputing

Max. Marks: 10 **Date:09/09/2022**

Branches: CSE&IT (UNIVERSITY CODE: R194105G) **Time: 90 min**

Answer all the questions **REG.NO:**

Q.N0			Marks
1(a)	Explain CloudComputing and its delivery models?	[BT:2] [Understand]	2M
1(b)	Explain the challenges for cloud computing?	[BT:2] [Understand]	1.5M
2(a)	Examine the Storage resources in AWS?	[BT:4][Analyze]	2M
2(b)	Classify the following terms i)Ec2 ii)SQS iii)CloudWatch	[BT:4][Analyze]	2M
3	Develop Virtualization in CloudComputing?	[BT:3][Apply]	2.5M

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DEPARTMENT OF INFORMATION TECHNOLOGY

SCHEME OF EVALUATION – MID-1 EXAMINATION

COURSE : **CloudComputing**	DEGREE: **B.Tech**
COURSE CODE: **R194105G**	YEAR: **IV** SEMESTER: **I**
REGULATION: **R19**	COURSE TYPE: **REGULAR**
ACADEMIC YEAR: **2022-23**	CREDITS: **3**

Q.No.	Solution	Marks Allotted	Course Outcome mapping	Taxonomy level
1	a)Explain CloudComputing and its delivery models?	2M	C405.1	Understand
	b)Explain the challenges for cloud computing?	1.5M		
2	a)Examine the Storage resources in AWS?	2M	C405.2	Analyze
	b)Classify the following terms i)Ec2 ii)SQS iii)CloudWatch	2M		
3	Develop Virtualization in CloudComputing?	2.5M	C405.3	Apply

Course Outcome Number	Marks Allotted	Percentage of Marks
C405.1	3.5	35.00
C405.2	4	40.00
C405.3	2.5	33.33
Total Marks	10	100

Taxonomy level	Marks Allotted	Percentage of Marks
Remember	0	0.00
Understand	3.5	35.00
Apply	2.5	25.00
Analyze	4	40.00
Evaluate	0	0.00
Create	0	0.00
Total Marks	10	100

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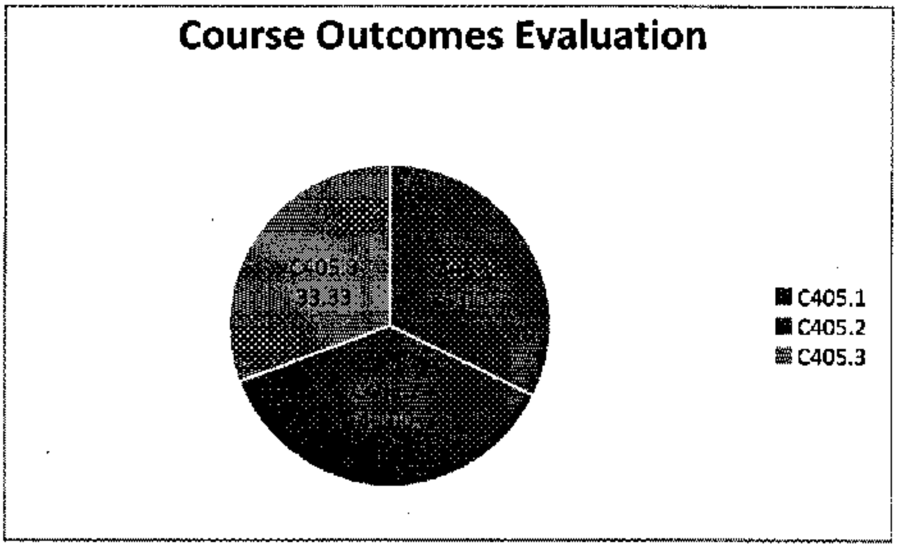

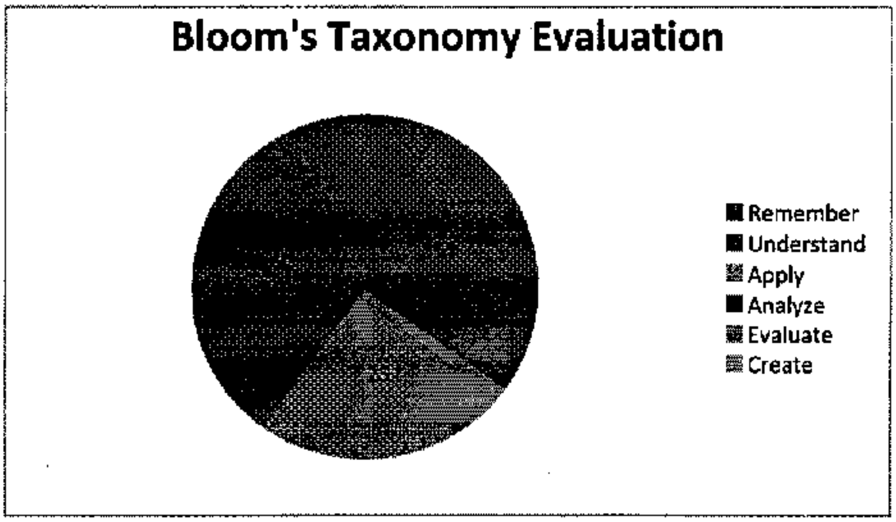

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IV-BTECH I SEMESTER MID-II QUESTION PAPER

COURSE: CloudComputing

Max. Marks: 10 **Date:04/11/2022**

Branches: CSE&IT (UNIVERSITY CODE: R194105G) **Time: 90 min**

Answer all the questions **REG.NO:**

Q.NO			Marks
1.	Develop Sheduling Algorithms in Cloud Computing	[BL:3][Apply]	2.5M
2.	Examine the Storage System of Apache Hadoop	[BL:4][Analyze]	2.5M
3.	Explain how to provide Security to VirtualMachine	[BL:4][Analyze]	2.5M
4	Build EC2 and Steps for Create and Launching Instances in AWS	[BL:3][Apply]	2.5M

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SCHEME OF EVALUATION – MID-II EXAMINATION

COURSE : **CloudComputing**	DEGREE: **B.Tech**
COURSE CODE: **R194105G**	YEAR: **IV** SEMESTER: **I**
REGULATION: **R19**	COURSE TYPE: **REGULAR**
ACADEMIC YEAR: **2022-23**	CREDITS: **3**

Q.No.	Solution	Marks Allotted	Course Outcome mapping	Taxonomy level
1	Develop Sheduling Algorithms in Cloud Computing	2.5M	C405.4	**Analyze**
2	Examine the Storage System of Apache Hadoop	2.5M	C015.5	**Apply**
3	Explain how to provide Security to VirtualMachine	2.5M	C405.4	**Analyze**
4	Build EC2 and Steps for Create and Launching Instances in AWS	2.5M	C405.6	**Apply**

Course Outcome Number	Marks Allotted	Percentage of Marks		Taxonomy level	Marks Allotted	Percentage of Marks
C405.4	5	50.00		Remember	0	0.00
C405.5	2.5	25.00		Understand	0	0.00
C405.6	2.5	25.00		Apply	5	50.00
Total Marks	10	100		Analyze	5	50.00
				Evaluate	0	0.00
				Create	0	0.00
				Total Marks	10	100

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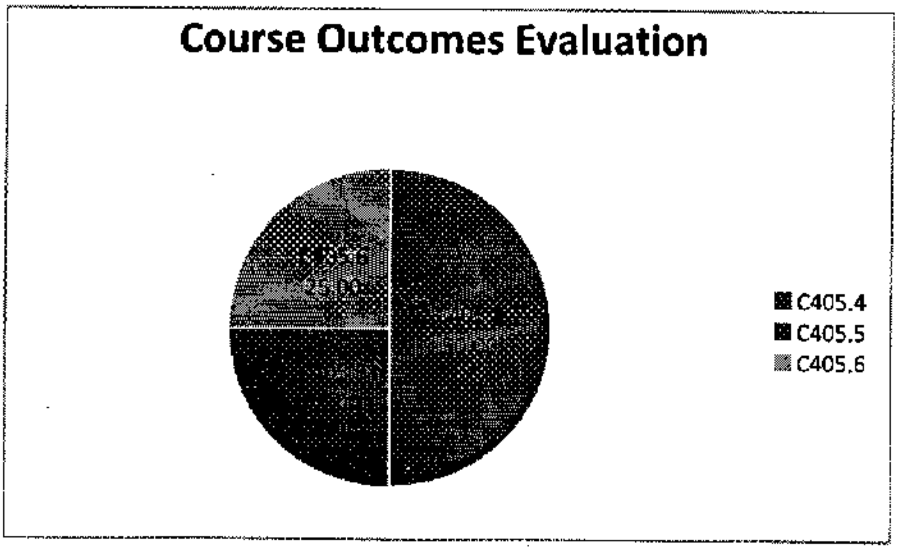

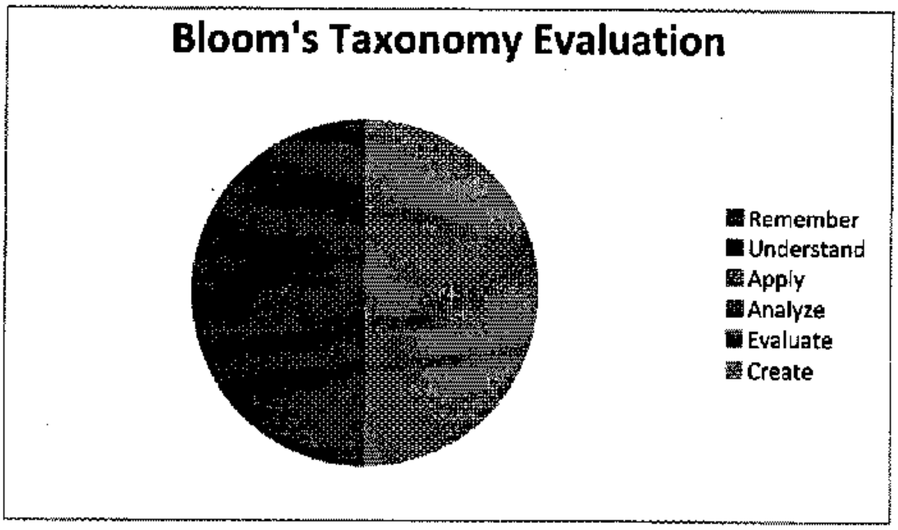

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COURSE CODE: **R194105G**	YEAR: **IV** SEMESTER: **I**
REGULATION: **R19**	COURSE TYPE: **REGULAR**
ACADEMIC YEAR : **2022-23**	CREDITS: **3**

STUDENT RESULT ANALYSIS FOR MID-I

S.NO	ROLL.NO	NAME OF THE STUDENT	DESCRIPTIVE	OBJECTIVE	ASSIGNMENT	TOTAL
1	19KE1A1201	AKULA RAJYALAKSHMI	6	5	5	16
2	19KE1A1202	AINAMPUDI KRISHNA CHAITANYA	6	3	5	14
3	19KE1A1203	ANNA SAHITHI	6	3	5	14
4	19KE1A1204	AVVARU UHA SAI	10	6	5	21
5	19KE1A1205	BANDLAMUDI LAKSHMI HARIKA	2	2	5	9
6	19KE1A1206	BODDAPATI SANDHYA	6	5	5	16
7	19KE1A1207	BODDU SAI RUPA	5	6	5	16
8	19KE1A1208	BODDULURI AKANKSHA	5	6	5	16
9	19KE1A1209	BOMMU HIMA BINDU	8	0	5	13
10	19KE1A1210	BOPPUDI UDAYA SRI	5	8	5	18
11	19KE1A1211	CHINNAM PRASANNA	5	5	5	15
12	19KE1A1212	CHITTINENI GNANIKA	8	4	5	17
13	19KE1A1213	DARAPANENI MOUNIKA	5	6	5	16
14	19KE1A1214	DASARI MADHU SRI	9	5	5	19
15	19KE1A1215	DEVINENI BHAGYALAKSHMI	4	5	5	14
16	19KE1A1216	DHARMAVARAPU ANUDEEPTHI	7	2	5	14
17	19KE1A1217	DIRISALA VYSHNAVI	7	2	5	14
18	19KE1A1218	GADDAM LAVANYA	5	4	5	14
19	19KE1A1219	GANDIKOTA TEJASWINI	8	5	5	18
20	19KE1A1220	GOTTAM ANUSHA	7	2	5	14
21	19KE1A1221	GUNTUPALLI BHULAKSHMI	6	3	5	14
22	19KE1A1222	GUNTUPALLI LAKSHMI PUJITHA	4	7	5	16
23	19KE1A1223	JADDA ASWINI	10	10	5	25
24	19KE1A1224	JULAKANTI SUSMITHA	5	4	5	14
25	19KE1A1225	KALLURI JAYA SRI	5	4	5	14
26	19KE1A1227	KOTA RAGA MADHURI	2	2	5	9
27	19KE1A1228	KOTAPATI NAVYA SREE	7	1	5	13
28	19KE1A1229	KOTHAMASU NAGA MALLESWARI	6	4	5	15
29	19KE1A1231	KOYA PRIYANKA	6	3	5	14

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30	19KE1A1232	KURAPATI ANITHA	7	4	5	16
31	19KE1A1233	LELLA PRATHIMA BHAVANA	6	2	5	13
32	19KE1A1234	LINGA KALPANA	8	1	5	14
33	19KE1A1235	MODUGULA THRIVENI	8	1	5	14
34	19KE1A1236	MOVVA UDAYA BHANU	10	3	5	18
35	19KE1A1237	MACHAVARAPU CHITRA MEGHANA	8	2	5	15
36	19KE1A1238	MADANA SRAVANI	8	4	5	17
37	19KE1A1239	MADDULA RAJYA LAKSHMI	10	0	5	15
38	19KE1A1240	MAKKENA DEVI PRIYANKA	8	1	5	14
39	19KE1A1241	MAKKENA NAGA SHARMILA	7	2	5	14
40	19KE1A1242	MANDALAPU BHAVANI	9	2	5	16
41	19KE1A1243	MANIKONDA MADHURI	8	4	5	17
42	19KE1A1244	MANUKONDA MANISHA	8	3	5	16
43	19KE1A1245	MATLURI DIVYA SAI	10	4	5	19
44	19KE1A1246	MUTCHINTALA BHAVANI	8	6	5	19
45	19KE1A1247	MUKKAMALA MOUNISHA	7	2	5	14
46	19KE1A1248	MUNAGALA GAYATHRI	8	4	5	17
47	19KE1A1249	MUPPA JYOTHIRMAYI	9	5	5	19
48	19KE1A1250	MUPPALLA LAKSHMI PRASANNA	6	3	5	14
49	19KE1A1251	NAGALLA SRI LAKSHMI SAI	10	3	5	18
50	19KE1A1252	PALADUGU VENKATA BHANU PRIYANKA	8	4	5	17
51	19KE1A1253	PAMIREDDY PALLAVI	8	3	5	16
52	19KE1A1254	PAPIREDDYGARI SUDHAMANI	8	5	5	18
53	19KE1A1255	POTLA SRAVANI	10	4	5	19
54	19KE1A1256	POTTI HEMALATHA	10	3	5	18
55	19KE1A1257	RAMUNI LAVANYA	0	0	0	0
56	19KE1A1258	THATAVARTHI BHARGAVI	9	4	5	18
57	19KE1A1259	THUMMALACHERUVU NAGA REVATHI	8	4	5	17
58	19KE1A1260	THOKALA LAKSHMI SIREESHA	8	3	5	16
59	19KE1A1262	VASAM HARSHITHA	7	3	5	15
60	19KE1A1263	YAMPARALA NANDINI	7	3	5	15

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DEPARTMENT OF INFORMATION TECHNOLOGY

COURSE : **CloudComputing**	DEGREE: **B.Tech**
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REGULATION: **R19**	COURSE TYPE: **REGULAR**
ACADEMIC YEAR : **2022-23**	CREDITS: **3**

ADVANCED LEARNERS FOR MID-I EXAMINATION

S.NO	ROLL.NO	NAME OF THE STUDENT	Grade
1	19KE1A1201	AKULA RAJYALAKSHMI	AL
2	19KE1A1204	AVVARU UHA SAI	AL
3	19KE1A1206	BODDAPATI SANDHYA	AL
4	19KE1A1207	BODDU SAI RUPA	AL
5	19KE1A1208	BODDULURI AKANKSHA	AL
6	19KE1A1210	BOPPUDI UDAYA SRI	AL
7	19KE1A1211	CHINNAM PRASANNA	AL
8	19KE1A1212	CHITTINENI GNANIKA	AL
9	19KE1A1213	DARAPANENI MOUNIKA	AL
10	19KE1A1214	DASARI MADHU SRI	AL
11	19KE1A1219	GANDIKOTA TEJASWINI	AL
12	19KE1A1222	GUNTUPALLI LAKSHMI PUJITHA	AL
13	19KE1A1223	JADDA ASWINI	AL
14	19KE1A1229	KOTHAMASU NAGA MALLESWARI	AL
15	19KE1A1232	KURAPATI ANITHA	AL
16	19KE1A1236	MOVVA UDAYA BHANU	AL
17	19KE1A1237	MACHAVARAPU CHITRA MEGHANA	AL
18	19KE1A1238	MADANA SRAVANI	AL
19	19KE1A1239	MADDULA RAJYA LAKSHMI	AL
20	19KE1A1242	MANDALAPU BHAVANI	AL
21	19KE1A1243	MANIKONDA MADHURI	AL
22	19KE1A1244	MANUKONDA MANISHA	AL
23	19KE1A1245	MATLURI DIVYA SAI	AL
24	19KE1A1246	MUTCHINTALA BHAVANI	AL
25	19KE1A1248	MUNAGALA GAYATHRI	AL
26	19KE1A1249	MUPPA JYOTHIRMAYI	AL
27	19KE1A1251	NAGALLA SRI LAKSHMI SAI	AL

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28	19KE1A1252	PALADUGU VENKATA BHANU PRIYANKA	AL
29	19KE1A1253	PAMIREDDY PALLAVI	AL
30	19KE1A1254	PAPIREDDYGARI SUDHAMANI	AL
31	19KE1A1255	POTLA SRAVANI	AL
32	19KE1A1256	POTTI HEMALATHA	AL
33	19KE1A1258	THATAVARTHI BHARGAVI	AL
34	19KE1A1259	THUMMALACHERUVU NAGA REVATHI	AL
35	19KE1A1260	THOKALA LAKSHMI SIREESHA	AL
36	19KE1A1262	VASAM HARSHITHA	AL
37	19KE1A1263	YAMPARALA NANDINI	AL

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SLOW LEARNERS FOR MID-I EXAMINATION

S.NO	ROLL.NO	NAME OF THE STUDENT	Grade
1	19KE1A1202	AINAMPUDI KRISHNA CHAITANYA	SL
2	19KE1A1203	ANNA SAHITHI	SL
3	19KE1A1205	BANDLAMUDI LAKSHMI HARIKA	SL
4	19KE1A1209	BOMMU HIMA BINDU	SL
5	19KE1A1215	DEVINENI BHAGYALAKSHMI	SL
6	19KE1A1216	DHARMAVARAPU ANUDEEPTHI	SL
7	19KE1A1217	DIRISALA VYSHNAVI	SL
8	19KE1A1218	GADDAM LAVANYA	SL
9	19KE1A1220	GOTTAM ANUSHA	SL
10	19KE1A1221	GUNTUPALLI BHULAKSHMI	SL
11	19KE1A1224	JULAKANTI SUSMITHA	SL
12	19KE1A1225	KALLURI JAYA SRI	SL
13	19KE1A1227	KOTA RAGA MADHURI	SL
14	19KE1A1228	KOTAPATI NAVYA SREE	SL
15	19KE1A1231	KOYA PRIYANKA	SL
16	19KE1A1233	LELLA PRATHIMA BHAVANA	SL
17	19KE1A1234	LINGA KALPANA	SL
18	19KE1A1235	MODUGULA THRIVENI	SL
19	19KE1A1240	MAKKENA DEVI PRIYANKA	SL
20	19KE1A1241	MAKKENA NAGA SHARMILA	SL
21	19KE1A1247	MUKKAMALA MOUNISHA	SL
22	19KE1A1250	MUPPALLA LAKSHMI PRASANNA	SL
23	19KE1A1257	RAMUNI LAVANYA	SL

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STUDENT RESULT ANALYSIS FOR MID-II

S.NO	ROLL.NO	NAME OF THE STUDENT	DESCRIPTIVE	OBJECTIVE	ASSIGNMENT	TOTAL
1	19KE1A1201	AKULA RAJYALAKSHMI	7	2	5	14
2	19KE1A1202	AINAMPUDI KRISHNA CHAITANYA	9	2	5	16
3	19KE1A1203	ANNA SAHITHI	7	5	5	17
4	19KE1A1204	AVVARU UHA SAI	10	6	5	21
5	19KE1A1205	BANDLAMUDI LAKSHMI HARIKA	7	4	5	16
6	19KE1A1206	BODDAPATI SANDHYA	9	3	5	17
7	19KE1A1207	BODDU SAI RUPA	8	5	5	18
8	19KE1A1208	BODDULURI AKANKSHA	8	7	5	20
9	19KE1A1209	BOMMU HIMA BINDU	9	3	5	17
10	19KE1A1210	BOPPUDI UDAYA SRI	9	6	5	20
11	19KE1A1211	CHINNAM PRASANNA	9	3	5	17
12	19KE1A1212	CHITTINENI GNANIKA	7	3	5	15
13	19KE1A1213	DARAPANENI MOUNIKA	9	6	5	20
14	19KE1A1214	DASARI MADHU SRI	10	4	5	19
15	19KE1A1215	DEVINENI BHAGYALAKSHMI	7	4	5	16
16	19KE1A1216	DHARMAVARAPU ANUDEEPTHI	9	3	5	17
17	19KE1A1217	DIRISALA VYSHNAVI	6	3	5	14
18	19KE1A1218	GADDAM LAVANYA	9	3	5	17
19	19KE1A1219	GANDIKOTA TEJASWINI	9	5	5	19
20	19KE1A1220	GOTTAM ANUSHA	8	5	5	18
21	19KE1A1221	GUNTUPALLI BHULAKSHMI	9	6	5	20
22	19KE1A1222	GUNTUPALLI LAKSHMI PUJITHA	8	4	5	17
23	19KE1A1223	JADDA ASWINI	9	5	5	19
24	19KE1A1224	JULAKANTI SUSMITHA	8	7	5	20
25	19KE1A1225	KALLURI JAYA SRI	9	4	5	18
26	19KE1A1227	KOTA RAGA MADHURI	7	4	5	16
27	19KE1A1228	KOTAPATI NAVYA SREE	7	7	5	19
28	19KE1A1229	KOTHAMASU NAGA MALLESWARI	8	6	5	19
29	19KE1A1231	KOYA PRIYANKA	7	5	5	17
30	19KE1A1232	KURAPATI ANITHA	7	4	5	16

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31	19KE1A1233	LELLA PRATHIMA BHAVANA	9	3	5	17
32	19KE1A1234	LINGA KALPANA	7	1	5	13
33	19KE1A1235	MODUGULA THRIVENI	6	4	5	15
34	19KE1A1236	MOVVA UDAYA BHANU	9	4	5	18
35	19KE1A1237	MACHAVARAPU CHITRA MEGHANA	7	3	5	15
36	19KE1A1238	MADANA SRAVANI	8	8	5	21
37	19KE1A1239	MADDULA RAJYA LAKSHMI	9	4	5	18
38	19KE1A1240	MAKKENA DEVI PRIYANKA	7	3	5	15
39	19KE1A1241	MAKKENA NAGA SHARMILA	8	3	5	16
40	19KE1A1242	MANDALAPU BHAVANI	7	3	5	15
41	19KE1A1243	MANIKONDA MADHURI	9	5	5	19
42	19KE1A1244	MANUKONDA MANISHA	8	6	5	19
43	19KE1A1245	MATLURI DIVYA SAI	10	7	5	22
44	19KE1A1246	MUTCHINTALA BHAVANI	8	8	5	21
45	19KE1A1247	MUKKAMALA MOUNISHA	8	3	5	16
46	19KE1A1248	MUNAGALA GAYATHRI	7	5	5	17
47	19KE1A1249	MUPPA JYOTHIRMAYI	9	8	5	22
48	19KE1A1250	MUPPALLA LAKSHMI PRASANNA	8	3	5	16
49	19KE1A1251	NAGALLA SRI LAKSHMI SAI	9	3	5	17
50	19KE1A1252	PALADUGU VENKATA BHANU PRIYANKA	8	5	5	18
51	19KE1A1253	PAMIREDDY PALLAVI	7	6	5	18
52	19KE1A1254	PAPIREDDYGARI SUDHAMANI	7	4	5	16
53	19KE1A1255	POTLA SRAVANI	9	5	5	19
54	19KE1A1256	POTTI HEMALATHA	9	5	5	19
55	19KE1A1257	RAMUNI LAVANYA	8	4	5	17
56	19KE1A1258	THATAVARTHI BHARGAVI	9	5	5	19
57	19KE1A1259	THUMMALACHERUVU NAGA REVATHI	9	3	5	17
58	19KE1A1260	THOKALA LAKSHMI SIREESHA	8	3	5	16
59	19KE1A1262	VASAM HARSHITHA	6	3	5	14
60	19KE1A1263	YAMPARALA NANDINI	9	4	5	18

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DEPARTMENT OF INFORMATION TECHNOLOGY

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ADVANCED LEARNERS FOR MID-II EXAMINATION

S.NO	ROLL.NO	NAME OF THE STUDENT	Grade
1	19KE1A1202	AINAMPUDI KRISHNA CHAITANYA	AL
2	19KE1A1203	ANNA SAHITHI	AL
3	19KE1A1204	AVVARU UHA SAI	AL
4	19KE1A1205	BANDLAMUDI LAKSHMI HARIKA	AL
5	19KE1A1206	BODDAPATI SANDHYA	AL
6	19KE1A1207	BODDU SAI RUPA	AL
7	19KE1A1208	BODDULURI AKANKSHA	AL
8	19KE1A1209	BOMMU HIMA BINDU	AL
9	19KE1A1210	BOPPUDI UDAYA SRI	AL
10	19KE1A1211	CHINNAM PRASANNA	AL
11	19KE1A1212	CHITTINENI GNANIKA	AL
12	19KE1A1213	DARAPANENI MOUNIKA	AL
13	19KE1A1214	DASARI MADHU SRI	AL
14	19KE1A1215	DEVINENI BHAGYALAKSHMI	AL
15	19KE1A1216	DHARMAVARAPU ANUDEEPTHI	AL
16	19KE1A1218	GADDAM LAVANYA	AL
17	19KE1A1219	GANDIKOTA TEJASWINI	AL
18	19KE1A1220	GOTTAM ANUSHA	AL
19	19KE1A1221	GUNTUPALLI BHULAKSHMI	AL
20	19KE1A1222	GUNTUPALLI LAKSHMI PUJITHA	AL
21	19KE1A1223	JADDA ASWINI	AL
22	19KE1A1224	JULAKANTI SUSMITHA	AL
23	19KE1A1225	KALLURI JAYA SRI	AL
24	19KE1A1227	KOTA RAGA MADHURI	AL
25	19KE1A1228	KOTAPATI NAVYA SREE	AL
26	19KE1A1229	KOTHAMASU NAGA MALLESWARI	AL
27	19KE1A1231	KOYA PRIYANKA	AL
28	19KE1A1232	KURAPATI ANITHA	AL

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29	19KE1A1233	LELLA PRATHIMA BHAVANA	AL
30	19KE1A1235	MODUGULA THRIVENI	AL
31	19KE1A1236	MOVVA UDAYA BHANU	AL
32	19KE1A1237	MACHAVARAPU CHITRA MEGHANA	AL
33	19KE1A1238	MADANA SRAVANI	AL
34	19KE1A1239	MADDULA RAJYA LAKSHMI	AL
35	19KE1A1240	MAKKENA DEVI PRIYANKA	AL
36	19KE1A1241	MAKKENA NAGA SHARMILA	AL
37	19KE1A1242	MANDALAPU BHAVANI	AL
38	19KE1A1243	MANIKONDA MADHURI	AL
39	19KE1A1244	MANUKONDA MANISHA	AL
40	19KE1A1245	MATLURI DIVYA SAI	AL
41	19KE1A1246	MUTCHINTALA BHAVANI	AL
42	19KE1A1247	MUKKAMALA MOUNISHA	AL
43	19KE1A1248	MUNAGALA GAYATHRI	AL
44	19KE1A1249	MUPPA JYOTHIRMAYI	AL
45	19KE1A1250	MUPPALLA LAKSHMI PRASANNA	AL
46	19KE1A1251	NAGALLA SRI LAKSHMI SAI	AL
47	19KE1A1252	PALADUGU VENKATA BHANU PRIYANKA	AL
48	19KE1A1253	PAMIREDDY PALLAVI	AL
49	19KE1A1254	PAPIREDDYGARI SUDHAMANI	AL
50	19KE1A1255	POTLA SRAVANI	AL
51	19KE1A1256	POTTI HEMALATHA	AL
52	19KE1A1257	RAMUNI LAVANYA	AL
53	19KE1A1258	THATAVARTHI BHARGAVI	AL
54	19KE1A1259	THUMMALACHERUVU NAGA REVATHI	AL
55	19KE1A1260	THOKALA LAKSHMI SIREESHA	AL
56	19KE1A1263	YAMPARALA NANDINI	AL

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COURSE : **CloudComputing**	DEGREE: **B.Tech**
COURSE CODE: **R194105G**	YEAR: **IV** SEMESTER: **I**
REGULATION: **R19**	COURSE TYPE: **REGULAR**
ACADEMIC YEAR : **2022-23**	CREDITS: **3**

SLOW LEARNERS FOR MID-II EXAMINATION

S.NO	ROLL.NO	NAME OF THE STUDENT	Grade
1	19KE1A1201	AKULA RAJYALAKSHMI	SL
2	19KE1A1217	DIRISALA VYSHNAVI	SL
3	19KE1A1234	LINGA KALPANA	SL
4	19KE1A1262	VASAM HARSHITHA	SL

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REMEDIAL CLASS SCHEDULE

COURSE: **CloudComputing**	DEGREE: **B.Tech**
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REGULATION: **R19**	COURSE TYPE: **REGULAR**
ACADEMIC YEAR: **2022-23**	CREDITS: **3**

Class: IV-B.Tech IT **Semester: I** **LH. NO.513** **W.E.F:05-09-2022**

Day	9:00--12:30					01:20-03:30	03:30-04:30
Monday					L		CNS
Tuesday					U		ML
Wednesday					N		ACN
Thursday					C		DevOps
Friday					H		CC
Saturday							ES

Subject Code	Subject	Name of the Faculty
R1941051	Cryptography and Network Security	Hoora Mahammad
R1941053	Machine Learning	V. Sudhakar
R1941121	Advanced Computer Networks	D. U. Durga Rani
R194112E	DevOps	Dr. K. Sunitha
R194105G	**CloudComputing**	N. Nandini
R194104K	Embedded systems	Y. Ajay Sankar

Course Instructor

Program Coordinator

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Attendence Sheet For Remedial Classes

COURSE: **CloudComputing**	DEGREE: **B.Tech**
COURSE CODE: **R194105G**	YEAR: **IV** SEMESTER: **I**
REGULATION: **R19**	COURSE TYPE: **REGULAR**
ACADEMIC YEAR: **2022-2023**	CREDITS: **3**

S.NO	ROLL.NO	Date 09-09-22	Date 16-09-22	Date 23-09-22	Date 7-10-22	Date 14-10-22	Date 28-10-22
1	19KE1A1202	A.Krishna	A.Krishna	A.Krishna	A.Krishna	A.Krishna	A.Krishna
2	19KE1A1203	A.Sahithi	A.Sahithi	A.Sahithi	A.Sahithi	A.Sahithi	A.Sahithi
3	19KE1A1205	Bf	Bf	Bf	Bf	Bf	Bf
4	19KE1A1209	B.Bindu	B.Bindu	B.Bindu	B.Bindu	B.Bindu	B.Bindu
5	19KE1A1215	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
6	19KE1A1216	Anudeepthi	Anudeepthi	Anudeepthi	Anudeepthi	Anudeepthi	Anudeepthi
7	19KE1A1217	vyshnavi	vyshnavi	vyshnavi	vyshnavi	vyshnavi	vyshnavi
8	19KE1A1218	lavanya	lavanya	lavanya	lavanya	lavanya	lavanya
9	19KE1A1220	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
10	19KE1A1221	Bhulakshmi	Bhulakshmi	Bhulakshmi	Bhulakshmi	Bhulakshmi	Bhulakshmi
11	19KE1A1224	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
12	19KE1A1225	Jaya	Jaya	Jaya	Jaya	Jaya	Jaya
13	19KE1A1227	Madhuri	Madhuri	Madhuri	Madhuri	Madhuri	Madhuri
14	19KE1A1228	Navyasree	Navyasree	Navyasree	Navyasree	Navyasree	Navyasree
15	19KE1A1231	Priya	Priya	Priya	Priya	Priya	Priya
16	19KE1A1233	Bh	Bh	Bh	Bh	Bh	Bh
17	19KE1A1234	Kalpana	Kalpana	Kalpana	Kalpana	Kalpana	Kalpana
18	19KE1A1235	Thriveni	Thriveni	Thriveni	Thriveni	Thriveni	Thriveni
19	19KE1A1240	M.priyanka	M.priyanka	M.priyanka	M.priyanka	M.priyanka	M.priyanka
20	19KE1A1241	Sharmila	Sharmila	Sharmila	Sharmila	Sharmila	Sharmila
21	19KE1A1247	Mounisha	Mounisha	Mounisha	Mounisha	Mounisha	Mounisha
22	19KE1A1250	Prasanna	Prasanna	Prasanna	Prasanna	Prasanna	Prasanna

Topics Covered:

1. Cloud delivery Models.
2. Architecture of distributed System.
3. Cloud Infrastructure at Amazon.
4. The Zookeeper in Amazon.
5. Virtualization & Types of Virtualization.
6. Scheduling algorithms.
7. scheduling Map Reduce applications.
8. Two-Level Resource allocation architecture.
9. Amazon Simple Storage Service
10. Virtual machine Security.
11. Cloud-based Simulation of a Distributed trust-algorithm.

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IMPACT ANALYSIS ON SLOW LEARNERS

S.NO	ROLL.NO	NAME OF THE STUDENT	MID -1 MARKS	MID-2 MARKS	REMARKS
1	19KE1A1202	AINAMPUDI KRISHNA CHAITANYA	14	16	IMPROVED
2	19KE1A1203	ANNA SAHITHI	14	17	IMPROVED
3	19KE1A1205	BANDLAMUDI LAKSHMI HARIKA	9	16	IMPROVED
4	19KE1A1209	BOMMU HIMA BINDU	13	17	IMPROVED
5	19KE1A1215	DEVINENI BHAGYALAKSHMI	14	16	IMPROVED
6	19KE1A1216	DHARMAVARAPU ANUDEEPTHI	14	17	IMPROVED
7	19KE1A1217	DIRISALA VYSHNAVI	14	14	-----------
8	19KE1A1218	GADDAM LAVANYA	14	17	IMPROVED
9	19KE1A1220	GOTTAM ANUSHA	14	18	IMPROVED
10	19KE1A1221	GUNTUPALLI BHULAKSHMI	14	20	IMPROVED
11	19KE1A1224	JULAKANTI SUSMITHA	14	20	IMPROVED
12	19KE1A1225	KALLURI JAYA SRI	14	18	IMPROVED
13	19KE1A1227	KOTA RAGA MADHURI	9	16	IMPROVED
14	19KE1A1228	KOTAPATI NAVYA SREE	13	19	IMPROVED
15	19KE1A1231	KOYA PRIYANKA	14	17	IMPROVED
16	19KE1A1233	LELLA PRATHIMA BHAVANA	13	17	IMPROVED
17	19KE1A1234	LINGA KALPANA	14	13	-------------
18	19KE1A1235	MODUGULA THRIVENI	14	15	IMPROVED
19	19KE1A1240	MAKKENA DEVI PRIYANKA	14	15	IMPROVED
20	19KE1A1241	MAKKENA NAGA SHARMILA	14	16	IMPROVED
21	19KE1A1247	MUKKAMALA MOUNISHA	14	16	IMPROVED
22	19KE1A1250	MUPPALLA LAKSHMI PRASANNA	14	16	IMPROVED

IMPACT EFFECT:
Slow Learners identified based on Mid-1 Marks, 80% of them are improved in the Mid-2 Marks.

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LESSON PLAN FOR TUTORIAL CLASSES

T.No	Name of the Topic	Teaching Aid	Books
1	Explain the Cloudcomputing delivery Models? Define Logical Clocks?	Chalk & Talk	T1
2	Explain Architecture of Parallel Systems? Define Communication Protocols?	Chalk & Talk	T1
3	Define Concurrency and Model Concurrency with Petri Nets? Ethical Issues of CloudComputing	Chalk & Talk	T1
4	Examine the Cloud Infrastructure at Amazon AWS?	Chalk & Talk	T2
5	Explain Microsoft Cloud services i)Microsoft Azure ii)Sharepoint services iii)Microsoft CRM iv)ExchangeOnline v)Windows Live	Chalk & Talk	T2
6	Steps for create EC2 Instances and connecting clients through firewalls How to use S3 in java	Chalk & Talk	T1
7	Explain Zookeeper at amazon? Explain HPC(High Performance computing) on cloud?	Chalk & Talk	T2
8	Explain the architecture of Google App engine ?		

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TEXT BOOKS:

T1	Cloud Computing, Theory and Practice,1st Edition, Dan C Marinescu, MK Elsevier publisher ,2013
T2	Cloud Computing, A Practical Approach, 1st Edition, Anthony T Velte, Toby J Velte, Robert Elsenpeter, TMH,2017

REFERENCE BOOKS:

R1	Mastering Cloud Computing, Foundations and Application Programming,1st Edition, Raj Kumar Buyya, Christen vecctiola, S Tammarai selvi, TMH,2013
R2	Essential of Cloud Computing, 1st Edition, K Chandrasekharan, CRC Press, 2014.
R3	Cloud Computing, A Hands on Approach, Arshdeep Bahga, Vijay Madisetti, Universities Press, 2014.

Course Instructor():

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TUTORIAL QUESTIONS

1.Explain the Cloudcomputing delivery Models?
2.Define Logical Clocks?

Course Instructor:

Program Coordinator

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ACADEMIC YEAR : **2022-23**	CREDITS: **3**

TUTORIAL QUESTIONS

1.Explain Architecture of Parallel Systems?
2.Define Communication Protocols?

Course Instructor:

Program Coordinator

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TUTORIAL QUESTIONS

1.Define Concurrency and Model Concurrency with Petri Nets?
2.Ethical Issues of CloudComputing?

Course Instructor:

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TUTORIAL QUESTIONS

1.Examine the Cloud Infrastructure at Amazon AWS?

Course Instructor:

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TUTORIAL QUESTIONS

1. Explain Microsoft Cloud services
   i)Microsoft Azure
   ii)Sharepoint services
   iii)Microsoft CRM
   iv)ExchangeOnline
   v)Windows Live

Course Instructor:

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REGULATION: **R19**	COURSE TYPE: **REGULAR**
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TUTORIAL QUESTIONS

1.Steps for create EC2 Instances and connecting clients through firewalls
2.How to use S3 in java

Course Instructor:

Program Coordinator

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TUTORIAL QUESTIONS

1.Explain Zookeeper at amazon?
2.Explain HPC(High Performance computing) on cloud?

Course Coordinator(s):

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REGULATION: **R19**	COURSE TYPE: **REGULAR**
ACADEMIC YEAR : **2022-23**	CREDITS: **3**

TUTORIAL QUESTIONS

1.Explain the architecture of Google App engine ?

Course Instructor:

Program Coordinator

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UNIT I

Introduction: Network centric computing, Network centric content, peer-to –peer systems, cloud computing delivery models and services, Ethical issues, Vulnerabilities, Major challenges for cloud computing. Parallel and Distributed Systems: introduction, architecture, distributed systems, communication protocols, logical clocks, message delivery rules, concurrency, and model concurrency with Petri Nets.

Network – centric computing:

- In the early 1980s major research organizations such as the National Laboratories and large companies had powerful computing centers supporting large user populations scattered throughout wide geographic areas.
- Then the idea to link such centers in an infrastructure resembling the power grid was born; the model known as network-centric computing was taking shape.
- A computing grid is a distributed system consisting of a large number of loosely coupled, heterogeneous, and geographically dispersed systems in different administrative domains.
- The term computing grid is a metaphor for accessing computer power with similar ease as we access power provided by the electric grid. Software libraries known as middleware have been furiously developed since the early 1990s to facilitate access to grid services.

• The companies promoting cloud computing seem to have learned the most important lessons from the grid movement.

• Computer clouds are typically homogeneous.

• An entire cloud shares the same security, resource management, cost and other policies, and last but not least, it targets enterprise computing.

• some of the reasons that several agencies of the US Government, including 1. Health and Human Services (HHS), 2. the Centers for Disease Control (CDC), 3. the National Aeronautics and Space Administration (NASA), 4. the Navy's Next Generation Enterprise Network (NGEN), and 5. the Defense Information Systems Agency (DISA), have launched cloud computing initiatives and conduct actual system development intended to improve the efficiency and effectiveness of their information processing needs.

Network-centric content

The term content refers to any type or volume of media, be it static or dynamic, monolithic or modular, live or stored, produced by aggregation, or mixed.

- Information is the result of functions applied to content.

- The creation and consumption of audio and visual content are likely to transform the Internet to support increased quality in terms of resolution, frame rate, color depth, and stereoscopic information, and it seems reasonable to assume that the Future Internet3 will be content-centric. Network-centric computing and network-centric content share a number of characteristics:
- Most applications are data-intensive.
- Computer simulation becomes a powerful tool for scientific research in virtually all areas of science, from physics, biology, and chemistry to archeology.
- Sophisticatedtools for computer-aided design, such as Catia (Computer Aided Threedimensional Interactive Application), are widely used in the aerospace and automotive industries
- The wide spread use of sensors contributes to increases in the volume of data. Multimedia applications are increasingly popular; the ever-larger media increase the load placed on storage, networking, and processing systems.
- Virtually all applications are network-intensive. Indeed, transferring large volumes of data requires
- high-bandwidth networks; parallel computing, computation steering,4 and data streaming are examples of applications that can only run efficiently on low-latency networks.
- The systems are accessed using thin clients running on systems with limited resources. In June 2011
- Google released Google Chrome OS, designed to run on primitive devices and based on the browser with the same name.
- The infrastructure supports some form of workflow management. Indeed, complex computational tasks require coordination of several applications; composition of services is a basic tenet ofWeb 2.0.

Computing

Computing is nothing but process of completing a task by using this computer technology and it may involve computer hardware and/or software.

When a problem is solved by the computer, during that computer uses many devices, arranged in different ways and which work together to solve problems. This constitutes a computing environment.

Based on the organization of different computer devices and communication processes there exists multiple types of **computing environments**. Now lets know about different types of computing environments.

Personal Computing Environment :
In personal computing environment there is a stand-alone machine. Complete program resides on computer and executed there. Different stand-alone machines that constitute a personal computing environment are laptops, mobiles, printers, computer systems, scanners etc. That we use at our homes and offices

Time-Sharing Computing Environment :
In Time Sharing Computing Environment multiple users share system simultaneously. Different users (different processes) are allotted different time slice and processor switches rapidly among users according to it. For example, student listening to music while coding something in an IDE. Windows 95 and later versions, Unix, IOS, Linux operating systems are the examples of this time sharing computing environment.

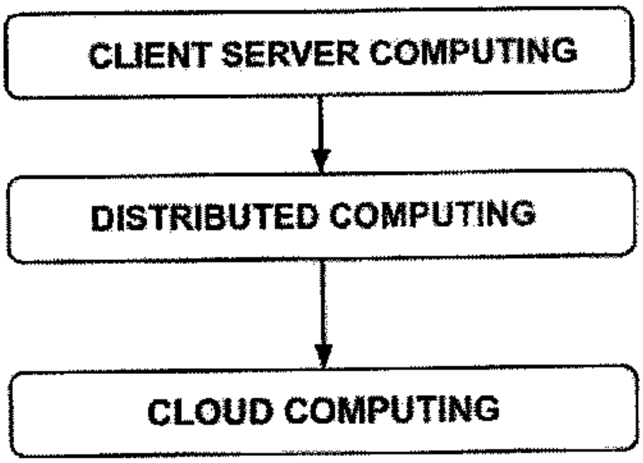
Client Server Computing Environment :
In client server computing environment two machines are involved i.e., client machine and server machine, sometime same machine also serve as client and server. In this computing environment client requests resource/service and server provides that respective resource/service. A server can provide service to multiple clients at a time and here mainly communication happens through computer network.

Distributed Computing Environment :
In a distributed computing environment multiple nodes are connected together using network but physically they are separated. A single task is performed by different functional units of different nodes of distributed unit. Here different programs of an application run simultaneously on different nodes, and communication happens in between different nodes of this system over network to solve task.

Cloud Computing Environment :
In cloud computing environment on demand availability of computer system

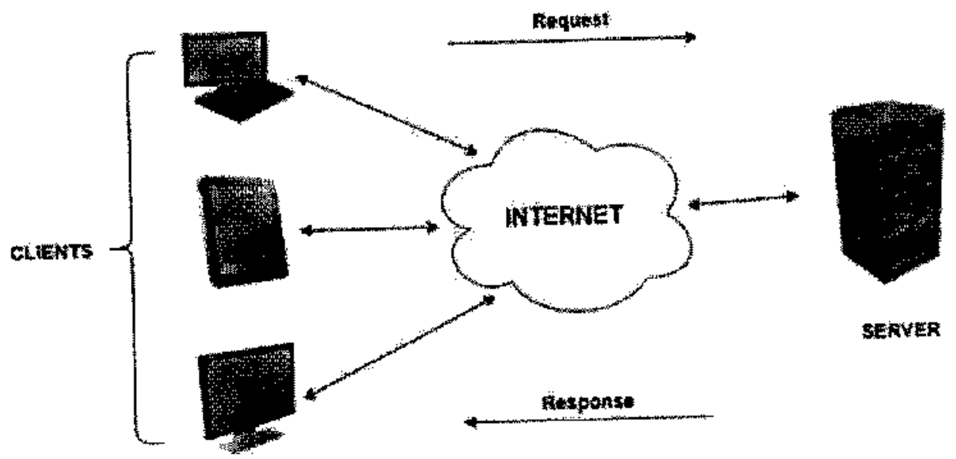
resources like processing and storage are availed. Here computing is not done in individual technology or computer rather it is computed in cloud of computers where all required resources are provided by cloud vendor. This environment primarily comprised of three services i.e software-as-a-service (SaaS), infrastructure-as-a-service (IaaS), and platform-as-a-service (PaaS).

- Before Computing was come into existence, client Server Architecture was used where all the data and control of client resides in Server side. If a single user want to access some data, firstly user need to connect to the server and after that user will get appropriate access. But it has many disadvantages. So, After Client Server computing, Distributed Computing was come into existence, in this type of computing all computers are networked together with the help of this, user can share their resources when needed. It also has certain limitations. So in order to remove limitations faced in distributed system, cloud computing was emerged.



Client -Server Computing

In client server computing, the clients requests a resource and the server provides that resource. A server may serve multiple clients at the same time while a client is in contact with only one server. Both the client and server usually communicate via a computer network but sometimes they may reside in the same system.



Disadvantages of Client Server Computing

The different disadvantages of client server computing are –

- If all the clients simultaneously request data from the server, it may get overloaded. This may lead to congestion in the network.
- If the server fails for any reason, then none of the requests of the clients can be fulfilled. This leads of failure of the client server network.
- The cost of setting and maintaining a client server model are quite high.

Why Cloud Computing?

Small as well as large IT companies, follow the traditional methods to provide the IT infrastructure. That means **for any IT company, we need a Server Room that is the basic need of IT companies.**

In that server room, there should be a database server, mail server, networking, firewalls, routers, modem, switches, QPS (Query Per Second means how much queries or load will be handled by the server), configurable system, high net speed, and the maintenance engineers.

To establish such IT infrastructure, we need to spend lots of money. To overcome all these problems and to reduce the IT infrastructure cost, Cloud Computing comes into existence.

Cloud

The term cloud refers to a network or the internet. In other words, we can say that Cloud is something, which is present at remote location.

Cloud Computing

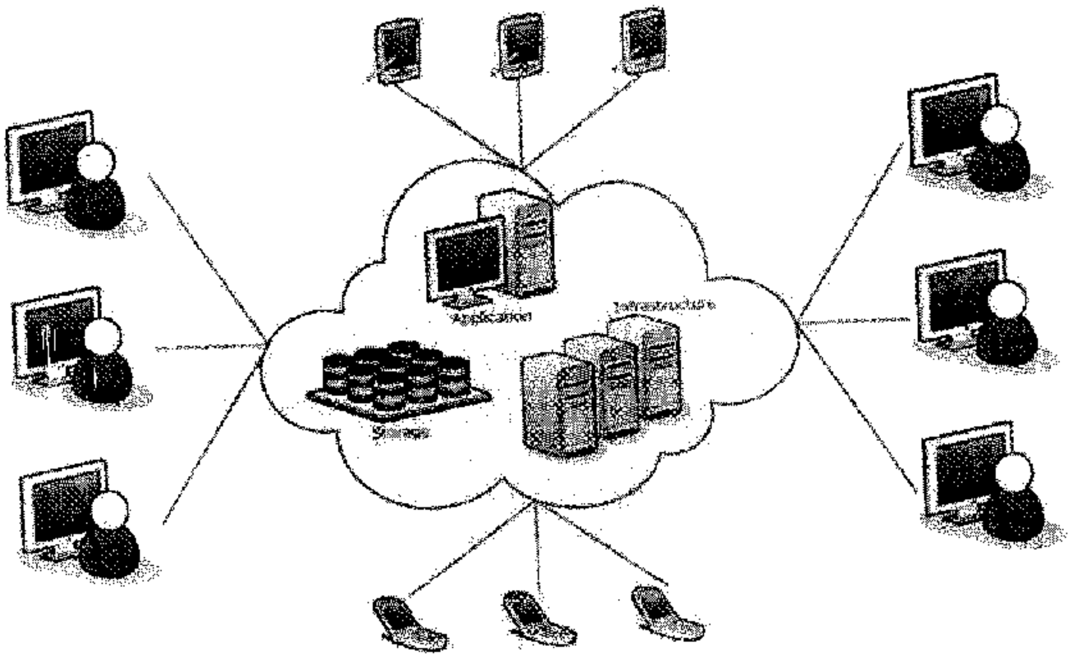
Cloud Computing is a technology that uses remote servers on the internet to **store**, **manage**, and **access** data online rather than local drives. The data can be anything such as files, images, documents, audio, video, and more.

(OR)

Cloud Computing refers to **manipulating, configuring,** and **accessing** the hardware and software resources remotely. It offers online data storage, infrastructure, and application.

(OR)

In Simplest terms, cloud computing means **storing** and **accessing** the data and programs on remote servers that are hosted on internet instead of computer's hard drive or local server.



There are the following operations that we can do using cloud computing:

- Developing new applications and services
- Storage, back up, and recovery of data
- Hosting blogs and websites
- Delivery of software on demand
- Analysis of data
- Streaming videos and audios

Characteristics of Cloud Computing

The characteristics of cloud computing are given below:

1) Agility

The cloud **works in a distributed computing environment**. It shares resources among users and works very fast.

2) High availability and reliability

The availability of servers is high and more reliable because the **chances of infrastructure failure are minimum**.

3) High Scalability

Cloud offers **"on-demand" provisioning of resources on a large scale**, without having engineers for peak loads.

4) Multi-Sharing

With the help of cloud computing, **multiple users and applications can work more efficiently** with cost reductions by sharing common infrastructure.

5) Device and Location Independence

Cloud computing enables the users to access systems using a web browser regardless of their location or what device they use e.g. PC, mobile phone, etc. **As infrastructure is off-site** (typically provided by a third-party) **and accessed via the Internet, users can connect from anywhere.**

6) Maintenance

Maintenance of cloud computing applications is easier, since they **do not need to be installed on each user's computer and can be accessed from different places.** So, it reduces the cost also.

7) Low Cost

By using cloud computing, the cost will be reduced because to take the services of cloud computing, **IT company need not to set its own infrastructure** and pay-as-per usage of resources.

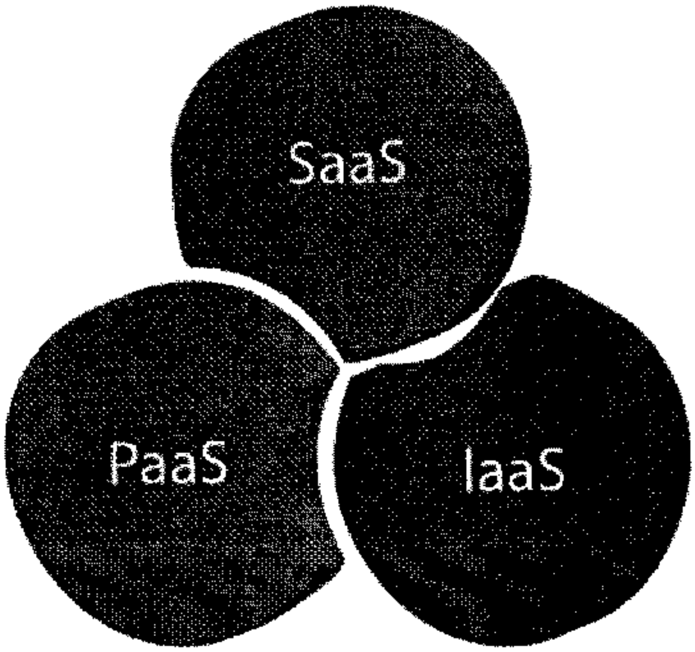
8) Services in the pay-per-use mode

Application Programming Interfaces (**APIs) are provided to the users so that they can access services on the cloud** by using these APIs **and pay the charges as per the usage of services.**

Cloud computing delivery models and services

There are the following three types of cloud service models -

1. Infrastructure as a Service (IaaS)
2. Platform as a Service (PaaS)
3. Software as a Service (SaaS)



1.Infrastructure as a Service (IaaS)

- **Infrastructure-as-a-Service** provides access to fundamental resources such as physical machines, database,webservers, virtual machines, virtual storage, etc
- IaaS is also known as **Hardware as a Service (HaaS)**.
- It is a computing infrastructure managed over the internet.
- It allows customers to outsource their IT infrastructures such as servers, networking, processing, storage, virtual machines, and other resources. Customers access these resources on the Internet using a pay-as-per use model.
- The main advantage of using IaaS is that it helps users to avoid the cost and complexity of purchasing and managing the physical servers.

Applications deployed can scale from one to thousands of users without any changes to the applications.

3.Software as a Service(SaaS)

- SaaS is also known as "**On-Demand Software**".
- It is a software distribution model in which services are hosted by a cloud service provider. These services are available to end-users over the internet so, the end-users do not need to install any software on their devices to access these services.
- SaaS provides a complete software solution that you purchase on a **pay-as-you-go** basis from a cloud service provider.
- Most SaaS applications can be run directly from a web browser without any downloads or installations required.

There are the following services provided by SaaS providers -

Business Services - SaaS Provider provides various business services to start-up the business. The SaaS business services include **ERP** (Enterprise Resource Planning), **CRM** (Customer Relationship Management), **billing**, and **sales**.

Document Management - SaaS document management is a software application offered by a third party (SaaS providers) to create, manage, and track electronic documents.

Example: Slack, Samepage, Box, and Zoho Forms.

Social Networks - As we all know, social networking sites are used by the general public, so social networking service providers use SaaS for their convenience and handle the general public's information.

Mail Services - To handle the unpredictable number of users and load on e-mail services, many e-mail providers offering their services using SaaS.

2. Application frameworks

PaaS providers provide application frameworks to easily understand the application development. Some popular application frameworks provided by PaaS providers are Node.js, Drupal, Joomla, WordPress, Spring, Play, Rack, and Zend.

3. Databases

PaaS providers provide various databases such as ClearDB, PostgreSQL, MongoDB, and Redis to communicate with the applications.

4. Other tools

PaaS providers provide various other tools that are required to develop, test, and deploy the applications.

Advantages of PaaS

There are the following advantages of PaaS -

1) Simplified Development

PaaS allows developers to focus on development and innovation without worrying about infrastructure management.

2) Lower risk

No need for up-front investment in hardware and software. Developers only need a PC and an internet connection to start building applications.

3) Prebuilt business functionality

Some PaaS vendors also provide already defined business functionality so that users can avoid building everything from very scratch and hence can directly start the projects only.

4) Instant community

PaaS vendors frequently provide online communities where the developer can get the ideas to share experiences and seek advice from others.

5) Scalability

SaaS services can be accessed from any device such as desktops, laptops, tablets, phones, and thin clients.

7. API Integration

SaaS services easily integrate with other software or services through standard APIs.

8. No client-side installation

SaaS services are accessed directly from the service provider using the internet connection, so do not need to require any software installation.

Types of Cloud

There are the following 4 types of cloud that you can deploy according to the organization's needs

- Public Cloud
- Private Cloud
- Hybrid Cloud
- Community Cloud

Public Cloud

- Public cloud is **open to all** to store and access information via the Internet using the pay-per-usage method.
- In public cloud, computing resources are managed and operated by the Cloud Service Provider (CSP).
- In the Public cloud, the same storage is being used by multiple users at the same time.
- Public cloud is **owned, managed,** and **operated** by businesses, universities, government organizations, or a combination of them.
- Amazon Elastic Compute Cloud (EC2), Microsoft Azure, IBM's Blue Cloud, Sun Cloud, and Google Cloud are examples of the public cloud.

Advantages of SaaS cloud computing layer

1) SaaS is easy to buy

SaaS pricing is based on a monthly fee or annual fee subscription, so it allows organizations to access business functionality at a low cost, which is less than licensed applications.

Unlike traditional software, which is sold as a licensed based with an up-front cost (and often an optional ongoing support fee), SaaS providers are generally pricing the applications using a subscription fee, most commonly a monthly or annually fee.

2. One to Many

SaaS services are offered as a one-to-many model means a single instance of the application is shared by multiple users.

3. Less hardware required for SaaS

The software is hosted remotely, so organizations do not need to invest in additional hardware.

4. Low maintenance required for SaaS

Software as a service removes the need for installation, set-up, and daily maintenance for the organizations. The initial set-up cost for SaaS is typically less than the enterprise software. SaaS vendors are pricing their applications based on some usage parameters, such as a number of users using the application. So SaaS does easy to monitor and automatic updates.

5. No special software or hardware versions required

All users will have the same version of the software and typically access it through the web browser. SaaS reduces IT support costs by outsourcing hardware and software maintenance and support to the IaaS provider.

6. Multidevice support

4. IaaS providers focus on the organization's core business rather than on IT infrastructure.
5. On-demand scalability is one of the biggest advantages of IaaS. Using IaaS, users do not worry about to upgrade software and troubleshoot the issues related to hardware components.

2.Platform as a Service / PaaS

- Platform as a Service (PaaS) provides a runtime environment.
- It allows programmers to easily create, test, run, and deploy web applications.
- PaaS is a service of cloud computing that provides a platform and environment to allow developers to build applications and services over the internet.
- PaaS services are hosted in the cloud and accessed by users simply via their web browser.
- You can purchase these applications from a cloud service provider on a pay-as-per use basis and access them using the Internet connection.
- In PaaS, back end scalability is managed by the cloud service provider, so end- users do not need to worry about managing the infrastructure.
- PaaS includes infrastructure (servers, storage, and networking) and platform (middleware, development tools, database management systems, business intelligence, and more) to support the web application life cycle.

Example: Google App Engine, Force.com, Joyent, Azure.

PaaS providers provide the Programming languages, Application frameworks, Databases, and Other tools:

1. Programming languages

PaaS providers provide various programming languages for the developers to develop the applications. Some popular programming languages provided by PaaS providers are Java, PHP, Ruby, Perl, and Go.

- In traditional hosting services, IT infrastructure was rented out for a specific period of time, with pre-determined hardware configuration. The client paid for the configuration and time, regardless of the actual use. With the help of the IaaS cloud computing platform layer, clients can dynamically scale the configuration to meet changing requirements and are billed only for the services actually used.
- IaaS cloud computing platform layer eliminates the need for every organization to maintain the IT infrastructure.
- IaaS is offered in three models: public, private, and hybrid cloud.
- The private cloud implies that the infrastructure resides at the customer-premise.
- In the case of public cloud, it is located at the cloud computing platform vendor's data center,
- The hybrid cloud is a combination of the two in which the customer selects the best of both public cloud or private cloud

IaaS provider provides the following services -

1. **Compute:** Computing as a Service includes virtual central processing units and virtual main memory for the Vms that is provisioned to the end- users.
2. **Storage:** IaaS provider provides back-end storage for storing files.
3. **Network:** Network as a Service (NaaS) provides networking components such as routers, switches, and bridges for the Vms.
4. **Load balancers:** It provides load balancing capability at the infrastructure layer.

Example: DigitalOcean, Linode, Amazon Web Services (AWS), Microsoft Azure, Google Compute Engine (GCE), Rackspace, and Cisco Metacloud.

There are the following advantages of IaaS computing layer -

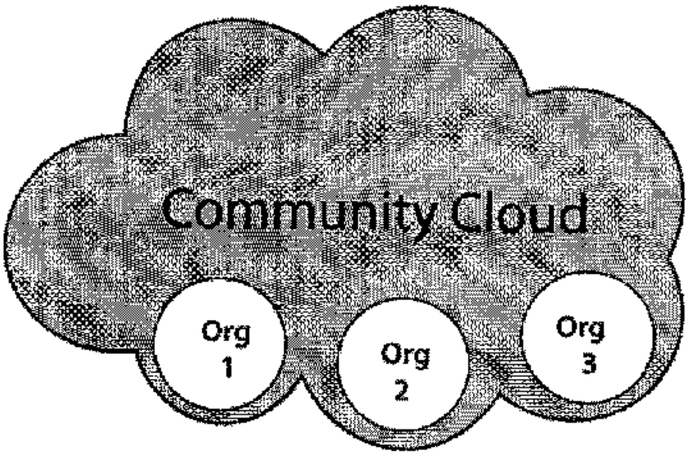
1. IaaS allows multiple users to share the same physical infrastructure.
2. Iaas allows IT users to access resources over the internet.
3. IaaS providers provide services based on the pay-as-per-use basis. The users are required to pay for what they have used.

Disadvantages of Hybrid Cloud

- In the Hybrid Cloud, networking becomes complex because of the private and the public cloud.
- The reliability of the services depends on cloud service providers

Community Cloud

Community cloud is a cloud infrastructure that allows systems and services to be accessible by a group of several organizations to share the information. It is owned, managed, and operated by one or more organizations in the community, a third party, or a combination of them.



Example: Our government organization within India may share computing infrastructure in the cloud to manage data.

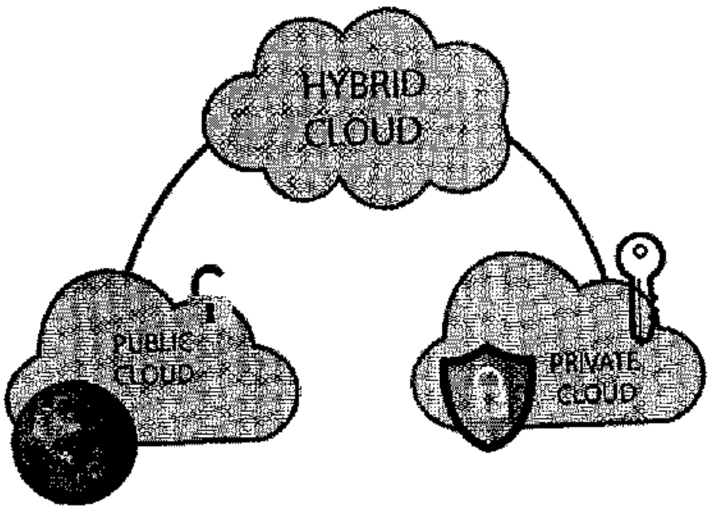
Ethical issues in cloud computing

Cloud computing is based on a paradigm shift with profound implications on computing ethics. The main elements of this shift are:

1. the control is relinquished to third party services;
2. the data is stored on multiple sites administered by several organizations;
3. multiple services interoperate across the network.

Hybrid Cloud

- Hybrid cloud is a combination of **public and private** clouds. **Hybrid cloud = public cloud + private cloud**
- The main aim to combine these cloud (Public and Private) is to create a unified, automated, and well-managed computing environment.
- In the Hybrid cloud, **non-critical activities** are performed by the **public cloud** and **critical activities** are performed by the **private cloud**.
- Mainly, a hybrid cloud is used in finance, healthcare, and Universities.
- The best hybrid cloud provider companies are **Amazon, Microsoft, Google, Cisco,** and **NetApp**.

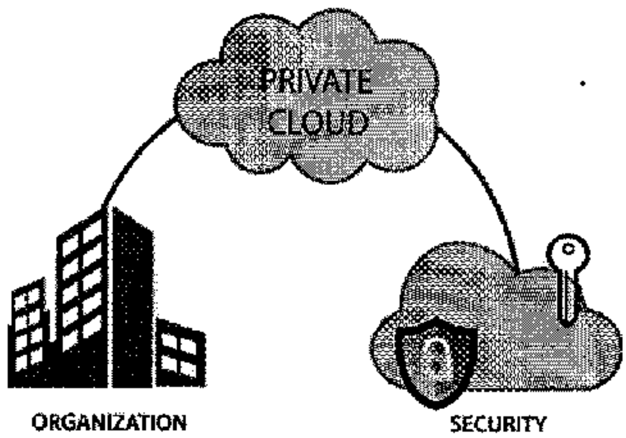


Advantages of Hybrid Cloud

There are the following advantages of Hybrid Cloud -

- It provides flexible resources because of the public cloud and secure resources because of the private cloud.
- Hybrid cloud costs less than the private cloud. It helps organizations to save costs for both infrastructure and application support.
- Hybrid cloud is secure because critical activities are performed by the private cloud.

- Private cloud provides a **high level of security** and **privacy** to data through firewalls and internal hosting. It also ensures that operational and sensitive data are not accessible to third-party providers.
- HP Data Centers, Microsoft, Elastra-private cloud, and Ubuntu are the example of a private cloud.

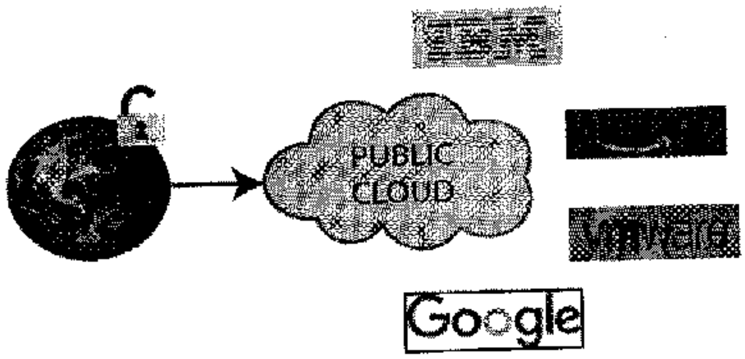


Advantages of Private cloud

- There are the following advantages of Private Cloud -
- Private clouds have more control over their resources and hardware than public clouds because it is only accessed by selected users.
- Security & privacy are one of the big advantages of cloud computing. Private cloud improved the security level as compared to the public cloud.
- Private cloud offers better performance with improved speed and space capacity.

Disadvantages of Private Cloud

- The cost is higher than a public cloud because set up and maintain hardware resources are costly.
- As we know, private cloud is accessible within the organization, so the area of operations is limited.
- Private clouds are scaled only within the capacity of internal hosted resources.



Advantages of Public Cloud

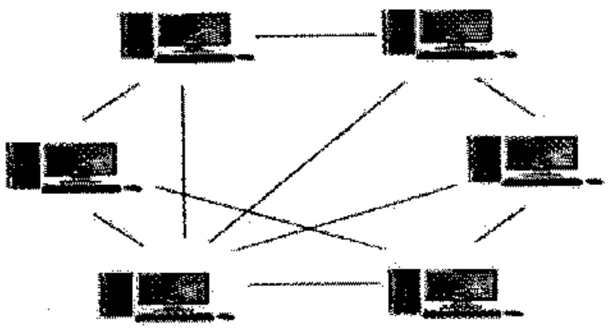
- ❖ There are the following advantages of public cloud -
- ❖ Public cloud has a lower cost than private, or hybrid cloud, as it shares the same resources with a large number of consumers.
- ❖ Public cloud is location independent because its services are offered through the internet.
- ❖ In Public cloud, the cloud service provider is responsible for the manage and maintain data centers in which data is stored, so the cloud user can save their time to establish connectivity, deploying new products, release product updates, configure, and assemble servers.
  Public cloud offers scalable (easy to add and remove) and reliable (24*7 available) services to the users at an affordable cost.

Disadvantages of Public Cloud

- ❖ Public Cloud is less secure because resources are shared publicly.
- ❖ In the public cloud, performance depends upon the speed of internet connectivity.
- ❖ Public cloud is less customizable than the private cloud.

PrivateCloud

- ❖ Private cloud is also known as an **internal cloud** or **corporate cloud**.
- ❖ It is used by organizations to build and manage their own data centers internally or by the third party.
- ❖ Private cloud provides computing services to a **private internal network (within the organization)** and **selected users** instead of the general public.



Advantages Of Peer-To-Peer Network:

- It is less costly as it does not contain any dedicated server.
- If one computer stops working but, other computers will not stop working.
- It is easy to set up and maintain as each computer manages itself.

Disadvantages Of Peer-To-Peer Network:

- In the case of Peer-To-Peer network, it does not contain the centralized system . Therefore, it cannot back up the data as the data is different in different locations.
- It has a security issue as the device is managed itself.

Parallel Computing

- ❖ Parallel computing refers to the process of executing several processors an application or computation simultaneously.
- ❖ Generally, it is a kind of computing architecture where the large problems break into independent, smaller, usually similar parts that can be processed in one go.
- ❖ It is done by multiple CPUs communicating via shared memory, which combines results upon completion.
- ❖ It helps in performing large computations as it divides the large problem between more than one processor
- ❖ Parallel computing also helps in faster application processing.
- ❖ Typically, this infrastructure is housed where various processors are installed in a server rack; the application server distributes the computational requests into small chunks then the requests are processed simultaneously on each server.

- Unauthorized access, data corruption, infrastructure failure, or unavailability are some of the risks related to relinquishing the control to third party services moreover, it is difficult to identify the source of the problem and the entity causing it.
- Unwanted dependency on a cloud service provider, the so-called vendor lock-in, is a serious concern and the current standardization efforts at NIST attempt to address this problem. Another concern for the users is a future with only a handful of companies which dominate the market and dictate prices and policies
- Accountability is a necessary ingredient of cloud computing; adequate information about how data is handled within the cloud and about allocation of responsibility are key elements to enforcing ethics rules in cloud computing. Recorded evidence allows us to assign responsibility; but there can be tension between privacy and accountability and it is important to establish what is being recorded, and who has access to the records.

Peer-To-Peer network

- Peer-To-Peer network is a network in which all the computers are linked together with equal privilege and responsibilities for processing the data.
- Peer-To-Peer network is useful for small environments, usually up to 10 computers.
- Peer-To-Peer network has no dedicated server.
- Special permissions are assigned to each computer for sharing the resources, but this can lead to a problem if the computer with the resource is down.
- The peer to peer computing architecture contains nodes that are equal participants in data sharing.
- All the tasks are equally divided between all the nodes. The nodes interact with each other as required as share resources.

- If you upload a file to S3 bucket, then you will receive an HTTP 200 code means that the uploading of a file is successful.

Create Buckets: Firstly, we create a bucket and provide a name to the bucket. Buckets are the containers in S3 that stores the data. Buckets must have a unique name to generate a unique DNS address.

Storing data in buckets: Bucket can be used to store an infinite amount of data. You can upload the files as much you want into an Amazon S3 bucket, i.e., there is no maximum limit to store the files. Each object can contain upto 5 TB of data. Each object can be stored and retrieved by using a unique developer assigned-key.

Download data: You can also download your data from a bucket and can also give permission to others to download the same data. You can download the data at any time whenever you want.

Permissions: You can also grant or deny access to others who want to download or upload the data from your Amazon S3 bucket. Authentication mechanism keeps the data secure from unauthorized access.

Standard interfaces: S3 is used with the standard interfaces REST and SOAP interfaces which are designed in such a way that they can work with any development toolkit.

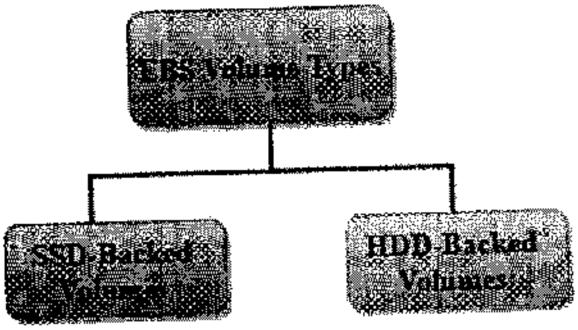
Security: Amazon S3 offers security features by protecting unauthorized users from accessing your data.

EBS

- EBS stands for **Elastic Block Store**.
- EC2 is a virtual server in a cloud while EBS is a virtual disk in a cloud.
- Amazon EBS allows you to create storage volumes and attach them to the EC2 instances.
- Once the storage volume is created, you can create a file system on the top of these volumes, and then you can run a database, store the files, applications or you can even use them as a block device in some other way.

- Amazon EBS volumes are placed in a specific availability zone, and they are automatically replicated to protect you from the failure of a single component.
- EBS volume does not exist on one disk, it spreads across the Availability Zone. EBS volume is a disk which is attached to an EC2 instance.
- EBS volume attached to the EC2 instance where windows or Linux is installed known as Root device of volume.

EBS Volume Types



Amazon EBS provides two types of volume that differ in performance characteristics and price. EBS Volume types fall into two parts:

- SSD-backed volumes
- HDD-backed volumes

SSD

- SSD stands for solid-state Drives.
- In June 2014, SSD storage was introduced.
- It is a general purpose storage.
- It supports up to 4000 IOPS which is quite very high.
- SSD storage is very high performing, but it is quite expensive as compared to HDD (Hard Disk Drive) storage.
- SSD volume types are optimized for transactional workloads such as the frequent read/write operations with small I/O size, where the performance attribute is IOPS.

HDD

- It stands for Hard Disk Drive.

- HDD based storage was introduced in 2008.
- The size of the HDD based storage could be between 1 GB to 1TB.
- It can support up to 100 IOPS which is very low.

Amazon RDS

- Amazon Relational Database Service (RDS) is a managed SQL database service provided by Amazon Web Services (AWS). Amazon RDS supports an array of database engines to store and organize data.
- It also helps with relational database management tasks, such as data migration, backup, recovery and patching.

The Database Engines are

Amazon Aurora is a proprietary AWS relational database engine. Amazon Aurora is compatible with MySQL and PostgreSQL.

RDS for MariaDB is compatible with MariaDb, an open source relational database management system that's an offshoot of MySQL.

RDS for MySQL is compatible with the MySQL open source RDBMS.

RDS for Oracle Database is compatible with several editions of Oracle Database, including bring-your-own-license and license-included versions.

RDS for PostgreSQL is compatible with PostgreSQl open source object-RDBMS.

RDS for SQL Server is compatible with Microsoft SQL Server, an RDBMS

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Cloud Infrastruture at Microsoft Azure

- Microsoft Azure is a cloud computing platform that provides a wide variety of services that we can use without purchasing and arranging our hardware.
- It enables the fast development of solutions and provides the resources to complete tasks that may not be achievable in an on-premises environment.
- Microsoft Azure is a growing set of cloud computing services created by Microsoft that hosts your existing applications, streamline the development of a new application, and also enhances our on-premises applications.
- It helps the organizations in building, testing, deploying, and managing applications and services through Microsoft-managed data centers.

Azure Services

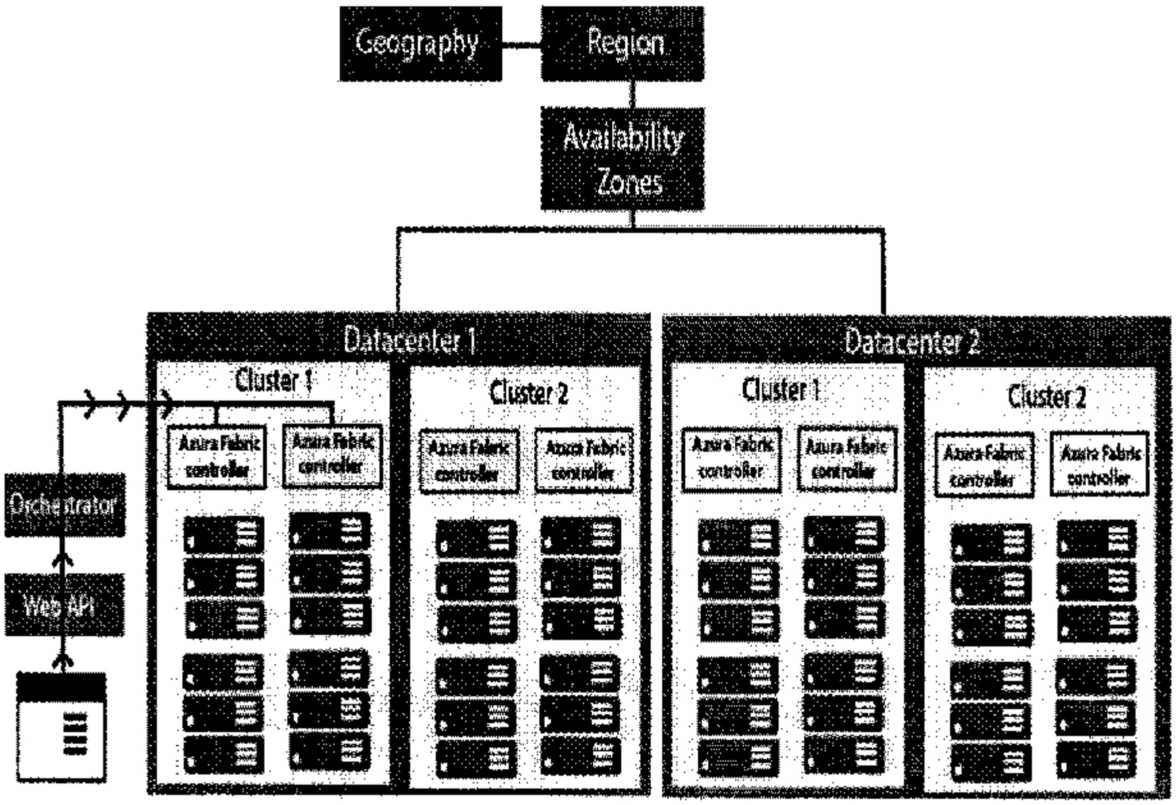
Compute services: It includes the Microsoft Azure Cloud Services, Azure Virtual Machines, Azure Website, and Azure Mobile Services, which processes the data on the cloud with the help of powerful processors.

Data services: This service is used to store data over the cloud that can be scaled according to the requirements. It includes Microsoft Azure Storage (Blob, Queue Table, and Azure File services), Azure SQL Database, and the Redis Cache.

Application services: It includes services, which help us to build and operate our application, like the Azure Active Directory, Service Bus for connecting distributed systems, HDInsight for processing big data, the Azure Scheduler, and the Azure Media Services.

Network services: It helps you to connect with the cloud and on-premises infrastructure, which includes Virtual Networks, Azure Content Delivery Network, and the Azure Traffic Manager.

It is essential to understand the internal workings of Azure so that we can design our applications on Azure effectively with high availability, data residency, resilience, etc.



Microsoft Azure is completely based on the concept of virtualization. So, similar to other virtualized data center, it also contains *racks*. Each rack has a separate power unit and network switch, and also each rack is integrated with a software called *Fabric-Controller*. This *Fabric-controller* is a distributed application, which is responsible for managing and monitoring servers within the rack. In case of any server failure, the Fabric-controller recognizes it and recovers it. And Each of these Fabric-Controller is, in turn, connected to a piece of software called *Orchestrator*. This *Orchestrator* includes web-services, Rest API to create, update, and delete resources.

When a request is made by the user either using PowerShell or Azure portal. First, it will go to the Orchestrator, where it will fundamentally do three things:

1. Authenticate the User
2. It will Authorize the user, i.e., it will check whether the user is allowed to do the requested task.

3. It will look into the database for the availability of space based on the resources and pass the request to an appropriate Azure Fabric controller to execute the request.

Combinations of racks form a cluster. We have multiple clusters within a data center, and we can have multiple Data Centers within an Availability zone, multiple Availability zones within a Region, and multiple Regions within a Geography.

- **Geographies:** It is a discrete market, typically contains two or more regions, that preserves data residency and compliance boundaries.
- **Azure regions:** A region is a collection of data centers deployed within a defined perimeter and interconnected through a dedicated regional low-latency network.

Azure Virtual Machines

Azure Virtual machine will let us create and use virtual machines in the cloud as Infrastructure as a Service. We can use an image provided by Azure, or partner, or we can use our own to create the virtual machine.

Virtual machines can be created and managed using:

- Azure Portal
- Azure PowerShell and ARM templates
- Azure CLI
- Client SDK's
- REST APIs

Following are the configuration choices that Azure offers while creating a Virtual Machine.

- Operating system (Windows and Linux)
- VM size, which determines factors such as processing power, how many disks we attach etc.
- The region where VM will be hosted

- A storage account can contain an unlimited number of containers, and each container can contain an unlimited number of blobs up to the maximum limit of storage account size (up to 500 TB).
- To refer this blob, once it is placed into a container inside a storage account, we can use the URL, which looks like http://mystorageaccount.blob.core.windows.net/mycontainer/myblob.

Queues

In the common language used by developers, a queue is a data structure used to store data which follows First in-First out rule. A data item can be inserted from back of the queue while it is retrieved from front. Azure queues are a very similar concept that is used to store the messages in a queue

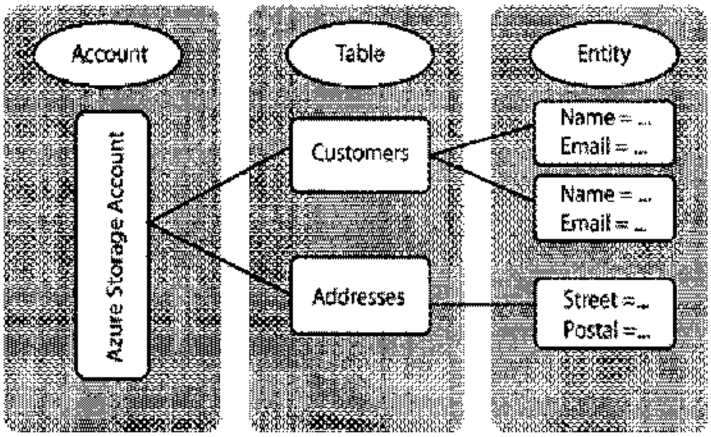
- It is a service for storing a large number of messages in the cloud that can be accessed from anywhere in the world using HTTP and HTTPS.
- A queue contains a set of message. Queue name must be all lowercase.
- A single queue message can be up to 64KB in size. A message can remain in the queue for a maximum time of 7 days
- URL format is http://<storage account>.queue.core.windows.net/<queue>
- When the message is retrieved from the queue, it stays invisible for 30 seconds. A message needs to be explicitly deleted from the queue to avoid getting picked up by another application.

Table

Azure Table storage is used for storing a large amount of structured data. This service is a NoSQL data storageIt is ideal for storing structured and non-relational data.

We need to create a storage account first because Azure table storage is offered under storage account, and then you have tables within that storage account. E.g., you can create employee table, address table, and each table will contain entities and entities will further include key-value pair like name email within an employee table.

Azure Table structure

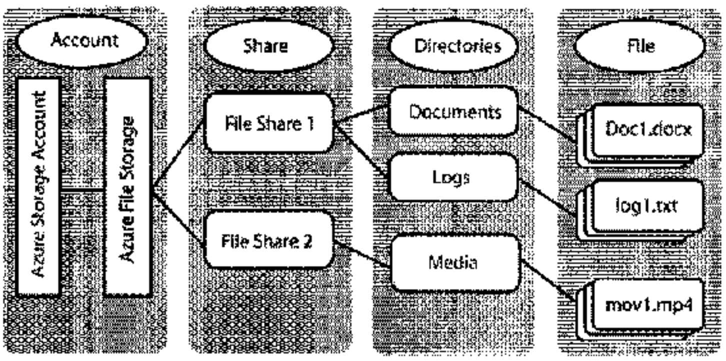


Azure File Storage Service

Azure file storage mainly can be used if we want to have a shared drive between two servers or across users. In that case, we will go for Azure file storage. In the Azure file storage structure, the first thing we need to have is an Azure storage account. Azure file storage is offered under the umbrella of the Azure storage account. And once we have created an Azure storage account, we'll create a file share.

We can create an unlimited number of file shares within a storage account. Once we create a file share, then we can create directories, just like folders, and then we can upload files into it. Once we create a file share, we can mount that on any virtual machine, whether it is in Azure or outside.

Azure file storage



CloudComputing at Google Perspective

Google is concentrated in the area of Software as a service(Saas).

It provides the services such as **Gmail,Google Drive,GoogleCalandar,Picasa** And **Google Groups** are free of charge for individual users and available for a fee for organizations.

These services are running on a cloud and can be invoked from any device like iphones,ipads,laptops and tablets.

The **Gmail service** host the emails in Google Servers and it provides webInterface to access them.

Google Docs is a web based software it allows you building text documents,spreadsheets,and presentations.It also supports fetures such as tables,bullet points,basic fonts and text size.It allows multiple users to edit and update the same document.It provides Spell checker facility.It also enalble the users to import and export files in several formats including Microsoftoffice,PDF,text files.

GoogleCalendar

- **It** is a time-management and scheduling calendar service developed by Google.
- Google Calendar allows users to create and edit events. Events have a set start time and stop time, with an option for an "All-day event".
- Locations can be added for easy understanding of an event's place.
- Reminders can be enabled for events, with options available for type and time
- Google Calander is accessible from mobile devices.
- Event remainders can be received via SMS,desktop popups.
- Users can invite other people to events; for other Google Calendar users, the event becomes visible in their calendar, and for non-Google Calendar users, an email will have options for "Yes", "No", or "Maybe".

Picasa is a tool to upload and share and edit images in online.It provides 1 GB of disk space per user free of charge.Users can add tags to images and attach location to photos using Google Maps.

- VM extension, which gives additional capabilities such as running anti-virus etc.
- Compute, Networking, and Storage elements will be created during the provisioning of the virtual machine.

Azure Storage Building Blocks

The fundamental building block of Azure storage service is the ***Azure storage account***. The Storage account is more like an administrative container for most of the Azure storage services.

Azure Storage Account

An Azure Storage Account is a secure account, which provides you access to services in Azure Storage. The storage account is like an administrative container, and within that, we can have several services like blobs, files, queues, tables, disks, etc. And when we create a storage account in Azure, we will get the unique namespace for our storage resources. That unique namespace forms the part of the URL. The storage account name should be unique across all existing storage account name in Azure.

BLOB

- The word 'Blob' expands to **B**inary Large **OB**ject. Blobs include images, text files, videos and audios.
- All the blobs must be inside a container in your storage.
- The container is more like a folder where different blobs are stored. At the container level, we can define security policies and assign those policies to the container, which will be cascaded to all the blobs under the same container.
- There are three options in the Access dropdown which sets the permission of who can access the blobs.

1.'Private' option will let only the account owner to access it.

2.'Public Container' will allow anonymous access to all the contents of that container.

3.'Public blob' option will set open access to blob but won't allow access to the container.

- OpenStack offers many cloud-related services (such as networking, storage, image services, identity, etc.) by default. This can be handled by users through a web-based dashboard, a RESTful API, or command-line tools. OpenStack manages a lot of virtual machines; this permits the usage of physical resources to be reduced.

Components of OpenStack

Major components of OpenStack are given below:

Compute (Nova): Compute is a controller that is used to manage resources in virtualized environments. It handles several virtual machines and other instances that perform computing tasks.

Object Storage (Swift): To store and retrieve arbitrary data in the cloud, object storage is used. In Swift, it is possible to store the files, objects, backups, images, videos, virtual machines, and other unstructured data. Developers may use a special identifier for referring the file and objects in place of the path, which directly points to a file and allows the OpenStack to manage where to store the files.

Block Storage (Cinder): This works in the traditional way of attaching and detaching an external hard drive to the OS for its local use. Cinder manages to add, remove, create new disk space in the server. This component provides the virtual storage for the virtual machines in the system.

Networking (Neutron): This component is used for networking in OpenStack. Neutron manages all the network-related queries, such as IP address management, routers, subnets, firewalls, VPNs, etc. It confirms that all the other components are well connected with the OpenStack.

Dashboard (Horizon): This is the first component that the user sees in the OpenStack. Horizon is the web UI (user interface) component used to access the other back-end services. Through individual API (Application programming interface), developers can access the OpenStack's components, but through the dashboard, system administrators can look at what is going on in the cloud and manage it as per their need.

Identity Service (Keystone): It is the central repository of all the users and their permissions for the OpenStack services they use. This component is used to manage identity services like authorization, authentication, AWS Styles (Amazon

Google Groups is a service from Google that provides discussion groups for people sharing common interests.Google groups allows users to host discussion forums to create messages online or via email.

Google also provides Platform As a Service space. **Google App Engine** (GAE) is a service for developing and hosting Web applications in Google's data centers, belonging to the platform as a service (PaaS) category of cloud computing. Initially supported only Python but support for java was added later.

GoogleDrive is an online service for datastorage that has been available in apr 2012.It gives users 5GB of free storage and charges $4 per month for 20GB.

Open Source Software Platforms

Open-source cloud is any cloud service or solution that is built using open-source software and technologies. This includes any public, private or hybrid cloud model providing SaaS, IaaS, PaaS or XaaS built and operated entirely on open-source technologies.

Open source Software means the source code of the software is available to all users.The Open source softwares are

1.Openstack

2.Euclayptus

3.OpenNebula

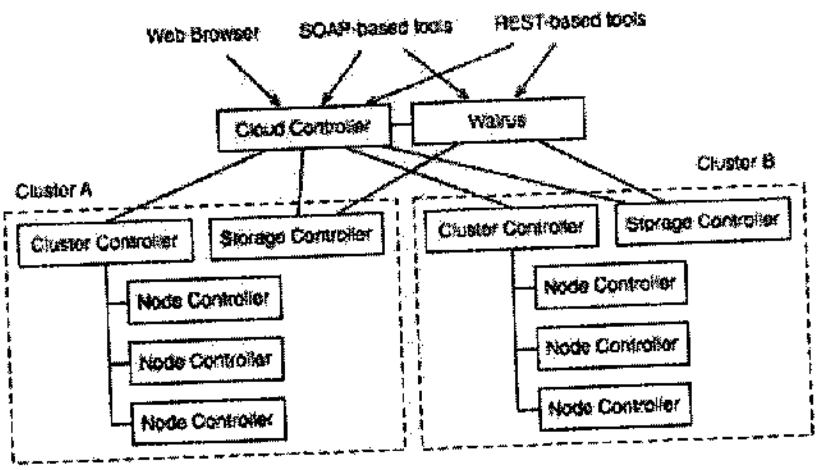
4.Nimbus

1.Openstack

- OpenStack is a cloud OS that is used to control the large pools of computing, storage, and networking resources within a data center.
- OpenStack is an open-source and free software platform. This is essentially used and implemented as an IaaS for cloud computing.
- We can call the OpenStack a software platform that uses pooled virtual resources to create and manage private and public cloud.

manages the networking for the running instances under certain types of networking modes available in Eucalyptus.

