Dr. AMBEDKAR GOVERNMENT ARTS COLLEGE
(AUTONOMOUS)
CHENNAI - 600 039

(Accredited by NAAC at level "B")

M. Sc. (MATHEMATICS)

(FOR CANDIDATES ADMITTED FROM 2022-23 ONWARDS)

Syllabus

Under Choice Based Credit System

LEARNING OUTCOMES BASED CURRICULUM FRAMEWORK (LOCF)

PG & RESEARCH DEPARTMENT OF MATHEMATICS

Based on UGC – Learning Outcomes-Based Curriculum Framework

Course Structure under Choice Based Credit System

(For the candidates admitted from the academic year 2022-2023 onwards)

Sem. No.	Part	Course	Subject code	Course Title	Ins. Hrs/Week	Credit	Exam Hrs	Marks		Total
								Int	Ext	
I	A	CC-I	22PAMAC1	Abstract Algebra	6	4	3	25	75	100
	A	CC-II	22PAMAC2	Real Analysis –I	6	4	3	25	75	100
	A	CC-III	22PAMAC3	Ordinary Differential Equations	6	4	3	25	75	100
	A	CC-IV	22PAMAC4	Graph Theory	5	4	3	25	75	100
	A	CEC-I	*	One from Elective-I Group	5	3	3	25	75	100
	B	SBE - I	22PASBE1	Employability Skills	2	2	3	25	75	100
				Total	**30**	**21**				
II	A	CC-V	22PBMAC1	Linear Algebra	6	4	3	25	75	100
	A	CC-VI	22PBMAC2	Real Analysis–II	5	4	3	25	75	100
	A	CC-VII	22PBMAC3	Partial Differential Equations	5	4	3	25	75	100
	A	CC-VIII	22PBMAC4	Topology	5	4	3	25	75	100
	A	CEC-II	**	One from Elective-II Group	5	3	3	25	75	100
	A	EDS-I	22PBMAD1	Mathematics For Competitive Examinations	2	3	3	25	75	100
	B	SBE - II	22PBSBE2	Leadership and Communication Skills	2	2	3	25	75	100
				Total	**30**	**24**				
III	A	CC-IX	22PCMAC1	Mathematical Methods	6	4	3	25	75	100
	A	CC-X	22PCMAC2	Differential Geometry	5	4	3	25	75	100
	A	CC-XI	22PCMAC3	Mathematical Statistics	5	4	3	25	75	100
	A	CEC-III	***	One from Elective-III Group	5	3	3	25	75	100
	A	CEC-IV	****	One from Elective-IV Group	5	3	3	25	75	100
	A	EDS-II	22PCMAD2	Applied Statistics	2	3	3	25	75	100
	B	SBE - III	22PCSBE3	Managerial Skills	2	2	3	25	75	100
	C	Intern-ship	22PCINT1	Internship	-	2	-	-	-	-
				Total	**30**	**25**				
IV	A	CC-XII	22PDMAC1	Complex Analysis	6	4	3	25	75	100
	A	CC-XIII	22PDMAC2	Optimization Techniques	6	4	3	25	75	100

Sem. No.	Part	Course	Subject code	Course Title	Ins. Hrs/Week	Credit	Exam Hrs	Marks		Total
								Int	Ext	
	A	CC-XIV	22PDMAC3	Functional Analysis	6	4	3	25	75	100
	A	CC-XV	22PDMAC4	Mechanics	5	4	3	25	75	100
	A	CEC-V	*****	One from Elective-V Group	5	3	3	25	75	100
	B	SBE - IV	22PDSBE4	Personality Development	2	2	3	25	75	100
				Total	**30**	**21**				
				Overall Total	**120**	**91**				

CORE ELECTIVE COURSES:

***Elective-I** (Any one subject of the following Core Elective chosen by the candidate)		****Elective-II** (Any one subject of the following Core Elective chosen by the candidate)	
Sub. Code	**Core Elective Courses**	**Sub. Code**	**Core Elective Courses**
22PAMAE1A	Difference Equations	22PBMAE2A	Numerical Analysis
22PAMAE1B	Resource Management Techniques	22PBMAE2B	Formal Languages and Automata Theory

*****Elective-III** (Any one subject of the following Core Elective chosen by the candidate)		******Elective-IV** (Any one subject of the following Core Elective chosen by the candidate)	
Sub. Code	**Core Elective Courses**	**Sub. Code**	**Core Elective Courses**
22PCMAE3A	Tensor Analysis and Theory of Relativity	22PCMAE4A	Stochastic Processes
22PCMAE3B	Wavelets	22PCMAE4B	Number Theory and Cryptography

*******Elective-V** (Any one subject of the following Core Elective chosen by the candidate)	
Sub. Code	**Core Elective Courses**
22PDMAE5A	Fluid Dynamics
22PDMAE5B	Fuzzy sets and their applications

SEMESTER - I

M.Sc. Degree Programme in MATHEMATICS

FIRST SEMESTER				
Course Title		**ABSTRACT ALGEBRA**		
Course Code		**22PAMAC1**		
Course No.	Course Category Core / Elective /Allied/NME/SSE	No. of Credits	No. of hours /week	Total marks (Int+Ext)
CC I	**Core**	**4**	**6**	**25 + 75=100**

Course objectives:

- To have an understanding of Sylow's theorem and its applications.
- To acquire knowledge of finite Abelian groups, direct products and learns structure theorem.
- To have an in-depth study of polynomial rings and extension fields.
- To get glimpse of Galois theory understands the concept of splitting fields, simple extensions and separable extensions.
- To explain Galois group, fundamental theorem and solvability by radicals.

UNIT I: Sylow's Theorem: **(18 hours)**

Another Counting Principle – 1st, 2nd and 3rd parts of Sylow's Theorems – double coset – the normalizer of a group.

UNIT II: Finite Abelian Groups: **(18 hours)**

External and Internal direct Products – structure theorem for finite Abelian groups – non isomorphic Abelian groups.

UNIT III: Polynomial Rings: **(18 hours)**

Polynomial rings – Polynomials over rational fields – the Eisenstein criterion - extension fields.

UNIT IV: Galois Theory: **(18 hours)**

Roots of polynomials – splitting fields, More about roots – simple extension – separable extension.

UNIT V: Solvability by radicals: **(18 hours)**

Fixed fields – symmetric rational functions – normal extension - Galois group – fundamental theorem of Galois theory, Solvable group – the commutator sub group – Solvability by radicals.

Contents and Treatments as in:

1. I.N. Herstein, Topics in Algebra, 2nd Edition, John Wiley and Sons, New York, 1975.

UNIT	Chapter(s)	Sections
I	2	2.11 & 2.12
II	2	2.13 & 2.14
III	3 & 5	3.9, 3.10, 5.1
IV	5	5.3 & 5.5
V	5 & 7	5.6, 5.7

Reference Books:

1. S. Lang, *"Algebra"*, 3rd Edition, Addison-Wesley, Mass, 1993.
2. John B. Fraleigh, *"A First Course in Abstract Algebra"*, Addison Wesley, Mass, 1982.
3. M. Artin, *"Algebra"*, Prentice-Hall of India, New Delhi, 1991.
4. V. K. Khanna and S.K. Bhambri, *"A Course in Abstract Algebra"*, Vikas Publishing House Pvt Limited, 1993.

Web Resources:

1. https://nptel.ac.in

METHODOLOGY OF TEACHING:

Class lectures, Group Discussion, Assignments, Seminars.

Course Outcomes (COs):

Upon completion of this course, the students will be able to

CO code	Course Outcomes	K-levels
CO1	Recall the fundamentals of Group theory, define conjugacy as an equivalence relation, Prove Cauchy's and Sylow's theorems and find the p-Sylow's subgroup of a given group.	**K1, K2, K3, K5**
CO2	Summarize various properties of the External and internal direct product of finite number of groups,define the invariants of a group,and explain the relation between isomorphic groups of prime order and their variants.	**K1, K2**
CO3	Define the degree of a polynomial and it's properties, explain the concept of principal ideal ring, and elaborate the connections between algebraic elements and finite extension.	**K1, K2, K6**
CO4	Prove the Remainder theorem, explain the splitting fields, demonstrate the concept of multiple roots, discuss simple extension of a field.	**K2, K3, K5, K6**
CO5	Understand the relation between normal extensions and the splitting field of some polynomial over F, analyze the fundamental theorem of Galois theory and solvability by radicalsand solve simple problems.	**K2, K4, K3, K4**

CO- PO Mapping (Course Articulation Matrix)

CO / PO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	2	3	1	1	2
CO2	3	2	3	1	1	2
CO3	3	2	3	1	1	2
CO4	3	3	3	1	1	2
CO5	3	3	3	1	1	2
Total	15	12	15	5	5	10
Average	3	2.4	3	1	1	2

BLOOM TAXANOMY BASED QUESTION PAPER PATTERN

PG Degree Pattern

Knowledge Level	Section	Marks	Description	Total Marks
K1, K2, K3, K4	A (Answer all the questions)	10 x 2	Short Answer (Two questions from each unit)	20
K1, K2, K3, K4,K5	B (**INTERNAL CHOICE**) EITHER (a) OR (b)	5 x 5	Question (a) OR (b) from the same Unit and same K Level	25
K2, K3, K4, K5, K6	C (Answer any threequestions from five questions)	3 x10	One question from each unit (No unit missing)	30
Grand Total				**75**

M.Sc. Degree Programme in MATHEMATICS

FIRST SEMESTER				
Course Title		**REAL ANALYSIS – I**		
Course Code		**22PAMAC2**		
Course No.	Course Category Core / Elective /Allied/NME/SSE	No. of Credits	No. of hours /week	Total marks (Int+Ext)
CC II	**Core**	**4**	**6**	**25 + 75=100**

Course objectives:

- To make students familiar with functions of bounded variation and Total variation.
- To have in depth study of Riemann-stieltjes integral.
- To study the Mean value theorem for Riemann and Riemann-stieltjes integral.
- To have understanding of Absolute and Conditional Convergence.
- To define and explain Uniform convergence and pointwise convergence.

UNIT-I: **Functions of bounded variation:** **(18 hours)**

Introduction - Properties of monotonic functions - Functions of bounded variation - Total variation - Additive property of total variation – Total variation on [a, x] as a function of x - Functions of bounded variation expressed as the difference of two increasing functions - Continuous functions of bounded variation.

Chapter – 6 : Sections 6.1 to 6.8

UNIT-II: The Riemann - Stieltjes Integral: **(18 hours)**

Introduction - Notation - The definition of the Riemann - Stieltjes integral - Linear Properties - Integration by parts- Change of variable in a Riemann - Stieltjes integral - Reduction to a Riemann Integral –Step functions as integrators-Reduction to a Riemann- Stieltjes Integral to a finite sum- Euler's summation formula.

Chapter - 7 : Sections 7.1 to 7.10

UNIT-III: The Riemann - Stieltjes Integral (Continued): **(18 hours)**

Monotonically increasing integrators, Upper and lower integrals - Additive and linearity properties of upper and lower integrals - Riemann's condition - Comparison theorems - Integrators of bounded variation-Sufficient conditions for the existence of Riemann-Stieltjes integrals-Necessary conditions for the existence of Riemann-Stieltjes integrals- Mean value theorems for Riemann - Stieltjes integrals.

Chapter - 7 : 7.11 to 7.18

UNIT-IV: Infinite Series & infinite products: **(18 hours)**

Absolute and conditional convergence - Dirichlet's test and Abel's test - Rearrangement of series - Riemann's theorem on conditionally convergent series.

Chapter - 8 Sec, 8.8, 8.15, 8.17,8.18.

UNIT-V: Sequences of Functions: **(18 hours)**

Pointwise convergence of sequences of functions - Examples of sequences of real - valued functions - Definition of uniform convergence - Uniform convergence and continuity - The Cauchy condition for uniform convergence - Uniform convergence of infinite series of functions - Uniform convergence and Riemann - Stieltjes integration – Uniform convergence and differentiation.

Chapter -9 Sec 9.1 to 9.6, 9.8, 9.10.

Contents and Treatment as in:

Tom M.Apostol: Mathematical Analysis, 2nd Edition, Narosa, 1989.

Reference Books:

1. Bartle R. G. *Real Analysis*, John Wiley and Sons Inc., 1976.
2. Rudin W. Principles of Mathematical Analysis, 3rd Edition. McGraw Hill Company, New York, 1976.
3. Malik,S.C. and Savita Arora. Mathematical Anslysis, Wiley Eastern Limited. New Delhi, 1991.
4. Sanjay Arora and Bansi Lal, *Introduction to Real Analysis*, Satya Prakashan, New Delhi, 1991.
5. Gelbaum, B.R. and J. Olmsted, *Counter Examples in Analysis*, Holden day, San Francisco, 1964.
6. A.L.Gupta and N.R.Gupta, Principles of Real Analysis, Pearson Education, (Indian print) 2003.

Web Resources:

1. https://nptel.ac.in/

METHODOLOGY OF TEACHING:

Classroom lectures, Tutorial class, Discussions, Assignments, Seminars.

Course Outcomes (COs):

Upon completion of this course, the students will be able to

CO code	Course Outcomes	K-levels
CO1	Recall monotonic functions, bounded functions and understand the concepts of total variation and its properties.	**K1, K2, K3**
CO2	Understand Riemann Stieltjes integrals, its properties.	**K1, K2, K3, K4**
CO3	Understanding the difference between necessary and sufficient condition for Riemann-Stieltjes integral.	**K1, K2, K4, K5**
CO4	Demonstrate and the understanding of Riemann's theorem on conditionally convergent series and Euler's product for Riemann-Zeta function.	**K1, K2, K3, K5**
CO5	Recognize the difference between Pointwise convergence and uniform convergence of sequence of functions and illustrate the effect of uniform convergence on the limit function with respect to continuity, differentiability and integrability.	**K1, K2, K4, K5**

CO- PO Mapping (Course Articulation Matrix)

CO / PO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	3	3	3	2	2
CO2	3	3	3	3	2	2
CO3	3	3	3	3	2	2
CO4	3	3	3	3	2	2
CO5	3	3	3	3	2	2
Total	15	15	15	15	10	10
Average	3	3	3	3	2	2

BLOOM TAXANOMY BASED QUESTION PAPER PATTERN

PG Degree Pattern

Knowledge Level	Section	Marks	Description	Total Marks
K1, K2, K3, K4	A (Answer all the questions)	10 x 2	Short Answer (Two questions from each unit)	20
K1, K2, K3, K4,K5	B (**INTERNAL CHOICE**) EITHER (a) OR (b)	5 x 5	Question (a) OR (b) from the same Unit and same K Level	25
K2, K3, K4, K5, K6	C (Answer any threequestions from five questions)	3 x10	One question from each unit (No unit missing)	30
Grand Total				**75**

M.Sc Degree Programme in MATHEMATICS

FIRST SEMESTER				
Course Title		**ORDINARY DIFFERENTIAL EQUATIONS**		
Course code		**22PAMAC3**		
Course No.	Course Category Core / Elective /Allied/NME/SSE	No. of Credits	No. of hrs /week	Total marks (Int+Ext)
CC III	**Core**	**4**	**6**	**25 + 75=100**

Course objectives:

- Able to classify ODE and understand Linear Dependence and Linear Independence of solutions.
- Understand Existence and Uniqueness theorems and solve simple problems.
- Learn various methods for solving linear equations with constant as well as variable coefficients and apply them to solve simple problems.
- Summarize condition for convergence and Lipschitz condition for convergence of successive approximations.
- Outline series solution method, interpret and analyze special functions such as Legendre and Bessel's functions.

UNIT-I: **Linear equations with constant coefficients: (18 hours)**

Second order homogeneous equations-Initial value problems-Linear dependence and independence-Wronskian and a formula for Wronskian.

