APPENDIX – (i)33(R)
UNIVERSITY OF MADRAS

M.Sc. DEGREE COURSE IN MATHEMATICS
CHOICE BASED CREDIT SYSTEM
REGULATIONS
(w.e.f.2022-23)

Programme Outcomes at Postgraduate

Level Postgraduates will be able to:

PO1 : Demonstrate intense knowledge in their discipline.

PO2 : Exhibit specialized skills to plan, analyze and draw conclusions related to their respective field of study in theory and in practice.

PO3 : Develop expertise in their field of study through projects and research activities.

PO4 : Prepare themselves to incorporate new technologies in their own discipline and demonstrate excellence in their area of specialization.

PO5 : Develop social and ethical responsibility in the transfer and management of knowledge.

Programme Outcomes at Research Level

Research scholars will be able to:

PO1 : Develop and demonstrate deep knowledge in the field of study to become globally competent.

PO2 : Manage information, undertake investigations, conduct field study, do accurate document, network with experts and mobilize resources and skills.

PO3 : Develop and exhibit scientific temper and adopt professional code of conduct in pursuit of research activities.

Programme Specific Outcome

Mathematics Majors should:

PO1 : Apply the knowledge of mathematical concepts in interdisciplinary fields. Understand the nature of abstract mathematics and explore the concepts in further details.

PO2 : Identify challenging problems in mathematics and find appropriate solutions.

PO3 : Pursue research in challenging areas of pure/applied mathematics. Employ confidently the knowledge of mathematical software and tools for treating the complex mathematical problems and scientific investigations.

PO4 : Comprehend and write effective reports and design documentation related to mathematical research and literature, make effective presentations. Qualify national level tests like NET/GATE etc.

PO5 : Effectively communicate and explore ideas of mathematics for propagation of knowledge and popularization of mathematics in society.

Scheme of Examinations:

Semester – I

Course Components / Title of the course	Duration (Hours)	Credits	Marks		Total
			CIA	UE	
Core Paper – I - Algebra – I	6	4	25	75	100
Core Paper – II - Real Analysis – I	6	4	25	75	100
Core Paper – III - Ordinary Differential Equations	6	4	25	75	100
Core Paper – IV -Graph Theory	6	4	25	75	100
Elective Paper – I - (Choose One from Group – A)	4	3	25	75	100
Soft Skill Paper – I	3	2	40	60	100

Group – A (Elective Paper- I)

1. Formal Languages and Automata Theory
2. Discrete Mathematics
3. Fuzzy Sets and Applications

Semester – II

Course Components / Title of the course	Duration (Hours)	Credits	Marks		Total
			CIA	UE	
Core Paper – V - Algebra – II	6	4	25	75	100
Core Paper – VI - Real Analysis – II	6	4	25	75	100
Core Paper – VII - Partial Differential Equations	6	4	25	75	100
Core Paper – VIII – Probability	6	4	25	75	100
Elective Paper – II - (Choose ONE from Group – B)	4	3	25	75	100
Extra Disciplinary – I - (Choose any ONE)	4	3	25	75	100
Soft Skill Paper – II	3	2	40	60	100
Internship*	3	2			

Group – B (Elective Paper-II)

1. Mathematical Programming
2. Wavelets
3. Combinatorics

Extra Disciplinary- I

1. Mathematical Economics
2. Programming in C^{++}
3. Financial Mathematics

*** Internship will be carried out during the summer vacation of the first year and marks should be sent to the University by the College and the same will be included in the Third Semester Marks Statement.**

Semester – III

Course Components / Title of the course	Duration (Hours)	Credits	Marks		Total
			CIA	UE	
Core Paper – IX-Complex Analysis – I	6	4	25	75	100
Core Paper – X-Topology	6	4	25	75	100
Core Paper – XI-Operations Research	6	4	25	75	100
Core Paper – XII-Mechanics	6	4	25	75	100
Elective Paper – III-(Choose ONE from Group – C)	4	3	25	75	100
Extra Disciplinary- II-(Choose any ONE)	4	3	25	75	100
Soft Skill Paper - III	3	2	40	60	100

Group- C (Elective Paper– III)
1. Algebraic Theory of Numbers
2. Number Theory and Cryptography
3. Stochastic Processes

Extra Disciplinary II
1.Java Programming
2.Data Structures and Algorithms

Semester – IV

Course Components / Title of the course	Duration (Hours)	Credits	Marks		Total
			CIA	UE	
Core Paper – XIII- Complex Analysis - II	6	4	25	75	100
Core Paper – XIV- Differential Geometry	6	4	25	75	100
Core Paper – XV- Functional Analysis	6	4	25	75	100
Elective paper – IV-(Choose ONE from Group – D)	4	3	25	75	100
Elective Paper – V(Choose ONE from Group – E)	4	3	25	75	100
Soft Skill Paper – IV	3	2	40	60	100

Group – D (Elective Paper– IV)
1. Fluid Dynamics
2. Mathematical Statistics
3. Algebraic Topology

Group- E (Elective Paper- V)
1. Tensor Analysis and Relativity
2. Mathematical Physics
3. Calculus of Variations and Integral Equations.