2. Cloud Controller (CLC) Cloud Controller is front end for the entire ecosystem. CLC provides an Amazon EC2/S3 compliant web services interface to the client tools on one side and interacts with the rest of the components of the Eucalyptus infrastructure on the other side.
3. Node Controller (NC) It is the basic component for Nodes. Node controller maintains the life cycle of the instances running on each nodes. Node Controller interacts with the OS, hypervisor and the Cluster Controller simultaneously.
4. Walrus Storage Controller (WS3) Walrus Storage Controller is a simple file storage system. WS3 stores the the machine images and snapshots. It also stores and serves files using S3 APIs.
5. Storage Controller (SC) Allows the creation of snapshots of volumes. It provides persistent block storage over AoE or iSCSI to the instances.

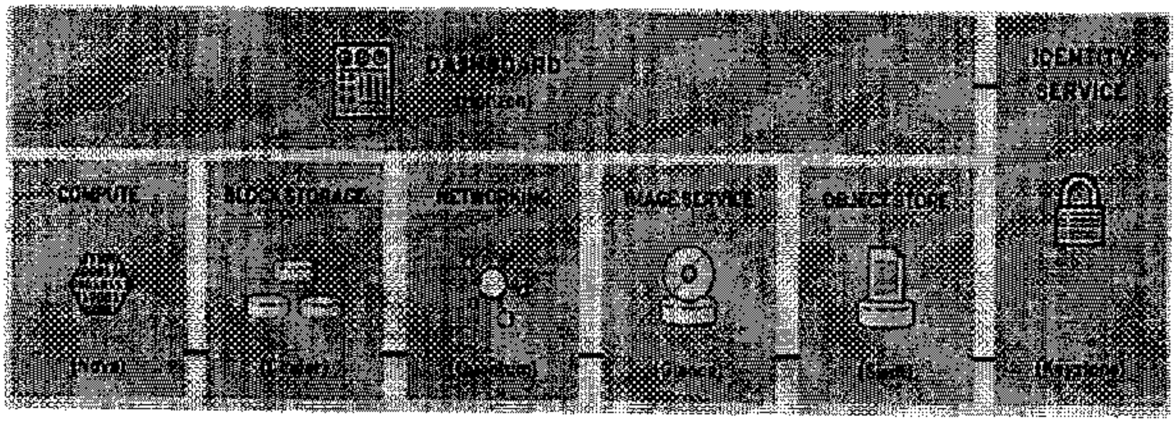


3.OpenNebula

- **OpenNebula** is a cloud computing platform for managing heterogeneous distributed data center infrastructures.
- OpenNebula is a free and open source software solution for building clouds and for data centre virtualisation.
- It is based on open technologies and is distributed under the Apache License 2. OpenNebula has features for scalability, integration, security and accounting. It offers cloud users and administrators a choice of interfaces.

Web Services) logins, token-based systems, and checking the other credentials (username & password).

Image Service (Glance): The glance component is used to provide the image services to OpenStack. Here, image service means the images or virtual copies of hard disks. When we plan to deploy a new virtual machine instance, then glance allows us to use these images as templates. Glance allows virtual box (VDI), VMware (VMDK, OVF), Raw, Hyper-V (VHD) and KVM (qcow2) virtual images.



2.Eucalyptus

- Eucalyptus is an open source cloud software storage for building aws-feasible private and hybrid clouds
- Eucalyptus is the acronym for Elastic Utility Computing Architecture for Linking your Programs To Useful Systems
- Eucalyptus can also be built on VMWare workstation using the 'VMware Eucalyptus image". Basically, Eucalyptus is used for building a private cloud in Amazon Web Services. This allows the eucalyptus users to run applications in compatible with the Amazon EC2 (Elastic Compute Cloud) and Amazon S3 (Storage).

The main components of Eucalyptus cloud architecture are as follows:

1. Cluster Controller (CC) Cluster Controller manages the one or more Node controller and responsible for deploying and managing instances on them. It communicates with Node Controller and Cloud Controller simultaneously. CC also

- **Nimbus Platform** is an integrated set of tools, operating in a multi-cloud environment, that deliver the power and versatility of infrastructure clouds to scientific users. Nimbus Platform allows you to reliably deploy, scale, and manage cloud resources.

Cloud Storage Diversity & Vendor-Lock-in

There are several risk involved when a large organization completely depends on a single cloud provider.

Risk1:Cloud services may be unavailable for short or extended period of time.such an interruption is likely negative impact the organization

Risk2:The Permanent data loss in case of catastrophic system failure i.e completely,unexcepted,breakdown of a system it occurs harddik crash and chip failure etc.

Risk3:The cloud service provider (CSP)may decide to the prices for service and charge more for computing cycles,memory,storage space and network bandwidth than other CSP's.

The alternative in this case is switching to another provider but this solution could be very costly due to large volume of data to be transferred from old to new provider its take long time and high expensive.

A solution to guarding against vendor lock is to replicate the data into multiple cloud service providers. But this straight forward replication is costly and poses technical challenges at the same time. The overhead to maintain data consistency could drastically affect the performance of the virtual storage system consisting of multiple full replicas of the organization's data spread over multiple vendors.

Another solution is based on extension of design principle of a RAID-5 system used for reliable data storage. A RAID 5 system uses block level striping with distributed parity over a disk array.
DataStripes is a process of divide the data across the multiple harddisks
Parity is a calculated value which is used to recover the data from the disk when disk is failure.

The disk controller distributes the sequential block of data to the physical disk and computes a parity block by bitwise XORing the data block. The parity block is

Components of OpenNebula
Based on the existing infrastructure, OpenNebula provides various services and resources. You can view the components in Figure 3.

- ***APIs and interfaces:*** These are used to manage and monitor OpenNebula components. |To manage physical and virtual resources, they work as an interface.
- ***Users and groups:*** These support authentication, and authorise individual users and groups with the individual permissions.
- ***Hosts and VM resources:*** These are a key aspect of a heterogeneous cloud that is managed and monitored, e.g., Xen, VMware.
- ***Storage components:*** These are the basis for centralised or decentralised template repositories.
- ***Network components:*** These can be managed flexibly. Naturally, there is support for VLANs and Open vSwitch.

4.Nimbus

- Nimbus is an open-source toolkit to convert a computer cluster into an Infrastructure-as-a-Service cloud to provide compute cycles for scientific communities.
- The Nimbus cloud-computing infrastructure allows scientists working on data-intensive research to create and use such virtual machines with a cloud provider.
- Nimbus also allows users to create multiple virtual machines to complete specific computational jobs that can be deployed throughout the cloud and still work in tandem with each other. This flexibility allows a user to configure a virtual machine and then connect it to resources on a cloud, regardless of who is providing the cloud.

Nimbus is comprised of two products:

- **Nimbus Infrastructure** is an open source EC2/S3-compatible Infrastructure-as-a-Service implementation specifically targeting features of interest to the scientific community such as support for proxy credentials, batch schedulers, best-effort allocations and others.

InterCloud

- Now a days, there is an increased demand for cloud computing.
- As the number of cloud users increases, it is a challenge to provide to the requirements of all the users in order to maintain the Quality of the cloud providers.
- Cloud providers do not provide an infinite amount of resources and hence may get saturated at some point in time
- In such situations that intercloud comes as a benefit to the cloud provider.
- Intercloud can be basically viewed as a cloud of clouds.The concept of inter cloud introduced in 2010. Here, multiple cloud providers join hands to serve the customers. The major cloud providers are Amazon, Google, Microsoft, IBM, etc.,
- The use of intercloud avoids vendor lock- in where the customer becomes dependent on a particular vendor. Here, users depend on multiple vendors.
- By making use of intercloud, the users are assigned resources in a more flexible manner.

There are two types of inter clouds: 1.federation of clouds 2.multicloud.

1.Fedaration Cloud:is the process of interconnecting the cloud computing environments of two or more service providers. Here, infrastructures may be shared so as to enable resource sharing. The users need not bother about using more than one . cloud providers take up the responsibility of providing a transparent service to the customers. Here, one cloud provider can rent the resources of another cloud provider and offer it to the customers.

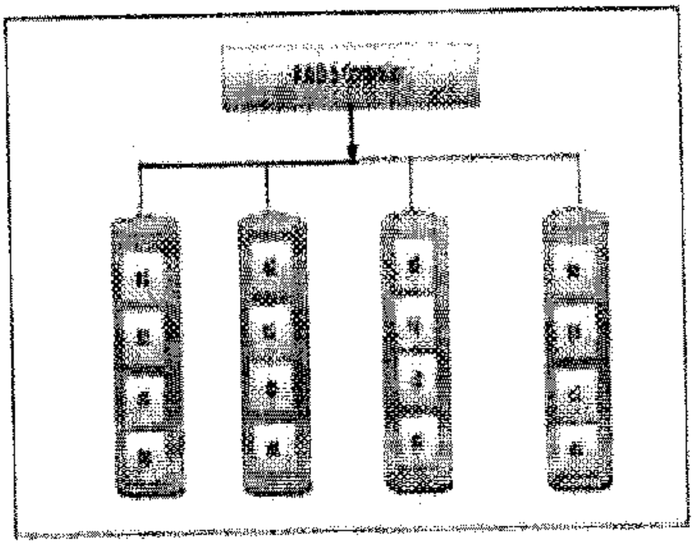
2.In multicloud: the client or service makes use of multiple clouds. Thus, the user is aware of the fact that they are being served by more than one cloud provider. It is the responsibility of the users to provide interoperability between the various cloud providers.

written on a different disk for each file when all parity is written to a dedicated disk as in RAID 4. This technique allows us to recover data after a single disk is lost.

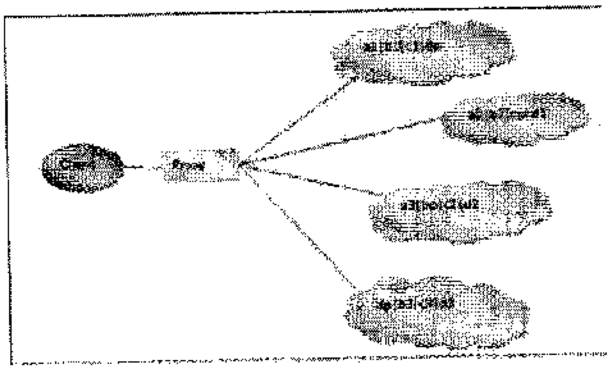
ap=a1XORa2XORa3
bp=b1XORb2XORb3
cp=c1XORc2XORc3

To recover the data from the disk

a2=a1XORa3XORap
b2=b1XORbpXORb3 etc.



The same process can be applied to detect and correct error in a single block. We can replicate this system in cloud, data may be stripped across four clouds, the proxy cloud provides transparent to data. Proxy carries out function of the RAID controller. The RADI controller allows multiple accesses to data. For example block a1, a2, a3 can be read and written concurrently.



However, it is not yet made possible because each of the cloud provider uses different standard languages for their platforms.

Interoperability

It means the application on one platform should be able to incorporate services from the other platforms. It is made possible via web services, but developing such web services is very complex.

Computing Performance

Data intensive applications on cloud requires high network bandwidth, which results in high cost. Low bandwidth does not meet the desired computing performance of cloud application.

Reliability and Availability

It is necessary for cloud systems to be reliable and robust because most of the businesses are now becoming dependent on services provided by third-party.

Responsibility sharing between user and cloud service provider

- In case of SAAS the service provider supplies both hardware and application software and user has direct access to these services through a web interface and has no control over cloud resources.Typical example are gmail,google docs,google groups,google drive etc.
- In case of PAAS the service provider provides only platform it contains both hardware and system software such as operating system and databases.The service provider is responsible for system updates,patches and software maintenance.user does not allow any user control of the operating system.Examples are Google App engine,Microsoft azure etc.
- In case of IAAS the service provider supplies the hardware and control over the provider.

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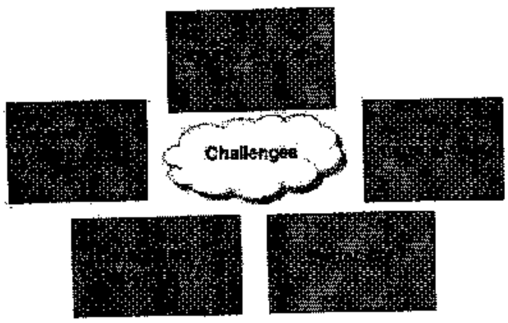
Cloud Computing Challenges

Cloud computing, an emergent technology, has placed many challenges in different aspects of data and information handling. Some of these are shown in the



following diagram:

Security and Privacy

Security and Privacy of information is the biggest challenge to cloud computing. Security and privacy issues can be overcome by employing encryption, security hardware and security applications.

Portability

This is another challenge to cloud computing that applications should easily be migrated from one cloud provider to another. There must not be vendor lock-in.

Unit -3

Virtualization

- Virtualization can be defined as a process that enables the creation of a virtual version of a desktop, operating system, network resources, or server. Virtualization plays a key and dominant role in cloud computing.

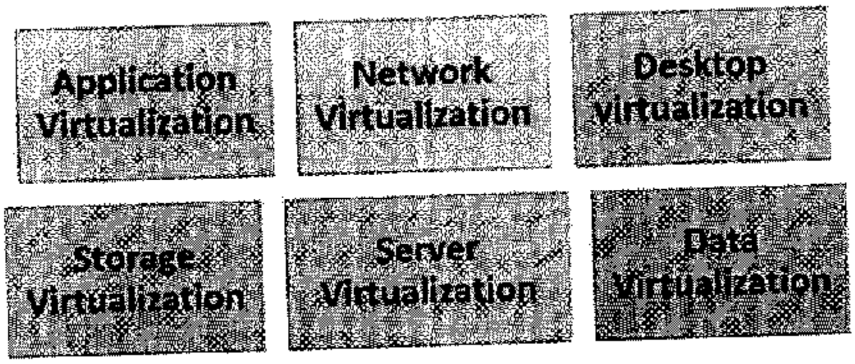
  (or)
- Virtualization in cloud computing is defined as a creation of a virtual version of a server, a desktop, a storage device, an operating system, or network resources. It is essentially a technique or method that allows the sharing of a single physical instance of a resource or an application amongst multiple organizations or customers.
- It is done by assigning a logical name or to the physical storage device and offering a pointer to a particular physical device when the requirement arises.
- The machine on which the virtual machine is built is called **the Host Machine** and the virtual machine is known as the **guest machine.**
- In cloud computing, Virtualization facilitates the creation of **virtual machines** and ensures the smooth functioning of multiple operating systems. It also helps create a virtual ecosystem for server operating systems and multiple storage devices.

BENEFITS OF VIRTUALIZATION

- Increases development productivity
- Diminishes the cost of obtaining IT infrastructure
- Provides rapid scalability and remote access.
- More flexible.
- Allows the user to run multiple operating systems.

Types of Virtualizations

There are many variants or types available under virtualization technology as listed below:



Types of Virtualizations

CHARACTERISTICS OF VIRTUALISATION

1. **Increased Security** – virtualization increases the hosts' ability to control the execution of guest programs with higlysecure and controlled execution environment.
2. **Sharing** – Sharing is a key feature of virtualization as through this process one can create a separate computing environment within the same host.
3. **Aggregation** –Groups of separate hosts can be ties together and be represented to guests as a single virtual host. This feature is used in cluster management software.
4. **Emulation** – An entirely different environment can be emulated, concerning the host, thereby allowing the execution of guest programs that require a specific set of characteristics.
5. **Isolation** – virtualization allows providing guest programs with completely separated and isolated environments.
6. **Portability** – portability has different applications per different types of virtualization.

Virtualization simulates the interface in any one of these notations:

Multiplexing.: Multiple virtual objects from one instance of a physical object. For example, a processor is multiplexed among a number of processes or threads.

Aggregation. Create one virtual object from multiple physical objects. For example, a number of physical disks are aggregated in to a RAID disk.

Emulation. Construct a virtual object from a different type of physical object. For example a physical disk emulates a random access memory.

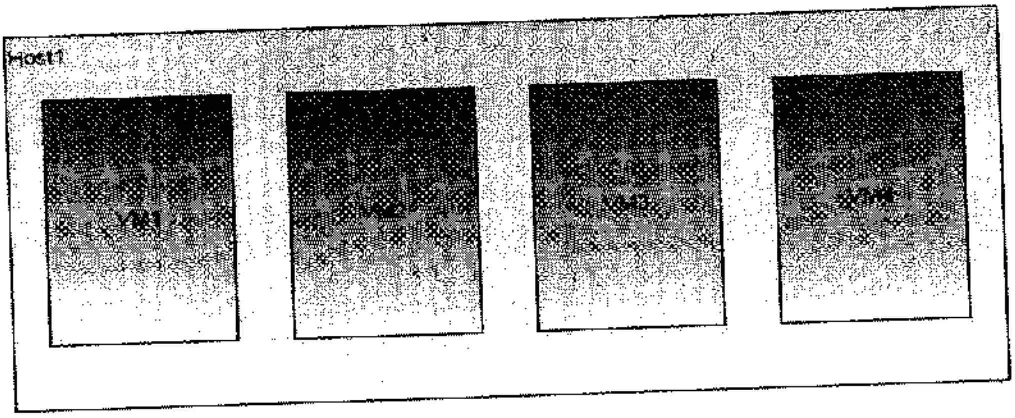
Multiplexing and emulation. Examples: Virtual memory with paging multiplexes real memory and disk, and a Virtual address emulates real address.

Virtual Machines

- A virtual machine (VM) is a digital version of a physical computer. Virtual machine software can run programs and operating systems, store data, connect to networks, and do other computing functions, and requires maintenance such as updates and system monitoring.
- A VM is a virtualized instance of a computer that can perform almost all of the same functions as a computer, including running applications and operating systems.
- Virtual machines run on a physical machine and access computing resources from software called a hypervisor.
- Virtual machine is a software-based-computer that exists within the operating system of another computer. In simpler terms, it is a virtualization of an actual computer, except that it exists on another system.

- **Hypervisor** is a software layer that allows you to virtualize the environment. The operating system running in the virtual machine is called as the Guest Operating System.
- Multiple virtual machines can share a single host; that is, they can run on the same physical machine. This increases the usage efficiency of the physical

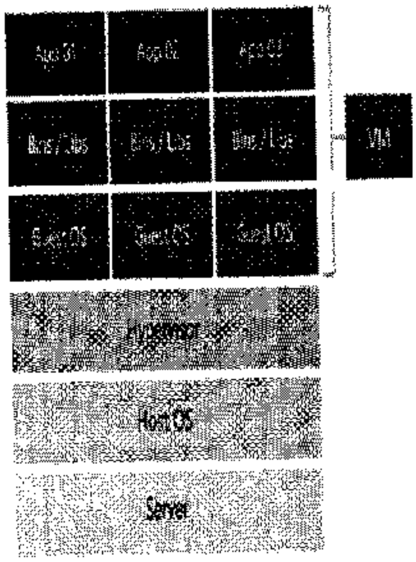
machine. The number of virtual machines on a single host is limited by the resources of the physical machine.

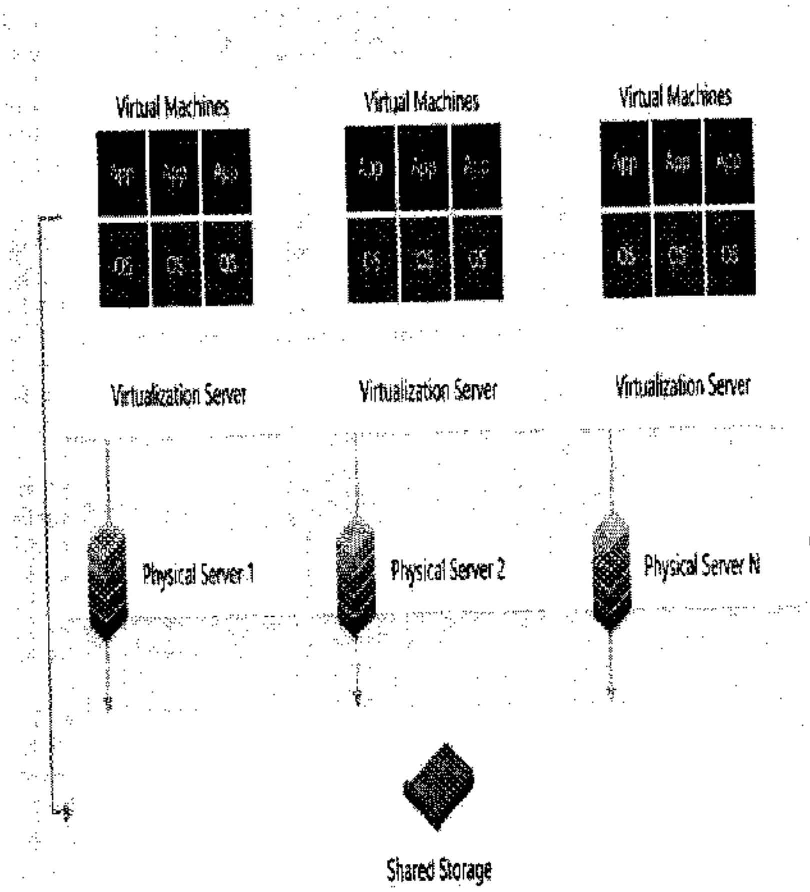


Virtual machines

There are many advantages to using cloud virtual machines instead of physical machines, including:

- **Low cost.**
- **Easy scalability**
- **Ease of setup and maintenance.**
- **Shared responsibility**





How multiple virtual machines work

Multiple VMs can be hosted on a single physical machine, often a server, and then managed using virtual machine software. This provides flexibility for compute resources (compute, storage, network) to be distributed among VMs as needed, increasing overall efficiency. This architecture provides the basic building blocks for the advanced virtualized resources we use today, including cloud computing.

There are two types of virtual machines:

1. Process.
2. System virtual machines.

- A process: VM is a virtual platform created for an individual process and destroyed once the process terminates. Virtually all operating systems provide a process VM for each one of the applications running, but the more interesting process VMs are those that support binaries compiled on a different instruction set.

- A system: VM supports an operating system together with many user processes. When the VM runs under the control of a normal OS and provides a platform-independent host for a single application, we have an application virtual machine (e.g., Java Virtual Machine [JVM]).

Virtual machine monitors

Sometimes the hardware supports a third mode of execution for the guest OS.

A Virtual Machine Monitor (VMM) is a software program that enables the creation, management and governance of virtual machines (VM) and manages the operation of a virtualized environment on top of a physical host machine.

VMM is also known as Virtual Machine Manager and Hypervisor. VMM is the primary software behind virtualization environments and implementations. When installed over a host machine, VMM facilitates the creation of VMs, each with separate operating systems (OS) and applications. The VMM runs in kernel mode, whereas a guest OS runs in user mode. VMM manages the backend operation of these VMs by allocating the necessary computing, memory, storage and other input/output (I/O) resources.

VMM also provides a centralized interface for managing the entire operation, status and availability of VMs that are installed over a single host or spread across different and interconnected hosts

VMMs allow several operating systems to run concurrently on a single hard ware platform; at the same time, VMMs enforce isolation among these systems, thus enhancing security. A VMM controls how the guest operating system uses the hardware resources. The events occurring in one VM do not affect any other VM running under the same VMM. At the same time, the VMM enables:

- Multiple services to share the same platform.

• The movement of a server from one platform to another, the so-called live migration.

• System modification while maintaining backward compatibility with the original system.

When a guest OS attempts to execute a privileged instruction, the VMM traps the operation and enforces the correctness and safety of the operation. The VMM guarantees the isolation of the individual VMs, and thus ensures security and encapsulation which is a major concern in cloud computing.

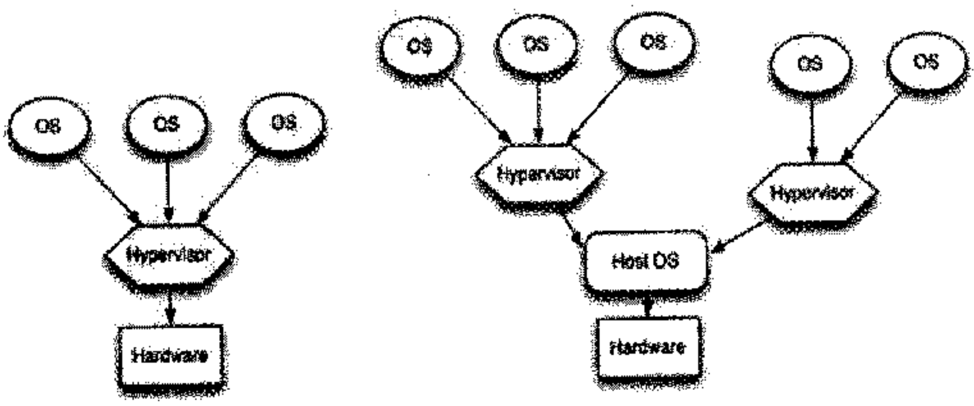
At the same time, the VMM monitors system performance and takes corrective action to avoid performance degradation; for example, the VMM may swap out a VM (copies all pages of that VM from real memory to disk and makes the real memory frames available for paging by other VMs) to avoid thrashing.

A VMM virtualizes the CPU and memory. For example, the VMM traps interrupts and dispatches them to the individual guest operating systems. If a guest OS disables interrupts, the VMM buffers such interrupts until the guest OS enables them.

The VMM maintains a shadow page table for each guest OS and replicates any modification made by the guest OS in its own shadow page table. This shadow page table points to the actual page frame and is used by the hardware component called the memory management unit (MMU) for dynamic address translation.

Memory virtualization has important implications on performance. VMMs use a range of optimization techniques; for example, VMware systems avoid page duplication among different virtual machines; they maintain only one copy of a shared page and use copy-on-write policies whereas Xen imposes total isolation of the VM and does not allow page sharing.

VMMs control the virtual memory management and decide what pages to swap out; for example, when the ESX VMware server wants to swap out pages, it uses a balloon process inside a guest OS and requests it to allocate more pages to itself, thus swapping out pages of some of the processes running under that VM. Then it forces the balloon process to relinquish control of the free page frames.



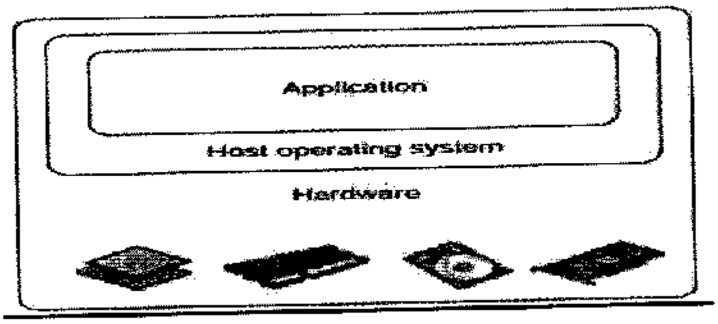
Type 1 Hypervisor

Type 2 Hypervisor

Layering and virtualization

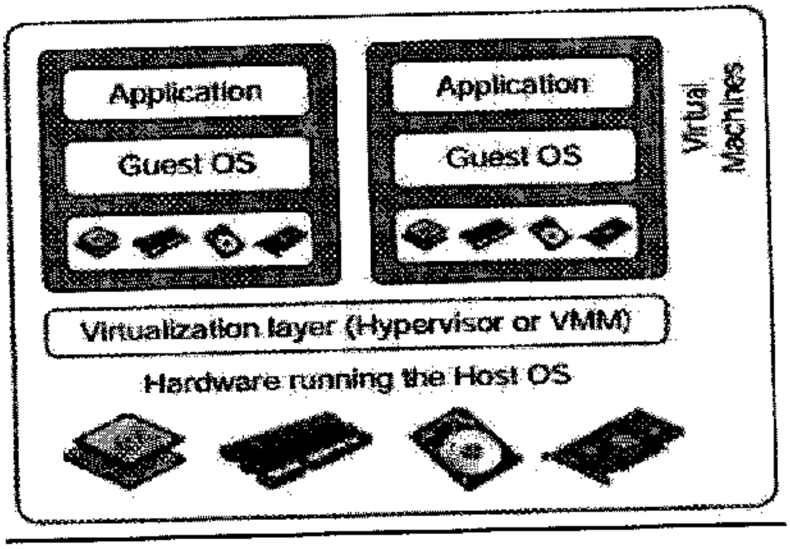
- A common approach to managing system complexity is to identify a set of *layers* with well defined *interfaces* among them. The interfaces separate different levels of abstraction. Layering minimizes the interactions among the subsystems and simplifies the description of the subsystems.

  A traditional computer runs with a host operating system specially tailored for its hardware architecture, as shown in Figure



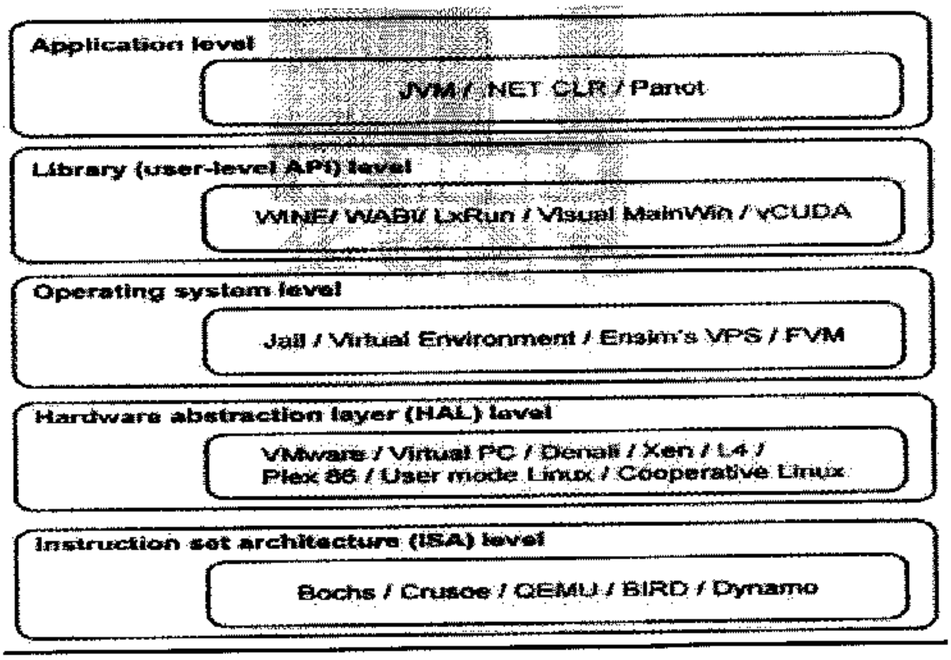
- After virtualization, different user applications managed by their own operating systems (guest OS) can run on the same hardware, independent of the host OS.

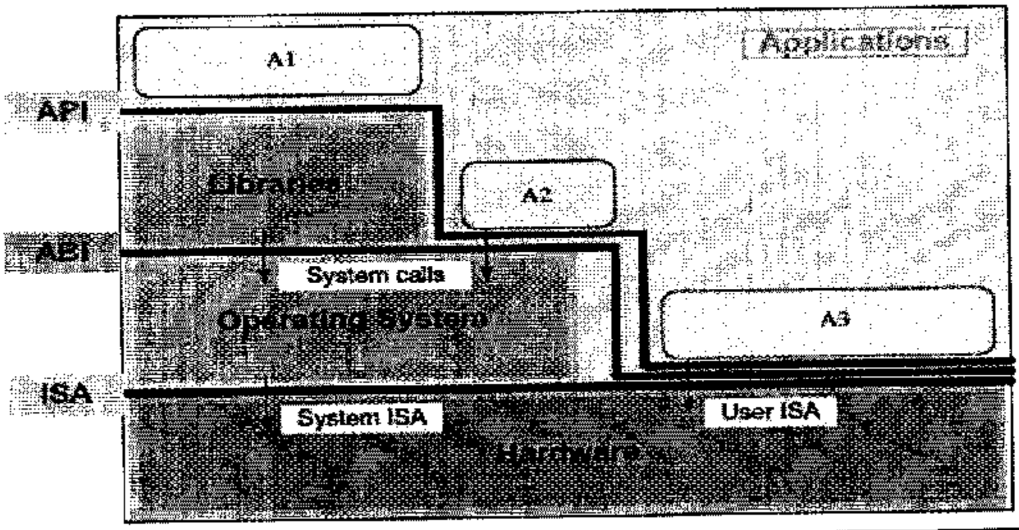
- This is often done by adding additional software, called a virtualization layer as shown in Figure. This virtualization layer is known as hypervisor or virtual machine monitor (VMM)



Common virtualization layers includes

- **Instruction set architecture (ISA) level**
- **Hardware level**
- **Operating system level, library support level**
- **Application level**





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- Any program written in the HLL and compiled for this VM will be able to run on it. The Microsoft .NET CLR and Java Virtual Machine (JVM) are two good examples of this class of VM.

FULL and Para Virtualization

- Virtualization refers to a creation of a virtual version of a server, desktop, operating system, storage device or a network resource. It also allows sharing a single physical instance of a resource or an application among multiple customers and organizations.
- The machine that creates the virtual machine is the host machine while the virtual machine is the guest machine.
- Cloud allows delivering computing, network, storage infrastructure resources, services, platforms and applications to multiple users across the network. On the other hand, virtualization is a technology that allows users to create multiple simulated environments from one physical hardware system.
- The main difference between Cloud and Virtualization is that the Cloud is a methodology that allows multiple users to share resources as required while virtualization is a technology to create multiple simulated environments from a single physical hardware system.
- A hypervisor is software that creates and manages virtual machines. Thus, after installing the hypervisor, the operating system and applications communicate with the virtualized resource created by the hypervisor.

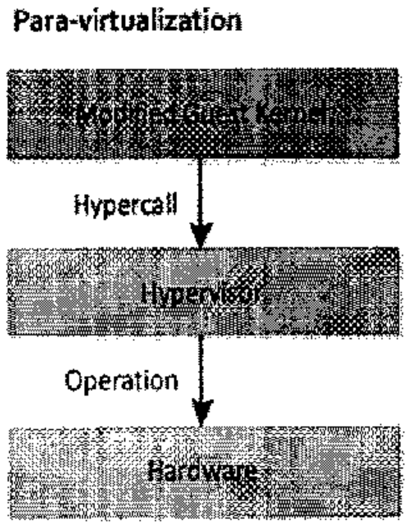
Two Basic Approaches are there for Virtualization. They are

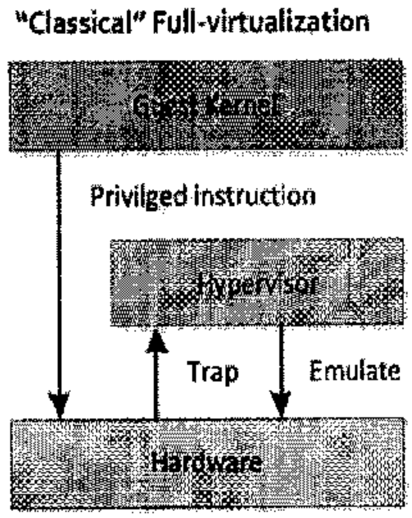
a) Full Virtualization

b) Para Virtualization

Full Virtualization: In Which A host operating system runs directly on the hardware while a guest operating system runs on the virtual machine.

In full virtualization, the guest operating systems do not concern about the presence of a hypervisor. Therefore, each virtual machine and its guest operating system operate as independent computers. In other words, multiple guest operating systems execute on a single host operating system in an isolated manner using direct execution and binary translation.





Moreover, one major drawback of full virtualization is that it affects the performance of the system. **Hypervisor** depends on the hardware emulator. Thus, the continuous translations between the physical and virtual resources such as memory and processor can impact the performance of the system.

b) Para virtualization was initially developed by IBM. In Para virtualization, the hypervisor is installed on the device. Then, the guest operating systems are installed into the environment. Here, the virtualization method modifies the guest operating system to communicate with the hypervisor.

Thus, it reduces the time taken by the operating system to perform operations that are difficult and take a longer time in a virtual environment. Also, it helps to increase the performance of the system. Moreover, the guest operating systems communicate with the hypervisor using API calls.

Difference between Full Virtualization and Para virtualization in Cloud

Full virtualization is a common and cost-effective type of virtualization in which computer service requests are separated from the physical hardware that facilitates them, while paravirtualization is an enhancement of virtualization technology in which a guest OS is recompiled prior to installation inside a virtual machine.

Functionality

Thus, the main difference between full virtualization and paravirtualization is that full virtualization allows guest operating systems to execute independently while paravirtualization allows guest operating systems to communicate with the hypervisor.

Accessing hardware

In full virtualization, guest operating system issues hardware calls to access hardware, whereas, in paravirtualization, guest operating system directly communicates with the hypervisor using drivers. Hence, this is also a difference between full virtualization and paravirtualization.

Performance

Performance is another difference between full virtualization and paravirtualization. Performance is higher in paravirtualization than in full virtualization.

Performance and Security Isolation in Cloud Virtulaization

- Performance isolation is a critical condition for quality-of-service (QoS) in shared computing environments because many resources have been sharing such as CPU cycles, cache, main memory, and disk and network access. And even it is rather difficult to predict the completion time also.
  - One of the primary benefits of cloud computing is concept of a shared, common infrastructure across numerous customers simultaneously, leading to economies of scale. This concept is called multi-tenancy.
  - This practice of multi-tenancy improves efficiency by multiplexing resources among disparate customers at low costs. Unfortunately, it also introduces the risk of sharing physical servers, sensitive data and other infrastructure resources malicious user.
  - In a non-isolated cloud system, the different tenants can freely use the resources of the server. Hereby, disruptive tenants who exceed their limits can

easily cause degradation of performance of the provided services for other tenants.

- To exhibit a predictable performance an application has to be isolated from other applications. Performance isolation is a critical condition for QoS in cloud computing where system resources are shared.
- If the run-time behavior of an application is affected by other applications running concurrently and thus, competing for CPU cycles, cache, main memory, disk and network access, it is rather difficult to predict its completion time. Therefore, it is equally difficult, or in some instances impossible, to optimize application's performance. Hence Performance is unpredictable

Several operating systems including Linux/RK, QLinux , and SILK support some performance isolation. Operating systems use process abstraction not only for resource sharing but also to support isolation.

This layer of software has the potential to provide a level of isolation nearly equivalent to the isolation presented by two different physical systems. Thus, the virtualization can be used to improve security in a cloud computing environment.

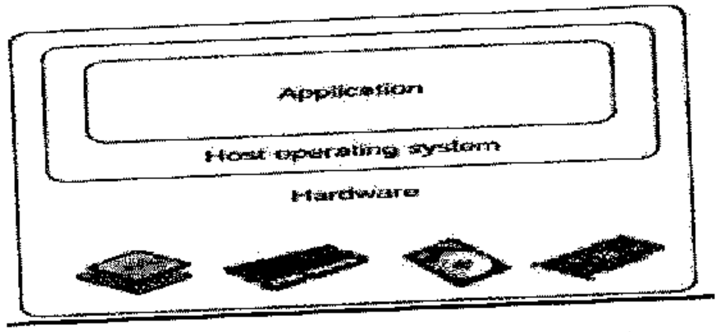
Traditional operating systems multiplex multiple processes or threads, while virtualization supported by a hypervisor multiplexes full operating systems.

A hypervisor executes directly on the hardware a subset of frequently-used machine instructions generated by the application and emulates privileged instructions including device I/O requests. A hypervisor is a much simpler and better specified system than a traditional OS

Layering and virtualization

- A common approach to managing system complexity is to identify a set of *layers* with well defined *interfaces* among them. The interfaces separate different levels of abstraction. Layering minimizes the interactions among the subsystems and simplifies the description of the subsystems.

A traditional computer runs with a host operating system specially tailored for its hardware architecture, as shown in Figure



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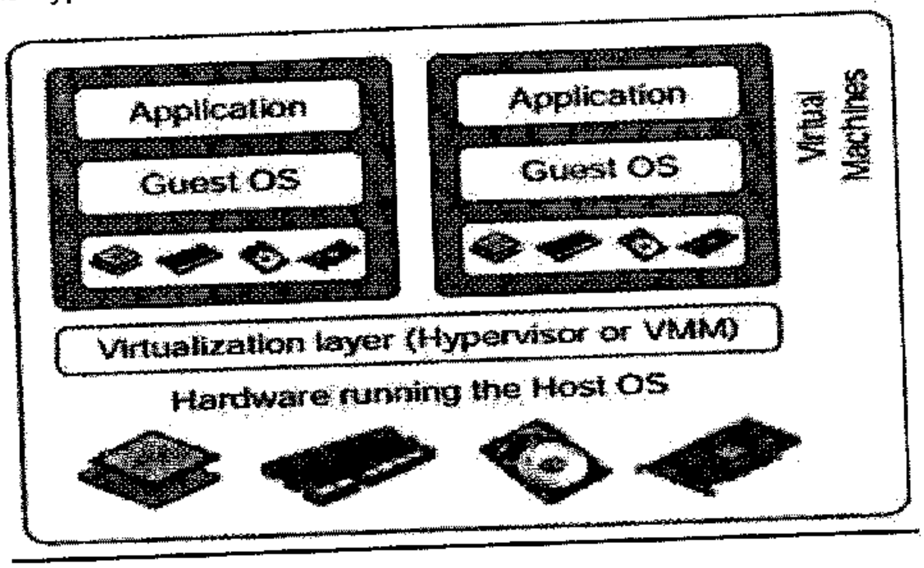

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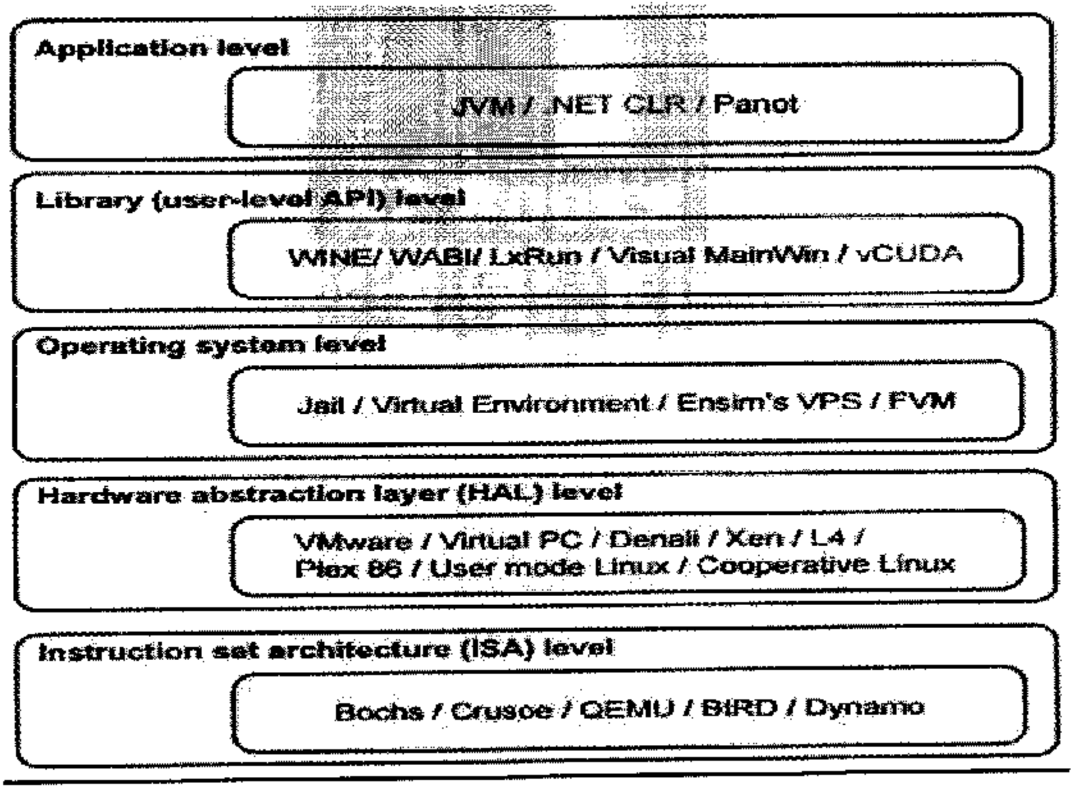

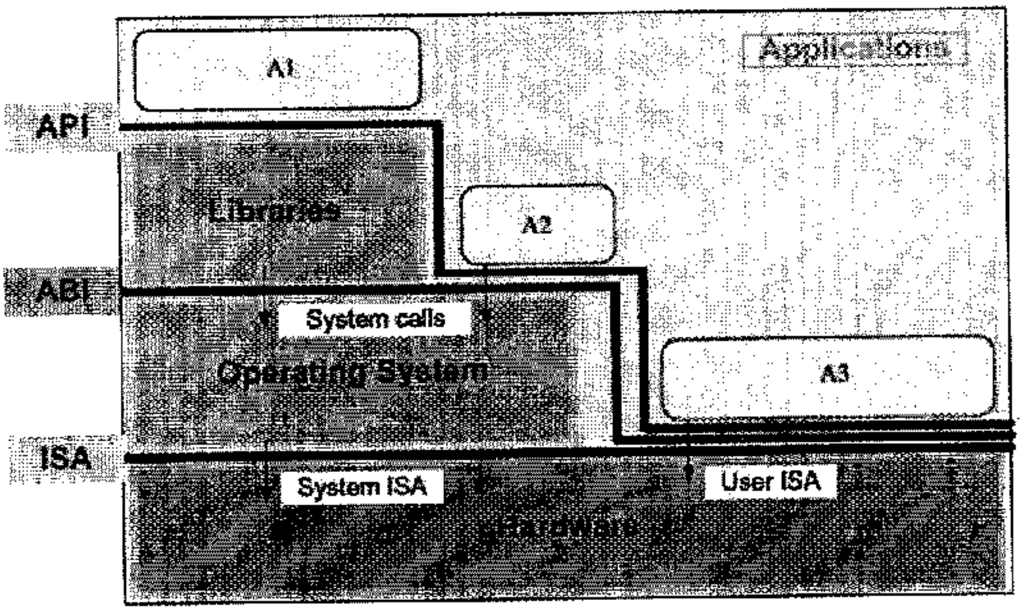

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XEN

Storage

Cloud Storage is a web service where your data can be stored, accessed, and quickly backed up by users on the internet. It is more reliable, scalable, and secure than traditional on-premises storage systems.

Cloud storage is offered in two models:

1. Pay only for what you use
2. Pay on a monthly basis

Amazon S3 (Simple Storage Service) provides object storage, which is built for storing and recovering any amount of information or data from anywhere over the internet. It provides this storage through a web services interface

- S3 is one of the first services that has been produced by aws.
- S3 stands for Simple Storage Service.
- S3 provides developers and IT teams with secure, durable, highly scalable object storage.
- It is easy to use with a simple web services interface to store and retrieve any amount of data from anywhere on the web.
- S3 is a safe place to store the files.
- It is Object-based storage, i.e., you can store the images, word files, pdf files, etc.
- The files which are stored in S3 can be from 0 Bytes to 5 TB.
- It has unlimited storage means that you can store the data as much you want.
- Files are stored in Bucket. A bucket is like a folder available in S3 that stores the files.
- S3 is a universal namespace, i.e., the names must be unique globally. Bucket contains a DNS address. Therefore, the bucket must contain a unique name to generate a unique DNS address.

If you create a bucket, URL look like:

https://s3-eu-west-1.amazonaws.com/acloudguru

Region name **Bucket name**

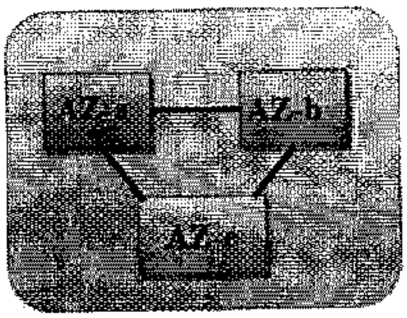
works with CloudFront CDN in which people spread all around the world, and they can turn on access to the web page, audio files, etc. in the UK.

Availability zone as a Data Center

- An availability zone is a facility that can be somewhere in a country or in a city. Inside this facility, i.e., Data Centre, we can have multiple servers, switches, load balancing, firewalls. The things which interact with the cloud sits inside the data centers.
- An availability zone can be a several data centers, but if they are close together, they are counted as 1 availability zone.

Region

- A region is a geographical area. Each region consists of 2 more availability zones.
- A region is a collection of data centers which are completely isolated from other regions.
- A region consists of more than two availability zones connected to each other through links.



- Availability zones are connected through redundant and isolated metro fibers.

VPC

VPC stands for Virtual Private Cloud. It is an isolated area of the AWS cloud where you can launch AWS resources in a virtual network that you define. It provides a complete control on your virtual networking environment such as selection of an IP address, creation of subnets, configuration of route tables and network gateways.

- It displays the metrics automatically about every AWS service that you choose.
- You can create the dashboard to display the metrics about your custom application and also display the metrics of custom collections that you choose.
- You can also create an alarm to watch metrics. For example, you can monitor CPU usage, disk read and disk writes of Amazon EC2 instance to determine whether the additional EC2 instances are required to handle the load or not. It can also be used to stop the instance to save money.

Simple Email Service(SES): Amazon Simple Email Service is a cloud-based email sending service that helps digital marketers and application developers to send marketing, notification, and transactional emails. This service is very reliable and cost-effective for the businesses of all the sizes that want to keep in touch with the customers.

SNS

SNS stands for Simple Notification Service. It is a web service that provides highly scalable, cost-effective, and flexible capability to publish messages from an application and sends them to other applications. It is a way of sending messages.

SQS stands for **Simple Queue Service**.SQS was the first service available in AWS.Amazon SQS is a web service that gives you access to a message queue that can be used to store messages while waiting for a computer to process them.

CloudFront CDN

- CloudFront CDN (Computer Delivery Network) is a system of distributed servers that deliver web pages and other web content to a user based on the geographic locations of the user, the origin of the webpage and a content delivery server.
- Suppose I am running the website outside the UK and I am serving the website all around the world. When the user wants to access my website, then they request to the web server, and users from different countries will have different latency.
- For example, People who live in Australia will have more latency than those who stay in India. South Africa has a terrible latency, but they would run internet backbone that makes quicker to connect to the UK. This is how it

Amazon EMR

An Amazon EMR stands for Amazon Elastic MapReduce. It is a web service used to process the large amounts of data in a cost-effective manner. The central component of an Amazon EMR is a cluster. Each cluster is a collection of EC2 instances and an instance in a cluster is known as node. Each node has a specified role attached to it known as a node type, and an Amazon EMR installs the software components on node type.

Auto Scaling

Auto Scaling is a feature in aws that automatically scales the capacity to maintain steady and predictable performance. While using auto scaling, you can scale multiple resources across multiple services in minutes. If you are already using Amazon EC2 Auto- scaling, then you can combine Amazon EC2 Auto-Scaling with the Auto-Scaling to scale additional resources for other AWS services.

Elasticache

- Elasticache is a web service used to deploy, operate, and scale an in-memory cache in the cloud.
- It improves the performance of web applications by allowing you to retrieve information from fast, managed in-memory cache instead of relying entirely on slower disk-based databases.
- For example, if you are running an online business, customers continuously asking for the information of a particular product. Instead of front-end going and always asking information for a product, you can cache the data using Elasticache.
- It is used to improve latency and throughput for many read-heavy application workloads (such as social networking, gaming, media sharing, and Q&A portals) or compute intensive workloads (such as a recommendation engine).

CloudWatch

- CloudWatch is a service used to monitor your AWS resources and applications that you run on AWS in real time. CloudWatch is used to collect and track metrics that measure your resources and applications.

EC2

- EC2 stands for Amazon Elastic Compute Cloud.
- Amazon EC2 is a web service that provides resizable compute capacity in the cloud.
- It is a web service that allows developers to rent virtual machines andautomatically scales the compute capacity when required.
- Amazon EC2 reduces the time required to obtain and boot new user instances to minutes rather than in older days, if you need a server then you had to put a purchase order, and cabling is done to get a new server which is a very time-consuming process. Now, Amazon has provided an EC2 which is a virtual machine in the cloud that completely changes the industry.
- You can scale the compute capacity up and down as per the computing requirement changes.
- It offers various instance types to developers so that they can choose required resources such as CPU, memory, storage, and networking capacity based on their application requirements.

AMI

- An AMI stands for **Amazon Machine Images.**
- An AMI is a virtual image used to create a virtual machine within an EC2 instance.
- You can also create multiple instances using single AMI when you need instances with the same configuration.
- You can also create multiple instances using different AMI when you need instances with a different configuration.
- It also provides a template for the root volume of an instance.
- There are two types AMI's1.Predefined AMI 2.CustomAMI
- Predefined AMI are designed by the Amazon and user launch it..
- Userdefined AMI are designed by the user based on requirements
- At the time of creating AMI we need to specify the requirements like os,ram size,HDD size Processor etc.

Cloud Infrastructure at Amazon

- AWS stands for **Amazon Web Services**.
- The AWS service is provided by the Amazon that uses distributed IT infrastructure to provide different IT resources available on demand. It provides different services such as infrastructure as a service (IaaS), platform as a service (PaaS) and packaged software as a service (SaaS).
- Amazon launched AWS, a cloud computing platform to allow the different organizations to take advantage of reliable IT infrastructure.

Uses of AWS

- A small manufacturing organization uses their expertise to expand their business by leaving their IT management to the AWS.
- A large enterprise spread across the globe can utilize the AWS to deliver the training to the distributed workforce.
- An architecture consulting company can use AWS to get the high-compute rendering of construction prototype.
- A media company can use the AWS to provide different types of content such as ebox or audio files to the worldwide files.

Amazon has many services for cloud applications. Let us list down a few key services of the AWS ecosystem and a brief description of how developers use them in their business.

Amazon has a list of services:

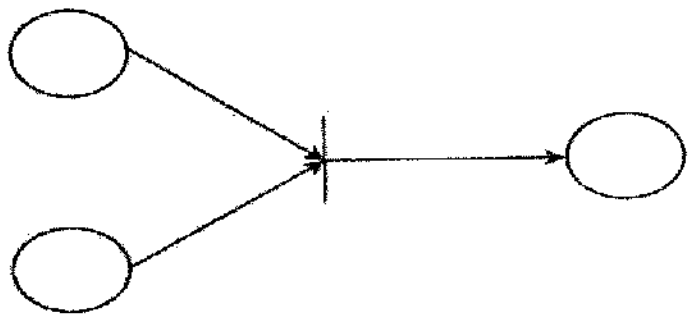
1. Compute service
2. Storage
3. Database
4. Networking and delivery of content
5. Security tools
6. Developer tools
7. Management tools

1.Compute

These services help developers build, deploy, and scale an application in the cloud platform.

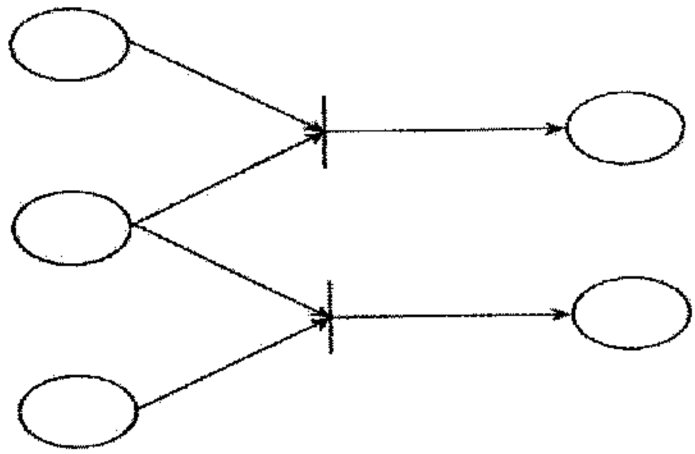
Dependency

A transition requires two inputs.

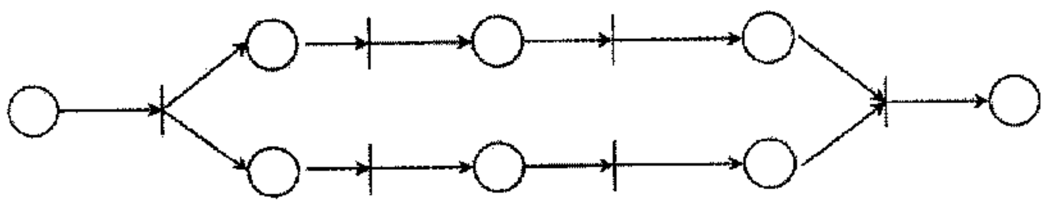


Conflict Construct

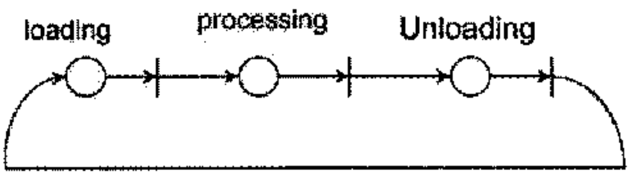
Only one of the two transitions can fire.

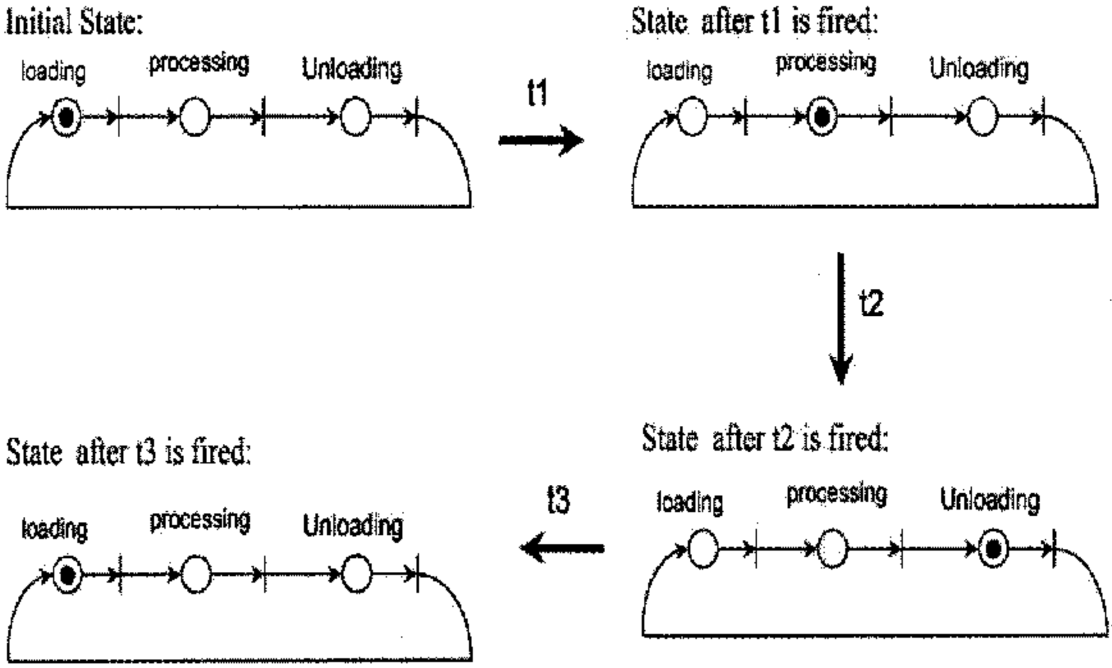


Concurrency Construct

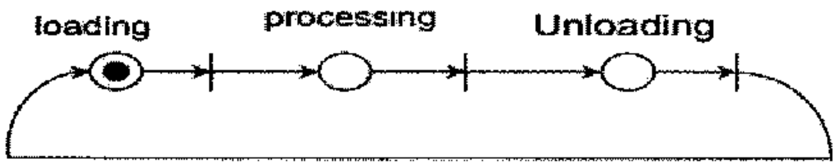


- Enabling Rule:
  - » A transition *t* is enabled if every input place contains at least one token
- Firing Rule:
  - » Firing an enabled transition
    - – removes one token from each input place of the transition
    - – adds one token to each output place of the transition



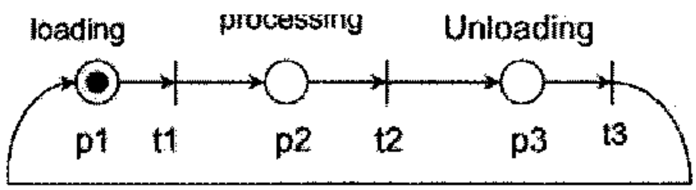


Sequential



A Petri net is a four-tuple:
$PN = <P, T, I, O>$
P: a finite set of places, $\{p_1, p_2, ..., p_n\}$
T: a finite set of transitions, $\{t_1, t_2, ..., t_s\}$
I: an input function, $(T \times P) \longrightarrow \{0, 1\}$
O: an output function, $(T \times P) \longrightarrow \{0, 1\}$

M^0: an initial marking, $P \longrightarrow N$
$<P, T, I, O, M^0>$ -- a marked Petri net



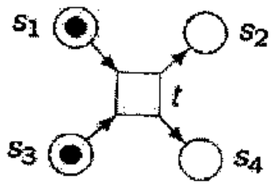
- $P = \{p1, p2, p3\}$
- $T = \{t1, t2, t3\}$
- $I = \begin{array}{c} \\ t1 \\ t2 \\ t3 \end{array} \begin{array}{c} \begin{array}{ccc} p1 & p2 & p3 \end{array} \\ \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \end{array}$
- $O = \begin{array}{c} \\ t1 \\ t2 \\ t3 \end{array} \begin{array}{c} \begin{array}{ccc} p1 & p2 & p3 \end{array} \\ \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ 1 & 0 & 0 \end{bmatrix} \end{array}$
- $M^0 = (1, 0, 0)$

Note:
p1 is the input place of transition t1
p2 is the output place of transition t1

Behaviour of Petri nets

Places may contain tokens that may move to other places by executing ("firing") actions.

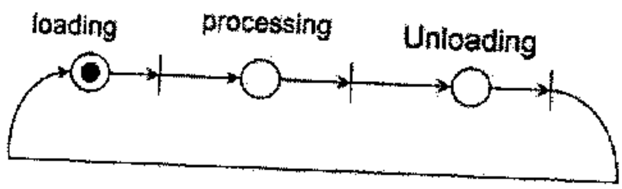
A token on a place means that the corresponding condition is fulfilled or that a resource is available:



In the example, transition *t* may "fire" if there are tokens on places s_1 and s_3. Firing *t* will remove those tokens and place new tokens on s_2 and s_4.

Basic Modeling Constructs

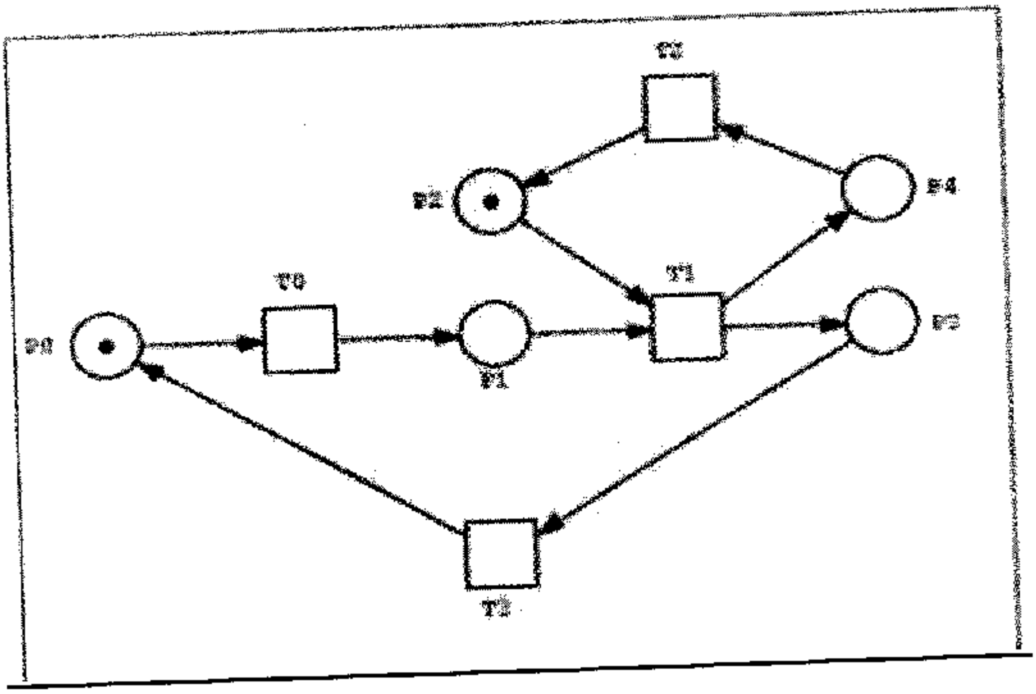
Some basic situations are taken which are encountered often during modeling a physical system. This section describes how Petri net handles these real life modeling situations, thus revealing the modeling power and ease of representation of Petri nets.



Places – buffers, locations, states

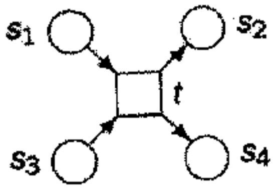
Transitions -- events, actions

Tokens -- parts



Petri nets

Petri nets are a basic model of parallel and distributed systems (named after Carl Adam Petri). The basic idea is to describe state changes in a system with transitions.



Petri nets contain places ○ and transitions □ that may be connected by directed arcs.

Places symbolise states, conditions, or resources that need to be met/be available before an action can be carried out.

Transitions symbolise actions.

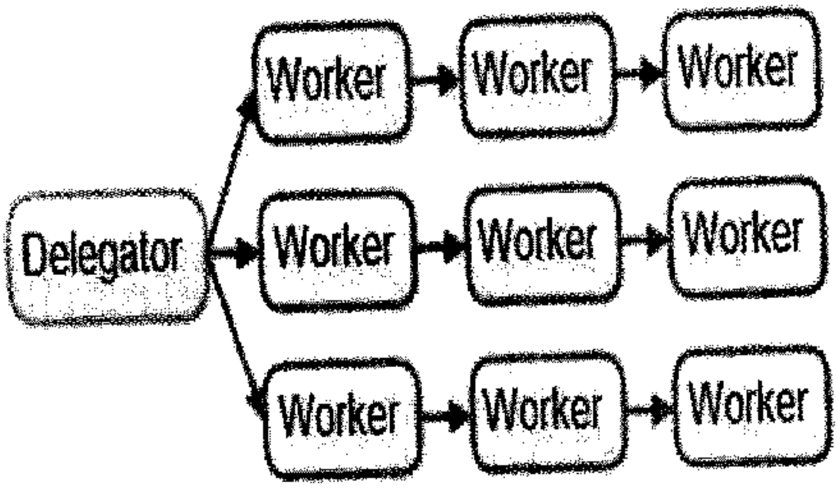
- Petri nets are specific types of modeling constructs useful in data analysis, simulations, business process modeling and other scenarios. This type of mathematical construct can help to plan workflows or present data on complicated systems.
- Petri nets are a graphical for representing a system in which there are multiple independent activities in progress at the same time. The ability to model multiple activities differentiates Petri nets from finite state machines.
- In a finite state machine there is always a single "current" state that determines which action can next occur. In Petri nets there may be several states any one of which may evolve by changing the state of the Petri net. Alternatively, some, of even all, of these states may evolve in parallel causing several independent changes to the Petri net to occur at once.
- Basic Structure A Petri net consists of four elements: places, transitions, edges, and tokens. Graphically, places are represented by circles, transitions by rectangles, edges by directed arrows, and tokens by small solid (filled) circles.
- A basic Petri net is shown in the following figure.
- This Petri net has four places, labeled P0 through P4, and three transitions, labeled T0 through T2. Notice that places P0 and P2 each have a single token represented by the black dot inside each place. Edges, represented as directed arcs, connect places to transitions and transitions to places.
- The state of a Petri net is represented by the occurrence of the tokens at various places.A Petri net changes from one state to the next state when a transition "fires".

Multiple long-running tasks are executed together by the underlying system. This is particularly effective when the tasks are blocked because of external resources they must wait upon, such as disk or network I/O operations.

Increase throughput

By executing multiple tasks concurrently, the general system throughput can be increased. It is important to notice that this also speeds up independent sequential tasks that have not been specifically designed for concurrency yet.

A number of mathematical models have been developed for general concurrent computing. One of such is petrinets.



Petrinets:

- Petri nets were invented by Carl Adam Petri in 1939 at the age of 13. This work was the foundation for his 1962 doctoral dissertation entitled Kommunikation mit Automaten.
- Petri nets have been used in a variety of fields including computer science, chemistry, and biology. He retired from the Theoretical Foundation of Computer Science group at the University of Hamburg in 1991.

- A number of mathematical models have been developed for general concurrent.
- Because computations in a concurrent system can interact with each other while being executed, the number of possible execution paths in the system can be extremely large, and the resulting outcome can be indeterminate.
- Concurrent use of shared resources can be a source of indeterminacy leading to issues such as deadlocks, and resource starvation.
- Design of concurrent systems often entails finding reliable techniques for coordinating their execution, data exchange, memory allocation, and execution scheduling to minimize response time and maximise throughput.
- Concurrent programming encompasses programming languages and algorithms used to implement concurrent systems.
- Concurrent programming is usually considered to be more general than parallel programming because it can involve arbitrary and dynamic patterns of communication and interaction, whereas parallel systems generally have a predefined and well-structured communications pattern.
- The base goals of concurrent programming include correctness, performance and robustness. Concurrent systems such as Operating systems and Database management systems are generally designed to operate indefinitely, including automatic recovery from failure, and not terminate unexpectedly.

Advantages of Concurrency

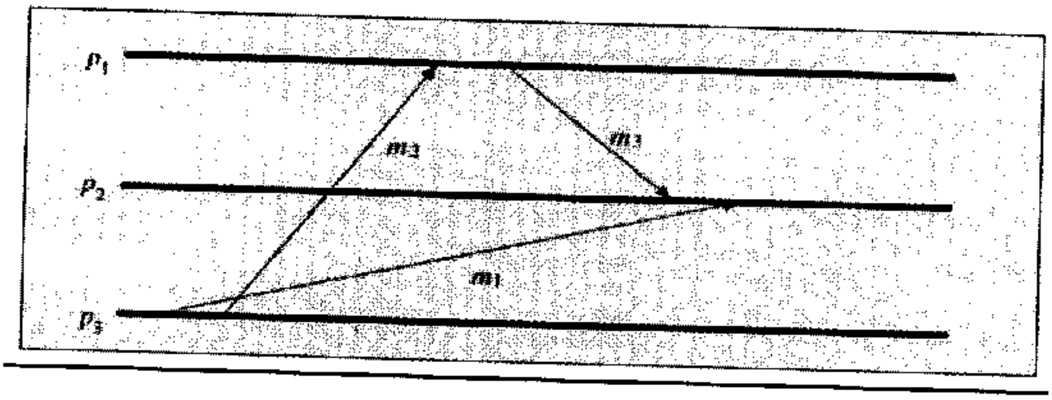
Reduce latency

A unit of work is executed in shorter time by subdivision into parts that can be executed concurrently.

Hide latency

When more than two processes are involved in a message exchange, the message delivery may be FIFO but not causal, as shown in Figure 2.7 where we see that

- $deliver(m_3) \rightarrow deliver(m_1)$, according to the local history of process p_2.
- $deliver(m_2) \rightarrow send(m_3)$, according to the local history of process p_1.
- $send(m_1) \rightarrow send(m_2)$, according to the local history of process p_3.



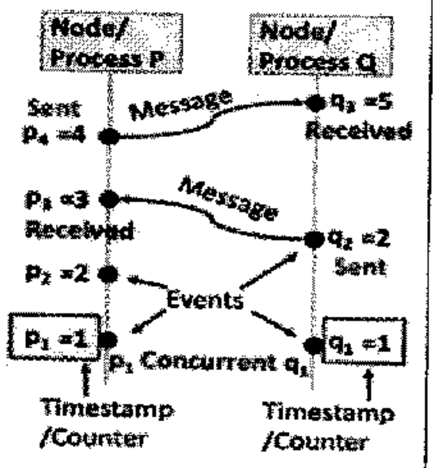
- $send(m_2) \rightarrow deliver(m_2)$.
- $send(m_3) \rightarrow deliver(m_3)$.

Concurrency

- Concurrency is a property of a system representing the fact that multiple activities are executed at the same time.
- Concurrency is the occurrence of multiple events within overlapping time frames, but not simultaneously.
- This allows for parallel execution of the concurrent units, which can significantly improve overall speed of the execution in multi-processor and multi-core systems.
- In more technical terms, concurrency refers to the decomposability property of a program, algorithm, or problem into order-independent or partially-ordered components or units.

Happened-Before (→) Relationship

- Concurrent Events: If two events a and b are occurring on two different nodes/processes in isolation, then it is possible that neither a→b (a Happened-Before b) nor b→a (b Happened-Before a). In that case, a and b are said to be concurrent events (a||b).
- Example:
Events p_1 and q_1 are occurring on the two different nodes/processes in isolation, thus $p_1 \,||\, q_1$ (p_1 Concurrent q_1).



Message Delivery Rules:

Message receiving and message delivery are two distinct operations; a *delivery rule* is an additional assumption about the channel-process interface. This rule establishes when a message received is actually delivered to the destination process. The receiving of a message m and its delivery are two distinct

events in a causal relation with one another. A message can only be delivered after being received (see Figure 2.6)

$$receive(m) \rightarrow deliver(m). \qquad (2.25)$$

First In, First Out (FIFO) delivery implies that messages are delivered in the same order in which they are sent. For each pair of source-destination processes (p_i, p_j), FIFO delivery requires that the following relation should be satisfied:

$$send_i(m) \rightarrow send_i(m') \Rightarrow deliver_j(m) \rightarrow deliver_j(m'). \qquad (2.26)$$

Even if the communication channel does not guarantee FIFO delivery, FIFO delivery can be enforced by attaching a sequence number to each message sent. The sequence numbers are also used to reassemble messages out of individual packets.

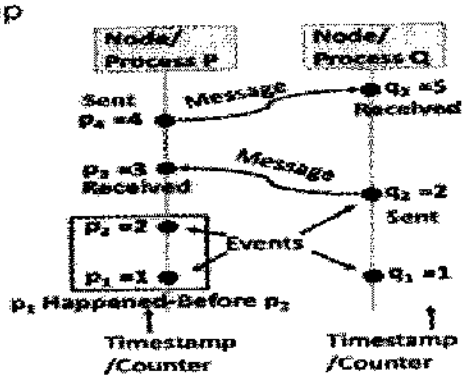
Causal delivery is an extension of the FIFO delivery to the case when a process receives messages from different sources. Assume a group of three processes, (p_i, p_j, p_k) and two messages m and m'. Causal delivery requires that

$$send_i(m) \rightarrow send_j(m') \Rightarrow deliver_k(m) \rightarrow deliver_k(m'). \qquad (2.27)$$

Happened-Before (→) Relationship

1. Condition I (Local Events): An event a happens before b (a→b), if and only if two events a and b are occurring on the same node/process and Timestamp(a) < Timestamp(b).

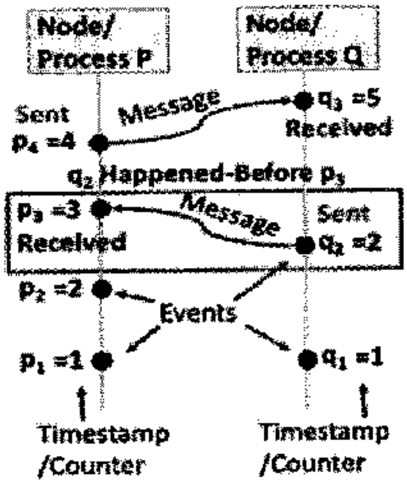
- Example:
  Timestamp(p_1) < Timestamp(p_2), thus p_1 → p_2 (p_1 Happened-Before p_2).



Happened-Before (→) Relationship

2. Condition II (Sent Messages and Received Messages/External Events): An event a happens before b (a→b), if and only if two events a and b are occurring on two different nodes/processes (where an event a is the sending event of the message m and event b is the receipt event of the same message m) and Timestamp(a) < Timestamp(b).

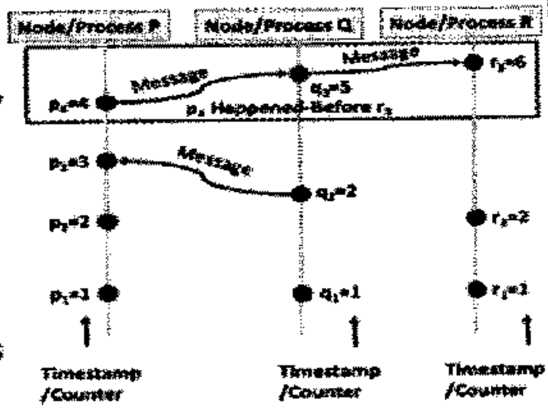
- Example:
  Timestamp(q_2) < Timestamp(p_3), thus q_2 → p_3 (q_2 Happened-Before p_3).



Happened-Before (→) Relationship

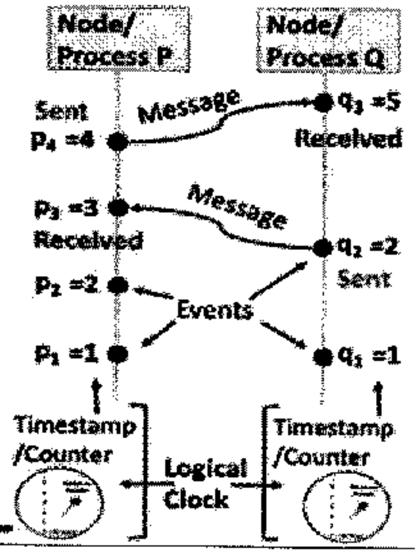
3. Condition III (Transitive Relation/Transitivity): An event a happens before c (a→c), if and only if a → b and b → c.
   a → b (a Happened-Before b) and
   b → c (b Happened-Before c), thus
   a → c (a Happened-Before c).

- Example:
  p_4 → q_3 (p_4 Happened-Before q_3) and
  q_3 → r_3 (q_3 Happened-Before r_3), thus
  p_4 → r_3 (p_4 Happened-Before r_3).



Ordering of Events: Logical Time and Logical Clock

- Logical time is the abstract division of the system into before and after intervals.
- A logical clock is simply a counter (or timestamp) that is incremented based on events on a node or process.
- A logical clock records chronological and causal relationship among events by attaching a timestamp to each event.
- A logical clock is used for ordering of events in a distributed system based on the happened-before relationship.

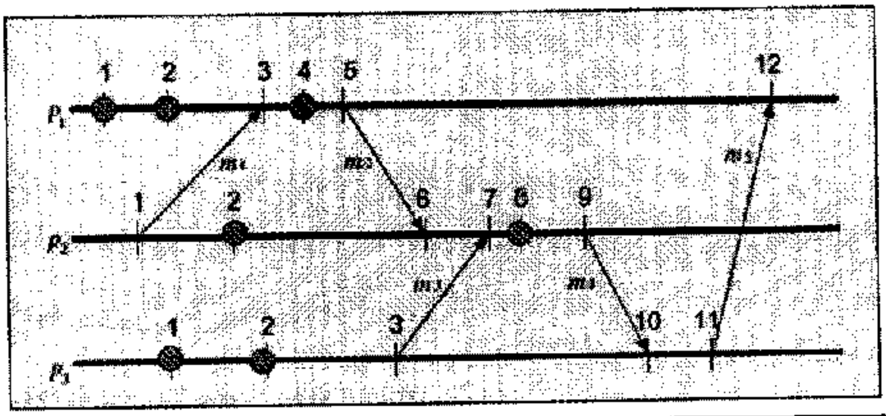


When two entities communicate by message passing, then the send event is said to happen-before the receive event, and the logical order can be established among the events. A distributed system is said to have partial order if we can have a partial order relationship among the events in the system. If 'totality', i.e., causal relationship among all events in the system, can be established, then the system is said to have total order.

For two events a and b, a → b if

- *a and b are events in the same process and a occurred before b, or*
- *a is a send event of a message m and b is the corresponding receive event at the destination process, or*
- *a → c and c → b for some event c*

- A physically synchronous global clock may not be present in a distributed system. In such systems a logical clock allows global ordering on events from different processes.
- The first logical clock implementation, was proposed by Leslie Lamport in 1978 the as Lamport timestamps.
- The Lamport timestamp algorithm is a simple logical clock algorithm used to determine the order of events in a distributed computer system.



Distributed algorithms such as resource synchronization often depend on some method of ordering events to function.

• In May 2009 Google was the target of a serious denial-of-service (DoS) attack that took down services such Google News and Gmail for several days.

• Lightning caused a prolonged downtime at Amazon on June 29 and 30, 2012; the AWS cloud in the Eastern region of the United States, which consists of 10 data centers across four availability zones, was initially troubled by utility power fluctuations, probably caused by an electrical storm.

A June 29, 2012 storm on the East Coast took down some Virginia-based Amazon facilities and affected companies using systems exclusively in this region. • Instagram, a photo-sharing service, was one of the victims of this outage, according to http://mashable.com/2012/06/30/aws-instagram/.

• The recovery from the failure took a very long time and exposed a range of problems. For example, one of the 10 centers failed to switch to backup generators before exhausting the power that could be supplied by uninterruptible power supply (UPS) units. AWS uses "control planes" to allow users to switch to resources in a different region, and this software component also failed.

• The booting process was faulty and extended the time to restart EC2 (Elastic Computing) and EBS (Elastic Block Store) services.

• Another critical problem was a bug in the elastic load balancer (ELB), which is used to route traffic to servers with available capacity.

• A similar bug affected the recovery process of the Relational Database Service (RDS). This event brought to light "hidden" problems that occur only under special circumstances.

Logical clock:

- It is a mechanism for capturing causal and chronological relationships in a distributed system.

8. Resource Allocation.

9. Maintenance

10. Virtualization.

11. Data Intensive

12. Data Storage

13. Confidence

14. Trust

15. Professional Ehtics.

16. Customer Satisfaction

17. Best service

18. Data Encryption and decryption

19. Special Attention

20. Infrastructure

21. Mainting private information

Cloud vulnerabilities

• Clouds are affected by malicious attacks and failures of the infrastructure (e.g., power failures).

• Such events can affect Internet domain name servers and prevent access to a cloud or can directly affect the clouds. For example, an attack at Akamai on June 15, 2004 caused a domain name outage and a major blackout that affected Google, Yahoo!, and many other sites.

7. Cloud service providers have already collected petabytes of sensitive personal information stored in data centers around the world.

8. The acceptance of cloud computing therefore will be determined by privacy issues addressed by these companies and the countries where the data centers are located.

9. Privacy is affected by cultural differences; though some cultures favor privacy, other cultures emphasize community.

10. Leads to an ambivalent attitude toward privacy on the Internet, which is a global system.

Major challenges faced by cloud computing Cloud computing inherits some of the challenges of parallel and distributed computing discussed in at the same time, it faces major challenges of its own

1. The three cloud delivery models, but in all cases the difficulties are created by the very nature of utility computing, which is based on resource sharing and resource virtualization and requires a different trust model than the ubiquitous user-centric model we have been accustomed to for a very long time.

2. Ssecurity gaining the trust of a large user base is critical for the future of cloud computing.

3. It is unrealistic to expect that a public cloud will provide a suitable environment for all applications.

4. Highly sensitive applications related to the management of the critical infrastructure,

5. Healthcare applications, and others will most likely be hosted by private clouds.
6. Many real-time applications will probably still be confined to private clouds.

7. Some applications may be best served by a hybrid cloud setup; such applications could keep sensitive data on a private cloud and use a public cloud for some of the processing.

• Unauthorized access, data corruption, infrastructure failure, and service unavailability are some of the risks related to relinquishing the control to third-party services, whenever a problem occurs; it is difficult to identify the source and the entity causing it

. • Systems can span the boundaries of multiple organizations and cross security borders, a process called deperimeterization. As a result ofdeperimeterization, "not only the border of the organization's IT infrastructure blurs, also the border of the accountability becomes less clear"

• The complex structure of cloud services can make it difficult to determine who is responsible in case something undesirable happens.

• In a complex chain of events or systems, many entities contribute to an action, with undesirable consequences.

• Some of them have the opportunity to prevent these consequences, and therefore no one can be held responsible – the so-called "problem of many hands."

Some more Ethical issues

1. Ubiquitous and unlimited data sharing and storage among organizations test the selfdetermination of information.

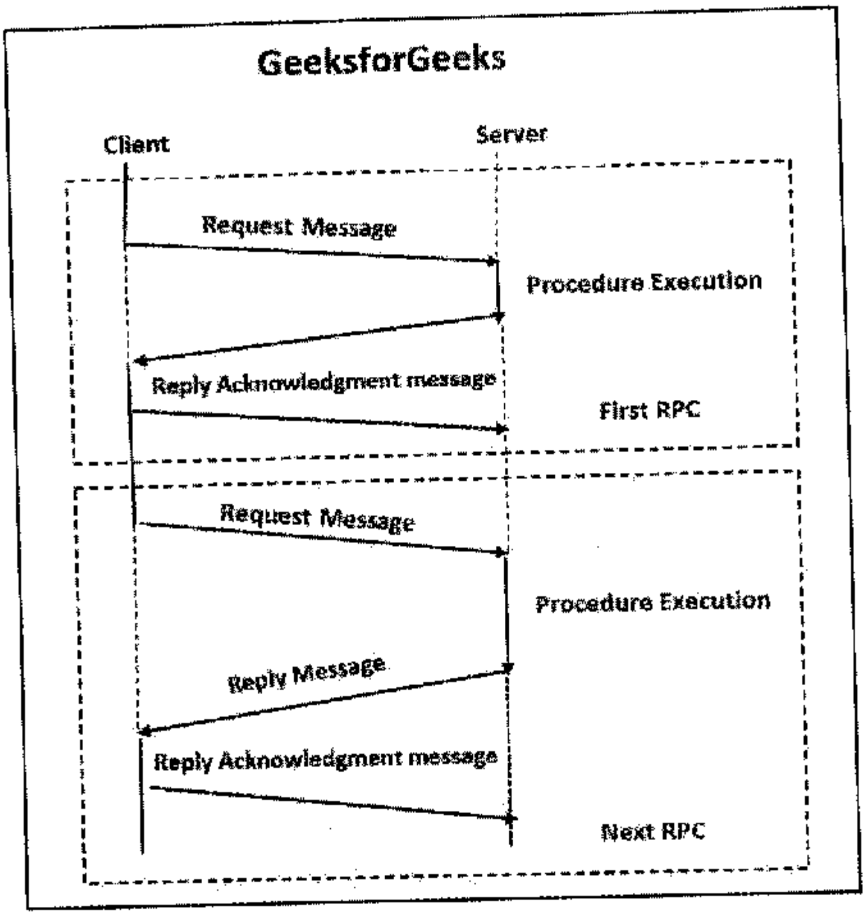
2. The right or ability of individuals to exercise personal control over the collection.

3. Use and disclosure of their personal data by others.

4. Confidence and trust in today's evolving information society.

5. Identity fraud and theft are made possible by the unauthorized access to personal data in circulation.

6. New forms of dissemination through social networks, which could also pose a danger to cloud computing.



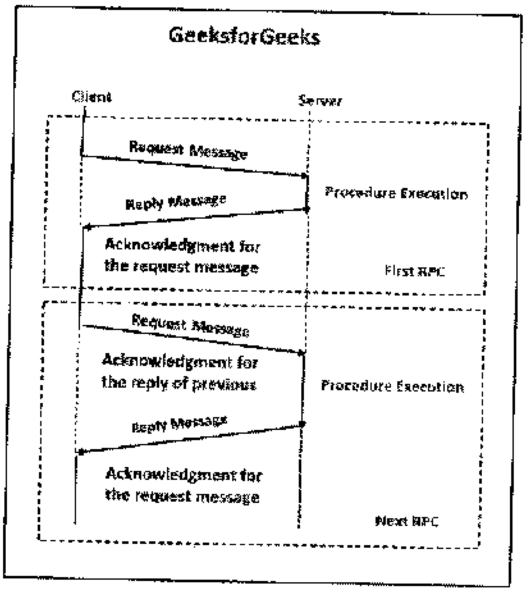
Ethical issues in cloud computing Cloud computing is based on a paradigm shift with profound implications for computing ethics.

The main elements of this shift are:

(i) the control is relinquished to third-party services;

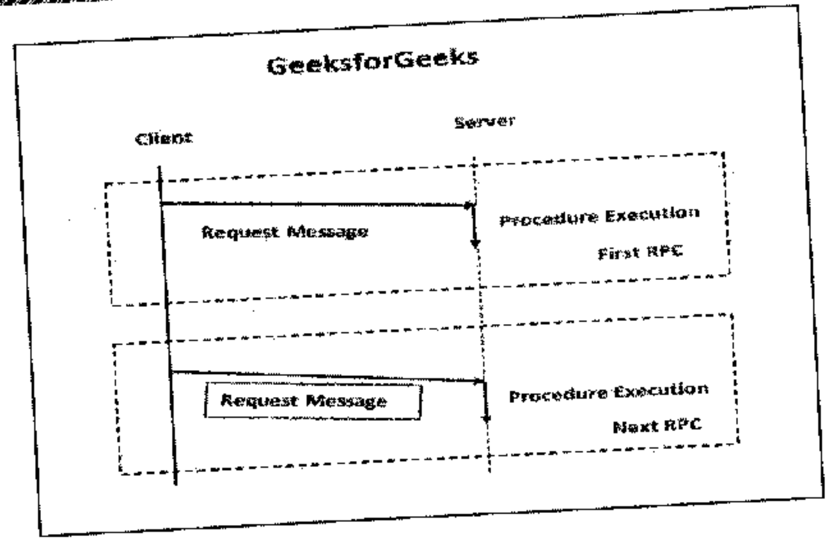
(ii) (ii) the data is stored on multiple sites administered by several organizations; and

(iii) (iii) multiple services interoperate across the network.



The Request/Reply/Acknowledgement-Reply Protocol:

- This protocol is also known as the RRA protocol (request/reply/acknowledge-reply).
- Exactly-once semantics is provided by RR protocol which refers to the responses getting held in reply cache of servers resulting in loss of replies that have not been delivered.
- The RRA (Request/Reply/Acknowledgement-Reply) Protocol is used to get rid of the drawbacks of the RR (Request/Reply) Protocol.
- In this protocol, the client acknowledges the receiving of reply messages and when the server gets back the acknowledgement from the client then only deletes the information from its cache.
- Because the reply acknowledgement message may be lost at times, the RRA protocol requires unique ordered message identities. This keeps track of the acknowledgement series that has been sent.