Chapter 2: Sections 1 to 5

UNIT-II: **Linear equations with constant coefficients (Continued…): (18 hours)**

Homogeneous and non-homogeneous equation of order n –Initial value problems-Annihilator method to solve non-homogeneous equation.

Chapter 2: Sections 7 to 11.

UNIT-III: **Linear equation with variable coefficients: (18 hours)**

Initial value problems -Existence and uniqueness theorems – Solutions to solve a non homogeneous equation – Wronskian and linear dependence – reduction of the order of a homogeneous equation – homogeneous equation with analytic coefficients- The Legendre equation.

Chapter 3: Sections 1 to 8 (Omit section 9)

UNIT-IV: **Linear equation with regular singular points: (18 hours)**

Euler equation – Second order equations with regular singular points –Exceptional cases – Bessel‘s Function.

Chapter 4: Sections 1 to 4 and 6 to 8 (Omit sections 5 and 9)

UNIT-V: **Existence and uniqueness of solutions to first order equations: (18 hours)**

Equation with variables separated – Exact equation – method of successive approximations – the Lipschitz condition – convergence of the successive approximations and the existence theorem.

Chapter 5: Sections 1 to 6 (Omit Sections 7 to 9)

Contents and Treatment as in:

E.A.Coddington, An introduction to ordinary differential equations (3rd Printing) Prentice-Hall of India Ltd., New Delhi, 1987.

Reference Books:

1. Williams E. Boyce and Richard C. Di Prima, Elementary differential equations and boundary value problems, John Wiley and sons, New York, 1967.

2. George F Simmons, Differential equations with applications and historical notes, Tata McGraw Hill, New Delhi, 1974.
3. N.N. Lebedev, Special functions and their applications, Prentice Hall of India, New Delhi, 1965.
4. W.T.Reid. Ordinary Differential Equations, John Wiley and Sons, New York, 1971
5. M.D.Raisinghania, Advanced Differential Equations, S.Chand & Company Ltd. New Delhi 2001.
6. B.Rai, D.P.Choudhury and H.I. Freedman, A Course in Ordinary Differential Equations, Narosa Publishing House, New Delhi, 2002.

Web Resources:

1. https://nptel.ac.in

METHODOLOGY OF TEACHING:

Class lectures, Group Discussion, Assignments, Seminars.

Course Outcomes (COs):

Upon completion of this course, the students will be able to

CO code	Course Outcomes	K-levels
CO1	Recall and understand fundamentals, degree and order. Solve second order homogeneous equation, understand and illustrate Wronskian.	**K1, K2, K3, K4, K5**
CO2	Solve homogeneous equation of order n. Demonstrate solution methodologies such as Annihilator method to solve non-homogeneous equation.	**K1, K2, K3, K4, K5**
CO3	Explain regular singular points, power series solution method to solve Legendre equation.	**K1, K2, K4, K5**
CO4	Explain the nature of singular points. Discuss solutions to Euler equation and Bessel's equation.	**K1, K2, K5, K6**
CO5	Analyze existence and uniqueness of solutions, in particular Lipschitz condition. Evaluate successive approximations and solve Exact equation.	**K1, K3, K4, K5, K6**

CO- PO Mapping (Course Articulation Matrix)

CO / PO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	3	2	2	1	1
CO2	3	3	2	2	1	1
CO3	3	3	2	2	1	1
CO4	3	3	2	2	1	1
CO5	3	3	2	2	1	1
Total	15	15	10	10	5	5
Average	3	3	2	2	1	1

BLOOM TAXANOMY BASED QUESTION PAPER PATTERN

PG pattern

Knowledge Level	Section	Marks	Description	Total Marks
K1, K2, K3, K4	A (Answer all the questions)	10 x 2	Short Answer (Two questions from each unit)	20
K1, K2, K3, K4,K5	B (**INTERNAL CHOICE**) EITHER (a) OR (b)	5 x 5	Question (a) OR (b) from the same Unit and same K Level	25
K2, K3, K4, K5, K6	C (Answer any threequestions from five questions)	3 x10	One question from each unit (No unit missing)	30
Grand Total				**75**

M.Sc. Degree Programme in MATHEMATICS

FIRST SEMESTER				
Course Title		**GRAPH THEORY**		
Course Code		**22PAMAC4**		
Course No.	Course Category Core / Elective /Allied/NME/SSE	No. of Credits	No. of hours /week	Total marks (Int+Ext)
CC IV	**Core**	**4**	**5**	**25 + 75=100**

Course objectives:

- To achieve the command of fundamental definitions and concepts of graph theory.
- To understand connectivity, Eulerian and Hamiltonian graphs.
- To familiarize matching and edge colorings.
- To describe coloring and planarity in graphs.

UNIT-I: Graphs, subgraphs and Trees: (15 hours)

Graphs and simple graphs – Graph Isomorphism – The Incidence and Adjacency Matrices – Subgraphs – Vertex Degrees – Paths and Connection – Cycles – Trees – Cut Edges and Bonds – Cut Vertices.
Chapter 1 (Section 1.1 – 1.7)
Chapter 2 (Section 2.1 – 2.3)

UNIT-II: Connectivity, Euler tours and Hamilton Cycles: (15 hours)

Connectivity – Blocks – Euler tours – Hamilton Cycles.
Chapter 3 (Section 3.1 – 3.2)
Chapter 4 (Section 4.1 – 4.2)

UNIT-III: Matchings, Edge Colourings: (15 hours)

Matchings – Matchings and Coverings in Bipartite Graphs – Edge Chromatic Number – Vizing's Theorem.
Chapter 5 (Section 5.1 – 5.2)
Chapter 6 (Section 6.1 – 6.2)

UNIT-IV: Independent sets and Cliques, Vertex Colourings: (15 hours)

Independent sets – Chromatic Number – Brooks' Theorem – Chromatic Polynomials.
Chapter 7 (Section 7.1)
Chapter 8 (Section 8.1, 8.2, 8.4)

UNIT-V: Planar graphs: (15 hours)

Plane and planar Graphs – Dual graphs – Euler's Formula – The Five- Colour Theorem and the Four-Colour Conjecture (omit Theorem 9.12).
Chapter 9 (Section 9.1 – 9.3, 9.6)

Contents and Treatment as in:

1. J.A.Bondy and U.S.R. Murty , Graph Theory and Applications , Macmillan, London, 1976.

Reference Books:

1. J.Clark and D.A.Holton, A First look at Graph Theory, Allied Publishers, New Delhi, 1995.
2. R. Gould. Graph Theory, Benjamin/Cummings, Menlo Park, 1989.
3. A.Gibbons, Algorithmic Graph Theory, Cambridge University Press, Cambridge, 1989.
4. R.J.Wilson and J.J.Watkins, Graphs: An Introductory Approach, John Wiley and Sons, New York, 1989.

5. R.J. Wilson, Introduction to Graph Theory, Pearson Education, 4th Edition, 2004, Indian Print.
6. 6. S.A.Choudum, A First Course in Graph Theory, MacMillan India Ltd. 1987.

Web Resources:

1. https://nptel.ac.in/
2. https://mathworld.wolfram.com/

METHODOLOGY OF TEACHING:

Classroom lectures, Tutorial class, Discussions, Assignments, Seminars.

Course Outcomes (COs):

Upon completion of this course, the students will be able to

CO code	Course Outcomes	K-levels
CO1	Analyze the types of graphs, represent them in matrix form and explain paths and connections.	**K1, K2, K4**
CO2	Determine the connectivity of graphs, prove theorems related to connectivity, understand Eulerian and Hamiltonian graphs.	**K1, K2, K3, K5**
CO3	Define matchings and edge colourings, applying these concepts in some real life situations.	**K1, K3, K4, K6**
CO4	Discuss vertex coloring and find chromatic polynomials for graphs.	**K2, K5, K6**
CO5	Illustrate the concept of planarity and to solve problems that can be modeled by graphs.	**K2, K4, K6**

CO- PO Mapping (Course Articulation Matrix)

CO / PO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	3	2	1	1	2
CO2	3	3	2	1	1	2
CO3	3	3	2	1	1	2
CO4	3	3	2	1	1	2
CO5	3	3	2	1	1	2
Total	15	15	10	5	5	10
Average	3	3	2	1	1	2

BLOOM TAXANOMY BASED QUESTION PAPER PATTERN

PG Degree Pattern

Knowledge Level	Section	Marks	Description	Total Marks
K1, K2, K3, K4	A (Answer all the questions)	10 x 2	Short Answer (Two questions from each unit)	20
K1, K2, K3, K4,K5	B (**INTERNAL CHOICE**) EITHER (a) OR (b)	5 x 5	Question (a) OR (b) from the same Unit and same K Level	25
K2, K3, K4, K5, K6	C (Answer any threequestions from five questions)	3 x10	One question from each unit (No unit missing)	30
Grand Total				**75**

M.Sc. Degree Programme in MATHEMATICS

FIRST SEMESTER				
Course Title		**DIFFERENCE EQUATIONS**		
Course Code		**22PAMAE1A**		
Course No.	Course Category Core / Elective /	No. of Credits	No. of hours /week	Total marks (Int+Ext)
CEC I	**Elective**	**3**	**5**	**25 + 75=100**

Course objectives:

- Could understand foundations for the study of Difference Equations
- Could summarize solution methodologies for linear equations with constant coefficients and utilize them to solve some simple equations.
- Learn solution methodologies for some special types of linear equation with variable coefficients and solve related equations.
- Understand Z- transforms and apply them to solve difference equations and summation equations
- Understand theorems on linear systems. Learn Putzer algorithm.

Unit-I: Difference Calculus: **(15 hours)**

Difference operator-Summation-Generating Functions and approximate summation.
Chapter 2: 2.1-2.3

Unit-II: Linear Difference Equations: **(15 hours)**

First order equations – General Results for Linear Equations-solving Linear equations.
Chapter 3: 3.1to 3.3

Unit-III: Linear Difference Equations (Continued...): **(15 hours)**

Equations with variable coefficients – Nonlinear Equations that can be Linearized.
Chapter 3: 3.5 and 3.6

Unit – IV: Z transforms: **(15 hours)**

Linear Difference Equations: Z transforms.
Chapter 3: 3.7

Unit-V: Stability Theory: **(15 hours)**

Initial value problems for linear systems – Stability of linear systems.
Chapter 4: 4.1 and 4.2

Text Book:

1. W.G.Kelley and A.C.Peterson: Difference equations, An introduction with applications, Second Editions Academic Press, New York, 2001.

Reference Books:

1. S.N.Elaydi, An introduction to Difference Equations, Springer Verlag, New York, 1996.
2. S.Goldberg, Introduction to Difference Equations, Dover Publications, 1986.
3. R.P.Agarwal, Difference Equations and Inequalities, Mercel Dekker, New York, 2000.

Web Resources:

1. https://nptel.ac.in/

METHODOLOGY OF TEACHING:

Class lectures, Group Discussion, Assignments, Seminars.

COURSE OUTCOMES (COs):

Upon completion of this course, the students will be able to:

CO code	Course Outcomes	K - Levels
CO1	Recall Difference operator, list their properties, understand summation and their properties and apply them to solve some summation problems.	K1,K2,K3,K4
CO2	Summarize and analyze solution methodologies for linear equations with constant coefficients such as annihilator method, variation of parameters and utilize them to solve some simple equations.	K2,K3,K4
CO3	Demonstrate solution methodologies for some special types of linear equation with variable coefficients and solve related equations.	K2,K3,K4
CO4	Recall transformation techniques, Understand Z- transforms and list their properties, find Z- transforms of some simple functions and apply them to solve difference equations and summation equations.	K1,K2,K3
CO5	Understand theorems on linear systems, explain Putzer algorithm and apply it to solve systems and analyze theorems on stability.	K1,K2,K3,K4

CO- PO Mapping (Course Articulation Matrix)

CO / PO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	2	2	1	1	2
CO2	3	2	2	1	1	2
CO3	3	2	2	1	1	2
CO4	3	2	2	1	1	2
CO5	3	2	2	1	1	2
Total	15	10	10	5	5	10
Average	3	2	2	1	1	2

BLOOM TAXANOMY BASED QUESTION PAPER PATTERN
PG Degree Pattern

Knowledge Level	Section	Marks	Description	Total Marks
K1, K2, K3, K4	A (Answer all the questions)	10 x 2	Short Answer (Two questions from each unit)	20
K1, K2, K3, K4,K5	B (**INTERNAL CHOICE**) EITHER (a) OR (b)	5 x 5	Question (a) OR (b) from the same Unit and same K Level	25
K2, K3, K4, K5, K6	C (Answer any threequestions from five questions)	3 x10	One question from each unit (No unit missing)	30
Grand Total				**75**

M.Sc. Degree Programme in MATHEMATICS

FIRST SEMESTER				
Course Title		**RESOURCE MANAGEMENT TECHNIQUES**		
Course Code		**22PAMAE1B**		
Course No.	Course Category Core / Elective /	No. of Credits	No. of hours /week	Total marks (Int+Ext)
CEC I	**Elective**	**3**	**5**	**25 + 75=100**

Course objectives:

- To simulate the real-life complicated problems using Monte-Carlo technique.
- To classify and analyze the decision-making environments and to determine optimal solutions.
- To find the economic order quantity for some deterministic inventory models.
- To determine the optimal order size for some stochastic inventory models and able to classify the items in the inventory.
- To build a mathematical model for some queueing systems and to find its performance measures.

UNIT-I: Simulation: (15 hours)

Introduction – Types of Simulation – Use of simulation – Limitations of simulation – Phases of Simulation model – Event type simulation – Monte-Carlo simulation – Applications to inventory problems and queueing problems – Scope of simulation.
Chapter: 21

UNIT-II: Decision Analysis: (15 hours)

Introduction - Types of decisions - Decision-Making Environments –Decision Making under Uncertainty – Decision Making under Risk – Decision Tree Analysis.
Chapter: 22

UNIT-III: Deterministic Inventory Models: (15 hours)

Introduction – Classification of Inventory Models - Inventory Models without shortages: Model I(a) and I(c) – Inventory models with Shortages: Model II(a) and II(c).Deterministic models with Price Breaks – Purchase inventory model: with one price break, with two price breaks and with any number of price breaks.
Chapter: 25

UNIT-IV: Stochastic Inventory Models: (15 hours)

Introduction - Instantaneous stochastic Demand without Setup cost: Model VI(a) and VI(b) – Uniform Demand, No Setup cost Model: Model VII(a), VII(b).
Selective Inventory Management: ABC analysis.
Chapter: 26

UNIT-V: Queueing Theory: (15 hours)

Introduction - Essential Features of Queueing System – Performance measures of Queuing System – Probability Distributions in Queuing Systems – Classification of Queuing Models – The following models only: Model I, III, IV(a), IV(b).
Chapter: 28

Contents and Treatments as in:

1. S.D. Sharma, "Operations Research" 17th Edition, Kedar Nath Ram Nath Publisher, Meerut, 2014.

Reference Books:

1. Hamdy A. Taha, *Operations Research*, (seventh edition) Prentice – Hall of India Private Limited, New Delhi, 1997.

2. F.S. Hiller and J.Lieberman -, Introduction to Operations Research (7th Edition), Tata McGraw Hill Publishing Company, New Delhi, 2001.
3. Beightler. C, D. Phillips, B. Wilde, Foundations of Optimization (2nd Edition) Prentice Hall Pvt Ltd., New York, 1979
4. Bazaraa, M.S; J.J.Jarvis, H.D.Sharall , Linear Programming and Network flow, John Wiley and sons, New York 1990.
5. Gross, D and C.M.Harris, Fundamentals of Queueing Theory, (3rd Edition), Wiley and Sons, New York, 1998.

Web Resources:

1. https://nptel.ac.in/
2. https://www.wolframalpha.com/widgets/view.jsp?id=daa12bbf5e4daec7b363737d6d496120
3. https://mathworld.wolfram.com/

METHODOLOGY OF TEACHING:

Classroom lectures, Tutorial class, Discussions, Assignments, Seminars, Flipped classroom.