Question Paper Pattern from the academic year 2022-2023

Time **THREE** Hours Max marks **75**

Part A

Answer **ALL** questions (20 × 1 = 20 marks)
- Only objective type allowed
- Definitions should not be asked.

Part B

Answer any **FIVE** questions out of **SEVEN** (5 × 5 = 25 marks)

Part C

Answer any **THREE** questions out of **FIVE** ($3 \times 10 = 30$ marks)

S.SENATE. SEPT'2022

APPENDIX – 33(S)
M.Sc. DEGREE COURSE IN MATHEMATICS
CHOICE BASED CREDIT SYSTEM

REVISED SYLLABUS
(With effect from 2022-2023)

SEMESTER -I

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="6">Core Paper : I ALGEBRA-I</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="6">I</td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">Core</td><td>Year</td><td>I</td><td rowspan="2">Credits</td><td rowspan="2">4</td><td rowspan="2">Course Code</td><td rowspan="2"></td></tr>
<tr><td>Semester</td><td>I</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="6">Basics in groups and linear transformatin</td></tr>
</table>

Objective : To give the students a thorough knowledge of the various aspects of Linear Algebra. To study Linear Transformations, Jordan form, Trace and Transpose.

UNIT I – Another Counting Principle: Cauchy's theorem- Sylow Theorems
Chapter 2: Sections 2.11 and 2.12

UNIT II - Direct products - Finite abelian groups- Modules
Chapter 2: Sections 2.13 and 2.14
Chapter 4: Section 4.5

UNIT III - Linear Transformations - Canonical forms -Triangular form – Nilpotent transformations.
Chapter 6: Sections 6.4 , 6.5

UNIT IV - Jordan form - rational canonical form.
Chapter 6 : Sections 6.6 and 6.7

UNIT V - Trace and transpose - Hermitian, unitary, normal transformations, real quadratic form.
Chapter 6 : Sections 6.8, 6.10 and 6.11 (Omit 6.9)

Recommended Text :

I.N. Herstein. Topics in Algebra (II Edition) Wiley, 2006.

Books for Reference :

1. M.Artin, *Algebra*, Prentice Hall of India, 1991.
2. P.B.Bhattacharya, S.K.Jain, and S.R.Nagpaul, *Basic Abstract Algebra*, (II Edition) Cambridge University Press, 1997. (Indian Edition)
3. J.B. Fraleigh, A first course in Abstract Algebra, 5th edition.
4. K.Thirusangu and K.Balasangu, Elements of University Algebra, KTM Publications, 2021
5. D.S.Dummit and R.M.Foote, *Abstract Algebra*, 2nd edition, Wiley, 2002.
6. N.Jacobson, *Basic Algebra*, Vol. I & II W.H.Freeman (1980); also published by Hindustan Publishing Company, New Delhi.

Course Learning Outcomes

This course will enable the students to :

CO Number	CO Statement	Knowledge Level
CO1	understand linear transformations and represent in matrix form.	K2
CO2	compute minimal polynomial and characteristic polynomial of linear transformation.	K3
CO3	find applicability of the inner product spaces.	K5
CO4	outline and formulate the theory of the course to solve variety of problems at an appropriate level of difficulty.	K4, K6
CO5	examine bi-linear and Jordan canonical forms.	K1

Title of the Course		Core Paper –II REAL ANALYSIS					
Paper Number		**II**					
Category	Core	**Year**	**I**	**Credits**	**4**	**Course Code**	
		Semester	**I**				
Pre-requisite		An introductory real analysis course					

Objective : To study the real number system, Functions of Bounded Variation and Rectifiable, Riemann-Stieltjes integral, Lebesgue Integral and Square Space.