Request/Reply Protocol:

- The Request-Reply Protocol is also known as the RR protocol.
- It works well for systems that involve simple RPCs.
- The parameters and result values are enclosed in a single packet buffer in simple RPCs. The duration of the call and the time between calls are both briefs.
- This protocol has a concept base of using implicit acknowledgements instead of explicit acknowledgements.
- Here, a reply from the server is treated as the acknowledgement (ACK) for the client's request message, and a client's following call is considered as an acknowledgement (ACK) of the server's reply message to the previous call made by the client.
- To deal with failure handling e.g. lost messages, the timeout transmission technique is used with RR protocol.
- If a client does not get a response message within the predetermined timeout period, it retransmits the request message.
- Exactly-once semantics is provided by servers as responses get held in reply cache that helps in filtering the duplicated request messages and reply messages are retransmitted without processing the request again.
- If there is no mechanism for filtering duplicate messages then at least-call semantics is used by RR protocol in combination with timeout transmission.

Communication Protocols

The following are the communication protocols that are used:

1. Request Protocol
2. Request/Reply Protocol
3. The Request/Reply/Acknowledgement-Reply Protocol

Request Protocol:

- The Request Protocol is also known as the R protocol.
- It is used in Remote Procedure Call (RPC) when a request is made from the calling procedure to the called procedure. After execution of the request, a called procedure has nothing to return and there is no confirmation required of the execution of a procedure.
- Because there is no acknowledgement or reply message, only one message is sent from client to server.
- A reply is not required so after sending the request message the client can further proceed with the next request.
- May-be call semantics are provided by this protocol, which eliminates the requirement for retransmission of request packets.
- Asynchronous Remote Procedure Call (RPC) employs the R protocol for enhancing the combined performance of the client and server. By using this protocol, the client need not wait for a reply from the server and the server does not need to send that.
- In an Asynchronous Remote Procedure Call (RPC) in case communication fails, the RPC Runtime does not retry the request. TCP is a better option than UDP since it does not require retransmission and is connection-oriented.
- In most cases, asynchronous RPC with an unstable transport protocol is utilized to implement periodic update services. One of its applications is the Distributed System Window.

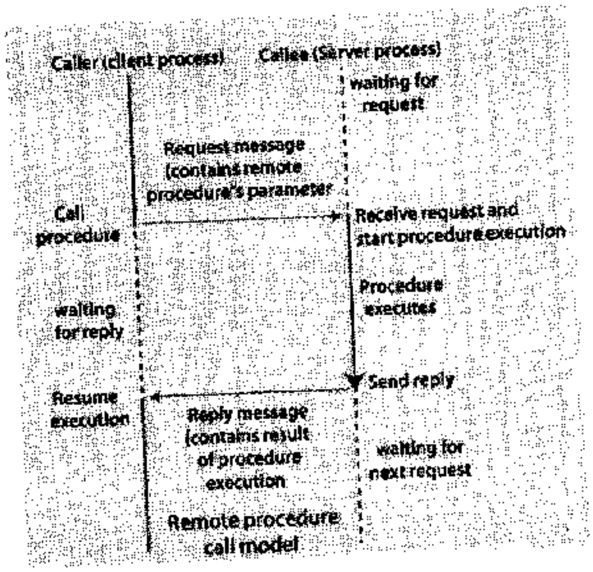
Applications Area of Distributed System:

Finance and Commerce: Amazon, eBay, Online Banking, E-Commerce websites.
Information Society: Search Engines, Wikipedia, Social Networking, Cloud Computing.
Cloud Technologies: AWS, Salesforce, Microsoft Azure, SAP.
Entertainment: Online Gaming, Music, youtube.
Healthcare: Online patient records, Health Informatics.
Education: E-learning.
Transport and logistics: GPS, Google Maps.
Environment Management: Sensor technologies.

RPC Mechanism in Distributed System

Remote Procedure Call (RPC) is a communication technology that is used by one program to make a request to another program for utilizing its service on a network without even knowing the network's details. A function call or a subroutine call are other terms for a procedure call.

An RPC, like a local procedure call, is based on the synchronous operation that requires the requesting application to be stopped until the remote process returns its results.



in remote locations. Every local system has its independent Operating Systems and Resources.

Scalability: It increases the scale of the system as a number of processors communicate with more users by accommodating to improve the responsiveness of the system.

Fault tolerance: It cares about the reliability of the system if there is a failure in Hardware or Software, the system continues to operate properly without degrading the performance the system.

Transparency: It hides the complexity of the Distributed Systems to the Users and Application programs as there should be privacy in every system.

The following are the various kinds of transparency that exist in distributed systems:

- Access Transparency
- Location Transparency
- Concurrency Transparency
- Replication Transparency
- Failure Transparency
- Mobility Transparency
- Performance Transparency
- Scaling Transparency
- Parallelism Transparency

Advantages of Distributed System:

- Applications in Distributed Systems are Inherently Distributed Applications.
- Information in Distributed Systems is shared among geographically distributed users.
- Resource Sharing (Autonomous systems can share resources from remote locations).
- It has a better price performance ratio and flexibility.
- It has shorter response time and higher throughput.
- It has higher reliability and availability against component failure.
- It has extensibility so that systems can be extended in more remote locations and also incremental growth.

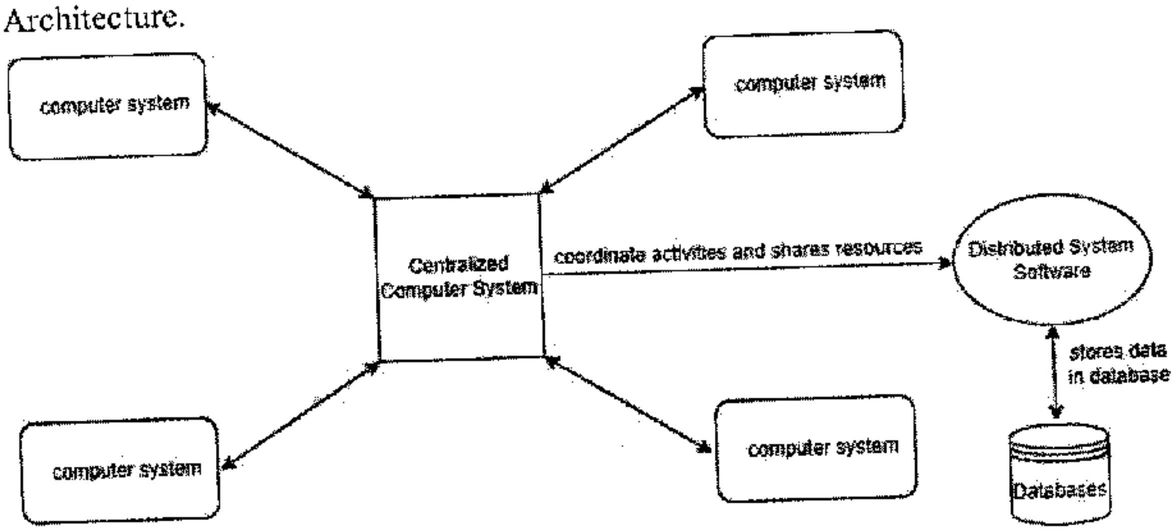
Disadvantages of Distributed System:

- Relevant Software for Distributed systems does not exist currently.
- Security possess a problem due to easy access to data as the resources are shared to multiple systems.
- Networking Saturation may cause a hurdle in data transfer i.e., if there is a lag in the network then the user will face a problem accessing data.

DistributedSystems

Distributed System is a collection of autonomous computer systems that are physically separated but are connected by a centralized computer network that is equipped with distributed system software. The autonomous computers will communicate among each system by sharing resources and files and performing the tasks assigned to them.

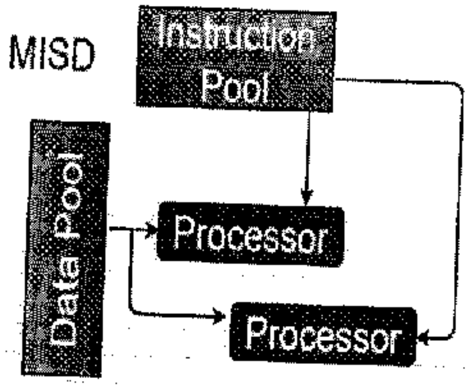
Example of Distributed System:
Any Social Media can have its Centralized Computer Network as its Headquarters and computer systems that can be accessed by any user and using their services will be the Autonomous Systems in the Distributed System Architecture.



Distributed System Software: This Software enables computers to coordinate their activities and to share the resources such as Hardware, Software, Data, etc.
Database: It is used to store the processed data that are processed by each Node/System of the Distributed systems that are connected to the Centralized network.

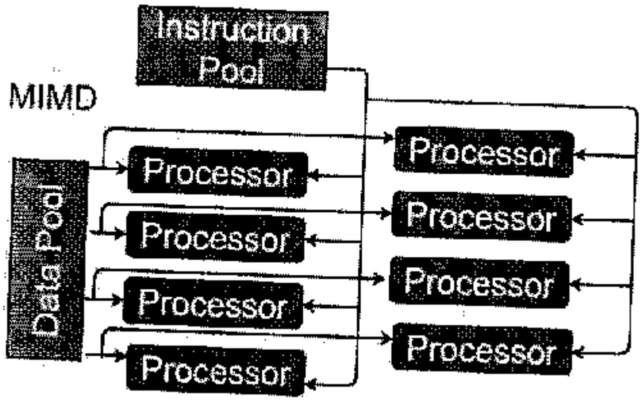
Characteristics of Distributed System:

Resource Sharing: It is the ability to use any Hardware, Software, or Data anywhere in the System.
Openness: It is concerned with Extensions and improvements in the system (i.e., How openly the software is developed and shared with others)
Concurrency: It is naturally present in the Distributed Systems, that deal with the same activity or functionality that can be performed by separate users who are



Example Z = sin(x)+cos(x)+tan(x)
The system performs different operations on the same data set. Machines built using the MISD model are not useful in most of the application, a few machines are built, but none of them are available commercially.

4.Multiple-instruction, multiple-data (MIMD) systems –
An MIMD system is a multiprocessor machine which is capable of executing multiple instructions on multiple data sets. Each PE in the MIMD model has separate instruction and data streams; therefore machines built using this model are capable to any kind of application. Unlike SIMD and MISD machines, PEs in MIMD machines work asynchronously.



MIMD machines are broadly categorized into **shared-memory MIMD** and **distributed-memory MIMD** based on the way PEs are coupled to the main memory.

In the **shared memory MIMD** model (tightly coupled multiprocessor systems), all the PEs are connected to a single global memory and they all have access to it. The communication between PEs in this model takes place through the shared memory, modification of the data stored in the global memory by one PE is visible to all other PEs.

Where, CU = Control Unit, PE = Processing Element, M = Memory

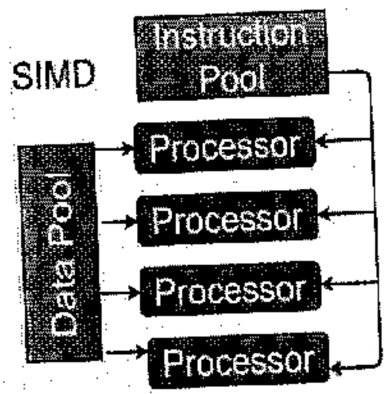
Instructions are decoded by the Control Unit and then the Control Unit sends the instructions to the processing units for execution.

Data Stream flows between the processors and memory bi-directionally.

Older generation computers, minicomputers, and workstations.

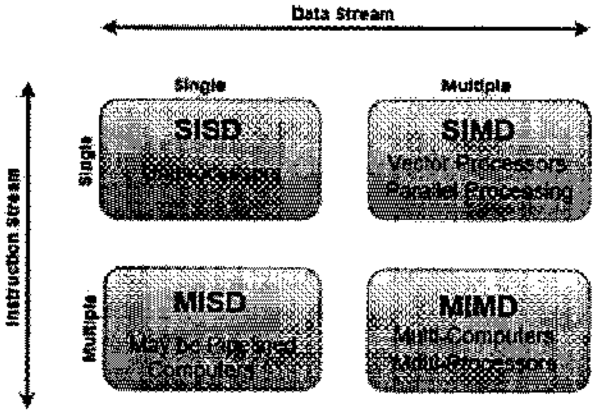
2. SIMD:

- An SIMD system is a multiprocessor machine capable of executing the same instruction on all the CPUs but operating on different data stream
- Machines based on an SIMD model are well suited to scientific computing since they involve lots of vector and matrix operations.
- So that the information can be passed to all the processing elements (PEs) organized data elements of vectors can be divided into multiple sets(N-sets for N PE systems) and each PE can process one data set.



3.MISD:Multiple-instruction, single-data (MISD) systems –
An MISD computing system is a multiprocessor machine capable of executing different instructions on different PEs but all of them operating on the same dataset .

Flynn's Classification of Computers

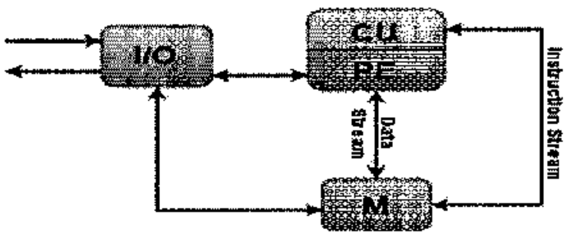


1. <u>SISD:</u>

- **SISD** stands for ***'Single Instruction and Single Data Stream'***. It represents the organization of a single computer containing a control unit, a processor unit, and a memoryunit.

- An SISD computing system is a uniprocessor machine which is capable of executing a single instruction, operating on a single data stream
- In SISD, machine instructions are processed in a sequential manner and computers adopting this model are popularly called sequential computers.
- Most conventional computers have SISD architecture.
- All the instructions and data to be processed have to be stored in primary memory.

SISD:



4.Data-level parallelism (DLP)
Instructions from a single stream operate concurrently on several data – Limited by non-regular data manipulation patterns and by memory bandwidth.

Architecture

Parallel computing is a computing where the jobs are broken into discrete parts that can be executed concurrently. Each part is further broken down to a series of instructions. Instructions from each part execute simultaneously on different CPUs. Parallel systems deal with the simultaneous use of multiple computer resources that can include a single computer with multiple processors, a number of computers connected by a network to form a parallel processing cluster or a combination of both.
Parallel systems are more difficult to program than computers with a single processor because the architecture of parallel computers varies accordingly and the processes of multiple CPUs must be coordinated and synchronized.

M.J. Flynn proposed a classification for the organization of a computer system by the number of instructions and data items that are manipulated simultaneously.

The sequence of instructions read from memory constitutes an **instruction stream.**

The operations performed on the data in the processor constitute a **data stream.**

Parallel processing may occur in the instruction stream, in the data stream, or both.

Flynn's classification –

1. Single instruction stream, single data stream (SISD)
2. Single instruction stream, multiple data stream (SIMD)
3. Multiple instruction stream, single data stream (MISD)
4. Multiple instruction stream, multiple data stream (MIMD)

- There are many reasons to use parallel computing, such as save time and money, provide concurrency, solve larger problems, etc.
- parallel computing reduces complexity
- In the real-life example of parallel computing, there are two queues to get a ticket of anything; if two cashiers are giving tickets to 2 persons simultaneously, it helps to save time as well as reduce complexity.

Advantages of Parallel Computing over Serial Computing are as follows:

- It saves time and money as many resources working together will reduce the time and cut potential costs.
- It can be impractical to solve larger problems on Serial Computing.
- It can take advantage of non-local resources when the local resources are finite.
- Serial Computing 'wastes' the potential computing power, thus Parallel Computing makes better work of the hardware.

Types of Parallelism:

1.Bit-level parallelism –

It is the form of parallel computing which is based on the increasing processor's size. It reduces the number of instructions that the system must execute in order to perform a task on large-sized data.

Example: Consider a scenario where an 8-bit processor must compute the sum of two 16-bit integers. It must first sum up the 8 lower-order bits, then add the 8 higher-order bits, thus requiring two instructions to perform the operation. A 16-bit processor can perform the operation with just one instruction.

2.Instruction-level parallelism

A processor can only address less than one instruction for each clock cycle phase. These instructions can be re-ordered and grouped which are later on executed concurrently without affecting the result of the program. This is called instruction-level parallelism.

3.Task Parallelism

Task parallelism employs the decomposition of a task into subtasks and then allocating each of the subtasks for execution. The processors perform the execution of sub-tasks concurrently.

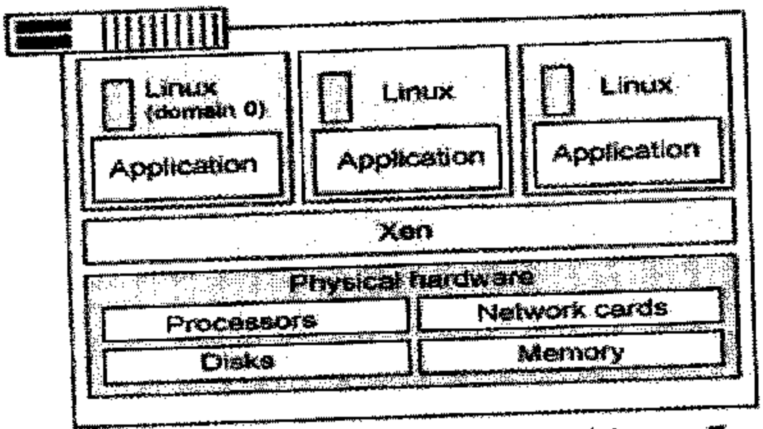
Xen is a hypervisor that enables the simultaneous creation, execution and management of multiple virtual machines on one physical computer.

Xen was developed by XenSource, which was purchased by Citrix Systems in 2007. Xen was first released in 2003. It is an open source hypervisor. It also comes in an enterprise version.

Xen is primarily a bare-metal, type-1 hypervisor that can be directly installed on computer hardware without the need for a host operating system. Because it's a type-1 hypervisor, Xen controls, monitors and manages the hardware, peripheral and I/O resources directly.

Guest virtual machines request Xen to provision any resource and must install Xen virtual device drivers to access hardware components.

Xen supports multiple instances of the same or different operating systems with native support for most operating systems, including Windows and Linux. Moreover, Xen can be used on x86, IA-32 and ARM processor architecture.



Xen is running three virtual machines. Each virtual machine is running a guest operating system and applications independent of other virtual machines while sharing the same physical resources.

These are some of the features of the Xen hypervisor.

- **Dom0** – Xen launches a virtual machine called Dom0. Dom0 is the only virtual machine that has direct access to hardware by default and it provides a tool stack to create, destruct, and configure virtual machines.
- **Small footprints** – Xen comes with a small microkernel and it provides a limited guest interface Hence it is more secure and robust.
- **Driver Isolation** – Xen can isolate divers on multiple virtual machines. This helps you to avoid crashing multiple drivers when one driver breaks down.
- **Paravirtualization** – Xen provides modified guest OS that is similar to the underlying software interface or hardware that can make calls to hypervisors for resources, storage, and CPU access.

Xen can run several guest operating systems each running in its own virtual machine or domain. When Xen is first installed, it automatically creates the first domain, Domain 0 (or dom0).

- The Xen server is built on the open source Xen hypervisor and uses a combination of paravirtualization and hardware-assisted virtualization. This collaboration between the OS and the virtualization platform enables the development of a simpler hypervisor that delivers highly optimized performance.
- Xen provides sophisticated workload balancing that captures CPU, memory, disk I/O, and network I/O data; it offers two optimization modes: one for performance and another for density.
- The Xen server takes advantage of a unique storage integration feature called the Citrix Storage Link. With it, the sysadmin can directly leverage features of arrays from such companies as HP, Dell Equal Logic, NetApp, EMC, and others.
- The Xen server includes multicore processor support, live migration, physical-server-to-virtual-machine conversion (P2V) and virtual-to-virtual conversion (V2V) tools, centralized multiserver management, real-time performance monitoring, and speedy performance for

Windows and Linux.

Cloud Resource Management and Scheduling

Cloud resource management requires complex policies and decisions for multi-objective optimization. Effective resource management is extremely challenging due to the scale of the cloud infrastructure and to the unpredictable interactions of the system with a large population of users.

Policies and mechanisms for resource management

A policy typically refers to the principal guiding decisions, whereas mechanisms represent the means to implement policies.

The main aims of this Resource Management is for the

- Efficient and dynamic utilization of the resources in cloud
- Balance the load
- Avoid situations like a slow run of systems.

Cloud resource management policies can be loosely grouped into five classes:

1. Admission control.
2. Capacity allocation.
3. Load balancing.
4. Energy optimization.
5. Quality-of-service (QoS) guarantees.

Admission control: The explicit goal of an admission control policy is to prevent the system from accepting workloads in violation of high-level system policies; for example, a system may not accept an additional workload that would prevent it from completing work already in progress or contracted. Limiting the workload requires some knowledge of the global state of the system. In a dynamic system such knowledge, when available, is at best obsolete.

Capacity Allocation means to allocate resources for individual instances; an instance is an activation of a service. Locating resources subject to multiple global optimization constraints requires a search of a very large search space when the state of individual systems changes rapidly.

Load balancing and energy optimization are correlated and affect the cost of providing the services; they can be done locally, but global load balancing and energy optimization policies encounter the same difficulties as the capacity allocation.

Load balancing and energy optimization can be done locally, but global load-balancing and energy optimization policies encounter the same difficulties, Load balancing and energy optimization are correlated and affect the cost of providing the services.

The common meaning of the term *load balancing* is that of evenly distributing the load to a set of servers. For example, consider the case of four identical servers, A,B,C, and D, whose relative loads are 80%,60%,40%, and 20%, respectively, of their capacity. As a result of perfect load balancing, all servers would end with the same load -50% of each server's capacity.

This leads to a different meaning of the term load balancing; instead of having the load evenly distributed among all servers, we want to concentrate it and use the smallest number of servers while switching the others to standby mode, a state in which a server uses less energy. In our example, the load from D will migrate to A and the load from C will migrate to B ; thus, and will be loaded at full capacity, whereas C and D will be switched to standby mode

Quality-of-service (QoS) guarantees

Many techniques are concentrated on system performance in terms of throughput and time in system, but they rarely include energy tradeoffs or QoS guarantees. Some techniques are based on unrealistic assumptions; for example, capacity allocation is viewed as an optimization problem, but under the assumption that servers are protected from overload

Allocation techniques in computer clouds must be based on a disciplined approach rather than ad hoc methods.

The four basic mechanisms for the implementation of resource management policies are:

•***Control theory***. Control theory uses the feedback to guarantee system stability and predict transient behavior , but can be used only to predict local rather than global behavior.

•***Machine learning.*** A major advantage of machine learning techniques is that they do not need a performance model of the system. This technique could be applied for the coordination of several autonomic system managers.

•***Utility-based.*** Utility-based approaches require a performance model and a mechanism to correlate user-level performance with cost.

•***Market-oriented/economic mechanisms.*** Such mechanisms do not require a model of the system, e.g., combinatorial auctions for bundles of resources

Applications of control theory to task scheduling on a cloud:

- In Cloud Environment, Control theory has been used to design adaptive resource management for many classes of applications, including power management, task scheduling, QoS adaptation in Web servers and load balancing.
- **Control theory** deals with the control of dynamical systems in engineered processes and machines. The objective is to develop a model or algorithm governing the application of system inputs to drive the system to a desired state.
- A **controller** is the component of a system that monitors certain input variables and adjusts other output variables to achieve the

desired operation. For example, a house may have a heating system equipped with a controller known as a thermostat.

- The thermostat senses when the temperature (input) in the house is too cold, and starts up the heater (controlled output). After a while, the thermostat senses when the temperature is too hot, and shuts off the heater.

In control theory there are two basic types of control are there.

They are

- Feedforward and
- Feedback.

- The input to a feedback controller is the same as what it is trying to control - the controlled variable is "fed back" into the controller.
- The thermostat of a house is an example of a feedback controller. This controller relies on measuring the controlled variable, in this case the temperature of the house, and then adjusting the output, whether or not the heater is on.
- **Feedforward** control can avoid the slowness of feedback control. With feedforward control, the disturbances are measured and accounted

Fundamentally, two types of control loops are used they are:

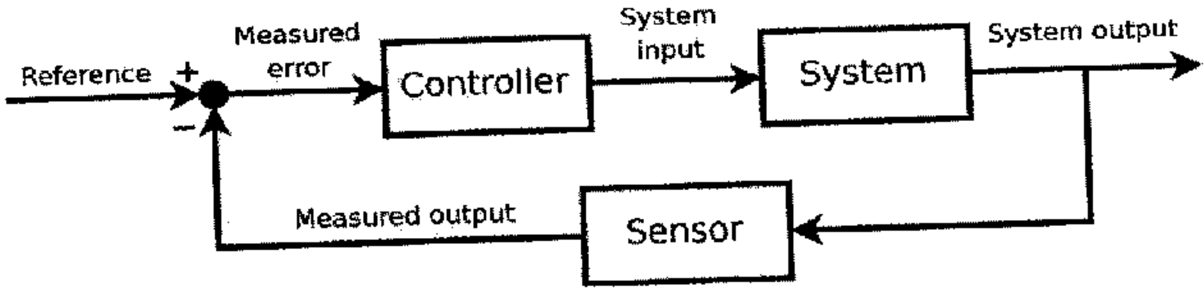
1. **Open loop control**
2. **Closed loop (feedback) control.**

In Open loop control: The control action from the controller is independent of the "process output". A good example of this is a central heating boiler controlled only by a timer, so that heat is applied for a constant time, regardless of the temperature of the building.

In closed loop control, the control action from the controller is dependent on feedback from the process in the form of the value of the process variable (PV). A closed loop controller, therefore, has a feedback loop which ensures the controller.

For Task Scheduling in Cloud based on Control Theory, the classical feedback control methods are used.

This controller is based on an open-loop system transfer function that satisfies stability and sensitivity constraints.

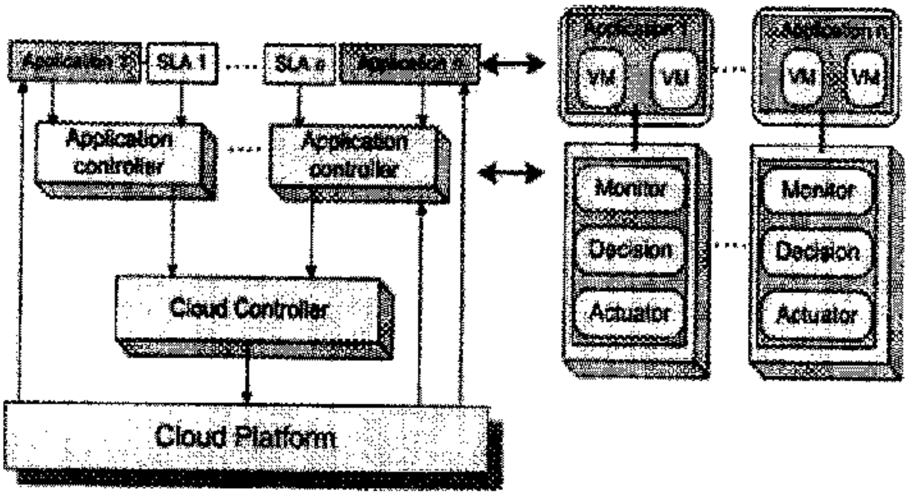


- The technique allows multiple QoS objectives and operating constraints to be expressed as a cost function and can be applied to stand-alone or distributed Web servers, database servers, high performance application servers, and even mobile/embedded systems.

Stability of a two-level resource allocation architecture

In this Architecture , A server with a closed-loop control system are sued for resource allocation.

The automatic resource management is based on two levels of controllers, one for the service provider and one for the application



The main components of a control system are

1. The Inputs
2. The Control system
3. The Outputs.

<u>The Inputs:</u>

The inputs in such models are the offered workload and the policies which are applied, the capacity allocation, the load balancing, the energy optimization, and the QoS guarantees in the cloud.

<u>The Control system components</u>

The elements involved in a control system are **sensors, monitors, and actuators**. The sensors measure the parameter(s) of interest and then transmit the measured values to a monitor, which determines whether the system behavior must be changed, and, if so, it requests that the actuators carry out the necessary actions.

<u>The output</u>

Output is the resource allocations to the individual applications.

The controllers use the feedback provided by the sensors to stabilize the system; stability is related to the change of the output. If the change is too large, the system may become unstable.

Generally the following are the sources of **instability in any control system** , **They are**

1. **The Delay:** Getting the system reaction after a control action.

2. **The granularity of the control:** A small change enacted by the controllers leads to very large changes of the output.

3. **Oscillations:** Which occur when the changes of the input are too large and the control is too weak, such that the changes of the input propagate directly to the output.

The following are the policy mechanisms used Control systems:

(i) threshold-based policies

(ii) Sequential decision policies

Threshold-based policies

Thresholds: A threshold is the value of a parameter related to the state of a system that triggers a change in the system behavior. Thresholds are used in control theory to keep critical parameters of a system in a predefined range.

The threshold could be static or it could be dynamic.

- **Static threshold is** defined once and for all.
- Dynamic threshold could be based on an average of measurements carried out over a time interval.
- To maintain the system parameters in a given range, a high and a low threshold are often defined.

  The two thresholds determine **different actions**; for example, a high threshold could force the system to limit its activities and a low threshold could encourage additional activities.

Feedback control based on dynamic thresholds :

Threshold-based Dynamic Resource Allocation Scheme

2.1. The principle of the threshold-based dynamic resource allocation : In general, the workload of network applications (such as Web applications) fluctuates over the application lifetime.

If we use a static resource allocation scheme to assign fixed resources to an application, the application may be slowed down sometimes due to insufficient resources, or excessive resources are wasted when application is not at its peak load. Therefore, it is ideal to design a dynamic resource allocation scheme that can adjust the resources allocated to an application according to its workload, thus, improving the resource utilization.

- The main idea of the proposed threshold-based dynamic resource allocation scheme is to monitor and predict the resource needs of the cloud applications and adjust the virtual resources based on application's actual needs.
- A dynamic resource allocation scheme needs to address two issues: They are
    a) When to reallocate resources and
    b) How much resource to be adjusted.
- If the time interval between two resource re-allocation events is too large, the system may not be able to respond the load changes timely. Such a slow response may either affect the performance of certain applications or waste virtual resources. On the other hand, if the time interval between two allocation events is too short, the overhead for resource allocation is too much.
- In the dynamic resource allocation scheme, the interval between two consecutive allocation events is set to be adaptive to the load change of a cloud application. If the load of an application changes slowly in a steady pace, a longer interval is selected. If the load of an application changes rapidly, a shorter interval is used. However, sometimes, the load of an application oscillates during the application's lifetime.

So to allocate resources dynamically we use this approach.

Scheduling algorithms for computing clouds

- Scheduling is a critical component of cloud resource management.
- Scheduling is responsible for resource sharing/multiplexing at several levels.

- A server can be shared among several virtual machines, each virtual machine could support several applications, and each application may consist of multiple threads.

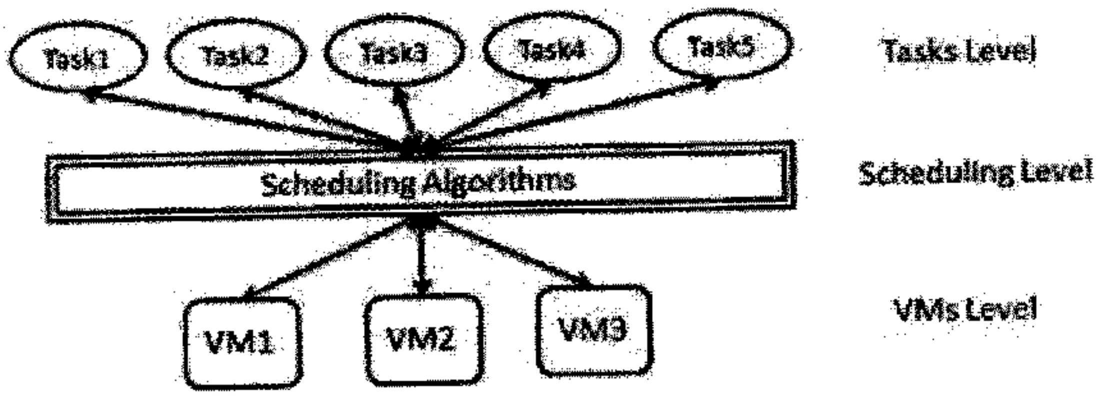
Scheduling algorithms schedule processes on the processor in an efficient and effective manner. This scheduling is done by a Process Scheduler. It maximizes CPU utilization by increasing throughput.

The task scheduling system in cloud computing passes through three levels.

The first task level: is a set of tasks (Cloudlets) that is sent by cloud users, which are required for execution.

The second scheduling level: is responsible for mapping tasks to suitable resources to get highest resource utilization with minimum makespan. The makespan is the overall completion time for all tasks from the beginning to the end.

The third VMs level: is a set of (VMs) which are used to execute the tasks



Following are the popular process scheduling algorithms about which we are going to talk in this chapter:

1. First-Come, First-Served (FCFS) Scheduling

2. Shortest-Job-Next (SJN) Scheduling

3. Priority Scheduling

4. Shortest Remaining Time

5. Round Robin (RR) Scheduling

6. Multiple-Level Queues Scheduling

7. Multi level Feedback Queues Scheduling

8. Highest Response Ratio Next

1. First-Come, First-Served (FCFS)

In this scheduling algorithm, jobs are executed on a first come, first serve basis irrespective of burst time or priority It is based on the First In First Out (FIFO) queue.

2. Shortest Job Next (SJN)

Also known as shortest job first (SJF), this scheduling algorithm is both a non-preemptive and preemptive scheduling algorithm. Process with the minimum burst time at an instance executes first. It is very efficient in minimizing the waiting time and is easy to implement in Batch systems..

3. Priority Scheduling

This scheduling algorithm is commonly used in batch systems and is a non-preemptive scheduling algorithm. In this each process is assigned a priority and the process with the highest priority executes first followed by the ones lower in priority. If two processes share the same priority then execution is done on a first come first served basis. Priority is decided based on memory requirements, time requirements, or any Waiting time of each process:

4. Shortest Remaining Time (SRT)

This scheduling algorithm is the preemptive version of the SJN algorithm. The OS allocates the processor to the job that is closest to completion. Though there is a chance of this job being preempted, if another job is ready with a shorter time to completion. It is used in batch environments where short jobs are given preference and cannot be implemented in interactive systems where required CPU time is unknown.

5. Round Robin (RR)

This scheduling algorithm is a preemptive process scheduling algorithm where each process is provided a fixed time to execute. This fixed time is called a quantum. It uses context switching to save states of preempted processes. Once a process is done executing for a given time period, it is preempted and another process executes for a given time period.

Waiting time of each process:

6. Multiple-Level Queues

In this scheduling algorithm multiple algorithms with common characteristics come together to form a group and then schedule jobs as a whole. Thus, it is not an independent scheduling algorithm. There are multiple queues for processes with common characteristics and each queue has its own scheduling algorithms. The OS assigns priorities to each queue.

7. Multilevel Feedback Queue

This scheduling algorithm is similar to multilevel queue scheduling except that the processes here can change their queue too i.e., if a process is in queue1, then after partial execution, it can switch to queue2.

8. Highest Response Ratio Next

In this scheduling algorithm, scheduling is done on the basis of response ratio. The process with the highest response ratio is scheduled next which reduces starvation in the system.

Purpose of a Scheduling algorithm

The purpose of a scheduling algorithm is to provide:

- Maximum CPU utilization
- Minimum turnaround time
- Fair allocation of CPU
- Maximum throughput
- Minimum waiting time
- Minimum response time

Round-robin, FCFS, shortest-job-first (SJF), and priority algorithms are among the most common scheduling algorithms for best-effort applications.

- As cloud computing is serving millions of users simultaneously, it must have the ability to meet all users requests with high performance and guarantee of quality of service (QoS). Therefore, we need to implement an appropriate task scheduling algorithm to fairly and efficiently meet these requests.

Fair queuing

Fair queuing is a family of scheduling algorithms used in some process and network schedulers.

a) Computing and communication on a cloud are intimately related to each other.
b) Interconnection networks allow cloud servers to communicate with one another and with users. These networks consist of communication links with limited bandwidth and switches/routers/gateways with limited capacity.
c) When the load exceeds its capacity, a switch starts dropping packets because it has limited input buffers for the switching.
d) A switch must handle multiple flows and pairs of source-destination endpoints.
e) Thus, a scheduling algorithm has to manage several quantities at the same time such as the **bandwidth, the amount of data transferring, the timing and the buffer space allocated to each flow**. To manage all these the first strategy used is a FCFS scheduling algorithm.
f) The advantage of the FCFS algorithm is a simple management of these three quantities: **bandwidth, timing, and buffer space.** But the FCFS algorithm does **not guarantee fairness**. Greedy flow sources can transmit at a higher rate and benefit from a larger share of the bandwidth.
g) To address this problem, a fair queuing algorithm proposed.
h) In which it **maintains separate queues, one per each flow.** This algorithm **guarantees the fairness of buffer space management**, but does not **guarantee fairness of bandwidth allocation.**
i) First, it introduces a ***bit-by-bit round-robin (BR)* strategy**; in which **a single bit from each queue is transmitted** and the queues are visited in a round-robin fashion.

j) The advantage over conventional <u>first in first out</u> (FIFO) or <u>priority queuing</u> is that a high-data-rate flow, consisting of large packets or many data packets, cannot take more than its fair share of the link capacity.

k) Fair queuing is used in routers, switches, and <u>statistical multiplexers</u> that forward packets from a <u>buffer</u>. The buffer works as a queuing system, where the data packets are stored temporarily until they are transmitted.

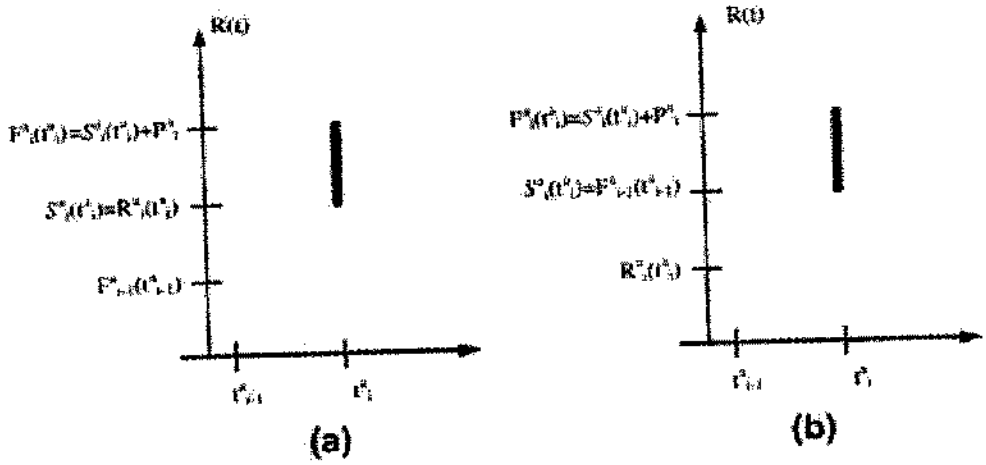
l) (Let R(t) be the number of rounds and Nactive(t) be the number of active flows through the switch. Call t^i_a is the time when the packet i of flow a, of size P^i_a bits arrives, and call S^i_a and F^i_a the values of R(t) when the first and the last bit, respectively, of the packet i of flow a are transmitted. Then,

$$F_i^a = S_i^a + P_i^a \quad \textbf{and} \quad S_i^a = \max\left[F_{i-1}^a, R(t_i^a)\right]. \tag{6.28}$$

The quantities $R(t)$, $N_{active}(t)$, S_i^a, and F_i^a depend only on the arrival time of the packets, t_i^a, and not on their transmission time, provided that a flow a is active as long as

$$R(t) \leqslant F_i^a \quad \textbf{when} \quad i = \max(j \mid t_j^a \leqslant t). \tag{6.29}$$

Transmission of a packet i of flow a arriving at time t_i^a of size P_i^a bits. The transmission starts at time $S_i^a = \max[F_{i-1}^a, R(t_i^a)]$ and ends at time $F_i^a = S_i^a + P_i^a$ with $R(t)$ the number of rounds of the algorithm. (a) The case $F_{i-1}^a < R(t_i^a)$. (b) The case $F_{i-1}^a \geqslant R(t_i^a)$.



)

Suppose we have just *one* input queue, and assume the output line transmits one bit per tick. If the ith packet arrives at time A[i], of size P[i], then consider the time when it finishes transmitting, F[i]. If the queue was empty on arrival,

F[i] = A[i] + P[i];

if the queue was nonempty then we have to wait for the previous packet to finish before we can start and so

F[i] = F[i-1] + P[i]. Combining, F[i] = Max(F[i-1], A[i]) + P[i]

This allows us to compute the finishing time. Packets, of course, would be sent in order of increasing F[i].

Our formula,

F[i] = Max(F[i-1], A[i]) + P[i]

still works.

F[i] = virtual finishing time of ith packet

A[i] = arrival time

S[i] = start time = max(F[i-1], A[i])

P[i] = size of packet

For each arriving packet, we compute F[i] as a timestamp, and send packets in order of increasing F[i]. What the F[i] thus represents, *exactly* (ignoring one-bit rounding) is the FQ-clock time at which the ith packet would finish, *if* we were using true bbrr.

1. The transmission rule emulates the BR strategy: The next packet to be transmitted is the one with the smallest Fai. The current packet be interrupted as soon as one with a shorter finishing time, Fai arrives.
2. Suppose we have several competing flows at a router:

```
flow1--\
        \
flow2----[R]----output
```

/
flow3--/

A typical router allocates output bandwidth in proportion to the input bandwidth. That is, if the three input flows above send 12, 4, and 2 packets per second, for a total of 18, but the output can only handle 9 packets per second, then the flows will successfully transmit 6, 2, and 1 packet per second respectively.

This can, of course, be seen as "fair": each flow gets bandwidth in proportion to its demand.

"Fair Queuing" is an attempt to give the flows above equal shares, at least within the limits of actual demand.

It is important for a queuing strategy to be *work-conserving*; that is, for it to schedule no idle output time unless all inputs are idle.

The simplest algorithm for **fair queuing is round-robin queue service,** with all packets of equal size; this is sometimes called **Nagle Fair Queuing**. This means we keep a separate input queue for each flow, and offer service to the nonempty queues in round-robin (cyclic) fashion. Empty queues do not tie up resources. Shares are divided equally among the active flows. As soon as a flow becomes active (that is, its queue becomes nonempty) it gets to start sharing in the bandwidth allocation; it does not have to wait for other flows to work through their backlogs.

- Round-robin works as fair queuing as long as all packets have the same size! If packets have different sizes, then flows all get their fair share of packets per second, but this may not relate to bytes per second.
- Once we begin transmission of a packet, it is quite possible that a shorter packet arrives on another queue that would have a smaller finishing time under bbrr(Bit-

By-Bit-Round Robbin) strategy. However, fair queuing is **non-preemptive**; we continue with the packet we've started.

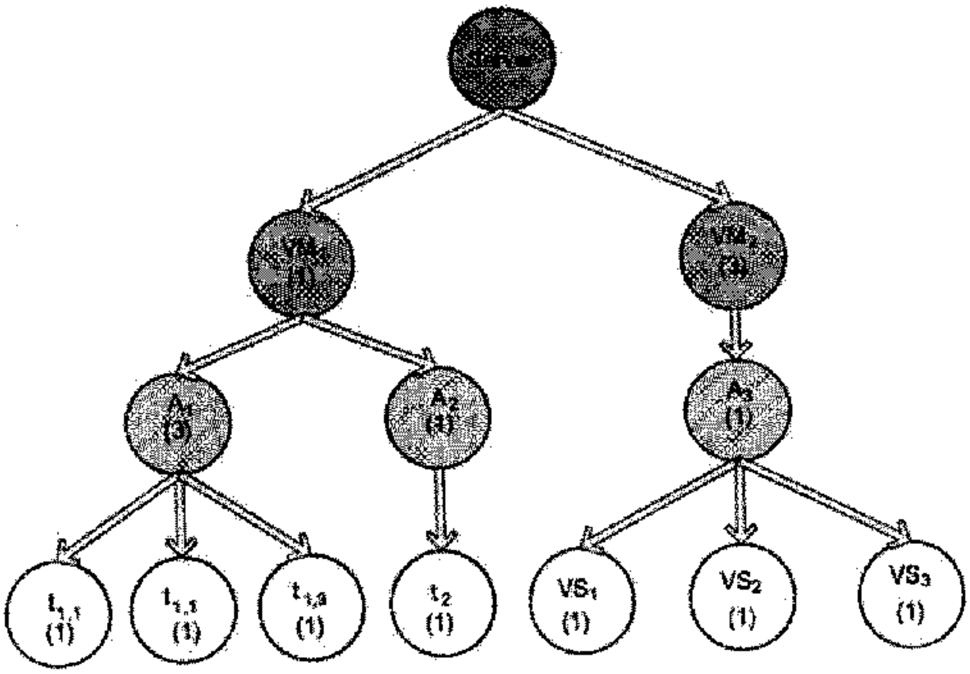
- If a packet is sitting in the output queue with its finishing time computed, it is quite possible for another packet to come along and have a smaller finishing time, and so the other packet will thus be sent first.

<u>So in this approach, Each source is served one at a time in a round robin manner. Sources with no incoming packets are skipped in that round.</u>

<u>Start-Time Fair Queuing Algorithm</u>

- Start Time Fair Queuing (SFQ)2 orders packets by calculating a start-sending time stamp for each packet.
- The packet with the earliest starting time will be served first. Similar to VC, it is designed to reduce computational complexity.
- SFQ has also been claimed to be the first queuing algorithm focusing on handling both CBR and VBR (variable bit rate traffic).

- The basic idea of the *start-time fair queuing (SFQ)* algorithm is to organize the consumers of the CPU bandwidth in a tree structure; the root node is the processor and the leaves of this tree are the threads of each application.
- A scheduler acts at each level of the hierarchy. When a virtual machine is not active, its bandwidth is reallocated to the other VMs active at the time.
- When one of the applications of a virtual machine is not active, its allocation is transferred to the other applications running on the same VM. Similarly, if one of the threads of an application is not runnable, its allocation is transferred to the other threads of the applications.
- Call va(t) and vb(t) the virtual time of threads a and b, respectively, at real time t. The virtual time of the scheduler at time t is denoted by v(t). Call q the time quantum of the scheduler in milliseconds.



The SFQ tree for scheduling when two virtual machines, VM_1 and VM_2, run on a powerful server. VM_1 runs two best-effort applications A_1, with three threads $t_{1,1}$, $t_{1,2}$, and $t_{1,3}$, and A_2 with a single thread, t_2. VM_2 runs a video-streaming application, A_3, with three threads vs_1, vs_2, and vs_3. The weights of virtual machines, applications, and individual threads are shown in parenthesis.

- The threads a and b have their time quanta, qa and qb, weighted by wa and wb, respectively; thus, time quanta of the two threads are q/wa and q/wb, respectively. The i -th activation of thread a will start at the virtual time Sia and will finish at virtual time Fia.

An SFQ scheduler follows several rules:

1. R1. The threads are serviced in the order of their virtual start-up time; ties are broken arbitrarily.
2. R2. The virtual startup time of the i -th activation of thread x to be started is that thread $(i-1)$ has finished and that the scheduler is active.

$$S_x^i(t) = \max\left[v\left(\tau^j\right), F_x^{(i-1)}(t)\right] \quad \text{and} \quad S_x^0 = 0.$$

3.

R3. The virtual finish time of the i-th activation of thread x is

$$F_x^i(t) = S_x^i(t) + \frac{q}{w_x}. \tag{6.33}$$

A thread is stopped when its time quantum has expired; its time quantum is the time quantum of the scheduler divided by the weight of the thread.

R4. The virtual time of all threads is initially zero, $v_x^0 = 0$. The virtual time $v(t)$ at real time t is computed as follows:

$$v(t) = \begin{cases} \text{Virtual start time of the thread in service at time } t, & \text{if CPU is busy} \\ \text{Maximum finish virtual time of any thread}, & \text{if CPU is idle.} \end{cases} \tag{6.34}$$

- The algorithm allocates CPU fairly when the available bandwidth varies in time and provides throughput as well as delay guarantees.
- The algorithm schedules the threads in the order of their virtual start-up time, the shortest one first.

The SFQ algorithm can be summarized as follows:

- The router serves packets in order of start time. The basic idea is as follows:
- A packet arriving in flow f is assigned a "start tag" .
- If there are packets from flow f waiting in the buffer, the new packet should be scheduled behind them. Thus the start tag is set to be the "finish tag" of the previous packet.
- The finish tag is actually pre-assigned based on the size of packet divided by the rate assigned to the flow.
- However, if the start tag of the packet currently being serviced (from any flow) is higher than the finish tag of the previous packet, use the currently servicing start tag that instead.

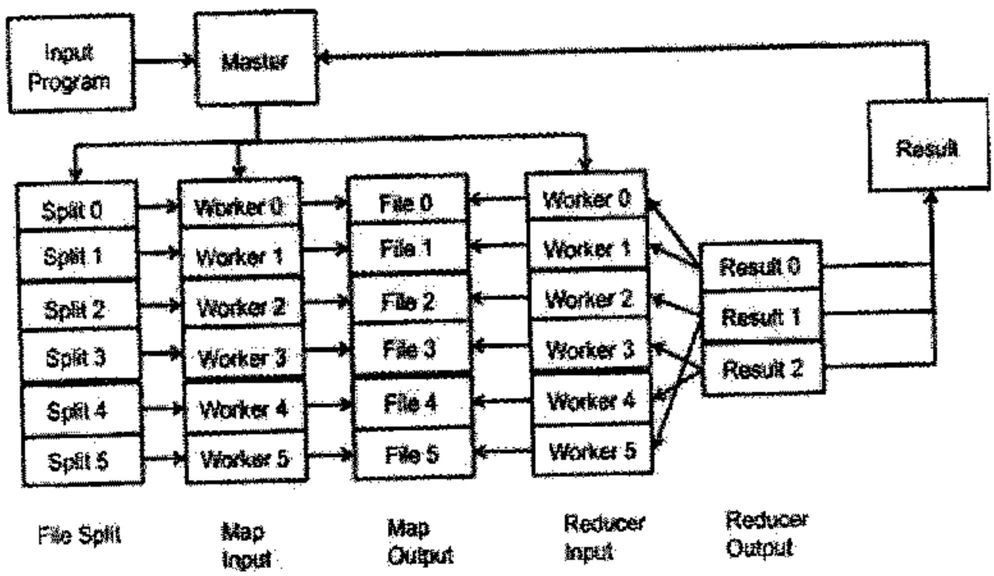
Scheduling *MapReduce* applications subject to deadlines

MapReduce is widely used as a powerful parallel data processing model to solve a wide range of large-scale computing problems. MapReduce is a Hadoop structure utilized for composing applications that can process large amounts of data on clusters.

The **MapReduce algorithm contains two important tasks, namely Map and Reduce.**

1. The Map task takes a set of data and converts it into another set of data, where individual elements are broken down into tuples (key-value pairs).
2. The Reduce task takes the output from the Map as an input and combines those data tuples (key-value pairs) into a smaller set of tuples.

Deadline scheduling means - tasks are scheduled as per their deadlines. The task with the earliest deadline being run first..



- Current MapReduce implementations are based on a master–slave architecture. A user node submits a job to a master node, which selects idle workers and assigns a map or reduce task to each one. When all the tasks are complete, the master node returns the result to the user node.

- The model splits the problem at hand into smaller subproblems as requested, distributes these sub problems among the computers in the cluster, and collects and combines the results that are passed back.
- Today, MapReduce is widely recognized as one of the most important programming models for cloud computing environments, as it is supported by Google and other leading cloud providers such as Amazon, with its Elastic MapReduce service and Microsoft, with its HDInsight and used on top of private cloud infrastructures such as OpenNebula, with its Sahara service.
- MapReduce is designed to process very large amounts of data using hundreds or thousands of machines in distributed/parallel environments, so the model must tolerate machine failures. The failure of a worker is managed by re-executing its task on another worker. A MapReduce frameworks is the scheduling of redundant execution of tasks.

Scheduling of *MapReduce* applications on the cloud subject to deadlines are categorized as

- The default FIFO schedule.
- The Fair Scheduler
- The Capacity Scheduler.
- The Dynamic Proportional Scheduler

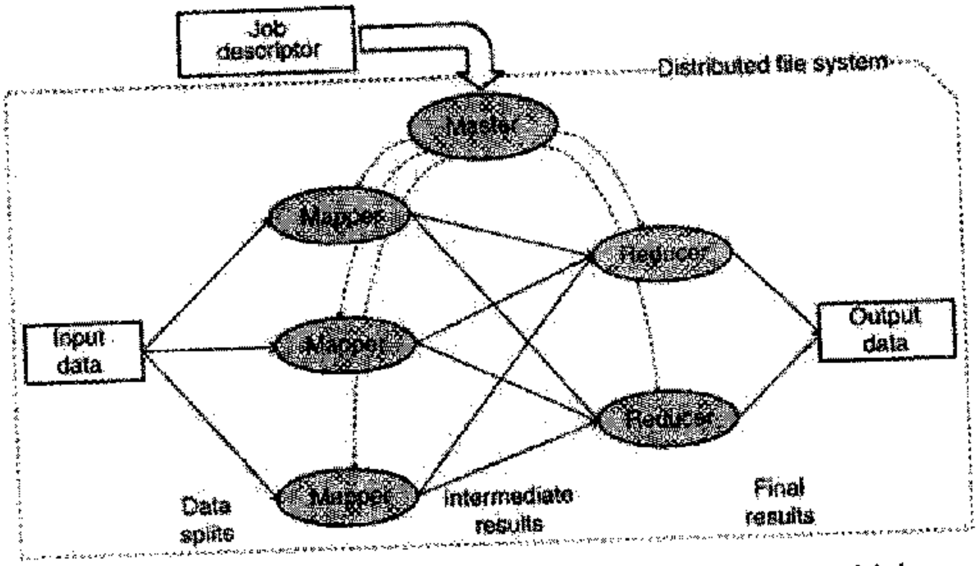
Users must define a *map* and a *reduce* function (Dean and Ghemawat, 2008). The *map* function processes a (*key, value*) pair and returns a list of intermediate (*key, value*) pairs:

map(k1,v1) → list(k2,v2)

The *reduce* function merges all intermediate values having the same intermediate key:

reduce(k2,list(v2)) → list(v3)

In general, the whole transformation process performed in a MapReduce application can be described through the following steps:



1. Master process receives a job descriptor, which specifies the MapReduce job to be executed. The job descriptor contains, among other information, the location of the input data, which may be accessed using a distributed file system.
2. According to the job descriptor, the master starts a number of mapper and reducer processes on different machines. At the same time, it starts a process that reads the input data from its location, partitions that data into a set of splits, and distributes those splits into various mappers.
3. After receiving its data partition, each mapper process executes the *map* function to generate a list of intermediate key/value pairs. Then these pairs are grouped on the basis of their keys.
4. All pairs with the same keys are assigned to the same reducer process. Hence, each reducer process executes the *reduce* function.
5. Then results generated by each reducer process is collected and delivered to a location specified by the job descriptor, so as to form the final output data.

Resource management and dynamic application scaling

In cloud computing, resource management comprises of **provisioning, allocation, and monitoring**. Cloud resources consist of the **servers, memory, storage, network, CPU, application servers, and cybernetic systems otherwise called virtual machines**. These machines are the processing units in cloud.

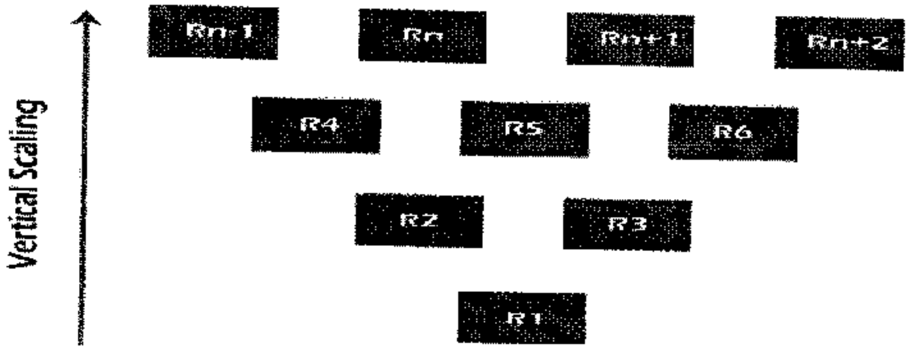
- Cloud scalability refers to increasing or decreasing IT resources as needed to meet changing demand. Scalability is one of the hallmarks of the cloud and the primary driver of its explosive popularity with businesses.
- Data storage capacity, processing power, and networking can all be increased by using existing cloud computing infrastructure. Scaling can be done quickly and easily, usually without any disruption or downtime.

Types of scaling

- Vertical Scalability (Scaled-up)
- horizontal scalability
- diagonal scalability

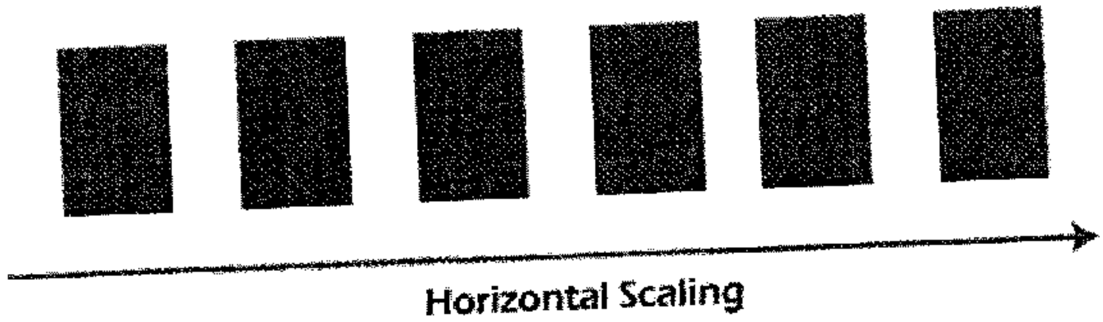
Vertical Scalability (Scaled-up)

With computing, you can add or subtract resources, including memory or storage, within the server, as long as the resources do not exceed the capacity of the machine.



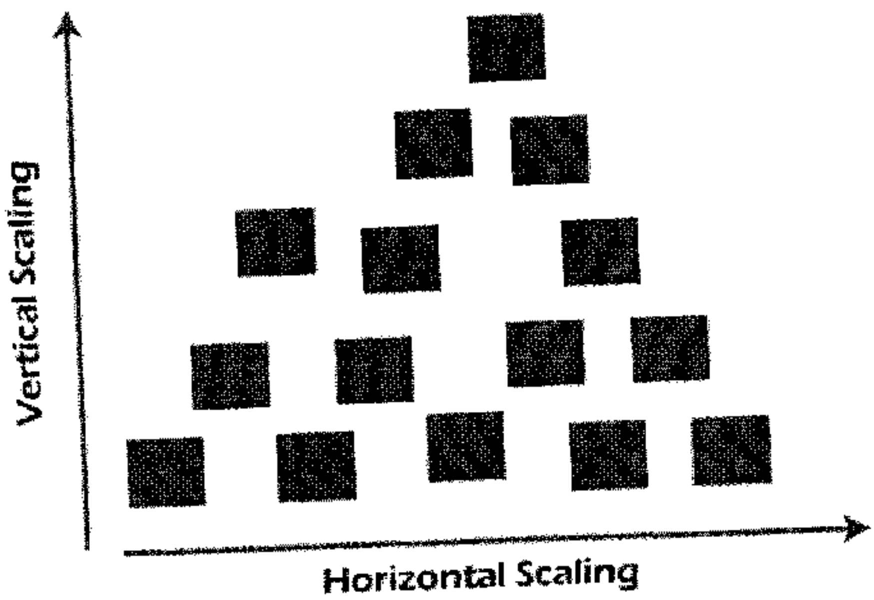
- **horizontal scalability**

Horizontal scaling refers to adding more servers to your network, rather than simply adding resources like with vertical scaling. This method tends to take more time and is more complex, but it allows you to connect servers together, handle traffic efficiently and execute concurrent workloads.



Diagonal Scaling

It is a mixture of both Horizontal and Vertical scalability where the resources are added both vertically and horizontally. Well, you get diagonal scaling, which allows you to experience the most efficient infrastructure scaling.



When we apply scaling into the cloud, an enormous amount of flexibility which saves both money and time for a business.

Scalable cloud architecture is made possible through virtualization. They can be moved to a different server or hosted on multiple servers at once; workloads and applications can be shifted to larger VMs as needed.

Successful businesses use scalable business models to grow rapidly and meet changing demands. Scalability is one of the driving reasons for migrating to the cloud. Whether traffic or workload demands increase suddenly or increase gradually over time, a scalable cloud solution enables organizations to respond appropriately and cost-effectively to increased storage and performance.

Benefits of cloud scalability

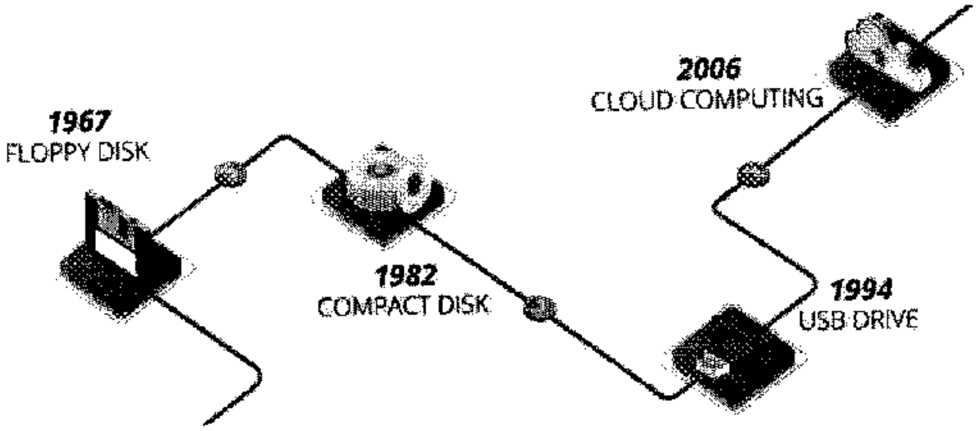
Key cloud scalability benefits driving cloud adoption for businesses large and small:

- **Convenience**: Often, with just a few clicks, IT administrators can easily add more VMs that are available-and customized to an organization's exact needs-without delay.
- **Flexibility and speed**: As business needs change and grow, including unexpected demand spikes, cloud scalability allows IT to respond quickly. **Cost Savings**: businesses can avoid the upfront cost of purchasing expensive equipment that can become obsolete in a few years.
- **Disaster recovery**: With scalable cloud computing, you can reduce disaster recovery costs by eliminating the need to build and maintain secondary data centers.

Dynamic scaling is a feature of auto scaling. That allows us to automatically scale the capacity of our group in response to changing demand. So we can configure scaling policies that track a specific needs.

UNIT- 4 Cloud Computing

Storage Systems



Here's a look at the evolution of storage devices:

1. **Floppy disks: 1967**

Designed to store text and image documents, the storage capacity of a floppy is just 1.4 MB. While that may seem to be a minuscule storage space, compared to the devices we use today; it was sufficient for the period since the information stored on the drive was limited. Computers, laptops and even game consoles from olden times, consist of a floppy disk drive. But today, FDDs (Floppy disk drives) are rarely used or seen.

Compact disks: 1982

As time went on, people had more data that needed to be stored, and CD-ROMs helped serve this need. The acronym ROM – Read-Only Memory, means that the data can be read but not written or erased. This was revolutionary, because other than computer data, audio files could be stored and played using a CD player. CDs contain up to 680 MB of storage space and can store software and game consoles.

USB flash drive:

Unlike floppies and CDs, USB drives can store, erase and reprogram data. USBs a.k.a thumb drives or pen drives are exactly the size of a human thumb. USBs simply need to be connected to a USB port in a desktop or a laptop. Similar to

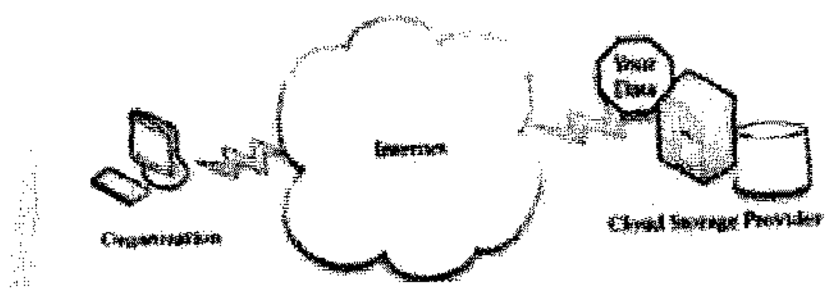
USBs are External portable hard drives that hold up to 1 Terabyte of information and work similar to a USB.

Cloud Computing:

Cloud Computing was a ground-breaking discovery in the information age. The entire concept of storage was repurposed by removing the need for active management by the user. The user can remotely access data that is present on "clouds" that belong to either the same organization or multiple organizations. The need for finding a storage space that is virtual and accessible from anywhere led to the development of cloud storage.

CLOUD STORAGE

- Now there is an opportunity to store all **our data in the internet**. Those off-site storages are provided and maintained by the third parties through the Internet Cloud storage offers a large pool of storage was available for use with immediate availability of very large quantities of storage.
- The evolution of Cloud Storage based on traditional network storage and hosted storage. Benefit of cloud storage is the access of your data from anywhere.
- Cloud storage providers provide storage varying from small amount of data to even the entire warehouse of an organization.
- Subscriber can pay to the cloud storage provider for what they are using and how much they are transferring to the cloud storage.



- *Journal storage* is an elaborate organization for storing composite objects such as records consisting of multiple fields.
- Journal storage consists of **a *manager* and *cell storage*,** where the entire history of a variable is maintained, rather than just the current value.
- The user does not have direct access to the *cell storage*; instead the user can request the *journal manager* to

  (i) start a new action;

  (ii) read the value of a cell;

  (iii) write the value of a cell;

  (iv) commit an action;

  (v) abort an action.

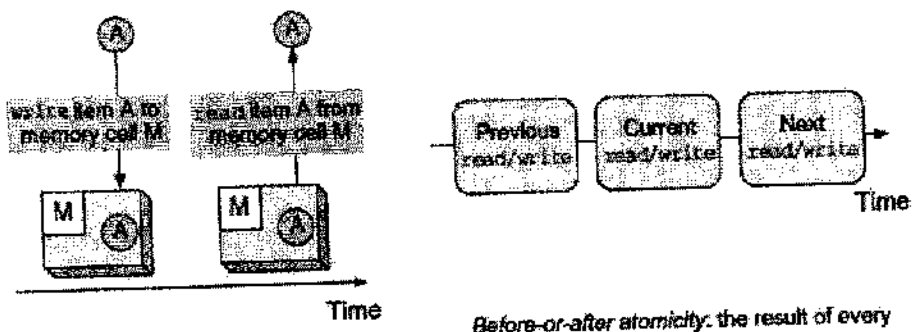
The *journal manager* translates user requests to commands sent to the cell storage:

  (i) read a cell;

  (ii) write a cell;

  (iii) Allocate a cell;

  (iv) Deallocate a cell.



read/write *coherence*: the result of a read of memory cell M should be the same as the most recent write to that cell

Before-or-after atomicity: the result of every read or write is the same as if that read or write occurred either completely before or completely after any other read or write.

- In the context of storage systems, **a *log* contains** a history of all variables in ***cell storage***. The information about the updates of each data item forms a record at the end of the log.

- Basically the cloud storage subscriber copies the data into any one of the data server of the cloud storage provider. That copy of data will be made available to all the other data servers of the cloud storage provider.

BENEFITS OF CLOUD STORAGE:

- No need to invest any capital on storage devices.
- No need for technical expert to maintain the storage, backup, replication and importantly disaster management.
- Allowing others to access our data for collaborative working style instead of individual work.

Storage models, file systems, and databases

A storage model describes the **layout of a data structure in physical storage**; a data model captures the most important logical aspects of a data structure in a database. The physical storage can be a **local disk, a removable media, or storage accessible via a network.**

Two abstract models of storage are commonly used: They are

I. **Cell storage**
II. **Journal storage.**

Cell storage

- Cell storage assumes that the storage consists of cells of the same size and that each object fits exactly in one cell.
- This model reflects the physical organization of several storage media; The primary memory of a computer is organized as an array of memory cells.

Journal storage.

- Today high-performance systems can choose among three classes of file system: **network file systems (NFSs), storage area networks (SANs), and parallel file systems (PFSs).**

Network file systems (NFSs)

- The NFS is very popular and has been used for some time, but it does not scale well and has reliability problems; an NFS server could be a single point of failure.

Storage area networks (SANs):

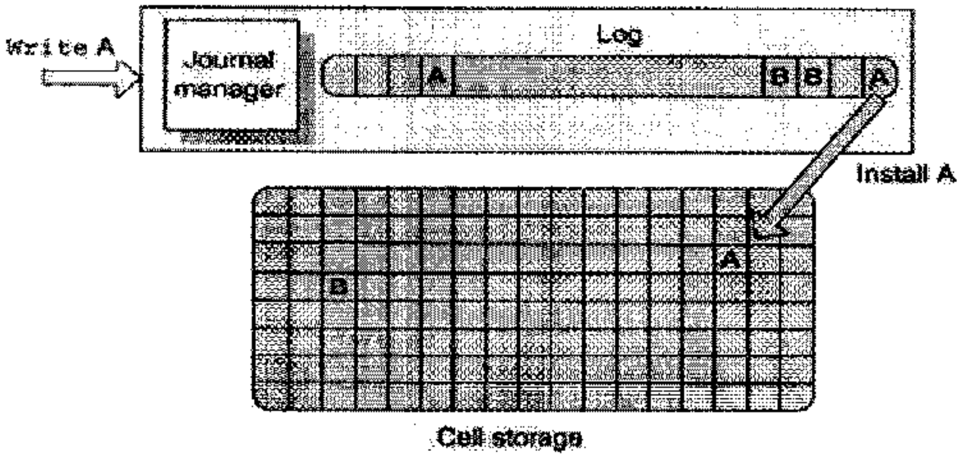
- Advances in networking technology allow the separation of storage systems from computational servers; The two can be connected by a SAN.
- SANs offer additional flexibility and allow cloud servers to deal with non disruptive changes in the storage configuration. Moreover, the storage in a SAN can be pooled and then allocated based on the needs of the servers; pooling requires additional software and hardware support and represents another advantage of a centralized storage system.
- A SAN-based implementation of a file system can be expensive, since each node must have a Fibre Channel adapter to connect to the network.

Pparallel file systems (PFSs)

- Parallel file systems are scalable and are capable of distributing files across a large number of nodes, and provide a global naming space.
- In a parallel data system, several I/O nodes serve data to all computational nodes and include a metadata server that contains information about the data stored in the I/O nodes. The interconnection network of a parallel file system could be a SAN.

Data Bases:

- A log provides authoritative information about the outcome of an action involving ***cell storage***; the cell storage can be reconstructed using the log, which can be easily accessed – we only need a pointer to the last record.
- The ***log*** **is always kept** on nonvolatile storage (e.g., disk) and the considerably larger ***cell storage*** resides typically on nonvolatile memory, but can be held in memory for real-time access or using a write-through cache.



- Many cloud applications must support online transaction processing and have to guarantee the correctness of the transactions.
- Transactions consist of multiple actions; for example, the transfer of funds from one account to another requires withdrawing funds from one account and crediting it to another. The system may fail during or after each one of the actions, and steps to ensure correctness must be taken. Correctness of a transaction means that the result should be guaranteed to be the same as though the actions were applied one after another, regardless of the order. More stringent conditions must be taken.

<u>**A file system**</u> consists of a collection of directories. Each directory provides information about a set of files.

types, such as key-value stores, BigTable implementations, document store databases, and graph databases.

- Replication, used to ensure fault tolerance of large-scale systems built with commodity components, requires mechanisms to guarantee that all replicas are consistent with one another. This is another example of increased complexity of modern computing and communication systems due to physical characteristics of components.

Distributed file systems:

- A Distributed File System (DFS) is a file system that is distributed on multiple file servers or multiple locations. It makes the programs to access or to store isolated files with the local ones, allowing programmers to access files from any network or computer. It manages files and folders on different computers.
- A DFS is a client-server architecture based application, which allows the user or clients to access the data from the server as it is stored in their own computer. It provides location transparency and redundancy help to improve the data availability. And also use data replication strategy on multiple servers to prevent data access failure.

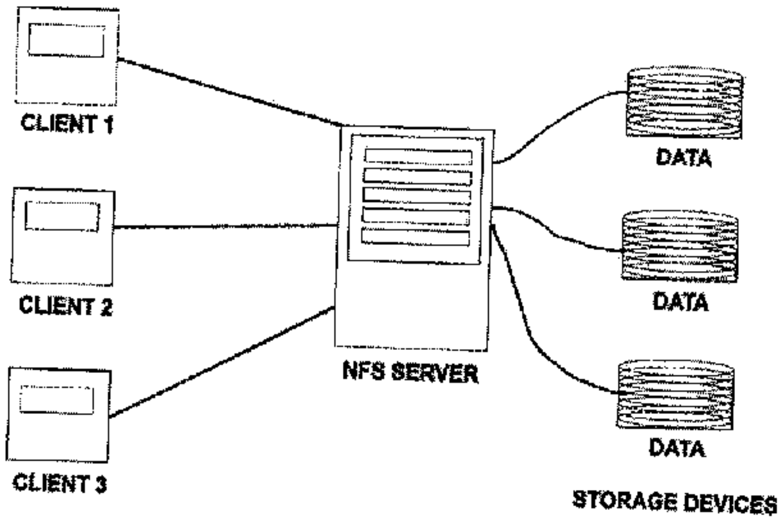
- A database is a collection of logically related records. The software that controls the access to the database is called a database management system (DBMS).
- The main functions of a DBMS are to enforce data integrity, manage data access and concurrency control, and support recovery after a failure.
- A DBMS supports a query language, a dedicated programming language used to develop database applications. Several database models, including the **navigational model of the 1960s**, the **relational model** of the 1970s, **the object-oriented model of the** 1980s, and the ***NoSQL* model** of the first decade of the 2000s, reflect the limitations of the hardware available at the time and the requirements of the most popular applications of each period.
- Most cloud applications are data intensive and test the limitations of the existing infrastructure.. At the same time, cloud applications require low latency, scalability, and high availability and demand a consistent view of the data.
- These requirements cannot be satisfied simultaneously by existing database models; for example, relational databases are easy to use for application development but do not scale well.
- As its name implies, the NoSQL model does not support SQL as a query language and may not guarantee the atomicity, consistency, isolation, durability (ACID) properties of traditional databases.
- NoSQL usually guarantees the eventual consistency for transactions limited to a single data item. The NoSQL model is useful when the structure of the data does not require a relational model and the amount of data is very large.
- Several types of NoSQL database have emerged in the last few years. Based on the way the NoSQL databases store data, we recognize several

linked to any other DFS. Standalone DFS roots are rarely come across because of their limited advantage.

- **Domain-based DFS namespace –**

  It stores the configuration of DFS in Active Directory, creating the DFS namespace root accessible

  at **<domainname>\\<dfsroot>** or **<FQDN>\\<dfsroot>**

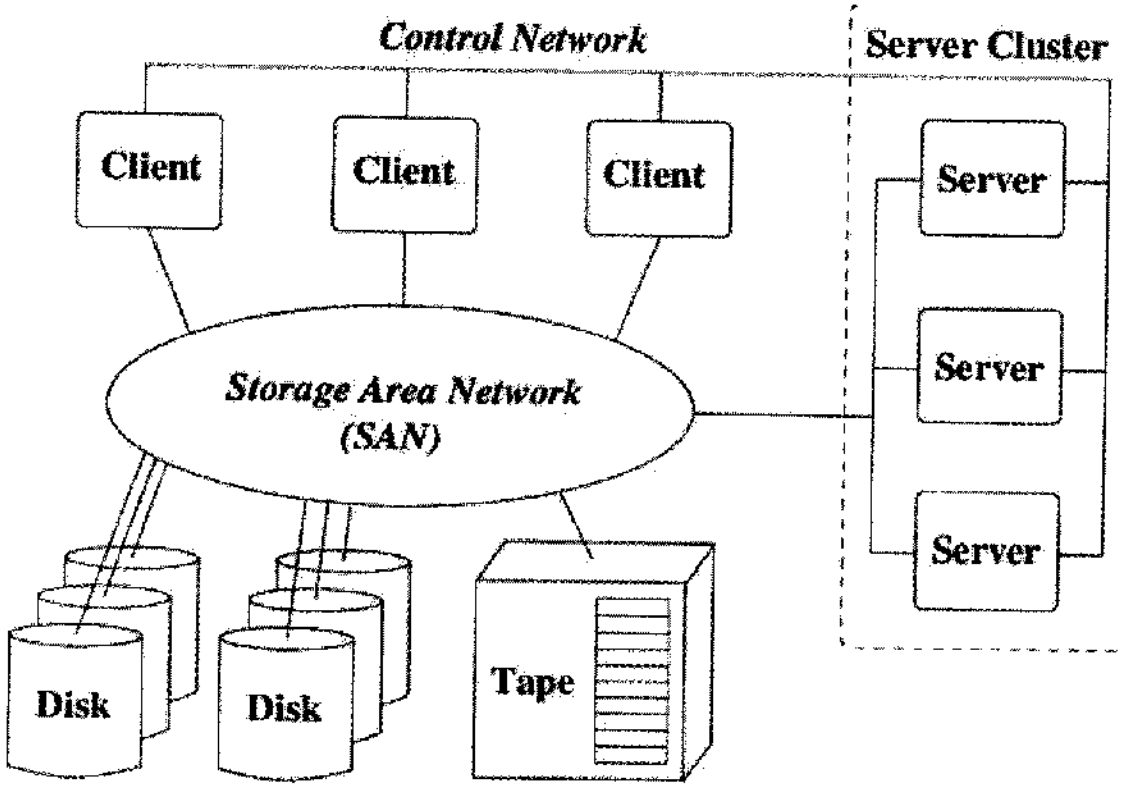


There are various advantages of the distributed file system. Some of the advantages are as follows:

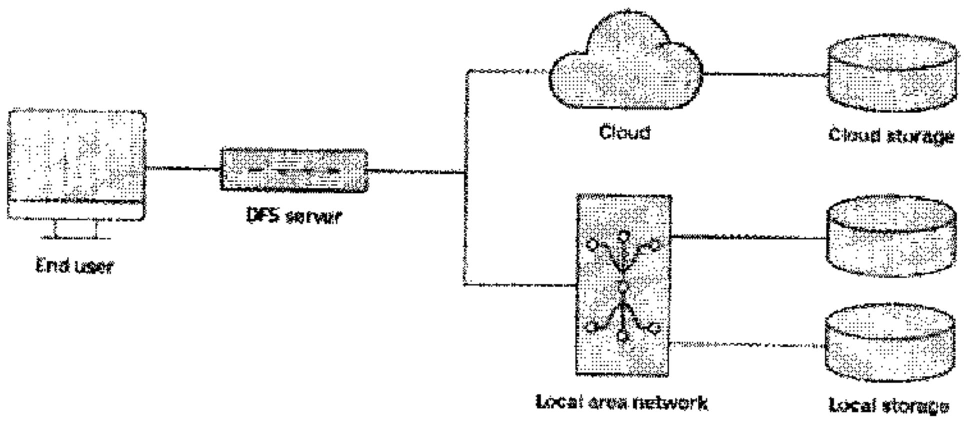
1. It allows the users to access and store the data.
2. It helps to improve the access time, network efficiency, and availability of files.
3. It provides the transparency of data even if the server of disk files.
4. It permits the data to be shared remotely.
5. It helps to enhance the ability to change the amount of data and exchange data.

<u>NFS Network File System</u>

- Network File System is a type of distributed file system protocol where storage resources connect to a computer by network resources, such as a LAN or SAN. Hosts can access data using NFS. A DFS should create backup copies to prevent data loss if there are drive failures.



Distributed file system architecture



Working of DFS :

There are two ways in which DFS can be implemented:

- **Standalone DFS namespace –**

  It allows only for those DFS roots that exist on the local computer and are not using Active Directory. It does not provide any fault liberation and cannot be members of the Carnegie Mellon University community. Network Drive storage on Mac lab computers uses AFS space.

- An AFS presents a homogeneous, location-independent file namespace to all client workstations via a group of trustworthy servers.
- After login onto workstations the users exchange data and programs (DCI). The goal is to facilitate large-scale information exchange by reducing client-server communication.
- This is accomplished by moving whole files between server and client computers and caching them until the servers get a more recent version.
- An AFS uses a local cache to improve speed and minimize effort in dispersed networks. A server, for example, replies to a workstation request by storing data in the workstation's local cache.

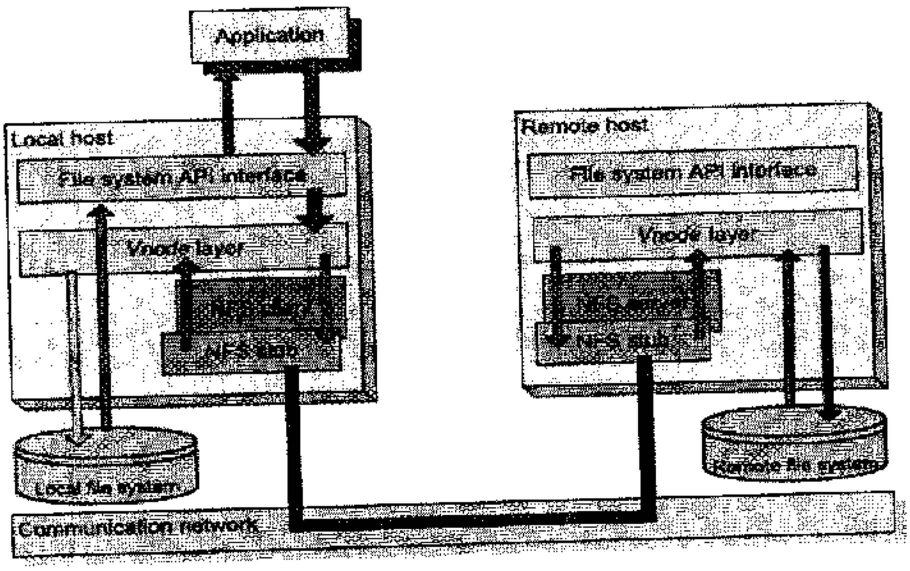
Andrew File System Architecture:

Vice: The Andrew File System provides a homogeneous, location-transparent file namespace to all client workstations by utilizing a group of trustworthy **servers known as Vice.**

Venus: **The mechanism, known as Venus, caches** files from Vice and returns updated versions of those files to the servers from which they originated. Only when a file is opened or closed does Venus communicate with Vice.

Venus performs as much work as possible rather than Vice. Vice only keeps the functionalities that are necessary for the file system's integrity, availability, and security. The servers are set up as a loose confederacy with little connectivity between them.

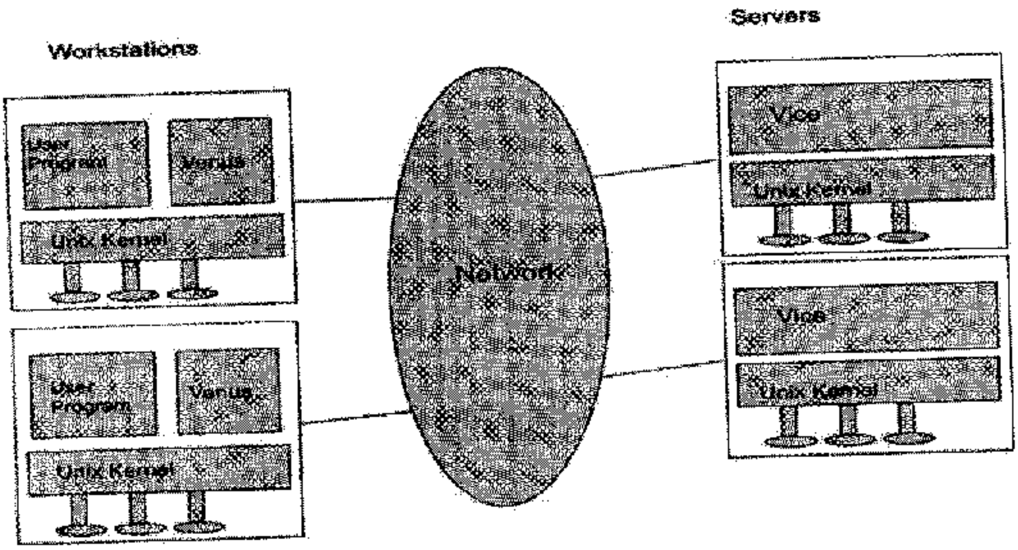
- NFS is derived from the distributed file system mechanism. It is generally implemented in computing environments where the centralized management of data and resources is critical. Network file system works on all IP-based networks. It uses TCP and UDP for data access and delivery, depending on the version in use.
- Network file system is implemented in a client/server computing model, where an NFS sever manages the authentication, authorization and management of clients, as well as all the data shared within a specific file system. Once authorized, clients can view and access the data through their local systems much like they'd access it from an internal disk drive.



- It uses the Transmission Control Protocol (TCP) and User Datagram Protocol (UDP) for accessing and delivering the data and files.

Andrew File System (AFS)

- **Andrew File System (AFS) is a global file system** that allows access to files from Mac, Windows or Linux computers.
- It is similar to cloud-based storage, however, data is stored locally at Carnegie Mellon University. AFS also allows file sharing with other



The following are the server and client components used in AFS networks:

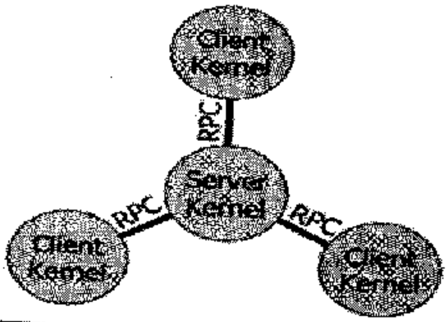
- Any computer that creates requests for AFS server files hosted on a network qualifies as a client.
- The file is saved in the client machine's local cache and shown to the user once a server responds and transmits a requested file.
- When a user visits the AFS, the client sends all modifications to the server via a callback mechanism. The client machine's local cache stores frequently used files for rapid access.

Advantages:

1. Shared files that aren't updated very often and local user files that aren't updated too often will last a long time.
2. It sets up a lot of storage space for caching.
3. It offers a big enough working set for all of a user's files.

Sprite File System: SFS

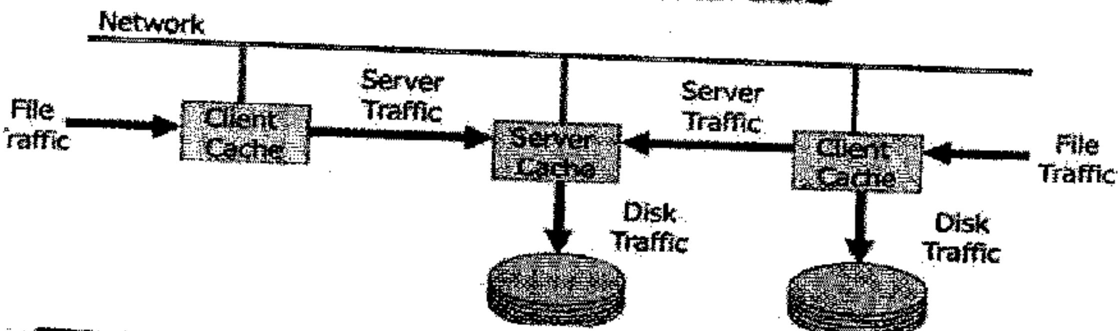
The SFS is functionally similar to Unix File System



- Read, write, open, and close calls provide access to files
- Sprite communicates kernel-to-kernel
- Remote-procedure-calls (RPC) allow kernels to talk to each other

SFS is a component of the Sprite network operating system. SFS uses caching on the server side and on the client side also.

- Two different caching mechanisms
  - Server workstations use caching to reduce delays caused by disk accesses
  - Client workstations use caching to minimize the number of calls made to non-local disks

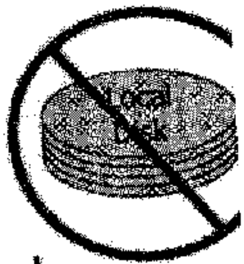


Three main issues are addresse by Sprite's caching system

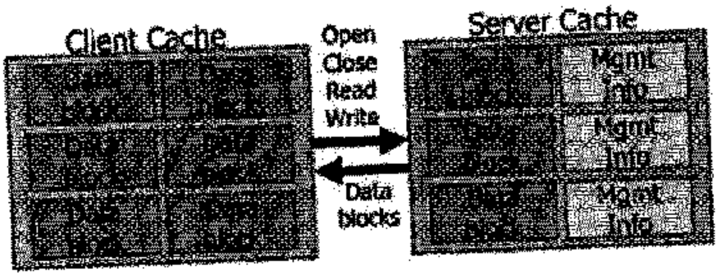
1. Should client caches be kept in main memory or on local disk?
2. What structure and addressing schem should be used for caching?
3. What should happen when a block is written back to disk?