Course Outcomes (COs):

Upon completion of this course, the students will be able to

CO code	Course Outcomes	K-levels
CO1	Simulate inventory problems and queueing problems using Monte-Carlo simulation.	**K1, K2, K3, K4, K5, K6**
CO2	Solve the decision-making problems under uncertainty and decision-making problems under risk.	**K1, K2, K3, K4, K5, K6**
CO3	Classify and build a mathematical model to some deterministic inventory problems with and without shortages and determine an optimal order quantity for them.	**K1, K2, K3, K4, K5, K6**
CO4	Construct a mathematical model and find an optimal solution to some stochastic inventory problems in real-life and also classify the items in the inventory using ABC analysis.	**K1, K2, K3, K4, K5, K6**
CO5	Develop a mathematical model for some real-life queueing problems and analyze them by finding its performance measures.	**K1, K2, K3, K4, K5, K6**

CO- PO Mapping (Course Articulation Matrix)

CO / PO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	3	3	2	1	3
CO2	3	3	3	2	1	2
CO3	3	3	3	2	1	2
CO4	3	3	3	2	1	2
CO5	3	3	3	2	1	2
Total	15	15	15	10	5	11
Average	3	3	3	2	1	2.2

BLOOM TAXANOMY BASED QUESTION PAPER PATTERN

PG Degree Pattern

Knowledge Level	Section	Marks	Description	Total Marks
K1, K2, K3, K4	A (Answer all the questions)	10 x 2	Short Answer (Two questions from each unit)	20
K1, K2, K3, K4,K5	B (**INTERNAL CHOICE**) EITHER (a) OR (b)	5 x 5	Question (a) OR (b) from the same Unit and same K Level	25
K2, K3, K4, K5, K6	C (Answer any three questions from five questions)	3 x10	One question from each unit (No unit missing)	30
Grand Total				**75**

SEMESTER - II

M.Sc Degree Programme in MATHEMATICS

SECOND SEMESTER				
Course Title		**LINEAR ALGEBRA**		
Course Code		**22PBMAC1**		
Course No.	Course Category Core / Elective /Allied/NME/SSE	No. of Credits	No. of hours /week	Total marks (Int+Ext)
CC V	**Core**	**4**	**6**	**25 + 75=100**

Course objectives:

- To know the basis about linear transformation, their Algebra, their representation by Matrices and other related item.
- To study about the algebra of polynomials, ideals in that algebra and the prime factorization of a polynomial.
- To develop determinants of square matrices in terms of alternating n-linear functions.
- To study about the characteristic values and diagonalizable transformation.
- To study about the cyclic decomposition of a finite-dimensional vector space and to discuss about the various rational forms of a matrix.

UNIT I: Linear transformations: (18 hours)

Linear transformations – Isomorphism of vector spaces – Representations of linear transformations by matrices – Linear functionals.

UNIT II: Algebra of polynomials: (18 hours)

The algebra of polynomials –Polynomial ideals - The prime factorization of a polynomial - Determinant functions.

UNIT III: Determinants: (18 hours)

Permutations and the uniqueness of determinants – Classical adjoint of a (square) matrix –Inverse of an invertible matrix using determinants – Characteristic values – Annihilating polynomials.

UNIT IV: Diagonalization: (18 hours)

Invariant subspaces – Simultaneous triangulations – Simultaneous diagonalization – Direct-sum decompositions – Invariant direct sums – Primary decomposition theorem.

UNIT V: The Rational and Jordan forms: (18 hours)

Cyclic subspaces – Cyclic decompositions theorem (Statement only) – Generalized Cayley – Hamilton theorem - Rational forms – Jordan forms.

Text Book:

1. Kenneth M Hoffman and Ray Kunze, Linear Algebra, 2nd Edition, Prentice-Hall of India Pvt. Ltd, New Delhi, 2013.

UNIT	Chapter(s)	Sections
I	3	3.1 – 3.5
II	4 & 5	4.1, 4.2, 4.4, 4.5 and 5.1, 5.2
III	5 & 6	5.3, 5.4 and 6.1 – 6.3
IV	6	6.4 – 6.8
V	7	7.1– 7.3

REFERENCE BOOKS:

1. M. Artin, *"Algebra"*, Prentice Hall of India Pvt. Ltd., 2005.

2. S.H. Friedberg, A.J. Insel and L.E Spence, "*Linear Algebra*", 4th Edition, Prentice-Hall of India Pvt. Ltd., 2009.
3. I.N. Herstein, "*Topics in Algebra*", 2nd Edition, Wiley Eastern Ltd, New Delhi, 2013.
4. J.J. Rotman, "*Advanced Modern Algebra*", 2nd Edition, Graduate Studiesin Mathematics, Vol. 114, AMS, Providence, Rhode Island, 2010.
5. G. Strang, "*Introduction to Linear Algebra*", 2nd Edition, Prentice Hall of India Pvt. Ltd, 2013.

Web Resources:

1. https://nptel.ac.in

METHODOLOGY OF TEACHING:

Class lectures, Group Discussion, Assignments, Seminars.

Course Outcomes (COs):

Upon completion of this course, the students will be able to

CO code	Course Outcomes	K-levels
CO1	Define linear transformation and its properties,explain Invertible and Non -singular transformation, discuss linear functional.	**K1, K2, K3,K4**
CO2	Understand the algebra of polynomials and its ideals,define determinant functions	**K1, K2, K3,K5**
CO3	summarize the additional properties of determinants,understands permutations and the uniqueness of determinants,explain annihilating polynomials.	**K1, K2, K3**
CO4	Define Invariant subspaces, discuss simultaneous diagonalization, prove the primary decomposition theorem.	**K1, K2, K3,K6**
CO5	understand the concept of cyclic subspaces and cyclic vectorsprove the cyclic decomposition theorem and the generalized Cayley-Hamilton theorem,discuss the Jordan Canonical forms.	**K1, K2,K5,K6**

CO- PO Mapping (Course Articulation Matrix)

CO / PO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	3	3	1	1	2
CO2	3	3	3	1	1	2
CO3	3	3	3	1	1	2
CO4	3	2	3	1	1	2
CO5	3	2	3	1	1	2
Total	15	13	15	5	5	10
Average	3	2.6	3	1	1	2

BLOOM TAXANOMY BASED QUESTION PAPER PATTERN

PG Degree Pattern

Knowledge Level	Section	Marks	Description	Total Marks
K1, K2, K3, K4	A (Answer all the questions)	10 x 2	Short Answer (Two questions from each unit)	20
K1, K2, K3, K4,K5	B (**INTERNAL CHOICE**) EITHER (a) OR (b)	5 x 5	Question (a) OR (b) from the same Unit and same K Level	25
K2, K3, K4, K5, K6	C (Answer any threequestions from five questions)	3 x10	One question from each unit (No unit missing)	30
Grand Total				**75**

M.Sc. Degree Programme in MATHEMATICS

SECOND SEMESTER				
Course Title		**REAL ANALYSIS – II**		
Course Code		**22PBMAC2**		
Course No.	Course Category Core / Elective /Allied/NME/SSE	No. of Credits	No. of hours /week	Total marks (Int+Ext)
CC VI	**Core**	**4**	**5**	**25 + 75=100**

Course objectives:

- To gain knowledge of Measurable sets and Measurable functions.
- To learn the basic concepts of integration of non-negative functions.
- To learn the basic concepts of multi-variable differential calculus.

UNIT I:Measure on the Real line: (15 hours)

Lebesgue Outer Measure - Measurable sets - Measurable Functions.
Chapter - 2 Sec 2.1, 2.2, 2.4 of de Barra.

UNIT II: Integration of Functions of a Real variable: (15 hours)

Integration of Non- negative functions - The General Integral - Riemann and Lebesgue Integrals.
Chapter - 3 Sec 3.1,3.2 and 3.4 of de Barra

UNIT III:Fourier Series and Fourier Integrals: (15 hours)

Introduction - Orthogonal system of functions - The theorem on best approximation - The Fourier series of a function relative to an orthonormal system - Properties of Fourier Coefficients - The Riesz-Fischer Theorem.
Chapter 11 : Sections 11.1 to 11.6 of Apostol.

UNIT IV:Multivariable Differential Calculus: (15 hours)

Introduction - The Directional derivative - Directional derivative and continuity - The total derivative - The total derivative expressed in terms of partial derivatives - The matrix of linear function - The Jacobian matrix – The chain rule - The mean - value theorem for differentiable functions - A sufficient condition for differentiability.
Chapter 12 : Section 12.1 to 12.13 (omit 12.6, 12.10, 12.12) of Apostol.

UNIT V:Implicit Functions and Extremum Problems: (15 hours)

Functions with non-zero Jacobian determinants – The inverse function theorem-The Implicit function theorem.
(Sections 13.1 ,13.2)

Contents and Treatments as in:

1. G. de Barra, *Measure Theory and Integration*, New Age International, 2003. (for Units I and II)
2. Tom M.Apostol : *Mathematical Analysis*, 2nd Edition, Narosa Publications, 1989. (for Units III, IV and V)

Reference Books:

1. Burkill,J.C. *The Lebesgue Integral*, Cambridge University Press, 1951.
2. Munroe, M.E. *Measure and Integration*. Addison-Wesley, Mass.1971.
3. Royden, H.L. *Real Analysis*, Macmillan Pub. Company, New York, 1988.
4. Rudin, W. *Principles of Mathematical Analysis*, McGraw Hill Company, New York,1979.

5. Malik, S.C. and Savita Arora. *Mathematical Analysis,* Wiley Eastern Limited. New Delhi, 1991.

Web Resources

1. https://nptel.ac.in/courses/111106053
2. https://nptel.ac.in/courses/111108135
3. https://ocw.mit.edu/courses/18-02sc-multivariable-calculus-fall-2010/

METHODOLOGY OF TEACHING

Class lectures, Group Discussion, Assignments, Field-based learning.

Course Outcomes (COs):

Upon completion of this course, the students will be able to

CO code	Course Outcomes	K-levels
CO1	Explain the basic knowledge measurable sets and measurable.	K2, K3
CO2	Know how to classify the Riemann and Lebesgue Integral.	K1, K2, K3, K5
CO3	Demonstrate the concepts of orthogonal, orthonormal system of functions and its applications.	K2, K4
CO4	Understand the concept of directional derivative, continuity and total derivative; using these concepts they gain knowledge about mean value theorem and chain rule for multi-variable functions.	K1, K3, K4
CO5	Discuss and prove the inverse function theorem, implicit function theorem.	K6

CO- PO Mapping (Course Articulation Matrix)

CO / PO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	3	2	3	1	2
CO2	3	3	1	2	1	1
CO3	3	2	2	2	1	1
CO4	3	3	3	3	1	2
CO5	3	2	2	1	1	1
Total	15	13	10	11	5	7
Average	3	2.6	2	2.2	1	1.4

BLOOM TAXANOMY BASED QUESTION PAPER PATTERN
PG Degree Pattern

Knowledge Level	Section	Marks	Description	Total Marks
K1, K2, K3, K4	A (Answer all the questions)	10 x 2	Short Answer (Two questions from each unit)	20
K1, K2, K3, K4,K5	B (**INTERNAL CHOICE**) EITHER (a) OR (b)	5 x 5	Question (a) OR (b) from the same Unit and same K Level	25
K2, K3, K4, K5, K6	C (Answer any threequestions from five questions)	3 x10	One question from each unit (No unit missing)	30
Grand Total				**75**

M.Sc. Degree Programme in MATHEMATICS

SECOND SEMESTER				
Course Title		**PARTIAL DIFFERENTIAL EQUATIONS**		
Course Code		**22PBMAC3**		
Course No.	Course Category Core / Elective /	No. of Credits	No. of hours /week	Total marks (Int+Ext)
CC VII	**Core**	**4**	**5**	**25 + 75=100**

Course objectives:

- To provide a clear understanding of the concepts of PDE, its solution and the reduction to canonical form.
- To introduce three main types of PDEs (Parabolic, Elliptic, Hyperbolic) and to find the solution.
- To apply Laplace and Fourier transform techniques to find the solution of PDE.

UNIT-I: Partial Differential Equations of First Order: **(15 hours)**

Formation and solution of PDE – Integral surfaces – Cauchy Problem for first order equations- Orthogonal surfaces – Compatible system.

Fundamental concepts : Classification and canonical forms of PDE.

Chapter 0: 0.4 to 0.8, 0.10 (omit 0.1,0.2.0.3, 0.9 and 0.11) and Chapter 1: 1.1 to 1.3

UNIT-II: Elliptic Differential Equations: **(15 hours)**

Derivation of Laplace and Poisson equation – BVP – Separation of Variables – Dirichlet's Problem and Neumann Problem for a rectangle – Interior and Exterior Dirichlet's problems for a circle – Interior Neumann problem for a circle – Solution of Laplace equation in Cylindrical and spherical coordinates (Derivations only, omit problems).

Chapter 2: 2.1, 2 2 ,2.5 to 2.12 (omit 2.3, 2.4 and 2.13)

UNIT-III: Parabolic Differential Equations: **(15 hours)**

Occurrence of Diffusion Equation - Boundary conditions - Elementary solution of the diffusion equation - Dirac Delta function - Separation of variables method – Solution of Diffusion Equation in Cylindrical and spherical coordinates (Derivations only, omit problems).

Chapter 3: 3.1 to 3.7

UNIT-IV: Hyperbolic Differential equations: **(15 hours)**

Occurrence of the wave equation - solution of one-dimensional wave equation by canonical reduction – IVP- D'Alembert's solution – Vibrating string – Periodic solution of one-dimensional wave equation in cylindrical and spherical coordinate systems – Uniqueness of the solution for the wave equation.

Chapter 4: 4.1 to 4.11(omit 4.6, 4.7, 4.10)

UNIT-V: Solving PDE using Laplace and Fourier Transforms: **(15 hours)**

Laplace Transform method: Solution of Diffusion and Wave equation by Laplace Transform. Fourier Transform Method: Finite Fourier sine and cosine transforms – solutions of Diffusion, Wave and Lapalce equations by Fourier Transform Method.

Chapter 6: 6.13.1 and 6.13.2 only (omit (6.14) Chapter 7: 7.10 to 7.13 (omit 7.14)

Contents and Treatment as in:

1. K. Sankara Rao, *Introduction to Partial Differential Equations*, 2nd Edition, Prentice Hall of India, New Delhi. 2005

Reference Books:

1. R.C. McOwen, *Partial Differential Equations*, 2nd Edn. Pearson Education, New Delhi, 2005.

2. I.N. Sneddon, *Elements of Partial Differential Equations,* McGraw Hill, New Delhi, 1983.
3. R. Dennemeyer, *Introduction to Partial Differential Equations and Boundary Value Problems,* McGraw Hill, New York, 1968.
4. M.D. Raisinghania, *Advanced Differential Equations,* S. Chand & Company Ltd., New Delhi, 2001.

Web Resources:

1. https://nptel.ac.in/
2. https://mathworld.wolfram.com/

METHODOLOGY OF TEACHING:

Classroom lectures, Tutorial class, Discussions, Assignments, Seminars.