Sprite caches client data in main memory, not on local disk

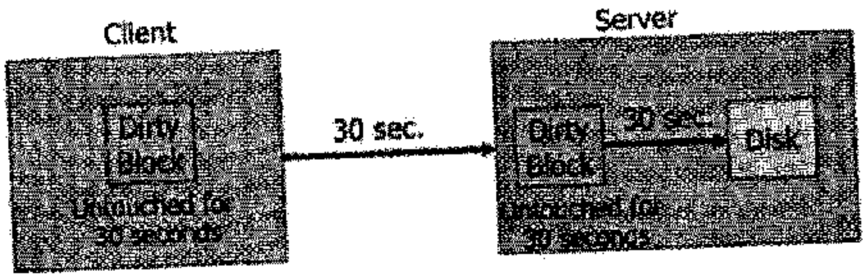
- Allows clients to be diskless
  - Cheaper
  - Quieter
- Data access is faster
- Physical memory is large enough
  - Provides a high hit ratio
  - Memory size will continue to grow
- A single caching mechanism can be used for both client and server



A virtual addressing structure is used for caching



Sprite uses a delayed-write policy to write dirty blocks to disk



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Legal protection of cloud users

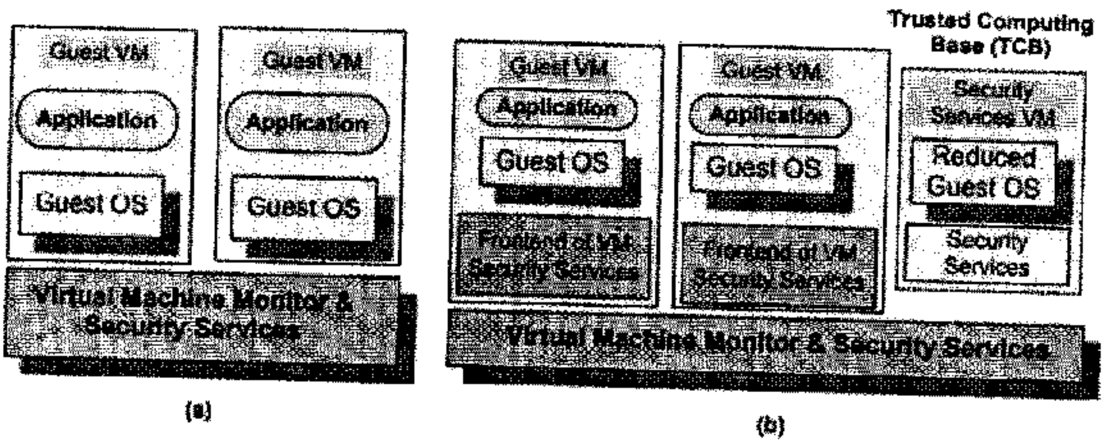
- The contract between the user and the Cloud Service Provider (CSP) should spell out explicitly:
  - CSP obligations to handle securely sensitive information and its obligation to comply to privacy laws.
  - CSP liabilities for mishandling sensitive information.
  - CSP liabilities for data loss.
  - The rules governing ownership of the data.
  - The geographical regions where information and backups can be stored.

Privacy Impact Assessment (PIA)

- The need for tools capable to identify privacy issues in information systems.
- There are no international standards for such a process, though different countries and organization require PIA reports.
- The centerpiece of A proposed PIA tool is based on a SaaS service.
  - The users of the SaaS service providing access to the PIA tool must fill in a questionnaire.
  - The system used a knowledge base (KB) created and maintained by domain experts.
  - The system uses templates to generate additional questions necessary and to fill in the PIA report.
  - An expert system infers which rules are satisfied by the facts in the database and provided by the users and executes the rule with the highest priority.

Virtual machine security

- Hybrid and hosted VMs, expose the entire system to the vulnerability of the host OS.
- In a traditional VM the Virtual Machine Monitor (VMM) controls the access to the hardware and provides a stricter isolation of VMs from one another than the isolation of processes in a traditional OS.
  - A VMM controls the execution of privileged operations and can enforce memory isolation as well as disk and network access.
  - The VMMs are considerably less complex and better structured than traditional operating systems thus, in a better position to respond to security attacks.
  - A major challenge → a VMM sees only raw data regarding the state of a guest operating system while security services typically operate at a higher logical level, e.g., at the level of a file rather than a disk block.
- A secure TCB (Trusted Computing Base) is a necessary condition for security in a virtual machine environment; if the TCB is compromised then the security of the entire system is affected.



alternate file system, the NameNode, secondary NameNode, and DataNode architecture of HDFS are replaced by the file-system-specific equivalents.

Hadoop distributed file system

The *Hadoop distributed file system* (HDFS) is a distributed, scalable, and portable file system written in Java for the Hadoop framework.

HDFS has five services as follows:

1. Name Node
2. Secondary Name Node
3. Job tracker
4. Data Node
5. Task Tracker

- Top **three are Master Services/Daemons/Nodes** and
- Bottom **two is Slave Services.**

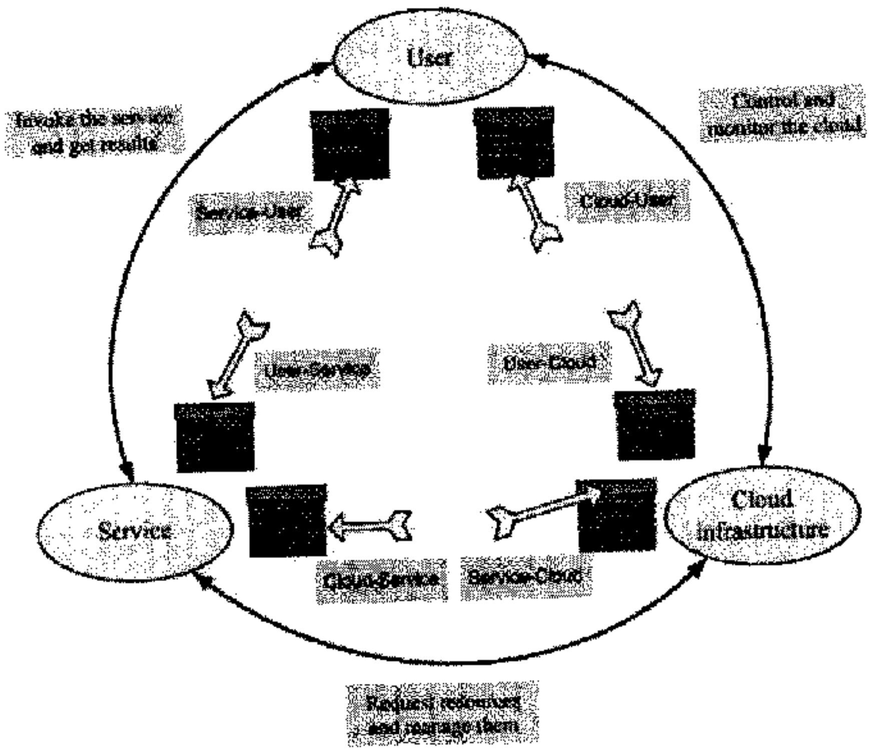
Master Services can communicate with each other and in the same way Slave services can communicate with each other.

Name Node:

- HDFS consists of only one Name Node that is called the Master Node. The master node can track files, manage the file system and has the metadata of all of the stored data within it.
- In particular, the name node contains the details of the number of blocks, locations of the data node that the data is stored in, where the replications are stored, and other details. The name node has direct contact with the client.

Data Node:

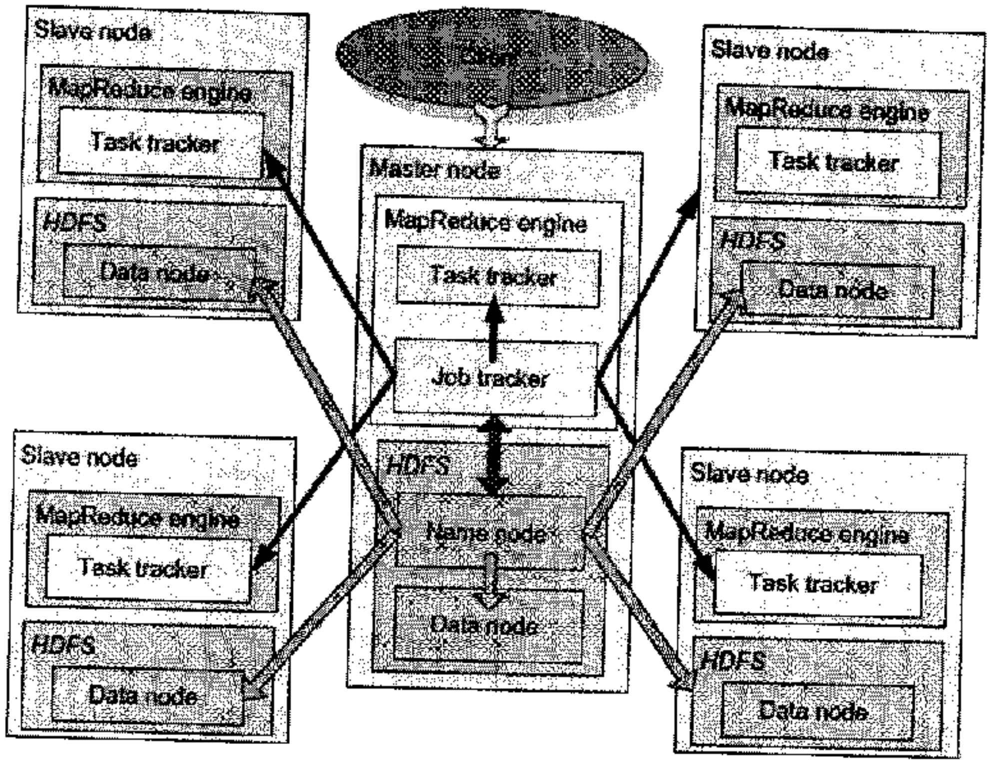
- A Data Node stores data in it as blocks.
- This is also known as the slave node and it stores the actual data into HDFS which is responsible for the client to read and write.
- These are slave daemons.



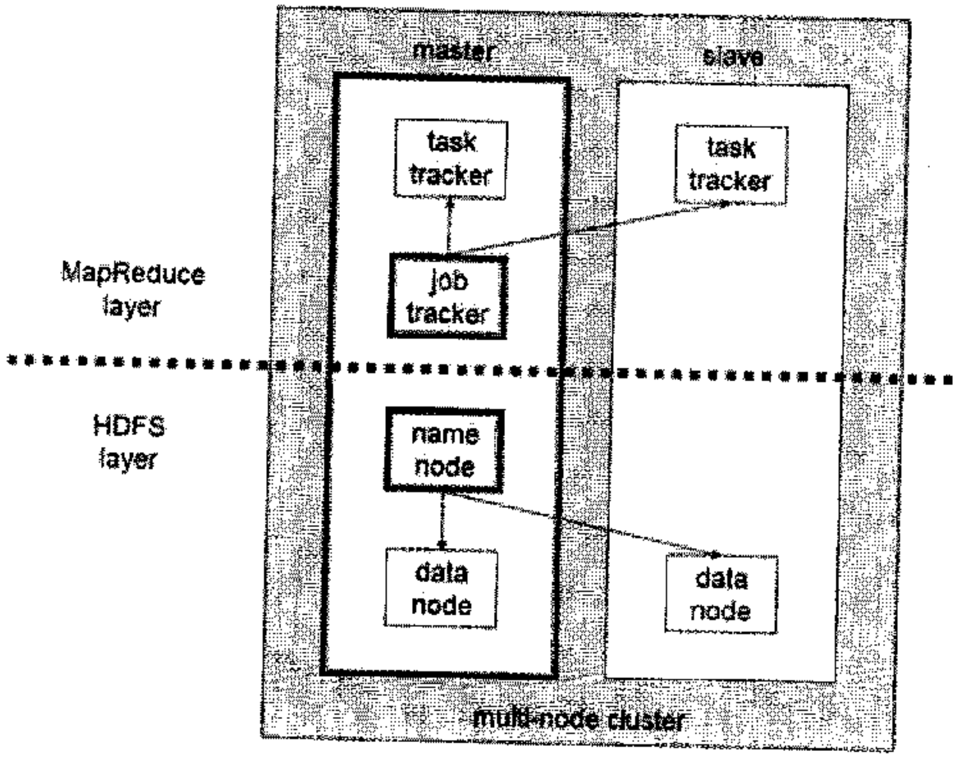
Surfaces of attacks in a cloud computing environment.

Top threats to cloud computing

- Identified by a 2010 Cloud Security Alliance (CSA) report:
  - The abusive use of the cloud - the ability to conduct nefarious activities from the cloud.
  - APIs that are not fully secure - may not protect the users during a range of activities starting with authentication and access control to monitoring and control of the application during runtime.
  - Malicious insiders - cloud service providers do not disclose their hiring standards and policies, so this can be a serious threat.
  - Shared technology.
  - Account hijacking.
  - Data loss or leakage - if the only copy of the data is stored on the cloud, then sensitive data is permanently lost when cloud data replication fails followed by a storage media failure.
  - Unknown risk profile - exposure to the ignorance or underestimation of the risks of cloud computing.



A Hadoop cluster using HDFS. The cluster includes a master and four slave nodes



A multi-node Hadoop cluster

3. Allowing multiple applications operating concurrently to append to the same file.
4. Build the cluster around a high-bandwidth rather than low-latency interconnection network.
5. Separate the flow of control from the data flow;
6. Schedule the high-bandwidth data flow by pipelining the data transfer over TCP connections to reduce the response time.
7. Exploit network topology by sending data to the closest node in the network.
8. Eliminate caching at the client site;
9. Ensure consistency by channeling critical file operations through a master controlling the entire system.
10. Minimize master's involvement in file access operations to avoid hot-spot on tension and to ensure scalability.
11. Support efficient check pointing and fast recovery mechanisms.
12. Support efficient garbage collection mechanisms.

Apache Hadoop

- Apache Hadoop is an open source framework that is used to efficiently store and process large datasets ranging in size from gigabytes to petabytes of data.
- Instead of using one large computer to store and process the data, Hadoop allows clustering multiple computers to analyze massive datasets in parallel more quickly.
- It provides a software framework for distributed storage and processing of big data using the MapReduce programming model.
- Hadoop was originally designed for computer clusters built from commodity hardware, which is still the common use.

3. Manage identities, people and roles

A firm must ensure that the cloud service provider has sufficient policies to govern who has access to sensitive data and software. The cloud service provider must give the customer the privilege to manage and assign authorization for the users. They must also ensure their system is secure enough to handle different types of attacks on client data.

4. Enforcing privacy policies

Privacy and protection of personal and sensitive information are crucial to any organization's success. Personal data held by an organization could face bugs or security negligence. If a provider is not offering adequate security measures, the firm should consider seeking a different cloud service provider or not uploading sensitive information on the cloud.

5. Assess security vulnerabilities for cloud applications

Organizations have different types of data that they store in the cloud. Different considerations should be made according to the kind of data the firm intends to secure.

6. Cloud networks security

Audits of the cloud networks should be able to establish malicious traffic that can be detected and blocked. However, the cloud service providers have no way of knowing which network traffic its users plan to send or receive.

7. Evaluating physical infrastructure and security controls

Facilities and infrastructure should be stored in secure locations and backed up to protect against external threats.It is becoming more critical to maintain privacy and security with more data and software being migrated to the cloud. The IT groups must consider the cloud security risks and implement solutions to ensure the security of client data stored and processed in the cloud.

stakeholder shares responsibility in securing data. Every client should be inclined to take precautionary measures to protect their sensitive data.

7. Attacks to deny service to legitimate users

Denial of service attacks, unlike cyber-attacks, do not attempt to bypass your security protocol. Instead, they make your servers unavailable to illegitimate users. However, in some cases, DoS is used as a smokescreen for a variety of other malicious activities. They can also be used to take down some security appliances like web application firewalls.

8. Insecure APIs

API or Application Programming Interfaces offer users the opportunity to customize their cloud service experience. APIs can, however, be a threat to cloud security due to their very nature. As APIs evolve to provide better service to users, they also increase their security risk on the data client's store. APIs provide programmers with the tools to integrate their programs with job-critical applications.

9. Loss of data

Data stored on cloud servers can be lost through a natural disaster, malicious attacks, or a data wipe by the service provider. Losing sensitive data is devastating to firms, especially if they have no recovery plan. Google is an example of the big tech firms that have suffered permanent data loss after being struck by lightning four times in its power supply lines.

Amazon was another firm that lost its essential customer data back in 2011. An essential step in securing data is carefully reviewing the terms of service of your provider and their back up procedures. The backup protocol could relate to physical access, storage locations, and natural disasters.

10. Diminished customer trust

It is inevitable for customers to feel unsafe after data breach concerns at your firm. There have been massive security breaches that resulted in the theft of millions of customer credit and debit card numbers from data storage facilities.

This GFS consistency model is very effective and scalable.

- Operations, such as file creation, are atomic and are handled by the master.
- To ensure scalability, the master has a minimal involvement in file mutations, operations such as write or appends which occur frequently.
- In such cases the master grants a lease for a particular chunk to one of the chunk servers called the primary; then, the primary creates a serial order for the updates of that chunk.

Flow of Data and Read and Write operations is as follows

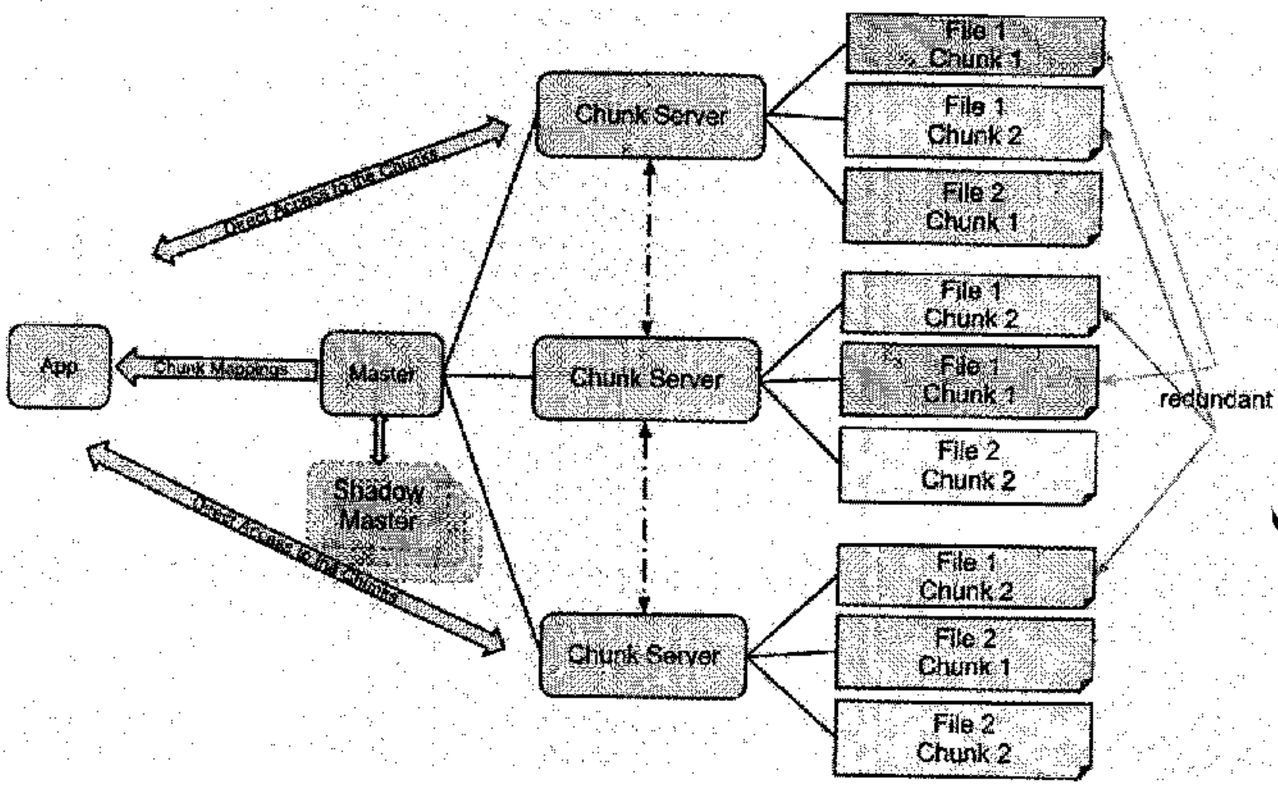
1. The client contacts the master which assigns a lease to one of the chunk servers for the particular chunk, if no lease for that chunk exists; then, the master replies with the Ids of the primary and the secondary chunk servers holding replicas of the chunk. The client caches this information.
2. The client sends the data to all chunk servers holding replicas of the chunk; each one of the chunk servers stores the data in an internal LRU buffer and then sends an acknowledgment to the client.
3. The client sends the write request to the primary chunk server once it has received the acknowledgments from all chunk servers holding replicas of the chunk.
4. The primary chunk server identifies mutations by consecutive sequence numbers.
5. The primary chunk server sends the write requests to all secondaries.
6. Each secondary chunk server applies the mutations in the order of the sequence number and then sends an acknowledgment to the primary chunk server.
7. Finally, after receiving the acknowledgments from all secondaries, the primary informs the client.

Cloud Security

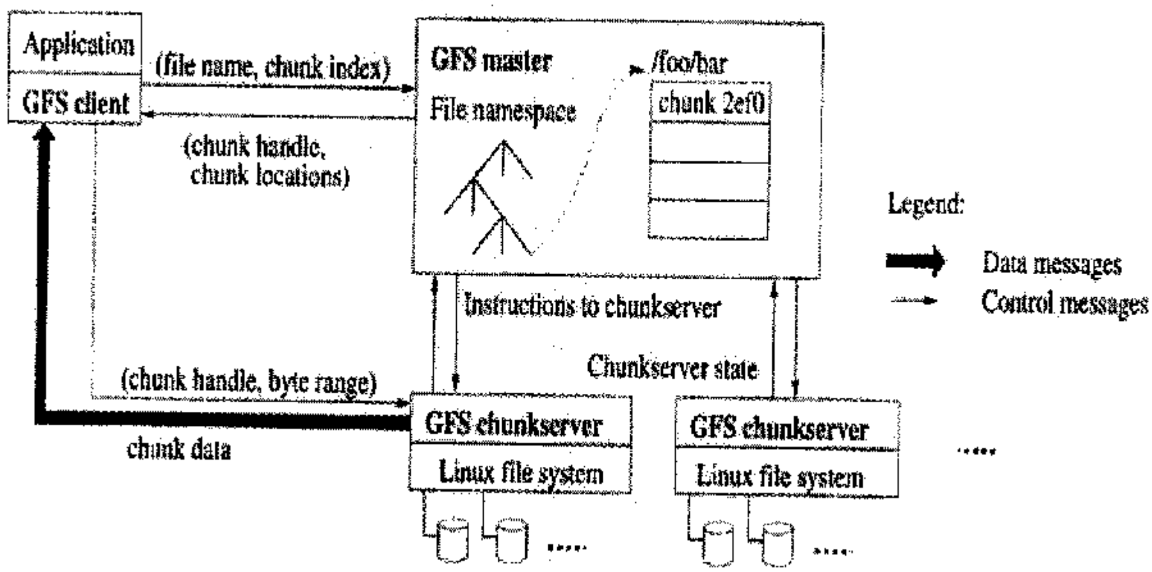
- Cloud security, also known as cloud computing security, is a collection of security measures designed to protect cloud-based infrastructure, applications, and data.
- These measures ensure user and device authentication, data and resource access control, and data privacy protection.
- They also support regulatory data compliance. Cloud security is employed in cloud environments to protect a company's data from distributed denial of service (DDoS) attacks, malware, hackers, and unauthorized user access or use.
  - Cloud computing is continually transforming the way companies store, use, and share data, workloads, and software.
  - The volume of cloud utilization around the globe is increasing, leading to a greater mass of sensitive material that is potentially at risk.
    The market for worldwide cloud computing is projected to grow to $191 billion in two years.
  - There are many pros of cloud computing, which are driving more firms and individuals to the cloud. The benefits include low costs, improved employee productivity, and faster to market, among many more.
  - Regardless of the great advantages, saving a firm's workloads to a cloud service that is publicly hosted exposes the organization to new data security risks which cause unease for some firms' IT departments and clients.
  - With more and more data and software moving to the cloud, unique info-security challenges crop up. Here are the top cloud computing security risks that every firm faces.

Cloud security risks

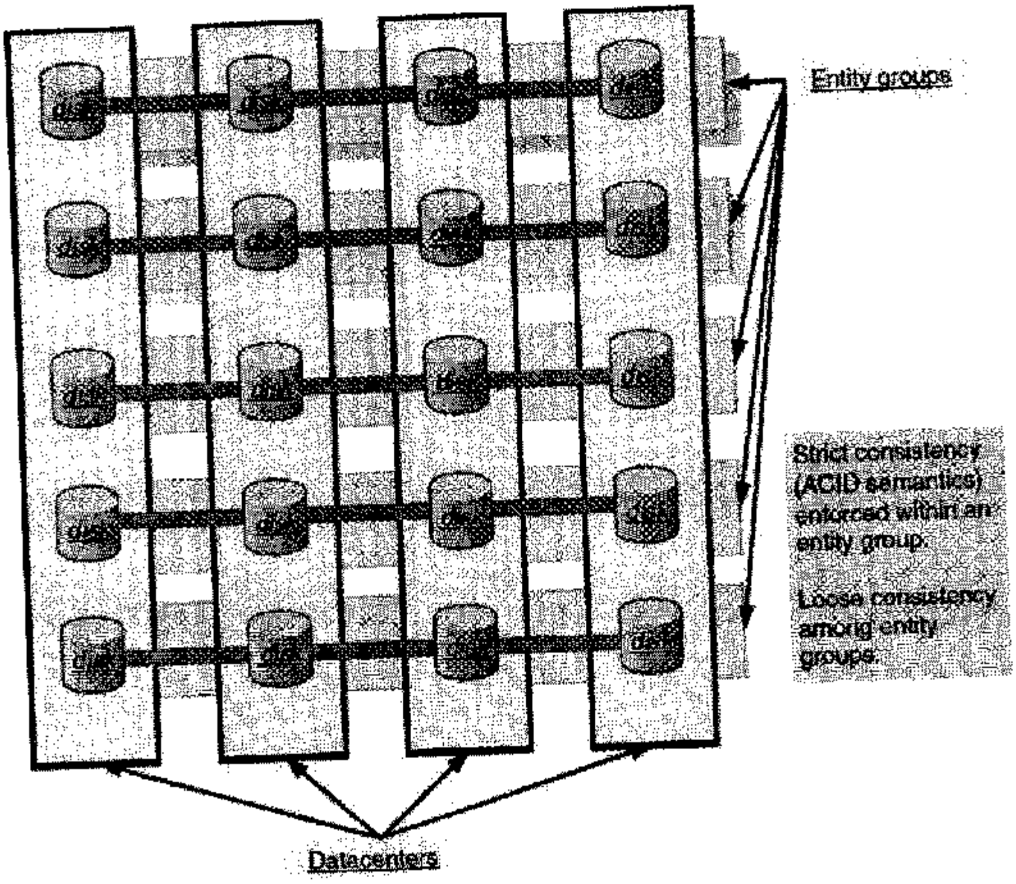
Following are the important Cloud security risks



Architecture

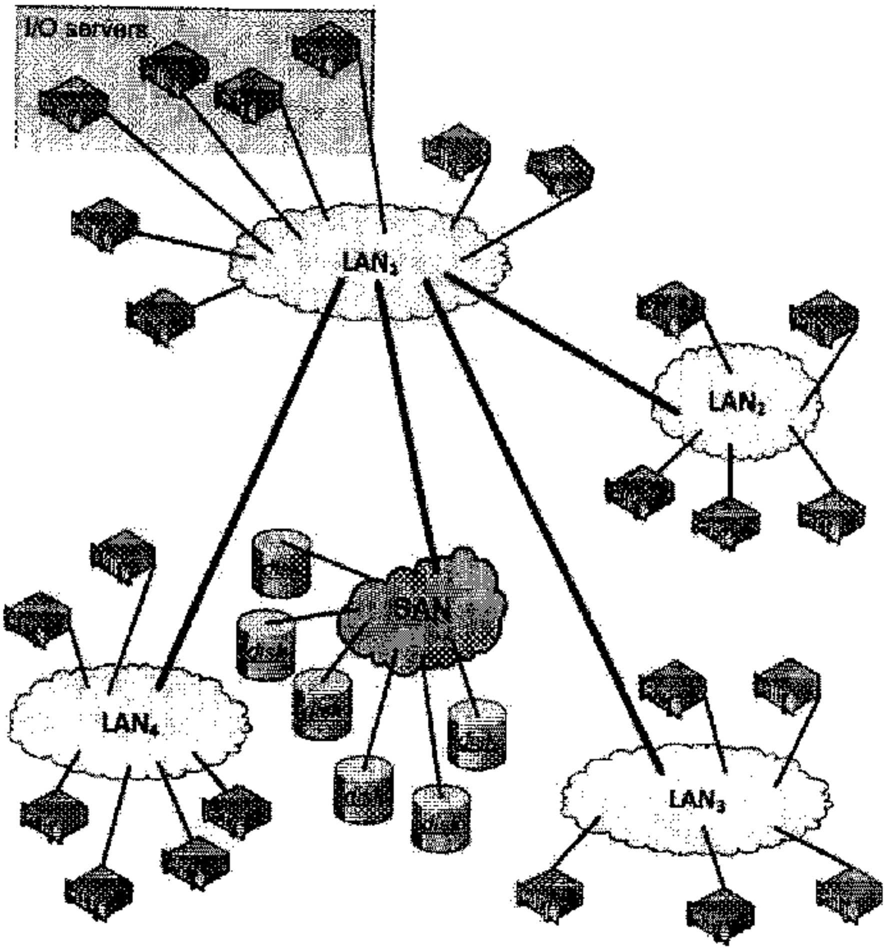


- Megastore handles more than 3 billion write and 20 billion read transactions daily and stores a petabyte of primary data across many global datacenters.



- The basic design philosophy of the system is to partition the data into entity groups and replicate each partition independently in data centers located in different geographic areas.
- Megastore tries to provide the convenience of using traditional RDBMS with the scalability of NOSQL: It is a scalable transactional indexed record manager (built on top of BigTable), providing full ACID semantics within partitions but lower consistency guarantees across partitions . To achieve these strict consistency requirements, Megastore employs a Paxos-based algorithm for synchronous replication across geographically distributed datacenters.

- An allocation manager running on one of the I/O nodes is responsible for actions involving multiple disk map regions.

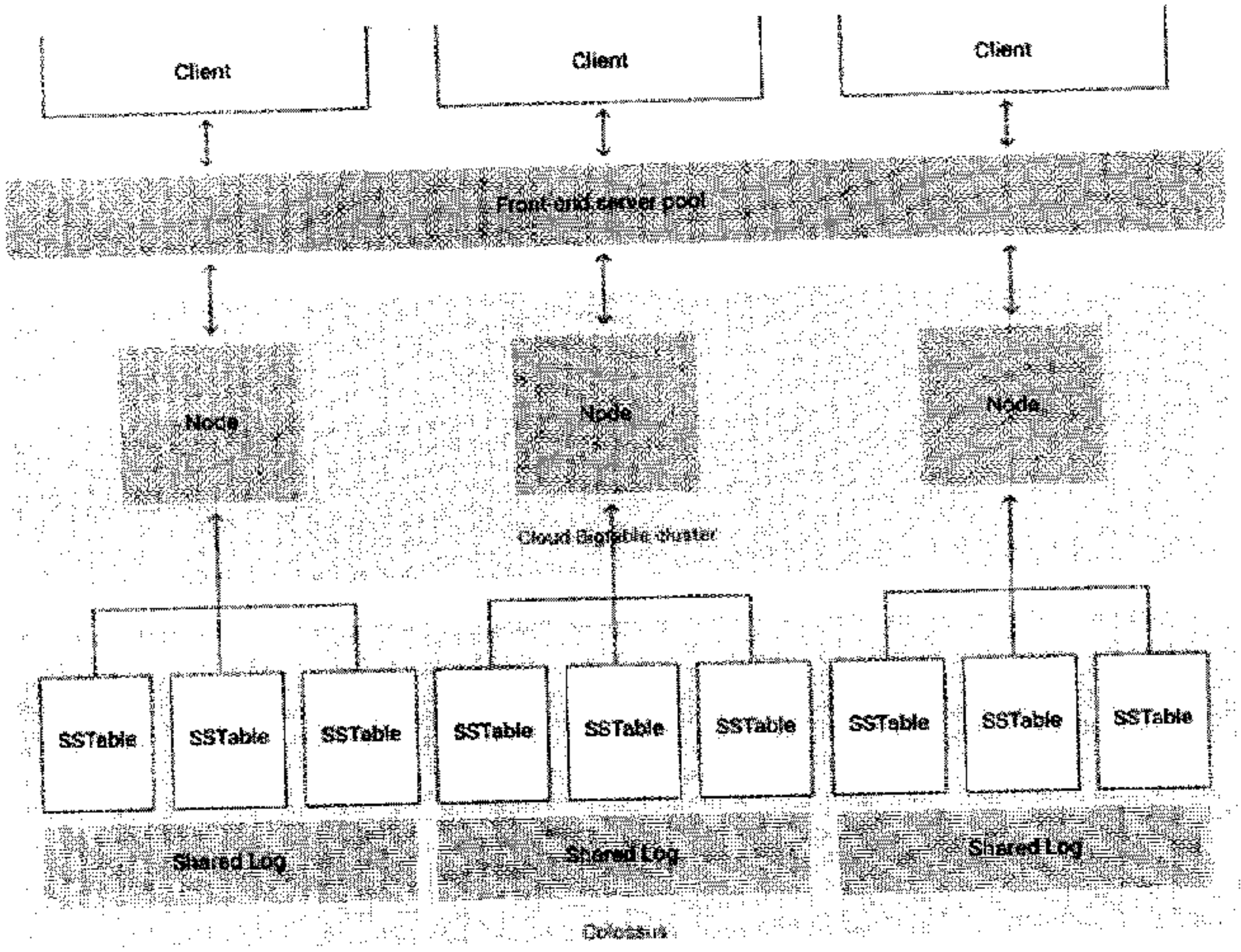


A GPFS configuration. The disks are interconnected by a SAN and compute servers are distributed in four LANs, LAN1–LAN4.

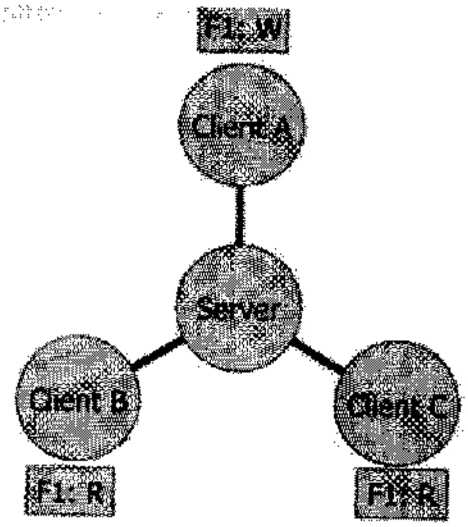
Google File System

- The Google File System (GFS) was developed in the late 1990s. It uses thousands of storage systems.
- Google File System (GFS) is a scalable distributed file system (DFS) created by Google Inc. and developed to accommodate Google's expanding data processing requirements.
- GFS provides fault tolerance, reliability, scalability, availability and performance to large networks and connected nodes.

Bigtable architecture



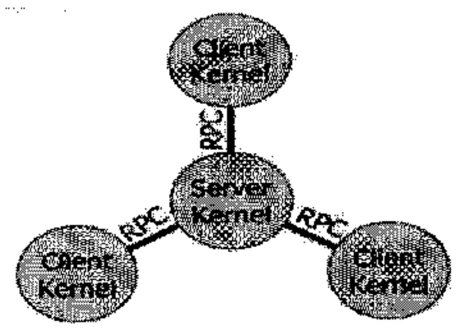
- All client requests go through a frontend server before they are sent to a Bigtable node.
- The nodes are organized into a Bigtable cluster, which belongs to a Bigtable instance, a container for the cluster.
- Each node in the cluster handles a subset of the requests to the cluster.
- By adding nodes to a cluster, you can increase the number of simultaneous requests that the cluster can handle. Adding nodes also increases the maximum throughput for the cluster.
- A Bigtable table is sharded into blocks of contiguous rows, called tablets, to help balance the workload of queries.
- Tablets are stored on Colossus, Google's file system, in SSTable format.



- A file is opened by multiple clients
- At least one client has the file open for writing
- Concurrent write-sharing occurs

General Parallel File System

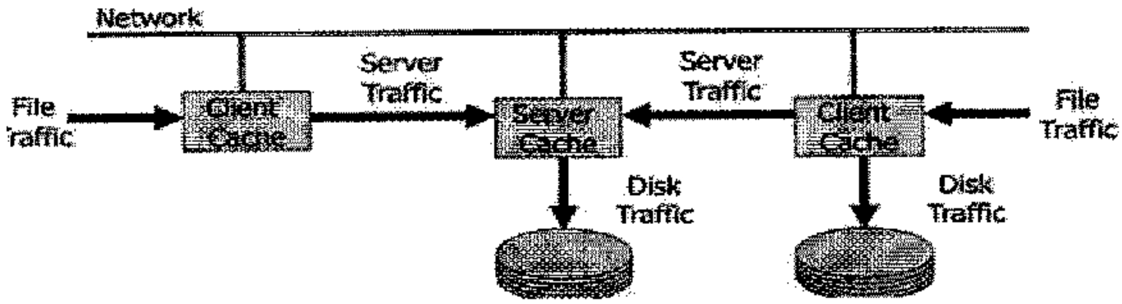
- The General Parallel File System (GPFS) was developed at IBM as a hgh performance Cluster System in the early 2000s as a successor to the Tiger Shark multimedia file system.
- GPFS is a parallel file system that emulates closely the behavior of a general-purpose POSIX system running on a single system.
- GPFS can support a file system of up to 4 PB consisting of up to 4,096 disks of 1 TB each.
- It is used by many of the World's Largest Commercial Companies.
- GPFS implies execution of multiple input/output operations concurrently.
- Parallel file systems allow multiple clients to read and write concurrently from the same file. Concurrency control is a critical issue for parallel file systems.



- Read, write, open, and close calls provide access to files
- Sprite communicates kernel-to-kernel
- Remote-procedure-calls (RPC) allow kernels to talk to each other

SFS is a component of the Sprite network operating system. SFS uses caching on the server side and on the client side also.

- Two different caching mechanisms
  - Server workstations use caching to reduce delays caused by disk accesses
  - Client workstations use caching to minimize the number of calls made to non-local disks



Three main issues are addressed by Sprite's caching system

1. Should client caches be kept in main memory or on local disk?
2. What structure and addressing scheme should be used for caching?
3. What should happen when a block is written back to disk?

Secondary Name Node:

- This is only to take care of the checkpoints of the file system metadata which is in the Name Node.
- This is also known as the checkpoint Node. It is the helper Node for the Name Node.

Job Tracker:

- Job Tracker receives the requests for Map Reduce execution from the client.
- Job tracker talks to the Name Node to know about the location of the data that will be used in processing.

Task Tracker:

- It is the Slave Node for the Job Tracker and it will take the task from the Job Tracker. It also receives code from the Job Tracker.
- Task Tracker will take the code and apply on the file. The process of applying that code on the file is known as Mapper.

By default Hadoop uses FIFO scheduling, and optionally 5 scheduling priorities to schedule jobs from a work queue.

BigTable

- Bigtable is a fully managed wide-column and key-value NoSQL database service for large analytical and operational workloads as part of the Google Cloud portfolio
- Bigtable is a sparsely populated table that can scale to billions of rows and thousands of columns, enabling us to store terabytes or even petabytes of data.
- Bigtable development began in 2004. It is now used by a number of Google applications, such as Google Analytics, web indexing, MapReduce, which is often used for generating and modifying data stored in Bigtable, Google Maps, Google Books search, "My Search History", Google Earth, Blogger.com, Google Code hosting, YouTube,and Gmail.

Architecture

- Hadoop consists of the Hadoop Common package, which provides file system and operating system level abstractions, A MapReduce engine (either MapReduce/MR1 or YARN/MR2 and the Hadoop Distributed File System (HDFS). The Hadoop Common package contains the Java Archive (JAR) files and scripts needed to start Hadoop.
- For effective scheduling of work, every Hadoop-compatible file system should provide location awareness, which is the name of the rack, specifically the network switch where a worker node is.
- Hadoop applications can use this information to execute code on the node where the data is, and, failing that, on the same rack/switch to reduce backbone traffic. HDFS uses this method when replicating data for data redundancy across multiple racks. This approach reduces the impact of a rack power outage or switch failure; if any of these hardware failures occurs, the data will remain available.
- A small Hadoop cluster includes a single master and multiple worker nodes. The master node consists of a Job Tracker, Task Tracker, NameNode, and DataNode. A slave or worker node acts as both a DataNode and TaskTracker, though it is possible to have data-only and compute-only worker nodes. These are normally used only in nonstandard applications.
- Hadoop requires Java Runtime Environment (JRE) 1.6 or higher. The standard startup and shutdown scripts require that Secure Shell (SSH) be set up between nodes in the cluster.
- In a larger cluster, HDFS nodes are managed through a dedicated NameNode server to host the file system index, and a secondary NameNode that can generate snapshots of the namenode's memory structures, thereby preventing file-system corruption and loss of data. Similarly, a standalone JobTracker server can manage job scheduling across nodes. When Hadoop MapReduce is used with an

members of the Carnegie Mellon University community. Network Drive storage on Mac lab computers uses AFS space.

- An AFS presents a homogeneous, location-independent file namespace to all client workstations via a group of trustworthy servers.
- After login onto workstations the users exchange data and programs (DCI). The goal is to facilitate large-scale information exchange by reducing client-server communication.
- This is accomplished by moving whole files between server and client computers and caching them until the servers get a more recent version.
- An AFS uses a local cache to improve speed and minimize effort in dispersed networks. A server, for example, replies to a workstation request by storing data in the workstation's local cache.

Andrew File System Architecture:

Vice: The Andrew File System provides a homogeneous, location-transparent file namespace to all client workstations by utilizing a group of trustworthy **servers known as Vice.**

Venus: **The mechanism, known as Venus, caches** files from Vice and returns updated versions of those files to the servers from which they originated. Only when a file is opened or closed does Venus communicate with Vice.

Venus performs as much work as possible rather than Vice. Vice only keeps the functionalities that are necessary for the file system's integrity, availability, and security. The servers are set up as a loose confederacy with little connectivity between them.

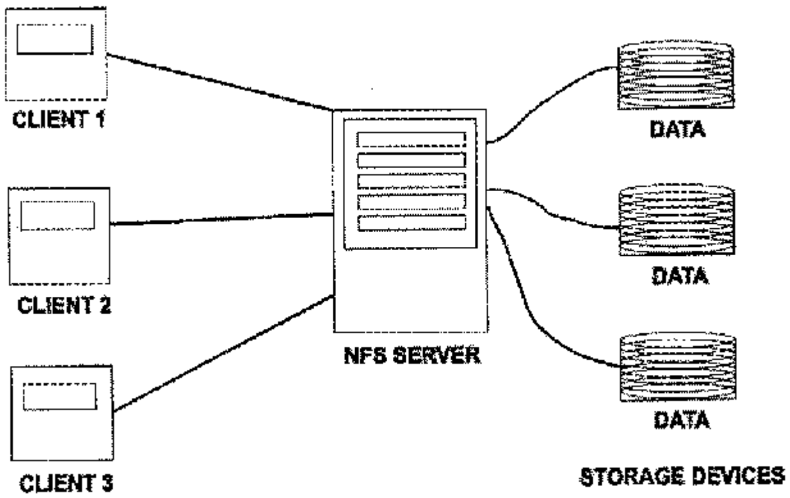
- All the modules in Hadoop are designed with a fundamental assumption that hardware failures are common occurrences and should be automatically handled by the framework.
- The core of Apache Hadoop consists of a storage part, known as Hadoop Distributed File System (HDFS), and a processing part which is a MapReduce programming model.
- Hadoop splits files into large blocks and distributes them across nodes in a cluster. It then transfers packaged code into nodes to process the data in parallel. This approach takes advantage of data locality, where nodes manipulate the data they have access to.
- This allows the dataset to be processed faster and more efficiently than it would be in a more conventional supercomputer architecture that relies on a parallel file system where computation and data are distributed via high-speed networking.

The base Apache Hadoop framework is composed of the following modules:

- ***Hadoop Common*** – contains libraries and utilities needed by other Hadoop modules;
- ***Hadoop Distributed File System (HDFS)*** – a distributed file-system that stores data on commodity machines, providing very high aggregate bandwidth across the cluster;
- ***Hadoop YARN*** – **(introduced in 2012)** a platform responsible for managing computing resources in clusters and using them for scheduling users' applications.
- ***Hadoop MapReduce*** – **an** implementation of the MapReduce programming model for large-scale data processing.
- ***Hadoop Ozone*** – (introduced in 2020) An object store for Hadoop

linked to any other DFS. Standalone DFS roots are rarely come across because of their limited advantage.

- **Domain-based DFS namespace** –
  It stores the configuration of DFS in Active Directory, creating the DFS namespace root accessible
  at **<domainname>****<dfsroot>** or **<FQDN>****<dfsroot>**



There are various advantages of the distributed file system. Some of the advantages are as follows:

1. It allows the users to access and store the data.
2. It helps to improve the access time, network efficiency, and availability of files.
3. It provides the transparency of data even if the server of disk files.
4. It permits the data to be shared remotely.
5. It helps to enhance the ability to change the amount of data and exchange data.

<u>**NFS Network File System**</u>

- Network File System is a type of distributed file system protocol where storage resources connect to a computer by network resources, such as a LAN or SAN. Hosts can access data using NFS. A DFS should create backup copies to prevent data loss if there are drive failures.

- The system supports an efficient check pointing procedure based on *copy-on-write* to construct system snapshots. A lazy garbage collection strategy is used to reclaim the space after a file deletion. The master periodically scans the namespace, removes the metadata for the files with a hidden name older than a few days. This mechanism gives a window of opportunity to a user who deleted files by mistake to recover the files with little effort.
- Periodically, chunk servers exchange with the master the list of chunks stored on each one of them; the master supplies them with the identity of orphaned chunks, whose metadata has been deleted and such chunks are then deleted. Even when control messages are lost, a chunk server will carry out the house cleaning at the next *heartbeat* exchange with the master. Each chunk server maintains in core the checksums for the locally stored chunks to guarantee data integrity.

The system was designed after a careful analysis of the file characteristics and the access models. This analysis reflected in the GFS design are

- Scalability and reliability are critical features of the system;
- The majority of files range in size from a few GB to hundreds of TB.
- The most common operation is to append to an existing file; random write operations to a file are extremely infrequent.
- Sequential read operations are the norm.
- Users process the data in bulk and are less concerned with the response time.
- To simplify the system implementation the consistency model should be relaxed without placing an additional burden on the application developers.

As a result of this analysis several design decisions were made:

1. Segment a file in large chunks.
2. Implement an atomic file append operation

types, such as key-value stores, BigTable implementations, document store databases, and graph databases.

- Replication, used to ensure fault tolerance of large-scale systems built with commodity components, requires mechanisms to guarantee that all replicas are consistent with one another. This is another example of increased complexity of modern computing and communication systems due to physical characteristics of components.

Distributed file systems:

- A Distributed File System (DFS) is a file system that is distributed on multiple file servers or multiple locations. It makes the programs to access or to store isolated files with the local ones, allowing programmers to access files from any network or computer. It manages files and folders on different computers.
- A DFS is a client-server architecture based application, which allows the user or clients to access the data from the server as it is stored in their own computer. It provides location transparency and redundancy help to improve the data availability. And also use data replication strategy on multiple servers to prevent data access failure.

- GFS is made up of several storage systems built from low-cost commodity hardware components.
- It is optimized to accommodate Google's different data use and storage needs, such as its search engine, which generates huge amounts of data that must be stored.

GFS features include:

- Fault tolerance
- Critical data replication
- Automatic and efficient data recovery
- High aggregate throughput
- Reduced client and master interaction because of large chunk server size
- Namespace management and locking
- High availability

GFS files are collections of fixed-size **segments called *chunks***; at the time of file creation each chunk is assigned a unique *chunk handle.* A chunk consists of 64 KB blocks and each block has a 32 bit checksum.

Chunks are stored on Linux files systems and are replicated on multiple sites. The chunk size is 64 MB.

A large chunk size increases the likelihood that multiple operations will be directed to the same chunk thus, it reduces the number of requests to locate the chunk and, at the same time, it allows an application to maintain a persistent network connection with the server where the chunk is located. Space fragmentation occurs infrequently as the chunk of a small file and the last chunk of a large file are only partially filled.

- *Journal storage* is an elaborate organization for storing composite objects such as records consisting of multiple fields.
- Journal storage consists of **a *manager* and *cell storage***, where the entire history of a variable is maintained, rather than just the current value.
- The user does not have direct access to the *cell storage*; instead the user can request the *journal manager* to

  (i) start a new action;

  (ii) read the value of a cell;

  (iii) write the value of a cell;

  (iv) commit an action;

  (v) abort an action.

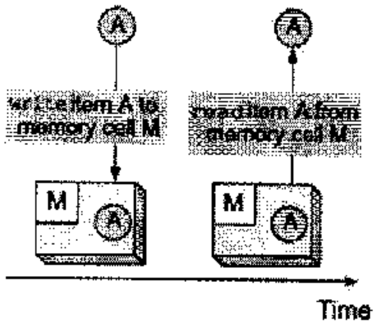
The *journal manager* translates user requests to commands sent to the cell storage:

(i) read a cell;

(ii) write a cell;

(iii) Allocate a cell;

(iv) Deallocate a cell.



`read/write` *coherence*: the result of a `read` of memory cell M should be the same as the most recent `write` to that cell

Before-or-after atomicity: the result of every `read` or `write` is the same as if that `read` or `write` occurred either completely before or completely after any other `read` or `write`.

- In the context of storage systems, **a *log* contains** a history of all variables in ***cell storage***. The information about the updates of each data item forms a record at the end of the log.

The Architecture of GFS is as follows

Chunk Server

1. Each chunk server is a commodity Linux system.
2. A chunk server receives instructions from the master and responds with status information.

The GFS Master

1. The GFS M*aster* controls a large number of *chunk servers*.
2. It maintains metadata such as the **file names, access control information, the location of all the replicas for every chunk of each file, and the state of individual chunk servers.**
3. Read or write operations an application sends to the master along with the file name, the chunk index, and the offset in the file.
4. The master responds with the chunk handle and the location of the chunk. Then the application communicates directly with the chunk server to carry out the desired file operation.

Chunks:

1. GFS files are collections of fixed-size **segments called *chunks***; at the time of file creation each chunk is assigned a unique *chunk handle*. A chunk consists of 64 KB blocks and each block has a 32 bit checksum.
2. Chunks are stored on Linux files systems and are replicated on multiple sites. The chunk size is 64 MB.
3. Some of the metadata is stored in persistent storage.
4. The locations of the chunks are stored only in the control structure of the master's memory and are updated at the system start up, or when a new chunk server joins the cluster. This strategy allows the master to have up-to-date information about the location of the chunks.

- Today high-performance systems can choose among three classes of file system: **network file systems (NFSs), storage area networks (SANs), and parallel file systems (PFSs).**

Network file systems (NFSs)

- The NFS is very popular and has been used for some time, but it does not scale well and has reliability problems; an NFS server could be a single point of failure.

Storage area networks (SANs):

- Advances in networking technology allow the separation of storage systems from computational servers; The two can be connected by a SAN.
- SANs offer additional flexibility and allow cloud servers to deal with non disruptive changes in the storage configuration. Moreover, the storage in a SAN can be pooled and then allocated based on the needs of the servers; pooling requires additional software and hardware support and represents another advantage of a centralized storage system.
- A SAN-based implementation of a file system can be expensive, since each node must have a Fibre Channel adapter to connect to the network.

Pparallel file systems (PFSs)

- Parallel file systems are scalable and are capable of distributing files across a large number of nodes, and provide a global naming space.
- In a parallel data system, several I/O nodes serve data to all computational nodes and include a metadata server that contains information about the data stored in the I/O nodes. The interconnection network of a parallel file system could be a SAN.

Data Bases:

USBs are External portable hard drives that hold up to 1 Terabyte of information and work similar to a USB.

Cloud Computing:

Cloud Computing was a ground-breaking discovery in the information age. The entire concept of storage was repurposed by removing the need for active management by the user. The user can remotely access data that is present on "clouds" that belong to either the same organization or multiple organizations. The need for finding a storage space that is virtual and accessible from anywhere led to the development of cloud storage.

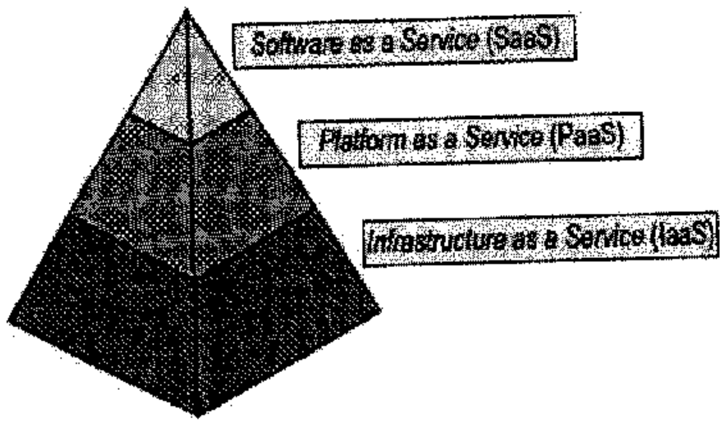
CLOUD STORAGE

- Now there is an opportunity to store all **our data in the internet**. Those off-site storages are provided and maintained by the third parties through the Internet Cloud storage offers a large pool of storage was available for use with immediate availability of very large quantities of storage.
- The evolution of Cloud Storage based on traditional network storage and hosted storage. Benefit of cloud storage is the access of your data from anywhere.
- Cloud storage providers provide storage varying from small amount of data to even the entire warehouse of an organization.
- Subscriber can pay to the cloud storage provider for what they are using and how much they are transferring to the cloud storage.

- Early supercomputers such as the Intel Paragon4 took advantage of parallel file systems to support applications based on the same program, multiple data (SPMD) paradigm.
- The maximum file size is $(2^{63}-1)$ bytes. A file consists of blocks of equal size, ranging from 16 KB to 1MB striped across several disks.
- The system could support not only very large files but also a very large number of files.
- The directories use extensible hashing techniques to access
- Reliability is a major concern in a system with many physical components. To recover from system failures, GPFS records all metadata updates in a write-ahead log file. Which is used to recover data from failures?
- The system maintains user data, file metadata along with allocation maps.
- Parallel File system is used to access data from multiple File Servers.
- GPFS uses disk maps to manage the disk space. The GPFS block size can be as large as **1 MB and a typical block size is 256 KB**. A block is divided into 32 sub blocks to reduce disk fragmentation for small files.
- The system disk map is partitioned into **n regions**, and each disk map region is stored on a different I/O node. This strategy reduces conflicts and allows multiple nodes to allocate disk space at the same time.

Unit-5

Cloud Application Development



A pyramid model of cloud computing paradigms

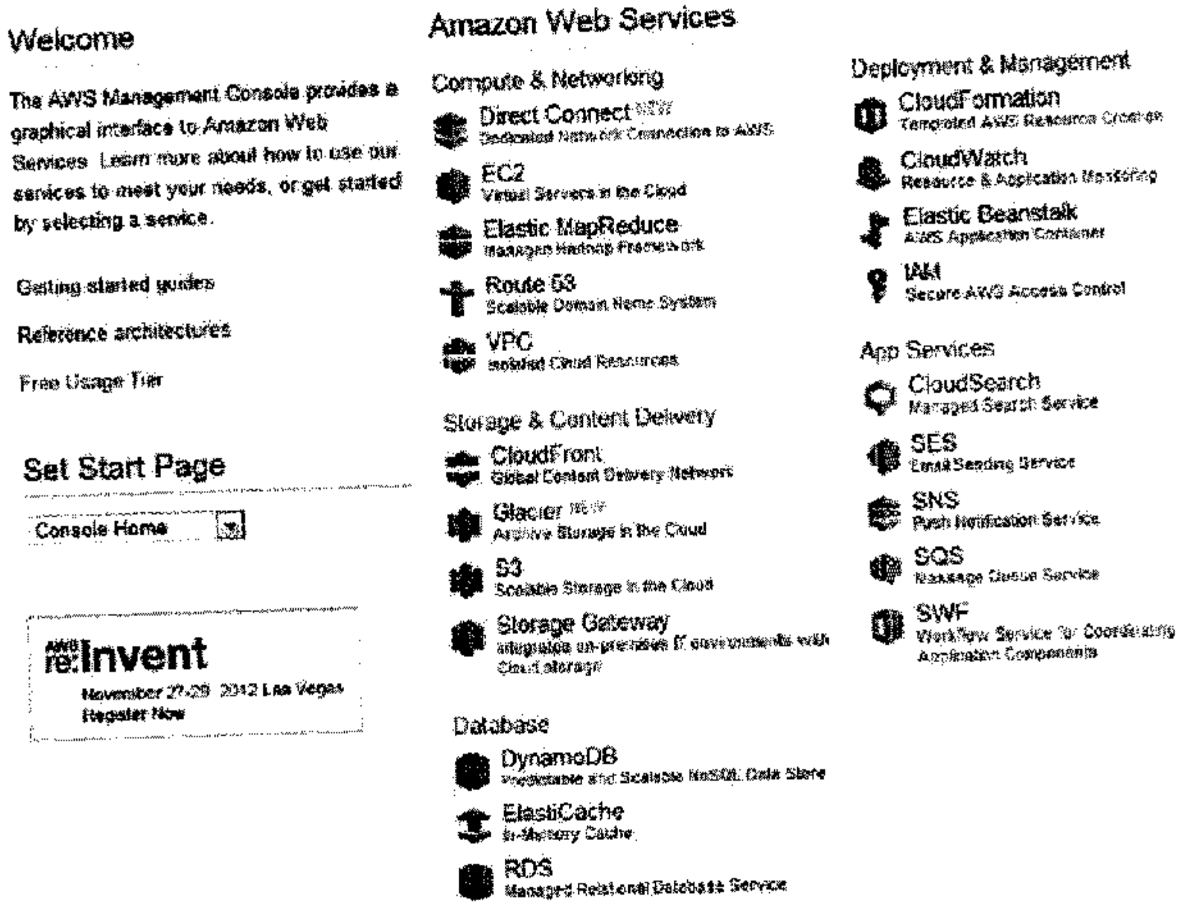
Amazon Web Services: *EC2* instances

Introduction about EC2 in previous units

1. To access AWS one must first create an account at http://aws.amazon.com/.
2. Once the account is created, the AMC allows the user to select one of the services, e.g., EC2, and then start an instance.
3. AWS EC2 instance is a virtual server started in a region and the availability zone isselected by the user.
4. Instances are grouped into a few classes, and each class has available to it a specific amount of resources, such as: CPU cycles, main memory, secondary storage, and communication and I/O bandwidth. Several operating systems are supported by AWS, including Amazon Linux, Red Hat Enterprise Linux,

6.3, SUSE Linux Enterprise Server 11, Ubuntu Server 12.04.1, and several versions of Microsoft Windows.

5. The next step is to create an (AMI)1 on one of the platforms supported by AWS and start an instance using the Run Instance API.
6. If the application needs more than 20 instances, a special form must be filled out. Once an instance is created, the user can perform several actions – for example, connect to the instance, launch more instances identical to the current one, or create an EBS AMI.
7. The user can also terminate, reboot, or stop the instance The *Network & Security* panel allows the creation of *Security Groups, Elastic IP addresses, Placement Groups, Load Balancers*, and *Key Pairs*(see the discussion in Section 11.3), whereas the EBS panel allows the specification of volumes and the creation of snapshots.

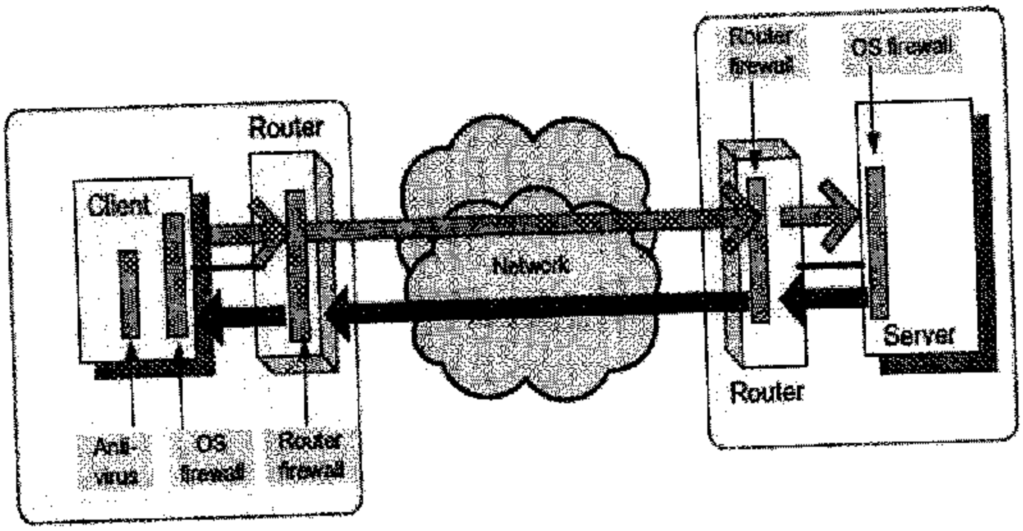


Connecting clients to cloud instances through firewalls

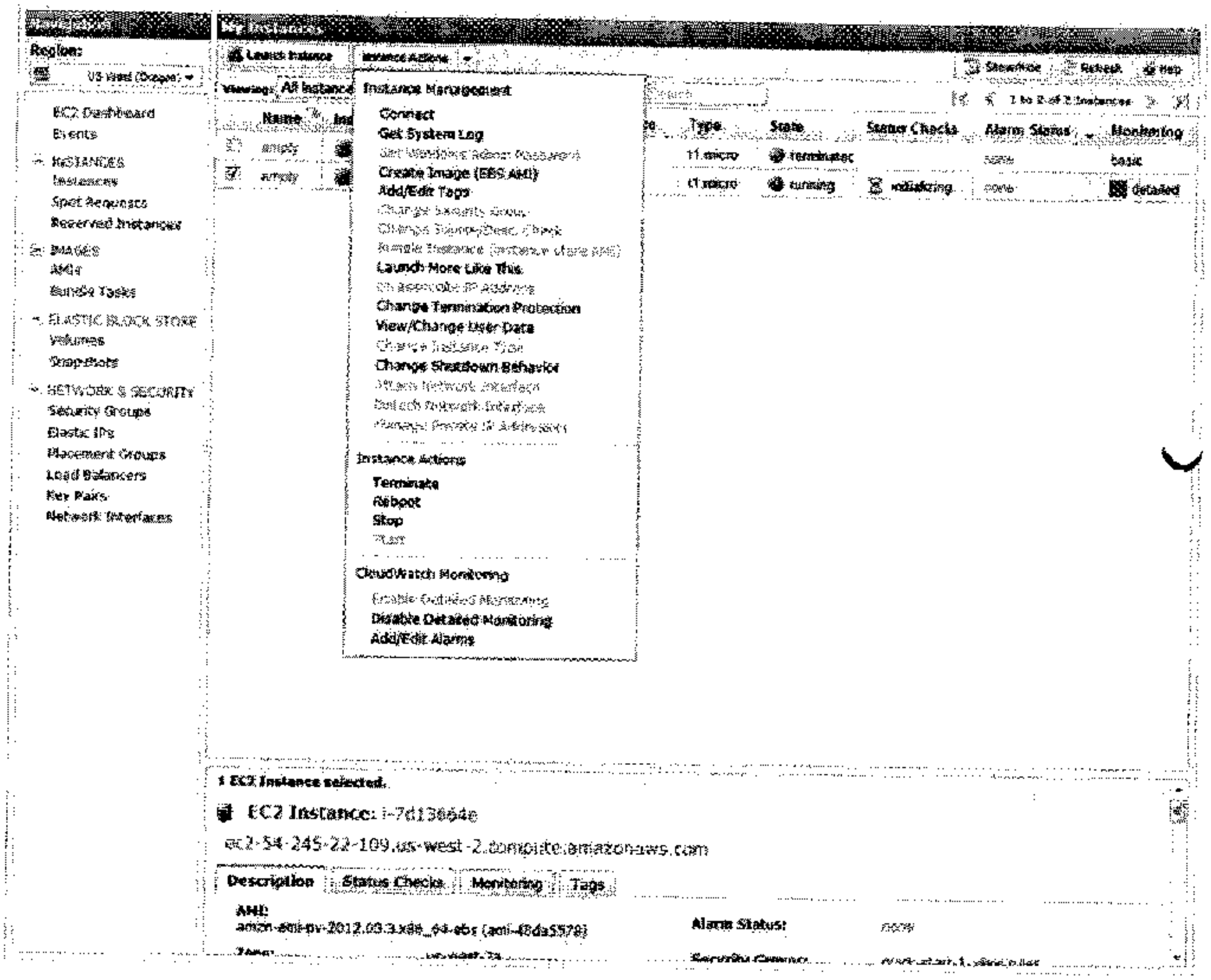
- A firewall is a software system based on a set of rules for filtering network traffic. Its function is to protect a computer in a local area network from unauthorized access.
- The first generation of firewalls, deployed in the late 1980s, carried out *packet filtering*; they discarded individual packets that did not match a set of acceptance rules.
- Such firewalls operated below the transport layer and discarded packets based on the information in the headers of physical, data link, and transport layer protocols.

- The second generation of firewalls operates at the transport layer and maintains the state of all connections passing through them. Unfortunately, this traffic-filtering solution opened the possibility of denial-of-service (DoS) attacks.
- A DoS attack targets a widely used network service and forces the operating system of the host to fill the connection tables with illegitimate entries. DoS attacks prevent legitimate access to the service.
- The third generation of firewalls "understand" widely used application layer protocols such as FTP, HTTP, TELNET, SSH, and DNS. These firewalls examine the header of application layer protocols and support intrusion detection systems (IDSs).
- Firewalls screen incoming traffic and sometimes filter outgoing traffic as well. A first filter encountered by the incoming traffic in a typical network is a firewall provided by the operating system of the router; the second filter is a firewall provided by the operating system running on the local computer (see Figure 11.5).
- Typically, the local area network (LAN) of an organization is connected to the Internet via a router. A router firewall often hides the true address of hosts in the local network using the Network Address Translation (NAT) mechanism. The hosts behind a firewall are assigned addresses in a "private address range," and the router uses theNAT tables to filter the incoming traffic and translate external IP addresses to private ones.
- If one tests a client-server application with the client and the server in the same LAN, the packets do not cross a router.

- Once a client from a different LAN attempts to use the service, the packets may be discarded by the router's firewall. The application may no longer work if the router is not properly configured.



Firewalls screen incoming and sometimes outgoing traffic. The first obstacle encountered by the inbound or outbound traffic is a router firewall. The next one is the firewall provided by the host operating system. Sometimes the antivirus software provides a third line of defense.



Security rules for application and transport layer protocols in *EC2*

A client must know the IP address of a virtual machine in the cloud to be able to connect to it. The Domain Name Service (DNS) is used to map human-friendly names of computer systems to IP addresses in the Internet or in private networks.

DNS is a hierarchical distributed database and plays a role reminiscent of a phone book on the Internet. In late 2010 Amazon announced a DNS service called *Route 53* to route users to *AWS* services and to infrastructure outside of *AWS*.

A network of DNS servers is scattered across the globe, which enables customers to gain reliable access to *AWS* and place strict controls over who can manage their DNS system by allowing integration with *AWS* Identity and Access Management (IAM).

For several reasons, including security and the ability of the infrastructure to scale up, the IP addresses of instances visible to the outside world are mapped internally to private IP addresses.

A virtual machine running under Amazon's *EC2* has several IP addresses: They are

1. EC2 Private IP Address. The internal address of an instance; it is only used for routing within the EC2 cloud.

2. EC2 Public IP Address. Network traffic originating outside the AWS network must use either the public IP address or the elastic IP address of the instance. The public IP address is translated using Network Address Translation (NAT) to the private IP address when an instance is launched and it is valid until the instance is terminated

3. EC2 Elastic IP Address. The IP address allocated to an AWS account and used by traffic originated outside AWS. NAT is used to map an elastic IP address to the private IP address. Elastic IP addresses allow the cloud user to mask instance or availability zone failures by programmatically remapping public IP addresses to any instance associated with the user's account. This allows fast recovery after a system failure.

Amazon Web Services use **security groups to control** access to users' virtual machines.

A virtual machine instance belongs to one and only one security group, which can only be defined before the instance is launched. Once an instance is running, the security group the instance belongs to cannot be changed. However, more than one instance can belong to a single security group.

Security group rules control inbound traffic to the instance and have no effect on outbound traffic from the instance. The inbound traffic to an instance, either from outside the cloud or from other instances running on the cloud.

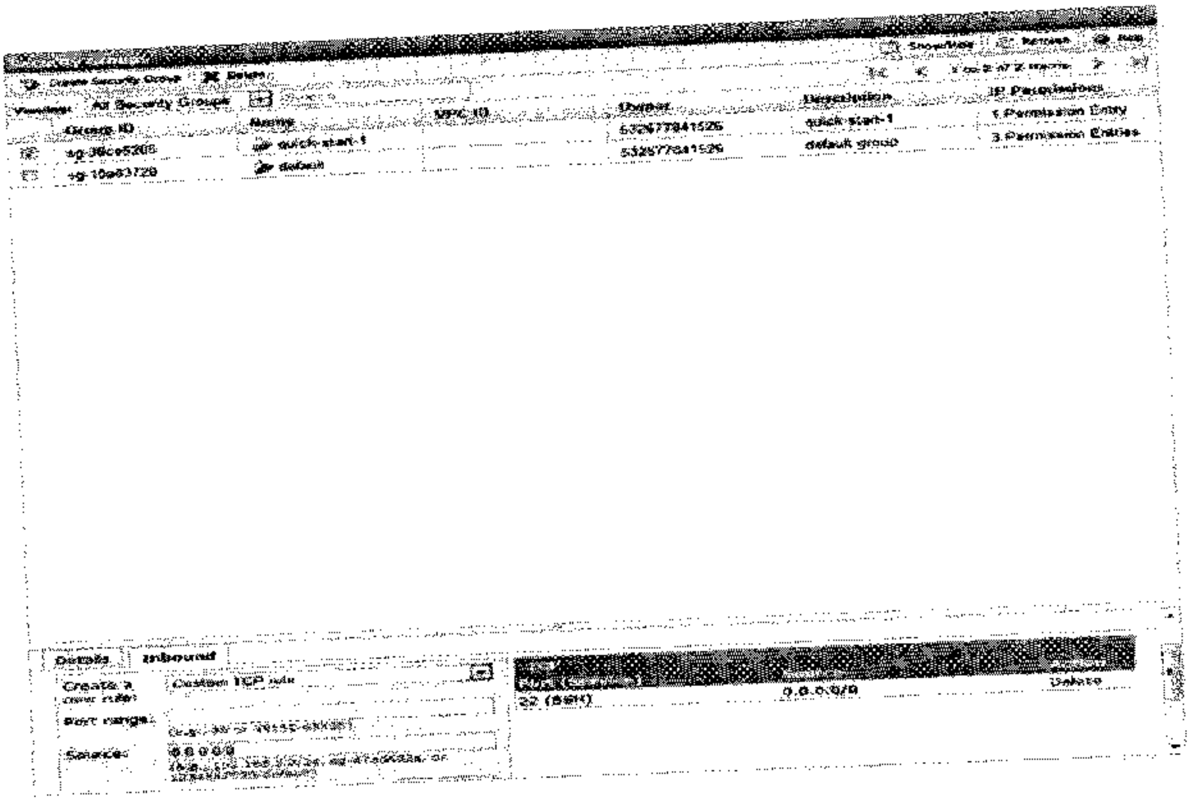
The following steps allow the user to add a security rule:

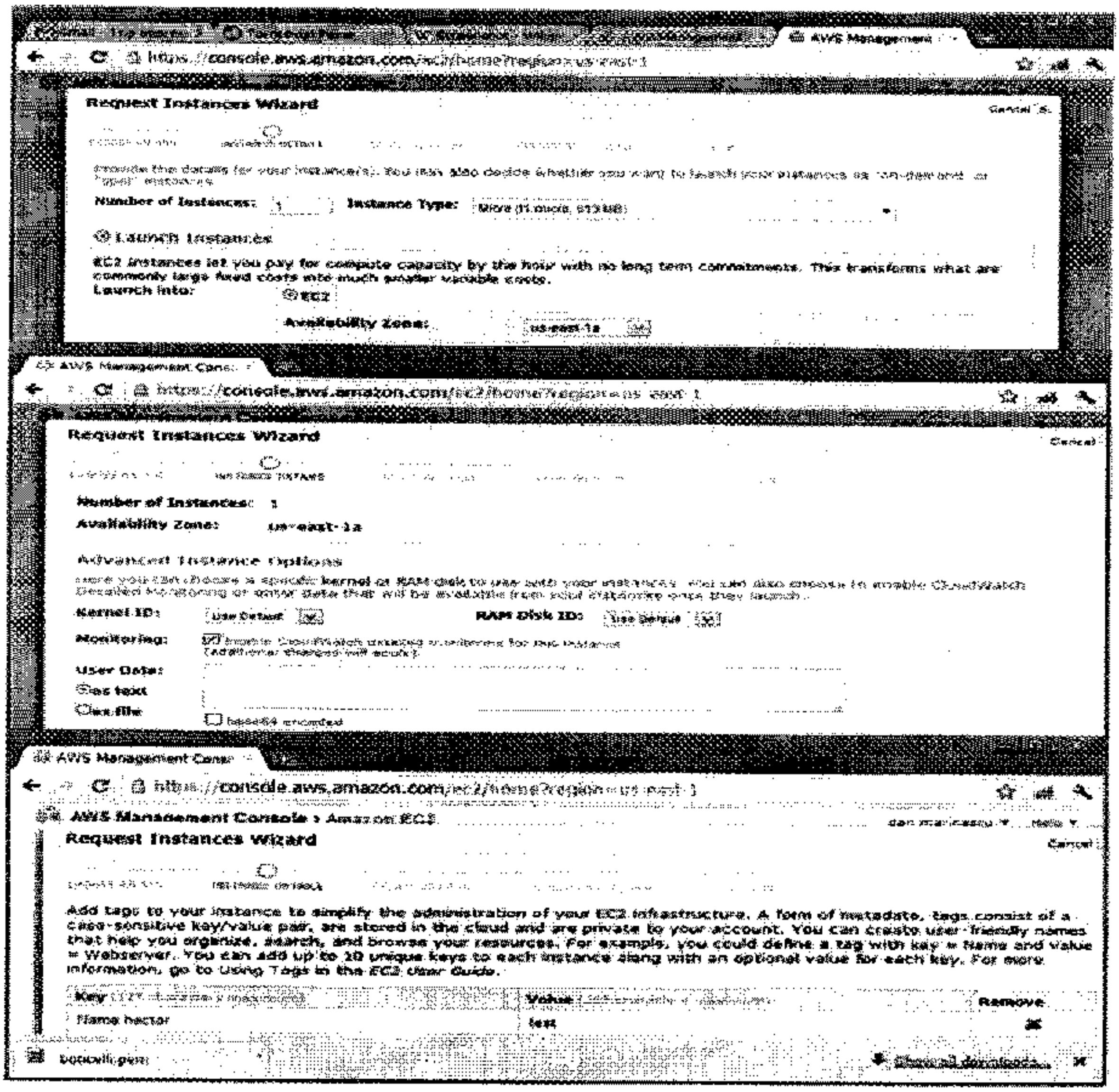
1. Sign in to the AWS Management Console at http://aws.amazon.com using your email address and password and select EC2 service.

2. Use the EC2 Request Instance Wizard to specify the instance type, whether it should be monitored, and specify a key/value pair for the instance to help organize and search

3. Provide a name for the key pair. Then on the left-side panel, choose Security Groups under Network & Security, select the desired security group, and click on the Inbound tab to enter the desired rule

To allocate an Elastic IP address, use the Elastic IPs tab of the Network & Security left-side panel.On Linux or Unix systems the port numbers below 1,024 can only be assigned by the root. The plain ASCII file called services maps friendly textual names for Internet services to their assigned port numbers and protocol types


Create Security Group
Delete
Viewing: All Security Groups
Group ID
Name
VPC ID
Owner
Description
IP Permissions
quick-start-1
default
default group
1 Permission Entry
3 Permission Entries
Details
Inbound
Create a new rule:
Custom TCP rule
Port range:
Source:
0.0.0.0/0
22 (SSH)
Delete



How to launch an *EC2 Linux* instance and connect to it

This section gives a step-by-step process to launch an EC2 Linux instance from a Linux platform.

To Launch an instance the following steps need to be done by the user.

1. From the AWS Management Console, **select EC2 and**, once signed in, go to Launch Instance Tab.

2. To determine the **processor architecture** when you want to match the instance with the hardware, enter the command **uname –m and choose an appropriate Amazon Linux AMI by pressing Select.**

3. Choose Instance Details to control the **number, size, and other settings** for instances.

4. To learn how the system works, **press Continue to select the default settings.**

5. Define the instance's security, as discussed in Section 11.3: In the Create Key Pair page enter a name for the pair and then press Create and Download Key Pair.

6. The key-pair file downloaded in the previous step is a **.pem file**, and it must be hidden to prevent unauthorized access. If the file is in the directory **awcdir/dada.pem** enter the commands **cd awcdir chmod 400 dada.pem**

7. **Configure the firewall.** Go to the page Configure firewall, select the option Create a New Security Group, and provide a Group Name. Normally we use ssh to communicate with the instance; the default port for communication is port 8080, and we can change the port and other rules by creating a new rule.

8. **Press Continue** and examine the review page, which gives a summary of the instance.

9. **Press Launch and examine** the confirmation page, then press Close to end the examination of the confirmation page.

10. **Press the Instances tab** on the navigation panel to view the instance.

11. Look for your Public DNS name. Because by default some details of the instance are hidden, click on the Show/Hide tab on the top of the console and select Public DNS.

12. **Record the Public DNS** as Public DNS name; it is needed to connect to the instance from the Linux terminal.

13. Use the **ElasticIP panel** to assign an Elastic IP address if a permanent IP address is required.

To Connect to the instance **using ssh and the TCP transport protocol,** following steps need to be done. They are

1. Add a rule to the *iptables* to allow ssh traffic using the TCP *protocol.* Without this step, either an *access denied* or *permission denied* error message appears when you're trying to connect to the instance.

    sudo iptables -A iptables -p -tcp -dport ssh -j ACCEPT

2. Enter the *Linux* command:

    ssh -i abc.pem ec2-user@PublicDNSname

If you get the prompt *You want to continue connecting?* respond *Yes*. A warning that the DNS name was added to the list of known hosts will appear.

3. An icon of the Amazon Linux AMI will be displayed.

To Gain root access to the instance the following steps need to be done.

1. By default the user does not have root access to the instance; thus, the user cannot install any software. Once connected to the EC2 instance, use the following command to gain root privileges:

    sudo -i

2. Then use yum install commands to install software, e.g., gcc to compile C programs on the cloud.

To Run the service ServiceName, the following steps need to be done, they are

1. If the instance runs under ***Linux*** **or** ***Unix***, the service is terminated when the *ssh* connection is closed. To avoid the early termination, use the command

    nohup ServiceName

2. To run the service in the background and redirect ***stdout*** **and** ***stderr*** **to files** *p.out* **and** *p.err*, respectively, execute the command

    nohup ServiceName > p.out 2 > p.err &

How to use *S3* in Java

- S3 is one of the first services that has been produced by aws.
- S3 stands for Simple Storage Service.
- S3 provides developers and IT teams with secure, durable, highly scalable object storage.
- It is easy to use with a simple web services interface to store and retrieve any amount of data from anywhere on the web.
- 3 is a safe place to store the files.
- It is Object-based storage, i.e., you can store the images, word files, pdf files, etc.
- The files which are stored in S3 can be from 0 Bytes to 5 TB.
- It has unlimited storage means that you can store the data as much you want.
- Files are stored in Bucket. A bucket is like a folder available in S3 that stores the files.
- S3 is a universal namespace, i.e., the names must be unique globally. Bucket contains a DNS address. Therefore, the bucket must contain a unique name to generate a unique DNS address.

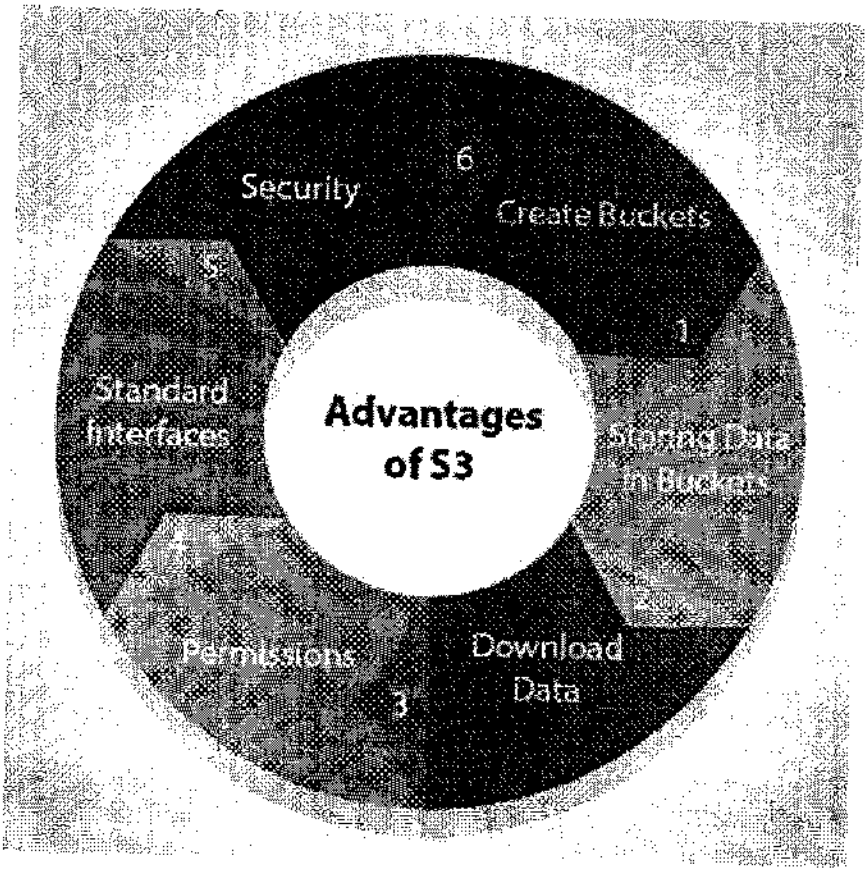
If you create a bucket, URL look like:

https://s3-eu-west-1.amazonaws.com/acloudguru

Region name **Bucket name**

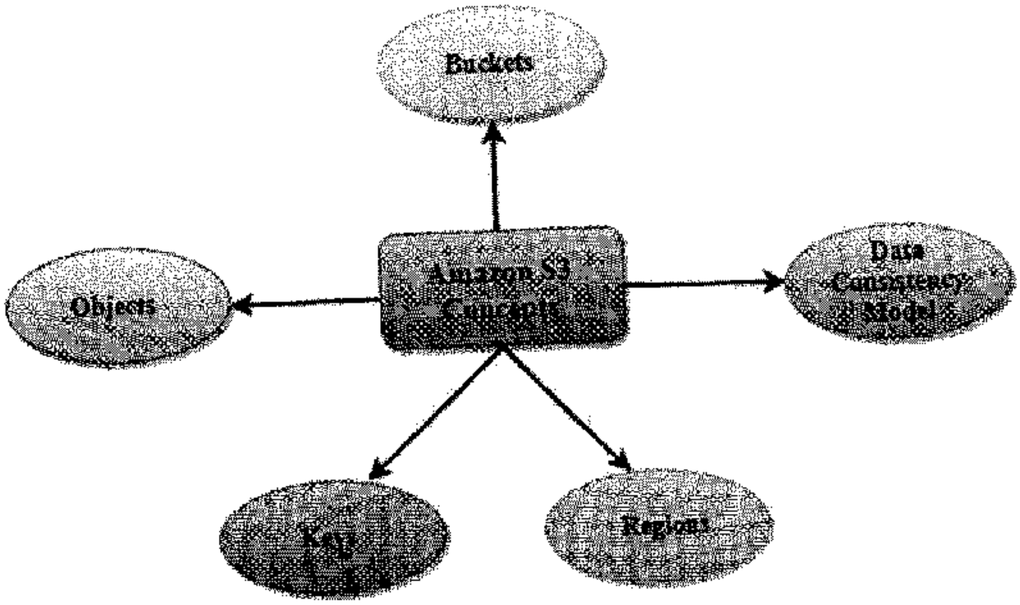
- If you upload a file to S3 bucket, then you will receive an HTTP 200 code means that the uploading of a file is successful.

Advantages of Amazon S3



- **Create Buckets:** Firstly, we create a bucket and provide a name to the bucket. Buckets are the containers in S3 that stores the data. Buckets must have a unique name to generate a unique DNS address.
- **Storing data in buckets:** Bucket can be used to store an infinite amount of data. You can upload the files as much you want into an Amazon S3 bucket, i.e., there is no maximum limit to store the files. Each object can contain upto 5 TB of data. Each object can be stored and retrieved by using a unique developer assigned-key.
- **Download data:** You can also download your data from a bucket and can also give permission to others to download the same data. You can download the data at any time whenever you want.
- **Permissions:** You can also grant or deny access to others who want to download or upload the data from your Amazon S3 bucket. Authentication mechanism keeps the data secure from unauthorized access.

- **Standard interfaces:** S3 is used with the standard interfaces REST and SOAP interfaces which are designed in such a way that they can work with any development toolkit.
- **Security:** Amazon S3 offers security features by protecting unauthorized users from accessing your data.



- S3 makes it easy for developers and other users to implement data storage for personal use or their applications. Data is stored using a model called Cloud Object Storage, which stores the data itself (usually from a file), some metadata describing the object, and an ID to uniquely identify the object.
- S3 provides a web interface which makes it easy to upload files for storage and retrieve them. Files can be organized into separate "S3 buckets" which are containers for data.
- Data files can be further categorized into folders within buckets for familiar path-based organization and access.
- Each bucket is mapped to a URL that allows files within the bucket to be accessed over HTTP. Users have full control to set bucket-level or file-level permissions and thus determine access to buckets and their contents.

- In addition to creating and working with S3 buckets through the web interface, AWS provides the SDKs that give us access to bucket operations.

The *Java API* for Amazon Web Services is provided by the *AWS* SDK.[3]
Create an S3 client. S3 access is handled by the class *AmazonS3Client* instantiated with the account credentials of the *AWS* user:

```
AmazonS3Client s3 = new AmazonS3Client(
new BasicAWSCredentials("your_access_key", "your_secret_key"));
```

Buckets. An *S3 bucket* is analogous to a file folder or directory, and it is used to store *S3 objects*. Bucket names must be *globally unique*; hence, it is advisable to check first to see whether the name exists:

```
s3.doesBucketExist("bucket_name");
```

This function returns "true" if the name exists and "false" otherwise. Buckets can be created and deleted either directly from the *AWS* Management Console or programmatically as follows:

```
s3.createBucket("bucket_name");
s3.deleteBucket("bucket_name");
```

S3 objects. An *S3 object* stores the actual data and it is indexed by a key string. A single key points to only one *S3* object in one bucket. Key names do not have to be globally unique, but if an existing key is assigned to a new object, the original object indexed by that key is lost. To upload an object in a bucket, we can use the *AWS Management Console* or, programmatically, a file *local_file_name* can be uploaded from the local machine to the bucket *bucket_name* under the key *key* using

```
File f = new File("local_file_name");
s3.putObject("bucket_name", "key", f);
```

To access

this object with key *key* from the bucket *bucket_name* use:

```
S3Object myFile = s3.getObject("bucket_name", "key");
```

To read this file, you must use the S3Object's *InputStream*:

```
InputStream in = myFile.getObjectContent();
```

The *InputStream* can be accessed using *Scanner, BufferedReader*, or any other supported method.

The *InputStream* can be accessed using *Scanner, BufferedReader*, or any other supported method. Amazon recommends closing the stream as early as possible, since the content is not buffered and it is streamed directly from the *S3*. An open *InputStream* means an open connection to *S3*. For example, the following code will read an entire object and print the contents to the screen:

```
AmazonS3Client s3 = new AmazonS3Client(
    new BasicAWSCredentials("access_key", "secret_key"));
    InputStream input = s3.getObject("bucket_name", "key")
      .getObjectContent();
    Scanner in = new Scanner(input);
    while (in.hasNextLine())
      {
       System.out.println(in.nextLine());
      }
in.close();
input.close();
```

Batch upload/download. Batch upload requires repeated calls of *s3.putObject()* while iterating over local files.

To view the keys of all objects in a specific bucket, use

```
ObjectListing listing = s3.listObjects("bucket_name");
```

ObjectListing supports several useful methods, including *getObjectSummaries()*. *S3ObjectSummary* encapsulates most of an *S3* object properties (excluding the actual data), including the key to access the object directly.

```
List<S3ObjectSummary> summaries = listing.getObjectSummaries();
```

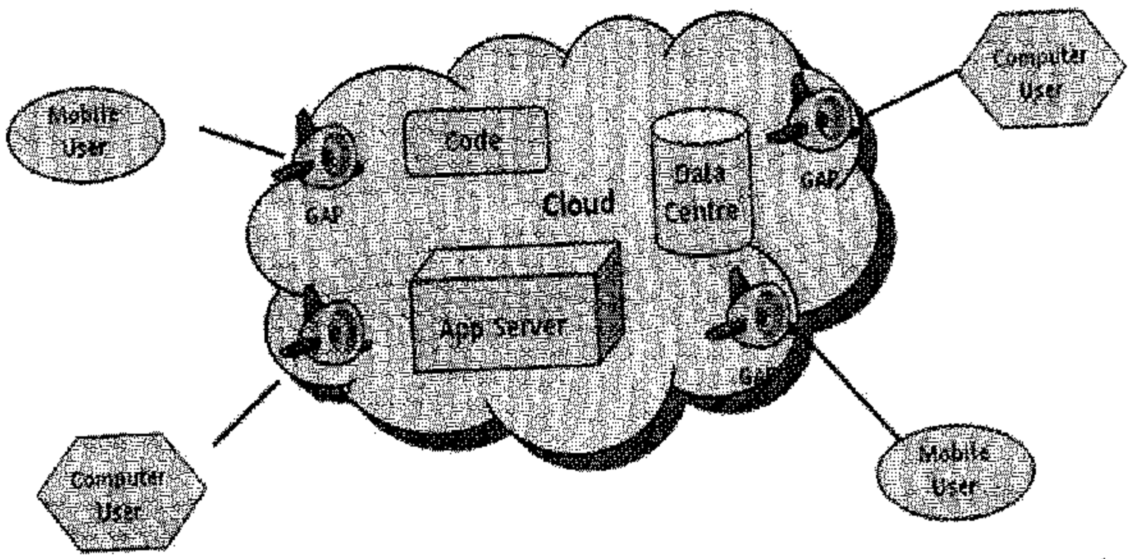
For example, the following code will create a list of all keys used in a particular bucket and all of the keys will be available in string form in *List < String >allKeys*:

Google App Engine

- Google App Engine (often referred to as GAE or simply App Engine) **is a cloud computing platform as a service** for developing and hosting **web applications** in Google-managed data centers.
- Applications are sandboxed and run across multiple servers. App Engine offers automatic scaling for web applications—as the number of requests increases for an application, In computer security, a sandbox is a security mechanism for separating running programs, usually in an effort to mitigate system failures and/or software vulnerabilities from spreading.
- App Engine automatically allocates more resources for the web application to handle the additional demand.
- Web applications hosted on GAE are sandboxed and run across multiple servers for redundancy and allowing for scaling of resources according to the traffic requirements of the moment. App Engine automatically allocates additional resources to the servers to accommodate increased load.
- Google App Engine primarily supports Go, PHP, Java, Python, Node.js, .NET, and Ruby applications, although it can also support other languages via "custom runtimes".
- The service is free up to a certain level of consumed resources and only in standard environment but not in flexible environment. Fees are charged for additional storage, bandwidth, or instance hours required by the application.
- As this is a managed service, your focus should be on the application only and Google will manage the resources needed to run the application. Thus App Engine users have less to manage, but you will have less control over the compute resources. The applications hosted on App Engine are highly scalable and run reliably even under heavy load.