Course Outcomes (COs):

Upon completion of this course, the students will be able to

CO code	Course Outcomes	K-levels
CO1	Develop skills in the formulation and solution of I order PDE, classify the PDE and reduce them into canonical form.	K1, K3,K4,K6
CO2	Elaborate Laplace and Poisson equation, solve the three kinds of BVP (Dirichlet, Neumann and mixed).	K2,K3,K6
CO3	Discuss the solution of BVP describing diffusion equation in various coordinate systems using variables separable method.	K1, K3,K6
CO4	Provide a detailed study of wave equation representing the hyperbolic PDE, present problems like vibrating string and periodic solutions of wave equation.	K2,K5,K6
CO5	Learn and understand the solution of PDE using transformation techniques (Laplace and Fourier).	K1,K2,K3,K6

CO- PO Mapping (Course Articulation Matrix)

CO / PO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	3	2	1	1	2
CO2	3	3	2	1	1	2
CO3	3	3	2	1	1	2
CO4	3	3	2	1	1	2
CO5	3	3	2	1	1	2
Total	15	15	10	5	5	10
Average	3	3	2	1	1	2

BLOOM TAXANOMY BASED QUESTION PAPER PATTERN

PG Degree Pattern

Knowledge Level	Section	Marks	Description	Total Marks
K1, K2, K3, K4	A (Answer all the questions)	10 x 2	Short Answer (Two questions from each unit)	20
K1, K2, K3, K4,K5	B (**INTERNAL CHOICE**) EITHER (a) OR (b)	5 x 5	Question (a) OR (b) from the same Unit and same K Level	25
K2, K3, K4, K5, K6	C (Answer any three questions from five questions)	3 x10	One question from each unit (No unit missing)	30
Grand Total				**75**

M.Sc. Degree Programme in MATHEMATICS

SECOND SEMESTER				
Course Title		**TOPOLOGY**		
Course course		**22PBMAC4**		
Course No.	Course Category Core / Elective /	No. of Credits	No. of hours /week	Total marks (Int+Ext)
CC VIII	**Core**	**4**	**5**	**25 + 75=100**

Course objectives:

- To introduce the concept of topology.
- To differentiate box topology from the product topology.
- To understand the concepts of connectedness and compactness of a subset of a topological space.
- To acquire the knowledge of Urysohn lemma and Urysohn Metrization theorem
- To analyze the compactification of topological spaces

Unit-I: Types of Topological spaces: (15 hours)

Types of Topological spaces and examples- Basis for a Topology- The order topology- The product Topology on X×Y- The subspace Topology- Closed sets and limit points.

Chapter 2: Sections 12 to 17.

Unit-II: Continuous functions: (15 hours)

Continuous functions- The product Topology- The Metric Topology- sequence lemma- Uniform limit theorem.

Chapter 2: Sections 18 to 21.

Unit-III: Connected spaces: (15 hours)

Connected spaces- connected subspaces of the Real line- components and local connectedness.

Chapter 3: Sections 23 to 25.

Unit –IV: Compact spaces: (15 hours)

Compact spaces – compact subspaces of the Real line- limit point compactness.

Chapter 3: Sections 26 to 28.

Unit-V: Axioms: (15 hours)

The countability axioms- The Separation axioms- Normal spaces- The Urysohn Lemma.

Chapter 4: Sections 30 to 33

Contents and Treatment as in:

1. James R. Munkres, Topology – second edition Prentice Hall of India, New Delhi, 2011.

Reference Books:

1. Introduction to Topology and Modern Analysis by George F. Simmons, International Student Edition.
2. J. Dugundhi, Topology, Prentice Hall of India, New Delhi, 1975.
3. J.L. Kelly, General Topology, Van Nostrand, Reinhold Co., New York.

Web Resources:

1. https://nptel.ac.in/

METHODOLOGY OF TEACHING:

Classroom lectures, Tutorial class, Discussions, Assignments, Seminars.

Course Outcomes (COs):

Upon completion of this course, the students will be able to

CO code	Course Outcomes	K-levels
CO1	Analyze basis and different types of topological space.	**K1, K2, K3, K4**
CO2	Compute limit points of a subset of a topological space.	**K2, K3, K4**
CO3	Apply the countability and separation axioms.	**K2, K3, K4**
CO4	Explain Metrization of spaces.	**K2, K3, K4**
CO5	Provide information on compactifying of topological spaces.	**K2, K3, K4**

CO- PO Mapping (Course Articulation Matrix)

CO / PO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	3	3	1	1	2
CO2	3	3	3	1	1	2
CO3	3	3	3	1	1	2
CO4	3	3	3	1	1	2
CO5	3	3	3	1	1	2
Total	15	15	15	5	5	10
Average	3	3	3	1	1	2

BLOOM TAXANOMY BASED QUESTION PAPER PATTERN

PG Degree Pattern

Knowledge Level	Section	Marks	Description	Total Marks
K1, K2, K3, K4	A (Answer all the questions)	10 x 2	Short Answer (Two questions from each unit)	20
K1, K2, K3, K4,K5	B (**INTERNAL CHOICE**) EITHER (a) OR (b)	5 x 5	Question (a) OR (b) from the same Unit and same K Level	25
K2, K3, K4, K5, K6	C (Answer any threequestions from five questions)	3 x10	One question from each unit (No unit missing)	30
Grand Total				**75**

M.Sc. Degree Programme in MATHEMATICS

SECOND SEMESTER				
Course Title		**NUMERICAL ANALYSIS**		
Course Code		**22PBMAE2A**		
Course No.	Course Category Core / Elective /	No. of Credits	No. of hours /week	Total marks (Int+Ext)
CEC II	**Elective**	**3**	**5**	**25 + 75=100**

Course objectives:

- To analyze the basic techniques for the efficient numerical solution of problems in science and Engineering.
- To create, analyze and solve numerically the problems of continuous mathematics in the are of mathematics and computer science.
- To concern all aspects of the numerical solution of a problem, from the theoretical development and understanding of numerical methods to the practical implementation as reliable and efficient computer programs.

Unit I: Solution to linear and non-linear equations: **(15 hours)**

The solution of nonlinear equations f(x)=0 - The solution of linear system AX = B.
Chapter 2: sec 2.1 to 2.4, and 2.6,2.7 (omit 2.5)
Chapter 3: sec 3.3 to 3.7

Unit II: Interpolation: **(15 hours)**

Interpolation and polynomial approximation - Curve fitting.
Chapter 4: sec 4.1 to 4.4
Chapter 5: sec 5.1 to 5.2

Unit III: Numerical differentiation and integration: **(15 hours)**

Numerical differentiation - Numerical integration.
Chapter 6: sec 6.1, 6.2
Chapter 7: sec 7.1 to 7.2

Unit IV: Numerical Solution to ODE: **(15 hours)**

Solution of ordinary differential equations
Chapter 9: sec 9.1 to 9.6

Unit V: Numerical Solution to PDE: **(15 hours)**

Solution of partial differential equations
Chapter 10: sec 10.1 to 10.3

Content and treatment as in:

1. *Numerical Methods for Mathematics, Science and Engineering* – John H.Mathews, 2nd edition, Prentice Hall, New Delhi, 2003

Reference Books:

1. Conte S.D and Carl de Boor (1980)- *Elementary Numerical Analysis, An AlgorithmicApproach*,Mc.Graw Hill, New York.
2. James B. Scarborough- *Numerical Mathematical Analysis*, Sixth Edition, Oxford &IBHPublishing Co. Pvt. Ltd., New Delhi.
3. Devi Prasad, *Numerical Analysis*, Narosa Publications.

Web Resources:

1. https://nptel.ac.in/
2. https://ocw.mit.edu/
3. https://web.njit.edu/

METHODOLOGY OF TEACHING:

Class lectures, Group Discussion, Assignments, Seminars.

COURSE OUTCOMES (CO):

Upon completion of this course, the students will be able to:

CO code	Course Outcomes	K - Levels
CO1	find the solution of nonlinear equations and also to Illustrate the solution of linear equations.	K1, K2
CO2	solve the problems based on Interpolation and polynomial approximation.	K3
CO3	solve and analyze the problems on Numerical Differentiation and Numerical Integration.	K3, K4
CO4	determine the solution of ordinary differential equations.	K5
CO5	estimate and also to find the solution for Partial differential equations.	K5, K6

CO- PO Mapping (Course Articulation Matrix)

CO / PO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	2	3	2	2	1
CO2	3	2	2	2	2	1
CO3	3	2	2	3	2	2
CO4	3	1	2	2	2	2
CO5	3	2	2	2	2	2
Total	15	9	11	11	10	8
Average	3	1.8	2.2	2.2	2	1.6

BLOOM TAXANOMY BASED QUESTION PAPER PATTERN

PG Degree Pattern

Knowledge Level	Section	Marks	Description	Total Marks
K1, K2, K3, K4	A (Answer all the questions)	10 x 2	Short Answer (Two questions from each unit)	20
K1, K2, K3, K4,K5	B (**INTERNAL CHOICE**) EITHER (a) OR (b)	5 x 5	Question (a) OR (b) from the same Unit and same K Level	25
K2, K3, K4, K5, K6	C (Answer any threequestions from five questions)	3 x10	One question from each unit (No unit missing)	30
Grand Total				**75**

M.Sc. Degree Programme in MATHEMATICS

SECOND SEMESTER				
Course Title		**FORMAL LANGUAGES AND AUTOMATA THEORY**		
Course Code		**22PBMAE2B**		
Course No.	Course Category Core / Elective /	No. of Credits	No. of hrs /week	Total marks (Int+Ext)
CEC II	**Elective**	**3**	**5**	**25 + 75=100**

Course objectives:

- To identify Finite Automata that applies to regular grammars.
- To apply Pumping lemma to regular sets and finds decision algorithms for regular sets.
- To build Context – free grammars and extend it to normal forms.
- To define Pushdown Automata and apply it to context-free languages.
- To analyze closure properties of context-free languages and extend it to decision algorithms.

UNIT-I: Finite automata: (15 hours)

Finite automata, regular expressions and regular grammars Finite state systems – Basic definitions – Nondeterministic finite automata – Finite automata with moves – Regular expressions – Regular grammars.

Chapter 2: Sections 2.1 to2.5

UNIT-II: Properties of regular sets: (15 hours)

The Pumping lemma for regular sets – Closure properties of regular sets – Decision algorithms for regular sets – The Myhill-Nerode Theorem and minimization of finite automata.

Chapter 3: Sections 3.1 to 3.4

UNIT-III: Context-free grammars: (15 hours)

Motivation and introduction – Context-free grammars – Derivation trees- Simplification of context-free grammars – Chomsky normal form – Greibach normal form.

Chapter 4: Section 4.1 to 4.6

UNIT-IV: Pushdown automata: (15 hours)

Informal description- Definitions-Pushdown automata and context-free languages – Normal forms for deterministic pushdown automata.

Chapter 5: Sections 5.1 to 5.3

UNIT-V: Properties of context-free languages: (15 hours)

The pumping lemma for CFL's – Closure properties for CFL's – Decision algorithms for CFL's.

Chapter 6: Sections 6.1 to 6.3

Contents and Treatment as in:

1. John E.Hopcraft and Jeffrey D.Ullman, *Introduction to Automata Theory, Languages and Computation*, Narosa Publishing House, New Delhi, 1987.

Reference Books:

1. A. Salomaa, *Formal Languages*, Academic Press, New York, 1973.
2. John C. Martin, *Introduction to Languages and theory of Computations* (2nd Edition) Tata- McGraw Hill Company Ltd., New Delhi, 1997.

Web Resources:

1. https://nptel.ac.in/

METHODOLOGY OF TEACHING:

Class lectures, Group Discussion, Assignments, Seminars.

Course Outcomes (COs):

Upon completion of this course, the students will be able to

CO code	Course Outcomes	K-levels
CO1	Able to define regular expressions and regular grammars, formulate Finite Automata that recognizes regular expressions and regular grammars.	**K1, K2, K3, K6**
CO2	Remember the properties of regular sets. Understand the Myhill-Nerode Theorem and minimization of finite automata.	**K1, K2, K3**
CO3	Define Context-free grammars, Create Derivation trees using the simplification of context-free grammars; Understand Chomsky normal form and Greibach normal form.	**K1, K2, K3, K6**
CO4	Design Pushdown Automata and apply it to context-free languages in order to recognize. Create Normal forms for deterministic pushdown automata.	**K1, K2, K3,K6**
CO5	Develop the pumping lemma for CFL's; Analyze the Closure properties for CFL's. Extend CFL to find its Decision algorithms.	**K1, K2, K3, K4, K6**

CO- PO Mapping (Course Articulation Matrix)

CO / PO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	3	2	1	1	2
CO2	3	3	2	1	1	3
CO3	3	3	2	1	1	2
CO4	3	3	2	1	1	3
CO5	3	3	2	1	1	2
Total	15	15	10	5	5	12
Average	3	3	2	1	1	2.4

BLOOM TAXANOMY BASED QUESTION PAPER PATTERN

PG Degree Pattern

Knowledge Level	**Section**	**Marks**	**Description**	**Total Marks**
K1, K2, K3, K4	A (Answer all the questions)	10 x 2	Short Answer (Two questions from each unit)	20
K1, K2, K3, K4,K5	B (**INTERNAL CHOICE**) EITHER (a) OR (b)	5 x 5	Question (a) OR (b) from the same Unit and same K Level	25
K2, K3, K4, K5, K6	C (Answer any three questions from five questions)	3 x10	One question from each unit (No unit missing)	30
Grand Total				**75**

M.Sc. Degree Programme in MATHEMATICS

SECOND SEMESTER				
Course Title		**MATHEMATICS FOR COMPETITIVE EXAMINATIONS**		
Course Code		**22PBMAD1**		
Course No.	Course Category Core / Elective /	No. of Credits	No. of hours /week	Total marks (Int+Ext)
EDS I	**Elective**	**3**	**2**	**25 + 75=100**

Course objectives:

- To apply knowledge and skill in logical reasoning and problem solving.
- To understand general aptitude techniques.
- To identify business application in Mathematics.

UNIT I: Arithmetical Ability: **(6 hours)**
Problems of Ages, Surds and indices.

UNIT II: Arithmetical Ability (Continued…): **(6 hours)**
Profit and Loss, Ratio and Proportions.

UNIT III: Arithmetical Ability (Continued…): **(6 hours)**
Time and work, Time and distance.

UNIT IV: Arithmetical Ability (Continued…): **(6 hours)**
Permutations and Combinations.

UNIT V: Arithmetical Ability (Continued…): **(6 hours)**
Stocks and Shares.

TEXT BOOK :

- R.S. Aggarwal, Quantitative Aptitude, S. Chand and Co, Ltd., 2007.

REFERENCE BOOKS:

1. U Mohan Rao, Quantitative Aptitude , Scitech Publication,2010.
2. P.R.Vittal, Business Statistics, Margham Publications, 2007.
3. P.R.Vittal, Allied Mathematics, Margham Publications,2009.

Web Resources

- http://mathforum.org
- https://digital.com/blog/profit-loss-statement/

METHODOLOGY OF TEACHING

Class lectures, Group Discussion, Assignments, Seminars.

Course Outcomes (COs):

Upon completion of this course, the students will be able to

CO code	Course Outcomes	K-levels
CO1	Solve simple problems in Problems of Ages, Surds and indices and use them in competitive exams.	K1, K2, K3, K4, K5, K6
CO2	Evaluate simple problems in Profit and Loss, Ratio and Proportions and apply them in real-life problems.	K1, K2, K3, K4, K5, K6
CO3	Solve simple problems in Time and work, Time and distance and use them in competitive exams.	K1, K2, K3, K4, K5, K6
CO4	Solve simple problems in Permutations and Combinations and use them in competitive exams.	K1, K2, K3, K4, K5, K6
CO5	Solve simple problems in Stocks and Shares and use them in competitive exams.	K1, K2, K3, K4, K5, K6

CO- PO Mapping (Course Articulation Matrix)

CO / PO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	3	2	3	1	2
CO2	3	3	2	3	1	2
CO3	3	3	3	3	1	2
CO4	3	3	3	3	1	2
CO5	3	3	3	3	1	2
Total	15	15	13	15	5	10
Average	3	3	2.6	3	1	2

BLOOM TAXANOMY BASED QUESTION PAPER PATTERN
PG Degree Pattern

Knowledge Level	Section	Marks	Description	Total Marks
K1, K2, K3, K4	A (Answer all the questions)	10 x 2	Short Answer (Two questions from each unit)	20
K1, K2, K3, K4, K5	B (**INTERNAL CHOICE**) EITHER (a) OR (b)	5 x 5	Question (a) OR (b) from the same Unit and same K Level	25
K2, K3, K4, K5, K6	C (Answer any three questions from five questions)	3 x 10	One question from each unit (No unit missing)	30
Grand Total				**75**

SEMESTER - III

M.Sc. Degree Programme in MATHEMATICS

THIRD SEMESTER				
Course Title		**MATHEMATICAL METHODS**		
CourseCode		**22PCMAC1**		
Course No.	Course Category Core / Elective /	No. of Credits	No. of hours /week	Total marks (Int+Ext)
CC IX	**Core**	**4**	**6**	**25 + 75=100**

Course objectives:

- To discuss the methods of testing extremum of functional with fixed and moving boundaries.
- To analyze extremal with corners and one-sided variations
- To understand the concepts of Fourier transforms and apply it in solving the Laplace equations.
- To explain the isoperimetric problems and solving variation problems using direct methods.
- To explain various types of integral equations and methods to solve the same.