- The App Engine supports the following languages:
    - Python
    - Go
    - Ruby
    - PHP
    - Node.js
    - Java
    - .NET

It also requires the use of Google query language and that the database used is Google Big Table. Applications must abide by these standards, so applications either must be developed with GAE in mind or else modified to meet the requirements.



The App Engine provides two types of runtime environments: standard and flexible.

1. The Standard environment provides a secured and sandboxed environment for running applications and distributes requests across multiple servers to

meet the demand. The applications run independently of the hardware, OS, and physical location of the server.

2. The Flexible environment provides more options and control to the developers who want to use App Engine, but without the language constraints of the standard environment. It uses Docker containers as the basic building blocks. These containers can be auto-scaled according to load.

Advantages of GAE include:

- Readily available servers with no configuration requirement
- Power scaling function all the way down to "free" when resource usage is minimal
- Automated cloud computing tools
- Help safeguard your application by defining access rules with App Engine firewall and leverage managed SSL/TLS certificates by default on your custom domain at no additional cost.
- Easily host different versions of your app, and easily create development, test, staging, and production environment

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Department of

DATA-SCIENCE

COURSEFILE

Course Name: FLAT

A.Y: 2022-23

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CONTENTS OF COURSE FILE

S.NO	CONTENTS	AVAILABLE/ NOT AVAILABLE
1	V/M/PEO/PO/PSO	Available
2	Course syllabus including course structure	Available
3	Course outcomes	Available
4	Mapping co with po/pso	Available
5	Academic calender	Available
6	Timetable	Available
7	Lesson plan	Available
8	Gaps beyond syllabus	Available
9	Gaps with-in syllabus	Available
10	Gaps addresed by a resourse person	Available
11	Gaps addressed by other methodology	Available
12	Web references	Available
13	Lecture notes	Available
14	List of ppt's & videos	Available
15	CD with ppt & videos	Available
16	End exam question papers	Available
17	Internal question paper with key	Available
18	Assignment question papers	Available
19	Scheme of evaluation (university, mid, assignment)	Available
20	Tutorial topics with evidence	Available
21	Result analysis to identify weak & advanced learners	Available
22	Result analysis at the end of course	Available
23	Remedial class schedule & evidences	Available
24	Bright student engagement documentation	Available
25	Course assessment	Available
26	CO PO attainment	Available
27	Observation for not attaining co or for improvement	Available
28	Plan of action for improve co attainment	Available
29	Attendance register	Available
30	Course file digital form	Available

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ESTD : 2008

DEPARTMENT OF CSE- DATA SCIENCE

INSTITUTE VISION AND MISSION

Institute Vision:

- To be a pioneer institute in engineering education, fostering academic excellence, and producing empowered women engineers, blended with ethics and values, to serve the society.

Institute Mission:

MI1	To achieve academic excellence through innovative teaching-learning practices.
MI2	To inculcate self-discipline, ethics and values amongst the learners.
MI3	To bridge the gap between industry and academia through the industry-institute interface.
MI4	To promote higher education, research and inculcate entrepreneurial attitude amongst the learners.

DEPARTMENT VISION AND MISSION

Department Vision:

- To emerge as center of excellence in IT education, research and innovation by promoting competent and woman engineers with ethical values for development of the society

Department Mission:

M1	Bringing innovative approach in teaching-learning process competent Information Technology engineers.
M2	To inculcate ethical and social values among the students for improving their life skills.
M3	To promote research and development in the domain of Information Technology to meet the emerging needs of the Society.
M4	To promote higher education, technological innovation and entrepreneurship in the areas of IT with interdisciplinary connection.

DEPARTMENT OF CSE- DATA SCIENCE

PO5	**Modern tools usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.
PO6	**The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply the set one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO12	**Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

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DEPARTMENT OF CSE - DATA SCIENCE

Department Calendar Year: 2021-2022(Even Semester)

Month	Activity	Activity dates
'ebruary	Date of Commencement of class work I unit Instructions	14-02-2022
March	A five day workshop for II B.Tech	14-03-2022 to 18-03-2022
April	Commencement of I mid Examination for II B. Tech	04-04-2022
April	A six-day Bootcamp and Ideathon on Machine Learning	25-04-2022 to 1-05-2022
May	Commencement of II mid Examination for II B. Tech	30-05-2022 to 04-06-2022
June	Commencement of University Practical Examination	06-06-2022 to 11-06-2022
March	Commencement of University Theory End Examination	13-06-2022 to 25-06-2022

Class In-Charge

Time Table Coordinator

Head of the Department

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DEPARTMENT OF CSE - DATA SCIENCE

II Year – II Semester		L	T	P	C
		3	0	0	3
FORMAL LANGUAGES AND AUTOMATA THEORY					

Course Objectives:

- To learn fundamentals of Regular and Context Free Grammars and Languages
- To understand the relation between Regular Language and Finite Automata and machines
- To learn how to design Automata's and machines as Acceptors, Verifiers and Translators
- To understand the relation between Contexts free Languages, PDA and TM
- To learn how to design PDA as acceptor and TM as Calculators

Course Outcomes:
By the end of the course students can

- Classify machines by their power to recognize languages.
- Summarize language classes & grammars relationship among them with the help of Chomskyhierarchy
- Employ finite state machines to solve problems in computing
- Illustrate deterministic and non-deterministic machines
- Quote the hierarchy of problems arising in the computer science

UNIT I

Finite Automata:Need of Automata theory, Central Concepts of Automata Theory, Automation, Finite Automation, Transition Systems, Acceptance of a String, DFA, Design of DFAs, NFA, Design of NFA, Equivalence of DFA and NFA, Conversion of NFA into DFA, Finite Automata with Є-Transitions, Minimization of Finite Automata, Finite Automata with output-Mealy and Moore Machines, Applications and Limitation of Finite Automata.

UNIT II

Regular Expressions, Regular Sets, Identity Rules, Equivalence of two RE, Manipulations of REs, Finite Automata and Regular Expressions, Inter Conversion, Equivalence between FA and RE, Pumping Lemma of Regular Sets, Closure Properties of Regular Sets, Grammars, Classification of Grammars, Chomsky Hierarchy Theorem, Right and Left Linear Regular Grammars, Equivalence between RG and FA, Inter Conversion.

UNIT III

Formal Languages, Context Free Grammar, Leftmost and Rightmost Derivations, Parse Trees, Ambiguous Grammars, Simplification of Context Free Grammars-Elimination of Useless Symbols, Є-Productions and Unit Productions, Normal Forms-Chomsky Normal Form and

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DEPARTMENT OF CSE - DATA SCIENCE

COURSE STRUCTURE:

II Year – II SEMESTER

S. No	Course Code	Courses	L	T	P	Credits
1	BS	Probability and Statistics	3	0	0	3
2	CS	Computer Organization	3	0	0	3
3	CS	Data warehousing and Mining	3	0	0	3
4	ES	Formal Languages and Automata Theory	3	0	0	3
5	HS	Managerial Economics and Financial Accountancy	3	0	0	3
6	CS	R Programming Lab	0	0	3	1.5
7	CS	Data Mining using Python Lab	0	0	3	1.5
8	ES	Web Application Development Lab	0	0	3	1.5
9	SO	Mongo DB	0	0	4	2
		Total Credits	**15**	**0**	**13**	**21.5**

Course Instructor(s):

Program Coordinator

HOD

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DEPARTMENT OF CSE - DATA SCIENCE

COURSE : **Formal Language and Automata theory**	DEGREE: **B.Tech**
COURSE CODE: **R2022053**	YEAR: **II** SEMESTER: **II**
REGULATION: **R20**	COURSE TYPE: **REGULAR**
ACADEMIC YEAR : **2021-2022**	CREDITS: **3**

Teaching/Instructional Plan

S.NO	Topic Name	No of hours	Teaching Aid Methodologies	Books
	UNIT- I: Finite Automata			
1.	Why Study Automata Theory?	1	Chalk & Talk	T1
2.	The Central Concepts of Automata Theory	1	Chalk & Talk	T1
3.	Automation, Finite Automation	1	Chalk & Talk	T1
4.	Transition Systems, Acceptance of a String by a Finite Automation	1	Chalk & Talk	T1
5.	DFA, Design of DFAs	2	Chalk & Talk	T1
6.	NFA, Design of NFA	2	Chalk & Talk	T1
7.	Equivalence of DFA and NFA	1	Chalk & Talk	T1
8.	Conversion of NFA into DFA,	1	PPT	W1
9.	Finite Automata with E-Transition	2	Chalk & Talk	T1
10.	Minimization of Finite Automata	2	PPT	W2
11.	Mealy and Moore Machines	2	Chalk & Talk	T1
12.	Applications and Limitation of Finite Automata	1	Chalk & Talk	T1
UNIT-II :Regular Expressions				
13.	Regular Expressions, Regular Sets	1	Chalk & Talk	T1
14.	Identity Rules, Equivalence of two Regular Expressions	1	Chalk & Talk	T1
15.	Manipulations of Regular Expressions	1	Chalk & Talk	T2
16.	FiniteAutomata and Regular Expressions	1	PPT	W3
17.	Inter Conversion	1	Chalk & Talk	T2
18.	Equivalence between Finite Automata and Regular Expressions	2	Chalk & Talk	T2
19.	Pumping Lemma, Closers Properties	1	PPT	W4
20.	Applications of Regular Expressions	1	Chalk & Talk	T2

47.	Techniques for Turing Machine Construction	1	Chalk & Talk	T1
48.	Types of Turing Machines	1	Chalk & Talk	T1
49.	Church's Thesis, Universal Turing Machine	1	Chalk & Talk	T1
50.	Restricted Turing Machine.	1	Chalk & Talk	T1
51.	Decidable and Un-decidable Problems,	1	Chalk & Talk	T2
52.	Halting Problem of Turing Machines	1	Chalk & Talk	T2
53.	Post's Correspondence Problem, Modified Post's Correspondence Problem	1	Chalk & Talk	T2
54.	Classes of P and NP	1	Chalk & Talk	T2
55.	Classes of P and NP, NP- Hard and NP-Complete Problems.	1	Chalk & Talk	T2

TEXT BOOKS:

T1	Introduction to Automata Theory, Languages and Computation, J.E.Hopcroft, .Motwani and J.D.Ullman, 3rd Edition, Pearson, 2008.
T2	Theory of Computer Science-Automata, Languages and Computation, .L.P.Mishra and N.Chandrasekharan, 3rd Edition, PHI, 2007.

REFERENCE BOOKS:

R1	Formal Language and Automata Theory, K.V.N.Sunitha and N.Kalyani, Pearson, 2015..
R2	Introduction to Automata Theory, Formal Languages and Computation, Shyamalendu Kandar, Pearson, 2013.
R3	Theory of Computation, V.Kulkarni, Oxford University Press, 2013.
R4	Theory of Automata, Languages and Computation, Rajendra Kumar, McGraw Hill, 2014.

WEB REFERENCE:

W1	https://www.slideshare.net/AnimeshChaturvedi/nfa-to-dfa?from_action=save
W2	https://www.slideshare.net/kunjdesai3/minimization-of-dfa-74421666
W3	https://www.cse.iitd.ac.in/~naveen/courses/COL352/slides/re1.ppt
W4	https://www.cse.iitd.ac.in/~naveen/courses/COL352/slides/rs1.ppt

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DEPARTMENT OF CSE - DATA SCIENCE

COURSE OBJECTIVES & OUTCOMES

COURSE : Formal Language And Automata Theory	DEGREE: **B.Tech**
COURSE CODE: **R2022053**	YEAR: **II** SEMESTER: **II**
REGULATION: **R20**	COURSE TYPE: **REGULAR**
ACADEMIC YEAR : **2021-2022**	CREDITS: **3**

COURSE OBJECTIVE:

1	To learn fundamentals of Regular and Context Free Grammars and Languages.
2	To understand the relation between Regular Language and Finite Automata and machines
3	To learn how to design Automata's and machines as Acceptors, Verifiers and Translators
4	To understand the relation between Contexts free Languages, PDA and TM
5	To learn how to design PDA as acceptor and TM as Calculators

COURSE OUTCOME:

By the end of the course students can:

CO.NO	Description
1	Classify machines by their power to recognize languages.
2	Summarize language classes & grammars relationship among them with the help of Chomskyhierarchy
3	Employ finite state machines to solve problems in computing
4	Illustrate deterministic and non-deterministic machines
5	Quote the hierarchy of problems arising in the computer science

Course Instructor(s):

Program Coordinator **HOD**

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DEPARTMENT OF CSE - DATA SCIENCE

COURSE : **Formal Language And Automata Theory**	DEGREE: **B.Tech**
COURSE CODE: **R2022053**	YEAR: **II** SEMESTER: **II**
REGULATION: **R20**	COURSE TYPE: **REGULAR**
ACADEMIC YEAR : **2021-2022**	CREDITS: **3**

After the completion of course, the student will be able to:

CO No.	Course Outcome Statement	Taxonomy Level
C224.1	Classify machines by their power to recognize languages.	Apply
C224.2	Summarize language classes & grammars relationship among them with the help of Chomskyhierarchy	Apply
C224.3	Employ finite state machines to solve problems in computing	Apply
C224.4	Illustrate deterministic and non-deterministic machines	Apply
C224.5	Quote the hierarchy of problems arising in the computer science	Apply

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Class: I1-B. Tech CSE **A.Y:**2021-2022 **Semester:** II **w.e.f.** **LH. NO:** 507

Period/ Day	1	2	3	4	5		6	7
	9:00-09:50	09:50-10:40	10:50-11:40	11:40-12:30	12:30-1:20	1:20-2:10	2:10-3:00	3:00-3:50
Monday	MEFA	WADLAB[5&6]			DWDM	LUNCH	FLAT	P&S
Tuesday	MEFA	DWDM	FLAT	P&S	DWDM LAB		DWDMLAB[5&6]	
Wednesday	DWDM	MEFA	CO	P&S	MONGO LAB		MONGO LAB[illegible]	
Thursday	FLAT	MEFA	DWDM	P&S	CO		DWDM	FLAT
Friday	P&S	CRT		CO	RLAB[7&8]		RLAB[7&8]	
Saturday	CO	DWDM	FLAT	MEFA	P&S		CRT	

Course	Course Name (Code)	Name of the Faculty	Course	Course Name	Name of the Faculty
P&S	ProbabilityandStatistics	Mr.B.Baji	WebapplicatinLab	WebApplicationDevelopmentLab	Mrs.R.P.Raja Lakshmi Mr.Y.V.Narayana Reddy
Co	ComputerOrganization	Dr.E.Nageswararao	MONGO LAB	MongoDB	Dr.E.Nageswararao Mrs.Venkata Rajitha
DWDM	DatawarehousingandMining	Mrs.S.Harathi	INTERNET	INTERNET	Mrs.S.Harathi
FLAT	FormalLanguagesand AutomataTheory	Mr.R.R.Tagore	LIBRARY	LIBRARY	Mrs.Venkata Rajitha
MEFA	Managerial Economics and FinancialAccountancy	Mr.B.BAJI	SPORTS	SPORTS	Mr.Y.V.Narayana Reddy
R LAB	RProgrammingLab	Mr.Y.V.NarayanaReddyMrs.R.P.Raja Lakshmi	MEN	MENTORING	Mrs.S.Harathi'Mr.R.R.Tagore Mrs.R.P.Raja LakshmI
DWDMLAB	DataMiningusingPythonLab	Mrs.S.Harathi Mrs.R.P.Raja Lakshmi	CRT	CampusRecruitment Training	Mrs.R.P.Raja Lakshmi

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WEB REFERENCES

COURSE : **Formal Language and Automata Theory**	DEGREE: **B.Tech**
COURSE CODE: **R2022053**	YEAR: **II** SEMESTER: **II**
REGULATION: **R20**	COURSE TYPE: **REGULAR**
ACADEMIC YEAR : **2021-2022**	CREDITS: **3**

W1	https://www.slideshare.net/AnimeshChaturvedi/nfa-to-dfa?from_action=save
W2	https://www.slideshare.net/kunjdesai3/minimization-of-dfa-74421666
W3	https://www.cse.iitd.ac.in/~naveen/courses/COL352/slides/re1.ppt
W4	https://www.cse.iitd.ac.in/~naveen/courses/COL352/slides/rs1.ppt
W5	https://www.slideshare.net/meresietesfay2/ch3-4-regular-expression-and-grammar
W6	https://www.powershow.com/view/14b8fa-MzkxZ/The_Chomsky_Hierarchy_ powerpoint _ppt_ presentation
W7	https://www.slideshare.net/chaudharyzohaib/pumping-lemma-for-cfl
W8	https://cs.wmich.edu/~elise/courses/cs6800/2-stack-PDA-2nd.ppt
W9	https://www.slideshare.net/aramrafeq7/turing-machine-45374231

Course Instructor(s):

Program Coordinator

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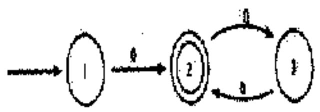
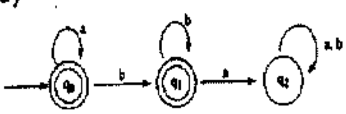
SCHEME OF EVALUATION – UNIVERSITY EXAMINATION

COURSE : **Formal Language and Automata Theory**	DEGREE: **B.Tech**
COURSE CODE: **R2022053**	YEAR: **II** SEMESTER: **II**
REGULATION: **R20**	COURSE TYPE: **REGULAR**
ACADEMIC YEAR : **2021-2022**	CREDITS: **3**

Q.No.	Question	Marks Allotted	Course Outcome mapping	Blooms Taxonomy level
1.	a) Outline formal language and Explain the Chomsky classification of grammars	7	C224.1	Understand
	b) Draw a DFA which accepts strings ending with 11 where the input is {0,1}	7	C224.1	Create
2..	a) List the various operations on languages in detail and relate with transition diagrams?	7	C224.1	Remember
	b) Draw a DFA which accepts strings ending with 01 where the input is {0,1}	7	C224.1	Create
3..	a) Compute the regular expression for the following machine. 	7	C224.2	Evaluate
	b) List and explain the closure properties of Regular grammar.	7	C224.2	Remember
4	a)  Compute the regular expression for the above machine.	7	C224.2	Evaluate

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	b)Demonstrate the conversion of PDA to grammar with a case study.	7	C224.4	Understand
9	a)Construct a TM that computes a function f(m, n) = m+ni.e, addition of two numbers.	7	C224.5	Create
	b)Construct a TM for computing ones complement calculation.	7	C224.5	Create
10	a)Discuss the languages accepted by Turing machines.	7	C224.5	Create
	b) Construct the Turing machine that computes subtraction, where the fist operandlength is more than the second operand. X is a symbol that separates the two operands. Example: 0000X00.	7	C224.5	Create

Course Instructor:

Program Coordinator

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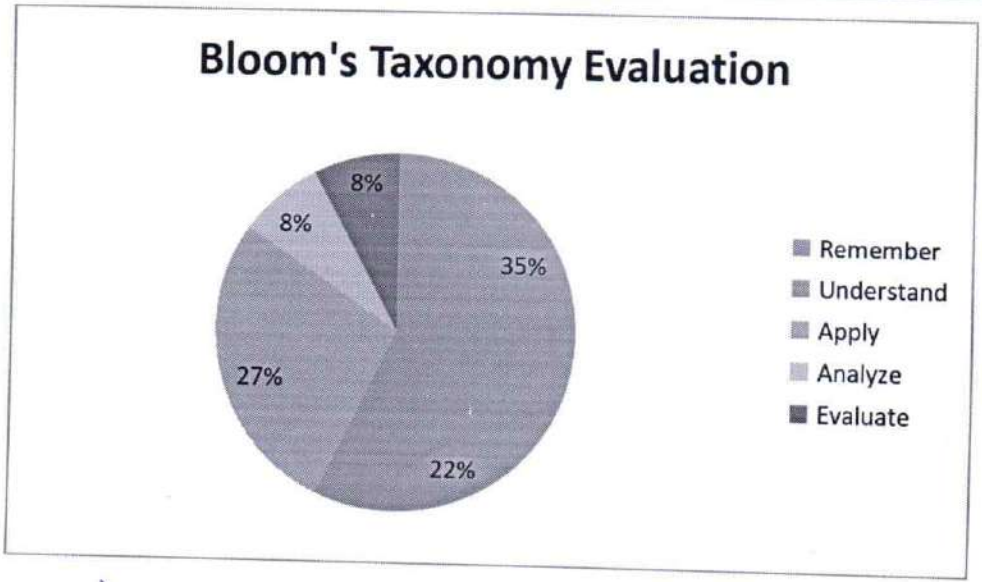

Course Instructor(s):

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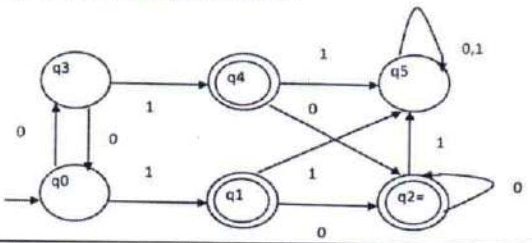
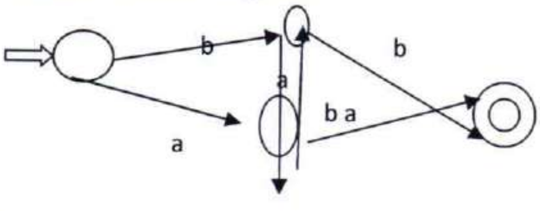
DEPARTMENT OF CSE - DATA SCIENCE

COURSE : **Formal Language and automata theory**	DEGREE: **B.Tech**
COURSE CODE: **R2022053**	YEAR: **II** SEMESTER: **II**
REGULATION: **R20**	COURSE TYPE: **REGULAR**
ACADEMIC YEAR : **2021-2022**	CREDITS: **3**

Branch: CSE - DS **Sub: FLAT** **Date:**
Max Time: 90 Minutes **Max Marks: 15**
Name of the Course Instructor/Advisor: **MID-I**

***Answer All Questions**

Q.NO.	QUESTION	MARKS ALLOTTED	COURSE OUTCOME MAPPING	BLOOM'S TAXONOMY LEVEL
1	a)Minimize the given DFA. 	2M	C224.1	Apply
	b)Define Mealy Machine With an Example.	3M	C224.1	Apply
2.	a) By using Pumping Lemma Show that the following Language is not Regular . L={W∋{0,1}*/The no.of 0's in W is a Perfect Square}	3M	C224.2	Apply
	b) Construct a Regular Grammar for given FA 	2M	C224.2	Apply
3.	a) Simplify the Following Grammar. S->AB A->a B->C B->b C->D D->E	2M	C224.3	Apply
	b) Convert the following grammar into CNF. S->aAD A->aB/bAB B->b D->d	3M	C224.3	Apply

Course Instructor :

Program Coordinator

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DEPARTMENT OF CSE - DATA SCIENCE

COURSE : **Formal Language and Automata Theory**	DEGREE: **B.Tech**
COURSE CODE: **R2022053**	YEAR: **II** SEMESTER: **II**
REGULATION: **R20**	COURSE TYPE: **REGULAR**
ACADEMIC YEAR : **2021-2022**	CREDITS: **3**

Branch: CSE -DS **Sub:FLAT** **Date:**
Max Time: 90 Minutes **Max Marks: 15**
Name of the Course Coordinator/Advisor: **MID-II**

***Answer All Questions**

Q.NO.	QUESTION	MARKS ALLOTTED	COURSE OUTCOME MAPPING	BLOOM'S TAXONOMY LEVEL
1.	a)Construct PDA Equivalent to S->0BB, B->0S|1S|0	2.5M	C224.4	Apply
	b) Construct PDA for L = { WCW^R /W=$(0+1)^*$ }	2.5M	C224.4	Apply
2.	a) Explain Types of Turing Machine?	2.5M	C224.5	Apply
	b) Construct TM L = {$a^n b^n c^n$ /n>=1}	2.5M	C224.5	Apply
3	a) What is Undecidability ?Explain in brief about undecidable problems?	2.5M	C224.6	Apply
	b) Define PCP with an Example?	2.5M	C224.6	Apply

Course Instructor

Program Coordinator

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ESTD : 2008

DEPARTMENT OF CSE - DATA SCIENCE

COURSE : **Formal Language and Automata Theory**	DEGREE: **B.Tech**
COURSE CODE: **R2022053**	YEAR: **II** SEMESTER: **II**
REGULATION: **R20**	COURSE TYPE: **REGULAR**
ACADEMIC YEAR : **2021-2022**	CREDITS: **3**

SCHEME OF EVALUATION – ASSIGNMENT-I

Q.No.	QUESTION	Marks Allotted	Course Outcome mapping	Taxonomy level
1	Minimization of DFA with Example?	2M	CO1	3
2	Usage of Arden's Theorem tom Construct Regular Expression?	1M	CO2	3
3	Convert the following grammar into CNF. S->aAD A->aB/bAB B->b D->d	2 M	CO3	2

Course Outcome Number	Marks Allotted	Percentage of Marks
C224.1	2	40.00
C224.2	1	20.00
C224.3	2	40.00
C224.4	0	0.00
C224.5	0	0.00
Total Marks	5	100

Taxonomy level	Marks Allotted	Percentage of Marks
Remember	0	0.00
Understand	0	0.00
Apply	5	100.00
Analyze	0	0.00
Evaluate	0	0.00
Total Marks	5	100

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DEPARTMENT OF CSE - DATA SCIENCE

COURSE : **Formal Language and Automata Theory**	DEGREE: **BTECH**
COURSE CODE: **R1622055**	YEAR: **II** SEMESTER: **II**
REGULATION: **R16**	COURSE TYPE: **REGULAR**
ACADEMIC YEAR : **2018-2019**	CREDITS: **3**

SCHEME OF EVALUATION – ASSAIGNMENT-II

Q.No.	QUESTION	Marks Allotted	Course Outcome mapping	Taxonomy level
1	Build a PDA that accepts the language L={W/W has equal no.of a's and b's} over an alphabet {a,b}	2M	CO4	3
2	Identify and Explain the types of TM?.	2M	CO5	3
3	Illustrate in detail about Halting problem of a TM?.	1M	CO6	3

Course Outcome Number	Marks Allotted	Percentage of Marks
C213.4	2	40.00
C213.5	2	40.00
C213.6	1	20.00
Total Marks	5	100

Taxonomy level	Marks Allotted	Percentage of Marks
Remember	0	0.00
Understand	0	0.00
Apply	5	100.00
Analyze	0	0.00
Evaluate	0	0.00
Create	0	0.00
Total Marks	5	100

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SCHEME OF EVALUATION – MID 1 EXAMINATION

COURSE : **Formal Language and Automata Theory**	DEGREE: **B.Tech**
COURSE CODE: **R2022053**	YEAR: **II** SEMESTER: **II**
REGULATION: **R20**	COURSE TYPE: **REGULAR**
ACADEMIC YEAR : **2021-2022**	CREDITS: **3**

Q.No.	Solution	Marks Allotted	Course Outcome mapping	Taxonomy level
1	a)DFA Minimization	2	C224.1	Apply
	b)Definition and Example	3		
2	a)Definition process	3	C224.2	Apply
	b)Regular grammar	2		
3	a)Simplification of Grammar	2	C224.3	Apply
	b)Conversion to CNF	3		

Course Outcome Number	Marks Allotted	Percentage of Marks	Taxonomy level	Marks Allotted	Percentage of Marks
C224.1	5	33.33	Remember	0	0.00
C224.2	5	33.33	Understand	0	0.00
C224.3	5	33.33	Apply	15	100.00
Total Marks	15	100	Analyze	0	0.00
			Evaluate	0	0.00
			Create	0	0.00

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DEPARTMENT OF CSE - DATA SCIENCE

SCHEME OF EVALUATION – MID II EXAMINATION

COURSE : **Formal Language and Automata Theory**	DEGREE: **B.Tech**
COURSE CODE: **R2022053**	YEAR: **II** SEMESTER: **II**
REGULATION: **R20**	COURSE TYPE: **REGULAR**
ACADEMIC YEAR : **2021-2022**	CREDITS: **3**

Q.No.	Solution	Marks Allotted	Course Outcome mapping	Taxonomy level
1	PDA Construction	2	C224.3	Apply
	Writing Language of PDA	1		
	Build PDA for that Language	2		
2	Definition Model of TM	1	C224.4	Apply
	Types of TM	2		
	Design TM	2		
3	NP Complete NP Hard	2	C224.5	Apply
	Halting Problem of TM	2		
	Explain Decidability and Undecidability	1		

Course Outcome Number	Marks Allotted	Percentage of Marks		Taxonomy level	Marks Allotted	Percentage of Marks
C224.3	5	33.33		Remember	0	0.00
C224.4	5	33.33		Understand	0	0.00
C224.5	5	33.33		Apply	15	100.00
Total Marks	15	100		Analyze	0	0.00
				Evaluate	0	0.00
				Create	0	0.00
				Total Marks	15	100

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DEPARTMENT OF CSE - DATA SCIENCE

LESSON PLAN FOR TUTORIAL CLASSES

COURSE : **Formal Language and Automata Theory**	DEGREE: **B.Tech**
COURSE CODE: **R2022053**	YEAR: **II** SEMESTER: **II**
REGULATION: **R20**	COURSE TYPE: **REGULAR**
ACADEMIC YEAR : **2021-2022**	CREDITS: **3**

T.No	Name of the Topic	Teaching Aid	Books
1	Finite Automata and its categories brief description.	Chalk & Talk	T1
2	Conversion from NFA to DFA	Chalk & Talk	T1
3	Minimization of FA	PPT	W1
4	Finite Automata, and Regular Expressions	Chalk & Talk	T2,
5	Pumping Lemma for RE	Chalk & Talk	T1
6	Regular Expressions and Regular Grammars.	Chalk & Talk	T1
7	Chomsky Hierarchy Theorem	PPT	W2
8	Simplification of Context Free Grammars	Chalk & Talk	T2
9	Normal Forms for Context Free Grammars	Chalk & Talk	T2
10	Design of Pushdown Automata	Chalk & Talk	T2
11	Deterministic and Non – Deterministic Pushdown Automata	Chalk & Talk	T1
12	Two Stack Pushdown Automata	Chalk & Talk	T1
13	Design of Turing Machines	Chalk & Talk	T1
14	Types of Turing Machines	PPT	W3
15	Halting Problem of Turing Machines	Chalk & Talk	T1
16	Classes of P and NP, NP- Hard and NP-Complete Problems.	Chalk & Talk	T1

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10	20KE1A4411	EVURI SWATHI	AL
11	20KE1A4412	GANTA MANISHA	AL
12	20KE1A4413	GORIJALA HRUDAYA VALLI	AL
13	20KE1A4414	GUDE PRASANTHI	AL
14	20KE1A4415	JADDA MOUNIKA	AL
15	20KE1A4416	JAMPANI LAKSHMI PRASANNA	AL
16	20KE1A4417	JANGILI PRAVALIKA	AL
17	20KE1A4418	KANCHARLA ANUSHA	AL
18	20KE1A4419	KATTA CHARITHA	AL
19	20KE1A4420	KOMMALAPATI RISHITHA	AL
20	20KE1A4421	KONDAVARDHU NANDINI	AL
21	20KE1A4422	KOTHAPALLI NIKHILESWARI	AL
22	20KE1A4423	KURIYALA HARIKA	AL
23	20KE1A4424	MADIREDDY HIMABINDU	AL
24	20KE1A4425	MANCHIKANTI BINDHU RAHITHA	AL
25	20KE1A4426	MANDALAPU NANDINI	AL
26	20KE1A4427	MEDAGAM SOBHA REDDY	AL
27	20KE1A4428	MEDIKONDA UMAMAHESWARI	AL
28	20KE1A4429	MULUKUTLA VENKATA NAGA RAMA ANJALI	AL
29	20KE1A4430	MUTHINENI KALPANA	AL
30	20KE1A4431	MYNENI SRUTHI	AL
31	20KE1A4432	NALABOLU KEERTHI	AL
32	20KE1A4433	NALABOLU SRAVANA SANDHYA	AL
33	20KE1A4434	NAMBURI LAKSHMI SAHITHI	AL
34	20KE1A4435	NANDURI LAKSHMI DIVYA	AL
35	20KE1A4436	NEPPALI VINEELA	AL
36	20KE1A4437	NIDAMANURI MOLIKA SUMA	AL
37	20KE1A4438	PABBISETTY DHANUJA NAGA SUVARNA	AL
38	20KE1A4439	PADIBANDLA SRAVANI	AL
39	20KE1A4440	PATHAN ASIFA KOUSAR	AL
40	20KE1A4441	PAVULURI SUSHMA SRI	AL
41	20KE1A4442	PENTYALA UMA MAHESWARI	AL
42	20KE1A4443	PERABATHULA MAA RENUKA	AL
43	20KE1A4444	POLISETTY ASRITHA LAKSHMI	AL
44	20KE1A4445	PULI ARUNA SIVA BINDU	AL
45	20KE1A4446	RAMISETTY POOJITHA	AL
46	20KE1A4447	SHAIK JASMINE	AL

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35	20KE1A4436	NEPPALI VINEELA	13	4	5	22
36	20KE1A4437	NIDAMANURI MOLIKA SUMA	11	3	5	19
37	20KE1A4438	PABBISETTY DHANUJA NAGA SUVARNA	13	3	5	21
38	20KE1A4439	PADIBANDLA SRAVANI	14	4	5	23
39	20KE1A4440	PATHAN ASIFA KOUSAR	12	4	5	21
40	20KE1A4441	PAVULURI SUSHMA SRI	14	4	5	23
41	20KE1A4442	PENTYALA UMA MAHESWARI	12	4	5	21
42	20KE1A4443	PERABATHULA MAA RENUKA	15	4	5	24
43	20KE1A4444	POLISETTY ASRITHA LAKSHMI	15	5	5	25
44	20KE1A4445	PULI ARUNA SIVA BINDU	15	4	5	24
45	20KE1A4446	RAMISETTY POOJITHA	11	2	5	18
46	20KE1A4447	SHAIK JASMINE	15	2	5	22
47	20KE1A4448	SHAIK SHAREEFA	15	4	5	24
48	20KE1A4449	SHAIK SUFFIYA	13	2	5	20
49	20KE1A4450	SIDDE TRIVENI	12	3	5	20
50	20KE1A4451	SUNKARA GOUTHAMI	15	5	5	25
51	20KE1A4452	SUNKARA VINDHYAVALI	10	5	5	20
52	20KE1A4453	TADIBOINA JAYA PRIYA	14	3	5	22
53	20KE1A4454	THAVVA USHA RANI	11	3	5	19
54	20KE1A4455	TOKALA SRUTHI	12	1	5	18
55	20KE1A4456	UPPALAPATI DHARANI	14	4	5	23
56	20KE1A4457	VALLAPUNENI TRIVENI	11	3	5	19

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Text Books:

T1	Introduction to Automata Theory, Languages and Computation, J.E.Hopcroft, .Motwani and J.D.Ullman, 3rd Edition, Pearson, 2008.
T2	Theory of Computer Science-Automata, Languages and Computation, .L.P.Mishra and N.Chandrasekharan, 3rd Edition, PHI, 2007..

References:

R1	Formal Language and Automata Theory, K.V.N.Sunitha and N.Kalyani, Pearson, 2015.
R2	Introduction to Automata Theory, Formal Languages and Computation, Shyamalendu Kandar , Pearson, 2013.

Web references:

W1	https://www.slideshare.net/maksudul983/dfa-minimization-74713930
W2	https://www.slideshare.net/DipankarBoruah/chomsky-classification-of-language
W3	https://www.slideshare.net/rajendranjrf/variants-of-turing-machine

Course Instructor(s):

Program Coordinator

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COURSE : **FLAT**	DEGREE: **B.Tech**
COURSE CODE: **R2022053**	YEAR: **II** SEMESTER: **II**
REGULATION: **R20**	COURSE TYPE: **REGULAR**
ACADEMIC YEAR : **2021-2022**	CREDITS: **3**

STUDENT RESULT ANALYSIS FOR MID-I

S.NO	ROLL.NO	NAME OF THE STUDENT	DESCRIPTIVE	OBJECTIVE	ASSIGNMENT	TOTAL
1	20KE1A4401	ADAPA TEJA SREE	14	4	5	23
2	20KE1A4402	BANDLA NAGA HYNDAVI	10	5	5	20
3	20KE1A4403	BATHULA VASANTHA LAKSHMI	13	4	5	22
4	20KE1A4404	BOLLINENI HEMA	14	3	5	22
5	20KE1A4405	CHEBROLU LAKSHMI NEERAJA	13	4	5	22
6	20KE1A4406	CHEKURI RUKMINI	10	5	5	20
7	20KE1A4407	CHINNI RAJESWARI	12	4	5	21
8	20KE1A4408	CHIRUMAMILLA YAMINI	10	3	5	18
9	20KE1A4410	DEVARAKONDA SAI SANDHYA	15	3	5	23
10	20KE1A4411	EVURI SWATHI	12	2	5	19
11	20KE1A4412	GANTA MANISHA	14	3	5	22
12	20KE1A4413	GORIJALA HRUDAYA VALLI	13	2	5	20
13	20KE1A4414	GUDE PRASANTHI	13	5	5	23

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SLOW LEARNERS FOR MID-I EXAMINATION

COURSE : **COMPUTER ORGANIZATION**	DEGREE: **B.Tech**
COURSE CODE: **R2022421**	YEAR: **II** SEMESTER: **II**
REGULATION: **R20**	COURSE TYPE: **REGULAR**
ACADEMIC YEAR : **2021-2022**	CREDITS: **3**

S.NO	ROLL.NO	NAME OF THE STUDENT	Grade
NILL			

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STUDENT RESULT ANALYSIS FOR MID-II

COURSE : **COMPUTER ORGANIZATION**	DEGREE: **B.Tech**
COURSE CODE: **R2022421**	YEAR: **II** SEMESTER: **II**
REGULATION: **R20**	COURSE TYPE: **REGULAR**
ACADEMIC YEAR : **2021-2022**	CREDITS: **3**

S.NO	HTNO	SUBJECT	MID_2	quiz_2	assign_2	Total
1	20KE1A4401	ADAPA TEJA SREE	14	2	5	21
2	20KE1A4402	BANDLA NAGA HYNDAVI	12	2	5	19
3	20KE1A4403	BATHULA VASANTHA LAKSHMI	12	2	5	19
4	20KE1A4404	BOLLINENI HEMA	11	3	5	19
5	20KE1A4405	CHEBROLU LAKSHMI NEERAJA	10	3	5	18
6	20KE1A4406	CHEKURI RUKMINI	13	1	5	19
7	20KE1A4407	CHINNI RAJESWARI	13	2	5	20
8	20KE1A4408	CHIRUMAMILLA YAMINI	13	1	5	19
9	20KE1A4410	DEVARAKONDA SAI SANDHYA	15	2	5	22
10	20KE1A4411	EVURI SWATHI	13	1	5	19
11	20KE1A4412	GANTA MANISHA	11	4	5	20

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30	20KE1A4431	MYNENI SRUTHI	12	4	5	21
31	20KE1A4432	NALABOLU KEERTHI	11	4	5	20
32	20KE1A4433	NALABOLU SRAVANA SANDHYA	13	3	5	21
33	20KE1A4434	NAMBURI LAKSHMI SAHITHI	12	2	5	19
34	20KE1A4435	NANDURI LAKSHMI DIVYA	11	3	5	19
35	20KE1A4436	NEPPALI VINEELA	11	2	5	18
36	20KE1A4437	NIDAMANURI MOLIKA SUMA	11	3	5	19
37	20KE1A4438	PABBISETTY DHANUJA NAGA SUVARNA	10	4	5	19
38	20KE1A4439	PADIBANDLA SRAVANI	11	3	5	19
39	20KE1A4440	PATHAN ASIFA KOUSAR	13	3	5	21
40	20KE1A4441	PAVULURI SUSHMA SRI	14	2	5	21
41	20KE1A4442	PENTYALA UMA MAHESWARI	11	3	5	19
42	20KE1A4443	PERABATHULA MAA RENUKA	13	3	5	21
43	20KE1A4444	POLISETTY ASRITHA LAKSHMI	14	4	5	23
44	20KE1A4445	PULI ARUNA SIVA BINDU	14	4	5	23
45	20KE1A4446	RAMISETTY POOJITHA	12	2	5	19
46	20KE1A4447	SHAIK JASMINE	10	3	5	18
47	20KE1A4448	SHAIK SHAREEFA	12	3	5	20

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ADVANCED LEARNERS FOR MID-II EXAMINATION

COURSE : **COMPUTER ORGANIZATION**	DEGREE: **B.Tech**
COURSE CODE: **R2022421**	YEAR: **II** SEMESTER: **II**
REGULATION: **R20**	COURSE TYPE: **REGULAR**
ACADEMIC YEAR : **2021-2022**	CREDITS: **3**

S.NO	ROLL.NO	NAME OF THE STUDENT	Grade
1	20KE1A4401	ADAPA TEJA SREE	AL
2	20KE1A4402	BANDLA NAGA HYNDAVI	AL
3	20KE1A4403	BATHULA VASANTHA LAKSHMI	AL
4	20KE1A4404	BOLLINENI HEMA	AL
5	20KE1A4405	CHEBROLU LAKSHMI NEERAJA	AL
6	20KE1A4406	CHEKURI RUKMINI	AL
7	20KE1A4407	CHINNI RAJESWARI	AL
8	20KE1A4408	CHIRUMAMILLA YAMINI	AL
9	20KE1A4410	DEVARAKONDA SAI SANDHYA	AL
10	20KE1A4411	EVURI SWATHI	AL
11	20KE1A4412	GANTA MANISHA	AL
12	20KE1A4413	GORIJALA HRUDAYA VALLI	AL
13	20KE1A4414	GUDE PRASANTHI	AL
14	20KE1A4415	JADDA MOUNIKA	AL
15	20KE1A4416	JAMPANI LAKSHMI PRASANNA	AL
16	20KE1A4417	JANGILI PRAVALIKA	AL
17	20KE1A4418	KANCHARLA ANUSHA	AL
18	20KE1A4419	KATTA CHARITHA	AL
19	20KE1A4420	KOMMALAPATI RISHITHA	AL
20	20KE1A4421	KONDAVARDHU NANDINI	AL
21	20KE1A4422	KOTHAPALLI NIKHILESWARI	AL
22	20KE1A4423	KURIYALA HARIKA	AL
23	20KE1A4424	MADIREDDY HIMABINDU	AL
24	20KE1A4425	MANCHIKANTI BINDHU RAHITHA	AL

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		VASIRAJU NAGA RENUKA DEVI	
58	20KE1A4459	VATLURI SAI ANUHYA	AL
59	20KE1A4460	VEJANDLA LEEKSHMITHA	AL
60	20KE1A4461	YAGANTI POOJITHA	AL
61	20KE1A4462	YARAMASU VARSHINI	AL
62	20KE1A4463	YARRAM UJWALA	AL

SLOW LEARNERS FOR MID-II EXAMINATION

COURSE : **COMPUTER ORGANIZATION**	DEGREE: **B.Tech**
COURSE CODE: **R2022421**	YEAR: **II** SEMESTER: **II**
REGULATION: **R20**	COURSE TYPE: **REGULAR**
ACADEMIC YEAR : **2021-2022**	CREDITS: **3**

S.NO	ROLL.NO	NAME OF THE STUDENT	Grade
		NILL	

Course Instructor

Program Coordinator

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DEPARTMENT OF CSE - DATA SCIENCE

CIRCULAR

COURSE : **Formal Language and Automata Theory**	DEGREE: **B.Tech**
COURSE CODE: **R2022053**	YEAR: **II** SEMESTER: **II**
REGULATION: **R20**	COURSE TYPE: **REGULAR**
ACADEMIC YEAR : **2021-2022**	CREDITS: **3**

It is observed that the following are the weak students in II CSE (A) (II-SEM) in **Formal Language and Automata Theory** . I am conducting remedial classes for the Slow learners from 6-06-2022 to 13-06-2022. Hence the following students should attend the remedial classes

S.NO	ROLL.NO	NAME OF THE STUDENT	Grade
1	20KE1A4402	BANDLA NAGA HYNDAVI	SL
2	20KE1A4406	CHEKURI RUKMINI	SL
3	20KE1A4402	BANDLA NAGA HYNDAVI	SL
4	20KE1A4406	CHEKURI RUKMINI	SL
5	20KE1A4412	GANTA MANISHA	SL
6	20KE1A4415	JADDA MOUNIKA	SL
7	20KE1A4419	KATTA CHARITHA	SL
8	20KE1A4423	KURIYALA HARIKA	SL
9	20KE1A4428	MEDIKONDA UMAMAHESWARI	SL
10	20KE1A4430	MUTHINENI KALPANA	SL
11	20KE1A4431	MYNENI SRUTHI	SL
12	20KE1A4435	NANDURI LAKSHMI DIVYA	SL
13	20KE1A4445	PULI ARUNA SIVA BINDU	SL
14	20KE1A4446	RAMISETTY POOJITHA	SL
15	20KE1A4451	SUNKARA GOUTHAMI	SL
16	20KE1A4459	VATLURI SAI ANUHYA	SL

Course Instrutor(s):

Program Coordinator

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Guntur-522017, Andhra Pradesh, India

ESTD : 2008

Department of CSE-Data Science

REMIDEAL CLASS SCHEDULE

COURSE : **FORMAL LANGUAGE AND AUTOMATA THEORY**	DEGREE: **B.Tech**
COURSE CODE: **R2022053**	YEAR: **II** SEMESTER: **II**
REGULATION: **R20**	COURSE TYPE: **REGULAR**
ACADEMIC YEAR : **2021-2022**	CREDITS: **3**

Class: II-B.Tech CSE-DS **Semester: II** **LH. NO. 507** **W.E.F.**

Day	9:00--12:30					01:20-03:30	03:30-04:30
Monday							FLAT
Tuesday					L		FLAT
Wednesday					U N		FLAT
Thursday					C		FLAT
Friday					H		FLAT
Saturday							FLAT

Subject Code	Subject	Name of the Faculty
R2022051	PROBABILITY AND STATISTICS	
R2022052	COMPUTER ORGANIZATION	
R2022053	FORMAL LANGUAGE AND AUTOMATA THEORY	N.Madhavi Latha
R2022054	DATAWAREHOUSING AND MINING	
R2022055	MANAGEMENT ECONOMICS AND FINANCIAL ACCOUNTANCY	

Course Instructor(s):

Program Coordinator

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COURSE : **Formal language and Automata Theory**	DEGREE: **B.Tech**
COURSE CODE: **R2022053**	YEAR: **II** SEMESTER: **II**
REGULATION: **R20**	COURSE TYPE: **REGULAR**
ACADEMIC YEAR : **2021-2022**	CREDITS: **3**

Question And Answers for Bright Students:

2 MARKS

1. Let $\Sigma\Sigma$ be the set of all bijections from {1, … , 5} to {1, … , 5}, where idid denotes the identity function, i.e. $id(j)=j, \forall j$id(j)=j,∀j. Let ∘∘ denote composition on functions. For a string $x=x_1x_2\ldots x_n\in\Sigma_n, n\leq 0$x=x1x2…xn∈Σn,n≤0 , let $\pi(x)=x_1\circ x_2\circ\cdots\circ x_n$π(x)=x1∘x2∘⋯∘xn. Consider the language $L=\{x\in\Sigma_*|\pi(x)=id\}$L={x∈Σ∗|π(x)=id}. The minimum number of states in any DFA accepting LL is .
2. Let N be an NFA with n states. Let *k* be the number of states of a minimal DFA which is equivalent to *N*. Which one of the following is necessarily true?
3. The minimum possible number of states of a deterministic finite automaton that accepts the regular language $L=\{w_1aw_2|w_1,w_2\in\{a,b\}*,|w_1|=2,|w_2|\geq 3\}$L={w1aw2|w1,w2∈{a,b}∗,|w1|=2,|w2|≥3} is _________.
4. Let $\delta\delta$ denote the transition function and $\hat{\delta}$δ^ denote the extended transition function of the $\in-NFA$∈−NFA whose transition table is given below:

δδ	∈∈	a	b
→→q_0	{q_2}	{q_1}	{q_0}
q_1	{q_2}	{q_2}	{q_3}
q_2	{q_0}	ϕϕ	ϕϕ
q_3	ϕϕ	ϕϕ	{q_2}

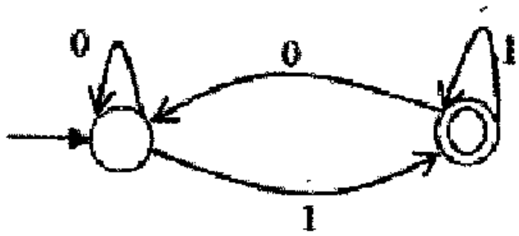
Then $\hat{\delta}(q_2,aba)$δ^(q2,aba) is

5. The number of states in the minimum sized DFA that accepts the language defined by the regular expression

$(0+1)*(0+1)(0+1)*$(0+1)∗(0+1)(0+1)∗
is __________.

6. Consider the following two statements:

I. If all states of an NFA are accepting states then the language accepted by the NFA is $\sum*$∑∗.
II. There exists a regular language *A* such that for all languages \$B\$, $A\cap B$A∩B is regular.
Which one of the following is **CORRECT**?



I)0*1(1+00*1)*
II)0*1*1+11*0*1
III) (0+1)*1

If $L_1=\{a_n|n\geq 0\}$ AND $L_2=\{b_n|n\geq 0\}$L1=an|n≥0 AND L2=bn|n≥0,consider
(I) $L_1.L_2$L1.L2 is a regular language
(I)$L_1.L_2=\{a_nb_n|n\geq 0\}$L1.L2=anbn|n≥0
Which one of the following is CORRECT?

- (A) Only (I)
- (B) Only (II)
- (C) Both (I) and (II)
- (D) Neither (I) nor (II)

12. Let $L_1=\{w \in \{0,1\}^*|w$ has at least as many occurence of (110)'s$\}$.L1=w ∈ 0,1*|w has at least as many occurence of 110's.Let $L_1=\{w \in \{0,1\}^*|w$ has at least as many occurence of (000)'s as (111)'s$\}$.L1=w ∈ 0,1*|w has at least as many occurence of 000's as 111's.Which one of the following is TRUE?

- (A) L_1 is regular but not L_2
- (B) L_2 is regular but not L_1
- (C) Both L_1 and L_2 are regular
- (D) Neither L_1 nor L_2 are regular

13. Consider the following languages over the alphabet $\sum=\{0,1,c\}$∑=0,1,c:
$L_1=\{0_n1_n|n\geq 0\}$L1=0n1n|n≥0
$L_2=\{wcw_r|w\in\{0,1\}_*\}$L2=wcwr|w∈0,1*
$L_3=\{ww_r|w\in\{0,1\}^*\}$L3=wwr|w∈0,1*
Here, w^r is the reverse of the string w. Which of these languages are deterministic Context-free languages?

- (A) None of the languages
- (B) Only L_1

Answer: (d). $D_f = N_f$ and $D_p \subset N_p$

The regular expression $0^*(10^*)^*$ denotes the same set as

$(1^*0)^*1^*$

$0 + (0 + 10)^*$

$(0 + 1)^*\ 10(0 + 1)^*$

none of these

Answer: (d). none of these

The smallest finite automation which accepts the language {x | length of x is divisible by 3} has :

2 states

3 states

4 states

5 states

48

Answer: (d).48

Let S and T be language over $\Sigma = \{a,b\}$ represented by the regular expressions $(a+b^*)^*$ and $(a+b)^*$, resp
f the following is true?

$S \subset T$

$T \subset S$

$S = T$

$S \cap T = \varphi$

Answer: (c).S = T

Let L denotes the language generated by the grammar S -> 0S0/00. Which of the following is true?

L = 0+

2

3

4

Answer: (b).2

Consider alphabet $\sum = \{0, 1\}$, the null/empty string λ and the sets of strings X0, X1 and X2 generated by corresponding non-terminals of a regular grammar. X0, X1 and X2 are related as follows.

X0 = 1 X1
X1 = 0 X1 + 1 X2
X2 = 0 X1 + {λ}

Which one of the following choices precisely represents the strings in X0?

10 (0* + (10)*)1

10 (* + (10)*)*1

1(0* + 10)*1

10 (0 + 10)*1 + 110 (0 + 10)*1

Answer: (c).1(0* + 10)*1

prefix of another. However, a letter may be ended in the letter of same alphabet i.e. one letter may be the suffix of another.

Σ= { a , b } (Valid Alphabet)
Σ= { a , b , cd } (Valid Alphabet)
Σ= { a , b , ac } (Invalid Alphabet)

AWT (Abstract Window Toolkit) Tutorial

5. Question 5. What Is Algol ?

Answer :

ALGOL (ALGOrithmic Language) is one of several high level languages designed specifically for programming scientific computations. It started out in the late 1950's, first formalized in a report titled ALGOL 58, and then progressed through reports ALGOL 60, and ALGOL 68. It was designed by an international committee to be a universal language. Their original conference, which took place in Zurich, was one of the first formal attempts to address the issue of software portability. ALGOL's machine independence permitted the designers to be more creative, but it made implementation much more difficult. Although ALGOL never reached the level of commercial popularity of FORTRAN and COBOL, it is considered the most important language of its era in terms of its influence on later language development.

ALGOL's lexical and syntactic structures became so popular that virtually all languages designed since have been referred to as "ALGOL – like"; that is they have been hierarchical in structure with nesting of both environments and control structures.

AWT (Abstract Window Toolkit) Interview Questions

6. Question 6. What Is Non-determinism And Determinism And What Is The Difference Between Them ?

Answer :

Determinism means that our computational model (machine) knows what to do for every possible inputs. Non determinism our machine may or may not know what it has to do on all possible inputs.

As you can conclude from above definition that Non-Deterministic machine can not be implemented (used) on computer unless it is converted in Deterministic machine.

7. Question 7. What Is Meant By Equivalent Fa's ?

Answer :

FA's that accept the same set of languages are called Equivalent FA's.

8. Question 8. What Is The Difference Between Palindrome And Reverse Function?

Answer :

It is to be denoted that the words of PALINDROME are called palindromes.

Reverse = w

Example: Σ={a,b},

PALINDROME={Λ , a, b, aa, bb, aaa, aba, bab, bbb, ...}

If a is a word in some language L, then reverse (a) is the same string of letters spelled backwards, called the reverse of a.

the machine carry no further structure. This kind of model is very widely used in the study of computation and languages.

14. Question 14. What Is The Difference Between Fa , Tg , Gtg. ?

Answer :

In every FA, we mark transitions with single letter of the given alphabet but in TG transitions can be marked with letters or strings (combination of letters).

In every FA, every state shows transition for all letters of given alphabet but in any TG it is not necessary to show all transition for all letters of given alphabet. In TG, we may or may not show all letter transitions according to requirement. We can also show transitions on reading any strings in TGs but it is not possible in FA's. In GTG Directed edges connecting some pair of states are labeled with regular expressions . It may be noted that in GTG, the labels of transition edges are corresponding regular expressions. In TG we write strings and in GTG we are bound to write RE. Every FA is also a TG but not every TG is FA.

15. Question 15. What Is The Difference Between Fa's And Tg's .why We Need Tg's When We Have Fa's?

Answer :

The Transition Graphs (TG) differ from FA in the following areas

- TG's are generalizations of FA's.
- TG's can change state without an input (Null transition).
- Can read more than one letter (words of the language they are accepting) along the transition edges at a time.
- Can have a regular expression as a edge label.
- Can have more then one start state.

We have been given more freedom in TG's. But this freedom is on the cost of more memory and processing power it means that if we implement TG's on computer using some programming language it will need more memory and processing power of computer than used in the implementation of FA's.

16. Question 16. What Is The Concept Of The Union Of Fa's ?

Answer :

When we take Union of two FA's it means that resultant FA's should accept all the words that were accepted by the two FA's individually. It is like taking union of two sets, the resultant set contain members of both sets.

For example

Let A ={1,3,5,7,9}

and

B = {0,2,4,6,8,10}

then. A U B = { 0,1,2,3,4,5,6,7,8,9,10 }

you can see that A U B contain elements of both sets similar is the case with FA's.

17. Question 17. What Is The Difference Between Is Tg And Gtg ?

Answer :

In FA there must be transition from each state for each letter (deterministic) while in TG there may be no transition for specific letter from a state and there may be more than one path for a string or letter from a state.

24. Question 24. What Is The Exact Definition Of Fa ?
Answer :
Definition: A Finite automaton (FA), is a collection of the followings

- Finite number of states, having one initial and some (maybe none) final states.
- Finite set of input letters (Ó) from which input strings are formed.
- Finite set of transitions i.e. for each state and for each input letter there is a transition showing how to move from one state to another.

25. Question 25. What Is The Concept Of Nondeterministic Finite Automaton (nfa) ?
Answer :
Nondeterminism plays a key role in the theory of computing. A nondeterministic finite state automaton is one in which the current state of the machine and the current input do not uniquely determine the next state. This just means that a number of subsequent states (zero or more) are possible next states of the automaton at every step of a computation. Of course, nondeterminism is not realistic, because in real life, computers must be deterministic. Still, we can simulate nondeterminism with deterministic programs. Furthermore, as a mathematical tool for understanding computability, nondeterminism is invaluable.

As with deterministic finite state automata, a nondeterministic finite state automaton has five components.

- a set of states
- a finite input alphabet from which input strings can be constructed
- a transition function that describes how the automaton changes states as it processes an input string
- a single designated starting state
- a set of accepting states

The only difference lies in the transition function, which can now target subsets of the states of the automaton rather than a single next state for each state, input pair.

26. Question 26. If A Language Can Be Expressed In The Form Of Fa Than Why It Is Needed To Use Nfa ?
Answer :
NFA stands for non-deterministic FA and this sort of structure has relaxation compared with FA. So it is rather more easy to represent a language using NFA.

We have methods to convert NFA into FA's so sometimes it is easier to build NFA of a given language and than convert its NFA into FA using these methods rather than directly building an FA for a language which may be very difficult.

27. Question 27. How To Made Nfa Corresponding To The Closure Of An Fa ?
Answer :

aaaaaaB , aabbaaaA , A.

Question 32. What Is The Difference Between Derivation Tree And Total Tree ?
Answer :
A Derivation tree is the one that shows how to derive any specific word of the language described by CFG but Total Language Tree shows all words of the Language described by CFG on it.

Question 33. What Does Mean The Language Is Closed?
Answer :
When we say that a Language is closed it is always with respect to certain operation.

A simple example may be that the set of integers is closed under addition. It means when we take two numbers from set of integer's say 3, 7 the result of their addition would also be in the set of integers.

Similarly if the result of an operation on the words of a language results in the word of the same language we say that the language is closed under that operation.

Question 34. What Are The Productions?
Answer :
Productions are the grammatical rules and regulations. These rules express the behavior of CFG. Using production in CFG terminals are converted into non-terminals and when all the terminals are converted using productions, a word is acquired.

Question 35. What Is The Difference Between Concatenation And Intersection Of Two Fa's Also What Is The Difference Among Union Of Two Fa's And Addition Of Them?
Answer :
In intersection of two FA's only those strings are accepted which are independently accepted by both FA's, while in concatenation of two FA's only those strings will be accepted in which first part of string is accepted by first FA and remaining part of string is accepted by the second FA.

While taking union of two FA's one can represent it using + sign. So (FA1 U FA2) and (FA + FA2) both are same. There is no difference between them.

Question 36. Is It Possible To Make Cfg For Infix And Post-fix Expression's Using Derivation Tree ?
Answer :
Derivation tree is only used to derive words of language that is described by a CFG. Yes, we can create CFG for languages infix expressions, postfix expressions.

Question 37. What Is The Uses Of Push Down Automata In Computing ?
Answer :
PDA is just an enhancement in FAs. i.e Memory is attached with machine that recognizes some language. FA is basic structure for most advanced electronic machines such as computer etc.

Question 38. What Is Difference Between Push Down Stack And Push Down Store ?
Answer :

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Department of CSE-Data Science

Faculty Course Assessment & Analysis Report (FCAAR)

COURSE : **Formal Language and Automata Theory**	DEGREE: **B.Tech** ACADEMIC YEAR : **2021-2022**
COURSE CODE: **R2022053**	YEAR: **II** SEMESTER: **II**
REGULATION: **R20**	COURSE TYPE: **REGULAR**
Faculty Name: **N.Madhavi Latha**	Designation: **Assistant Prof**
CREDITS: **3**	Target attainment: **%**

Course delivery methods: Black board, Power point presentations, quizzes, Assignments, Tutorials, videos, internal seminars.

Course Outcomes:

CO1 : Design automata for any given pattern

CO2 : Specify regular expression of string pattern

CO3 : Write context free grammar for any language

CO4 : Design PDA for the given language

CO5 : Apply Turing machine to propose computation solutions

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JUSTIFICATION FOR CO-PO-PSO CORRELATION:

JUSTIFICATION FOR CO-PO MAPPING

MAPPING	Slight1 / Moderate-2 / Strong-3	JUSTIFICATION
C224.1-PO1	3	Graduate is made
C224.1-PO2	2	Graduate is able /achieve
C224.1-PO3	2	Graduate is able /achieve
C224.1-PO4	1	Graduate attains
C224.2-PO1	3	Graduate is made
C224.2-PO2	1	Graduate attains
C224.2-PO3	2	Graduate is able /achieve
C224.2-PO4	1	Graduate attains
C224.3-PO1	2	Graduate is able /achieve
C224.3-PO2	2	Graduate is able /achieve
C224.3-PO3	2	Graduate is able /achieve
C224.4-PO1	3	Graduate is made

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ESTD : 2008

Department of CSE-Data Science

Course Outcome-Program Outcome (CO-PO) matrix:

The CO-PO matrix pertaining to this course is given in Table.1.

Table.1 CO-PO matrix

PO / CO	FLAT	2017-2018	4	0	0	3	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO 1	PSO 2
C223.1	Design automata for any given pattern						3	2	2	1	-							1		
C223.2	Specify regular expression of string pattern						3	2	2	1	-							1		
C223.3	Write context free grammar for any language						3	3	3		-									
C223.4	Design PDA for the given language						3	2	2	1	-									
C223.5	Apply Turing machine to propose computation solutions						3	2	3	1	-									
TOTAL							15	11	12	4										
No of Co's Mapping With Po/Pso							5	5	5	4										
Average							3	2.2	2.4	1										

[1-Slight (low), 2-Moderate (Medium), 3-Substantial (High)]

Course Outcome-Program Specific Outcome (CO-PSO) matrix:

Department of CSE-Data Science

The CO-PSO matrix pertaining to this course is given in Table.2.

Table.2 CO-PSO matrix

Course	PSO1	PSO2
CO1		
CO2		
CO3		
CO4		
CO5		
CO6		
Average		

[1-Slight (low), 2-Moderate (Medium), 3-Substantial (High)]

ASSESSMENT OF COURSE OUTCOMES

After the completion of the course, the course assessment is evaluated using the following methods

I. **Mid exams,**
II. **End exams, and**
III. **Course end survey (by feedback)**

Mid exams:

The weightage of mid marks for 25 consists of subjective (descriptive) – 15, objective -10, (Conducted by university through on line system at College level with 20 Multiple choice questions with a weightage of 0.5 Mark each). The objective examination is for 20 minutes duration. The subjective examination is for 120 minutes duration. Each subjective type test question paper shall contain 4 questions and all questions must be answered. As the syllabus is framed for 6 units, the 1st mid examination (Subjective and Objective) is conducted on 1-3 units and second mid examination on 4-6 units of each subject in a semester.

ANALYSIS

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I. MID examinations

The assessment of attainment of course outcomes in MID exams is performed by considering bench mark percentage of attainment of COs is of minimum 15% .

The percentage of assessment of COs for internal examinations is tabulated in Table.3.

Table.3 Assessment of course outcomes in MID examinations

MID-1:

Course outcome	CO1		CO2		CO3	
Number of attained	115	118	115	118	116	118
Number of attempted	116	118	116	118	116	118
Percentage	98.3		98.3		99.14	

MID-2:

Course outcome	CO4		CO5		CO6	
Number of attained	114	118	116	118		118
Number of attempted	116	118	116	118		118
Percentage	97.43		99.14			

COURSE OUTCOME ASSESSMENT

Course outcomes	**MID1**	**MID-2**
CO1	98.3	
CO2	98.3	
CO3	99.14	
CO4		97.43
CO5		99.14

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Number of attained	84
Number of attempted	116
Percentage	72.41

COURSE OUTCOME ASSESSMENT

Course outcomes	**END EXAM**
CO1	72.41
CO2	72.41
CO3	72.41
CO4	72.41
CO5	72.41

V. Course end survey (by feedback):

The assessment of attainment of course outcomes is performed by taking feedback (based on understanding of subject, quality of teaching, and coverage of syllabus) from the students after completion of each semester. The details of survey are tabulated in Table.6.

Table.6 Assessment of course outcomes using course end survey

Course outcomes	Number of Students						Attainment Percentage
	Participated	Poor(1)	Satisfactory (2)	Good (3)	Very Good(4)	Excellent(5)	
CO1	116	0	8	40	51	17	93.11
CO2	116	1	5	42	53	15	94.83
CO3	116	0	4	44	50	18	96.56
CO4	116	0	5	40	53	18	95.69
CO5	116	1	5	49	47	14	94.83

VI. Course outcomes final assessment:

The final assessment of attainment of course outcomes are performed using the below formula. The results of MID, End examination and Course end surveys as shown in Table.7.

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Course Outcome Assessment $= \sum$ (Direct Assessment + Indirect Assessment)

Table.7 Final assessment of course outcomes attainment

CO No	DIRECT ASSESSMENT					MID	END	DIRECT	INDIRECT	%FINAL ATTAINMENT	Target	Status
	MID1	OBJ-1	MID-2	OBJ-1	END EXAMS	25%	75%					
CO1	98.3	14.5			72.41	22.54	54.30	85.54	93.11	83.79	80	YES
CO2	98.3	14.5			72.41	22.54	54.30	85.54	94.83	83.92	80	YES
CO3	99.14	14.5			72.41	21.98	54.30	84.98	96.56	83.39	80	YES
CO4			97.4[illegible]	17.05	72.41	20.45	54.30	83.46	95.69	81.79	80	Y[illegible]
CO5			99.14	17.05	72.41	19.15	54.30	82.15	94.83	81.31	80	YES

VII. Attainment of Program Outcomes:

The final attainment status of course outcome with respect to program outcomes is given in Table.8, with respect to program specific outcomes is given in Table.9.

Table.8 Status of CO-PO final attainment

Details	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2.91	2.91	2.91	2.328	2.328	-	-	-	-	-	-	2.32
CO2	2.91	2.9[illegible]	2.91	2.3	2.32	-	-	-	-	-	-	2.32
CO3	2.91	2.9[illegible]	2.91	2.328	2.32	-	-	-	-	-	-	2.32
CO4	2.9	2.9	2.9	2.9	2.32	-	-	-	-	-	-	2.32
CO5	2.75	2.7[illegible]	2.75	2.75	2.75	-	-	-	-	-	-	2.2
CO FINAL	**2.83**	2.8[illegible]	2.83	**2.61**	**2.54**	-	2	2	2	-	-	2.33
Target attainment	3	3	3	2.63	2.5	-	2	2	2	-	-	2.13

Table.9 Status of CO-PSO final attainment

Details	PSO1	[illegible]2
CO1	2.32	[illegible]2

CO2	2.32	[illegible]
CO3	2.91	[illegible]
CO4	2.9	[illegible]
CO5	2.2	[illegible]
CO FINAL	**2.55**	[illegible]
Target attainment	2.5	[illegible]

Conclusion:

All the course outcomes are attained for the academic year 2017-18. where the target is set to 80%. For the next academic year the targets are redefined to 85% which is 5% higher than previous year.

Course Instructors **Course Coordinator** **Program Coordinator**

1.

2.

Head of the Department

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PLAN OF ACTION TO IMPROVE CO ATTAINMENT NEXT TIME

COURSE : **Formal Language and Automata Theory**	DEGREE : **BTECH** ACADEMIC YEAR : **2021-2022**
COURSE CODE: **R2022053**	YEAR: **II** SEMESTER: **II**
REGULATION: **R20**	COURSE TYPE: **REGULAR**
Faculty Name: N.Madhavi Latha	**Designation: Assistant Prof**
CREDITS: **3**	**Target attainment: %**

Conclusion:

All the course outcomes are attained for the academic year 2018-19. where the target is set to 85%. For the next academic year the targets are redefined to 90% which is 5% higher than previous year.

Course Instructors **Course Coordinator** **Program Coordinator**

1.

2.

Head of the Department

MANAGEMENT AND ORGANIZATION BEHAVIOUR

COURSE FILE

I MBA I SEMESTER

2022 - 2023

Prepared by

Dr. R. PURNA CHANDRARAO

Professor

Department of MBA

Department of Master of Business Administration

Malineni Lakshmaiah Women's Engineering College

Guntur

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CONTENTS OF COURSE FILE

S.NO	CONTENTS	AVAILABLE/ NOT AVAILABLE
1	V/M	Available
2	Course syllabus including course structure	Available
3	Course outcomes	Available
4	Web Reference	Available
5	Time Table	Available
6	Course Objectives and Course Outcomes	Available
7	CO-P0 & PSO mapping with justification	Available
8	Lesson plan	Available
9	Academic Calendar	Available
10	Lecture notes	Available
11	Question bank	Available
12	Question paper	Available
13	.Mid Assignment	Available
14	Mid Papers	Available
15	Mid Marks	Available
16	Beyond Syllabus	Available
17	Semester question paper	Available
18	Result Analysis	Available

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INSTITUTE VISION AND MISSION

Institute Vision:

- To be a pioneer institute in engineering education, fostering academic excellence, and producing empowered women engineers, blended with ethics and values, to serve the society.

Institute Mission:

MI1	To achieve academic excellence through innovative teaching-learning practices.
MI2	To inculcate self-discipline, ethics and values amongst the learners.
MI3	To bridge the gap between industry and academia through the industry-institute interface.
MI4	To promote higher education, research and inculcate entrepreneurial attitude amongst the learners.

DEARTMENT VISION AND MISSION

Department Vision:

To impart quality education as well as entrepreneurial culture and to develop managerial skills of the students foe the development of society.

Department Mission:

•	To impart quality education through teaching and learning methods
•	To promote self employment through Entrepreneurship
•	To interact with the industry, educational and research organizations in the field of curriculum development and training activities.
•	To promote ethical values professionally

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I YEAR I SEMESTER

C-101	**Management and Organizational Behavior**	**100**	**4**	**0**	**0**	**4**

Objective:
Objective of the course is to give a basic perspective of Management. This will form foundation to study other functional areas of management and to provide the students with the conceptual framework and the theories underlying Organizational Behaviour.

Course Outcomes:

- Understand the key management concepts, principles and contribution by different Management thinkers & Plan, forecast and make rational decisions.
- Designing the organizational structure and development of controls.
- Influence of personality and perception in individual and group behavior.
- Identifies the need for motivation and choice of motivational theory.
- Identifies the Organizational conflict and consequences

Unit – I
Definition, Nature, Functions and Importance of Management – Evolution of Management thought – Scientific management, administrative management, Haw throne experiments – systems approach - Levels of Management - Managerial Skills - Planning – Steps in Planning Process – importance and Limitations – Types of Plans - Characteristics of a sound Plan - Management By Objectives (MBO) - Techniques and Processes of Decision Making - Social Responsibilities of Business

Unit-II
Organizing – Principles of organizing – Organization Structure and Design – Types of power - Delegation of Authority and factors affecting delegation – Span of control – Decentralization – Line and staff structure conflicts - Coordination definition and principles - Emerging Trends in Corporate Structure – Formal and Informal Organization- Nature and importance of Controlling, process of Controlling, Requirements of effective control and controlling techniques.

Unit – III
Organizational behavior: Nature and scope – Linkages with other social sciences – Individual roles and organizational goals – perspectives of human behavior - Perception– perceptual process – Learning - Learning Process- Theories - Personality and Individual Differences - Determinants of Personality - Values, Attitudes and Beliefs - Creativity and Creative thinking.

Unit – IV

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Motivation and Job Performance – Content and process Theories of Motivation - Leadership - Styles - Approaches – Challenges of leaders in globalized era – Groups – stages formation of groups – **Group Dynamics** - Collaborative Processes in Work Groups - Johari Window-Transactional Analysis.

Unit – V:

Organizational conflict-causes and consequences-conflict and Negotiation Team Building, Conflict Resolution in Groups and problem solving Techniques – Organizational change - change process - resistance to change - Creating an Ethical Organization.

Relevant cases have to be discussed in each unit and in examination case is compulsory from any unit.

References Books:

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3. Kumar, Rao, Chhaalill "Introduction to Management Science" CengagePublications,New Delhi
4. V.S.P.Rao, Management Text and Cases, Excel, Second Edition, 2012.
5. K.Anbuvelan, Principles of Management, University SciencePress,2013.
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W2	Jacob Morgan, "5 Qualities of the Modern Manager," *Forbes,* July 23, 2013, https://www.forbes.com/sites/jacobmorgan/2013/07/23/5-must-have-qualities-of-the-modern-manager/#644a2b6a3a0b.

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(Approved by AICTE, Affiliated to JNTUK)
(An ISO9001:2008 Certified Institution)
Pulladigunta (Village), Vatticherukuru (Mandal),
Guntur-522017, Andhra Pradesh, India
Department of Master of Business Administration

COURSE OBJECTIVES & OUTCOMES

COURSE : **Management and Organization Behaviour**	DEGREE: **MBA**
COURSE CODE: C-101	YEAR: **I** SEMESTER: **I**
REGULATION: **R19**	COURSE TYPE: **REGULAR**
ACADEMIC YEAR:**2022-2023**	CREDITS: **4**

Course Objectives:

1. To identify the objectives, nature, scope, role & responsibilities of a manager and Management.
2. To gain the knowledge on levels of management and evolution of Management.
3. To explain the relevant theories of Classical and Neo Classical and Modern system. .
4. To know the knowledge on Organization and Behavior.
5. To identify the different structures of Management.
6. To know the meaning, importance, sources, & usage of Motivation.
7. To identify the conflict in organization.

COURSE OUTCOMES:

Students will be able to:

COURSE CODE	COURSE OUTCOME
C101.1	Understand the key management concepts, principles and contribution by different Management thinkers & Plan, forecast and make rational decisions
C101.2	Designing the organizational structure and development of controls.
C101.3	Influence of personality and perception in individual and group behaviour.
C101.4	Identifies the need for motivation and choice of motivational theory.
C101.5	Identifies the Organizational conflict and consequences.

Course Instructor **HOD**

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WOMEN'S ENGINEERING COLLEGE
PULLADIGUNTA, GUNTUR- 522017.

Website: www.jntuk.edu.in
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Phone: 7032894555

Directorate of Academics and Planning

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY KAKINADA
KAKINADA-533003, Andhra Pradesh, INDIA
(Established by AP Government Act No. 30 of 2008)

Lr. No. JNTUK/DAP/AC/I Year/MCA/2022-23 *Date: 23-10-2022*

Dr. KVSG Murali Krishna,
M.E. Ph.D.,
Director, Academics & Planning
JNTUK, Kakinada

To
All the Principals of Affiliated Colleges,
JNTUK, Kakinada.

Academic Calendar of I Year MBA/MCA for Academic year 2022-23

I SEMESTER			
Description	**From**	**To**	**Weeks**
Commencement of Class Work	25.10.2022		
Induction Classes	25.10.2022	29.10.2022	1W
I Unit of Instruction	31.10.2022	24.12.2022	8W
I Mid Examinations	19.12.2022	24.12.2022	
II Unit of Instructions	26.12.2022	18.02.2023	8W
II Mid Examinations	13.02.2023	18.02.2023	
Preparation & Practicals	20.02.2023	25.02.2023	1W
End Examinations	27.02.2023	11.03.2023	2W

KVSG 23/10/22

Director
Academics & Planning
JNTUK

Director
Academic Planning
JNTUK Kakinada

Copy to the Secretary to the Hon'ble Vice Chancellor, JNTUK
Copy to Rector, JNTUK
Copy to Registrar, JNTUK
Copy to Director Academic Audit, JNTUK
Copy to Director of Evaluation, JNTUK

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Malineni Lakshmaiah Women's Engineering College :: Guntur
(Approved by AICTE, Affiliated to JNTUK, Kakinada)

DEPARTMENT OF MASTER OF BUSINESS ADMINISTRATION

****

Department Academic Calendar (AY: 2022-23, I- SEMESTER

Department Academic Calendar (AY: 2022-23, I- SEMESTER)

S. No	Academic Schedule	Date
1	Commencement Of Class Work	25-10-2022.
	Induction Classes	25-10-2022 to 29-10-2022
2	I Unit Of Instructions	31-10-2022 To 17-12-2022.
3	I Mid Examinations	19-12.2022 To 24-12-2022
4	II Unit Of Instructions	10.10.2016 To 03.12.2022.
5	II Mid Examinations	26-02-2022 To 18-02-2023
6	Preparation & Practical's	20-02.2023 To 25-02-2023.
7	End Examinations	2-02-2023 To 11-03-2023.
S. No	**Department Events**	**Tentative Month & Date**
1	Staff meeting and class allocation	I week of October '2022
2	Fresher's Day celebrations	III week of October'2022
3	Staff Meeting & Subject syllabus completion status	III week of December'2022
4	REPUBLIC DAY CELEBRATIONS	26TH Jan' 2023
5	Staff Meeting & Subject syllabus completion status	III week off Fbruary'2023

HOD

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WOMEN'S ENGINEERING COLLEGE
PULLADIGUNTA, GUNTUR-522017.

MALINENI LAKSHMAIAH WOMEN'S ENGINEERING COLLEGE

Department of MBA

Time Table

Class: I Year, MBA   AY/ Semester: 2022-23 / I   W.E.F-25-10-2022

	I 9:00-9:50	II 9:50 -10:40	10:40-10:50	III 10:50-11:40	IV 11:40-12:30	12:30-1:20	V 1:20-2:10	VI 2:10-3:00	VII 3:00-3:50
MON	AFM	MOB	BREAK	ME	QABD	LUNCH	LBE	RIP	SPORTS
TUE	LBE	ME		RIP	QABD		IT-LAB		LIB
WED	RIP	LBE		MOB	AFM		MOB	ME	ACTIVITY
THU	MOB	QABD		LBE	BC&SS		RIP	BC&SS	LIB
FRI	ME	LBE		QABD	BC&SS		AFM	BC&SS	SPORTS
SAT	QABD	MOB		AFM	AFM		SEMINARS		

CLASS I/C   H.O.D   PRINCIPAL

MOB- DR.R.PURNA CHANDRA RAO
QABD- MVL NARAYANA
BC&SS- B. SRAVYA

AFM- G.BAJI
ME- I.NAGA JYOTHI
RIP- B.NAGA SHYAMALA

LBE- SK SHAKEEL AHAMED
IT LAB- D.U.DURGA RANI

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WEB REFERENCES

COURSE : **Management and Organization Behaviour**	DEGREE: **MBA**
COURSE CODE: C-101	YEAR: **I** SEMESTER: **I**
REGULATION: **R19**	COURSE TYPE: **REGULAR**
ACADEMIC YEAR:**2022-2023**	CREDITS: **4**

WEB REFERENCES:

W1	"The Future of Computing," *The Economist*, March 12, 2015, https://www.economist.com/leaders/2016/03/12/the-future-of-computing.
W2	Jacob Morgan, "5 Qualities of the Modern Manager," *Forbes*, July 23, 2013, https://www.forbes.com/sites/jacobmorgan/2013/07/23/5-must-have-qualities-of-the-modern-manager/#644a2b6a3a0b.

Course Instructor

HOD

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Department of Master of Business Administration

PROGRAM OUTCOMES (POs):

The students will be able to:	
PO 1	Apply knowledge of management theories and practices to solve Business Problems
PO 2	Foster Analytical and critical thinking abilities for data-based decision making
PO 3	Ability to develop value-based leadership ability
PO 4	Ability to understand, Analyze and communicate global, economic, legal and ethical aspects of business
PO 5	Ability to lead themselves and others in the achievement of organizational goals, contributing effectively to a team environment

PROGRAM SPECIFIC OUTCOMES (PSOs):

The students will be able to:	
PSO1	To ensure that post-graduates get good Employment
PSO2	To make post-graduates sole traders and entrepreneurs
PSO3	To make post- graduates Pursue research work in the area of their domain

T. Arul

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Department of Master of Business Administration

MAPPING COURSE OUTCOMES (COs) with POs and PSOs:

(3 = High; 2 = Medium; 1 = Low)

COs	POs				
	PO1	PO2	PO3	PO4	PO5
CO1	3.00	3.00	2.00	3.00	3.00
CO2	3.00	3.00	2.00	3.00	3.00
CO3	3.00	3.00	2.00	3.00	3.00
CO4	3.00	3.00	2.00	3.00	3.00
CO5	3.00	3.00	2.00	3.00	3.00

Course Instructor

HOD

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ESTD : 2008

Department of Master of Business Administration

COURSE : **Management and Organization Behavior**	DEGREE: **MBA**
COURSE CODE: C101	YEAR: **I** SEMESTER: **I**
REGULATION: **R19**	COURSE TYPE: **REGULAR**
ACADEMIC YEAR:**2022-2023**	CREDITS: **4**

CO-PO MAPPING WITH REASON

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5
C101.1			1	2	
C101.2		1	2		
C101.3			1	1	
C101.4			1	2	
C101.5			1	2	
C101		1	1.2	1.4	

NOTE: Enter correlation levels 1,2 or 3 as defined below:

1. Slight (Low), 2. Moderate (medium),3. Substantial (high). It there is no correlation put "-".

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ESTD : 2008

Department of Master of Business Administration

Course Code	Mapping with PO	Reason
C101.1	PO 1	Apply knowledge of management theories and practices to solve Business Problems
C101.2	PO 2	Foster Analytical and critical thinking abilities for data-based decision making
C101.3	PO 3	Ability to develop value-based leadership ability
C101.4	PO 4	Ability to understand, Analyze and communicate global, economic, legal and ethical aspects of business
C101.5	PO 5	Ability to lead themselves and others in the achievement of organizational goals, contributing effectively to a team environment

Signature of the HOD **Signature of the Faculty**

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Department of Computer Science and Engineering

CO-PSO MAPPING

Course Code	PSO1	PSO2	PSO3	PSO4	PSO5
C101.1	2		2		
C101.2		3			
C101.3	2				
C101.4					2
C101.5		3			
C101.		3			

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CO-PSO mapping Reasons

Course Code	Mapping with PSO	Reason
C101.1	PSO1	They can able to gain Professional skills
	PSO3	The student can able to get successful career in his life
C101.2	PSO2	It helps to solve different production problems
C101.3	PSO1	The student able to gain knowledge over markets
C101.4	PSO5	By analyzing different forms of business the student apply it in his real life time
C101.5	PSO3	can able to solve different managerial problems
C101.6	PSO3	can able to solve different investment problems

Signature of Faculty

Signature of HOD

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LESSON PLAN

Faculty Name : R. Purna Chandra Rao
Course Name : Management and Organizational Behavior
Academic Year : 2022-23 I Semester
Degree & Branch : I MBA

S.No	Topic	Teaching Aid	Books
UNIT- I			
1	Basics of Management,	Chalk & Talk	T2
2	Definitions & Nature of Management	Chalk & Talk	T2
3	Scope of Management	Chalk & Talk	T2
4	Functions of Management	Chalk & Talk	T2
5	Nature & Significance of Management	Chalk & Talk	T2
6	Evolution of Management thought	Chalk & Talk	T2 R3
7	Scientific management Principles	Chalk & Talk	T2
8	Administrative management	Chalk & Talk	T2 T3
9	Haw throne experiments, systems approach	Chalk & Talk	T2
10	Levels of Management ,Managerial Skills	Chalk & Talk	T2 T3
11	Managerial Skills	Chalk & Talk	T2
12	Planning: Introduction	Chalk & Talk	T3 T2
13	Steps in Planning Process	Chalk & Talk	R2
14	Types of Plans & Characteristics of a sound Plan	Chalk & Talk	T2
15	Management By Objectives (MBO)	Chalk & Talk	T2
16	Techniques Decision Making	Chalk & Talk	R4
17	Processes of Decision Making	Chalk & Talk	T2
18	Social Responsibilities of Business	Chalk & Talk	T2

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	UNIT- II: Organizing		
1	Organizing: Introduction	Chalk & Talk	R4
2	Principles of organizing	Chalk & Talk	T6
3	Organization Structure and Design	Chalk & Talk	T6
4	Organization Structure and Design	Chalk & Talk	T2
5	Types of power , Span of control	Chalk & Talk	T2
6	Decentralization	Chalk & Talk	T2
7	Line and staff structure conflicts	Chalk & Talk	T6
8	Coordination definition and principles	Chalk & Talk	T2 R2
9	Emerging Trends in Corporate Structure	Chalk & Talk	T2
10	Formal and Informal Organization	Chalk & Talk	T2
11	Nature and importance of Controlling	Chalk &Talk	T2
12	process of Controlling	Chalk & Talk	T2
13	Requirements of effective control and controlling techniques	Chalk & Talk	T2
	UNIT- III: Organizational behavior		
1	Organizational behavior: Introduction	Chalk & Talk	T1
2	Nature and scope	Chalk & Talk	T1
3	Linkages with other social sciences	Chalk & Talk	T1
4	Individual roles and organizational goals	Chalk & Talk	T1
5	perspectives of human behavior	Chalk & Talk	T6
6	perceptual process	Chalk & Talk	T6
7	Learning	Chalk & Talk	T2
8	Learning Process	Chalk & Talk	T2
9	Learning Theories	Chalk & Talk	T2
10	Personality and Individual Differences	Chalk & Talk	T6
11	Determinants of Personality	Chalk & Talk	T6
12	Values, Attitudes and Beliefs	Chalk & Talk	T6
13	Creativity	Chalk & Talk	T6
14	Creative thinking	Chalk & Talk	T2 R6
	UNIT- IV: Motivation and Job Performance		
1	Motivation and Job Performance: Introduction	Chalk & Talk	T6
2	Content and process Theories of Motivation	Chalk & Talk	T6

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3	Content and process Theories of Motivation	Chalk & Talk	T6
4	Leadership	Chalk & Talk	T1
5	Leadership - Styles	Chalk & Talk	T2
6	Leadership Approaches	Chalk & Talk	T2
7	Challenges of leaders in globalized era	Chalk & Talk	T5
8	stages formation of groups	Chalk & Talk	T5
9	Group Dynamics	Chalk & Talk	T5
10	Collaborative Processes in Work Groups	Chalk & Talk	T5
11	Johari Window	Chalk & Talk	T5
12	Transactional Analysis	Chalk & Talk	T5
	Unit – V: ORGANIZATIONAL CONFLICT		
1	Organizational conflict	Chalk & Talk	T2
2	causes and consequences	Chalk & Talk	T2
3	conflict and Negotiation Team Building	Chalk & Talk	T2
4	Conflict Resolution in Groups and problem solving Techniques	Chalk & Talk	T2
5	Organizational change	Chalk & Talk	T2
6	change process	Chalk & Talk	T4
7	resistance to change	Chalk & Talk	T4
8	Creating an Ethical Organization.	Chalk & Talk	T1
9	Seminar	Chalk & Talk	

TEXT BOOKS:

References Books:

1. Harold Koontz, Heinz Weihrich, A.R.Aryasri, Principles of Management, TMH, 2010.
2. Dilip Kumar Battacharya, Principles of Management, Pearson, 2012.
3. Kumar, Rao, Chhaalill "Introduction to Management Science" CengagePublications,New Delhi
4. V.S.P.Rao, Management Text and Cases, Excel, Second Edition, 2012.
5. K.Anbuvelan, Principles of Management, University Science Press,2013.
6. K.Aswathappa " Organisational Behaviour- Text, Cases and Games",Himalaya Publishing House, New Delhi,2008.
7. Steven L Mc Shane, Mary Ann Von Glinow, Radha R Sharma:"Organisational Behaviour", TMH Education, New Delhi,2008

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Signature of the faculty **Head of the department**

UNIT-1

Introduction of Management

Introduction:

One of the mostimportant activities in business is the management of the 4M's i.e., money, machine, material and methods. The term management can be interpreted differently in different contexts. Hence, it is difficult to define. In one context, it may comprisethe activities of executives and administrative personal in an organization, while in another; it may refer to a system of getting things done. In a broad perspective, management can be considered as a proper utilization of people and other resources in an organization to accomplish desired objectives. With increasing global competition, changes in the world of technology, change in business practices and increasing social responsibility of organizations the role of managers has became all more significant.

Meaning of management:

Management is an art of getting things done by a group of people with the effective utilization of available resources. An individual cannot be treated as a managing body running any organization. A minimum of two persons are essential to perform management. These persons perform the functions in order to achieve the objectives of an organization.

Definition of management:

According to:

- "Henry Fayol", to manage is to forecast plan to organize, to command, to co-ordinate and control.
- "Louis Allan", Management is what manager does.
- "Ross Moore", Management means decision making.
- "Koontz", Management is an art of getting things done through and with an informally organized group.
- "Donald J. clough", Management is an art and science of decision making and leadership.

Characteristics/Nature of management:

- Management is group activity.
- Management is group oriented.
- Management establishes the factors of production men, money, markets, methods, machinery, materials, maintenance and modernization.
- Management is universal in character.

- Management is art as well as science.
- Management is a profession.
- Management is separate from ownership.
- Management is a social process.
- Management is getting things done.
- Management is necessary for all types of organization.