Unit-I: Method of variations with fixed boundaries: (18 hours)

Variation and its properties-Euler's Equation-Functional dependence on first and higher order derivatives-functions of several independent variables - Variational problems in parametric form –Simple Problems.

Chapter 6 from Elsgolts: 6.1 to 6.6

Unit-II: Variational Problems with moving boundaries: (18 hours)

An Elementary problem with moving boundaries-Moving Boundary Problem for a functional of the form $\int_{x_0}^{x_1} F(x, y, z, y', z')dx$ – Extremals with corners – Simple Problems.

Chapter 7 from Elegolts : 7.1 to 7.3

Unit-III: Fourier Transforms: (18 hours)

Fourier Transforms, Fourier sine and cosine transforms – Fourier transforms of derivatives - convolution integral – Parseval's Theorem - Solution of Laplace Equations by Fourier transform.

Chapter 7: 7.1 to 7.7 and 7.13 from Sankara Rao

Unit-IV: Integral Equations: (18 hours)

Introduction - Integral Equations with Separable Kernels: Reduction to a system of algebraic equations – Fredholm Alternative (statement only)- examples – An approximate method.

Chapter 1 : Sections 1.1 to 1.7 from Kanwal

Chapter 2 : Sections 2.1 to 2.5 from Kanwal

Unit V: Method of successive approximations: (18 hours)

Iterative scheme – examples- Volterra Intergral Equation - examples– Some results about the resolvent kernel.

Chapter 3 : Sections 3.1 to 3.5 from Kanwal

Contents and treatment as in:

For Unit I and Unit II: L.Elegolts, Differential Equations and the Calculus of Variations, MIR Publications, Moscow 1973.

For Unit III: K. Sankara Rao, *Introduction to Partial Differential Equations*, Prentice-Hall of India Pvt. Ltd., NewDelhi, 2006.
For Unit IV and Unit V: Ram P.Kanwal, *Linear Integral Equations*, Academic Press, New York, 1971.

Web Resources:

1. https://nptel.ac.in/

METHODOLOGY OF TEACHING:

Classroom lectures, Tutorial class, Discussions, Assignments, Seminars.

Course Outcomes (COs):

Upon completion of this course, the students will be able to

CO code	Course Outcomes	K-levels
CO1	discuss functional of variational problems with fixed boundaries in real time situations.	**K1, K2, K3, K4, K5, K6**
CO2	demonstrate various types for the extremum of the functional in fixed and moving boundaries.	**K1, K2, K3, K4, K5, K6**
CO3	Apply Fourier transforms to solve Laplace equations.	**K1, K2, K3, K4, K5, K6**
CO4	explain the types of Integral equations and its kernels.	**K1, K2, K3, K4, K5, K6**
CO5	apply Green's function to solve integral equations.	**K1, K2, K3, K4, K5, K6**

CO- PO Mapping (Course Articulation Matrix)

CO / PO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	3	3	1	1	2
CO2	3	3	3	1	1	2
CO3	3	3	3	1	1	2
CO4	3	3	3	1	1	2
CO5	3	3	3	1	1	2
Total	15	15	15	5	5	10
Average	3	3	3	1	1	2

BLOOM TAXANOMY BASED QUESTION PAPER PATTERN
PG Degree Pattern

Knowledge Level	Section	Marks	Description	Total Marks
K1, K2, K3, K4	A (Answer all the questions)	10 x 2	Short Answer (Two questions from each unit)	20
K1, K2, K3, K4,K5	B (**INTERNAL CHOICE**) EITHER (a) OR (b)	5 x 5	Question (a) OR (b) from the same Unit and same K Level	25
K2, K3, K4, K5, K6	C (Answer any threequestions from five questions)	3 x10	One question from each unit (No unit missing)	30
Grand Total				**75**

M.Sc. Degree Programme in MATHEMATICS

THIRD SEMESTER				
Course Title		**DIFFERENTIAL GEOMETRY**		
Course Code		**22PCMAC2**		
Course No.	Course Category Core / Elective /	No. of Credits	No. of hours /week	Total marks (Int+Ext)
CC X	**Core**	**4**	**5**	**25 + 75=100**

Course objectives:

- To find arc length, curvature and torsion of space curves.
- To identify the point of contact between curves and surfaces and understand fundamental existence theorem.
- To explain the intrinsic properties of surfaces and isometric correspondence.
- To understand geodesics, Gaussian curvature and demonstrate Gauss-Bonnet theorem.
- To elaborate on the non-intrinsic properties of surfaces.

UNIT-I: Space curves: (15 hours)

Definition of a space curve – Arc length – tangent, normal and binormal curvature and torsion.

Chapter I: Sections 1 to 5.

UNIT –II: Space curves (Continued…): (15 hours)

Contact between curves and surfaces- tangent surface- involutes and evolutes- Intrinsic equations – Fundamental Existence Theorem for space curves- Helices.

Chapter I: Sections 6 to 9.

UNIT-III: Intrinsic properties of a surface: (15 hours)

Definition of a surface – curves on a surface – Surface of revolution – Helicoids – Metric- Direction coefficients-families of curves- Isometric correspondence- Intrinsic properties.

Chapter II: Sections 1 to 9.

UNIT-IV: .Geodesics: (15 hours)

Geodesics – Canonical geodesic equations – Normal property of geodesics- Existence Theorems – Geodesic parallels – Geodesics curvature- Gauss- Bonnet Theorem – Gaussian curvature- surface of constant curvature.

Chapter II: Sections 10 to 18.

UNIT-V: Non-intrinsic properties of a surface: (15 hours)

The second fundamental form- Principal curvature – Lines of curvature – Developables – Developables associated with space curves and with curves on surfaces - Minimal surfaces – Ruled surfaces.

Chapter III: Sections 1 to 8.

Contents and Treatment as in:

T.J. Willmore, An Introduction to Differential Geometry, Oxford University Press, (17th Impression) New Delhi 2002. (Indian Print)

Reference Books:

1. Struik, D.T. *Lectures on Classical Differential Geometry*, Addison – Wesley, Mass. 1950.
2. A.Pressley, *Elementary Differential Geometry*, Springer International Edition, 2004
3. Wilhelm Klingenberg: *A course in Differential Geometry*, Graduate Texts in Mathematics, Springer-Verlag 1978.

4. J.A. Thorpe *Elementary Topics in Differential Geometry*, Springer International Edition, 2004.

Web Resources:

1. https://nptel.ac.in/

METHODOLOGY OF TEACHING:

Classroom lectures, Tutorial class, Discussions, Assignments, Seminars.

Course Outcomes (COs):

Upon completion of this course, the students will be able to

CO code	Course Outcomes	K-levels
CO1	Find arc length, curvature and torsion of space curves.	**K1, K2, K3**
CO2	Find the point of contact between curves and surfaces.	**K1, K2, K3**
CO3	Outline intrinsic properties, understand surface of revolution and isometric correspondence.	**K1, K2, K3**
CO4	Explain Geodesics, Geodesic curvature and elaborate on Gauss-Bonnet theorem and find Gaussian curvature.	**K1, K2, K3, K4**
CO5	Understand lines of curvature, developables, minimal surfaces and ruled surfaces.	**K1, K2, K3**

CO- PO Mapping (Course Articulation Matrix)

CO / PO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	2	2	1	1	2
CO2	3	2	2	1	1	2
CO3	3	2	2	1	1	2
CO4	3	2	2	1	1	2
CO5	3	2	2	1	1	2
Total	15	10	10	5	5	10
Average	3	2	2	1	1	2

BLOOM TAXANOMY BASED QUESTION PAPER PATTERN

PG Degree Pattern

Knowledge Level	Section	Marks	Description	Total Marks
K1, K2, K3, K4	A (Answer all the questions)	10 x 2	Short Answer (Two questions from each unit)	20
K1, K2, K3, K4,K5	B (**INTERNAL CHOICE**) EITHER (a) OR (b)	5 x 5	Question (a) OR (b) from the same Unit and same K Level	25
K2, K3, K4, K5, K6	C (Answer any threequestions from five questions)	3 x10	One question from each unit (No unit missing)	30
Grand Total				**75**

M.Sc. Degree Programme in MATHEMATICS

THIRD SEMESTER				
Course Title		**MATHEMATICAL STATISTICS**		
CourseCode		**22PCMAC3**		
Course No.	Course Category Core / Elective /	No. of Credits	No. of hours /week	Total marks (Int+Ext)
CC XI	**Core**	**4**	**5**	**25 + 75=100**

Course objectives:

- To utilize probability and identify the various types of distributions.
- To find Expectation and Moments of random vectors.
- To solve the characteristic functions and moments.
- To evaluate the Bernoulli scheme and Poisson scheme.
- To categorize the sampling techniques.

Unit-I: Probability: (15 hours)

Probability axioms – Combinatorial formulae – conditional probability – Baye's Theorem – Independent events – Concept of Random Variables – Distribution Function – random variables of discrete and continuous types – functions of random variables – Marginal Distribution – Conditional Distribution – Independent random variables. (Simple problems only)

Chapter 1: Sections 1.3 to 1.7, Chapter 2: Sections 2.1 to 2.4, 2.6 to 2.8.

Unit-II: Parameters of the Distribution of a random variable: (15 hours)

Expectation - Moments – The Chebyshev Inequality – Absolute moments – Order parameters – Moments of random vectors.

Chapter 3: Sections 3.1 to 3.6

Unit-III: Characteristic functions: (15 hours)

Properties of characteristic functions – Characteristic functions and moments – characteristic function of the sum of the independent random variables – Determination of distribution function by the Characteristic function – Probability generating function.(Simple problems only)

Chapter 4: Sections 4.1 to 4.7 (omit 4.3, 4.6)

Unit-IV: **Some probability distributions: (15 hours)**

The Bernoulli scheme – Binomial distribution – Poisson scheme – the generalized Binomial distribution – Poisson distribution – Uniform distribution – normal distribution – gamma distribution – Beta distribution.

Chapter 5: Section 5.2 to 5.9 (omit 5.4)

Unit-V: Sample moments and their functions: (15 hours)

The notion of a sample – the notion of statistic – distribution of arithmetic means of independent normally distributed random variables – the chi-square distribution – the distribution of the statistics $(\underline{X},S)$ – student's t-distribution – Fisher's z-distribution.

Chapter 9: Section 9.1 to 9.7

Contents and Treatment as in:

M. Fisz, Probability theory and Mathematical Statistics, John Wiley and Sons, New York,1963.

Reference Books:

1. K.L.Chung, A course in Probability, Academic Press, New York, 1974.
2. Y.S.Chow and H.Teicher, Probability Theory, Springer Verlag. Berlin, 1988 (2nd Edition)

3. V.K.Rohatgi, An Introduction to Probability Theory and Mathematical Statistics, Wiley Eastern Ltd., New Delhi, 1988(3rd Print).
4. S.I.Resnick, A Probability Path, Birhauser, Berlin, 1999.
5. B.R.Bhat, Modern Probability Theory (3rd Edition), New Age International (P)Ltd, New Delhi, 1999.

Web Resources:

1. https://nptel.ac.in

METHODOLOGY OF TEACHING:

Class lectures, Group Discussion, Assignments, Seminars.

Course Outcomes (COs):

Upon completion of this course, the students will be able to

CO code	Course Outcomes	K-levels
CO1	Able to define the various types of random variables of discrete and continuous types. Evaluate problems on various types of random variables of discrete and continuous types	**K1, K2, K3**
CO2	Find the Chebyshev Inequality and Absolute moments.	**K1, K2, K3**
CO3	Determine distribution functions by the Characteristic function.	**K1, K2, K3, K5**
CO4	Define the distributions of Binomial, Poisson, Uniform, Normal, Gamma and Beta. Find the distributions of Binomial, Poisson, Uniform, Normal, Gamma and Beta and solve it.	**K1, K2, K3,K6**
CO5	Recall and distinguish the distributions like the chi-square distribution, student's t-distribution, Fisher's z-distribution and find its solution.	**K1, K2, K3,K4, K6**

CO- PO Mapping (Course Articulation Matrix)

CO / PO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	3	2	1	1	2
CO2	3	3	2	1	1	3
CO3	3	3	2	1	1	2
CO4	3	3	2	1	1	3
CO5	3	3	2	1	1	2
Total	15	15	10	5	5	12
Average	3	3	2	1	1	2.4

BLOOM TAXANOMY BASED QUESTION PAPER PATTERN

PG Degree Pattern

Knowledge Level	Section	Marks	Description	Total Marks
K1, K2, K3, K4	A (Answer all the questions)	10 x 2	Short Answer (Two questions from each unit)	20
K1, K2, K3, K4,K5	B (**INTERNAL CHOICE**) EITHER (a) OR (b)	5 x 5	Question (a) OR (b) from the same Unit and same K Level	25
K2, K3, K4, K5, K6	C (Answer any threequestions from five questions)	3 x10	One question from each unit (No unit missing)	30
Grand Total				**75**

M.Sc. Degree Programme in MATHEMATICS

THIRD SEMESTER				
Course Title		**TENSOR ANALYSIS AND THEORY OF RELATIVITY**		
Course Code		**22PCMAE3A**		
Course No.	Course Category Core / Elective /	No. of Credits	No. of hours /week	Total marks (Int+Ext)
CEC III	**Elective**	**3**	**5**	**25 + 75=100**

Course objectives:

- To formulate various types of tensors and evaluate it.
- To define Riemannian Space and Christoffel Symbols. Apply their properties.
- To understand Covariant Differentiation of Tensors and Intrinsic Differentiation.
- To apply tensors in Special Theory of Relativity and Relativistic Kinematics.
- To find the solution of Relativistic Dynamics and Accelerated Systems.

UNIT-I: Tensor Algebra: (15 hours)

Systems of Different orders – Summation Convention – Kronecker Symbols - Transformation of coordinates in Sn - Invariants – Covariant and Contravariant vectors - Tensors of Second Order – Mixed Tensors – Zero Tensor – Tensor Field – Algebra of Tensors – Equality of Tensors – Symmetric and Skew-symmetric tensors - Outer multiplication, Contraction and Inner Multiplication – Quotient Law of Tensors – Reciprocal Tensor – Relative Tensor – Cross Product of Vectors.

Chapter I: I.1 – I.3,I.7 and I.8 and Chapter II: II.1 – II.19

UNIT-II: Tensor Calculus: (15 hours)

Riemannian Space – Christoffel Symbols and their properties.

Chapter III: III.1 and III.2

UNIT-III: Tensor Calculus (continued…): (15 hours)

Covariant Differentiation of Tensors – Riemann– Christoffel Curvature Tensor – Intrinsic Differentiation.

Chapter III: III.3 – III.5

UNIT-IV: Special Theory of Relativity: (15 hours)

Galilean Transformations – Maxwell's equations – The ether Theory – The Principle of Relativity.

Relativistic Kinematics: Lorentz Transformation equations – Events and simultaneity – Example – Einstein Train – Time dilation – Longitudinal Contraction - Invariant Interval - Proper time and Proper distance - World line - Example – twin paradox – addition of velocities – Relativistic Doppler effect.

Chapter 7: Sections 7.1 and 7.2

UNIT-V: Relativistic Dynamics: (15 hours)

Momentum – Energy – Momentum energy four vector – Force - Conservation of Energy – Mass and energy – Example – inelastic collision – Principle of equivalence – Lagrangian and Hamiltonian formulations.

Accelerated Systems: Rocket with constant acceleration – example – Rocket with constant thrust.

Chapter 7: Sections 7.3 and 7.4

Contents and treatments as in:

1. U.C. De, Absos Ali Shaikh and Joydeep Sengupta, Tensor Calculus, Narosa Publishing House, New Delhi, 2004. (Unit I, Unit-II, Unit-III)

2. D.Greenwood, Classical Dynamics, Prentice Hall of India, New Delhi, 1985. (Unit-IV & Unit-V)

Reference Books:

1. J.L.Synge and A.Schild, Tensor Calculus, Toronto, 1949.
2. A.S.Eddington. The Mathematical Theory of Relativitity, Cambridge UniversityPress, 1930.
3. P.G.Bergman, An Introduction to Theory of Relativity, Newyor, 1942.
4. C.E.Weatherburn, Riemannian Geometry and the Tensor Calculus, Cambridge, 1938.

Web Resources:

1. https://nptel.ac.in/

METHODOLOGY OF TEACHING

Class lectures, Group Discussion, Assignments, Seminars.

COURSE OUTCOMES (CO):

Upon completion of this course, the students will be able to:

CO code	Course Outcomes	K - Levels
CO1	Able to define the various types of tensors. Evaluate problems on various types of tensors using Kronecker Symbols.	**K1, K2, K3, K5**
CO2	Find the Christoffel Symbols and estimate their values using their properties.	**K1, K2, K3, K6**
CO3	Determine Covariant Differentiation of Tensors and evaluate Riemann– Christoffel Curvature Tensor and Intrinsic Differentiation.	**K1, K2, K3, K5**
CO4	Define Special Theory of Relativityand Relativistic Kinematics. Determine the values of Special Theory of Relativityand Relativistic Kinematics using tensors.	**K1, K2, K3,K5**
CO5	Recall and distinguish the Relativistic Dynamics and Accelerated Systems. Solve its problems.	**K1, K2, K3, K4, K6**

CO- PO Mapping (Course Articulation Matrix)

CO / PO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	3	2	1	1	2
CO2	3	3	2	1	1	3
CO3	3	3	2	1	1	2
CO4	3	3	2	1	1	3
CO5	3	3	2	1	1	2
Total	15	15	10	5	5	12
Average	3	3	2	1	1	2.4

BLOOM TAXANOMY BASED QUESTION PAPER PATTERN

PG Degree Pattern

Knowledge Level	Section	Marks	Description	Total Marks
K1, K2, K3, K4	A (Answer all the questions)	10 x 2	Short Answer (Two questions from each unit)	20
K1, K2, K3, K4,K5	B (**INTERNAL CHOICE**) EITHER (a) OR (b)	5 x 5	Question (a) OR (b) from the same Unit and same K Level	25
K2, K3, K4, K5, K6	C (Answer any threequestions from five questions)	3 x10	One question from each unit (No unit missing)	30
Grand Total				**75**

M.Sc. Degree Programme in MATHEMATICS

THIRD SEMESTER				
Course Title		**WAVELETS**		
Course Code		**22PCMAE3B**		
Course No.	Course Category Core / Elective /	No. of Credits	No. of hours /week	Total marks (Int+Ext)
CEC III	**Elective**	**3**	**5**	**25 + 75=100**

Course objectives:

- To understand basic properties of discrete Fourier transforms.
- To be able to construct wavelets on $_{N.}$
- To learn Fourier transforms and convolution.
- To be able to understand and construct multi resolution analysis.
- To learn finite difference methods of differential equations.

UNIT-I: The Discrete Fourier Transforms: (15 hours)

Basic properties-Translation invariant linear transformations-Fast Fourier Transforms.
Chapter 2: 2.1 to 2.3

UNIT-II: Wavelets on $_{N}$: (15 hours)

Construction of wavelets on $_{N}$: The first stage, the iteration step- examples and applications
Chapter 3: 3.1 to 3.3

UNIT-III: Wavelets on : (15 hours)

$\ell^2(\ )$– complete orthonormal sets in Hilbert Spaces – $L^2([-\pi,\pi))$and Fourier series. – Fourier transform and convolution on $\ell^2(\ )$– First-stage wavelets on - the iteration steps for wavelets on - implementation and examples.
Chapter 4: 4.1 to 4.7

UNIT-IV: Wavelets on : (15 hours)

$L^2(\ )$ and approximate identities– Fourier transform on - multi resolution analysis and wavelets – construction of multi resolution analyses – wavelets with compact support and their computation.
Chapter 5: 5.1 to 5.5

UNIT-V: Wavelets and Differential Equations: (15 hours)

The condition number of a matrix – finite difference methods of differential equations – wavelet – Galerkin methods for differential equations.
Chapter 6: 6.1 to 6.3

Contents and Treatments as in:

- Michael W. Frazier, *An Introduction to Wavelets through Linear Algebra*, Springer Verlag, Berlin, 1999

Reference Books:

1. C.K.Chui, *An Introduction to Wavelets,* Academic Press, 1992
2. E.Hernandez and G.Weiss, *A First Course in Wavelets*, CRC Press, New York,1996
3. D.F.Walnut, *Introduction to Wavelet Analysis*, Birhauser, 2004.

Web Resources:

1. https://nptel.ac.in/

METHODOLOGY OF TEACHING

Class lectures, Group Discussion, Assignments, Seminars.

COURSE OUTCOMES (CO):

Upon completion of this course, the students will be able to:

CO code	Course Outcomes	K - Levels
CO1	Aquire knowledge in basics of discrete Fourier transforms and fast Fourier transforms.	K1, K2, K3, K4
CO2	Construct wavelets on $_N$ and apply them.	K1, K2, K3, K4, K5, K6
CO3	Able to understand Fourier transform and convolution on $\ell^2(\ )$ and implement.	K1, K2, K3, K4, K5, K6
CO4	Construct multi resolution analyses and computer wavelets with compact support.	K1, K2, K3, K4, K5
CO5	Solve differential equations using Galerkin methods.	K1, K2, K3, K4, K5, K6

CO- PO Mapping (Course Articulation Matrix)

CO / PO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	2	2	2	2	1
CO2	3	3	2	2	2	1
CO3	3	3	2	3	2	2
CO4	3	3	2	2	2	2
CO5	3	3	2	2	2	2
Total	15	14	10	11	10	8
Average	3	2.8	2	2.2	2	1.6

BLOOM TAXANOMY BASED QUESTION PAPER PATTERN

PG Degree Pattern

Knowledge Level	Section	Marks	Description	Total Marks
K1, K2, K3, K4	A (Answer all the questions)	10 x 2	Short Answer (Two questions from each unit)	20
K1, K2, K3, K4,K5	B (**INTERNAL CHOICE**) EITHER (a) OR (b)	5 x 5	Question (a) OR (b) from the same Unit and same K Level	25
K2, K3, K4, K5, K6	C (Answer any threequestions from five questions)	3 x10	One question from each unit (No unit missing)	30
Grand Total				**75**

M.Sc. Degree Programme in MATHEMATICS

THIRD SEMESTER				
Course Title		**STOCHASTIC PROCESSES**		
Course Code		**22PCMAE4A**		
Course No.	Course Category Core / Elective /	No. of Credits	No. of hours /week	Total marks (Int+Ext)
CEC IV	**Elective**	**3**	**5**	**25 + 75=100**

Course objectives:

- To introduce advanced topics in Markov processes, Markov chains and Renewal theory.
- To understand Markov processes in discrete and continuous time.

Unit-I: Introduction to Stochastic Processes: (15 hours)

Introduction to Stochastic Processes – Specifications of Stochastic Processes – Stationary processes – Martingales.

Chapter 2: Section 2.1 to 2.4

Unit-II: Markov Chain: (15 hours)

Definition of Markov Chain – Higher transition probabilities – classification of states and chains – determination of higher transition probabilities – stability of Markov chain.

Chapter 3: Sections 3.1, 3.2, 3.4 to 3.6

Unit-III: Poisson process: (15 hours)

Poisson process and related distributions – Generalizations of Poisson process.

Chapter 4: Sections 4.1 to 4.3

Unit-IV: Poisson process (continued…): (15 hours)

Birth and death process – Markov processes with discrete state space – Erlang process.

Chapter 4: Sections 4.4, 4.5, 4.7

Unit-V: Renewal process: (15 hours)

Renewal process – renewal processes in continuous time – renewal equation and renewal theorems.

Chapter 6: Sections 6.1 to 6.5.

Contents and treatment as in:

1. J. Medhi, *Stochastic Processes*, 2nd Edition, New Age International(P) Ltd. Publishers.

Reference Books:

1. Cinter E., Introduction to Stochastic Processes, Prentice Hall Inc., New Jersey, 1975.
2. Cox D.R. and H.D. Miller, Theory of Stochastic Processes (3rd Edition), Chapman and Hall, London, 1983.
3. Kannan D., An Introduction to stochastic processes, North Holland, New York, 1979.
4. H.W.Taylor and S.Kannan, An Introduction to Stochastic Modelling (3rd Edition), Academic Press, New York, 1998.
5. Sheldon M. Ross, Stochastic Processes, 2nd Edition, Wiley, 1995.
6. S.Karlin and H.M.Taylor, A first course in Stochastic Processes, 2nd Edition, Academic Press, New York, 1975.

Web Resources:

1. https://nptel.ac.in/

METHODOLOGY OF TEACHING

Class lectures, Group Discussion, Assignments, Seminars.

COURSE OUTCOMES (CO):

Upon completion of this course, the students will be able to:

CO code	Course Outcomes	K - Levels
CO1	Classify the stochastic processes.	K1, K2
CO2	Explain about the higher transition probability and the Markov chain	K2
CO3	Construct a very wide knowledge in Poisson process and also to analyze the process.	K3,K4
CO4	Determine the Birth and Death process of Markov process of discrete state space.	K5
CO5	Discuss about the Renewal process in continuous time and explain about the Renewal theorems.	K5, K6

CO- PO Mapping (Course Articulation Matrix)

CO / PO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	2	2	2	2	1
CO2	3	3	2	2	2	1
CO3	3	3	2	3	2	2
CO4	3	3	2	2	2	2
CO5	3	3	2	2	2	2
Total	15	14	10	11	10	8
Average	3	2.8	2	2.2	2	1.6

BLOOM TAXANOMY BASED QUESTION PAPER PATTERN
PG Degree Pattern

Knowledge Level	Section	Marks	Description	Total Marks
K1, K2, K3, K4	A (Answer all the questions)	10 x 2	Short Answer (Two questions from each unit)	20
K1, K2, K3, K4,K5	B (**INTERNAL CHOICE**) EITHER (a) OR (b)	5 x 5	Question (a) OR (b) from the same Unit and same K Level	25
K2, K3, K4, K5, K6	C (Answer any three questions from five questions)	3 x10	One question from each unit (No unit missing)	30
Grand Total				**75**

M.Sc. Degree Programme in MATHEMATICS

THIRD SEMESTER				
Course Title		**NUMBER THEORY AND CRYPTOGRAPHY**		
Course Code		**22PCMAE4B**		
Course No.	Course Category Core / Elective /	No. of Credits	No. of hours /week	Total marks (Int+Ext)
CEC IV	**Elective**	**3**	**5**	**25 + 75=100**

Course objectives:

- To have basic knowledge of divisibility and congruences.
- To learn some simple crypto systems.
- To understand finite fields and quadratic reciprocity.
- To have knowledge of public key cryptography.
- To understand the elliptic curve crypto systems.

UNIT-I: Elementary Number Theory: **(15 hours)**

Time Estimates for doing arithmetic – divisibility and Euclidean algorithm – Congruences – Application to factoring.
(Chapter 1)

UNIT-II: Finite fields: **(15 hours)**

Finite Fields, Quadratic Residues and Reciprocity
(Chapter 2)

UNIT-III: Introduction to Classical Crypto systems: **(15 hours)**

Some simple crypto systems – Enciphering matrices DES
(Chapter 3)

UNIT-IV: Public key cryptography: **(15 hours)**

Public Key Cryptography
(Chapter 4)

UNIT-V: Primality: **(15 hours)**

Primality , Factoring, Elliptic curves and Elliptic curve crypto systems
(Chapter 5, sections 1,2,3 &5 (omit section 4), Chapter 6, sections 1& 2 only)

Contents and Treatment as in:

- Neal Koblitz, *A Course in Number Theory and Cryptography*, Springer-Verlag, New York,1987.

Reference Books:

1. Niven and H.S.Zuckermann, *An Introduction to Theory of Numbers* (Edn. 3), Wiley Eastern Ltd., New Delhi,1976.
2. David M.Burton, *Elementary Number Theory*, Brown Publishers, Iowa,1989.
3. K.Ireland and M.Rosen, *A Classical Introduction to Modern Number Theory*, Springer Verlag, 1972.
4. N.Koblitz, *Algebraic Aspects of Cryptography*, Springer 1998.

Web Resources:

- https://nptel.ac.in/

METHODOLOGY OF TEACHING

Class lectures, Group Discussion, Assignments, Seminars.

COURSE OUTCOMES (CO):

Upon completion of this course, the students will be able to:

CO code	Course Outcomes	K - Levels
CO1	Understand and apply Euclidean algorithm, study congruences and their properties.	**K1, K2, K3, K4**
CO2	Elaborate on finite fields and quadratic reciprocity.	**K1, K2, K3, K6**
CO3	Encipher matrices DES	**K1, K2, K3, K5**
CO4	Assimilate the concept of public key cryptography and implement it.	**K1, K2, K3,K5**
CO5	Demonstrate the understanding of Elliptic curves and Elliptic curve crypto systems	**K1, K2, K3, K4, K6**

CO- PO Mapping (Course Articulation Matrix)

CO / PO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	3	2	1	1	2
CO2	3	3	2	1	1	3
CO3	3	3	2	1	1	2
CO4	3	3	2	1	1	3
CO5	3	3	2	1	1	2
Total	15	15	10	5	5	12
Average	3	3	2	1	1	2.4

BLOOM TAXANOMY BASED QUESTION PAPER PATTERN

PG Degree Pattern

Knowledge Level	Section	Marks	Description	Total Marks
K1, K2, K3, K4	A (Answer all the questions)	10 x 2	Short Answer (Two questions from each unit)	20
K1, K2, K3, K4,K5	B (**INTERNAL CHOICE**) EITHER (a) OR (b)	5 x 5	Question (a) OR (b) from the same Unit and same K Level	25
K2, K3, K4, K5, K6	C (Answer any threequestions from five questions)	3 x10	One question from each unit (No unit missing)	30
Grand Total				**75**

M.Sc. Degree Programme in MATHEMATICS

THIRD SEMESTER				
Course Title		**APPLIED STATISTICS**		
Course Code		**22PCMAD2**		
Course No.	Course Category Core / Elective /	No. of Credits	No. of hours /week	Total marks (Int+Ext)
EDS II	**Elective**	**3**	**2**	**25 + 75=100**

Course objectives:

- To gain knowledge of Standard Deviation and Quartile Deviation.
- To learn the concepts of correlation and regression.
- To learn the basic concepts of multi-variable differential calculus.