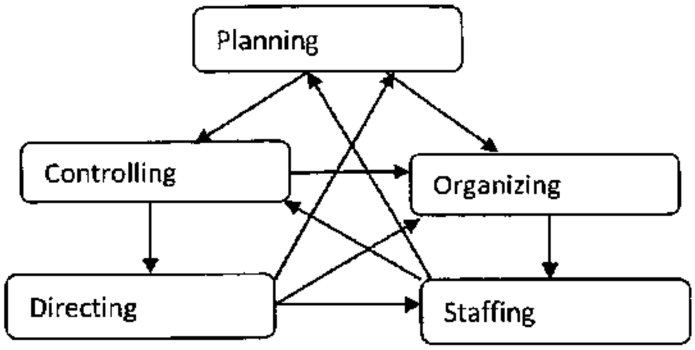
Importance/ Significance of management:

Management is an art of securing maximum prospectivity with the minimum of effort. The words of koontz o' donnel there is no more important area of human activity than management since its tasks is that of getting things done through others. Peter f. drucker quoted,"Management is a dynamic life giving element in an organization. In its absence resources of production remain resources and never became production. The following points further highlight importance of management:

- Achievement of group activities: Management makes the people realize the objectives of group and directs their efforts towards their achievement of the objectives. The management brings the human and the material sources together to mobilize the people for the achievement of organization objectives.
- Optimum utilization of resources: Any business activities can be undertaken these five factors. They are: land, labour, capital and enterprise. The management makes optimum utilization of resources is available.
- Minimization of cost: In the present days of increasing competition only those business enterprises can survive which can produce quality products at lower cost. It can be possible through better planning, sound organization and effective control.
- Increasing Profits: Profits can be increased in any organization either by increasing sales revenues of reducing costs. Sales revenue depends on capacity of organization. Management by reducing the cost and increase its profits and provides opportunity for future growth and development.
- Smooth running of business: Management ensures efficient and smooth running of business through better planning, and sound organization and effective control.
- Innovation: New ideas are developed by the management and implemented in the organization. Better performance is achieved through new ideas.
- Accomplishment of group goals: The achievement of objectives of business depends upon three factors------- The proper planning of an available resource, adjusting possibility, decision making.
- Social benefits: Management is beneficial not only to the business enterprises but also to the society. It raises the standard of giving of people by providing good quality of goods and services at lowest possible cost.

Functions of management:

The general functions of management are:



Different contributors are given different functions of management.

According to "Luther gullick",

- Planning
- Organizing
- Staffing
- Directing
- Co-coordinating
- Reporting
- Budgeting
- Planning: Planning is a first and foremost function of management. Planning can be defined as the process, by which manager decide the machine and objective of the firm and take necessary steps to achieve the desired objectives. At the same time, managers need to determine the future trends in business and in corporate change and innovation into the organization from time to time.

- Organizing: It is the process of dividing work in convenient tasks or duties, of grouping such duties in the form of posts, of delegating authority to each. So that work is carried as planned.

- Staffing: Staffing is better known as "Human resource management" and involves manning or filling various positions in the organizational hierarchy. Activities like determine manpower requirements, assessing the number of people presently available in the organization come under the purview of staffing.

- Directing: Directing defines as "the management function of influencing, motivating and leading people towards the achievement of organization goals.

- Controlling: The final step in the management process is to monitor the progress of an organization towards its goals. Controlling can be defined as the continuous measurement and analysis of actual operations against the established industry standards developed during the planning process and corrections of deviations if any.

Challenges of management:

Change is an important feature of modern organizations. Significant changes take place every day in social, technology, political and other aspects of modern world. These changes create new challenges and opportunities for the managers. No managers can afford to ignore these changes; rather than he has to make use of them to his advantage. In other words he has no options, but to accept the challenges.

The important areas which create challenges for the management are:

- Changes in social environment.
- Changes in economic environment.
- Changes in technological environment.
- Changes in political environment.
- Changes in International environment.
- **Changes in social environment**: Social factors which will shape the management strategies are as follows:
    - Population explosion: Population is increasing rapidly. The population will require new jobs, new methods of production and distribution and new modes of living. It also increases average life span.
    - Educational level: The governments of various countries are taking steps to eradicate illiteracy and to increase the education level of their citizens.
    - Leisure time: People will utilize the leisure time within working hours and increasing growth of the organization.
    - Public opinion: Public opinion about business will shape the attitudes of future managers. If the people have distrust in the market system, they will prefer government controls to growing competition.
- Changes in economic environment: The degree of resource exploitation will have a direct bearing on the economic environment and through this on the business. As it is obvious from the present trends, environment will not remain confined to land only, but would extent to oceans and space also.

- Changes in technological environment: Technological changes will effect management in the future. In future, all big organizations will be actively engaged in technological forecasting.
  - Automation: Automation has created new problems; jobs have become routinized and unchallenging. Introduction to industrial roots has created a feeling of job insecurity among workers.
  - Information technology: There will be a remarkable impact of computerized information systems on management. The impact of IT on management are follows:
    - There will be use of electronic to collect and process data.
    - Computers will help applications of quantitative techniques to management problems.
    - There will be simulations of higher order thinking through computer programs.
- Changes in political environment: There will be greater government's interference in business to safeguard the interests of workers, consumers and the public at large. Government participation will also pose May challengers before management.
- Changes in International environment: Multilateral trade among the nations will increase. The role of IMF, World Bank and other international institutions will change a new economic order will take place leading to globalization of economies. The international organizations will continue for the following reasons:
  - Transfer of technical know-how.
  - Resources advantages.
  - Fast communication & transport system.

Managing people and organizations in the context of new era:

Changes in management techniques are so wide and their consequences so far reaching that the modern age in known as the age of 'Managerial revolution'. In yester year, manager was also the owner of the industry; today there is complete discover between three factors- investors, workers and managers. Management today stands as an independent and very important factor of production.

To meet the forthcoming challenges, the manager will have to develop new principles, techniques and practice and modify the existing ones.

- Adoption of contingency approach
- Management of information
- Involvement in community affairs

- Management of human relations
- Forecasting trends.
- Adoption of contingency approach: The contingency approach to managers and management is based upon the major premise that there is no one best way to handle any of the management problems. The application of management techniques, principles and practices should be contingent upon the existing environment. There are three major parts of the overall conceptual framework for contingency management, namely:
    - Environment
    - Management concepts, principles and techniques
    - Contingent relationship between the two elements.
- Management of information: The important question here is how the future managers will use information technology for furthering the objectives of the enterprise. They will have to design management information system to suit their organizations.
- Involvement in community affairs: The need to deal with conflicting interest groups will mean that the future manager must sharpen his politic skills and ability. He will have to try to satisfy every group in order to have favorable public opinion.
- Management of human relations: Management of human relations in the future will be more complicated than it is today. Many of the new generation of employees will be more difficult to motivate than their predecessors. This will be in part the result of change in value systems coupled with raising educational level.
- Forecasting trends: Forecasting of changes in environment became essential for effective management of resources. Today's managers function and management in an economy of ideas, referred to as the new economy. The key components that reshape the world of this economy are as follows:
    - Rise of new communication technologies
    - Globalization.
    - Knowledge and ideas management.
    - Alliance across business boundaries.

Objectives of management:

Objectives are described as the results to be achieved by an organization. Managerial objects may be defined as the goals which are predetermined which have a defined scope and the methodologies that suggest direction to the efforts of managerial personnel.

The objectives of management are:

- Economic objectives
- Human objectives
- social objectives
- organic objectives

Economic objectives:

- Profit earning: Every business organization is established with a motto to sell or make goods and services to attain a substantial profit.
- Production of good: When an organization is established to earn profits, for doing so it has to produce goods by optimal utilization of resources like money, men, material and machinery which could lead to the increase in efficiency and getting higher productivity with minimum effort and the goods produced are sold in the market.
- Creating market: All the goods produced have to be sold for doing so the market, penetrate into existing markets, increasing the market share.
- Technological improvement: The technologies used for populationand change to the new market environment and should be in a position and offer good quality good with lower price.

Social objectives:

- Availability of goods: The business organizations should ensure the supply of products to meet the requirements of the society.
- Creating job oppurtunities: Every business can help the society by creating new job oppurtunities. The business expansion will help the firm in gaining more profits and also employment to the unemployed.
- Quality of goods and services: One of the basic responsibility of the businessman is to supply quality goods and services to customers at reasonable price.

Human objectives:

- Welfare of employees: The management creating minimum and living standards of the employees.
- Customer satisfaction: The customer should be provided with good quality products at reasonable prices.
- Satisfaction of share holders: The management should give reasonable return on the money invested by the shareholders and there should be a provisions to make the share holders aware of developments and profits earned, so that we can have a satisfaction of shareholders.

Organic objectives:

- Survival: The survival becomes crucial objectives.
- Growth: To increase the business, organizational activities, to gain profits.
- Recognition: The business organizations attains recognition in society by providing better customer services, increasing market share and by caring for society and environment.

Scope of Management:

Following are the main scope of management which is applied in the area of principles of management. It consists of six boundaries of management view:

- **From activity point of view:**
- ✓ Planning
- ✓ Organizing
- ✓ Staffing
- ✓ Directing
- ✓ Controlling
- **From Functional areas of management:**
- ✓ Financial management
- ✓ Personnel management/Human resource management
- ✓ Marketing management
- ✓ Production management
- ✓ Mainatainance management
- ✓ Office management
- ✓ Development management
- ✓ Purchase management
- **Universality of management**: The concept of universality suggest management is a universal activity to gain knowledge about organization, employees and employer.
- **The three essentials of management** are:
- ✓ Human relations
- ✓ Scientific method
- ✓ Quantitative techniques
- **Modern management is an agent of change**: These techniques are improved in the research and development.

Corporate social responsibility:

Social responsibility is understood as the obligation of the decision makers, to take actions which projects and improve the welfare of society as a whole along with their own interests.

Definition: According to 'A. Berle', social responsibility is "the manager's responsiveness to public consensus".

- According to 'Keith davis', Social responsibility refers to the businessmen's decisions and actions taken for reasons at least partially beyond the firm's direct economic or technical interest.

Importance of corporate social responsibility:

Corporate social responsibility is centrally concerned with the idea that companies need to take responsibility for their actions outside of a "Profit at all cost" ethos. the importance of CSR are:

- Ethical decision making
- Appraisal of behavioral patterns
- Taking economic environment
- Compliance with law
- Human resource management practice
- Health and safety performance
- Community involvement

Areas of corporate social responsibility:

There are certain facilities to conduct CSR, they are:

- Economy and environmental quality
- Labor relations
- Community needs
- Social and governmental relations
- Business policies
- Shareholder's relations
- Economic activities
- Minority and disadvantaged persons
- Consumerism

Business firm's responsibility:

Social responsibility requires the identification of various interest groups which may affects the functioning of a business organizations and may also effected by its functioning. The responsible groups associated with a business firms are:

- Shareholder
- Customers
- Creditors
- Suppliers
- Government
- Worker
- Society

Arguments in social responsibility:

Though there is no one core idea in the argument that business has social responsibility, there are several ideas about social responsibility of the business.

- Business: Business organizations are creators of society and must respond to social demands. A business operates within a set of cultural norms and restraints.
- Avoidance of government regulations: Business cannot remain a small basis of influence in a vast desert of poverty. Increasingly those who are deprived of opportunity for lack neither of skill nor of willingness to work, will look upon the existing social order with hostility.
- Long-run self-interest of business: it is the enlightened self-interest of corporations to promote the public welfare in a positive way.
- Traditional values: In any country, economic growth is not possible without the active co-operation of people.

Arguments against social responsibility:

- Profit maximization
- Lack of social skills
- Business has enough power
- Social overhead cost
- Lack of accountability
- Lack of Board support.

Henry Fayol Administrative principles:

Henry Fayol, also known as the 'father of modern management theory' gave a new perception of the concept of management. He introduced a general theory that can be applied to all levels of management and every department. The Fayol theory is practised by the managers to organize and regulate the internal activities of an organization. He concentrated on accomplishing managerial efficiency.

The fourteen principles of management created by Henri Fayol are explained below.

1. Division of Work-

Henri believed that segregating work in the workforce amongst the worker will enhance the quality of the product. Similarly, he also concluded that the division of work improves the productivity, efficiency, accuracy and speed of the workers. This principle is appropriate for both the managerial as well as a technical work level.

2. Authority and Responsibility-

These are the two key aspects of management. Authority facilitates the management to work efficiently, and responsibility makes them responsible for the work done under their guidance or leadership.

3. Discipline-

Without discipline, nothing can be accomplished. It is the core value for any project or any management. Good performance and sensible interrelation make the management job easy and comprehensive. Employees good behaviour also helps them smoothly build and progress in their professional careers.

4. Unity of Command-

This means an employee should have only one boss and follow his command. If an employee has to follow more than one boss, there begins a conflict of interest and can create confusion.

5. Unity of Direction-

Whoever is engaged in the same activity should have a unified goal. This means all the person working in a company should have one goal and motive which will make the work easier and achieve the set goal easily.

6. Subordination of Individual Interest-

This indicates a company should work unitedly towards the interest of a company rather than personal interest. Be subordinate to the purposes of an organization. This refers to the whole chain of command in a company.

7. Remuneration-

This plays an important role in motivating the workers of a company. Remuneration can be monetary or non-monetary. However, it should be according to an individual's efforts they have made.

8. Centralization-

In any company, the management or any authority responsible for the decision-making process should be neutral. However, this depends on the size of an organization. Henri Fayol stressed on the point that there should be a balance between the hierarchy and division of power.

9. Scalar Chain-

Fayol on this principle highlights that the hierarchy steps should be from the top to the lowest. This is necessary so that every employee knows their immediate senior also they should be able to contact any, if needed.

10. Order-

A company should maintain a well-defined work order to have a favorable work culture. The positive atmosphere in the workplace will boost more positive productivity.

11. Equity-

All employees should be treated equally and respectfully. It's the responsibility of a manager that no employees face discrimination.

12. Stability-

An employee delivers the best if they feel secure in their job. It is the duty of the management to offer job security to their employees.

13. Initiative-

The management should support and encourage the employees to take initiatives in an organization. It will help them to increase their interest and make then worth.

14. Esprit de Corps-

It is the responsibility of the management to motivate their employees and be supportive of each other regularly. Developing trust and mutual understanding will lead to a positive outcome and work environment.

.FW Taylor Principles of Scientific Management

Principles of Scientific Management by Taylor:

F.W. Taylor or Fredrick Winslow Taylor, also known as the 'Father of scientific management' proved with his practical theories that a scientific method can be implemented to management. Taylor gave much concentration on the supervisory level of management and performance of managers and workers at an operational level. Let's discuss in detail the five principles of management by F.W Taylor.

1. Science, not the Rule of Thumb-

This rule focuses on increasing the efficiency of an organization through scientific analysis of work and not with the 'Rule of Thumb' method. Taylor believed that even a small activity like loading paper sheets into boxcars can be planned scientifically. This will save time and also human energy. This decision should be based on scientific analysis and cause and effect relationships rather than 'Rule of Thumb' where the decision is taken according to the manager's personal judgement.

2. Harmony, Not Discord-

Taylor indicated and believed that the relationship between the workers and management should be cordial and completely harmonious. Difference between the two will never be beneficial to either side. Management and workers should acknowledge and understand each other's importance. Taylor also suggested the mental revolution for both management and workers to achieve total harmony.

3. Mental Revolution-

This technique involves a shift of attitude of management and workers towards each other. Both should understand the value of each other and work with full participation and cooperation. The aim of both should be to improve and boost the profits of the organisation. Mental Revolution demands a complete change in the outlook of both the workers and management; both should have a sense of togetherness.

4. Cooperation, not Individualism-

It is similar to 'Harmony, not discord' and believes in mutual collaboration between workers and the management. Managers and workers should have mutual cooperation and confidence and a sense of goodwill. The main purpose is to substitute internal competition with cooperation.

5. Development of Every Person to his Greatest Efficiency-

The effectiveness of a company also relies on the abilities and skills of its employees. Thus, implementing training, learning best practices and technology, is the scientific approach to brush up the employee skill. To assure that the training is given to the right employee, the right steps should be taken at the time of selection and recruiting candidates based on a scientific selection.

What Is The Systems Approach To Management?

The systems approach to management looks at a business in the same way. We can think of an organization as a series of systems and subsystems that interact with one another to create the overall organizational system. In businesses, a system refers to a cohesive collection of resources, activities and information.

Systems theory can be found everywhere in our world. We see it in science and medicine, where it has been used to better understand the human body. In the business world, it's used to improve the performance and results of businesses.

In the systems approach to management, employees are more focused on achieving a collective goal for an organization rather than operational output.

The theory was a radical departure from classical management thinking, which viewed organizations as simple machines that could be easily understood.

Importance Of Systems Theory

Here are some areas where systems theory can be of help in a modern workplace:

1. Strategic Planning
   Understanding how an organization functions is important for managers who are involved in strategic planning. They need to know how various departments work together and affect each other. This is where the systems theory of organization is very helpful. It allows managers and other decision-makers to look at things like organizational change and organizational development from a broader perspective.

2. Managing Change
   Looking at the big picture instead of looking just at the individual functions and aspects of an organization can be a valuable tool for those who need to make changes in an organization or who want to implement new initiatives within their businesses.

3. Project Management
   With large, multi-stakeholder projects, a systems approach allows for clear planning and delegation from the outset. It helps managers account for the interdependence between different verticals in an organization and assign ownership to achieve collective goals.

In large organizations and projects, systems theory forms the basis for many popular management techniques and practices.

Features Of Systems Theory

Let's look at a few distinctive features of the systems approach to management:

1. **Holistic**

The systems approach to management focuses on a collective view of an organization. Managers are focused on making sure that all parts of the business (and sometimes outside organizations) contribute to its success as a whole.

Offers Perspective: The systems approach allows you to look at an organization from the different perspectives of its subsystems, which gives you more insight and control. Changes can be made to each of the subsystems to make a positive impact on the entire organization.

Change-Friendly: Systems theory is one approach that may be useful for those who are interested in changing their organizations, or those who are interested in implementing new programs or initiatives within businesses. It can be highly effective in order to manage change and achieve desired outcomes through the coordinated use of scientific management techniques.

Contingency leadership theory is a practice of leadership. It believes there is no singular best way to structure an organization. Instead, the best leadership style will be contingent on the situation.

Effective **leadership** is one of the most attractive qualities in an employee. There are a variety of theories that explore different **leadership styles**. Each approach has its take on what works best to boost team productivity.

The contingency viewpoint will help you to -

- Combine management approaches in the best possible way.
- Increase management's ability to align employees with the leaders.
- Focus on the concept of adaptability.

So let's take a closer look at contingency theory and its different models. We'll also explore their biggest pros and cons.

The contingency theory of leadership effectiveness states that leadership styles are dependent on the situation.

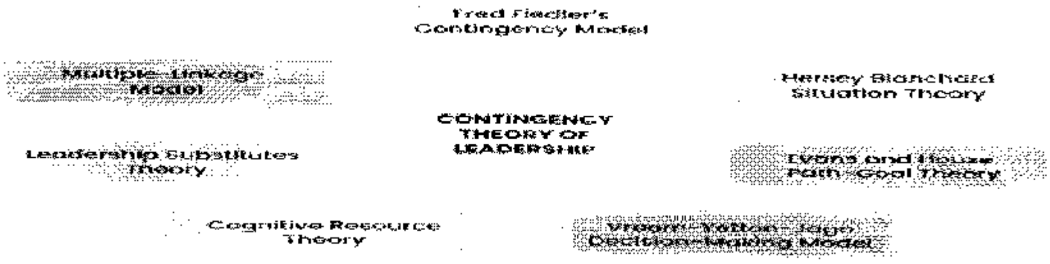
When determining distinct leadership styles, contingency theory highlights three main factors. They are as follows:

- Traits.
- Behavior.
- Situation.

Contingency theory emerged in the 1960s. It is founded on the principle that no single leadership style is appropriate for every circumstance.

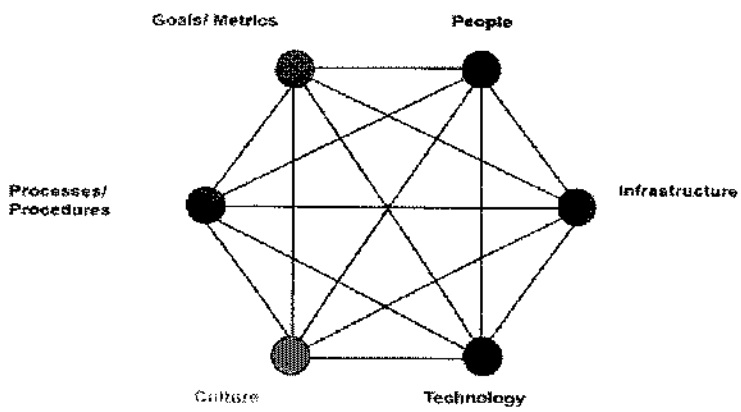
The approach emphasizes the importance of -

- The leaders' personality and,
- The situation in which that leader operates.The contingency approach to management is multifaceted and has many implications. In support of this theory, various contingency models of leadership were developed.



Socio-technical systems theory

Within the STC we adopt a systems view of organisations, represented by the hexagon. It is this hexagon that lies at the heart of our thinking. Within a socio-technical systems perspective, any organisation, or part of it, is made up of a set of interacting sub-systems, as shown in the diagram below. Thus, any organisation employs people with capabilities, who work towards goals, follow processes, use technology, operate within a physical infrastructure, and share certain cultural assumptions and norms.



Socio-technical theory has at its core the idea that the design and performance of any organisational system can only be understood and improved if both 'social' and 'technical' aspects are brought together and treated as interdependent parts of a complex system.

Organisational change programmes often fail because they are too focused on one aspect of the system, commonly technology, and fail to analyse and understand the complex interdependencies that exist.

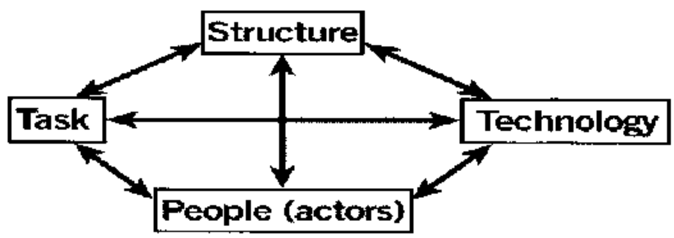
This is directly analogous to the design of a complex engineering product such as a gas turbine engine. Just as any change to this complex engineering system has to address the knock-on effects through the rest of the engine, so too does any change within an organisational system.

The potential benefits of such an approach include:

- Strong engagement
- Reliable and valid data on which to build understanding
- A better understanding and analysis of how the system works now (the 'as is')
- A more comprehensive understanding of how the system may be improved (the 'to be')
- Greater chance of successful improvements

The socio-technical perspective originates from pioneering work at the Tavistock Institute and has been continued on a worldwide basis by key figures such as Harold Leavitt, Albert Cherns, Ken Eason, Enid Mumford and many others.

Our use of the hexagon draws heavily on the work of Harold, J. Leavitt who viewed organisations as comprising four key interacting variables, namely task, structure, technology and people (actors).



Planning

Concept of planning:

Planning as a process involves the determination of future course of action, that is why an action, what action, how to take action, and when to take action. These why, what, how, and when are related with different aspects of planning process. According to Arnold Toynbee " one of the characteristic of being human is that he makes plan."

Definition:

- According to Kast---" A plan is a determined course of action."
- According to Allen---"A plan is a trap laid to capture the future."
- According to Haiman---"A plan is deciding in advance what is to be done."

Objectives:

- Reduces uncertainty
- Brings co-operation & co-ordination
- Economy in operation
- Anticipates unpredictable contingency
- Achieving the determined goals.
- Reduce competition

Charecteristics/ nature of planning:

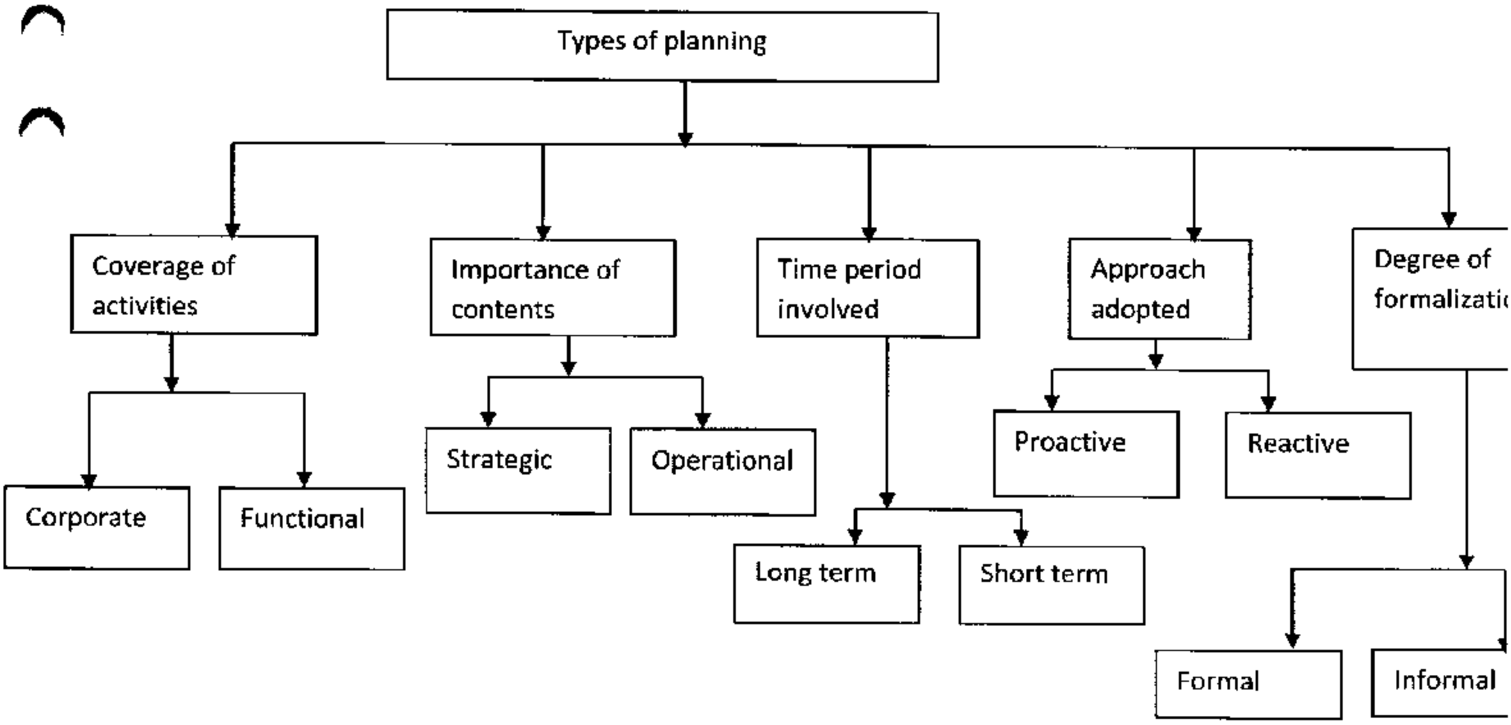
- Planning is looking into the future.
- Planning involves pre-determined line of action.
- Planning discovers the best alternatives out of available many alternatives.
- Planning is a continuous process.
- Planning is done for a specific period.
- Planning requires considerable time for implementation.
- Planning is required at all levels of management.
- Planning directs the members of the organization.
- Planning determines future action process.
- Planning is an interdependent process which co-ordinates the various business activities.

Types of planning:

- Corporate planning: The term corporate planning denotes planning activities at the top level, which cover the entire organizational activities.
- Functional planning: As against corporate planning which is integrative, functional planning is segmental and it is undertaken for each major function of the organization like production marketing, finance, human resource etc., At the second level functional planning is undertaken for sub-functions within each major function.
- Strategic planning: Strategic planning sets the long term direction of the organization in which it wants to proceed in future.
- Tact/ Operational planning: Operational planning is also known as tactical or short term planning, usually covers one year or so. It is aimed at sustaining the

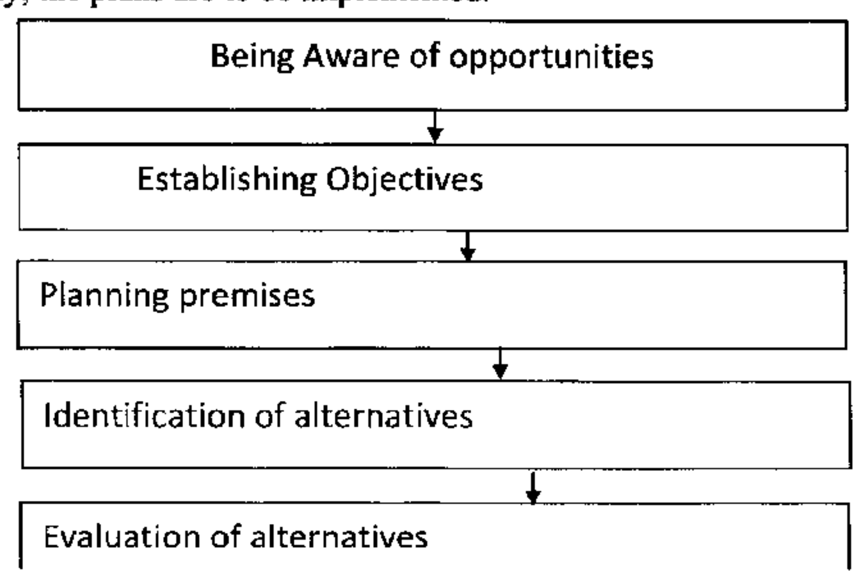
organization in its production and distribution of current products or services to the existing market.

* Long term planning: Long term planning is also called strategic planning, it involves more than one-year period extending to twenty years or so. However more common long term period is 3 to 10 years. The long term plans usually encompasses all the functional areas of the business and are effected within the existing and long term framework of economic, social and technological factors, it also involves analysis of environmental factors.
* Short term planning: Short term planning usually covers one year. These are aimed at sustaining organizational in its production and distribution of current products or service to the existing market.
* Proactive planning: Proactive planning involves designing suitable course of action in anticipation of likely changes in the relevant environment. Organization that use proactive planning use boarding plans, board environmental scanning, decentralized control and reserve some resources to be utilized for their future use.
* Reactive planning: In reactive planning, organizations response comes after the environmental changes have taken place. After the changes take place, these organizations start planning. That situations are the organizations lose opportunities to those organizations which adoptive proactive approaches.
* Formal planning: Formal planning is in the form of well structured process involved different steps. Generally, large organizations undertake planning in formal way in which they create separate corporate planning cell placed at sufficiently high level in the organizations.
* Informal organizations: As against formal planning, informal planning is undertaken generally by smaller organizations.



Steps/Process of planning:

- Being aware of opportunities: This awareness is very important for planning process because it leads to formulation of plans by providing clue whether oppurtunities exist for taking up particular plans.
- Establishing objectives: At this stage, major organizational and unit objectives are set. Objectives specify the result expected and indicated the end points of what is to be done, where the primary emphasis is to be placed, and what is to be accomplished by the various types of plans.
- Planning premises: After determination of organizational the next step is establishing planning premises that is the conditions under which planning activities will be undertaken. Planning premises are planning assumptions. The expected environmental and internal conditions.
- Identification of alternatives: Based on the organizational objectives and planning result, various alternatives can be identified. The concept of various alternatives suggests that a particular objective can be achieved through various actions.
- Evaluation of alternatives: Various alternatives which are considered feasible in terms of preliminary criteria may be taken for detailed evaluation. At this stage, an attempt is made to evaluate how each alternative conditions to the organizational objectives in the light of its resources and constraints.
- Choice of alternatives: After the evaluation of various alternatives, the most fit one is selected. Sometimes evaluation shows that more than one alternative is equally good. In such a case a planner may choose more than one alternative.
- Formulation of supporting plans: After formulating the basic plan, various plans are derived so as to support the main plan. In an organization there can be various derivative plans like planning form managements, buying raw materials,recruiting and training personnel, developing new products etc.,
- Establishing sequence of activities: After formulating basic and derivative plans,the sequence of activities is determined so that plans are put into action. Finally, the plans are to be implemented.



Advantages of planning:

- ✓ Linked to long term plans or objectives.
- ✓ Direction for action.
- ✓ Consistent
- ✓ Feasible.
- ✓ Simplicity.
- ✓ Flexible.

Disadvantages of planning:

- ✓ Difficulty of accurate premising
- ✓ Problems of rapid change
- ✓ Internal inflexibilities
- ✓ Political climate
- ✓ Time & cost factors
- ✓ Failure of people in planning
- ✓ External inflexibilities
- ✓ Capital investment.

Management by Objectives:

Management by objectives (MBO) is a systematic and organized approach that allows management to focus on achievable goals and to attain the best possible results from available resources. It aims to increase organizational performance by aligning goals and subordinate objectives throughout the organization. Ideally, employees get strong input to identify their objectives, time lines for completion, etc. MBO includes ongoing tracking and feedback in the process to reach objectives.

Management by Objectives (MBO) was first outlined by Peter Drucker in 1954 in his book 'The Practice of Management'. In the 90s, Peter Drucker himself decreased the significance of this organization management method, when he said: "It's just another tool. It is not the great cure for management inefficiency."

The main features of MBO are

1. Management by Objectives is a philosophy or a system, and not merely technique.
2. It emphasizes participative goal setting.
3. It clearly defines each individual responsibility in terms of results.
4. If focuses attention on what must be accomplished goals rather than on how it is to be accomplished.
5. It converts objective needs into personal goals at every level in the organization.
6. It establishes standards or yardsticks (goals) as operation guides and also as basis of performance evaluation.
7. It is a system intentionally directed toward effective and efficient attainment of organizational and personal goals.

Steps in MBO Process

Peter Drucker outlined the five-step process for MBO shown in figure below. Each stage has particular challenges that need to be addressed for the whole system to work effectively.

1. **Set or Review Organizational Objectives**

MBO starts with clearly defined strategic organizational objectives (see our article on Mission and Vision Statements for more on this.) If the organization isn't clear where it's going, no one working there will be either.

2. **Cascading Objectives Down to Employees**

To support the mission, the organization needs to set clear goals and objectives, which then need to cascade down from one organizational level to the next until they reach the everyone.

To make MBO goal and objective setting more effective, Drucker used the SMART acronym to set goals that were attainable and to which people felt accountable. He said that goals and objectives must be:

1. Specific
2. Measurable
3. Agreed (relating to the participative management principle)
4. Realistic
5. Time related

For each objective, you need to establish clear targets and performance standards. It's by using these that you can monitor progress throughout the organization. These are also important for communicating results, and for evaluating the suitability of the goals that have been set.

3. Encourage Participation in Goal Setting

Everyone needs to understand how their personal goals fit with the objectives of the organization. This is best done when goals and objectives at each level are shared and discussed, so that everyone understands "why" things are being done, and then sets their own goals to align with these.

This increases people's ownership of their objectives. Rather than blindly following orders, managers, supervisors, and employees in an MBO system know what needs to be done and thus don't need to be ordered around. By pushing decision-making and responsibility down through the organization, you motivate people to solve the problems they face intelligently and give them the information they need to adapt flexibly to changing circumstances.

Through a participative process, every person in the organization will set his or her own goals, which support the overall objectives of the team, which support the objectives of the department, which support the objectives of the business unit, and which support the objectives of the organization.

4. **Monitor Progress**

Because the goals and objectives are SMART, they are measurable. They don't measure themselves though, so you have to create a monitoring system that signals when things are off track. This monitoring system has to be timely enough so that issues can be dealt with before they threaten goal achievement. With the cascade effect, no goal is set in isolation, so not meeting targets in one area will affect targets everywhere.

On the other hand, it is essential that you ensure that the goals are not driving adverse behavior because they have not been designed correctly. For instance, a call centre goal of finishing all calls within seven minutes might be useful in encouraging the staff to handle each call briskly, and not spend unnecessary time chatting. However, it might be that customers' calls were becoming more complex, perhaps because of a faulty new product, and call centre operators were terminating the call after 6 minutes 59 seconds in order to meet their target, leaving customers to call back, frustrated. In this situation, the monitoring process should pick up the shift in the goal environment and change the goal appropriately.

Set up a specific plan for monitoring goal performance (once a year, combined with a performance review is not sufficient!) Badly-implemented MBO tends to stress the goal setting without the goal monitoring. Here is where you take control of performance and demand accountability.

Think about all the goals you have set and didn't achieve. Having good intentions isn't enough, you need a clear path marked by accountability checkpoints. Each goal should have mini-goals and a method for keeping on top of each one.

5. **Evaluate and Reward Performance**

MBO is designed to improve performance at all levels of the organization. To ensure this happens, you need to put a comprehensive evaluation system in place.

As goals have been defined in a specific, measurable and time-based way, the evaluation aspect of MBO is relatively straightforward. Employees are evaluated on their performance with respect to goal achievement (allowing appropriately for changes in the environment.) All that is left to do is to tie goal achievement to reward, and perhaps compensation, and provide the appropriate feedback.

Employees should be given feedback on their own goals as well as the organization's goals. Make sure you remember the participative principle: When you present organization-wide results you have another opportunity to link individual groups' performances to corporate performance. Ultimately this is what MBO is all about and why, when done right, it can spur organization-wide performance and productivity.

Advantages of MBO:

- MBO helps and increases employee motivation.
- Managers are more likely to compete with themselves than with other manager.

- MBO provides more objectives appraisal criteria.
- MBO identifies problems better and early.
- MBO forces and aids in planning.
- MBO results in 'means ends' chain.
- Helps the manager to develop personal leadership.

Disadvantages of MBO:

- Pressure oriented
- Time consuming.
- Goal setting problems.
- Increased paper work
- Organizational problems.
- It is not easy to understand.

UNIT-II

ORGANIZING

Organizing:

Organizing (management), **a process of coordinating task goals and activities to resources**. Community organizing, in which communities come together to act in their shared self-interest. Professional organizing, an industry build around creating organizational systems for individuals and businesses.

Definition: Organizing is one of the most prominent function of management that **aims attention at assigning and organizing human as well as other financial resources efficiently** to carry out the plans of the organization successfully. It also involved in constructing, establishing, and managing working relationships and requires the planning of tasks and an assorted way to accomplish that task.

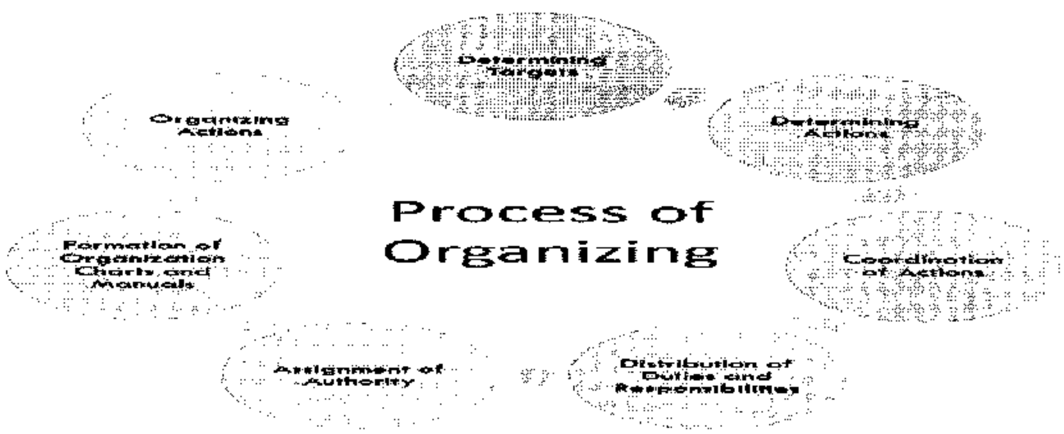
After competent planning, arranging the organization's framework effectively helps in identifying the similarities and differences among various organizations.

Content: Organizing

1. **Process of Organizing**
2. **Principles of Organizing**
3. **Conclusion**

Process of Organizing:

Organizing is a process that manages how the task is distributed amongst the employees and departments and determines the policies to be followed. The process of organizing consists of seven steps; they are as follows:



1. Determining Targets:

The first stage of organizing process should be to determine the targets to be fulfilled. Employee association, products, market, all rely upon the nature of the business. Both financial, as well as social targets, should be determined accordingly in a scheduled manner and then managing them according to their priority and categorize them as primary, secondary, long-term and short-term targets.

2. Determining Actions:

The second step is to find out and make a list of required actions to achieve the desired targets of the organization such as preparing accounts, computing sales, record-keeping, quality control, inventory control, etc. All such actions have to be arranged and classified into units.

3. Coordination of Actions:

After determining actions, it is necessary to coordinate actions, i.e., organizing jobs into uniform work units, departments, and segments, and all such functions come under departmentalization. For grouping purpose, distinct groups such as territorial, process, functional, product and customer can be used, which helps to protect specialization.

4. Distribution of Duties and Responsibilities:

The next step after coordination of actions should be a distribution of duties and responsibilities to the distinctive individual based on their ability and aptitude. The duties and responsibilities must be explicitly delegated to each individual to avoid the duplication of the work, as the best-suited individual will give his best to his specific delegated work.

5. Assignment of Authority:

To perform the delegated work, an individual along with responsibilities also needs authority or power to make decisions regarding his work so that he/ she can perform his/her task productively. As one cannot perform their work without necessary powers and authority and such authorities are given according to their work and level. With the delegation of work, a proper chain of command runs from top-level to bottom level of employees.

6. Formation of Organization Charts and Manuals:

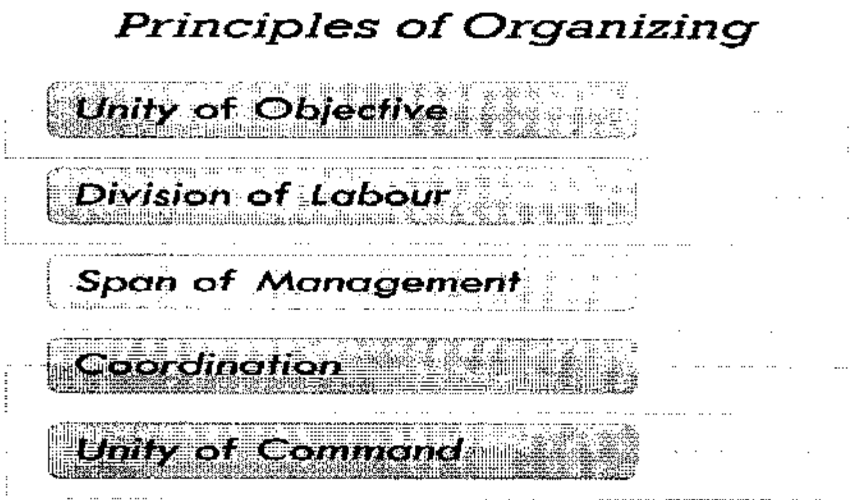
After delegating the work and authority to the employees, organization charts and manuals are prepared on the basis of the power, authority and responsibility. Manuals are prepared based on the organization charts stating the instructions for performing daily actions.

7. Organizing Actions:

Synchronizing all the actions and attempts of all the employees is necessary to establish the effectiveness of the specialized functions. The Interrelation between tasks and employees must be pre-defined so that everyone knows that, to whom they are answerable and from whom they have to take orders.

Principles of Organizing:

For forming the organizing structure or organizing the certain basic principles that are followed as a guideline so that it becomes easy to develop or built organizational structure, some basic principles are as follows:



- **Unity of Objective:**

The activities at all levels of organizational structure would be geared to achieve the main objective of the organization. The activities of the different departments or sections may be different in nature, having various distinctive objectives. But whatever objectives those departments have made should go in one direction only, so that there will be a unity of objectives in the organization.

- **Division of Labour:**

Division of Labour is one of the fundamental principles of organizing which implies differencing various departments or sections within the organization. In it, various different tasks are distributed amongst the employees of an organization according to their abilities and specialization. This principle enhances both the employee and the organization's productivity as it reduces the burden of several tasks, and employee can focus on particular assigned task and give his/her best in it.

For example: In case of machine actions there will be a separate group made to handle that department, similarly, for selling activity, a group will be made who will only handle selling functions and so on for all further activities in company labour gets divided as per their ability that leads to specialization in their field of work, since there are different departments all needs to be coordinated with each other.

- **Span of Management:**

A manager can supervise a limited number of persons effectively, and because of this span the organizational levels are created such as top managing director will manage general managers, then general managers will manage some deputy managers and so on the chain goes on from top to bottom level of employees. As the number of organizational levels increases vertically, it will lead to cost rising and communication barriers, as a result of which planning and control become more complicated.

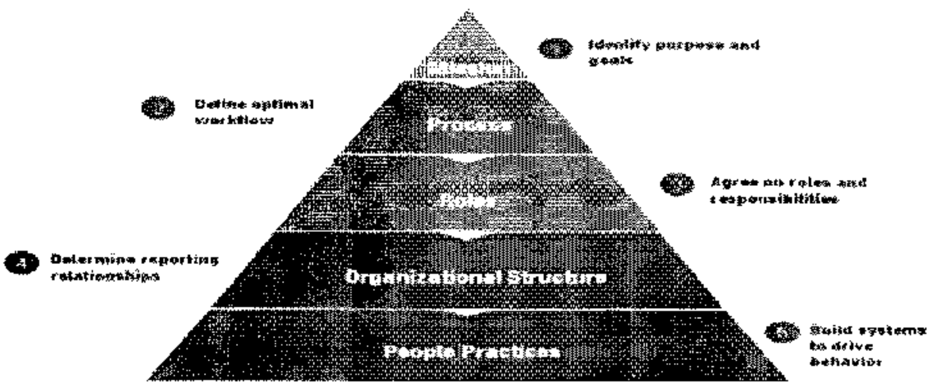
- **Coordination:**

Coordination is nothing but creating harmony amongst the group of personnel working in an organization. It is necessary for an organization's growth that the employees working in various departments should maintain synchronization as without proper coordination one cannot expect a smooth functioning in any organization as all departments are somehow inter-related with each other.

- **Unity of Command:**

Unity of command talks about the commanding power or responsibilities, i.e., it talks about that there should be only one person while taking control. Under this, we need to understand that the sub-ordinates should receive the orders from only one boss or there should be only one reporting person for particular sub-ordinate. Otherwise, it may result in non-completion of work as the sub-ordinate will get confused about whose order he has to follow.

<u>Organizational Design and Structure:</u>



Let us try to understand the term "**Organization Design and Structure.**" The structure of any building depends on its base or foundation. A strong foundation and a basic structure are critical to making a building strong. Although it is possible to redesign and restructure a building, if the base is weak, the whole structure of a building will be unstable.
We can clearly see how important a foundation is. Moreover, foundation and design are inter-related to each other. Similarly, from an organizational point of view, the foundation is the 'Organizational Structure' which demonstrates different roles, hierarchy levels and terms, and conditions in an organization. 'Organisational Design' encompasses restructuring and destructuring roles, hierarchy level, terms, and conditions as per business or organizational needs.

Definition:

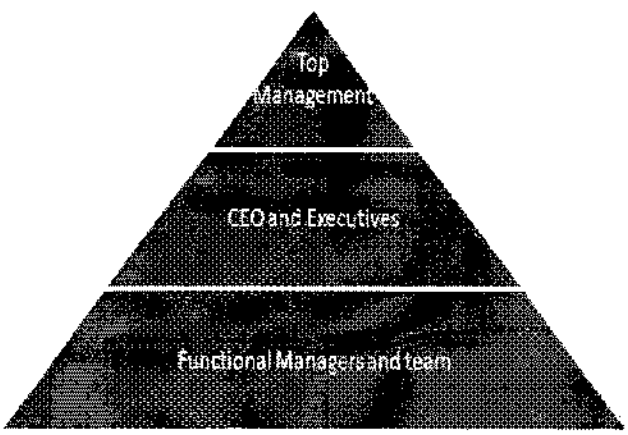
As stated above, the organization structure is the system which describes the organizational hierarchy in terms of different functions, roles, responsibilities, supervision, etc. It demonstrates different concerns including different roles of the employees, job descriptions, job functions, decision-making authorities, reporting structure, allocation of tasks in the department, individuals, project team, branch, etc.

The organizational structure also defines the flow of information between different levels of an organization, clarity of job of each employee, and its fitment in the overall system which motivates the employees to work efficiently by keeping their morale high; hence, increasing the overall productivity of an organization.

Organizational Structure Is Two Types

1. Centralized Structure

In this type of organizational structure, all decisions, as well as processes, are defined; and handled by the top management. Employees and managers are responsible for the successful implementation of decisions and have to follow them. The employees low in the chain of command play a minimal role in the process of decision-making. Few real-life examples of such organizations are Army, companies like Flipkart, Apple, McDonald's, etc. where the power of decision- making is held at the top level and there is a wide chain or hierarchy of managers and subordinates. Thus, the centralized structure has a top-down approach for decision flow.



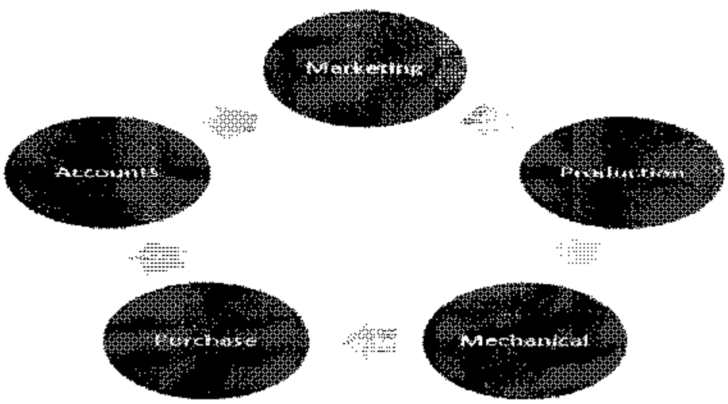
Centralized structure-Pyramid Shape

<u>Pros and Cons of Centralized Organization Structure:</u>

PROS	CONS
• Clear communication and chain of command	• Dictatorship in terms of Leadership
• Cost reduction i.e. administrative cost	• Work delays due to dependency on management
• Fast implementation of decisions	• Employees feel disconnected in result reduce work efficiency
• Improved work quality and reduction in task replication	• Lack of authority in Managers

2. Decentralized Organization Structure

In such type of organizations, day-to-day tasks and the decision-making processes are delegated to the supervisors at the middle and lower level by the top management for fast and effective decisions and to improve efficiency. By letting the middle and lower level executives jump in the process of decision-making, the top management can focus on other major decisions. This also increases the responsibility and accountability of the employees.



<u>Decentralized Organization structure</u>

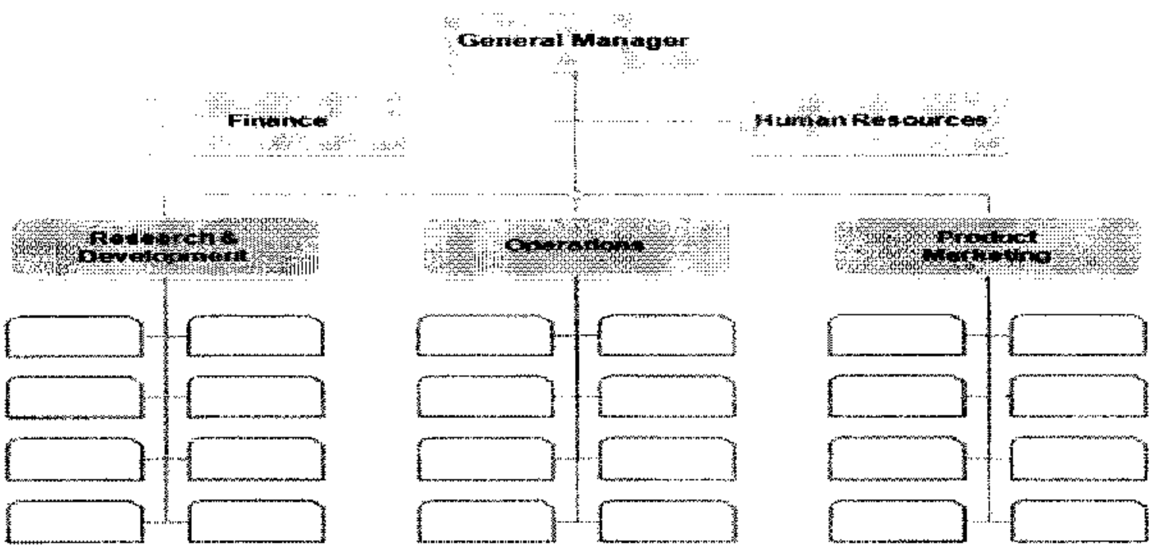
<u>Pros and Cons of Decentralized Organisation Structure:</u>

PROS	CONS
• Better customer service	• Difficult coordination
• Better staff motivation	• Expensive process
• Quick decisions	• Unnecessary cost increase due to benefits by external factors
• Effective Communication	
• Improved Supervision and control	

"Organizational Design" refers to defining, designing, and re-structuring organizational structure. The very process of organizational design is aimed at finding any type of defective or dysfunctional elements related to an organization's system, organization structure, process, and work culture. Identification of these elements leads to their rectification so that they can better fulfil an organization's objective.

It clarifies different aspects like authority, the responsibility of tasks and its limitations, reporting structure, a flaw of information, etc. With the help of organizational design, one can identify and eliminate any kind of duplicity in work, inefficient work, poor customer dealing, blame games, obstacles in the decision-making process, shortfalls in systems, and processes which result in the decline of efficiency of the employees, lack of trust among superiors and subordinates, etc.

So, organizational design and organizational structure are interrelated to each other, yet have a slight difference. The organizational structure represents organizations in an immovable or static form that can be presented through a diagram, popularly known as "Organogram." These diagrams or organization charts provide an easy interpretation of different functions of organizations and their relationships. Also, they show a hierarchy of the staff i.e. managers, leaders, other team members, and supervision levels.



A sample organogram

In contrast, the organizational design represents the dynamic view of an organization. It is more of processes and methods which help in organizational structuring and restructuring for smooth and effective functioning. It is also based on change management whereby the organizational demands change their structure and functioning to meet needs for technological advancements, market factors, meeting regulations, customer needs and expectations, etc. With the help of the organizational design, weaker systems of an organization can be identified and corrective steps can be taken to strengthen them.

Elements Of Organizational Design

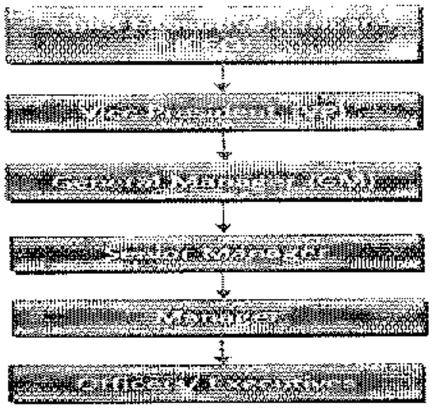
A well-designed organizational structure not only defines functions, hierarchy, roles, and responsibilities but also the alignment of organizational goals of staff/teams. Poor organizational design or structure may result in serious downfalls in organizations i.e. ambiguity of roles, lack of trust in team and superiors, rigid work environment, slow and ineffective decision-making, etc. The above-mentioned factors are further responsible for low productivity and turnover.

So, it is important to look for organizational design and structure as per a company's requirement. Also, there are certain segments of organizational design which are known as the key elements. Largely, there are 6 elements of organizational design and structure:

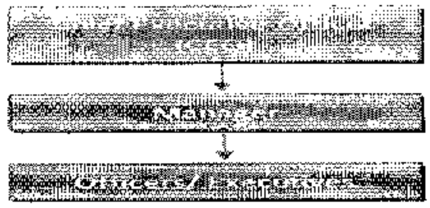
1. Chain Of Command/Line Of Command

In this, the authority and power are delegated from top to bottom i.e. in an organization top management gives instructions to the bottom team and all the employees at each level. Further, the accountability of an employee's job flows upward to the management. It gives clarity of the reporting structure in an organization. Let us have a look at the chain of command with a visual diagram:

Wider chain of command (Big organizations)



Narrow Chain of command (Small organizations)

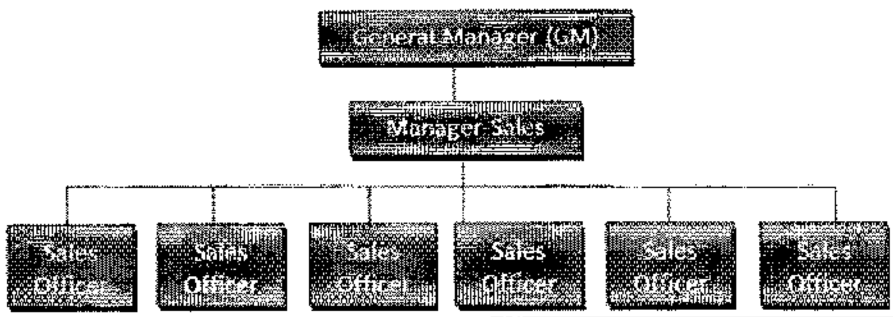


PROS	CONS
• Increase in the productivity due to close monitoring of employee's performance by supervisors	• Not feasible for big organizations due to tight management control on everything
• Increase in quality and profits	• Delay in decision-making due to much dependency on management
• Clear communication due to direct supervision	• Less sense of belongings by employees and less initiatives
• Conflict resolution, clear instructions	• Office politics due to power centralization

2. Span Of Control

"Span Of Control" demonstrates how wide is the area of the direct control of supervisors over their subordinates which is directly related to how many subordinates (in numbers) report to a senior or supervisor; which, in turn, depends on the number of tasks performed at different levels. In case of more tasks, the span of control will be wider. It also depends on other aspects like geographical location, the ability of the team and superior, the complexity of tasks, etc.

<u>Wide Span of Control:</u>

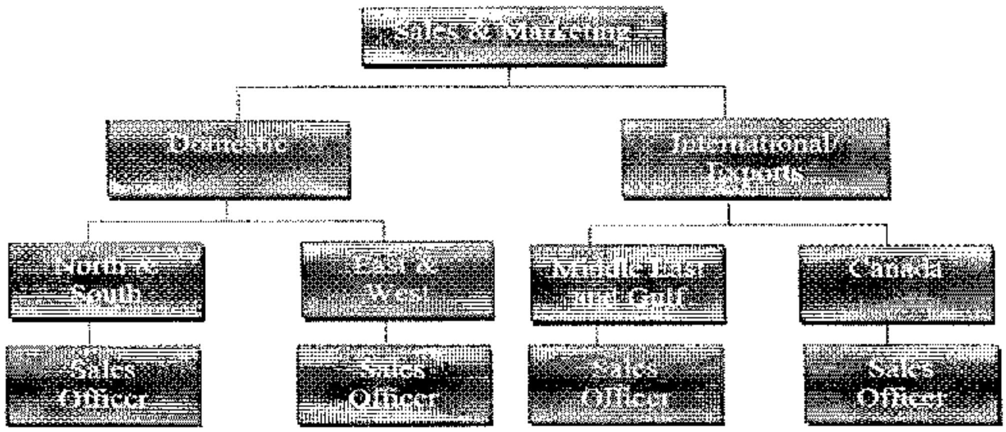


PROS	CONS
• Delegation of authority by superiors to subordinates	• Decision making barriers
• Clear communication	• Managers are overloaded
• Few managers and more employee empowerment	• Require more skilled and trained managers

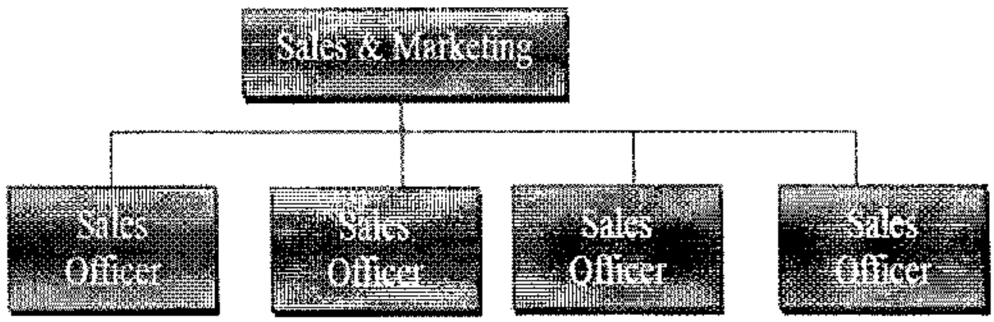
3. Specialization

Large organizations divide some of its functions based on the specialized areas and, so, subtasks are defined in different tasks. These subtasks are distributed among individual job roles.

High Level Specialization:



Low Level Specialization:



Pros and Cons of Specialization:

PROS	CONS
• Increased production or productivity	• Increase in cost
• Increase in job satisfaction	• Increase in employee turnover due to similar kind of job
• Increase in product quality	

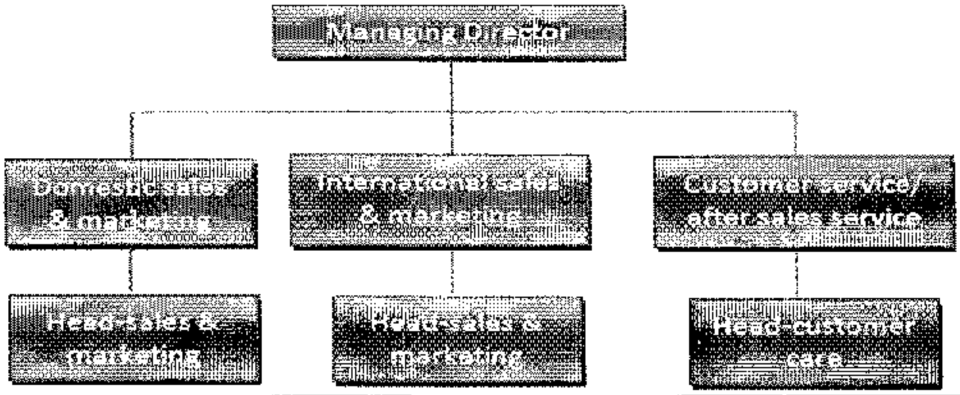
4. Formalization

Formalization refers to the process of specifying or mentioning rules, procedures, and duties to the employees as an individual as well as to the teams, departments, units, and the whole organization by managers in written form too. Formalization indicates the goals and vision of an organization, tasks, hierarchy and relationships, authority and responsibilities, different processes, and work methods.

A formal organization emphasizes on job roles, responsibilities, and assigning work to the individuals as per the requirement of roles. These are controlled by rules and procedures.

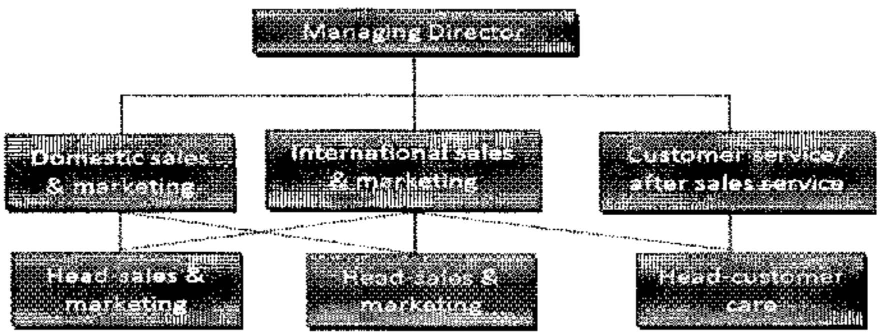
An informal organization emphasizes on individuals, and the job responsibilities are designed based on individual employee skills and preferences irrespective of the department in which he/she is working. An individual can be assigned the role of different departments as well based on self-interest, skills, etc.

Formal Organization:



PROS	CONS
• Increase in efficiency	• Lengthy decision-making process
• Smooth flow of authority	• Reduced professional morale of employees
• More disciplined staff, less ambiguity	• Rigid and formal relations

Informal Organization:



PROS	CONS
• Better communication	• Lacking in Specialization
• Positive impact on productivity	• Changes are not accepted easily.
• Meets social needs	

Type of Organizational Design and Structure

There are two major categories of organizations- formal and informal. The formal organizational structure includes a well-defined structure of jobs that clears authority, functions, and responsibility in organizations. Plans, processes, and policies are already defined in these types of organizations and the teams need to follow and perform their tasks based on these. Its main focus is on jobs and functions rather than the employees. Jobs in the formal organizations are divided into sub-tasks and employees are assigned these tasks as per their skills. It demands the intervention of different departments, which is based on a grouping of sub-tasks of common jobs.

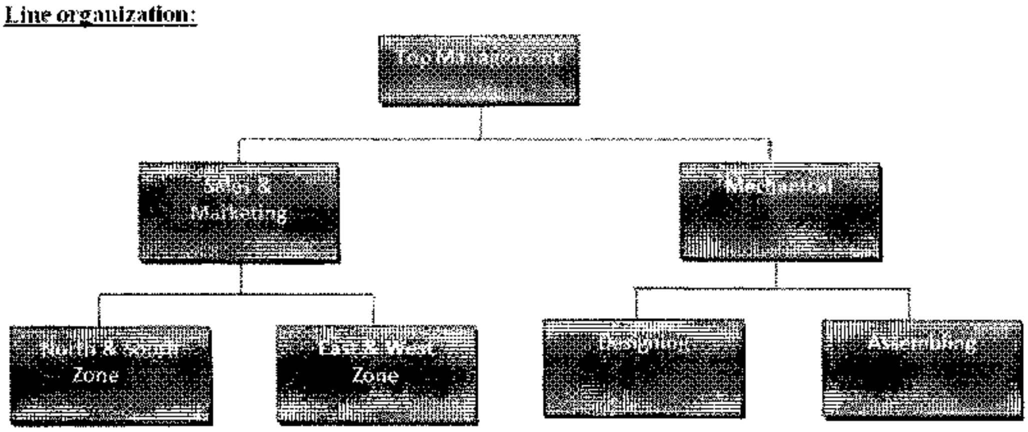
Types of formal organizational design and structure:

1. Line Organizational Structure & Design

Line organizations follow line/chain of command and demonstrate relationships at different levels in vertical form. The authority comes from top to bottom. There is no specialization existing in this.

PROS	CONS
• Simple method and clear chain of commands	• Lack of specialized functions
• Better control on activities	• Lack of inputs from lower staff and ineffective communication
• Clear responsibilities and flexible in approach	• Misuse of authority by superiors

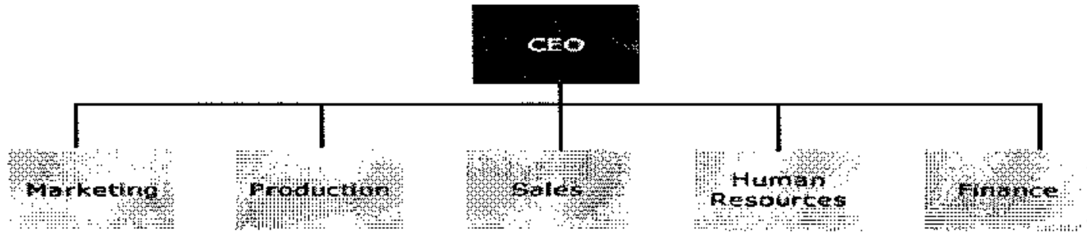
Line organization:



2. Functional Organizational Structure & Design

A functional structure groups employees into different departments by work specialization. Each department has a designated leader highly experienced in the job functions of each employee supervised by them.

Most often, it implements a top-down (centralized) decision-making process where department managers report to upper management. Ideally, leaders of different teams communicate regularly and coordinate their strategies while lower-level employees have little idea of the processes taking place outside their department.



Functional structure chart

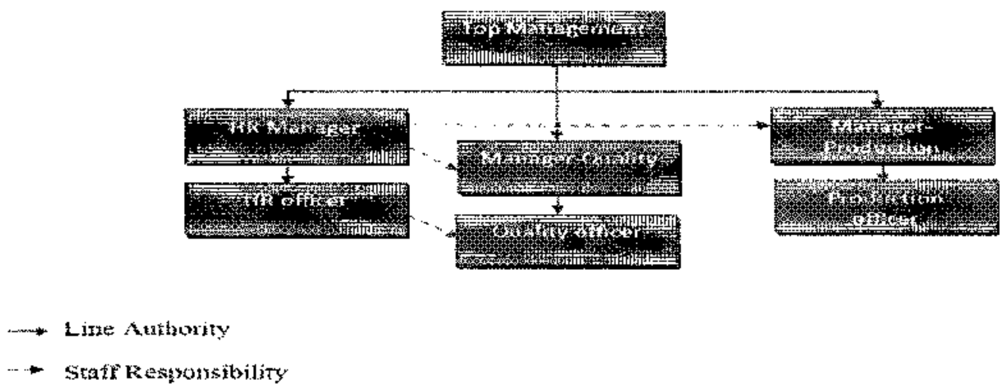
The main challenge companies with a functional structure face are the lack of coordination between departments. Employees may lose the larger company context when focusing on very specific tasks and failing to interact with members of other departments.

PROS	CONS
• Specialization ensures effective distribution of tasks	• Poor coordination
• Increase in production and minimal costs	• Increase in conflicts between different supervisors at same levels
• Better management functioning and increase in efficiency	• Hiring specialist staff is a bit costlier

3. Line and Staff Organizational Structure & Design

This concept works mostly in big organizations. The vertical but direct relation exists at different levels in these type of organizations where the specialist staff has the responsibility to advise the line managers and assist them whenever required. Both the departments, i.e., line and staff exist in such organizations. The specialized staff is present for assisting or advising and has direct control over the line staff.

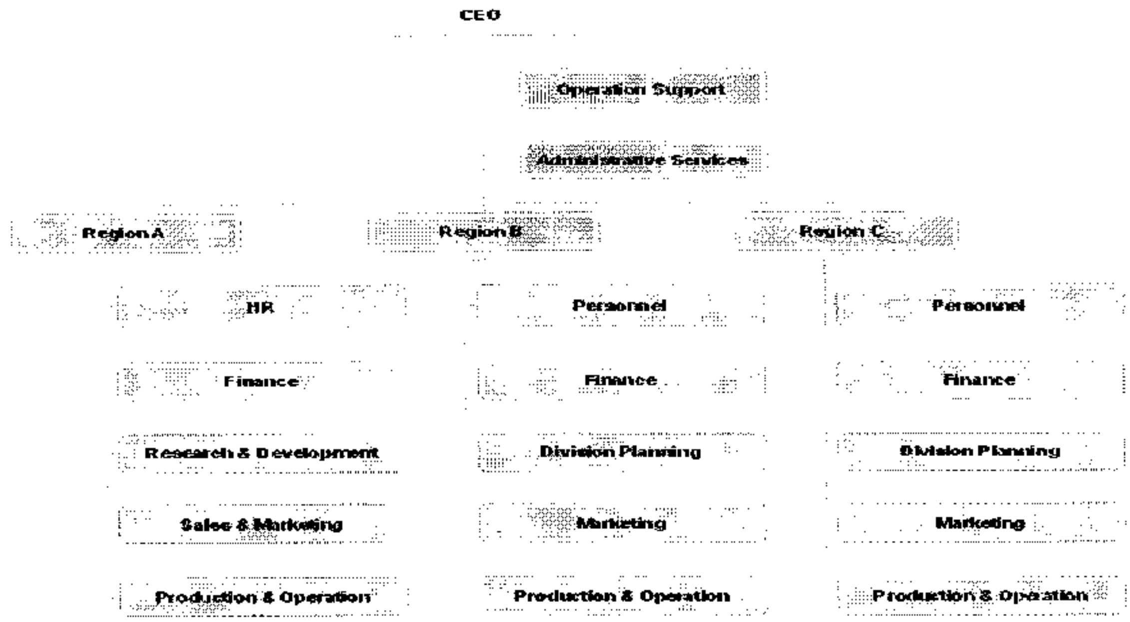
Line and staff organizations:



PROS	CONS
• Specialization is there for work efficiency as staff employees provide planning and direction wherein line employees focus on execution	• Confused authority relationship between line and staff employees
• More effective decisions can be made due to expert advice of staff employees	• Costly as it recruits more specialists
• More flexibility in hiring new line staff	• Rises of conflicts between line and staff employees especially at senior level due to seniority issues

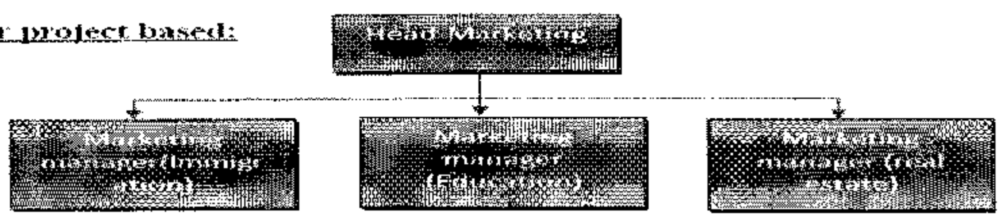
4. Divisional Organizations & Design

Divisional organizational structure is present in large organizations which are more than one product based, working in multiple territories or working on different projects with separate teams. In these, the different functions of organizations are grouped on the basis of geographic areas, products, projects, or in a combination.Each division has its own functions and resources like manpower and others for products or the geographic area to which it belongs.



5) **product- or project-based divisional organization & Design**, all activities like marketing, purchase, production, quality, etc. come under the supervision of a single head who is head of the department. For example: in the geographic division, all activities are combined based on particular geographic areas like the east or the west or international locations like middle-east etc. This division exists in organizations that work in more than one territory or geographic area and has different market strategies; and products are offered based on customer needs in that geographic area.

<u>Product or project based:</u>

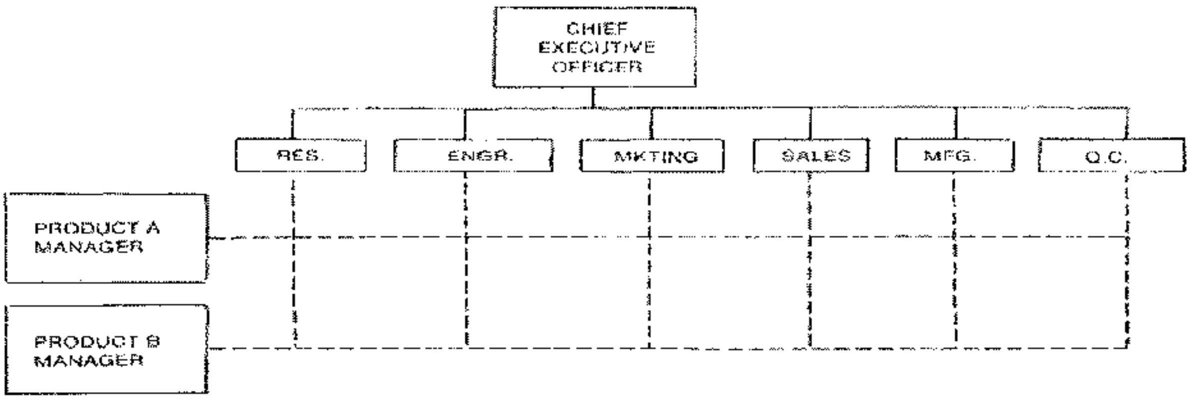


PROS	CONS
• Increase in accountability	• Cost increases due to duplication of tasks
• Fast decision-making due to different divisions	• Mismatch in goals of organization and divisions
• Assigning budget to divisions is easy	• Conflicts in divisions due to budget allocation

6. Matrix Organizational structure & Design

Within a matrix organizational structure, team members report to several managers at once. Wait, what's the point?

Having multiple supervisors allows for company-wide interaction and faster project delivery. For instance, when answering to functional managers and project managers, employees have a chance to collect experience outside their team. While functional managers can help to solve job-specific issues, project managers can bring in knowledge or talents from other departments.



PROS	CONS
• **Decentralization of decisions**	• **Rise in conflicts**
• **Increase in specialization**	• **Rise in administrative cost**
• **Productive exchange of information**	• **Ambiguity in responsibility and authority**

Coordination: Meaning, Features, Importance, Principles and Techniques

Meaning of Coordination:

Cooordination is very essential in management. Business has various functions. These functions are performed by different individuals.

Moreover, performance of these functions requires division of work and grouping of activities and making decisions at different levels.

All these necessitate co-ordination for attaining the desired goals. Co-ordination is concerned with synchronizing, integrating or unifying all the group actions in an enterprise to achieve its objectives.

It is a process by which the manager achieves harmonious group efforts and unity of actions through balancing the activities of different individuals and groups of individuals and reconciling their differences in interest or approach, for the attainment of common goals.

In the words of Mcfarland, **"Co-ordination is the process whereby an executive develops an orderly pattern of group efforts among his subordinates and secures unity of actions in the pursuit of a common purpose."**

This managerial function is known as 'co-ordination'. He is to ensure that everybody in the organisation understands the main objectives of the enterprise and works towards their fulfillment in active co-operation with others. Co-ordination is like the team spirit of a football match or the harmonious symphony of an orchestra.

Co-ordination eliminates conflict between the head office and branches as well as between departments of an organisation and removes difficulty in communication. Instead of regarding co-ordination as a separate function of management, it must be considered as the essence of management.

Features of Coordination:

The principal features of co-ordination may be stated as follows:

1. Co-ordination is concerned with the integration of group efforts and not individual effort

2. Co-ordination is the concerted efforts of requisite quality and quantity given at the proper time

3. Co-ordination is a continuous and dynamic process

4. Co-ordination has three important elements, namely, balancing, timing and integrating

5. The task of co-ordination and co-operation do not mean the same thing

6. Co-ordination is the responsibility of every manager

7. Co-ordination may be internal or external

8. Co-ordination may be horizontal and vertical

Principles of Coordination:

For achieving effective co-ordination, the following fundamental principles are to be followed:

1. Direct Contact:

Co-ordination should be attained by direct contact with the parties concerned. Direct personal communications bring about agreement on methods, actions and ultimate achievement. It also eliminates red-tapeism and ensures prompt action. Direct contact is an effective means of co-ordination.

2. Early Beginning:

Co-ordination can be achieved more readily at the initial stages of planning and policy-making. Therefore, direct contact must begin in the very early stages of the process. If an order for the supply of a particular goods has been booked and the raw materials to produce them are not available, there will be trouble.

Contact among the purchasing manager, production manager and sales manager at art early Stage would have made it possible to know whether the order could be executed.

3. Continuity:

Co-ordination must be maintained as a continuous process. It starts from planning and ends when the objective is accomplished. Whenever there is division and distribution of functions among the managers and departments, co-ordination is necessary. Every time a new situation arises, a fresh effort of co-ordination is needed. So, the manager must constantly work at it until the purpose is served.

4. Reciprocal Relationship:

Co-ordination should be regarded as a reciprocal relating to all factors in a situation, viz. production, sales, finance, men, and management. For example, when 'P' works with 'Q' and 'Q' in turn, works with 'R' and 'S' each of the four finds himself influenced by the others.

5. Pervasiveness:

Co-ordination is an all-embracing activity in every management function. It is required in all the activities at every level of the organisation. It is to be exercised both within and outside the organisation.

6. Leadership:

Leadership is the most effective instrument of co-ordination. A leader in a group is the coordinator of the group activities. He harmonizes all efforts of persons in the group. A manager does not himself produce anything nor does he sell anything in the market.

He gets the commodities produced by the workers and gets them sold in the market by the salesmen. In fact, he provides leadership and co-ordinates various functions.

7. Timing:

Timing is an important element of co-ordination. This principle points out that all functions in the enterprise are to be done at the same time and at the same speed. If the purchase department purchases and supplies materials timely to the production department, and if the production is done timely, then the sales department can deliver the commodities to the customers within the scheduled time.

8. Balancing:

This principle refers to the quantitative element of co-ordination. It means that all works are to be done in right quantity. For instance, if a department produces half, another one-third and the third the full quantity, their activities cannot be balanced. They have to perform their job in right quantity for achieving co-ordination of their jobs.

9. Integrating:

All activities, decisions and opinions are to be integrated to achieve the enterprise objective.

Controlling:

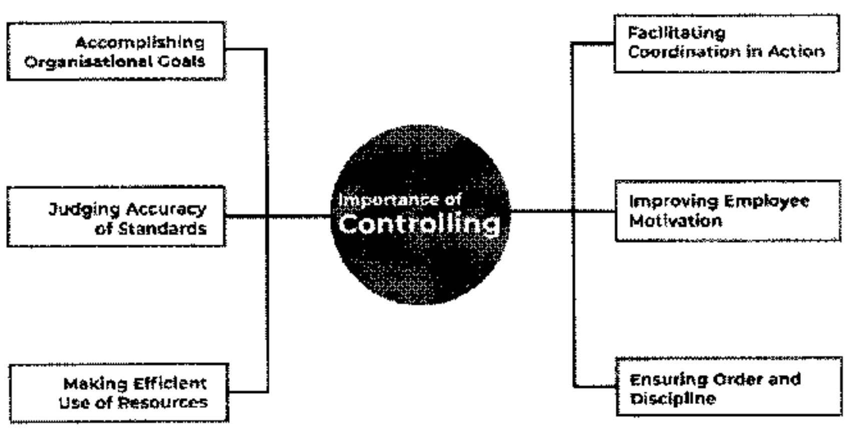
Controlling can be defined as that function of management which helps to seek planned results from the subordinates, managers and at all levels of an organization. The controlling function helps in measuring the progress towards the organizational goals & brings any deviations, & indicates corrective action.

Nature of Controlling

1. Controlling is a **goal-oriented** function of management. It aims at ensuring that the resources of the organisation are used effectively and efficiently for the achievement of pre-determined organisational goals.
2. Controlling is a **continuous** process. It means that once the actual performance and standard performance of a business are compared and corrective actions are taken, the controlling process does not end. Instead, the firms have to continuously review the performance and revise the standards.
3. Controlling is **all-pervasive.** It means that the controlling function is exercised by the firms at all levels of management. The extent of control and nature of the function may vary at every level. Also, a controlling process is required in both non-business and business organisations.
4. Controlling process is both a **forward-looking** and **backward-looking** function. As a forward-looking function, it aims at improving the future performance of an organisation on the basis of its past experiences. However, as a backward-looking function, it measures and compares the actual performance and planned performance (fixed in past) of the organisation.

Importance of Controlling

Controlling function is important for every organisation due to the following reasons:



1. Accomplishing Organisational Goals

Controlling is a goal-oriented process as it aims at determining whether the pre-determined plans are being performed accordingly and whether required progress is made towards the achievement of the objectives. With the help of controlling, an organisation can keep the business activities on the right track and can achieve the organisational goals effectively and efficiently, and take the necessary corrective actions if required.

2. Judging Accuracy of Standards

An effective controlling process can help an organisation in verifying whether or not the firm has set the standards accurate. It also helps in keeping a check on the changes taking place in the business environment and making required changes in the standards whenever it is necessary.

3. Making Efficient Use of Resources
Controlling helps an organisation in reducing wastage of resources, as it aims at ensuring that every activity of the firm is performed according to the pre-determined goals.

4. Improving Employee Motivation
As controlling process includes comparing the pre-determined goals of an organisation with its actual performance, it properly communicates the role of employees in advance. It means that the employees know in advance on what standards their performance will be measured, compared, and appraised. This set of pre-determined goals motivates them to give a better performance.

5. Ensuring Order and Discipline
An efficient control system in an organisation can help its managers in creating an atmosphere of discipline and order in the firm. Besides, controlling also helps in keeping a continuous check on the employees so they can minimise undesirable activities, such as theft, corruption, fraud, etc.

6. Facilitating Coordination in Action
Controlling process also helps an organisation in facilitating coordination between different divisions and departments by providing the employees with unity of direction. In other words, every employee and department of the organisation is governed by a pre-determined set of goals. It also motivates employees in achieving these common goals through coordination to avoid duplication of efforts.

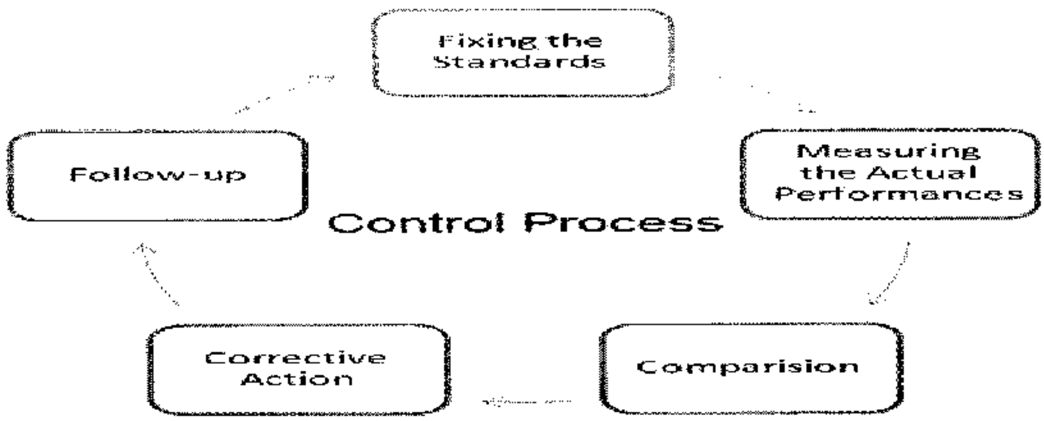
Features of a Good Control System

1. ***Suitable:*** *A good control system should be suitable for the needs and nature of the organisation.*
2. ***Simple:*** *A good controlling system should be easy to operate and understand.*
3. ***Economical:*** *The cost of setting, implementing, and maintaining a control system should not be more than the benefits gained from it.*
4. ***Flexible:*** *A good control system should have the ability to adjust according to the changing business environment and internal conditions.*
5. ***Forward Looking:*** *A good control system should move in a forward direction so that the managers can easily determine the deviations before they actually happen in the organisation.*
6. ***Objective:*** *The standards of the organisation, its measurement of performance, and corrective actions should be impersonal and objective.*
7. ***Management by exception:*** *A good control system should focus its attention on the significant deviations which are crucial for the organisation, instead of looking for the deviation which does not have much impact on the business.*

Limitations of Controlling

1. Difficulty in Setting Quantitative Standards
2. Little Control on External Factors
3. Resistance from employees
4. Costly Affair

Controlling Process



The control process consists of the following basic elements and steps: –

1. Establishing goals and standards

- The task of setting goals and standards is done in planning but it also plays a big role in controlling. This is because the main purpose of control is to direct the actions of a business towards its goals. If the members of an organization are clearly aware of their goals, they will devote their full attention in achieving them.
- It is very important for managers to communicate their organization's goals, standards, and objectives as clearly as possible. There should never be ambiguity among employees in this regard. If everyone works towards common goals, an organization can flourish.
- The goals that managers have to set and act on can be either tangible/specific or intangible/abstract. Tangible goals are those that are easy to quantify in numerical terms. For example, the sales achievement of Rs. The target of 100 crores within a year is a concrete target.

2. Measuring actual performance against goals and standards

- Once managers know what their goals are, they should measure their actual performance and compare. This step basically helps them know if their plans are working as intended.
- After implementing a plan, managers have to continuously monitor and evaluate them. If things are not working properly then they should always be ready to take corrective measures. To do this, they must keep comparing their actual performance with their ultimate goals.
- To compare their actual performance, managers must first measure it. They can employ financial experts by measuring results in a monetary context, seeking customer feedback, etc. This can often be difficult if managers want to measure intangible standards such as industrial relations, market reputation, and more.

3. Taking corrective action

- If there are discrepancies between actual performance and goals, managers need to take corrective action immediately. Timely corrective action can reduce the damage as well as prevent it from recurring in the future.
- Occasionally, business organizations take corrective actions as default in policies. However, when it comes to complex problems, it can be difficult to do.
- In such cases, managers first need to determine the amount of the defect and devise a course of action to measure it. Sometimes, they may have to take extraordinary measures for unexpected problems.

4. Following up on corrective action

- Merely taking corrective measures is not enough; Managers should also lead them to their logical conclusion. Even this step requires thorough evaluation and comparison.

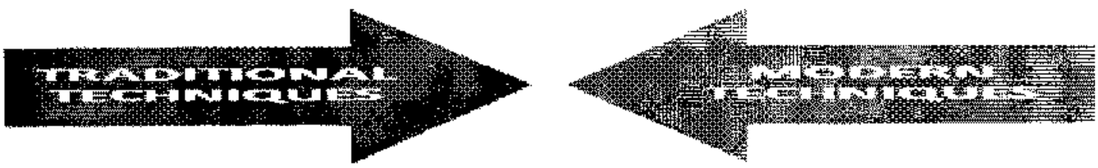
- Managers should solve the problem until they solve it. If they refer it to a subordinate, they should stick around and see that it accomplishes the task. They can also refer to him personally so that later he will be able to solve such problems by himself.

Controlling Techniques:

Control is a fundamental managerial function. Managerial control regulates the organizational activities. It compares the actual performance and expected organizational standards and goals. For deviation in performance between the actual and expected performance, it ensures that necessary corrective action is taken.

There are various techniques of managerial control which can be classified into two broad categories namely-

- Traditional techniques
- Modern techniques



Traditional Techniques of Managerial Control

Traditional techniques are those which have been used by the companies for a long time now. These include:

- Personal observation
- Statistical reports
- Break-even analysis
- Budgetary control

1. Personal Observation

This is the most traditional method of control. Personal observation is one of those techniques which enables the manager to collect the information as first-hand information.

It also creates a phenomenon of psychological pressure on the employees to perform in such a manner so as to achieve well their objectives as they are aware that they are being observed personally on their job. However, it is a very time-consuming exercise & cannot effectively be used for all kinds of jobs.

2. Statistical Reports: [illegible] reports can be defined as an overall analysis of reports and data which is used in the form of averages, percentage, ratios, correlation, etc., present useful information to the managers regarding the performance of the [illegible] in various areas.

This type of useful information when presented in the various forms like charts, graphs, tables, etc., enables the managers to read them more easily & allow a comparison to be made with performance in previous periods & also with the benchmarks.

3. Break-even Analysis

Breakeven analysis is a technique used by managers to study the relationship between costs, volume & profits. It determines the overall picture of probable profit & losses at different levels of activity while analyzing the overall position.

The sales volume at which there is no profit, no loss is known as the breakeven point. There is no profit or no loss. Breakeven point can be calculated with the help of the following formula:

Breakeven point = Fixed Costs/Selling price per unit – variable costs per unit

4. Budgetary Control

Budgetary control can be defined as such technique of managerial control in which all operations which are necessary to be performed are executed in such a manner so as to perform and plan in advance in the form of budgets & actual results are compared with budgetary standards.

Therefore, the budget can be defined as a quantitative statement prepared for a definite future period of time for the purpose of obtaining a given objective. It is also a statement which reflects the policy of that particular period. The common types of budgets used by an organization.

Some of the types of budgets prepared by an organisation are as follows,

- Sales budget: A statement of what an organization expects to sell in terms of quantity as well as value
- Production budget: A statement of what an organization plans to produce in the budgeted period
- Material budget: A statement of estimated quantity & cost of materials required for production
- Cash budget: Anticipated cash inflows & outflows for the budgeted period
- Capital budget: Estimated spending on major long-term assets like a new factory or major equipment

- Research & development budget: Estimated spending for the development or refinement of products & processes

Modern Techniques of Managerial Control

Modern techniques of controlling are those which are of recent origin & are comparatively new in management literature. These techniques provide a refreshingly new thinking on the ways in which various aspects of an organization can be controlled. These include:

- Return on investment
- Ratio analysis
- Responsibility accounting
- Management audit
- PERT & CPM

1. Return on Investment

Return on investment (ROI) can be defined as one of the important and useful techniques. It provides the basics and guides for measuring whether or not invested capital has been used effectively for generating a reasonable amount of return. ROI can be used to measure the overall performance of an organization or of its individual departments or divisions. It can be calculated as under-

Net income before or after tax may be used for making comparisons. Total investment includes both working as well as fixed capital invested in the business.