UNIT I:Measures of Central Tendency: (6 hours)

Mean, Median, Quartiles, Mode – Measures of Dispersion: Standard Deviation, Mean Deviation, Quartile Deviation, Coefficient of Variation.

UNIT II: Correlation: (6 hours)

Karl Person's Coefficient of Correlation – Spearman's Rank Coefficient of Correlation – Regression lines.

UNIT III:Testing of Hypothesis: (6 hours)

Introduction – Type I error and Type II error – Large Sample tests: Single mean, difference of means, single Proportion and difference of proportions.

UNIT IV:Small Sample Tests: **(6 hours)**

t – test for single mean, difference of means, paired t – test.

UNIT V: Small Sample Tests (continued…): (6 hours)

F – test for difference of variances, chi-square test for independence of attributes.

Text Book:

S. P. Gupta, "Statistical Methods", S.Chand& Co publisher.

Reference Books:

1. Murray R. Spiegel, "Statistics", Schuam's Outline series.
2. Snedecor G.W. and Cochran W.G., "Statistical Methods", Oxford and IBM Academic Press.
3. Croxten F.E. and Cowden O.J., "Applied General Statistics", Prentice Hall.

Web Resources:

1. https://www.cuemath.com/data/mean-median-mode/
2. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC374386/
3. https://stats.libretexts.org/Bookshelves/Introductory_Statistics/Book%3A_Introductory_Statistics_(Shafer_and_Zhang)/08%3A_Testing_Hypotheses/8.02%3A_Large_Sample_Tests_for_a_Population_Mean
4. https://www.statisticssolutions.com/free-resources/directory-of-statistical-analyses/chi-square-goodness-of-fit-test/

METHODOLOGY OF TEACHING:

Class lectures, Group Discussion, Assignments, Field-based learning.

COURSE OUTCOMES (CO):

Upon completion of this course, the students will be able to:

CO code	Course Outcomes	K - Levels
CO1	Demonstrate the basic knowledge of various measures of central tendency and their properties.	K2
CO2	Know how to compute correlation and rank correlation and construct the relationship between two variables using regression.	K1, K3, K4
CO3	Know how to solve the problems related to testing of hypothesis (large sample tests).	K1, K4
CO4	Demonstrate the knowledge of testing of small sample tests.	K2
CO5	Acquire the knowledge to examine the goodness of fit and test for independence of attributes.	K4

CO- PO Mapping (Course Articulation Matrix):

CO / PO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	3	2	3	1	2
CO2	3	3	2	3	1	2
CO3	3	3	3	3	1	2
CO4	3	3	3	3	1	2
CO5	3	3	3	3	1	2
Total	15	15	13	15	5	10
Average	3	3	2.6	3	1	2

BLOOM TAXANOMY BASED QUESTION PAPER PATTERN

PG Degree Pattern

Knowledge Level	Section	Marks	Description	Total Marks
K1, K2, K3, K4	A (Answer all the questions)	10 x 2	Short Answer (Two questions from each unit)	20
K1, K2, K3, K4,K5	B (**INTERNAL CHOICE**) EITHER (a) OR (b)	5 x 5	Question (a) OR (b) from the same Unit and same K Level	25
K2, K3, K4, K5, K6	C (Answer any threequestions from five questions)	3 x10	One question from each unit (No unit missing)	30
Grand Total				**75**

SEMESTER - IV

M.Sc. Degree Programme in MATHEMATICS

FOURTH SEMESTER				
Course Title		**COMPLEX ANALYSIS**		
Course Code		**22PDMAC1**		
Course No.	Course Category Core / Elective /	No. of Credits	No. of hours /week	Total marks (Int+Ext)
CC XII	**Core**	**4**	**6**	**25 + 75=100**

Course objectives:

- To enable to tell the local properties of Analytical function in great detail, including the classification of singularities.
- To understand Cauchy and Residue theorems and could evaluate integrals.
- To illustrate some facts about harmonic function that is intimately connected with Cauchy's theorem.
- To determine explicit analytic expressions. Evaluate similar representations of arbitrary meromorphic functions.
- To understand periodicity and elaborate on certain theorems like Weierstrass, Schwartz, Mittag-Lefler etc.

Unit-1: Cauchy's Integral Formula: (18 hours)

Definition of analytic function and Introduction to complex integration - The index of a point with respect to a closed curve- The integral formula – Higher derivatives. Local properties of analytical functions: Removable singularities – Taylor's theorem – zeros and poles – The local mapping – The maximum principle.

Chapter4: Sections 2.1 to 2.3

Chapter4: Sections 3.1 to 3.4

Unit – II: The general form of Cauchy's theorem : (18 hours)

Chains and Cycles – simple continuity – Homology – The general statement of Cauchy's theorem, proof of Cauchy's theorem, - Calculus of residues : The Residue theorem – The argument principle.

Chapter4: Sections4.1 to 4.5

Chapter4: Sections 5.1to 5.2

Unit-III: Harmonic Functions: (18 hours)

Definition of Harmonic function and basic properties – Mean value property – Poisson formula. Harmonic Functions and power series expansions: Schwarz theorem – The reflection principle – weierstrass's theorem – Taylor's series-Laurent series.

Chapter 4: Section 6.1 to 6.5

Chapter 5: Section 1.1 to 1.3

Unit-IV: Partial Fractions and Factorization: (18 hours)

Partial fractions – Infinite products – Canonical products-Gamma Function.

Chapter 5: Section 2.1 to 2.4

Unit-V: Simply Periodic functions: (18 hours)

Representation by Exponentials – The Fourier Developments – Functions of finite order. Doubly Periodic Functions: The Period Module – Unimodular transformations – Canonical basis – General properties of elliptic functions. The Weierstrass theory: The Weierstrass p function – The functions $\zeta(z)$ and $\sigma(z)$ – The differential equation.

Chapter 7: Sections 1.1 to 3.3

Contents and treatments as in:

1. Lars V.Ahlfors, Complex Analysis (3rd Edition),McGraw Hill Co., New York, 1979.

Reference Books:

1. H.A. Prestly, Introduction to complex analysis, Clarendon Press, Oxford, 1990.
2. J.B.Conway, Functions of one complex variables, springer-verlag, International student edition, Narosa Publishing Co.,

Web Resources:

1. https://nptel.ac.in

METHODOLOGY OF TEACHING:

Classroom lectures, Tutorial class, Discussions, Assignments, Seminars.

Course Outcomes (COs):

Upon completion of this course, the students will be able to

CO code	Course Outcomes	K-levels
CO1	Find Index of a point, zeros, poles and examine singularities also evaluate Complex integrals by applying Cauchy's integral formula.	**K1, K2, K3, K4, K5**
CO2	Summarize Chains, cycles, simple connectivity, homology and prove General Cauchy's theorem, Residue theorem, Rouche's theorem and find residues.	**K1, K2, K3, K5**
CO3	Define harmonic function and its properties. Demonstrate related results such as Mean Value theorem, Poisson's formula, Poisson's integral and its properties, Hurwitz's theorem etc.	**K1, K2, K3, K4, K5**
CO4	Define Meromorphic function. Explain Mittag-Lefler theorem and summarize Infinite Products, Canonical products and solve problems. Elaborate on Legendre Duplication formula, Genus, Gamma function and its properties.	**K1, K2, K3, K4, K5, K6**
CO5	Define Elliptic function and explain its properties. Analyze periodic and doubly periodic functions and prove Weierstrass functions.	**K1, K2, K4, K5**

CO- PO Mapping (Course Articulation Matrix)

CO / PO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	2	1	1	1	1
CO2	3	2	1	1	1	1
CO3	3	2	1	1	1	1
CO4	3	2	1	1	1	1
CO5	3	2	1	1	1	1
Total	15	10	5	5	5	5
Average	3	2	1	1	1	1

BLOOM TAXANOMY BASED QUESTION PAPER PATTERN

PG Degree Pattern

Knowledge Level	Section	Marks	Description	Total Marks
K1, K2, K3, K4	A (Answer all the questions)	10 x 2	Short Answer (Two questions from each unit)	20
K1, K2, K3, K4,K5	B (**INTERNAL CHOICE**) EITHER (a) OR (b)	5 x 5	Question (a) OR (b) from the same Unit and same K Level	25
K2, K3, K4, K5, K6	C (Answer any three questions from five questions)	3 x10	One question from each unit (No unit missing)	30
Grand Total				**75**

M.Sc. Degree Programme in MATHEMATICS

FOURTH SEMESTER				
Course Title		**OPTIMIZATION TECHNIQUES**		
Course Code		**22PDMAC2**		
Course No.	Course Category Core / Elective /	No. of Credits	No. of hours /week	Total marks (Int+Ext)
CC XIII	**Core**	**4**	**6**	**25 + 75=100**

Course objectives:

- To recall simplex algorithm to solve a LPP and extend it for Gomory's cutting plane algorithm to solve an integer programming problem.
- To understand the concept of goal programming and learn the methods to solve it.
- To learn how to estimate an optimal solution to a non-linear function with constraints.
- To decide a suitable method to solve a non-linear programming problem.
- To make use of dynamic programming to find an optimal solution to various types of real time problems.

UNIT-I :Integer Linear Programming: (18 hours)

Introduction – Importance of Integer Programming Problem - Gomory's Cutting Plane Method – Branch and Bound Method.
Chapter: 14.

UNIT-II :Goal Programming: (18 hours)

Introduction - Concept of Goal Programming – Goal Programming Model formulation – Graphical Solution Method of Goal Programming – Modified Simplex method of Goal Programming.
Chapter: 17.

UNIT-III :Classical Optimization Techniques: (18 hours)

Introduction – Unconstrained Optimization – Constrained Multi-variable Optimization with Equality Constraints – Lagrangian Method - Constrained Multi-variable Optimization with inequality Constraints – Kuhn-Tucker conditions.
Non-linear Programming Problem: Introduction – Formulation of NLPP – General NLPP – Graphical solution.
Chapters: 33 and 34.

UNIT-IV: Quadratic Programming: (18 hours)

Introduction – Kuhn-Tucker conditions – General Quadratic Programming Problem – Wolfe's Modified simplex method – Beale's Method.
Chapters: 35.

UNIT-V: Dynamic Programming: (18 hours)

Introduction – Bellman's Principle of Optimality – Minimum Path problem – Single additive constraint: Multiplicative separable return – Additively separable return – Single multiplicative constraint: Additively separable return.
Chapter: 51.

Contents and Treatments as in:

1. S.D. Sharma, "Operations Research" 17th Edition, Kedar Nath Ram Nath Publisher, Meerut, 2014.

Reference Books:

1. Hamdy A. Taha, *Operations Research,* (seventh edition) Prentice - Hall of India Private Limited, New Delhi, 1997.

2. F.S. Hiller &J.Lieberman*Introduction to Operation Research* (7th Edition) Tata-McGraw Hill Company, New Delhi, 2001.
3. Beightler. C, D.Phillips, B. Wilde ,Foundations of Optimization (2nd Edition) Prentice Hall Pvt Ltd., New York, 1979.
4. S.S. Rao - *Optimization Theory and Applications*, Wiley Eastern Ltd. New Delhi. 1990

Web Resources:

1. https://nptel.ac.in/
2. https://www.wolframalpha.com/widgets/view.jsp?id=daa12bbf5e4daec7b363737d6d496120
3. https://mathworld.wolfram.com/

METHODOLOGY OF TEACHING:

Classroom lectures, Tutorial class, Discussions, Assignments, Seminars, Flipped classroom.

Course Outcomes (COs):

Upon completion of this course, the students will be able to

CO code	Course Outcomes	K-levels
CO1	Model an integer programming problem and find an optimal solution to the real-life cases.	**K1, K2, K3, K5, K6**
CO2	Develop a goal programming model, analyze it and determine an optimal solution using modified simplex algorithm and graphical methods.	**K1, K2, K3, K4, K5, K6**
CO3	Formulate and classify a non-linear programming problem and determine an optimal solution using different methods.	**K1, K2, K3, K4, K5, K6**
CO4	Apply Kuhn-Tucker conditions to a quadratic programming problem and find an optimal solution using Wolfe's and Beale's methods.	**K1, K2, K3, K4, K5, K6**
CO5	Predict an optimal solution to various types of problems in real-life using dynamic programming principle.	**K1, K2, K3, K4, K5, K6**

CO- PO Mapping (Course Articulation Matrix)

CO / PO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	3	3	1	1	2
CO2	3	3	3	1	1	2
CO3	3	3	3	1	1	2
CO4	3	3	3	1	1	2
CO5	3	3	3	1	1	2
Total	15	15	15	5	5	10
Average	3	3	3	1	1	2

BLOOM TAXANOMY BASED QUESTION PAPER PATTERN

PG Degree Pattern

Knowledge Level	Section	Marks	Description	Total Marks
K1, K2, K3, K4	A (Answer all the questions)	10 x 2	Short Answer (Two questions from each unit)	20
K1, K2, K3, K4,K5	B (**INTERNAL CHOICE**) EITHER (a) OR (b)	5 x 5	Question (a) OR (b) from the same Unit and same K Level	25
K2, K3, K4, K5, K6	C (Answer any three questions from five questions)	3 x10	One question from each unit (No unit missing)	30
Grand Total				**75**

M.Sc. Degree Programme in MATHEMATICS

FOURTH SEMESTER				
Course Title		**FUNCTIONAL ANALYSIS**		
Course Code		**22PDMAC3**		
Course No.	Course Category Core / Elective /	No. of Credits	No. of hours /week	Total marks (Int+Ext)
CC XIV	**Core**	**4**	**6**	**25 + 75=100**

Course objectives:

- To make students familiar with Normed Linear Spaces, functional and continuous linear transformation.
- To have in depth understanding of open mapping theorem and conjugate of an operator.
- To acquire knowledge of Hilbert Space and its properties.
- To have glimpse operators (adjoint, self-adjoint, normal and unitary).
- To have Understanding of Banach algebras and Spectral theory.

UNIT-I: **Banach Spaces:** **(18 hours)**

Definition – Some examples – Continuous Linear Transformations – The Hahn-Banach Theorem.

Chapter 9: Sections 46 to 48.

UNIT-II: Banach Spaces (continued): **(18 hours)**

The natural embedding of N in N** - Open mapping theorem – conjugate of an operator.

Chapter 9: Sections 49, 50 and 51

UNIT-III: Hilbert Spaces: **(18 hours)**

Definition and properties – Orthogonal complements – Orthonormal sets.

Chapter 10: Sections 52, 53 and 54.

UNIT-IV: Hilbert Spaces(continued): **(18 hours)**

Conjugate space H* - Adjoint of an operator – Self-adjoint operator – Normal and Unitary Operators – Projections.

Chapter 10 : Sections 55 to 59.

UNIT-V:General preliminaries on Banach Algebras: **(18 hours)**

Definition and some examples – Regular and singular elements – Topological divisors of zero – spectrum – the formula for the spectral radius-the radical and semi-simplicity

Chapter 12 : Sections 64 to 69.

Contents and treatments as in:

1. Simmons G.F., "Introduction to Topology and Modern Analysis", McGraw Hill International Book Company, New York, 1963.

Reference Books:

1. W. Rudin Functional Analysis, Tata McGraw-Hill Publishing Company, New Delhi, 1973.
2. G. Bachman &L. Narici, Functional Analysis Academic Press, New York, 1966.
3. C. Goffman and G. Pedrick, First course in Functional Analysis, Prentice Hall of India, New Delhi, 1987.
4. E. Kreyszig Introductory Functional Analysis with Applications, John Wiley & Sons, New York.,1978.

5. M.Thamban Nair, Functional Analysis. A First Course, Prentice Hall of India, New Delhi, 2002.
6. Limaye B.V., "Functional Analysis", Second Edition, New Age International (P) Limited Pub., New Delhi, 1996.

Web Resources:

1. https://nptel.ac.in/

METHODOLOGY OF TEACHING

Class lectures, Group Discussion, Assignments, Seminars.