2. Ratio Analysis

The most commonly used ratios used by organizations can be classified into the following categories:

- Liquidity ratios
- Solvency ratios
- Profitability ratios
- Turnover ratios

3. Responsibility Accounting: Responsibility accounting can be defined as a system of accounting in which overall involvement of different sections, divisions & departments of an organization are set up as 'Responsibility centers'. The head of the center is responsible for achieving the target set for his center. Responsibility centers may be of the following types:

- Cost center
- Revenue center
- Profit center
- Investment center

4. Management Audit: Management audit refers to a systematic appraisal of the overall performance of the management of an organization. The purpose is to review the efficiency &n effectiveness of management & to improve its performance in future periods.

PERT & CPM: PERT (programmed evaluation & review technique) & CPM (critical path method) are important network techniques useful in planning & controlling. These techniques, therefore, help in performing various functions of management like planning; scheduling & implementing time-bound projects involving the performance of a variety of complex, diverse & interrelated activities.

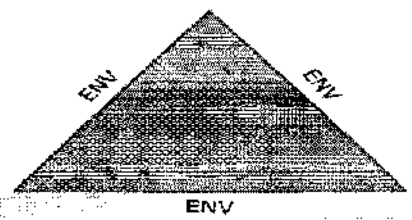
Therefore, these techniques are so interrelated and deal with such factors as time scheduling & resources allocation for these activities.

UNIT – III
ORGANIZATIONAL BEHAVIOR

Organizational Behavior is so important matter for an organization to operate their business. We know every organization their ultimate target is to maximize profit by satisfying customers need, want and demand successfully. If any organization wants to do business for a long time they must have to organize their business organization to compete in the highly competitive global market.

There are three major factors that affect OB. The working environment being the base for all three factors, they are also known as the determinants of OB. The three determinants are –

- People
- Structure
- Technology



People
An organization consists of people with different traits, personality, skills, qualities, interests, background, beliefs, values and intelligence. In order to maintain a healthy environment, all the employees should be treated equally and be judged according to their work and other aspects that affects the firm.

Example – A company offers campus placement to trainees from different states like Orissa, Haryana, Arunachal Pradesh and many more. However, during and after training, all trainees are examined only on the basis of their performance in the tasks assigned.

Structure: Structure is the layout design of an organization. It is the construction and arrangement of relationships, strategies according to the organizational goal.
Example – Organizational structure defines the relation of a manager with employees and co-workers.

Technology: Technology can be defined as the implementation of scientific knowledge for practical usage. It also provides the resources required by the people that affect their work and task performance in the right direction.
Example – Introduction of SAP, big data and other software in the market determines individual and organizational performance.

Environment

All companies function within a given internal and external environment. Internal environment can be defined as the conditions, factors, and elements within an enterprise that influences the activities, choices made by the firm, and especially the behavior of the employees. While external environment can be defined as outside factors that affect the company's ability to operate. Some of them can be manipulated by the company's marketing, while others require the company to make adjustments.

Definition of Organizational Behavior

According to Robbins___"Organisational behaviour is a field of study that investigates the impact that individuals, groups and structure have on behaviour within the organisations to apply such knowledge toward improving an organization's effectiveness".

Fred Luthans Defines___"Organisational behaviour is directly concerned with the understanding, production and control of human behaviour in organisations".

According to Davis___"Organisational behaviour is the study and application of knowledge about how people act within an organisation. It is a human tool for human benefit. It applies broadly to the behaviour of people in all types of organisation."

Nature of O.B

- It is a study of human behaviour in individuals as well as in groups.
- The study involves human behaviour in organizations.
- Knowing human behaviour and improving organizational effectiveness.
- OB believes that human behaviour in an organization can be studied predicted and influenced to improve efficiency.
- It is an optical behavioural science that is built on contributions from several behaviour disciplines such as psychology, sociology, social psychology, anthropology and economics.

Importance of Organizational Behavior

- Organizational Behaviour builds better relationships by achieving people's, organizational objectives.
- It covers a wide array of human resources like behaviour, training and development, change management, leadership, teams etc.
- Organizational Behavior brings coordination which is the essence of management.
- It improves the goodwill of the organization.
- It helps to achieve objectives quickly.
- OB makes optimum utilization of resources.
- Facilitates motivation.
- It leads to higher efficiency.

- It improves relations in the organization.
- OB is multidisciplinary, in the sense that applies different techniques, methods, and theories to evaluate the performances.

Scope of Organizational Behavior

1. **People:** The people constitute the internal social system of the organization. They consist of individuals and groups. Groups may be large or small, formal or informal, official or unofficial. They are dynamic. They form, change and disband. Human organization changes every day. Today, it is not the same as it was yesterday. People are living, thinking and feeling being who created the organization and try to achieve the objectives and goals. Thus, organizations exist to serve the people and not the people exist to serve the organization.
2. **Technology:** Technology imparts the physical and economic conditions within which people work. The nature of technology depends very much on the nature of the organization and influences the work or working conditions. Thus, technology brings effectiveness and at the same restricts people in various ways.
3. **Social System:** O.B. is the study of human behaviour at work in organizations. Accordingly, the scope of O.B. includes the study of individuals, groups and organization/structure. Let us briefly reflect on what aspects each of these three covers.

Organizational behavior Linkages with other social sciences

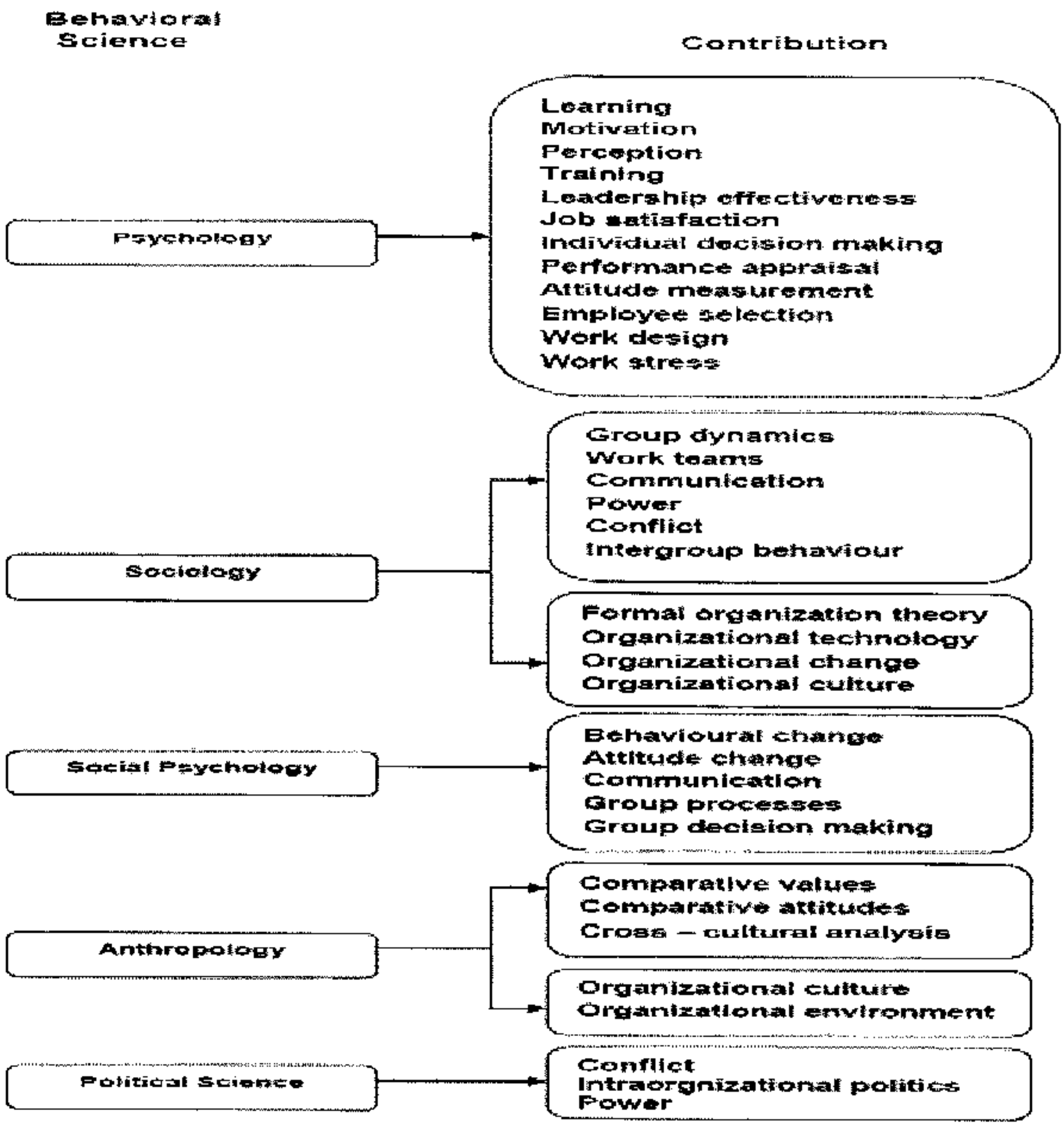
Organisational behaviour is an interdisciplinary approach as it has borrowed concepts, theories, models and practices of physical sciences as well as social sciences. The main features of organisational behaviour are primarily based on behavioural sciences. The organisational behaviour is studied in relation to psychology, sociology, political science, anthropology, economics, science, technology and environmental sciences. OB is, in fact, called an applied behavioural science.

The relationship of OB with other fields of study is depicted in the following diagram:

Psychology:
Psychology is the science that attempts to measure, explain, and at times change the behavior of humans and other animals. Early industrial/organizational psychologists were concerned with problems of fatigue, boredom, and other factors relevant to working conditions that could disrupt/ impede efficient work performance. More recently, their contributions have been expanded to include learning, perception, personality, emotions, training, leadership effectiveness, needs and motivational forces, job satisfaction, decision making processes, performance appraisals, attitude measurement, employee selection techniques, work design, and job stress.

Sociology: Sociologists study the social system in which individuals fill their roles; that is, sociology studies people in relation to their fellow human beings. Their significant contribution to OB is through their study of group behavior in organizations, particularly formal and complex organizations.

Social Psychology: Social psychology blends the concepts of psychology and sociology. It focuses on the influence of people on one another. The major challenge deals with the issue of how to implement it and how to reduce barriers to its acceptance.



Anthropology: Anthropology is the study of societies to learn about human beings and their activities. Anthropologists work on cultures and environments; for example, they have aided in understanding differences in fundamental values, attitudes, and behavior among people in different countries and within different organizations.

Political Science: Political science studies the behavior of individuals and groups within a political environment. It focuses on areas, such as, conflict, intra-organizational politics and power.

IMPORTANCE OF ORGANIZATIONAL BEHAVIOUR

1. Responding to Globalisation.
2. Managing Workforce Diversity.
3. Improving Quality and Productivity.
4. Responding to Labour Shortage.
5. Improving customer service.
6. Improving People skill.
7. Empowering People.

Individual roles: Individual Behavior

Individual behavior can be defined as a mix of responses to external and internal stimuli. It is the way a person reacts in different situations and the way someone expresses different emotions like anger, happiness, love, etc.

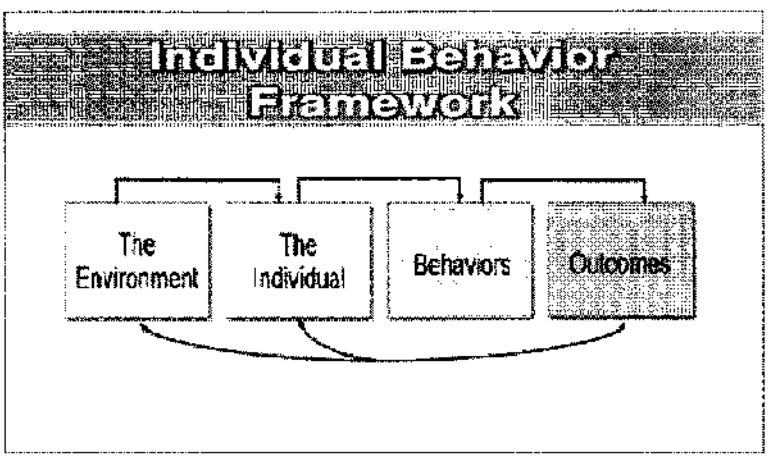
To get a brief idea about the individual behavior let us learn about the individual behavior framework and other key elements related to it.

Individual Behavior Framework

On the basis of these elements, psychologist Kurt Lewin stated the Field theory and outlined the behavior framework. This psychological theory studies the patterns of interaction between an individual and the environment. The theory is expressed using the formula. $B = F(P,E)$

where, B – Behavior, F - Behavior Function, P – Person, and E - Environment around the person.

Say for example, a well payed person who loses his job in recession may behave differently when unemployed.



Causes of Individual Behavior

Certain individual characteristics are responsible for the way a person behaves in daily life situations as well as reacts to any emergency situations. These characteristics are categorized as –

- Inherited characteristics
- Learned characteristics

Inherited Characteristics

The features individuals acquire from their parents or from our forefathers are the inherited characteristics. In other words, the gifted features an individual possesses by birth is considered as inherited characteristics.

Following features are considered as inherited characteristics –

- Color of a person's eye
- Religion/Race of a person
- Shape of the nose
- Shape of earlobes

Learned Characteristics

Nobody learns everything by birth. First our school is our home, then our society followed by our educational institutions. The characteristics an individual acquires by observing, practicing and learning from others and the surroundings is known as learned characteristics.

It consists of the following features –

- **Perception** – Result of different senses like feeling, hearing etc.
- **Values** – Influences perception of a situation, decision making process.
- **Personality** – Patterns of thinking, feeling, understanding and behaving.
- **Attitude** – Positive or negative attitude like expressing one's thought.

Factors Influencing Individual Behavior

The way an individual addresses a situation single-handedly or say in a group is influenced by many factors. The key factors influencing an individual's attitude in personal as well as social life are –

- Abilities
- Gender
- Race and culture
- Attribution
- Perception
- Attitude

Abilities: Abilities are the traits a person learns from the environment around as well as the traits a person is gifted with by birth. These traits are broadly classified as –

- Intellectual abilities
- Physical abilities
- Self-awareness abilities

In order to understand how these affect a person's behavior, we need to know what these abilities are.

- **Intellectual abilities** – It personifies a person's intelligence, verbal and analytical reasoning abilities, memory as well as verbal comprehension.
- **Physical abilities** – It personifies a person's physical strength, stamina, body coordination as well as motor skills.
- **Self-awareness abilities** – It symbolizes how a person feels about the task, while a manager's perception of his abilities decides the kind of work that needs to be allotted to an individual.

Thus the psychological, physical, self-assurance traits owned by a person defines the behavior of a person in social and personal life. For ex: Ram has a high IQ level, whereas Rahul can lift a bike and is a strong guy.

Gender: Research proves that men and women both stand equal in terms of job performance and mental abilities; however, society still emphasizes differences between the two genders. Absenteeism is one area in an organization where differences are found as women are considered to be the primary caregiver for children. A factor that might influence work allocation and evaluation in an organization is the manager's perception and personal values.

For example – An organization encourages both genders to work efficiently towards the company's goal and no special promotion or demotion is given or tolerated for any specific gender.

Race & Culture: Race is a group of people sharing similar physical features. It is used to define types of persons according to perceived traits. For example – Indian, African. On the other hand, culture can be defined as the traits, ideas, customs and traditions one follows either as a person or in a group. For example – Celebrating a festival.

Race & culture have always exerted an important influence both at the workplace as well as in the society. The common mistakes such as attributing behavior and stereotyping according to individual's race & culture basically influences an individual's behavior.

In today's diverse work culture, the management as well as staff should learn and accept different cultures, values, and common protocols to create more comfortable corporate culture.

For example – A company invites candidates for a job post and hires one on the basis of eligibility criteria and not on the basis of the country a person belongs to or the customs one follows.

Perception

Perception is an intellectual process of transforming sensory stimuli into meaningful information. It is the process of interpreting something that we see or hear in our mind and use it later to judge and give a verdict on a situation, person, group, etc.

It can be divided into six types namely –

- **Of sound** – The ability to receive sound by identifying vibrations.
- **Of speech** – The competence of interpreting and understanding the sounds of language heard.
- **Touch** – Identifying objects through patterns of its surface by touching it.
- **Taste** – The ability to detect flavor of substances by tasting it through sensory organs known as taste buds.
- **Other senses** – Other senses include balance, acceleration, pain, time, sensation felt in throat and lungs etc.
- **Of the social world** – It permits people to understand other individuals and groups of their social world.

For example – Priya goes to a restaurant and likes their customer service, so she will perceive that it is a good place to hang out and will recommend it to her friends, who may or may not like it. However, Priya's perception about the restaurant remains good.

Attribution: Attribution is the course of observing behavior followed by determining its cause based on individual's personality or situation.

Attribution framework uses the following three criteria –

- **Consensus** – The extent to which people in the same situation might react similarly.
- **Distinctiveness** – The extent to which a person's behavior can be associated to situations or personality.

- **Consistency** – The frequency measurement of the observed behavior, that is, how often does this behavior occur.

  The framework mentioned says it is all about how an individual behaves in different situations.

  For example – Rohit invites Anisha and two more friends for a movie and they agree to bunk and watch the movie, this is consensus. Bunking of class says that they are not interested in their lectures, this is distinctiveness. A little change in the situation, like if Rohit frequently starts bunking the class then his friends may or may not support him. The frequency of their support and their rejection decides consistency.

Attitude: Attitude is the abstract learnt reaction or say response of a person's entire cognitive process over a time span.

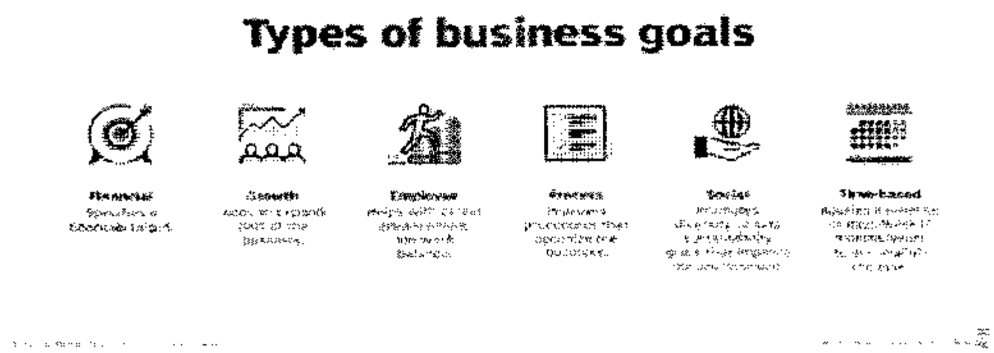
For example – A person who has worked with different companies might develop an attitude of indifference towards organizational citizenship.

Now we have a clear idea about what are the factors responsible for the way we behave. We never think about these elements and how they affect our daily life but we can't ignore the fact that they are responsible for the way we walk, talk, eat, socialize, etc.

organizational goals:

Organizational goals are strategic objectives that a company's management establishes to outline expected outcomes and guide employees' efforts.

There are many advantages to establishing organizational goals. They guide employee efforts, justify a company's activities and existence, define performance standards, rovide constraints for pursuing unnecessary goals and function as behavioral incentives. For the goals to have business merit, organizations must craft a strategic plan for choosing and meeting them. A company's big picture strategy also includes organizational goals.



Organizations strive to reach different types of goals.

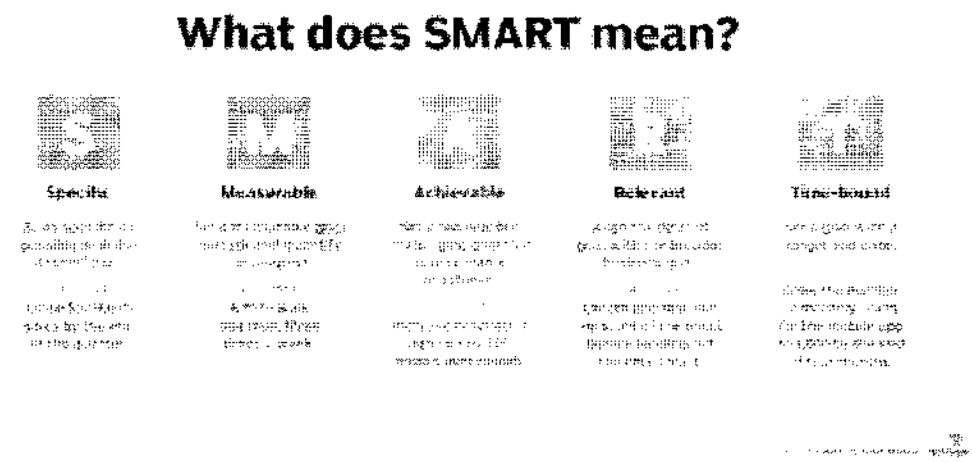
Why is having organizational goals important?

Goals can help a business grow and achieve compliance, and establish its big picture financial objectives. Organizations set specific goals to help measure their progress and determine the tasks that must be improved.

Goals need to be the following:

- specific,
- measurable,
- achievable,
- relevant and
- timely.

Together, these criteria form SMART goals, which is a framework businesses use to set organizational goals.



SMART goals give organizations a framework for setting and reaching quality goals.

By setting comprehensive, realistic goals, organizations have a clearer path to achieve success and realize their vision. Goal setting, and attaining these goals, can also help an organization achieve increased efficiency, productivity and profitability.

Organizations should communicate goals to engage employees in their work and to achieve the organization's desired results. Having a clear idea of organizational goals helps employees determine their course of action to help the business achieve those goals. Employees should also have the proper tools and resources to help them meet organizational goals.

Setting goals can help companies evaluate employee performance -- for example, creating individual employee goals that support organizational goals and measuring individual performance against those individual goals. While an organization can communicate its organizational goals through formal channels, the most effective and direct way to do so is through employees' direct supervisors. This enables managers to work with their staff to develop SMART goals that align with the organization's goals. Setting organizational goals also helps build workplace harmony because it makes employees work toward attaining similar goals.

While developing sound goals helps organizations with strategic planning, over time, goals might turn out to be unrealistic and need to be modified.

Types of organizational goals

There are three main types of organizational goals:

1. Strategic goals: These are goals -- often big picture, qualitative, long-term goals -- an organization aims to achieve. They may also be referred to as *strategic goals*.Strategic goals detail a company's objectives as described in its mission statement or in public statements, such as a corporate charter or annual reports. They help to build the organization's public image and reputation. Such goals are often qualitative and harder to measure.
2. Tactical goals: These are smaller picture, qualitative goals -- often with a quantitative element -- that focus on transforming official goals into operational goals. These are team goals.Tactical goals bridge the gap between strategic and operative goals. They help connect measurable everyday business processes to the big picture goals outlined in a company's strategic plan.
3. Operative goals: These are goals with measurable steps required to achieve a desired outcome. They're often smaller team goals or individual goals. Operative goals are the actual, concrete steps an organization intends to take to achieve its purpose. A business's operative goals often don't parallel its official goals; for example, while a nonprofit volunteer organization's main official goal may be community service, limited funding might mean that its operative goal of fundraising will take precedence. Operative goals are often short-term goals organizations seek to achieve through their operating policies and undertakings and are measured quantitatively. Their success is based on metrics. Companies can outline the specific steps they need to take to achieve operative goals.

Steps for setting organizational goals

A company can take the following general steps when setting up organizational goals:

1. **Assess the state of the business.** Examine the current state of the business and external factors that affect it, such as industry trends. A SWOT analysis can help identify a company's -- or team within the company -- strengths, weaknesses, opportunities and threats. A PESTLE (political, economic, social, technological, legal, environmental factors) analysis can be useful for accounting for external factors. If setting operational goals, a team might cross-reference its strengths and weaknesses against the larger goals set by the organization.
2. **Establish each goal.** Decide how the business or team wants to use this information to improve itself. Brainstorm goals and choose those goals that capitalize on opportunities for growth.
3. **Prioritize goals.** Establish a time frame and delegate the goals to different teams or team members based on responsibility and ranking. Consider external factors when determining goal deadlines.
4. **Establish measurement metrics.** Determine how the progress of goals will be measured. Some goals may more readily lend themselves to quantitative measurement. Set tangible benchmarks that teams can reach.
5. **Integrate goals with processes.** Incorporate the goals into the team's or business's way of working and develop methods to achieve them.

6. **Communicate goals to those involved.** Share the goals with others who weren't immediately involved in devising the goals and look for ways that different teams can work together to reach goals. Make goals visible and communicate them in a clear and concise fashion.

7. **Evaluate progress.** As time goes by and progress is made or circumstances change, evaluate progress using predefined metrics, and revise goals and optimize processes if appropriate. Encourage feedback to help assess goals and team performance.

Perception:

Perception in Organisational Behavior: – Perception in Organisational Behavior is defined as the process by which an **individual selects**, organizes and interprets **stimuli** into a meaningful and **coherent picture of the world**. Perception is an intellectual process of transforming sensory stimuli to meaningful information. It involves both recognizing environmental stimuli and actions in response to these stimuli. It is a cognitive process by which people attend to incoming stimuli, organise and interpret such stimuli into behaviour.

Stimulus is any **unit of input** to any of the **senses**; examples of stimuli (i.e. Sensory inputs) include products, packages, brand names; advertisement and commercials. Sensory receptors are the human organs (the eyes, ears, nose, mouth and skin) that receive sensory inputs. These sensory functions are to see, hear, smell, taste and feel respective.

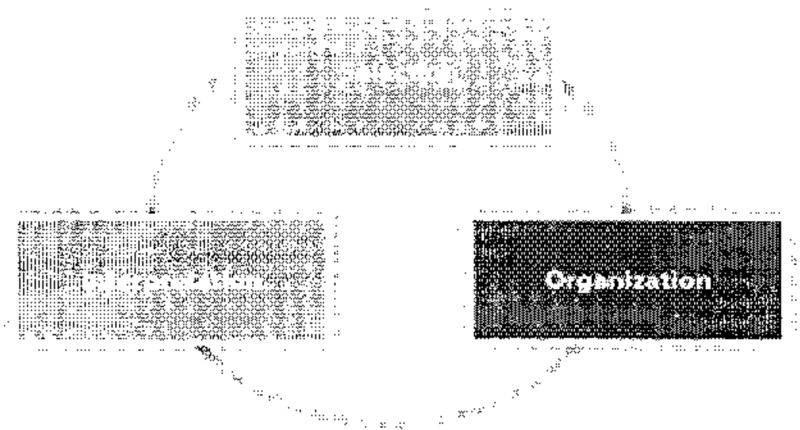
Definitions by Different Authors

1. ***Stephen P. Robbins***: – "Perception may be defined as a process by which individuals organise and interpret their sensory impressions in order to give meaning to their environment."
2. ***Joseph Reitz***: – "Perception includes all those processes by which an individual receives information about his environment—seeing, hearing, feeling, tasting and smelling."
3. ***Fred Luthans***: – "Perception is an important meditative cognitive process through which persons make interpretations of the stimuli or situation they are faced with"

The nature of Perception in Organisational Behavior are as follows: –

1. Perception is the process by which a person gives meaning to the environment;
2. People's actions, feelings, thoughts and emotions are driven by their perceptions about their surroundings;
3. Perception has been defined in various ways; It basically refers to the way in which a person experiences the world; and
4. Perception is an almost automatic process and works the same way within each individual, yet it usually produces different perceptions.

Perceptual Process



1. Perceptional Selection

Consumers subconsciously exercise a great deal of selectivity as to which aspects of the environment they perceive. An individual may look at some things, ignore others, and turn away from still others. In actually, people receive only a small fraction of the stimuli to which they were exposed.

Which stimuli get selected depends on two major factors in addition to the nature of the stimulus itself. (1) Consumers previous experience as it affects their expectations. And (2) their motives at the time. Ease of these factors can serve to increase or decrease the probability that a stimulus will be perceived.

Nature of the stimulus

Marketing stimuli include an enormous number of variables that affect the consumers perception, such as nature of the product, its physical attributes, the package design, the brand name, the advertisements and commercials including copy claims, choice and sex of model, size of ad, topography, the position of print ad or a commercial, and the editorial environment.

Expectations

People usually see what they expect to see, and what they expect to see is usually based on familiarity, . Previous experience, or preconditioned set. In a marketing context, people tend to perceive products and product attributes according to their own expectations.

Motives

People tend to perceive the things they need or want; the stronger the need the greater the tendency to ignore unrelated stimuli in the environment. In general, there is heightened awareness of stimuli that are relevant to ones needs and interests and a decreased awareness of stimuli that are irrelevant to those needs.

Selective perception

The consumers "selection" of stimuli from the environment is based on the interactions of expectations and motives with the stimulus itself. These factors give rise to four important concepts concerning perception.

Selective Exposure

Consumers actively seek out messages that they find pleasant or with which they are sympathetic. And they actively avoid painful or threatening ones. They also selectively expose themselves to advertisements that reassure them of the wisdom of their purchase decisions.

Selective attention

Consumers exercise a great deal of selectivity in terms of the attention they give to commercial stimuli. They have a heightened awareness of stimuli that meet their needs or interests and minimal awareness of stimuli irrelevant to their needs. Thus, consumers are likely to note ads for products that would satisfy their needs and disregard those in which they have no interest.

Perceptual Defense

Consumers subconsciously screen out stimuli that they find psychologically threatening, even though exposure has already taken place. Thus, threatening or otherwise damaging stimuli are less likely to be consciously perceived than are neutral stimuli at the same level of exposure.

Perceptual Blocking

Consumers protect themselves from being bombarded with stimuli by simply "tuning out" – blocking such stimuli from conscious awareness. They do so out of self – protecting because of the visually overwhelming nature of the world in which we live. The popularity of such devices as TiVo and Replay TV, which enable viewers to skip over TV commercials with great ease, is, in part, a result of perceptual blocking.

2. **Perceptual Organization**

People do not experience a numerous stimuli they select from the environment as separate and discrete sensations rather they tend to organize them into groups and perceive them as unified wholes.

Figure and Grounds

People have tendency to organize their perceptions into figure and ground relationship. How a figure- ground pattern is perceived can be influenced by prior pleasant or painful associations with one or the other element in isolation.

Grouping

Individuals tend to group stimuli so that they form a unified picture or impression. The perception of stimuli as groups or chunks of information, rather than as discrete bits of information, facilitates their memory and recall. Grouping can be used advantageously by marketers to simply certain desired meanings in connection with their products.

Closure

Individuals have a need for closure. They express this need by organizing their perceptions so that they form a complete picture. If the pattern of stimuli to which they are exposed is incomplete, they tend to perceive it, nevertheless, as complete; that is, they consciously or subconsciously fill in the missing pieces.

3. **Perceptual interpretation**

Stimuli are often highly ambiguous. Some stimuli are weak because of such factors as poor visibility, brief exposure, high noise level or constant fluctuations. Even the stimuli that are strong tend to fluctuate dramatically because of such factors as different angles of viewing, varying distances, and changing levels if illumination.

Perceptual distortion

Individuals are subject to a number of influences that tend to distort their perceptions, such as physical appearances, stereotypes, first impressions, jumping to conclusions and the halo effect.

Consumer imagery

Consumers have a number of enduring perceptions, or images, that are particularly relevant to the study of consumer behavior. Products and brands have symbolic value for individuals, who evaluate them on the basis of their consistency with their personal pictures of themselves.

Product positioning

The essence of successful marketing is the image that a product has in the mind of the consumer-that is positioning. Positioning is more important to the ultimate success of a product than are its actual characteristics, although products are poorly made will not succeed in the long run on the basis of image alone.

Learning:

Learning is described as the process of having one's behavior modified, more or less permanently, by what he does and the consequences of his action, or by what he observes.

Definitions:

1. According to S.P. Robbins, "Learning is any relatively permanent change in behavior resulting from experience."
2. According to Scott Miller, "Learning is a change that occurs in response to thinking or other sensual stimuli."
3. According to S. P. Robbins, "Learning is any relatively permanent change in behavior resulting from experience."

Nature of Learning

Nature of learning means the characteristic features of learning. Learning involves change; it may or may not guarantee improvement. It should be permanent in nature, that is learning is for lifelong.

The change in behavior is the result of experience, practice and training. Learning is reflected through behavior.

Factors Affecting Learning

Learning is based upon some key factors that decide what changes will be caused by this experience. The key elements or the major factors that affect learning are motivation, practice, environment, and mental group.

Coming back to these factors let us have a look on these factors –

- **Motivation** – The encouragement, the support one gets to complete a task, to achieve a goal is known as motivation. It is a very important aspect of learning as it acts gives us a positive energy to complete a task. **Example** – The coach motivated the players to win the match.

- **Practice** – We all know that "Practice makes us perfect". In order to be a perfectionist or at least complete the task, it is very important to practice what we have learnt. **Example** – We can be a programmer only when we execute the codes we have written.

- **Environment** – We learn from our surroundings, we learn from the people around us. They are of two types of environment – internal and external. **Example** – A child when at home learns from the family which is an internal environment, but when sent to school it is an external environment.

- **Mental group** – It describes our thinking by the group of people we chose to hang out with. In simple words, we make a group of those people with whom we connect. It can be for a social cause where people with the same mentality work in the same direction. **Example** – A group of readers, travelers, etc.

These are the main factors that influence what a person learns, these are the root level for our behavior and everything we do is connected to what we learn.

How Learning Occurs?

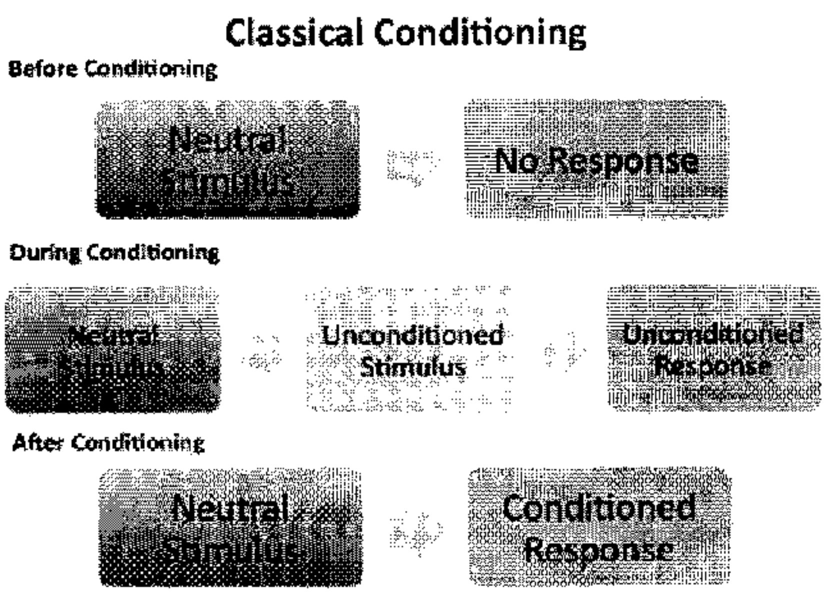
Learning can be understood clearly with the help of some theories that will explain our behavior. Some of the remarkable theories are –

- Classical Conditioning Theory
- Operant Conditioning Theory
- Social Learning Theory
- Cognitive Learning Theory

Classical Conditioning Theory

The classical conditioning occurs when a conditioned stimulus is coupled with an unconditioned stimulus. Usually, the conditioned stimulus (CS) is an impartial stimulus like the sound of a tuning fork, the unconditioned stimulus (US) is biologically effective like the taste of food and the unconditioned response (UR) to the unconditioned stimulus is an unlearned reflex response like salivation or sweating.

After this coupling process is repeated (for example, some learning may already occur after a single coupling), an individual shows a conditioned response (CR) to the conditioned stimulus, when the conditioned stimulus is presented alone. The conditioned response is mostly similar to the unconditioned response, but unlike the unconditioned response, it must be acquired through experience and is nearly impermanent.



Operant Conditioning Theory

Operant conditioning theory is also known as instrumental conditioning. This theory is a learning process in which behavior is sensitive to, or controlled by its outcomes.

Let's take an example of a child. A child may learn to open a box to get the candy inside, or learn to avoid touching a hot stove. In comparison, the classical conditioning develops a relationship between a stimulus and a behavior. The example can be further elaborated as the child may learn to salivate at the sight of candy, or to tremble at the sight of an angry parent.

In the 20th century, the study of animal learning was commanded by the analysis of these two sorts of learning, and they are still at the core of behavior analysis.

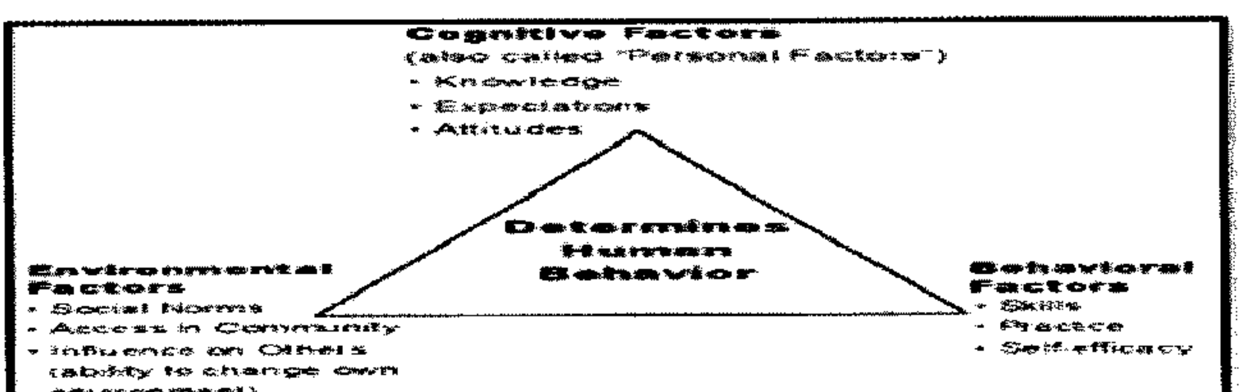
Operant Conditioning

	Reinforcement Increase Behavior	Punishment Decrease Behavior
Positive Stimulus (something added)	Positive Reinforcement Add something to increase behavior	Positive Punishment Add something to decrease behavior
Negative Stimulus (something removed)	Negative Reinforcement Remove something to increase behavior	Negative Punishment Remove something to decrease behavior

Social Learning Theory

The key assumptions of social learning theory are as follows −

- Learning is not exactly behavioral, instead it is a cognitive process that takes place in a social context.
- Learning can occur by observing a behavior and by observing the outcomes of the behavior (known as vicarious reinforcement).
- Learning includes observation, extraction of information from those observations, and making decisions regarding the performance of the behavior (known as observational learning or modeling). Thus, learning can occur beyond an observable change in behavior.
- Reinforcement plays an important role in learning but is not completely responsible for learning.
- The learner is not a passive receiver of information. Understanding, environment, and behavior all mutually influence each other.



Cognitive Learning Theory

Cognition defines a person's ideas, thoughts, knowledge, interpretation, understanding about himself and environment.

This theory considers learning as the outcome of deliberate thinking on a problem or situation based upon known facts and responding in an objective and more oriented manner. It perceives that a person learns the meaning of various objects and events and also learns the response depending upon the meaning assigned to the stimuli.

This theory debates that the learner forms a cognitive structure in memory which stores organized information about the various events that occurs.

Learning & Organizational Behavior

An individual's behavior in an organization is directly or indirectly affected by learning.

Example – Employee skill, manager's attitude are all learned.

Behavior can be improved by following the listed tips –

- Reducing absenteeism by rewarding employees for their fair attendance.
- Improving employee discipline by dealing with employee's undesirable behavior, drinking at workplace, stealing, coming late, etc. by taking appropriate actions like oral reprimands, written warnings and suspension.
- Developing training programs more often so as to grab the trainees' attention, provide required motivational properties etc.

The word personality is derived from a Greek word *"persona"* which means "to speak through." Personality is the combination of characteristics or qualities that forms a person's unique identity. It signifies the role which a person plays in public. Every individual has a unique, personal and major determinant of his behavior that defines his/her personality.

Personality trait is basically influenced by two major features –

- Inherited characteristics
- Learned characteristics

Inherited Characteristics

The features an individual acquires from their parents or forefathers, in other words the gifted features an individual possesses by birth is considered as inherited characteristics. It consists of the following features –

- Color of a person's eye
- Religion/Race of a person
- Shape of the nose
- Shape of earlobes

Learned Characteristics

Nobody learns everything by birth. First, our school is our home, then our society, followed by educational institutes. The characteristics an individual acquires by observing, practicing, and learning from others and the surroundings is known as learned characteristics.

Learned characteristics includes the following features –

- **Perception** – Result of different senses like feeling, hearing etc.
- **Values** – Influences perception of a situation, decision making process.
- **Personality** – Patterns of thinking, feeling, understanding and behaving.
- **Attitude** – Positive or negative attitude like expressing one's thought.
- Personality describes the unique patterns of thoughts, feelings, and behaviors that distinguish a person from others. A product of both biology and environment, it remains fairly consistent throughout life.
- Examples of personality can be found in how we describe other people's traits. For instance, "She is generous, caring, and a bit of a perfectionist," or "They are loyal and protective of their friends."
- The word "personality" stems from the Latin word *persona*, which refers to a theatrical mask worn by performers to play roles or disguise their identities.

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Definition: The **Personality** refers to the distinct traits, thoughts, feelings, actions and characteristics of an individual that differentiates him from other individuals. Simply, the personality is the typical behavior of a person in which he responds to the given situations.
Personality Characteristics

What exactly makes up a personality? Traits and patterns of thought and emotion play important roles, and so do these fundamental characteristics of personality:

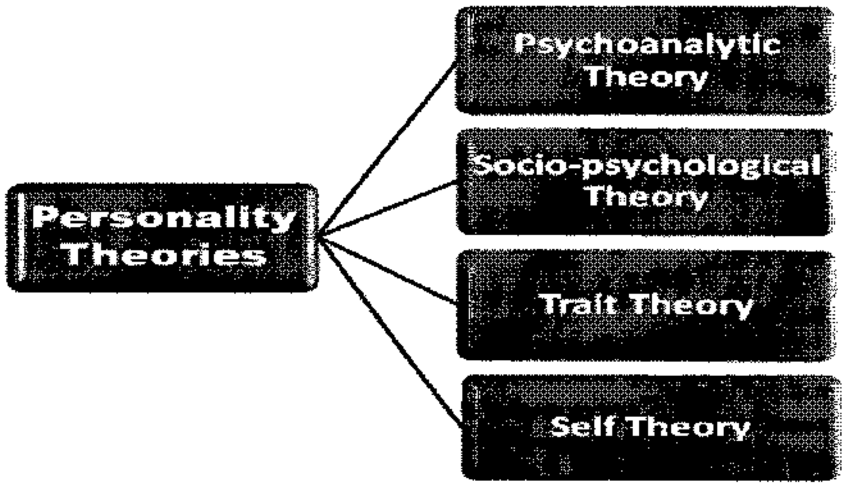
- **Consistency**: There is generally a recognizable order and regularity to behaviors. Essentially, people act in the same way or in similar ways in a variety of situations.
- **Both psychological and physiological**: Personality is a psychological construct, but research suggests that it is also influenced by biological processes and needs.
- **Affects behaviors and actions:** Personality not only influences how we move and respond in our environment, but it also *causes* us to act in certain ways.

- **Multiple expressions**: Personality is displayed in more than just behavior. It can also be seen in our thoughts, feelings, close relationships, and other social interactions.

Theories of Personality:

Since there is no exact definition of the term personality, different theorists from psychology field as well as from other fields dealing with human behavior have carried on researches to find out the answers to certain questions Viz. What is Personality? What does it constitute? How is behavior governed by Personality?

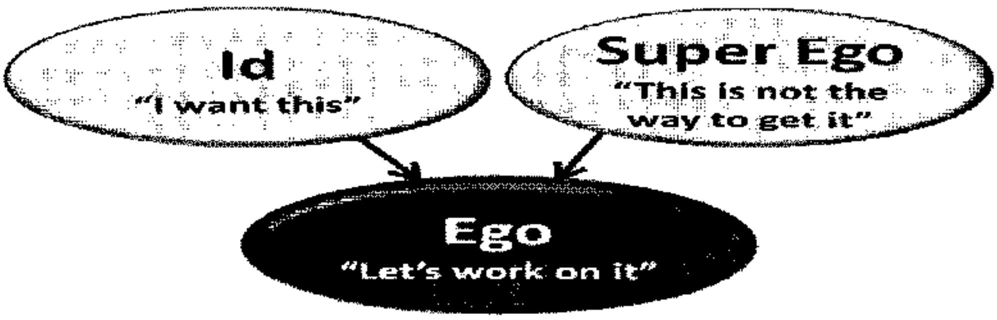
The theories of personality have been grouped as:



Psychoanalytic Theory:

Definition: The **Psychoanalytic Theory** is the personality theory, which is based on the notion that an individual gets motivated more by unseen forces that are controlled by the conscious and the rational thought.

Sigmund Freud is closely related to the psychoanalytic theory. According to him, the human behavior is formed through an interaction between three components of the mind, i.e. Id, Ego and Super Ego.



1. **Id:** Id is the primitive part of the mind that seeks immediate gratification of biological or instinctual needs. The biological needs are the basic physical needs and while the instinctual needs are the natural or unlearned needs, such as hunger, thirst, sex, etc. Id is the unconscious part of the mind; that act instantaneously without giving much thought to what is right and what is wrong.

   Example: If your Id passed through a boy playing with a ball, the immediate urge to get that ball will drive you to snatch it by any means, this is irrational and may lead to the conflict between the boys. Thus, Id is the source of psychic energy, a force that is behind all the mental forces.

2. **Super-Ego:** The Super-Ego is related to the social or the moral values that an individual inculcates as he matures. It acts as an ethical constraint on behavior and helps an individual to develop his conscience. As the individual grows in the society, he learns the cultural values and the norms of the society which help him to differentiate between right and wrong.

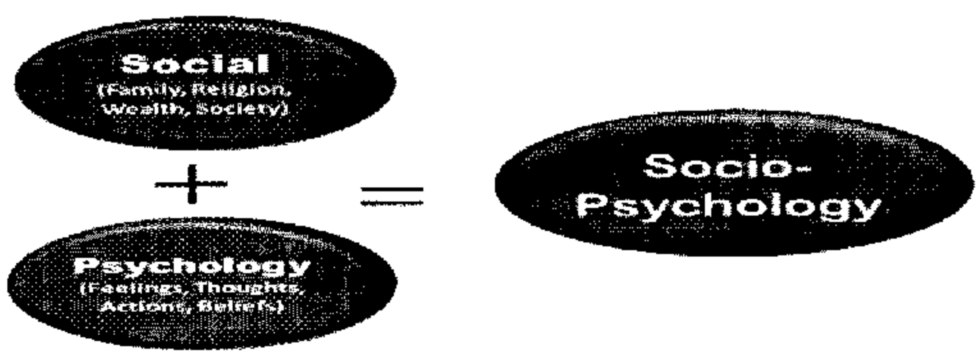
   Example: If the super-ego passed that boy playing with a ball, it would not snatch it, as it would know that snatching is bad and may lead to a quarrel. Thus, super ego act as a constraint on your behavior and guides you to follow the right path. But if the Id is stronger than super-ego, you will definitely snatch the ball by any means.

3. **Ego:** Ego is the logical and the conscious part of the mind which is associated with the reality principle. This means it balances the demands of Id and super-ego in the context of real life situations. Ego is conscious and hence keep a check on Id through a proper reasoning of an external environment.

   Example: If you pass through the same boy playing with the ball, your ego will mediate the conflict between the Id and super-ego and will decide to buy a new ball for yourself. This may hurt you Id, but the ego would take this decision to reach to a compromise situation between the Id and super-ego by satisfying the desire of getting a ball without committing any unpleasant social behavior.

Socio-Psychological Theory:

Definition: The **Socio-Psychological Theory** asserts that individual and society are interlinked. This means, an individual strives to meet the needs of the society and the society helps him to attain his goals. Through this interaction, the personality of an individual is determined.



The Socio-Psychological theory is the contribution of Adler, Horney, Forman and Sullivan. This theory is also called as Neo-Freudian Theory because it differs from the Freud's psychoanalytic theory in the following respects:

1. According to this theory, the social variables and not the biological instincts, are the important determinants in shaping the individual's personality.
2. Here, the motivation is conscious, i.e. an individual knows what are his needs and wants and what kind of behavior is required to meet these needs.

Thus, the theorists believe that socio-psychological factors, i.e. the combination of both the social (family, society, wealth, religion) and the psychological factors (feelings, thoughts, beliefs) play an important role in shaping the personality of an individual.

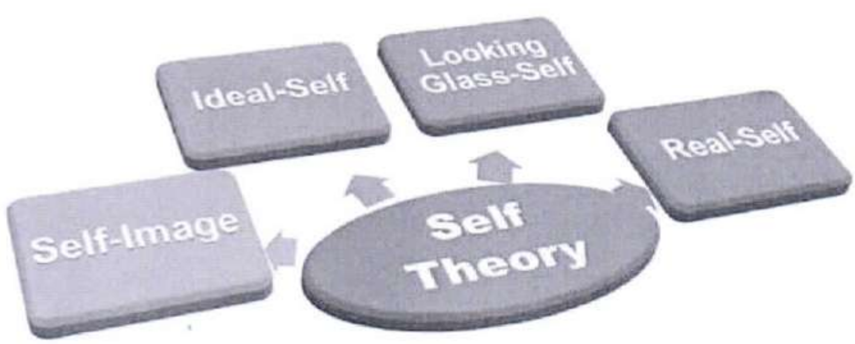
Personality Traits: Trait theories tend to view personality as the result of internal characteristics that are genetically based and include: (Factors)

- **Agreeable**: Cares about others, feels empathy, enjoys helping others
- **Conscientiousness**: High levels of thoughtfulness, good impulse control, goal-directed behaviors
- **Eager-to-please**: Accommodating, passive, and conforming
- **Extraversion**: Excitability, sociability, talkativeness, assertiveness, and high amounts of emotional expressiveness
- **Introversion**: Quiet, reserved
- **Neuroticism**: Experiences stress and dramatic shifts in mood, feels anxious, worries about different things, gets upset easily, struggles to bounce back after stressful events
- **Openness**: Very creative, open to trying new things, focuses on tackling new challenges

Self Theory

Definition: The **Self Theory** emphasizes on the set of perceptions an individual has for himself and the perceptions of the relationships he has with others and the other aspects of life. Carl Rogers has contributed significantly towards the self theory.

The self theory comprises of four factors that are explained below:



1. **Self-Image:** Self-image means what an individual thinks about himself. Everybody has certain beliefs about themselves, such as who or what they are, these beliefs form the self image and identity of a person.

   According to Erikson, identity is formed through a lifelong development usually unconscious to the individual and his society, i.e. an individual forms perception about himself unconsciously, according to the social circumstances.

2. **Ideal-Self:** The ideal-self means, the way an individual would like to be. It is very much different from the self-image, as it shows the ideal position perceived by an individual, whereas the self-image is the reality that an individual perceives.Thus, there could be a gap between these two.

   The ideal-self-acts as a stimulus to motivate an individual to undertake those activities that are in compliance with the characteristics of his ideal self.

3. **Looking-Glass-Self:** The looking-glass self means, an individual's perception of how others are perceiving his qualities or feeling about him. Simply, it is the perception of other's perception, i.e. perceiving what others perceive about yourself and not see what actually you are.
4. **Real-Self:** The real-self is what others show you with respect to your self-image. An individual's self-image is confirmed when others responses to him and shares their beliefs or perception, about what they actually feel about him.

   This is taken as feedback from the environment that helps an individual to adjusts his self-image accordingly and be in line with the cues he had received.

Thus, according to Carl Rogers, the self theory is composed of several perceptions of **"I" or "me"** and the perception of relationships of **"I" and "me"** to others.

Creative Thinking

_Creative thinking is the ability to consider something in a new way. Employers in all industries want employees who can think creatively and bring new perspectives to the workplace.[1]

Creative thinking can involve:

- A new approach to a problem
- A resolution to a conflict between employees
- A new result from a data set
- A previously untried approach to earn revenue
- A new product—or product feature

Find out more about the various types of creative thinking, and why having this ability is very beneficial in the workplace.

Five characteristics that creative leaders seem to have in common:

- Perseverance in the face of obstacles and adversity

- Willingness to take risks
- Willingness to grow and openness to experience
- Tolerance of ambiguity
- Effective use of analogy to apply a known situation to an unknown situation

Organizationally (and individually) speaking, there are certain factors that, when they exist, tend to point to a more creative atmosphere.

- **Questioning attitude.** Organizations that don't invite the questioning of values, assumptions or norms are not likely to be very creative. Organizations need to continually question the long-held beliefs of their industry if they're going to stay ahead of the curve and come up with creative ways to bring services and products to their customers.
- **Culture.** Our traditional values are sometimes at odds with the creative solutions we might come up with to solve organizational problems. If an organization's culture puts too much emphasis on tradition, they're likely to stifle creativity around problem solving.
- **Leadership.** Similar to culture, leaders who are bound to traditional characteristics of the leader-follower relationship, who don't promote questioning attitudes or invite their employees to challenge the status quo, will not do much to foster a creative environment.
- **Attitude toward risk.** Finally, employees who are afraid to try something new will never put their creative solutions into action! Just as one of the characteristics of a creative leader is a willingness to take risks, so must employees feel comfortable doing so in an organization.

The Three Components of Creativity

Studies show that most individuals have the capability of being at least moderately creative, so if organizations want to help individuals develop their creativity, they can leverage the three components of creativity. The three components of creativity suggest that creativity lies at the intersection of motivation, expertise and developed creative thinking skills.

Expertise—technical, procedural and intellectual knowledge—is the foundation for all creative work. You wouldn't expect someone who knows very little about software programming to come up with creative solutions to problems. The potential for creativity in a given area is enhanced when the individual has an exceptional grasp of the information around a problem or issue. Organizations can have a positive impact on increasing employee expertise with training, mentorship programs, etc.

Creative thinking skills encompass all those personality traits we talked about earlier that are common to creative leaders. Organizations, when cognizant of the traits that foster creativity, can interview and select candidates for hire that have these characteristics.

Motivation here means that an individual wants to work on a particular task because it's interesting and engaging. An individual who is more intrinsically motivated is likely to have an easier time developing creativity than one who is more extrinsically motivated. Motivation determines the extent to which an individual will engage his expertise and creative thinking skills.

Benefits of creative thinking

Developing your creative thinking skills is highly beneficial for any field of work. After all, every area needs people that can come up with the best solutions to the everyday problems that arise and **creativity is critical** to do that.

You can experience advantages such as these by developing creative thinking skills:

- ability to **create the best solutions** to daily demands, which provides value to clients and your own business;
- improvement on **problem-solving** for not only work-related matters but also those in your personal life;
- higher **workplace involvement** in daily activities and engagement, which is beneficial to a healthier environment;
- a better **understanding of data** — also known as data literacy — and how to present it through data storytelling;
- focus on **self-improvement** as you and your teammates will develop more soft skills.
- more effective **teamwork and bonding**, since people grow used to bouncing off original ideas and learn each other's creative traits.

Unit – IV

Motivation and Job Performance

Motivation describes the wants or needs that direct behavior toward a goal. It is an urge to behave or act in a way that will satisfy certain conditions, such as wishes, desires, or goals. Older theories of motivation stated that rational thought and reason were the guiding factors in human motivation; however, psychologists now believe that motivation may be rooted in basic impulses to optimize well-being, minimize physical pain, and maximize pleasure.

Definition of Motivation:

Motivation is an inspirational process which impels the members of the team to pull their weight effectively to give their loyalty to the group, to carry out the tasks properly that they have accepted, and generally to play an effective part in the job that the group has undertaken.

In the words of **Michael Jucious**, 'motivation is the act of stimulating someone or oneself to get a desired course of action, to push the right button to get a desired reaction'.

S. Zedeck and M. Blood defines, 'Motivation is a predisposition to act in a specific goal-directed way'.

Features of Motivation

Motivation is an internal feeling, that is, it defines the psychological state of a person. It is a continuous process and we should make sure that it is not disturbed. A person should be encouraged completely.

Motivation consists of three interacting and dependent elements –

- Needs – The requirements or deficiency which is created whenever there is physiological imbalance.
- Drives – The various camps or events organized to motivate the employees and give them new opportunities.
- Incentives – Employees need to be rewarded for their nice work in order to keep them encouraged.

Importance of Motivation

We need to motivate employees because of the following reasons –

- Motivated employee are more quality oriented.
- Highly motivated employees are more productive as compared to other employees.
- It helps in achieving three behaviour dimension of human resource namely
  - Candidates must be attracted not only to join but also remain in the firm.
  - Employees must perform task in a dependable manner.
  - Employees should be creative, spontaneous and innovative at work.

Maslow's Hierarchy of Needs Theory

This theory was produced in order to answer the question "What motivates an individual". Every second need comes to force when the first need is satisfied completely. Maslow explained the hierarchy of needs by grouping them into two: deficiency needs and growth needs.

Physiological Needs

Every individual needs to take care of the basic requirements required to sustain. These requirements include food to eat, clothing to wear and shelter to live in. These necessities are relatively independent of each other but are finite.

Safety Needs

Everybody wants to stay in a protected environment with minimal danger so that they can have a peaceful life. Safety needs basically includes protection from physiological danger like accident and having economic security like bank accounts, health insurance

In an enterprise, it includes job security, salary increment, etc. The managerial practice to satisfy this involves offering pension scheme, provident fund, gratuity etc.

Social Needs

We have all heard that man is a social animal, we want to be there with those people where we are loved and we are accepted as we are; nobody wants to be judged. This is a common requirement every human desires.

This theory helps managers to think about encouraging their employees by identifying employee needs. In short, it presents motivation as constantly changing force, expressing itself to the constant need for fulfilment of new and higher levels of needs.

Esteem

Esteem means the typical human desire to be accepted and valued by others. People often involve in a profession or hobby to gain recognition, earn fame and respect. According to Maslow, the needs of humans have strict guidelines - the hierarchies rather than being sharply separated, are interrelated. This means that esteem and the consequent levels are not strictly separated but are closely related.

Self-Actualization

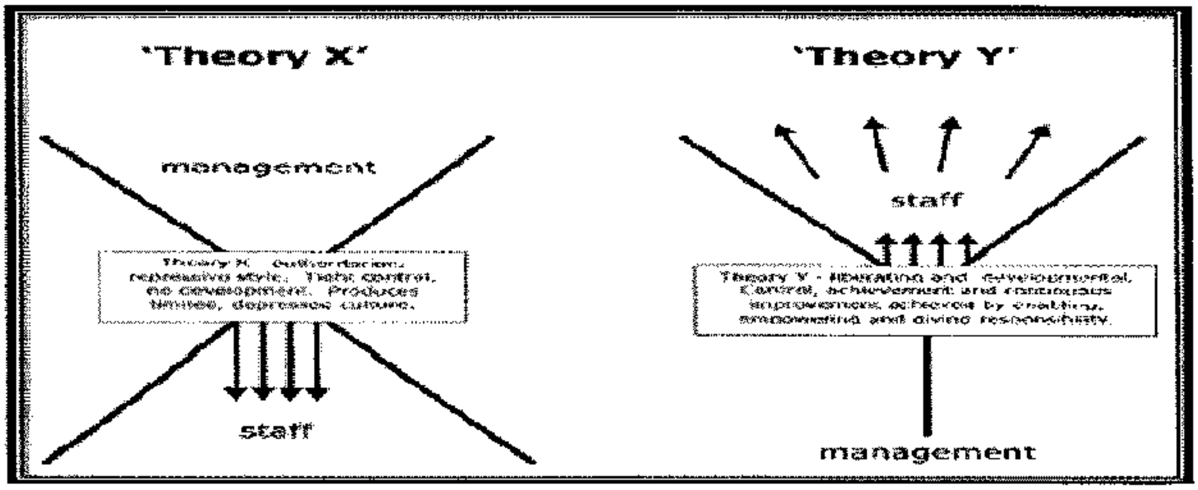
Self-actualization means realizing one's full potential. Maslow describes this as a desire to complete everything that one can, to become the most that one can be.

Theory X & Theory Y

Our management style is firmly influenced by our beliefs and assumptions about what encourages members of our team like: If we believe that our team members dislike work, then we tend towards an authoritarian style of management. However, if we assume that employees take pride in doing a good job, we tend to adopt a more participative style.

Douglas McGregor, the eminent social psychologist, divides management style into two contrasting theories –

- Theory X
- Theory Y



Theory X

This theory believes that employees are naturally unmotivated and dislike working, and this encourages an authoritarian style of management. According to this theory, management must firmly intervene to get things done. This style of management concludes that workers –

- Disfavor working.
- Abstain responsibility and the need to be directed.
- Need to be controlled, forced, and warned to deliver what's needed.
- Demand to be supervised at each and every step, with controls put in place.
- Require to be attracted to produce results, else they have no ambition or incentive to work.

McGregor observed that X-type workers are in fact mostly in minority, and yet in mass organizations, such as large scale production environment, X Theory management may be needed and can be unavoidable.

Theory Y

This theory explains a participative style of management, that is, distributive in nature. It concludes that employees are happy to work, are self-motivated and creative, and enjoy working with greater responsibility. It estimates that workers –

- Take responsibility willingly and are encouraged to fulfill the goals they are given.

- Explore and accept responsibility and do not need much guidance.
- Assume work as a natural part of life and solve work issues imaginatively.

In Y-type organizations, people at lower levels are engaged in decision making and have more responsibility.

Comparing Theory X & Theory Y

Let us now compare both the theories –

Motivation Theory X considers that people dislike work, they want to avoid it and do not take responsibilities willingly.

While, Theory Y considers that people are self-motivated, and sportingly take responsibilities.

Management Style and Control

In Theory X-type organization, management is authoritarian, and centralized control is maintained.

While in Theory Y-type organization, the management style is participative, employees are involved decision making, but the power retains to implement decisions.

Work Organization

Theory X employees are specialized and the same work cycle continues.

In Theory Y, the work tends to be coordinated around wider areas of skill or knowledge. Employees are also motivated to develop expertise, and make suggestions and improvements.

Rewards and Appraisals

Theory X-type organizations work on a 'carrot and stick' basis, and performance assessment is part of the overall mechanism of control and compensation.

Coming to Theory Y-type organizations, appraisal is also regular and crucial, but is usually a separate mechanism from organizational controls. Theory Y-type organizations provide employees frequent opportunities for promotion.

Application

Admitting the fact that Theory X management style is widely accepted as inferior to others, it has its place in large scale production procedure and unskilled production-line work.

Many of the principles of Theory Y are widely accepted by different types of organization that value and motivate active participation.

Theory Y-style management is appropriate for knowledge work and licensed services. Licensed service organizations naturally develop Theory Y-type practices by the nature of their work, even high structure knowledgprinciples to motivate knowledge sharing and continuous improvement.e framework, like call center operations, benefit from its

Groups

A group is a collection of individuals who interact with each other such that one person's actions have an impact on the others. In other words, a group is defined as two or more individuals, interacting and interdependent, who have come together to achieve particular objectives.

Groups where people get along, feel the desire to contribute to the team, and are capable of coordinating their efforts may have high-performance levels. Group can be defined as a collection of individuals who have regular contact and frequent interaction, mutual influence, the common feeling of camaraderie, and who work together to achieve a common set of goals.

Some other simple ways like: can give the definition of a group

- Several people or things that are together or in the same place.
- Several people who are connected by some shared activity, interest, or quality.
- Several individuals assembled or having some unifying relationship.
- A set of people who meet or do something together because they share the same purpose or ideas.

The term group can be defined in several different ways, depending on the perspective that is taken.

A comprehensive definition would say that is a group exists in an organization, its members:

- Are motivated to join.
- Perceive the group as a unified unit of interacting with people.
- Contribute in various amounts to the group processes (that is, some people contribute more time or energy to the group than do Others).
- Reach agreements and have disagreements through various forms of interaction.

Functions of Groups

The organizational functions of groups help to realize an organization's goals.

Such functions include the following:

- Working on a complex and independent task that is too complex for an individual to perform and that cannot be easily broken down into independent tasks.
- Generating new ideas or creative solutions to solve problems that require inputs from several people.
- Serving liaison or coordinating functions among several workgroups whose work is to some extent independent.
- Facilitating the implementation of complex decisions. A group composed of representatives from various working groups can coordinate the activities of these interrelated groups.
- Serving as a vehicle for training new employees, groups teach new members methods of operations and group norms.

Types of Groups; Groups may be classified according to many dimensions, including function, personal involvement, and organization.

Types of Groups are;

- Formal Group.

- Informal Group.
- Managed Group.
- Process Group.
- Semi-Formal Groups.
- Goal Group.
- Learning Group.
- Problem-Solving Group
- Friendship Group.
- Interest Group.

Formal Groups

Formal groups are created to achieve specific organizational objectives. Usually, they are concerned with the coordination of work activities.

People are brought together based on different roles within the structure of the organization. The nature of the task to be undertaken is a predominant feature of the formal groups.

Goals are identified by management and short and rules relationships and norms of behavior established. Formal groups chain to be related to permanent although there may be changes in actual membership.

However temporary formal groups may also be created by management, such as project teams in a matrix organization.

Informal Groups

Within the formal structure of the organization, there will always be an informal structure.

The formal structure of the organization and system of role relationship, rule, and procedures, will be augmented by interpretation and development at the informal level.

Informal groups are based more on personal relationships and agreement of group's members than on defined role relationships. They serve to Satisfy psychological and social needs not related necessarily to the tasks to be undertaken.

Groups may devise ways of attempting to satisfy members' affiliations and other social motivations that are lacing in the work situation, especially in industrial organizations.

Managed Group

Groups may be formed under a named manager, even though they may not necessarily work together with a great deal. They have the main thing in common, at least the manager and perhaps a similar type of work.

Process Group

The process group acts together to enact a process, going through a relatively fixed set of instructions. The classic environment is a manufacturing production line, where every movement is prescribed.

There may either be little interaction within process groups or else it' is largely prescribed, for example where one person hands something over to another.

Semi-Formal Groups

Many groups act with less formality, in particular where power is distributed across the group, forcing a more collaborative approach that includes- negotiation rather than command and control.

Families, communities and tribal groups often act as semi-formal ways as they both have nominal leaders yet members can have a high degree of autonomy.

Goal Group

The goal group acts together to achieve a shared objective or desired outcome. Unlike the process groups, there is no clear instruction on how they should achieve this, although they may use some processes and methods along the way.

As there is no detailed instruction, the members of the goal group need to bring more intelligence, knowledge, and experience to the task.

Learning Group

The learning group comes together to increase their net knowledge. They may act collaboratively with discussion and exploration, or they may be taught with a teacher and a syllabus.

Problem-Solving Group

Problem-solving groups come together to address issues that have arisen. They have a common purpose in understanding and resolving their issue, although their different perspectives can lead to particular disagreements.

Problem-solving may range along a spectrum from highly logical and deterministic, to uncertain and dynamic situations there creativity and instinct may be better ways of resolving the situation.

Friendship Group

Groups often develop because individual members have one or more common characteristics. We call these formations of friendship groups.

Social alliances, which frequently extend outside the work situation, can be based on similar age or ethnic heritage, support for Kolkata Knight Riders cricket, or the holding of similar political views, to name just a few such characteristics.

Interest Group

People who may or may not be aligned into a common command or task groups may affiliate to attain a specific objective with which each is concerned. This is an interest group.

Employees who band together to alter their vacation schedules, support a peer who has been fired, or seek improved working conditions represent the formation of a united body to further their common interest.

Differences between Formal Group and Informal Group

Basis for Comparison	Formal Group	Informal Group
Meaning	Groups created by the organization, to accomplish a specific task, are known as Formal Groups.	Groups created by the employees themselves, for their own sake are known as Informal Groups.
Formation	Deliberately.	Voluntarily
Size	Large.	Comparatively small.
Life	It depends on the type of group.	It depends on the members.
Structure	Well Defined.	Not well defined.
The importance is given to	Position.	Person.
Relationship	Professional.	Personal.

Communication	Moves in a defined direction.	Stretches in all the directions.

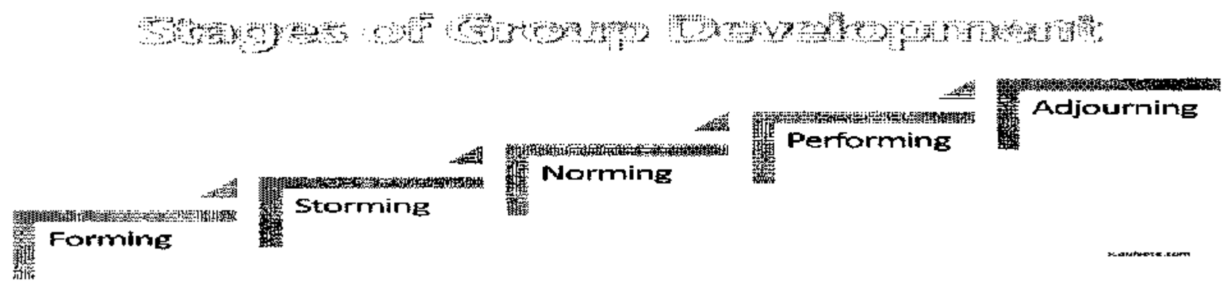
The 5 Stages of Group Formation

Tuckman was responsible for coining the 5 main stages in the process of group discussion. They are also known as Tuckman's 5 stages of group development. Moreover, these stages of group formation are meant to be followed in the exact sequence as they are below:

Forming: This is a beginning stage and lasts only a few days (or weeks). Members begin by planning their work and their new roles. Moreover, the emotions here are positive. The groups should begin by learning about team processes in preparation for the rough times ahead.However, it is crucial for them to learn the aspects of conflict resolution, communication, group decision-making and time management.

Storming: There exists a considerable amount of fights and arguments in this stage. People begin to feel the stress of frustration, resentment, and anger. Moreover, as the problem festers, the job remains undone.

Managers also experience frustration and are worried about the situation, thereby, are tempted to intervene. Members experience a drastic emotional roller coaster from elation to depression.Moreover, the situation seems bleak. Usually, the storming period may last 1-2 months. Also, without effective training and support, the team may experience retarded growth.Conflicts are usually frowned upon. However, they are the definition of normal, natural, and even necessary events in an organization. It is critical for the group to handle it well because they are great in helping to build skill and confidence for the next stage



Norming: In the norming stage, the group works through individual and social issues. The group establishes its own norms of behaviour and begin to trust each other. Moreover, as the group develops interpersonal skills, it becomes all the more skilled.

Members begin the art and knack of problem-solving. They also cross-train and learn new and adequate job skills. This stage usually lasts for 4-12 months.

Performing: In this stage, the group is ready to begin performing its respective task and assigned jobs. In this stage, the group has become well acquainted with one another and has clarity with regard to what needs to and has to be done. The performing stage begins when the group is comfortable to work and ends when the job is completed.

Adjourning: Post the performing stage, the group is adjourned. The adjourning stage ends the process of group formation. Because the group is adjourned once the task that is assigned to the group is completed.

Skills for a Healthy Group Climate

To work together successfully, group members must demonstrate a sense of cohesion. Cohesion emerges as group members exhibit the following skills:

- Openness.
- Trust and Self-Disclosure.
- Support.
- Respect.
- Individual Responsibility and Accountability.
- Constructive Feedback.

Openness

Group members are willing to get to know one another, particularly those with different interests and backgrounds. They are open to new ideas, diverse viewpoints, and the variety of individuals present within the group.

They listen to others and elicit their ideas. They know how to balance the need for cohesion within a group with the need for individual expression.

Trust and Self-Disclosure

Group members trust one another enough to share their ideas and feelings.

A sense of mutual trust develops only to the extent that everyone is willing to self-disclose and be honest yet respectful. Trust also grows as a group. The members demonstrate personal accountability for the tasks they have been assigned.

Support

Group members demonstrate support for one another as they accomplish their goals. They exemplify a sense of team loyalty and cheer on the group as a whole and help members experiencing difficulties.

They view one another not as competitors (common within a typically individualistic educational system) but as collaborators.

Respect

Group members communicate their opinions in a way that respects others, focusing on "What can we learn?" rather than "Who is to blame?"

Individual Responsibility and Accountability

All group members agree on what needs to be done and by whom. Each member determines what he or she needs to do and takes responsibility to complete the task(s).

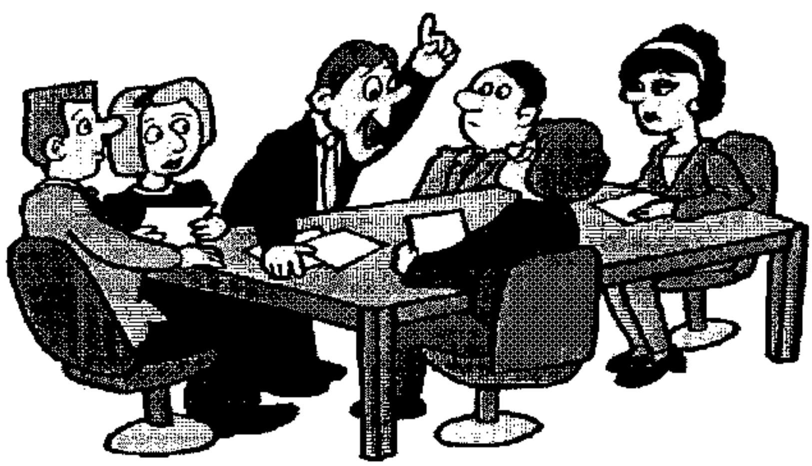
They can be held accountable for their tasks, and they hold others accountable for theirs.

Constructive Feedback

Group members can give and receive feedback about group ideas. Giving constructive feedback requires focusing on ideas and behaviors instead of individuals, being as positive as possible, and offering suggestions for improvement.

Receiving feedback requires listening well, asking for clarification if the comment is unclear, and being open to change and other ideas.

6 Reasons Why Individuals Join Groups



A small group is a combination of more than two people who are interdependent on one another.

So communication among the group members consisting of a small number of members is known as small group communication.

Every organization employs small groups to collect, process, and produce information, solve problems and make decisions.

Group communication helps to get a synergistic benefit. Synergy means combined efforts of a group result in greater output than the sum of the individual output.

That is, groups can do more for individuals than individuals can do for themselves. People join groups for many reasons.

Some group members are motivated by working in a group and others are motivated by creating interpersonal relationships with other group members.

Great OB scholar K. Aswathappa said there is no single reason why individuals join groups.

Since most people belong to many groups, it is obvious that different groups offer different attractions and benefits to their members.

The most popular reasons for joining a group are related to our needs for security, esteem, affiliation, power, identity, huddling, and task functions.

1. Security.
2. Esteem.
3. Affiliation.
4. Power.
5. Identity.
6. Huddling.

Security

Probably the strongest reason for group formation is the people's need for security. By joining a group, we can reduce our insecurity – we feel stronger, have fewer self-doubts, and are more resistant to threats.

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Esteem

An individual can increase his self-esteem through group membership.

First, one may gain esteem by becoming a member of a high-status group. Associating with high-status people is reinforcing, and outsiders usually accord one who belongs to such a group a high status.

Second, the close relationship an individual can develop as a group member provides opportunities for recognition and praise that are not available outside of the group.

Affiliation

Another reason why people join groups is that they enjoy the regular company of other people, particularly those who possess common interests. Individuals may seek out others at work who shares common hobbies or common backgrounds.

Power

Membership of groups offers power to members in at least two ways.

First, there are sayings such as "united we stand, divided we fall" and there is strength in numbers." These are driving forces behind unionizations, and workers enjoy much greater power collectively than they do as individuals.

Second, the leadership of an informal group enables an individual to exercise power over group members, even if he does not enjoy the formal position of authority in the organization.

Identity

Group membership contributes to the individual's eternal quest for an answer to the question "who am I." It is common knowledge that' tries to understand ourselves through the behavior of others towards us.

If others praise us, we feel we are great, if others enjoy our jokes, we see ourselves as funny persons, and so on. Groups provide several "others" who will laugh, praise, or admire us.

Huddling

One more reason why individuals want to join groups is for huddling.

Because of the way bureaucracies work, individuals, particularly executives, make use of informal get-togethers called huddles. There are intimate task-oriented encounters of executives trying to get something done, and huddling enables executives to deal with emerging matters and minimize the amount of surprise.

The following points help us understand the need of joining a group by individuals –

- Security mirrors strength in numbers. Status pinpoints a prestige that comes from belonging to a specific group. Inclusion in a group is considered as important because it provides recognition and status.

- Self-esteem transmits people's feelings of self-worth. Membership can sometimes raise feelings of self-esteem like being accepted into a highly valued group.

- Affiliation with groups can meet one's social needs. Work groups significantly contribute to meet the need for friendships and social relations.

- Groups represent power. What mostly cannot be achieved individually becomes possible with group effort. Power might be aimed to protect themselves from unreasonable demands. Informal groups provide options for individuals to practice power.

- People may join a group for goal achievement. Sometimes it takes more than one person to accomplish a particular task.

Group Roles

The concept of roles is applicable to all employees within an organization as well as to their life outside the organization. A role is a set of expected behavior patterns attributed to the one who occupies the position demanded by the social unit.

Individuals play multiple roles at the same time. Employees attempt to understand what kind of behavior is expected from them. An individual when presented by divergent role expectations experiences role conflict. Group roles are divided into three types –

- Task-oriented Roles
- Relationship-oriented Roles
- Individual Roles

Task-oriented Roles

Roles allotted to individuals according to their work and eligibility is known as task-oriented roles. Task-oriented roles can broadly divide individuals into six categories initiator, informer, clarifier, summarizer, reality tester and information seekers or providers respectively.

- Initiator – The one who proposes, suggests, defines.
- Informer – The one who offers facts, expresses feelings, gives opinions.
- Clarifier – The one who interprets, defines, clarifies everything.
- Summarizer – The one who links, restates, concludes, summarizes.
- Reality Tester – The one who provides critical analysis.
- Information seekers or providers – The one who gives information and data.

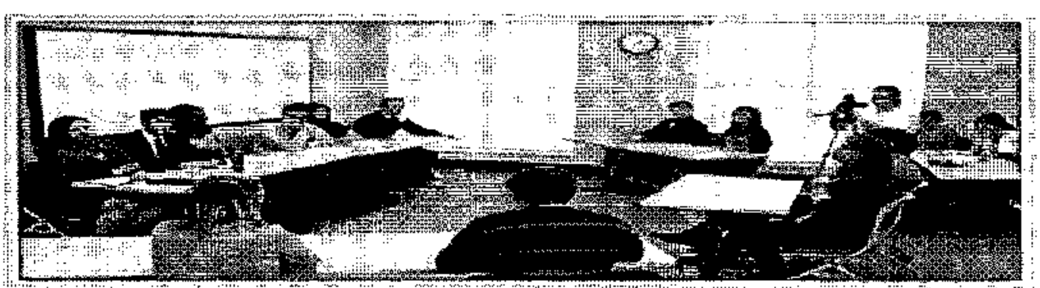
These roles present the work performed by different individuals according to their marked designation.

Group Decision Making

Group decision-making commonly known as collaborative decision-making is a situation faced when individuals collectively make a choice from the alternatives before them.

The decision is then no longer attributable to any individual group member as all the individuals and social group processes like social influence contribute to the decision outcome.

The decisions made by groups are mostly different from those made by individuals. For example, groups tend to make decisions that are more extreme than those made by individual members, as individuals tend to be biased.



Advantages of Group Decision Making

Group decision making has two advantages over individual decision making.

Synergy

It is the idea that the whole is greater than the aggregate of its parts. When a group makes a decision collectively, its judgment can be powerful than that of any of its members. Through discussing, questioning, and collaborative approach, group members can identify more complete and robust solutions and recommendations.

Sharing of information

Group decisions take into account a wider scope of information as each group member may contribute distinct information and expertise. Sharing information increases understanding, clarifies issues, and facilitates movement towards a collective decision.

Disadvantages of Group Decision Making

Lower Efficiency

Group decisions can sometimes be less efficient than individual decisions. It takes additional time because there is a need of active participation, discussion, and coordination among group members. Without good facilitation and structure, meetings can get eliminated in trivial details that may matter a lot to one person but not to the others.

Leadership

Leadership can be defined as the ability of the management to make sound decisions and inspire others to perform well. It is the process of directing the behavior of others towards achieving a common goal. In short, leadership is getting things done through others.

Importance of Leadership

Leadership is very important in a firm as it leads to higher performance by the team members, it improves motivation and morale within the members, and helps to respond to change.

Leadership facilitates organizational success by creating responsibility and accountability among the members of the organization. In short, it increases value in an organization.

Leader Vs Manager

A leader is someone whom people follow or someone who guides or directs others. A manager is someone who is responsible for directing and controlling the work and staff in an organization, or of a department within it.

The main difference between the two is that a leader works by example, while a manager dictates expectations. If a manager goes against the rules, that will tarnish his position as a manager. If a leader goes against the example he or she is trying to set, that will be seen as a setback. Following are a few subtle differences between the two –

- A leader is an innovator and creator whereas a manager is a commander.
- A leader can't be a manager but the opposite is possible, a manager is more than a leader.
- A leader does what is right, while the manager makes things right.
- A leader deals with change whereas a manager plans for a change.

- A leader gives direction to do something whereas the manager plans for everything that is to be done.
- A leader encourages people whereas the manager controls people.
- A leader handles communication, credibility, and empowerment whereas a manager deals with organizing and staffing.

Leadership Styles

Different leadership styles exist in work environments. The culture and goal of an organization determine which leadership style fits best. Some organizations offer different leadership styles within an organization, depending on the necessary tasks to complete and departmental needs.

We find five different leadership styles in the corporate world. They are as follows –

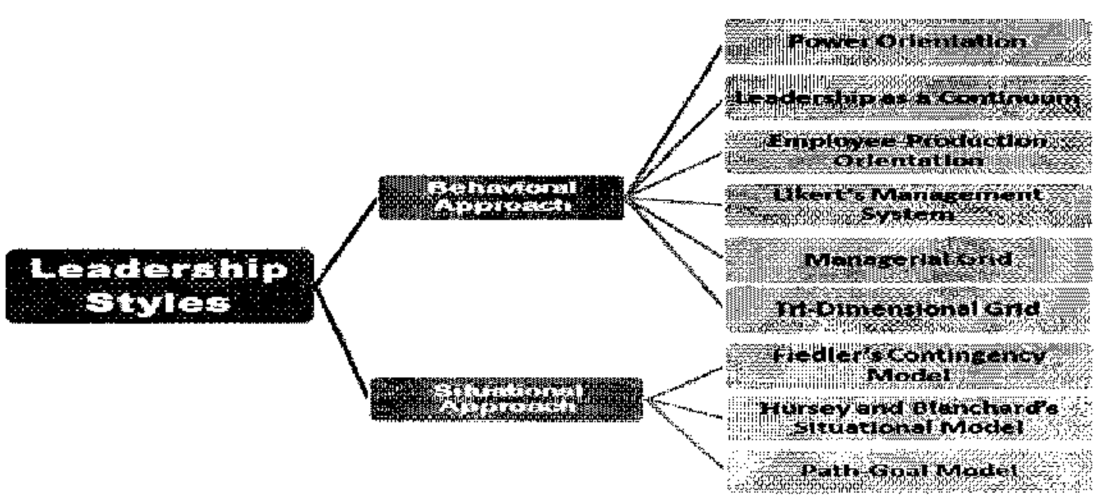
Leadership Styles

Definition: The **Leadership Styles** are the behavioral patterns that a leader adopt to influence the behavior of his followers, i.e. the way he gives directions to his subordinates and motivates them to accomplish the given objectives.

The leadership styles can either be classified on the basis of behavioral approach or situational approach. These approaches are comprised of several theories and models which are explained below:

Based on Behavioral Approach

- **Power Orientation:** The power orientation refers to the **"degree of authority"** that a leader adopts to influence the behavior of his subordinates. Based on this, the leadership styles can be further classified as:
  - Autocratic Leadership
  - Participative Leadership
  - Laissez-Faire



Autocratic leadership style

The autocratic leadership style permits managers to make decisions alone without the input of others. Managers access total authority and impose their will on employees. No one opposes the decisions of autocratic leaders. Countries like Cuba and North Korea operate under the autocratic leadership style.

This leadership style benefits those who require direct supervision. Creative employees who participate in group functions detest this leadership style.

Participative leadership style

This is also known as the democratic leadership style. It values the input of team members and peers, but the responsibility of making the final decision rests with the participative leader. Participative leadership motivates employee morale because employees make contributions to the decision-making process. It accounts to a feeling that their opinions matter.

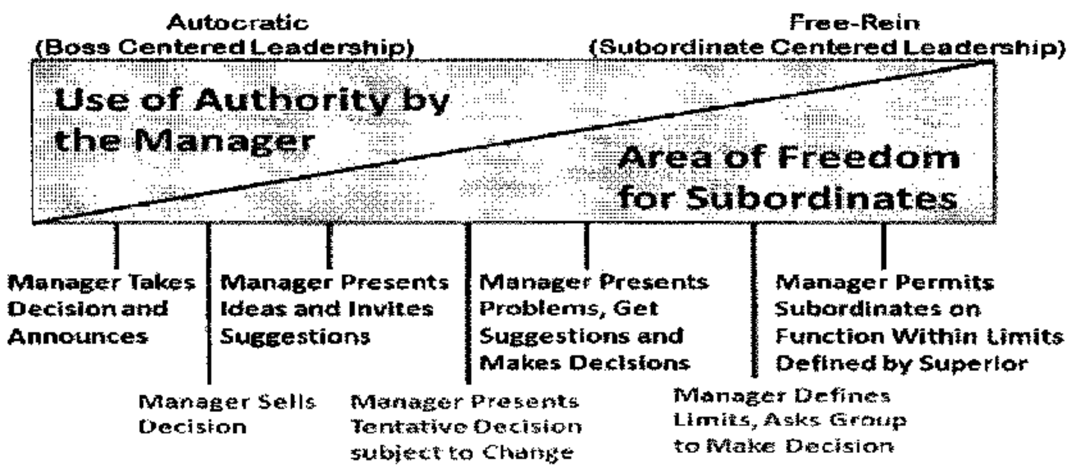
When an organization needs to make changes within itself, that is internally, the participative leadership style helps employees accept changes easily as they play a role in the process. This leadership style meets challenges when companies need to make a decision in a short period of time.

Laissez-Faire leadership style

A laissez-faire leader does not directly supervise employees and fails to provide regular updates to those under his supervision. Highly experienced and trained employees with minimal requirement of supervision fall under the laissez-faire leadership style.

But, not all employees possess these features. This leadership style blocks the production of employees needing supervision. The laissez-faire style implements no leadership or supervision efforts from managers, which can lead to poor production, lack of control and increasing costs.

- **Leadership as a continuum:** This model is given by Tannenbaum and Schmidt, who believed that there are several leadership styles that range between two extremes of autocratic and free-rein, which are shown below:

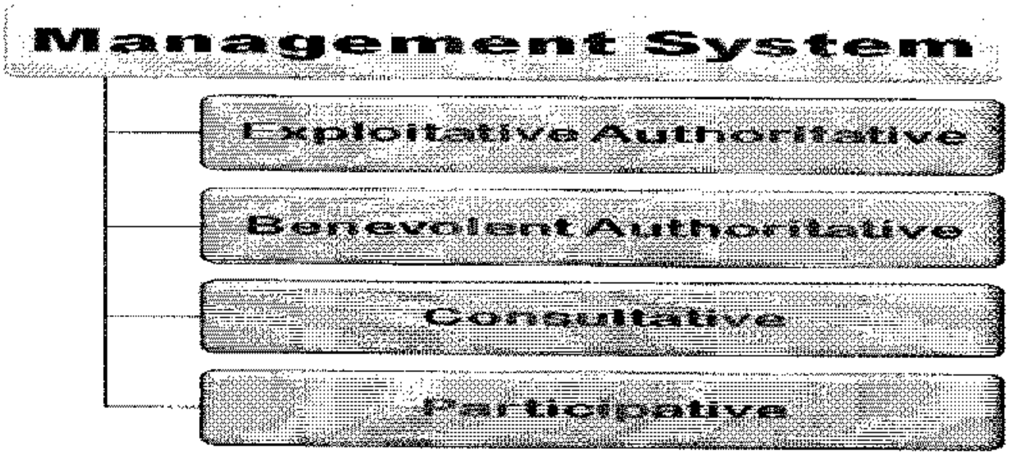


- **Employee-Production Orientation:** Several types of research were conducted to study the leadership behavior that gets affected by the several characteristics that are related to each other. It was found that employee orientation and production orientation play an important role in determining the leadership style.The employee orientation is based on the premise that an employee is an important part of the group and is in parallel to the democratic leadership style.

Whereas the production Orientation focuses on the production and technical aspects of the job and the employees are considered as the tools for accomplishing the jobs. Thus, the production orientation is parallel to the autocratic leadership style.

- **Likert's Management System:** Rensis Likert along with his associates studied the patterns and behavior of managers to identify the leadership styles and defined four systems of management. These four systems are: Exploitative Authoritative, Benevolent Authoritative, consultative system and participative system.

  Rensis Likert along with his associates in Michigan University, USA conducted research to study the patterns and styles of managers over three decades, across 200 organizations and developed a four-fold model of the management system that helped in understanding the leadership behavior. **Likert's four systems of management are categorized as follows:**



- **Managerial Grid:** The managerial grid is the tool designed by Blake and Mouton to determine the leadership style. According to them, the leadership style gets influenced by both the task-oriented and relation-oriented behavior in varying degrees.

  Robert Blake and Jane Mouton have developed the Managerial Grid, also called as a leadership grid. According to them, the leadership styles can be identified on the basis of manager's concern for people and production. Here, concern for people means the degree to which an individual is committed towards the goal achievement, maintaining self-esteem to workers and satisfying interpersonal relationships. Whereas, the concern for production means an attitude of superiors towards the quality of procedures and policies, creativeness of research, effectiveness of staff, work efficiency and volume of output.

The managerial grid identifies five leadership styles based on two behavioral dimensions as shown in the figure below:

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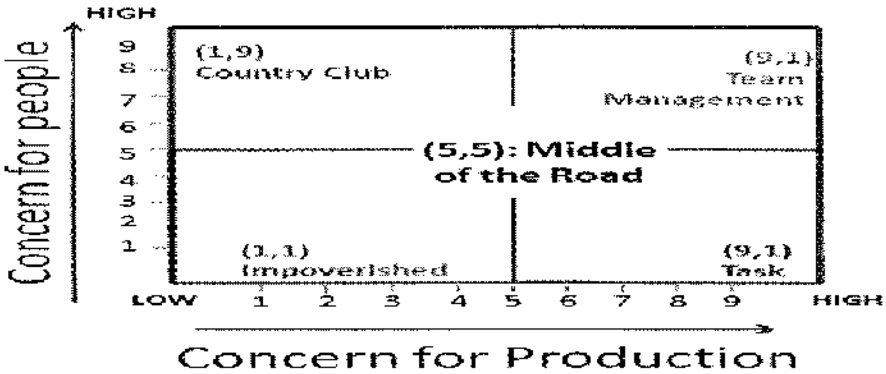


In the figure, there are 81 possible categories where the leader's style may fall.

1. **Impoverished Management (1,1):** The managers with this leadership style exert minimum effort to get the work done by the subordinates. They have minimal concern for both the people and production, and they function merely to preserve their jobs and seniority. Therefore, the disharmony, dissatisfaction, disorganization arises within the organization.
2. **Task Management (9,1):** Here, the leader is more concerned with the production and lay less emphasis on the personal needs of his subordinates. This leadership style is also called as a dictatorial or perish style, where the subordinates are required to perform the task as directed by the superiors. In this leadership style, the output in the short run may increase drastically, but due to stringent rules and procedures, there could be a high labor turnover.
3. **Middle of the Road (5,5):** The manager with this style tries to keep a balance between the organizational goals and the personal needs of his subordinates. Here, the leader focuses on an adequate performance through a balance between the work requirements and satisfactory morale. Both the people and production needs are not completely met, and thus the organization land up to an average performance.
4. **Country Club (1,9):** Here, the leader lays more emphasis on the personal needs of the subordinates and give less attention to the output. The manager adopts this style of leadership with the intent to have a friendly and comfortable working environment for the subordinates, who gets self-motivated and work harder on their own. But however, less attention to the production can adversely affect the work goals and may lead to the unsatisfactory results.
5. **Team Management (9,9):** According to Blake and Mouton, it is the most effective leadership style wherein the leader takes both people and production hand in hand. This style is based on McGregor's Theory Y, where the employees are believed to be committed towards the goal achievement and need not require manager's intervention at every step.The leader with this style feels that empowerment, trust, respect, commitment helps in nurturing the team relationships, which ultimately results in the increased employee satisfaction and overall production of the organization.

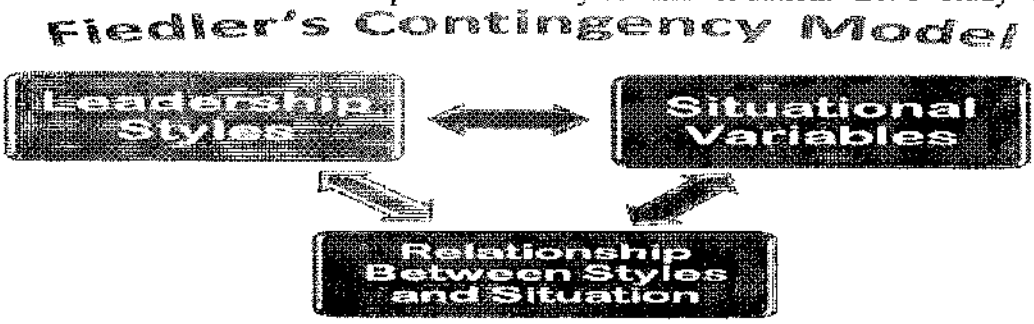
➢ **Three Dimensional Grid:** The three-dimensional grid is also called as a 3-D leadership model given by W.J. Reddin. Reddin included the effectiveness dimension along with the task-oriented and relationship-oriented dimensions to study how a leader behaves in a given situation and a specific environment.

Based on Situational Approach

Fiedler's Contingency Model: **This theory is given by Fred Fiedler, who, along with his associates identified the situational variables and their relationship to determine the leadership styles. Thus, this model is comprised of three elements, leadership styles, situational variables and the interrelationship between these two.** Fiedler's Contingency Model

Definition: Fred Fiedler was the first amongst all the leadership theorists to talk about the situational variables. According to him, the effectiveness of the leadership style depends on the situation. Thus, he along with his associates identified the situational variables and studied about their relationship with the appropriateness of leadership styles.

Fiedler's contingency model is comprised of three elements, Viz, Leadership styles, situational variables and the relationship between styles and situation. Let's study these in detail:



1. Leadership Style: According to Fiedler, the leadership style depends on two dimensions, task-oriented and human-relations oriented. The task-oriented leader is primarily concerned with the task performance and the accomplishment of task goals. He gets satisfied with the accomplishment of task performance. While, the manager concerned with human relations lay more emphasis on developing the interpersonal relationship with his subordinates.In order to understand the attitude of a leader, Fiedler developed a "Least Preferred Co-worker Scale (LPC)", wherein the leaders are asked to rate a person on a scale ranging from lowest (1) to highest (8) on several parameters to identify the worker with whom they least like to work. Certain parameters on the LPC scale are: pleasant/unpleasant, friendly/unfriendly, tense/relaxed, supportive/hostile, cooperative/uncooperative, quarrelsome/harmonious, etc. The leaders with high LPC scores are said to be relationship-oriented whereas the ones with the low LPC scores are considered as task-oriented.
2. Situational Variables: It has been observed that, several situational factors influence the effectiveness of the leadership styles, but however, Fiedler has talked about three critical dimensions: Leader's Position Power: This element is concerned with the power or authority a leader derives from the position held by him in the organization. It has been observed, that a manager with absolute power influences the behavior of others more than the ones without power.Task Structure: The task structure means the extent to which the task requirements are clearly defined in terms of the task goals, processes and relationship with other tasks. It has been observed, that with the clear definition of task structure the actions of the subordinates can be well directed and their performances can be well controlled, which may not be possible in case of unclear task structure.

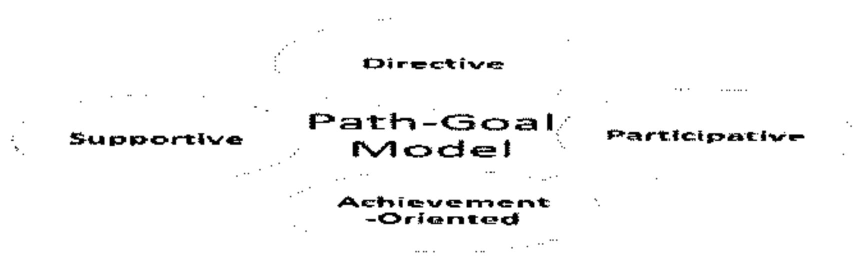
Leader-member Relations: This dimension talks about the degree to which the members have trust, confidence and faith in their manager.

3. Relation Between Styles and Situations: This is the last element of Fiedler's contingency model, wherein he talks about the relationship between the situation and the appropriateness of leadership style. According to him, the leadership effectiveness depends on the situation, as one style favoring one situation may not necessarily be appropriate in any other situation. Thus, it is the situation that gives an opportunity to the leader to influence his subordinates through the right kind of leadership style.

   Thus, Fiedler's contingency model posits that the situation decides the style of leadership and influences the behavior of a manager.

- **Hursey and Blanchard's Situational Model:** According to this model, the leader has to adopt the leadership style that matches up with the subordinate's maturity i.e. his willingness to direct his behavior towards the goal.
- **Path-Goal Model:** The Path-Goal Model is given by Robert House, who, along with his associates tried to predict the effectiveness of leadership styles in varied situations. He believed that the foremost function of any leader is to define the goals to the subordinates clearly and assist them in finding the best path to accomplish that goal

Robert House and Mitchell have identified four types of leadership styles:



1. **Supportive Leadership:** Here, leader emphasizes on establishing the interpersonal relationships with the subordinates by showing concern for their welfare and building a friendly environment within the organization. This kind of leadership style is adopted with the intent to make the job more interesting when the work is more stressful or hazardous.
2. **Directive Leadership:** The directive leadership style is followed when the subordinates are inexperienced, or the job is quite complex that cannot be performed without the manager's directions. Here, manager properly tells the subordinates about the task and the ways to perform it.
3. **Participative Leadership:** This kind of leadership style is adopted when the subordinates are experienced, and the job is complex. Here, the leader involves the team members who are experts to give their input in the decision-making process.
4. **Achievement-Oriented Leadership:** Here, the manager sets high standard goals for his teammates with the intent to motivate them to achieve those goals. The leader has full confidence in his subordinates and adopts this leadership style for the self-improvement of each group member and to make a task more exciting. Generally, this style is followed when the task is quite complex, and the subordinates are less motivated.

What is a Collaboration Process?

A collaboration process is a work methodology in which the work environment is made efficient, foreseeable, dependable, and highly supportive using unified digital platforms that are not dependent on individuals or multiple types of applications. The idea behind the ideal collaborative process is to keep work going smoothly and teams collaborating seamlessly without loss of information even if individuals leave or tools fail. A collaboration process is ideally supported by a unified platform or tool that all employees use to transact work and store information.

principles of effective collaboration While the above skills can set you up to collaborate well, working successfully with others isn't just about what you do but how you do it. Collaboration styles vary wildly, so the mindset you take to approach collaboration can make a world of difference. The next time you need to collaborate with your team, keep these values in the back of your mind.

1. Efficiency: Meetings are an essential element to collaboration but over the years, they've gotten a bad rap. After all, who hasn't been in a meeting that felt overly long or unnecessary? There are a few things you can do to turn your team into a productivity machine.

One is to only have meetings when necessary. Virtual collaboration is great, but everyone has heard of video burn out due to the pandemic. By choosing your meetings wisely, you can improve collaboration and efficiency.

2. Trust: People need to feel safe to give and receive genuinely constructive feedback, be inspired by a common goal, and have the tools and opportunities to connect. This can only happen in a trusting environment where employees feel like their teammates and leaders have their best interests at heart.

3. Empathy: Every team member has an important part to play. Nevertheless, collaboration can break down when one or more people feel like they have it harder than everyone else or feel like other team members are trying to bring them down. The more you get to know your colleagues and understand how they work and what challenges they're dealing with, the better chance you'll have at successfully collaborating with them. (Learn about empathy exercises you can try with your team.)

4. Positivity: Just because you had a group project go poorly in the past doesn't mean that the same thing will happen again. Try to shake off any past hang-ups you might have and approach every group work situation like a new start, with an open and positive mindset.

5. Clarity: It's rare for everyone on a team to be on the same page from the very beginning. It's natural for people to have their own priorities or interests. That's why it's important to identify everybody's priorities and agendas upfront to find a common denominator that will move the project forward.

6. Accountability: The most successful businesses have systems and processes where employees can reference a project's schedule and tasks so they have a clear understanding of how their contributions affect the group. That way if deadlines are missed or someone isn't pulling their weight, it can be addressed quickly.

WORK COLLABORATIVE	WORK COOPERATIVE	WORK GROUP WORK
Horizontality agreed by teamwork. Group of internally organized individuals with a clear objective.	Focused on a person acting as a supervisor.	Set of individuals with something in common.
The collaborator shares their experiences and interests. Mutual support.	Optimization and division of labor prevail.	Individual success. Own benefit.
It fosters shared and collective responsibility.	It is more direct and controlled.	Individual responsibility.
It is supported by mediated interaction and dialogical communication. It favors interdependence.	Privileges verticality and control.	Independence.

Johari Window

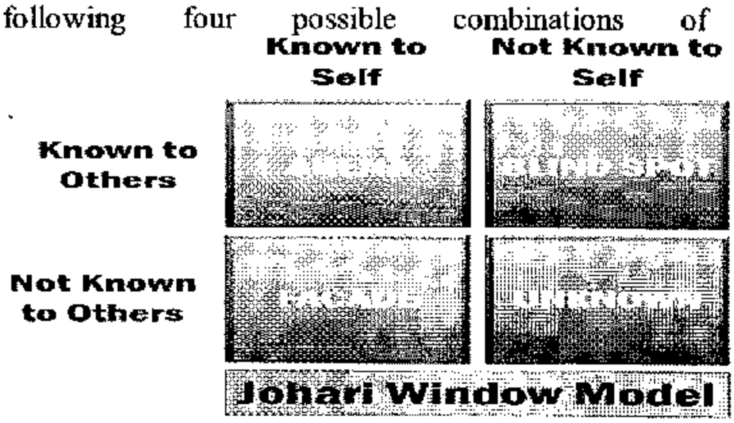
Definition: Johari window is a psychological tool to self-assess one's behaviour as well as the relationship with others, through feedback or disclosure. It is one of the most effective means of self-analysis by considering the other's perspective to understand oneself in a better way.

It helps in determining the areas of expertise or strengths, the shortcomings, the scope of development and challenge to be faced.

Johari Window Model

The Johari Window model was propounded by Joseph Luft and Harrington Ingham in the year 1955.

The model consists of four quadrants, each of which determines a different combination. These combinations are a result of facts known or unknown by oneself about himself along with the facts known or unknown to others.To better understand this model, let us go through the following four possible combinations of the Johari Window Model:



- **Arena**: The arena or open area represents everything which is made public or is commonly known oneself and to others too. It includes a person's behaviour, attitude, skills, strengths, weaknesses, etc.
- **Blind Spot**: The area of talent or a specific trait or behaviour of a person which can be positive or negative, known to others; however, the person himself is unaware of it.
- **Facade**: It is a hidden area which is secretly known to the person alone, i.e. his feeling, emotions, ideas, etc., while others are unaware of it.
- **Unknown Area**: The area which remains undiscovered by the person himself or herself and also hidden from others, is termed as unknown areas. This area consists of new opportunities and scope for development along with threats and uncertainties.

Need for Johari Window

Johari window is one of the most useful tools for organizations to become successful and succeed over its competitors. To learn about its other advantages, read below:

Self-Awareness: It acts as a self-analysis tool. Thus, making oneself aware of his strengths, weaknesses, opportunities and threats by considering the views of others too.

Cordial Relationships: It helps to improve the interpersonal relations since everyone gets to know each other in a better way and each focus on self-improvement.

Improves Communication: Johari window paves the way for open interaction and develops understanding among the managers and the subordinates.

Team Development: Strong **team building** is difficult if the team members are not familiar with each other. This model enhances the interpersonal relationship among the team members by making each familiar with the others in the team.

Personal Development: It provides scope for betterment since the blind area reveals those unknown facts which are known to others but may have been ignored by the individual himself. These facts are sometimes related to the individual's attitude, habits, behaviour which needs to be mended.

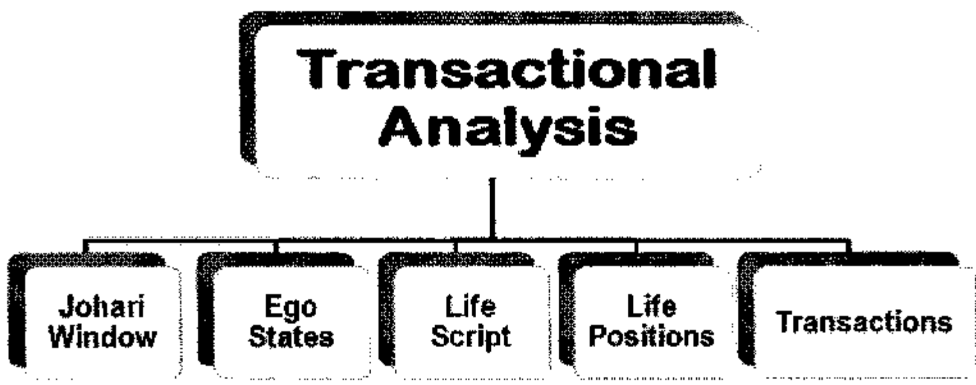
Group Dynamics: The Johari window encourages open conversations and feedback within a group. This enhances group performance and develops a mutual understanding among the group members by eliminating the problem areas and misunderstandings.

Transactional Analysis

Definition: The **Transactional Analysis** refers to the psychoanalytic process wherein the interpersonal behaviors are studied. In other words, a social psychological model that talks about the personal growth and personal change, i.e., identifying the ego states of each individual to understand their behaviors and altering them to solve the emotional problems.

his model was originally developed by Dr Eric Berne, who during his observation found that his patients behaved in a way as if several different people were inside them. This forced him to study the personality and dynamics of self and its relationship with others which helped in determining the kinds of behaviors that an individual shows in different real time situations.

Now, this study has become a well-established approach and is being widely used in several fields such as psychotherapy, counseling, education, organizational development, etc. The transactional analysis gives birth to several models that help in explaining the relationship formed between the individuals as a result of their interactions. It mainly involves:

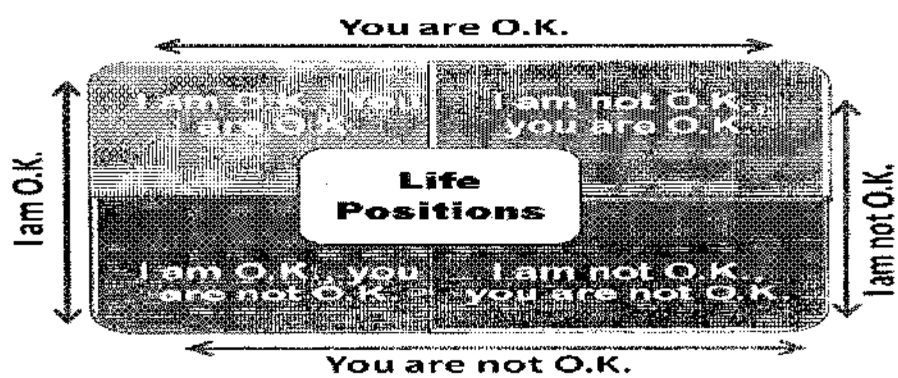


1. Johari Window (Analysis of Awareness)
2. Ego States or PAC Model (Structural Analysis)
3. Life Positions
4. Life Script
5. Analysis of Transactions

Life Positions

Definition: The **Life Positions** refers to the specific behavior towards others that an individual learns on the basis of certain assumptions made very early in the life.

The life positions can be categorized as follows:



1. **I am O.K., You are O.K.:** This life position shows that an individual has several O.K. experiences with others. This means, an individual encountered no severe problems or issues with others in his childhood and had a normal relationship with them. People with such life positions about themselves and others around him can solve any problem very easily and realizes the significance of others being in his life. This position is based on the adult ego.
2. **I am O.K., You are not O.K.:** This life position is created when an individual was too much ignored when he was a child. Here, an individual believes that he is right, and all the others around him are wrong. These are the individual who possesses the rebellion child ego and put blame on others for anything that goes wrong with them.
3. **I am not O.K., you are O.K.:** This life position gets created when an individual feels that others do things better than him. He feels inferior to others and believes that others can do many things which he cannot do by himself. These kinds of people always complain about one thing or the other and remain highly dissatisfied with their lives.
4. **I am not O.K., you are not O.K.:** This kind of life position is created by those who lacks interest in living. They feel life is not worth living and are the ones who have been neglected by their parents in their childhood and were brought up by the servants. Such kind of people commits suicide or homicide to end their lives.

Thus, the life positions talk about the individual developing his identity, sense of worth and perception about others during his childhood and believing it to be true until and unless some major experience changes it

ransactional Analysis has its base on the Ego States or the Parent-Adult-Child (PAC) model.

1. Ego State or the Parent-Adult-Child (PAC) Model

Let's understand the situation. Emily is married and is often demanding in her relationship. She is also known to throw a tantrum when things don't go her way. Emily's partner cannot understand her behavior and has quietly put up with her tantrums. Over time, their relationship turns strained.

Emily here does not operate her thinking as an Adult, displays behaviors learned in her childhood to make things go her way. Let's understand the complexity of human behavior by knowing the PAC model.

a) Parent Ego State

There are moments when you behave in your current state just the way your Parents would do. The Parent Ego-State is about the behaviors and feelings that were copied from your parents or from your early caregivers.

In the case of Emily, she would probably be copying her dominant behavior and using it without consideration towards her partner.

Parents, when in their role, are quite critical in their behavior towards the child. They give us a set of instructions which may often sound like -

"Don't do this…"

"Always do this…"

"Be this…"

"Stop doing this…"

Their non-verbal communication may tend to be protective (gestures) or nurturing (hugs).

A person in this Ego-State as an adult may tend to be highly critical, judgmental, often deciding for others, protective, nurturing, etc.

Transactional Analysis is also useful in the treatment of psychological disorders, is an important part of counseling, and coaching

b) Adult Ego-State

When a person is in the Adult Ego-State, he/she displays behaviors that are directly related to the here-and-now situation. The individual is free to choose their response without being influenced by any other Ego-State. He/she will look for solutions in the most effective and rational manner without being too emotional about a situation. A person in the Adult Ego-State is often straightforward in their approach, is interested in the conversation without being judgmental, and will know how to use logic in conflicting situations.

A person in this Ego-State tends to question different sides to a situation such as the what and why, where, and know what he/she sees versus what opinions they hold.

c) Child Ego-State

A person in this Ego-State displays behaviors, feelings or may think about situations while being influenced by their thoughts as replayed in childhood. Emily's sulking would be influenced by her Child Ego-State wherein her reaction is influenced by emotions that are driven through past behavior. If you had to ask Emily, "Does this situation resonate with something in your childhood?" Emily would have answered, "Yes, every time I wanted my mother's attention, I used to throw my toys and sulk."

A person in this Ego-State may display rebellion, delight, whining, sulking, panic, fear, or even a lot of laughter.

A person is never consciously aware of their Ego-States. Every person re-experiences a part of the Parent Ego-State or the Child Ego-State to base their communication in the present situation.

Had Emily to use her Adult Ego-State, she could have thought, "Oh! I must not get angry but work on finding a solution. What is truly making me angry though?"

Eric Berne outlines the presence of each Ego-State in daily life. A person will always find the use of traffic rules for instance as highly beneficial in life. These are derived from the Parent Ego-State. The Child Ego-State is beneficial to keep one's creativity and intuitive skills active. An Adult Ego-State helps one to make decisions based in the present moment to resolve problems with greater accuracy without displaying any influenced behaviors from other Ego States.

Definition of Ego-States by Eric Berne:

A consistent pattern of feeling and experience directly related to a corresponding consistent pattern of behavior.

Life Script

Definition: The **Life Script** refers to the meaning that one attributes to the events that happened to him at the early stage of life. Psychologists believe that an individual's life script gets created in his childhood when he learns things unconsciously from the transactions between father, mother and the child.

Whenever an individual face any situation, he acts with reference to the script created as a result of the past experiences and the way he views his life positions, i.e. I am O.K you are O.K, I am not O.K. you are O.K., I am O.K. you are not O.K., I'm not O.K. you are not O.K.

An individual can determine his life script by understanding how his thoughts, behavior, ideas, etc. get influenced due to his past experiences. Every individual has a life script. A script is a complete plan of living that offers two structures: a structure that defines a winner or looser and the structure of authoritative warning or order, prescriptions and consent.

The life scripts can be changed with the time since these are not inborn but rather learned. The life script resembles the drama or a movie script that includes the characters, dialogues, actions, plays, etc. and move towards the climax and ultimately reach the end with the closure of curtains.

Transactions and Strokes

Eric Berne referred to transactions as the 'basic unit of social discourse.'

Transactions are of many types.

For example, you greet a colleague with a 'hello' and get a 'how are you' as a response. When you continue a conversation, you receive a series of transactions. Transactions can be complementary, crossed, ulterior, and angular ulterior. They can occur between different Ego-states.

An individual can observe their communication which includes verbal, non-verbal gestures and body language to identify problems in their transactions. A Transactional Analyst is able to rectify and modify a client's approach to communication to create better results in life.

Berne defined Strokes as a 'unit of recognition.' You exchange a stroke when you say a friendly greeting and receive one in response. However, a person who does not receive a stroke in return may feel deprived as mentioned by Berne. A person's hunger for Strokes begins at an early age. For example, a baby longs to be held and in physical contact with their parents. However, a baby deprived of the same will grow up to experience emotional difficulties and problems.

Strokes are defined as:

Verbal or non-verbal

Positive or negative

Conditional or unconditional

A simple example would be the constant need of sharing updates and selfies on social media. A person expects "Likes" which are nothing but seeking positive strokes from their friends and family. A child may often be made to experience he/she does not need strokes creating a hunger for strokes within.

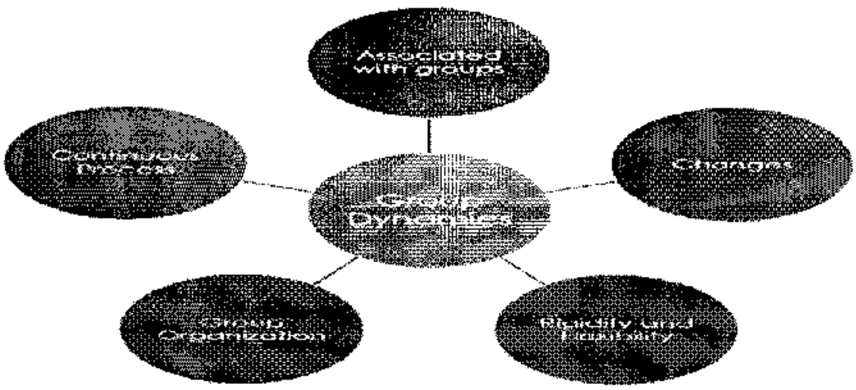
However, strokes are available in plenty, and it's advisable to indulge in self-stroking in moderate

Group Dynamics

Definition: Group Dynamics can be understood as a process, wherein the attitude and behaviour of a member influence the behaviour of another or other members of the group, either by choice or circumstances. Factors such as individual personality, cultural traditions and social situations, often affect the group dynamics.It has the ability to change each member's conduct, outlook, thinking pattern and relationship with each other.

Group Dynamics is **part of social psychology** which deals with the development and change in the overall structure and function of the psychological groups into self-directing ones.

Salient Features of Group Dynamics: The salient features of Group Dynamics are given as under:

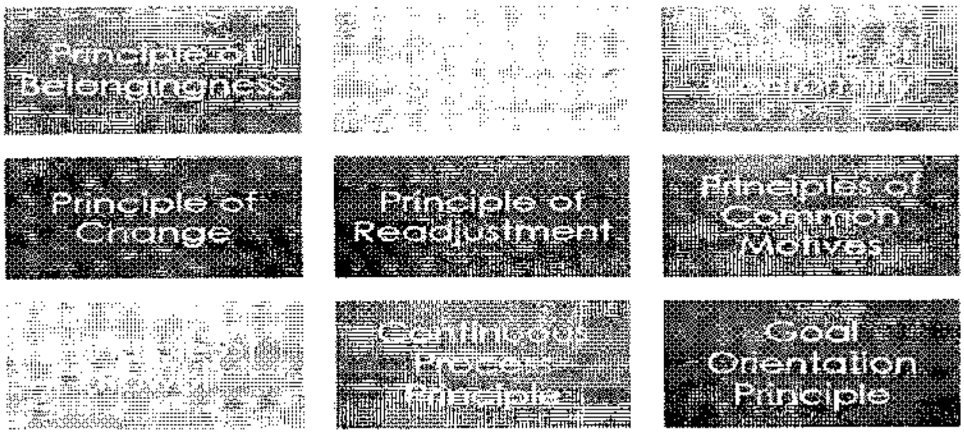


- Group Dynamics is **associated with groups**, which means that if there exists a group, the members of such group tend to interact, change and adjust themselves according to the changing circumstances and their relationship with one another.
- **Changes occur continuously** in a group, i.e. entry and exit of members, change in leadership, type of task assigned, etc.
- Group dynamics are affected by **rigidity or flexibility**.
- **Group organization** leads to group effectiveness, participation, cooperation and coordination of members, as well as boosts morale.
- Groups tend to **continuously restructure, adjust and readjust** members, so as to release stress, eliminating conflicts, better decision making and problem-solving, which affects the group members.

Group dynamics describes how groups and group members act and react to dynamic circumstances. It deals with the changes that occur within the groups along with the interaction and forces operating with the group in a social organization.

Further, there are various behavioural and psychological forces which leads to the development and performance of a group. These forces are present within the group and differ from one group to another, as well as they vary in different kinds of group situations. The scientific study of these forces functioning within the group or amidst two groups is called as **group dynamics.**

Principles of Group Dynamics



- **Principle of Belongingness**: A good sense of belongingness must exist or develop in the members of the group
- **Principle of Perception**: Changes can be implemented in the group by creating a common perception in the minds of the members regarding the need for change.
- **Principle of Conformity**: When continuous efforts are made in the direction of removing individual subparts of the group, it may result in the conformity to the norms of the group.
- **Principle of Change**: All the relevant information concerning the need, plan, strategy and outcome of change has to be shared amongst the group members.
- **Principle of Readjustment**: Changes in a particular part of the group is likely to create stress in the other parts, which can be reduced either by reversing the change or introducing readjustments in the related parts.
- **Principle of Common Motives**: A group is formed and operated because of common or shared motives.
- **Principle of Power**: The higher the level of the group to its members, the higher will be the influence which can be exercised on its members.
- **Continuous Process Principle**: Every member who is a part of a certain group is responsible for its continuous operation, so they must ensure that the activities and tasks assigned to the group are performed uninterruptedly.
- **Goal Orientation Principle**: The survival of a group is ensured by placing the members into an operational hierarchy and a goal-oriented action.

UNIT-5

CONTENT:

Organizational conflict-causes and consequences-conflict and Negotiation Team Building, Conflict Resolution in Groups and problem solving Techniques
– Organizational change - change process - resistance to change - Creating anEthical Organization

1Q) DEFINE Organizational Conflict & EXPLAIN ITS CAUSES AND CONSEQUENCES?

DEFINITION: Organizational Conflict or otherwise known as workplace conflict, is described as the state of disagreement or misunderstanding, resulting from the actual or perceived dissent of needs, beliefs, resources and relationship between the members of the organization. At the workplace, whenever, two or more persons interact, conflict occurs when opinions with respect to any task or decision are in contradiction.

In simple terms, organizational conflict alludes to the result of human interaction that starts when one member of the organization discerns that his /her goals, values or attitude are incompatible, with those of other members of the organization. The incompatibility in opinionscan come into being, within a member, between two members, or between groups of the organization.

Factors Influencing Organizational Conflict

- ✓ Unclear Responsibility: If there is lack of clarity, regarding who is responsible for which section of a task or project, conflict takes place. And, to avoid this situation, the roles and responsibility of the team members should be stated clearly and also agreed upon by all.
- ✓ Interpersonal Relationship: Every member of an organization, possesses different personality, which plays a crucial role in resolving conflict in an organization. Conflicts at the workplace, are often caused by interpersonal issues between the members of the organization.
- ✓ Scarcity of Resources: One of the main reasons for occurrence of conflict in an organization is the inadequacy of resources like time, money, materials etc. due to which members of the organization compete with each other, leading to conflict between them.
- ✓ Conflict of Interest: When there is a disorientation between the personal goals of the individual and the goals of the organization, conflict of interest arises, as the individual may fight for his personal goals, which hinders the overall success of the project.

  Conflicts alleviate at the workplace due to individual and inter-individual factors. Individual related causes entails attitudes, beliefs, personality orientation and human-frailties. Inter- individual conflicts arises when a manager breaches norms of the organization.

TYPES OF ORGANIZATIONAL CONFLICT:
RELATIONSHIP CONFLICT: The conflict arising out of interpersonal tension among employees, which is concerned with the relationship intrinsically, not the project at hand.

TASK CONFLICT: When there is a discord, among members regarding nature of work to be performed is task conflict

PROCESS CONFLICT: Clashes among the team members due to the difference in opinions, on how work should be completed, is called process conflict.
Organizational conflict can also be personal conflict (one that exist between two people because of mutual dislike), intragroup conflict (one arising out of lack of liberty, resource, etc. in a group) and intergroup conflict (one that exist between two groups).

CAUSES OF ORGANIZATIONAL CONFLICT:

- **Managerial Expectations:** Every employee is expected to meet the targets, imposed by his/her superior and when these expectations are misunderstood or not fulfilled within the stipulated time, conflicts arises.
- **Communication Disruption:** One of the major cause of conflict at the workplace is disruption in the communication, i.e. if one employee requires certain information from another, who does not respond properly, conflict sparks in the organization.
- **Misunderstanding:** Misunderstanding of information, can also alleviate dispute in organization, in the sense that if one person misinterpret some information, it can lead to series of conflicts.
- **Lack of accountability:** If in a project, responsibilities are not clear and some mistake has arisen, of which no member of the team wants to take responsibility can also become a cause of conflict in the organization.

The causes of organizational conflict are to be known, to resolve them as early as possible, because it hinders the efficiency, effectiveness and productivity of the employees and the organization as well, which ultimately hampers its success.

Ways to Manage Conflicts in Organization

- ✓ Handle the conflict positively.
- ✓ Formation of official grievance procedure for all members.
- ✓ Concentrate on the causes rather than their effect, to assess conflicts.
- ✓ Parties to conflicts should be given an equal voice, irrespective of their position, term orpolitical influence.
- ✓ Active participation of all the parties to conflict can also help to counter it.
- ✓ In an organization, conflict is inevitable and so various means are to be discovered to resolve them or use them in a way that can help the organization to increase its productivity.

The consequences of Conflict within an Organization

As organizations strive to achieve their goals, they are often met with challenges they must overcome as a team. Challenges leave room for conflict between members, other organizations, communities and other parties involved in the organization's mission. While "conflict" often has a negative connotation, the effects of conflict within an organization can be positive and negative.

Mental Health Concerns: Conflict within an organization can cause members to become frustrated if they feel as if there's no solution in sight, or if they feel that their opinions go unrecognized by other group members. As a result, members become stressed, which adversely affects their professional and personal lives. Organization members may have problems sleeping, loss of appetite or overeating, headaches and become unapproachable. In some instances, organization members may avoid meetings to prevent themselves from experiencing stress and stress-related symptoms.

Decrease in Productivity: When an organization spends much of its time dealing with conflict, members take time away from focusing on the core goals they are tasked with achieving. Conflict causes members to focus less on the project at hand and more on gossiping about conflict or venting about frustrations. As a result, organizations can lose money, donors and access to essential resources.

Employee Turnover Impacts: Organization members who are increasingly frustrated with the level of conflict within an organization may decide to end their membership. This is especially detrimental when members are a part of the executive board or heads of committees. Once members begin to leave, the organization has to recruit new members and appoint acting board members. In extreme cases, where several members leave or an executive board steps down, organizations risk dissolution.

Conflict Escalation and Violence: When conflict escalates without mediation, intense situations may arise between organization members. It's unfortunate, but organizational conflicts may cause violence among members, resulting in legal problems for members and possibly the organization.

Inspire Creativity to Solve Problems: Fortunately, some organization members view conflict as an opportunity for finding creative solutions to solve problems. Conflict can inspire members to brainstorm ideas, while examining problems from various perspectives.

Share And Respect Opinions: As organization members work together to solve conflict, they are more willing to share their opinions with the group. Conflict can also cause members to actively listen to each as they work to accomplish the organizations' goals.

Improve Future Communication: Conflict can bring group members together and help them learn more about each other. From learning each others' opinions on topics relevant to the organization's growth to understanding each member's preferred communication style, conflict within an organization can give members the tools necessary to easily solve conflicts in the future.

Identify New Members: Within organizations members actively participate in each meeting, enjoy serving on multiple committees and have an opinion on each topic the group discusses. There are also members who seemingly contribute little to the group and observe more than talk. Conflict within an organization can inspire typically silent members to step up and demonstrate their leadership skills by offering meaningful solutions to the problem the group is facing.

FIVE BASIC MODES OF CONFLICT

The ability to manage conflict is a very important part of the managerial repertoire. The Thomas-Kilmann Conflict Mode Inventory, which popularized the notion of the five basic modes of conflict when it first debuted in 1974, measures individuals' personalities in two areas: cooperativeness and assertiveness. Kilmann believed these traits combine to produce our response to conflict. These assessments can help managers of big and small businesses better understand their own responses to conflict, possibly leading to smoother conflict resolution, increased morale and a better working environment.

Accommodating: Accommodating mode denotes low assertiveness and high cooperativeness. Accommodating people will give in to other people's needs and be very reluctant to stand up for their own. Accommodating people tend to shy away from conflict and prefer to do what they are told rather than continue an unpleasant interaction. They perceive conflict as lose- win.

Avoiding: Avoiding mode denotes low assertiveness and low cooperativeness. Avoidant peopleneither accede to others' needs nor assert their own. They remain above the fray and refuse toengage in conflict. They often are perceived as diplomatic. In reality, they perceive conflict as lose-lose.

Collaborating: Collaborative mode denotes high assertiveness and high cooperativeness. Collaborative people will plainly state their own needs while attempting to work with a group to find a solution that meets others' stated needs as well. Collaborative people facilitate win- win solutions and make excellent managers.

Competing: Competing mode denotes high assertiveness and low cooperativeness. Competitive people will be aggressive about getting their needs met while being unresponsive to others' needs. Competitive people tend to use their perceived power or throw their weight around. They perceive conflict as win-lose.

Compromising: Compromising mode denotes moderate assertiveness and moderate cooperativeness. Compromising people try to arrange middle-of-the-road compromises without treating situations in depth, meaning that conflicts end with no one getting their needsfully met.

Negotiation Team Building, Conflict Resolution in Groups and problem solving

2Q) NEGOTIATION TEAM BUILDING

Negotiation a process that is predicated on a manager's ability to use influence productivelyQuestions to Ask Prior to Entering a Negotiation

1) How much power do I have?
2) What sort of time pressures are there?
3) Do I trust my opponent?

Principled Negotiation

1) Separate the people from the problem
2) Focus on interests, not positions
3) Invent options for mutual gain
4) Insist on using objective criteria

Summary

1) Understand the steps involved in project team building.
2) Know the characteristics of effective project teams and why teams fail.
3) Know the stages in the development of groups.
4) Describe how to achieve cross-functional cooperation in teams.
5) See the advantages and challenges of project teams.
6) Understand the nature of conflict and evaluate response method.
7) Understand the importance of negotiation skills in project management.

3Q) Conflict Resolution in Groups and problem solving Techniques

Definition of Conflict

It is a process that begins when one party perceives that another party has negatively affected, or is about to negatively affect something that the first party cares about.

- ✓ Conflict is a psychological state of mind when people are in a dilemma whether to do ornot to do a thing, is a state of conflict.

Nature of Conflict

- Conflict occurs when individuals are not able to choose among the available alternative courses of action.
- Conflict between two individuals implies that they have conflicting perception, valuesand goals.
- Conflict is a dynamic process as it indicates a series of events.
- Conflict must be perceived by the parties to it. If no one is aware of a conflict, then it isgenerally agree that no conflict exists.

Who do we come into conflict with?
Views on conflict

- **Traditional view:** The early approach to conflict assumed that all conflict was bad. Conflict was viewed negatively, and it was used synonymously with such terms asviolence, destruction.
- **Human Relations view:** The human relations position argued that conflict was a natural occurrence in all groups and organizations. Since conflict was inevitable(which cannot be avoided) it is accepted and there are even times when conflict may benefit a group's performance.
- **Integrationist View(Modern View):** This view is based on the belief that conflict is not only a positive force in a group but is also necessary for a group to perform effectively. This approach encourages group leaders to maintain an ongoing minimum level ofconflict – enough to keep the group viable, self-critical and creative.

Traditional View Current View

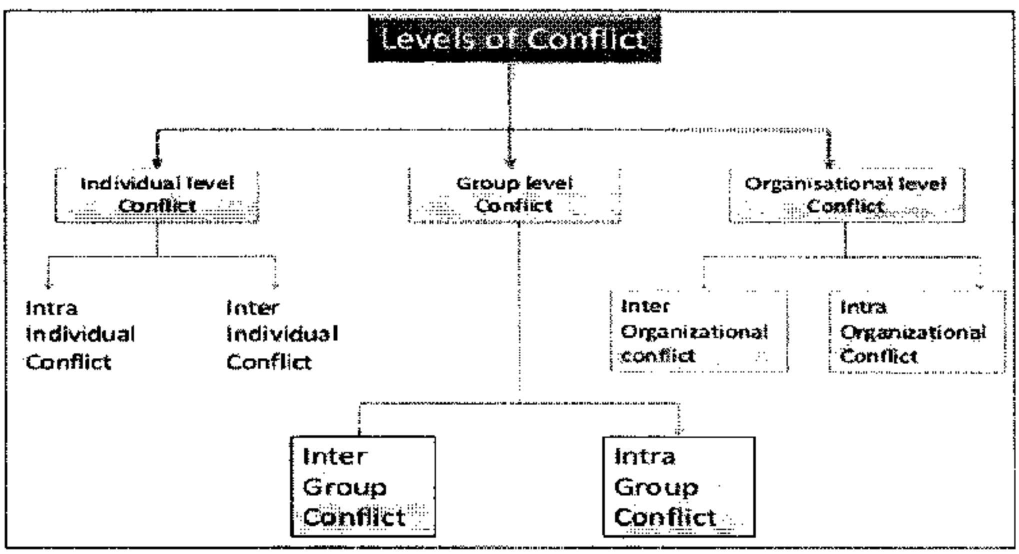
Types of conflict

- Functional – support the goals of the group and improves its performance.
- Dysfunctional – conflict that hinders group performance The functional conflicts can be differentiated from the dysfunctional conflicts on the basis of the following three attributes:

- ✓ **Task Conflict:** Related to content and goals of the work.
- ✓ **Relationship Conflict**: Focuses on interpersonal relationships.
- ✓ **Process Conflict:** Process conflict relates to how the work gets done.

- Latent Conflict (Stage 1): When two or more parties need each other to achieve desired objectives, there is potential for conflict. Latent Conflict often arises when change occurs. Conflict is likely to be caused by a budget cutback, a change in organizational direction, a change in personal goals or the assignment of a new project to an already overloaded team.
- Perceived Conflict (Stage 2): This is the stage at which members become aware of a problem. Incompatibility of needs is perceived and tension begins as the parties being to worry about what will happen. But no party feels that it is being overly threatened.
- Felt Conflict (Stage 3): At this stage parties become emotionally involved and begin to focus on differences of opinion and opposing interests. Internal tensions and frustration being to crystallize, and people begin to build and emotional commitment to their position.

- Manifest Conflict (Stage 4): At this stage parties engage in actions that help to achieve their own objectives and ruin those of others. Conflict behaviors vary from the subtle, indirect and highly controlled forms of interface to direct, aggressive, violent and uncontrolled struggle. At the organisational level strikes or lock-outs are the result.
- Conflict Outcome (Stage 5): The conflict finally results in an outcome which may be functional or dysfunctional. If handled well, the result is functional conflict. If mishandled, the consequences are dysfunctional conflict.



- Intra Individual Conflict: These conflicts arise within a person and are of psychological nature. These conflicts are generally related to the goals a person wants to achieve or roles in the manner he wants to achieve.
- Inter individual Conflict: Inter personal conflict arise between two individuals having competition for achieving scarce things, such as status, power, position, promotion or resources.
- Intra Group Conflict (With in the group): Intra group conflict refers to disputes among some or all of a group's members, which often affect the group's performance. Family run business can be especially prone to severe intra-group and other types of conflicts. These conflicts typically become more intense when an owner-founder approaches retirement, actually retires or dies. The way the two sons of the late Dhirubhai Ambani are fighting on ownership and control of Reliance Industries is a typical example.
- Inter group Conflicts (Between groups): Inter group conflict arises out of the interaction of various groups. Inter group conflict is also called organisational conflict, refers to the conflict between groups, departments, or sections in an organisation. Conflict between groups is frequent and highly visible.

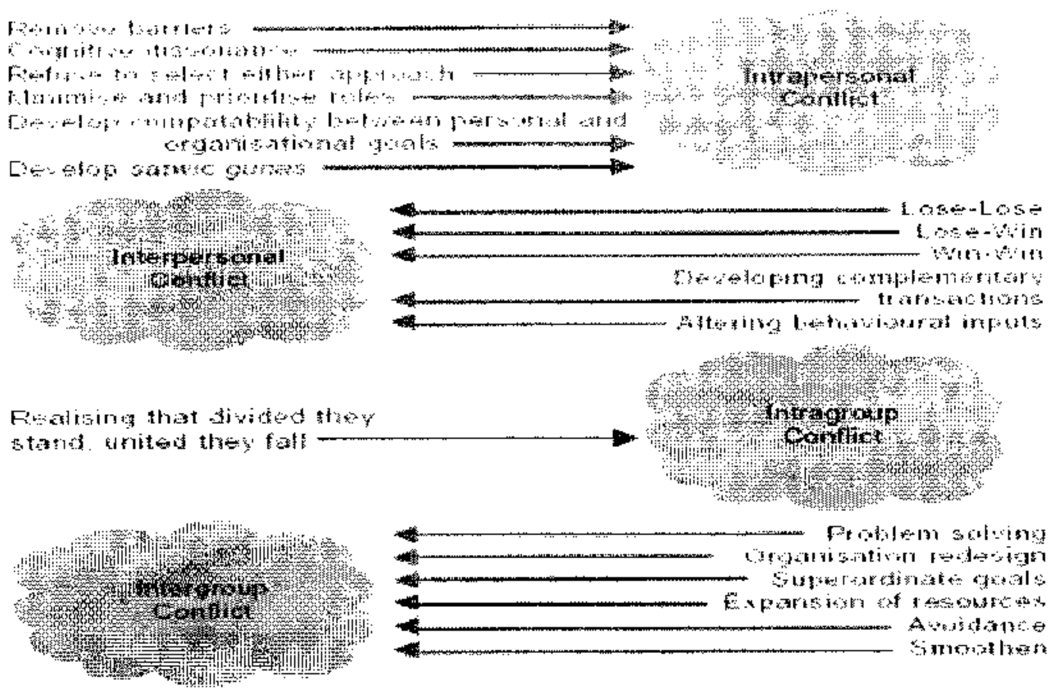
- Intra Organisational Conflict: The conflict which arises with in various levels and departments of organisation. Various kinds are:

I. Horizontal Conflict
II. Vertical Conflict
III. Line and Staff Conflict

- Inter Organisational Conflict: Inter organizational interaction results in conflict among different organizations. How ever, it is not necessary that such interaction may result in conflict.
- Inter Organizational Conflict may include:

i. Conflict between organizations pursuing similar objectives.
ii. Conflict between government agency and organization.
iii. Conflict between head office and a manufacturing unit.

While the last one is regularized by organizational rules and procedures, the other types of conflicts are regulated by State laws, administrative agencies, courts, and regulatory commissions.



Conflict Resolution in Groups

- Resolving Intra-Group Conflict : Conflict with in a family can be resolved if the members recognize and respect roles of family members. All the members need to realise that dived they stand, united they fall. Probably a family friend may intervene to resolve the dispute if the members fail to resolve the conflict themselves. This is what happened in Bajaj family. Sharad Pawar mediated to bring about a truce(An agreement between enemies or opponents to stop fighting or arguing for a certain time) in the troubled family.

- Resolving Inter-Group Conflict: The approaches that are available for resolving inter-group conflict are as follows.

a. Problem-Solving
b. Avoidance
c. Smoothen
d. Compromise
e. Expansion of Resources
f. Organization Redesign
g. Superordinate goals

- Problem-solving: Problem-solving is considered to be the most effective approach available as it emphasizes the attainment of the common interests of both conflicting parties. In Problem-solving strategy, attempts are made to find a solution that integrates the needs of both parties. The two parties work together both to define the problem and to identify mutually satisfactory solutions.

- Organization Redesign: Changing organizational structure is another approach for resolving conflict, particularly when the sources of conflict come from the coordination of work among different departments or divisions. One way of redesigning organizations is to reduce task interdependence between groups and give each group clear responsibilities. Another way is to transfer or exchange of members of conflicting groups. An appeal system may also be developed to eliminate the arbitrary use of power.

4Q) Organisational Change: Meaning, Causes and Its Process:

Meaning of Organisational Change:

Organisational change refers to any alteration that occurs in total work environment. Organisational change is an important characteristic of most organisations. An organisation must develop adaptability to change otherwise it will either be left behind or be swept away by the forces of change. Organisational change is inevitable in a progressive culture. Modern organizations are highly dynamic, versatile and adaptive to the multiplicity of changes.

Organisational change refers to the alteration of structural relationships and roles of people in the organization. It is largely structural in nature. An enterprise can be changed in several ways. Its technology can be changed; its structure, its people and other elements can be changed. Organisational change calls for a change in the individual behaviour of the employees.

Organizations survive, grow or decay depending upon the changing behaviour of the employees. Most changes disturb the equilibrium of situation and environment in which the individuals or groups exist. If a change is detrimental to the interests of individuals or groups, they will resist the change.

Causes of Organisational Change:

(A) External Pressures:

i. Change in Technology and Equipment:
Advancements in technology is the major cause (i.e., external pressure) of change. Each technological alternative results in new forms of organization to meet and match the needs.

ii. Market Situation:
Changes in market situation include rapidly changing goals, needs and desires of consumers, suppliers, unions etc. If an organization has to survive, it has to cope with changes in market situations.

iii. Social and Political Changes:
Organisational units literally have no control over social and political changes in the country. Relations between government and business or drive for social equality are some factors which may compel for organizational change.

(B) Internal Pressures (Pressures for Change from Within the Organisation):

i. Changes in the Managerial Personnel:
One of the most frequent reasons for major changes in the organisation is the change ofexecutives at the top. No two managers have the same style, skills or managerial philosophies.

ii. Deficiencies in the Existing Organization:

Many deficiencies are noticed in the organisations with the passage of time. A change is necessary to remove such deficiencies as lack of uniformity in the policies, obstacles in communication, any ambiguity etc.

iii. Other Factors:

Certain other factors such as listed below also demand a change in the organisation. Employee's desire to share in decision-making
Employee's desire for higher wage rate
Improvement in working conditions, etc.

Response to Organisational Change:

Every change is responded by the people working in the organisation. These responses may be positive or negative depending upon the fact as how they affect people.

Before introducing a change, the manager should study and understand employee's attitudes so as to create a positive response. Three sets of factors-psychological, personal and social- govern the attitude of people.

Process of Organisational Change:

Unless the behavioral patterns of the employees change, the change will have a little impact onthe effectiveness of the organisation.
A commonly accepted model for bringing change in people was suggested by Kurt Lewin interms of three phase process:-

(1) Unfreezing:

The essence of unfreezing phase is that the individual is made to realize that his beliefs, feelings and behavior are no longer appropriate or relevant to the current situation in the organisation. Once convinced, people may change their behaviour. Reward for those willing to change and punishment for others may help in this matter.

(2) Changing:

Once convinced and ready to change, an individual, under this phase, learns to behave in new ways. He is first provided with the model in which he is to identify himself. Gradually he will accept that model and behave in the manner suggested by the model. In another process (known as internalisation), the individual is placed in a situation where new behaviour is demanded of him if he is to operate successfully.

(3) Refreezing:

During this phase, a person has to practice and experiment with the new method of behaviour and see that it effectively blends with his other behavioural attitudes. Reinforcement, for creating a permanent set in the individual, is provided through either continuous or intermittent schedules.

Resistance to Organisational Change:

Resistance to change is perhaps one of the baffling problems a manager encounters because it can take many shapes. People may resign, they may show tardiness, loss of motivation to work, increased absenteeism, request for transfer, wild-cat strikes, shoddy work, reduction in productivity etc.

Classification of Resistance to Change:

Resistance to change may be classified as:

1. Industrial Resistance
2. Organisational Resistance

1. Industrial Resistance:

Individual resistance may be there because of the following reasons:

A. Economic Reasons:

(a) Obsolescence of Skills:

When a person feels that with the introduction of newer processes, his skills will just become obsolete, he will resist the change. For example, a twenty years experienced accountant is quite likely to resist the introduction of a computer for preparing the wage bills because he feels that might affect his pay and position.

(b) Fear of Economic Loss:

People resist change if it opens the possibility of lowering their income directly or indirectly.

B. Personal Reasons:

(a) Ego Defensiveness:

A sales manager may turn down the suggestions of a salesman simply because the managerperceives that his ego may be deflated by accepting the suggestion.

(b) Status Quo:

Most of the people feel comfortable with status quo and strongly resist change as it mayinvolve uncertainty and risk.

(c) Fear of Unknown:

Change presents unknown and unknown poses a constant threat and sores people. For fear of unknown, a manager may refuse promotion that requires his relocating in another state.

C. Social Reasons:

(a) Social Displacement:

Introduction of change (e.g., relocating) may result in breaking up of work groups and thus result in disturbance of the existing social relationships of people.

(b) Peer Pressure:

Whenever change is unwilling to the peers, they force the individual subordinate employeeswho are bent of accepting the change, to resist it.

2. Organizational Resistance:

Resistance may also be present at organizational level. Some organizations are so designedthat they resist innovations.

Some of the reasons of organizational resistance are:

(a) Threats to Power and Influence:

Some people (especially sitting at the top levels) resist change because they feel that a changemight affect their position, power and influence in the organization.

(b) Organizational Structure:

Some organization structures (e.g., bureaucratic structure) have inbuilt mechanism for resis-tance to change.

(c) Resource Constraints:

Non-availability of financial, material and human resources may also act as a resistance tochange.

(d) Sunk Cost:

In some companies, heavy capital is blocked in the fixed or permanent assets. If such an organization wishes to introduce change, then difficulty arises because of these sunk costs.

Overcoming Resistance to Organisational Change:

Change creates tension and emotional turmoil in the minds of employees. Change thus results in resistance quite frequently; negative reactions doom the success of the change program especially when a manager is unable to handle it properly.

Some of the techniques to handle the change properly and to deal with resistance to change are:

(a) Education and Communication:

One of the easiest techniques to overcome resistance to change is to educate the people who resist it. In many cases, people do not properly understand the change and hence become afraid of its consequences and resist change.

(b) Participation and Involvement:

If subordinates are allowed to participate and involve themselves in the change process (decision-making regarding the implementation of the change), their misunderstandings about the consequences of change are cleared, they generally feel satisfied and do not oppose change.

(c) Support:

Support may be facilitative and emotional. Managers sometimes deal with potential resistance by being supportive. This includes listening, providing emotional support, providing training in new skills etc.

(d) Incentives:

Offering incentive is another fruitful way to overcome resistance to change.

(e) Manipulation:

Managers generally indulge in manipulation when all other tactics have failed to overcome resistance to change.

(f) Coercion:

At times, there is no way except to deal with resistance coercively. People are forced to accept change by threatening them with loss of their jobs, promotion possibilities and so forth.

5Q) Creating an ethical organisation

1) Be a role model and be visible. Your employees look to the behaviour of top management as a model of what's acceptable behaviour in the workplace. When senior management is observed (by subordinates) to take the ethical high road, it sends a positive message for allemployees.
2) Communicate ethical expectations. Ethical ambiguities can be reduced by creating and disseminating an organizational code of ethics. It should state the organization's primary values and the ethical rules that employees are expected to follow. Remember, however, that a code of ethics is worthless if top management fails to model ethical behaviours.
3) Offer ethics training. Set up seminars, workshops, and similar ethical training programs. Use these training sessions to reinforce the organization's standards of conduct, to clarify what practices are and are not permissible, and to address possible ethical dilemmas.
4) Visibly reward ethical acts and punish unethical ones. Performance appraisals of managers should include a point-by-point evaluation of how his or her decisions measure up against the organization's code of ethics. Appraisals must include the means taken to achieve goals as well as the ends themselves. People who act ethically should be visibly rewarded for their behaviour. Just as importantly, unethical acts should be punished.
5) Provide protective mechanisms. The organization needs to provide formal mechanisms so that employees can discuss ethical dilemmas and report unethical behaviour without fear of reprimand. This might include creation of ethical counsellors, ombudsmen, or ethical officers.

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Department of Master of Business Administration

COURSE : **Management and Organization Behaviour**	DEGREE: **MBA**
COURSE CODE: C-101	YEAR: **I** SEMESTER: **I**
REGULATION: **R19**	COURSE TYPE: **REGULAR**
ACADEMIC YEAR:**2022-2023**	CREDITS: **4**

QUESTION BANK

UNIT 1

S.NO	QUESTION	Blooms Taxonomy Level	Course Outcome
1	Definition and Nature of Management	L1	CO1
2	Explain the Functions and Importance of Management	L2	CO1
3	Discuss the Importance of Management	L2	CO1
4	Classify the Evolution of Management thought	L4	CO1
5	Explain the Scientific management	L2	CO1
6	Apply the Administrative management	L3	CO1
7	Role- play the aw throne experiments	L6	CO1
8	Demonstrate Levels of Management	L3	CO1
9	Show the Managerial Skills	L3	CO1
10	Identify the Steps in Planning Process	L2	CO1
11	Tabulate the Processes of Decision Making	L1	CO1

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QUESTION BANK

UNIT 2			
S.NO	QUESTION	Blooms Taxonomy Level	Course Outcome
1	Definition of organizing	L1	CO2
2	Discuss the Principles of organizing	L2	CO2
3	Sketch the Organization Structure and Design	L3	CO2
4	Divide the Delegation of Authority and factors affecting delegation	L3	CO2
6	Interpret the Line and staff structure conflicts	L3	CO2
7	definition Coordination principles	L1	CO2
8	Differentiate Formal and Informal Organization	L2	CO2
9	Nature and importance of Controlling, process, controlling techniques	L2	CO2

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QUESTION BANK

UNIT 3			
S.NO	**QUESTION**	**Blooms Taxonomy Level**	**Course Outcome**
1	Definition of organizational behaviour, nature and scope of OB	L1	CO3
2	Apply the OB linkages with other social sciences	L3	CO3
3	Indicate the Perception and its process	L2	CO3
4	Learning definition and its process, theories	L1	CO3
5	Explain the Personality and its determinants of personality	L5	CO3
6	Evaluate the Values, attitudes and beliefs	L6	CO3
7	Point out the Creativity and creative thinking	L5	CO3

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QUESTION BANK

UNIT 4			
S.NO	**QUESTION**	**Blooms Taxonomy Level**	**Course Outcome**
1	Classify the Motivation and its theories	L1	CO4
2	Explain the Leadership and its styles	L5	CO4
3	Define the Stages of group formation and its development	L1	CO4
4	Describe the Role of Group dynamics	L2	CO4
5	Compare the Collaborative process in work groups	L2	CO4
6	Prepare the Johari window –transactional analysis	L4	CO4

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ESTD : 2008

QUESTION BANK

UNIT 5			
S.NO	QUESTION	Blooms Taxonomy Level	Course Outcome
1	Assess the Conflict- causes and consequences	L5	CO5
2	Predict the importance the Team building	L5	CO5
3	Examine the Organizational change its process	L1	CO5
4	Associate the Resistance to change in organizations	L2	CO5
5	Identify the importance of Negotiations	L2	CO5

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MB1911/R19

MBA I Semester Regular/Supplementary Examinations, July [illegible]

MANAGEMENT AND ORGANIZATIONAL BEHAVIOUR

Time: 3 Hours

Answer Any FIVE Questions, one from each unit
Question No. 11 is Compulsory

UNIT-I

a What is management?
b Explain the nature, functions and importance of management.

OR

a What is Planning?
b Explain the steps in planning process.

UNIT-II

a What is delegation of authority?
b Explain VA Gracunas effective span of management.

OR

a Explain line and staff.
b Why conflicts arise between line and staff? Explain the strategies to overcome [illegible] conflicts.

UNIT-III

a What is Organizational Behaviour?
b Explain the nature, scope and importance of organization behavio[illegible]

OR

a What is personality?
b Explain the determinants of personality.

UNIT-IV

a What is motivation?
b Explain the Herzberg hygienic theory of motivation.

OR

a What is group dynamics?
b Explain the various stages of group formation.

UNIT-V

a What is organizational conflict?
b Explain the causes and consequences of conflicts in an organizatio[illegible]

OR

a What is organizational change?
b How would you manage the change in pandemics?

11. **CASE STUDY** 15M

Mr. Chinmai, the founder and the chief executive of a garment manufacturing company built his business from a one man operation to an organisation with fifty employees and an annual turnover of five crore rupees within five years. Although the business has grown in size and profitability, Chinmai's management has not changed to a noticeable extent. He was deeply involved in the day-to-day affairs of the business and hesitant to let his senior subordinates carry out some of the important tasks. Nothing seemed to move during his purchasing trips abroad. Chinmai believed that he was the only one who knew the business well and had the required knowledge and expertise to make the decisions pertaining to the well-being of his business.

Chinmai prepared all the plans for his business, centralised various activities, recruited personnel, guided their activities, solved their problems, and took care of all personnel-related matters. He knew all his employees by their names and practiced the open-door policy.

As his business was experiencing growth, Chinmai could not find time for formulating new strategies to cope with the challenges. Employees found it difficult to reach him when they faced certain important and difficult problems. The morale of the organisation has reached its lowest point.

As the problems grew and the pressure increased, Chinmai was contemplating getting rid of his business. He felt that his business has put him into deeper trouble, and as a result, he was experiencing health problems, and most of all, he had lost his peace of mind.

Questions:

i. What would be your assessment of Chinmai's situation?
ii. Comment on his managerial style.
iii. What advice would you give to Chinmai before he dissolves his business?
iv. Was Chinmai a good manager? Support your feelings.

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Department of Master of Business Administration

Subject: MOB

Branch: MBA **TIME 10.00 AM TO 12.00PM**

Answer all the questions **Mid- I** **Total Marks: 15** **DATE: 19-12-2022**

1. Define Management explain Nature, Importance, Functions, Scope of the Management 5M
2. Briefly Explain
   A) Scientific Management principles?
   B) Administrative Principles. 5M
3. Explain Organization. Explain Structure & Design? 5M

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MBA I YEAR I-SEM, MID-II
SUB: MANAGEMENT AND ORGANIZATIONAL BEHAVIOR MB1911

Time: 2hrs **Date: 13-02-2023** **Max Marks: 15**

1. How the organization linkages with other social sciences? 5M
2. Define motivation. Explain process and content theories of motivation.5M
3. What are the causes and consequences of organizational conflict? 5M

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CONTENT BEYOND SYLLABUS

Sl.No.	TOPIC	Mode of Teaching	Relevance with POs and PSOs
1		PPT	
2		PPT	

TOPIC Description

1. Communication skills are extremely essential in today's competitive environment. A good communicator should be able to receive information as sent.

   Good communication skills in a group discussion can show you are an active listener.

- It helps to clearly express your ideas.
- Good communication skills help to exchange ideas.
- Good communication skills avoid professional glitches in a team discussion.
- Good communication skills help to avoid misunderstandings.
- It helps to negotiate on various issues in a group discussion.
- It adds a lot of value in a presentation in a group discussion.
- Good communication skills can grab attention of evaluators.
- It can show that you are stable, level headed, confident and quite well aware of the arguments.

Communication skill is not just about speaking fluently in English. It's about being confident and the right attitude

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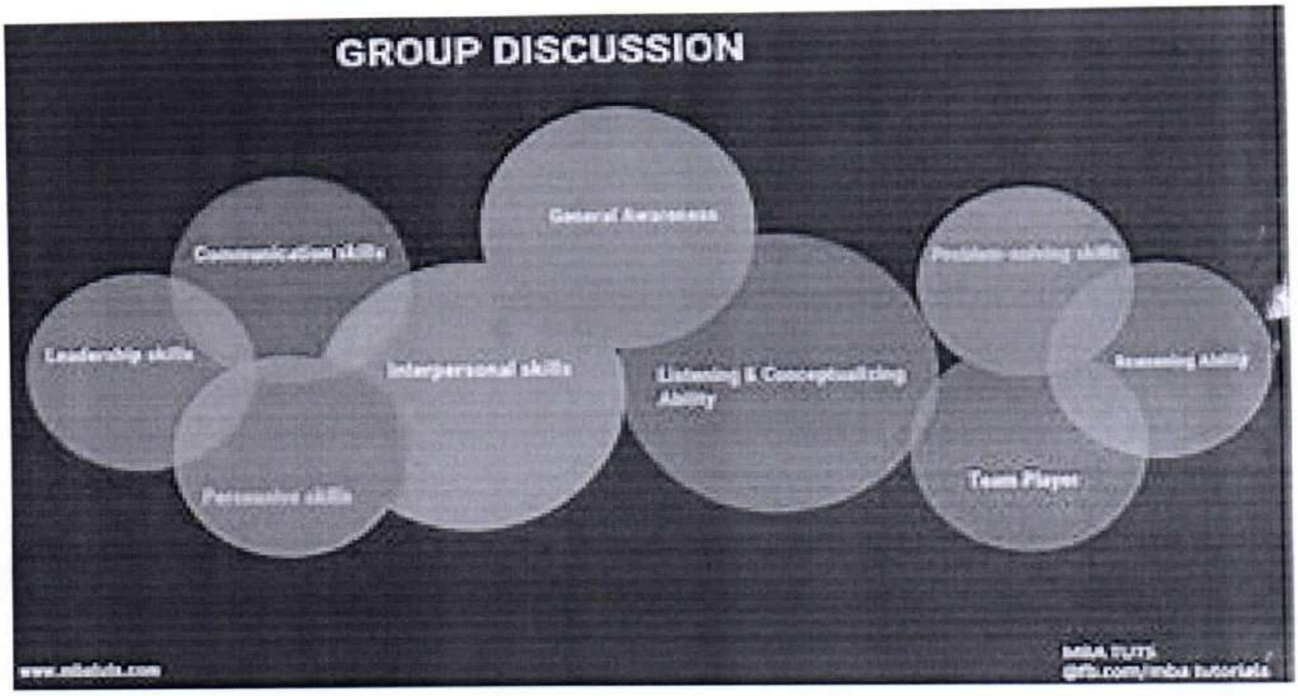

Group discussion is a method used by an organization to measure whether the candidate has convinced individuality traits and skills that it desires in its teammates. In this method, the group of candidates is given a topic or a situation, given a few minutes to consider about the same, and then asked to discuss the topic amongst themselves for 15-20 minutes. So, to make you aware more about group discussion skills and other important information we have mentioned below the details for the same.

What are the aspects that support a group discussion?

Some of the aspects are:

- Co- operation
- Verbal Communication
- Non- verbal behaviour
- verification to norms

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- Decision-making aptitude

Skills required for a group discussion:

- **Knowledge:**

Knowledge imitates your capability to have an estimation on issues and anxieties of modern significance and hence your aptitude to attach with diverse aspects of the surroundings. Here, knowledge refers to a sharp differentiator and helps you to influence a strong spirited advantage. Unless you have the necessary knowledge of the given topic, your discussion runs the hazard of being low and exterior. Being well versed in present affairs and issues of simultaneous importance can help you to do well along with this limitation.

- **Interpersonal skills:**

It is reflected in the aptitude of the candidate to interrelate with other members of the collection in a concise situation. Emotional mellowness and stability promote high-quality interpersonal relationships. The person has to be more community-centric and less self-centred.

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- **Proactive:**

If you have content to speak, don't wait for others to start with the group discussion. The one who gets an opportunity to speak first get an opportunity to drive the Group discussion. There may come a time where other members are not speaking up, or the situation is like a vegetable market that time you can take a proactive step and ace your group discussion round.

- **Leadership:**

Among the mass of brilliant candidates, there's always a possibility of getting overshadowed and dense. It could be the casing were smooth if the other candidate is not as much of well-informed in academics, but his or her one excellence of putting onward his positives and aptitude to manage the circumstances will make him/her earn a good point.

- **Time Management:**

Time is one of the innermost things. Its correct use can take you to heights, and its disregard can make you fall on the land. During the group discussion, make yourself definite that you will speak not less than two minutes.

For more, read: Top Time Management Skills for Career Success

- **Logical Ability:**

This indicates your aptitude to efficiently flowchart you're thought process and examine the topic in a comprehensive manner. It reflects your aptitude to build logical arguments and makeup the discussion in a sleek manner, avoiding chance forays.

- Communication skills:

This evaluates the candidate's aptitude to attach with the group and is calculated from a dual viewpoint - verbal and non-verbal. While verbal communication achieves the student on limitations like facility, articulation and intonation, the

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non-verbal quotient defines his/her body language, signal eye contact and bearing.

- **Group dynamics:**

This demonstrates the skill to smack stability between individual brilliance and group performance. A person scoring high on this parameter will be more credible to work in groups and hence donate successfully to organizations.

To improve your group discussion skills, you can enrol in online communication development and personality development courses.

TOPIC Description

No matter what degree you hold, how skilled you are, and what experience you hold, the very thought of facing an interview leads to goose bumps. To think about sitting in front of the interview panel causes stress to many people and it can be nerve-wrecking for them. Here we provide certain tips to face the interview confidently.

Recognize Your Problem: First you need to accept that you are under stress and it is normal in such conditions. This is the most important step, as it allows you to find ways to come out of it. There are various signs which indicate that the person is under stress, such as, tickling in the stomach, sweating, babbling, tightening of the shoulders and neck, etc. Early detection of such signs and symptoms is imperative when formulating a plan of action to combat stress during an interview.

Prepare In Advance: Before going for an interview, prepare both your mind and body. Some patent interview questions need to be prepared beforehand and body language such as posture must be rehearsed in advance. Preparation gives confidence to face the actual situation.

Do Not Succumb To The Interview Pressure: Giving in is very easy, but to succeed one has to face challenges and overcome them with determination. Remember that your interview performance is the index of your character. It shows how strong you are. Just focus on your strengths and try to overcome your shortcomings. It is for sure that the interview panel will not change; you have to change and adopt the never-to-quit attitude.

Respect the Interviewer: Listen carefully to what the interviewer is asking, answer politely and with patience. It is important to face the interview with a positive attitude and keep your mind alert and open.

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Only with confidence and determination one can come out of the pressure full situation. There is no shortcut to escape fear. One has to accept the fear and give his/her best to come out of difficult situations with the head held high.

10 Ways to Overcome Job Interview Anxiety

1. Treat Yourself Well physically and emotionally
2. Be confident about your success
3. Reduce stressors unrelated to the actual interview
4. Research your potential employer. Prepare answers to common questions.
5. Don't Succumb to Pressure and kick out all negative thinking's
6. Realize the truth that interviews are a two-way street
7. Find a way to release anxious energy that no one will notice
8. Don't answer questions immediately and take your time
9. Be sure to bring all important documents you need during an interview
10. Congratulate yourself afterward for taking the chance of this interview

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Pulladigunta (Village), Vatticherukuru (Mandal),
Guntur-522017, Andhra Pradesh, India
Department of Master of Business Administration

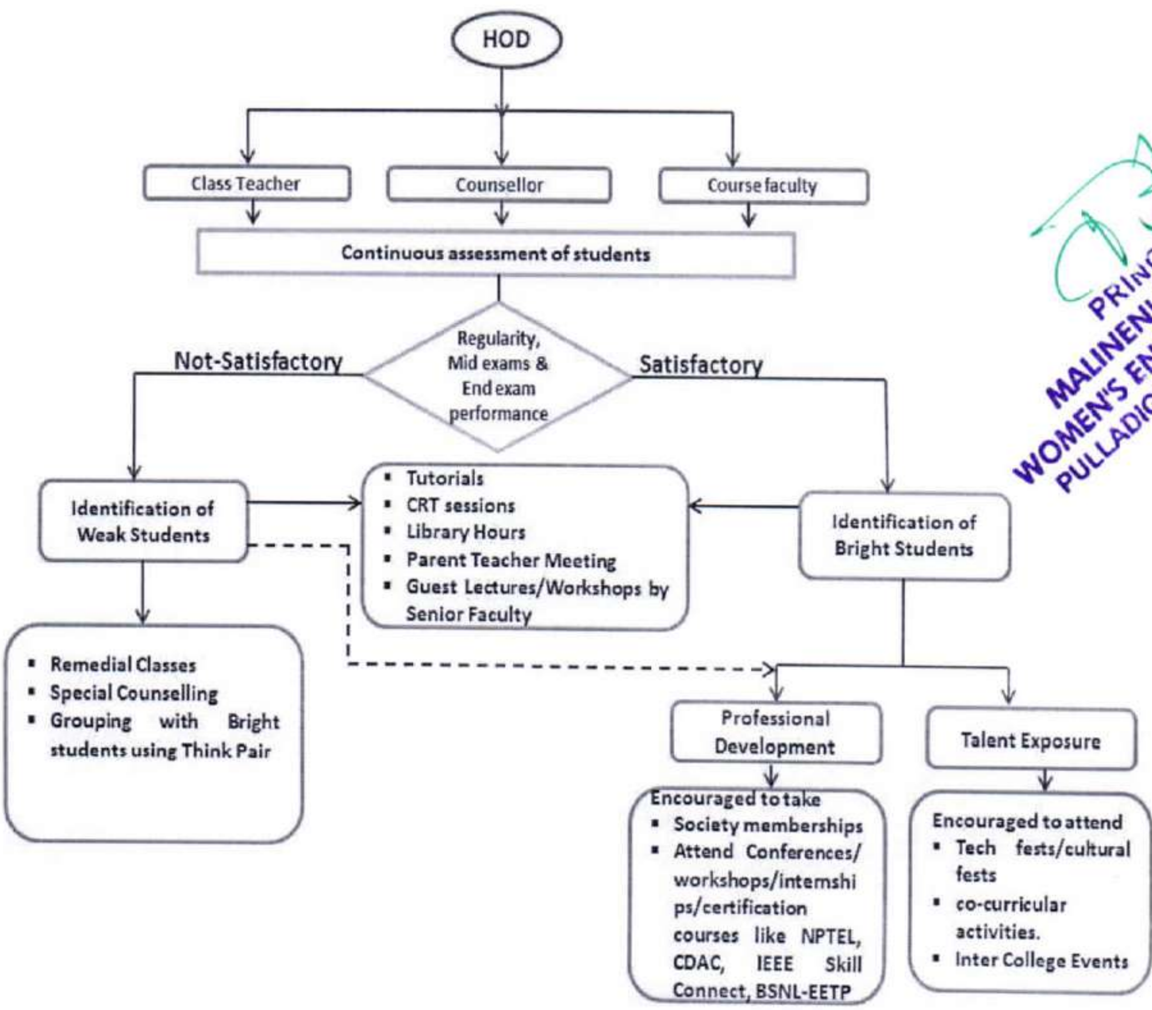
How do you overcome pressure?

Organize your time add Identify your best time of day, and do the important tasks that need the most energy and concentration at that time Make a list of things you have to do. ...Set smaller and more achievable targets. ...Vary your activities. ...Try not to do too much at once. ...Take breaks and take things slowly.

Methodologies to support weak students and encourage bright students

Each councilor is allocated maximum of 24 students for counseling. As the faculty is given maximum of 24 students for counseling, the possibility of weak students' number who are r e q u i r e d to be counseled, will be around 15%. Weak student/Bright student is identified based on the attendance in the present semester and the performance in previous semester and internal exams called CIE.

Measures taken by the department to support Weak Students



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Department of Master of Business Administration

The department has a well-defined process of monitoring, guiding, and assisting slow learners (weak students).Monthly consolidated attendance report is taken by the class teacher and the same is given to the counsellors.

- Counselors counsel the students in terms of having less regularity and performance of students in mid exams as well as semester end examinations. The same is communicated to parents and also in parent teacher meeting conducted once in a semester.
- The information regarding the regularity and performance of students in mid exam as well as semester end examinations is communicated to parents time to time.
- To support the weak students' tutorial and remedial classes are conducted.
- Special counselling is conducted by the faculty to motivate the slow learners.

Impact on Weak Students

By the motivation and monitoring from both parents and faculty created a positive mind set and helped the students in overcoming the inabilities and hurdles faced by the slow learners. The following are the improvements observed after timely counselling for students.

- Improvement in Regularity of students.
- Active participation of the students in various Programs.
- Active involvement of students in Professional bodies.
- Better interaction between students, faculty, and Parents.
- Appreciation from parents.
- Improvement in overall student's performance in scoring good percentage.

Measures taken by the department to encourage Bright Students

Students are encouraged to

- Take memberships in Professional Bodies like IEI, ISTE & IEEE.
- Register and complete certification courses like NPTEL, IEEE Skill Connect.
- To participate in various workshops/conferences.
- To apply for internships in Government Organizations.
- To participate in inter and intra college events like Technical Fest and Cultural fest.

RPCRao

T-Arul

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Code No: MB1911/R19 **Set: 1**

MBA I Semester Regular/Supplementary Examinations, May-2022

MANAGEMENT AND ORGANIZATIONAL BEHAVIOUR

Time: 3 Hours **Max. Marks: 75**

Answer Any **FIVE** *Questions, one from each unit*
Question No. 11 is Compulsory

UNIT-I

1.	a	Explain the nature and scope of management.	6M
	b	What are managerial skills? Who should have more of conceptual skills?	6M
		OR	
2.	a	Explain the principles of scientific management.	6M
	b	What is planning? Explain the process of planning.	6M
		UNIT-II	
3.	a	Explain the importance of organization.	6M
	b	Define delegation. Explain the benefits of delegation.	6M
		OR	
4.	a	Describe the various organizational structures.	6M
	b	What are the new forms in corporate structure? Explain.	6M
		UNIT-III	
5.	a	Explain nature & scope of organizational behavior.	6M
	b	How perceptual skills can be developed? Explain the importance of perception.	6M
		OR	
6.	a	Explain the role of individual in an organization.	6M
	b	Discuss the various phases in learning.	6M
		UNIT-IV	
7.	a	Explain the classification of motivation.	6M
	b	Write about McClelland's theory of motivation.	6M
		OR	
8.	a	Explain different types of leadership styles.	6M
	b	Describe the Path Goal theory of leadership.	6M
		UNIT-V	
9.	a	Analyze the causes and consequences of conflict.	6M
	b	Outline the steps involved in change process.	6M
		OR	
10.	a	Explain different types of conflicts and why they arise between groups in an organization.	6M
	b	Define team building. Explain the need for team building.	6M

11. **CASE STUDY** 15M

ABC company recently discovered that the costs due to shipment of defective items had risen to an alarming level. To correct the situation, they decided to implement a quality assurance program. Previously, all inspection was done by workers on their own work. Because of the lack of formal education in quality assurance for the present employees and managers, it was decided to form team of recent college graduates for quality assurance programs (QAP).

The team which was formed was given the responsibility of reducing the percentage of defective items being produced to half of the present level in one month. Problems, however, began to crop up immediately. Conflict arose between the inspectors of the QAP and the workers. Some of the older employees felt they were being insulted whenever a quality problem was traced to their work. This resentment often resulted in their work deteriorating further instead of improving. Other workers believed they were being wrongly accused of shoddy workmanship. Some even accused the inspectors of actually making defects in their work so that they could claim they had found a problem spot (defect) and hence, look good in the eyes of the QAP manager.

Monitoring reports after the first month showed that the quality level had actually worsened. Management felt that perhaps they had introduced the quality assurance program improperly.

Questions:

i) What errors do you feel the ABC company made in the implementation of QAP?

ii) What remedial actions would you take to improve the present situation?

*****

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Htno	Subcode	Subname	Internals	Grade	Credits
22KE1E0001	MB1911	MANAGEMENT AND ORGANIZATIONAL BEHAVIOR	25	C	4
22KE1E0002	MB1911	MANAGEMENT AND ORGANIZATIONAL BEHAVIOR	23	B	4
22KE1E0003	MB1911	MANAGEMENT AND ORGANIZATIONAL BEHAVIOR	24	C	4
22KE1E0004	MB1911	MANAGEMENT AND ORGANIZATIONAL BEHAVIOR	24	B	4
22KE1E0005	MB1911	MANAGEMENT AND ORGANIZATIONAL BEHAVIOR	23	C	4
22KE1E0006	MB1911	MANAGEMENT AND ORGANIZATIONAL BEHAVIOR	23	C	4
22KE1E0007	MB1911	MANAGEMENT AND ORGANIZATIONAL BEHAVIOR	22	C	4
22KE1E0008	MB1911	MANAGEMENT AND ORGANIZATIONAL BEHAVIOR	24	B	4
22KE1E0009	MB1911	MANAGEMENT AND ORGANIZATIONAL BEHAVIOR	24	C	4
22KE1E0010	MB1911	MANAGEMENT AND ORGANIZATIONAL BEHAVIOR	23	AB	0
22KE1E0011	MB1911	MANAGEMENT AND ORGANIZATIONAL BEHAVIOR	23	F	0
22KE1E0012	MB1911	MANAGEMENT AND ORGANIZATIONAL BEHAVIOR	17	AB	0
22KE1E0013	MB1911	MANAGEMENT AND ORGANIZATIONAL BEHAVIOR	25	B	4
22KE1E0014	MB1911	MANAGEMENT AND ORGANIZATIONAL BEHAVIOR	24	C	4
22KE1E0015	MB1911	MANAGEMENT AND ORGANIZATIONAL BEHAVIOR	22	C	4
22KE1E0016	MB1911	MANAGEMENT AND ORGANIZATIONAL BEHAVIOR	24	F	0
22KE1E0017	MB1911	MANAGEMENT AND ORGANIZATIONAL BEHAVIOR	25	B	4
22KE1E0018	MB1911	MANAGEMENT AND ORGANIZATIONAL BEHAVIOR	24	C	4
22KE1E0020	MB1911	MANAGEMENT AND ORGANIZATIONAL BEHAVIOR	23	B	4
22KE1E0021	MB1911	MANAGEMENT AND ORGANIZATIONAL BEHAVIOR	24	C	4
22KE1E0022	MB1911	MANAGEMENT AND ORGANIZATIONAL BEHAVIOR	24	C	4
22KE1E0023	MB1911	MANAGEMENT AND ORGANIZATIONAL BEHAVIOR	23	C	4
22KE1E0024	MB1911	MANAGEMENT AND ORGANIZATIONAL BEHAVIOR	23	F	0
22KE1E0025	MB1911	MANAGEMENT AND ORGANIZATIONAL BEHAVIOR	24	F	0
22KE1E0026	MB1911	MANAGEMENT AND ORGANIZATIONAL BEHAVIOR	24	B	4
22KE1E0027	MB1911	MANAGEMENT AND ORGANIZATIONAL BEHAVIOR	24	C	4

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22KE1E0028	MB1911	MANAGEMENT AND ORGANIZATIONAL BEHAVIOR	24	A	4
22KE1E0030	MB1911	MANAGEMENT AND ORGANIZATIONAL BEHAVIOR	24	C	4
22KE1E0031	MB1911	MANAGEMENT AND ORGANIZATIONAL BEHAVIOR	25	C	4
22KE1E0032	MB1911	MANAGEMENT AND ORGANIZATIONAL BEHAVIOR	22	C	4
22KE1E0033	MB1911	MANAGEMENT AND ORGANIZATIONAL BEHAVIOR	24	A	4
22KE1E0034	MB1911	MANAGEMENT AND ORGANIZATIONAL BEHAVIOR	24	B	4
22KE1E0035	MB1911	MANAGEMENT AND ORGANIZATIONAL BEHAVIOR	25	B	4
22KE1E0036	MB1911	MANAGEMENT AND ORGANIZATIONAL BEHAVIOR	25	S	4
22KE1E0037	MB1911	MANAGEMENT AND ORGANIZATIONAL BEHAVIOR	24	B	4
22KE1E0038	MB1911	MANAGEMENT AND ORGANIZATIONAL BEHAVIOR	24	C	4
22KE1E0039	MB1911	MANAGEMENT AND ORGANIZATIONAL BEHAVIOR	23	B	4
22KE1E0040	MB1911	MANAGEMENT AND ORGANIZATIONAL BEHAVIOR	24	B	4
22KE1E0041	MB1911	MANAGEMENT AND ORGANIZATIONAL BEHAVIOR	23	B	4
22KE1E0042	MB1911	MANAGEMENT AND ORGANIZATIONAL BEHAVIOR	23	C	4
22KE1E0043	MB1911	MANAGEMENT AND ORGANIZATIONAL BEHAVIOR	24	C	4
22KE1E0044	MB1911	MANAGEMENT AND ORGANIZATIONAL BEHAVIOR	25	F	0
22KE1E0045	MB1911	MANAGEMENT AND ORGANIZATIONAL BEHAVIOR	25	C	4
22KE1E0046	MB1911	MANAGEMENT AND ORGANIZATIONAL BEHAVIOR	24	AB	0
22KE1E0047	MB1911	MANAGEMENT AND ORGANIZATIONAL BEHAVIOR	23	B	4
22KE1E0048	MB1911	MANAGEMENT AND ORGANIZATIONAL BEHAVIOR	25	B	4
22KE1E0049	MB1911	MANAGEMENT AND ORGANIZATIONAL BEHAVIOR	25	F	0
22KE1E0050	MB1911	MANAGEMENT AND ORGANIZATIONAL BEHAVIOR	24	AB	0
22KE1E0051	MB1911	MANAGEMENT AND ORGANIZATIONAL BEHAVIOR	24	F	0
22KE1E0052	MB1911	MANAGEMENT AND ORGANIZATIONAL BEHAVIOR	24	B	4

TOTAL NO OF STUDENTS ATTENDED. –46

NO. OF STUDENT PASSED—39 NO. OF STUDENT FAILED—7

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DEPARTMENT OF MASTER OF BUSINESS ADMINISTRATION

I MBA I-SEM RESULT ANALYSIS

BRANCH :: MBA

ACADEMIC YEAR 2022-2023

SNO	Roll Number	Name of the Student		MOB	ME	AFM	QABD	LBE	BCSS	RIP	IT-LAB	BCSS-LAB
1	22KE1E0001	AMARA DIYVA		P	P	P	F	P	P	P	P	P
2	22KE1E0002	BANAVATU SWATHI BAI		P	P	P	F	P	P	P	P	P
3	22KE1E0003	BATTULA MOUNIKA	IR	P	P	P	P	P	P	P	P	P
4	22KE1E0004	BURAGADDA TEJASWI		P	P	P	P	P	P	P	P	P
5	22KE1E0005	CHADALAVADA GAYATHRI		P	P	F	F	P	F	P	P	P
6	22KE1E0006	CHAPARALA PRASESSI	IR	P	P	P	F	P	P	P	P	P
7	22KE1E0007	CHEVURI MOUNIKA TEJASWINI		P	P	P	P	P	P	P	P	P
8	22KE1E0008	CHILUKURI SIREESHA		P	P	P	P	P	P	P	P	P
9	22KE1E0009	CHUNDU PRANITHA		P	P	P	F	P	P	P	P	P
10	22KE1E0010	DASARI PREMA SWATHI	IR	AB	AB	AB	AB	AB	AB	AB	P	P
11	22KE1E0011	DEVARAKONDA BHAGYA LAKSHMI	IR	F	F	F	F	P	F	F	P	P
12	22KE1E0012	DUDEKULA ABDUL NAZIA		AB	AB	AB	AB	AB	AB	AB	AB	AB
13	22KE1E0013	GALLA DEEPIKA		P	P	P	P	P	P	P	P	P
14	22KE1E0014	GANDIKOTA NAGAJYOTHI		P	P	P	F	P	P	P	P	P
15	22KE1E0015	GURRAM ANUSHA	IR	P	P	F	F	P	P	P	P	P
16	22KE1E0016	ILAPOGU SIRISHA	IR	F	F	P	F	P	P	P	P	P
17	22KE1E0017	JIDUJU KEERTHI PRIYA		P	P	P	P	P	P	P	P	P
18	22KE1E0018	KAKARLAMUDI NAGA MANI		P	P	P	P	P	P	P	P	P
19	22KE1E0019	KALYANAM NAGA SAI KEERTHANA										
20	22KE1E0020	KAMMA NAGASAI SRILEKHA	IR	P	P	P	F	P	P	P	P	P
21	22KE1E0021	KOKA LALITHA	IR	P	P	P	P	P	P	P	P	P
22	22KE1E0022	KOKKIREKKALA INDU		P	P	P	F	P	P	P	P	P
23	22KE1E0023	KOLLU VEDA VARSHINI	IR	P	P	P	P	P	P	P	P	P
24	22KE1E0024	KOTA JHANSI LAKSHMI	IR	F	P	P	P	P	P	P	P	P

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25	22KE1E0025	KUNCHALA SIRISHA	IR	F	P	P	F	P	P	P	P	P
26	22KE1E0026	KURICHETI SUVARCHALA		P	P	P	P	P	P	P	P	P
27	22KE1E0027	LOKASANI ASWINI		P	P	P	F	P	P	P	P	P
28	22KE1E0028	NADENDLA BHARGAVI		P	P	P	P	P	P	P	P	P
29	22KE1E0029	NAGULAPATI SUJATHA										
30	22KE1E0030	ONGOLE DHARANI		P	P	P	P	P	P	P	P	P
31	22KE1E0031	PASUPULETI NEELIMA		P	P	P	P	P	P	P	P	P
32	22KE1E0032	PENUGONDA MOHANA LAKSHMI	IR	P	P	F	P	P	P	P	P	P
33	22KE1E0033	PONNEKANTI LAKSHMI SUPRAJA	IR	P	P	P	P	P	P	P	P	P
34	22KE1E0034	RAMISETTI APARNA	IR	P	P	P	F	P	P	P	P	P
35	22KE1E0035	RUSUM MOUNIKA		P	P	P	P	P	P	P	P	P
36	22KE1E0036	SABIHA SHAIK		P	P	P	P	P	P	P	P	P
SNO	Roll Number	Name of the Student		MOB	ME	AFM	QABD	LBE	BCSS	RIP	IT-LAB	BCSS-LAB
37	22KE1E0037	SANAKA BHUVANESWARI	IR	P	P	P	F	P	P	P	P	P
38	22KE1E0038	SANGA VENKATA LAKSHMI MONIKA		P	P	P	F	P	P	P	P	P
39	22KE1E0039	SHAIK AKHILA	IR	P	P	P	F	P	P	P	P	P
40	22KE1E0040	SHAIK KAMRUNNISHA	IR	P	P	P	P	P	P	P	P	P
41	22KE1E0041	SHAIK NAGURBI		P	P	P	P	P	P	P	P	P
42	22KE1E0042	SHAIK NAGURBI	IR	P	P	P	P	P	P	P	P	P
43	22KE1E0043	SHAIK SHAMEER BEGUM	IR	P	P	P	F	P	P	P	P	P
44	22KE1E0044	SODISETTI LEELA PRAVALLIKA		F	P	P	P	P	P	P	P	P
45	22KE1E0045	UGGIRALA SOWMYA		P	P	P	F	P	P	P	P	P
46	22KE1E0046	UPPADA BHARATHI	IR	AB	AB	F	AB	AB	P	P	P	P
47	22KE1E0047	UTUKURI SUPRIYA		P	P	P	P	P	P	P	P	P
48	22KE1E0048	VENNAPUSA NAGA LAKSHMI		P	P	P	P	P	P	P	P	P
49	22KE1E0049	TANNEERU SASI PRIYA		F	P	P	P	P	P	P	P	P
50	22KE1E0050	PASUPULETI SAI BHARGAVI	IR	AB	AB	AB	AB	AB	AB	AB	P	P
51	22KE1E0051	IMMADISETTY LAKSHMI SAI SUJATHA		F	P	F	F	P	F	P	P	P
52	22KE1E0052	CHERUKURI MOUNIKA		P	P	P	F	P	P	P	P	P

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Name of the Facuty	SUBJECTS & CODES	TOT REG	T. APP	T.PASS	T. FAIL	PER
Dr. R. PURNA CHANDRA RAO	MOB(MB1911)	50	46	39	7	84.78
Mrs. I.NAGA JYOTHI	ME(MB1912)	50	46	44	2	95.65
Mr G.BAJI	AFM(MB1913)	50	47	41	6	87.23
Mr M.V.L.NRAYANA	QABD(MB1914)	50	46	25	21	54.35
Mr SHAKEEL AHAMED	LBE(MB1915)	50	46	46	0	100.00
Miss B.SRAVYA	BCSS(MB1916)	50	47	44	3	93.62
Mrs. B.NAGA SYAMALA	RIP(MB191B)	50	47	46	1	97.87
Mrs. D.DURGA RANI	IT-LAB	50	49	49	0	100
Miss B.SRAVYA	BCSS-LAB	50	49	49	0	100

TOTAL PASS PERCENTAGE ::45.65%

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