COURSE OUTCOMES (CO):

Upon completion of this course, the students will be able to:

CO code	Course Outcomes	K - Levels
CO1	Understand and develops knowledge in Normed linear space, Continuous Linear Transformation.	**K1, K2, K3**
CO2	Demonstrate and the understanding of open mapping theorem, Closed graph theorem and uniform boundedness theorem.	**K2, K3**
CO3	Define and elaborate on Hilbert Space, its properties and orthogonalization.	**K1, K3, K4,K6**
CO4	Understand the concept of operators (adjoint, self-adjoint, normal and unitary) and projections.	**K1, K2**
CO5	Gains knowledge of Banach algebras, Topological divisors of zero, spectrum and spectral radius.	**K1, K2, K4**

CO- PO Mapping (Course Articulation Matrix)

CO / PO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	3	3	3	3	2
CO2	3	3	3	3	3	2
CO3	3	3	3	3	3	2
CO4	3	3	3	3	3	2
CO5	3	3	3	3	3	2
Total	15	15	15	15	15	10
Average	3	3	3	3	3	2

BLOOM TAXANOMY BASED QUESTION PAPER PATTERN

PG Degree Pattern

Knowledge Level	Section	Marks	Description	Total Marks
K1, K2, K3, K4	A (Answer all the questions)	10 x 2	Short Answer (Two questions from each unit)	20
K1, K2, K3, K4,K5	B (**INTERNAL CHOICE**) EITHER (a) OR (b)	5 x 5	Question (a) OR (b) from the same Unit and same K Level	25
K2, K3, K4, K5, K6	C (Answer any three questions from five questions)	3 x10	One question from each unit (No unit missing)	30
Grand Total				**75**

M.Sc. Degree Programme in MATHEMATICS

FOURTH SEMESTER				
Course Title		**MECHANICS**		
Course Code		**22PDMAC4**		
Course No.	Course Category Core / Elective /	No. of Credits	No. of hours /week	Total marks (Int+Ext)
CC XV	**Core**	**4**	**5**	**25 + 75=100**

Course objectives:

- To understand mechanical system and generalized co-ordinates.
- To derive Langrage's equation and integrals of motion.
- To understand Hamilton's principle and derive Hamilton's equations.
- To derive and apply Hamilton-Jacobi equations.
- To understand special transformations, Lagrange and Poisson brackets.

UNIT-I: **Mechanical Systems:** **(15 hours)**

The Mechanical system- Generalized coordinates – Constraints - Virtual work - Energy and Momentum.

Chapter 1: Sections 1.1 to 1.5

UNIT-II: **Lagrange's Equations**: **(15 hours)**

Derivation of Lagrange's equations- Examples- Integrals of the Motion.

Chapter 2 : Sections 2.1 to 2.3 (Omit Section 2.4)

UNIT-III: **Hamilton's Equations**: **(15 hours)**

Hamilton's Principle - Hamilton's – Other variational principles.

Chapter 4 : Sections 4.1 to 4.3 (Omit section 4.4)

UNIT–IV: **Hamilton-Jacobi Theory:** **(15 hours)**

Hamilton's Principle function – Hamilton –Jacobi Equation – Separability.

Chapter 5 : Sections 5.1 to 5.3

UNIT-V: **Canonical Transformation:** **(15 hours)**

Differential forms and generating functions – Special Transformations– Lagrange and Poisson brackets.

Chapter 6 : Sections 6.1, 6.2 and 6.3 (omit sections 6.4, 6.5 and 6.6)

Contents and Treatments as in:

1. D. Greenwood, Classical Dynamics, Prentice Hall of India, New Delhi, 1985.

Reference Books:

1. H. Goldstein, Classical Mechanics, (2nd Edition) Narosa Publishing House, New Delhi.
2. N.C.Rane and P.S.C.Joag, Classical Mechanics, Tata McGraw Hill, 1991.
3. J.L. Synge and B.A. Griffth, Principles of Mechanics (3rd Edition) McGraw Hill Book Co., New York, 1970.

Web Resources:

1. https://nptel.ac.in/

METHODOLOGY OF TEACHING:

Classroom lectures, Tutorial class, Discussions, Assignments, Seminars.

Course Outcomes (COs):

Upon completion of this course, the students will be able to

CO code	Course Outcomes	K-levels
CO1	Find generalized co-ordinates and using in solving problems on virtual work, energy and momentum.	**K1, K2, K3**
CO2	Apply Lagrange's equations in solving Kepler's problem and pendulums. Also to solve the problems using the concept of ignorable co-ordinates.	**K1, K2, K3, K4**
CO3	Discuss geodesic problem, Brachistochrone problem and projectile problem using Hamilton's principle.	**K1, K2, K3, K4, K5**
CO4	Find Hamilton-Jacobi equations and apply on separability of a system.	**K1, K2, K3, K4**
CO5	Verify conditions of canonical transformations and find relation between Lagrange and Poisson brackets.	**K1, K2, K3**

CO- PO Mapping (Course Articulation Matrix)

CO / PO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	3	3	1	1	2
CO2	3	3	3	1	1	2
CO3	3	3	3	1	1	2
CO4	3	3	3	1	1	2
CO5	3	3	3	1	1	2
Total	15	15	15	5	5	10
Average	3	3	3	1	1	2

BLOOM TAXANOMY BASED QUESTION PAPER PATTERN

PG Degree Pattern

Knowledge Level	Section	Marks	Description	Total Marks
K1, K2, K3, K4	A (Answer all the questions)	10 x 2	Short Answer (Two questions from each unit)	20
K1, K2, K3, K4,K5	B (**INTERNAL CHOICE**) EITHER (a) OR (b)	5 x 5	Question (a) OR (b) from the same Unit and same K Level	25
K2, K3, K4, K5, K6	C (Answer any three questions from five questions)	3 x10	One question from each unit (No unit missing)	30
Grand Total				**75**

M.Sc Degree Programme in MATHEMATICS

FOURTH SEMESTER				
Course Title		**FLUID DYNAMICS**		
Course Code		**22PDMAE5A**		
Course No.	Course Category Core / Elective /	No. of Credits	No. of hours /week	Total marks (Int+Ext)
CEC V	**Elective**	**3**	**5**	**25 + 75=100**

Course objectives:

- To understand classification of fluids and demonstrate equation of continuity.
- To explain pressure. Learn Euler's and Bernoulli equations.
- To able to find vel potential for some simple three dimensional flows and stokes function for axi symmetric flows.
- To understand the concept of CVP and find it for some simple flows. Learn image systems.
- To understand stress components and normal stresses. Learn Navier-stokes equation.

UNIT-I : Kinematics of Fluids in motion: (15 hours)

Real fluids and Ideal fluids- Velocity of a fluid at a point, Stream lines , path lines , steady and unsteady flows- Velocity potential - The vorticity vector- Local and particle rates of changes - Equation of continuity - Worked examples - Acceleration of a fluid - Conditions at a rigid boundary.

Chapter 2. Sec 2.1 to 2.10.

UNIT-II: Equations of motion of a fluid: (15 hours)

Pressure at a point in a fluid at rest.- Pressure at a point in a moving fluid - Conditions at a boundary of two inviscid immiscible fluids - Euler's equation of motion - Bernoulli's Equation – Worked examples - Discussion of the case of steady motion under conservative body forces.

Chapter 3. Sec 3.1 to 3.7

UNIT-III: Some three dimensional flows: (15 hours)

Introduction- Sources, sinks and doublets - Images in a rigid infinite plane - Axi symmetric flows : Stokes stream function

Chapter 4 Sec 4.1, 4.2, 4.3, 4.5**.**

UNIT-IV: Some two dimensional flows: (15 hours)

Meaning of two dimensional flow – Use of Cylindrical polar coordinates - The stream function - The complex potential for two dimensional , irrotational, incompressible flow - Complex velocity potentials for standard two dimensional flows - Some worked examples - Two dimensional Image systems - The Milne Thompson circle Theorem and some of its applications.

Chapter 5. Sec 5.1 to 5.8 (omit 5.8.2)

UNIT-V :Viscous flows: (15 hours)

Stress components in a real fluid. - Relations between Cartesian components of stress- Translational motion of fluid element - The rate of strain quadric and principle stresses - Some further properties of the rate of strain quadric - Stress analysis in fluid motion - Relation between stress and rate of strain- The coefficient of viscosity and Laminar flow - The Navier – Stokes equations of motion of a Viscous fluid.

Chapter 8. Sec 8.1 to 8.9

Text Book:

F. Chorlton, *Text Book of Fluid Dynamics* ,CBS Publications. Delhi ,1985.

Reference Book:

1. R.W.Fox and A.T.McDonald. *Introduction to Fluid Mechanics*, Wiley, 1985.
2. E.Krause, *Fluid Mechanics with Problems and Solutions*, Springer, 2005.
3. B.S.Massey, J.W.Smith and A.J.W.Smith, *Mechanics of Fluids*, Taylor and Francis, New York, 2005.
4. P.Orlandi, *Fluid Flow Phenomena*, Kluwer, New York, 2002.
5. T.Petrila, Basics *of Fluid Mechanics and Introduction to Computational Fluid Dynamics*, Springer, berlin, 2004.

Web Resources

1. https://nptel.ac.in
2. http://web.mit.edu/hml/ncfmf.html

METHODOLOGY OF TEACHING

Class lectures, Group Discussion, Assignments, Seminars.

COURSE OUTCOMES (CO):

Upon completion of this course, the students will be able to:

CO code	Course Outcomes	K - Levels
CO1	Classify fluids, define stream lines & equi potentials, analyze some simple flows and demonstrate equation of continuity.	K1,K2,K3,K4
CO2	Explain pressure. Learn Euler's and Bernoulli equations and solve problems.	K1,K2,K3
CO3	find velocity potential for some simple three dimensional flows, find stokes stream function for axisymmetric flows, and solve some simple problems.	K1,K2,K3
CO4	understand the concept of CVP and evaluate it for some simple flows, use CVP to analyze certain flows, Interpret image system, Milne Thompson circle theorm and its applications.	K1,K2,K3,K4,K5
CO5	Understand stress components and normal stresses. Discuss Navier-stokes equation.	K2,K4,K6

CO- PO Mapping (Course Articulation Matrix)

CO / PO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	3	3	1	1	2
CO2	3	3	3	1	1	2
CO3	3	3	3	1	1	2
CO4	3	3	3	1	1	2
CO5	3	3	3	1	1	2
Total	15	15	15	5	5	10
Average	3	3	3	1	1	2

BLOOM TAXANOMY BASED QUESTION PAPER PATTERN

PG Degree Pattern

Knowledge Level	Section	Marks	Description	Total Marks
K1, K2, K3, K4	A (Answer all the questions)	10 x 2	Short Answer (Two questions from each unit)	20
K1, K2, K3, K4,K5	B (**INTERNAL CHOICE**) EITHER (a) OR (b)	5 x 5	Question (a) OR (b) from the same Unit and same K Level	25
K2, K3, K4, K5, K6	C (Answer any three questions from five questions)	3 x10	One question from each unit (No unit missing)	30
Grand Total				**75**

M.Sc. Degree Programme in MATHEMATICS

FOURTH SEMESTER				
Course Title		**FUZZY SETS AND THEIR APPLICATIONS**		
Course Code		**22PDMAE5B**		
Course No.	Course Category Core / Elective /	No. of Credits	No. of hours /week	Total marks (Int+Ext)
CEC V	**Elective**	**3**	**5**	**25 + 75=100**

Course objectives:

- To understand what is fuzzy and how fuzzy sets have been defined.
- To understand the concept of fuzzy graphs.
- To acquire knowledge in fuzzy relations.
- To remember the laws of fuzzy compositions.
- To appreciate the applications of fuzzy sets.

UNIT I: Fuzzy Sets-Basic and Extensions: (15 hours)

Crispness, Vagueness, Fuzziness, Uncertainty, Fuzzy Set Theory, Basic Definitions, Basic Set-Theoretic Operations for Fuzzy Sets, Types of Fuzzy Sets, Further Operations on Fuzzy Sets, Algebraic Operations, Set-Theoretic Operations, Criteria for Selecting Appropriate Aggregation Operators

Chapter 1-4

UNIT II: The Extension Principle and Applications: (15 hours)

The Extension Principle, Operations for Type 2 Fuzzy Sets, Algebraic Operations with Fuzzy Numbers, Special Extended Operations, Extended Operations for LR-Representation of Fuzzy Sets

Chapter 5

UNIT III: Fuzzy Relations and Fuzzy Graphs: (15 hours)

Fuzzy Relations on Sets and Fuzzy Sets**,** Compositions of Fuzzy Relations, Properties of the Min-Max Composition, Fuzzy Graphs, Special Fuzzy Relations

Chapter 6

UNIT IV: Fuzzy Analysis: (15 hours)

Fuzzy Functions on Fuzzy Sets, Extrema of Fuzzy Functions, Integration of Fuzzy Functions, Integration of a Fuzzy Function over a Crisp Interval, Integration of a (Crisp) Real-Valued Function over a Fuzzy Interval, Fuzzy Differentiation

Chapter 7

UNIT V: Uncertainty Modelling: (15 hours)

Application-oriented Modelling of Uncertainty, Causes of Uncertainty, Type of Available Information, Uncertainty Methods, Uncertainty Theories as Transformers of Information, Matching Uncertainty Theory and Uncertain Phenomena, Possibility Theory, Fuzzy Sets and Possibility Distributions, Possibility and Necessity Measures, Probability of Fuzzy Events, Probability of a Fuzzy Event as a Scalar, Probability of a Fuzzy Event as a Fuzzy Set, Possibility vs. Probability

Chapter 8

Text Book:

H. J. Zimmermann, "Fuzzy Set Theory and Its Applications", Fourth Edition, Springer Science

Reference Books:

1. J.D. Lee , Fuzzy set theory.
2. George J.Klir and Bo Yuan, *Fuzzy sets and Fuzzy Logic-Theory and Applications*, Prentice Hall India, New Delhi, 2001.
3. A.Kaufman, *Introduction to the theory of Fuzzy subsets,* Vol.**I,** Academic Press, New York, 1975.

Web Resources:

1. https://nptel.ac.in/

METHODOLOGY OF TEACHING:

Class lectures, Group Discussion, Assignments, Seminars.

COURSE OUTCOMES (CO):

Upon completion of this course, the students will be able to:

CO code	Course Outcomes	K – Levels
CO1	Mention the fundamental notions in fuzzy.	K1, K2, K3
CO2	Do the fuzzy operations and apply them.	K1, K2, K3
CO3	List the relations in fuzzy sets and fuzzy graphs.	K1, K2, K3, K4, K5
CO4	Demonstrate the concept of fuzzy functions and fuzzy analysis.	K1, K2, K3, K4, K5, K6
CO5	Apply fuzzy sets in uncertainty modeling.	K1, K2, K3, K4, K5, K6

CO- PO Mapping (Course Articulation Matrix):

CO / PO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	3	3	2	1	3
CO2	3	3	3	2	1	2
CO3	3	3	3	2	1	3
CO4	3	3	3	2	1	2
CO5	3	3	3	2	1	3
Total	15	15	15	10	5	13
Average	3	3	3	2	1	2.6

BLOOM TAXANOMY BASED QUESTION PAPER PATTERN

PG Degree Pattern

Knowledge Level	Section	Marks	Description	Total Marks
K1, K2, K3, K4	A (Answer all the questions)	10 x 2	Short Answer (Two questions from each unit)	20
K1, K2, K3, K4,K5	B (**INTERNAL CHOICE**) EITHER (a) OR (b)	5 x 5	Question (a) OR (b) from the same Unit and same K Level	25
K2, K3, K4, K5, K6	C (Answer any three questions from five questions)	3 x10	One question from each unit (No unit missing)	30
Grand Total				**75**