UNIT-I : Functions of bounded variation - 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

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

Chapter 8 : Sections 8.8, 8.15, 8.17, 8.18

UNIT-II : The Riemann - Stieltjes Integral - 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 – Euler’s summation formula - Monotonically increasing integrators, Upper and lower integrals - Additive and linearity properties of upper and lower integrals - Riemann's condition - Comparison theorems.

Chapter - 7 : Sections 7.1 to 7.14

UNIT-III : The Riemann-Stieltjes Integral - 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 - The integrals as a function of the interval - Second fundamental theorem of integral calculus-Change of variable in a Riemann integral-Second Mean Value Theorem for Riemann integral-Riemann-Stieltjes integrals depending on a parameter-Differentiation under the integral sign-Lebesgue criteriaon for the existence of Riemann integrals.

Chapter - 7 : 7.15 to 7.26

UNIT-IV : Infinite Series and infinite Products - Double sequences - Double series - Rearrangement theorem for double series - A sufficient condition for equality of iterated series - Multiplication of series - Cesaro summability - Infinite products.

Chapter - 8 Sec, 8.20, 8.21 to 8.26

Power series - Multiplication of power series - The Taylor's series generated by a function - Bernstein's theorem - Abel's limit theorem - Tauber's theorem

Chapter 9 : Sections 9.14 9.15, 9.19, 9.20, 9.22, 9.23

UNIT-V: Sequences of Functions - 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 – Non-uniform Convergence and Term-by-term Integration - Uniform convergence and differentiation - Sufficient condition for uniform convergence of a series - Mean convergence.

Chapter -9 Sec 9.1 to 9.6, 9.8,9.9, 9.10,9.11, 9.13

Recommended Text :

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

Books for Reference :

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.

Course Learning Outcomes

This course will enable the students to :

CO Number	CO Statement	Knowledge Level
CO1	analyze and evaluate functions of bounded variation and Rectifiable Curves.	K4, K5
CO2	describe the concept of Riemann-Stieltjes integral and its properties.	K1
CO3	demonstrate the concept of step function, upper function, Lebesgue function and their integrals.	K2
CO4	construct various mathematical proofs using the properties of Lebesgue integrals and establish the Levi monotone convergence theorem.	K3
CO5	Formulate the concept and properties of inner products, norms and measurable functions.	K6

Title of the Course		**Core Paper : III ORDINARY DIFFERENTIAL EQUATIONS**					
Paper Number		**III**					
Category	Core	**Year**	**I**	**Credits**	**4**	**Course Code**	
		Semester	**I**				
Pre-requisite		Basics in differential equations					

Objective : To study the Differential equation of higher order, to find the power series solution of special type of Differential equations, to solve the system of linear Differential equations, to study existence and uniqueness of the solutions, boundary value problems.

UNIT-I : Linear equations with constant coefficients Second order homogeneous equations-Initial value problems-Linear dependence and independence-Wronskian and a formula for Wronskian-Non-homogeneous equation of order two.

Chapter 2: Sections 1 to 6

UNIT-II : Linear equations with constant coefficients 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 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 Second order equations with regular singular points –Exceptional cases – Bessel equation .

Chapter 4 : Sections 3, 4 and 6 to 8 (omit sections 5 and 9)

UNIT-V : Existence and uniqueness of solutions to first order equations: Equation with variable 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)

Recommended Text

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.

Course Learning Outcomes

This course will enable the students to :

CO Number	CO Statement	Knowledge Level
CO1	establish the qualitative behavior of solutions of systems of differential equations .	K3
CO2	recognize the physical phenomena modeled by differential equations and dynamical systems.	K1
CO3	analyze solutions using appropriate methods and give examples.	K2, K4
CO4	formulate Green's function for boundary value problems.	K6
CO5	understand and use various theoretical ideas and results that underlie the mathematics in this course.	K5

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="6">Core Paper : IV GRAPH THEORY</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="6">IV</td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">Core</td><td>Year</td><td>I</td><td rowspan="2">Credits</td><td rowspan="2">4</td><td rowspan="2">Course Code</td><td rowspan="2"></td></tr>
<tr><td>Semester</td><td>I</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="6">Basics in graph theory</td></tr>
</table>

Objective : To understand the concept of graphs, sub graphs, trees, connectivity, Euler tour, Hamilton cycle, matching, colouring of graphs, independent set, cliques, vertex colouring and planar graphs.

Unit–I

Graphs – Varieties of graphs – Walks and connectedness – degrees – the problem of Ramsey – External graphs

Chapter 2

Unit–II

Blocks – Cut points – Bridges and blocks – Block Graphs and Cut point graphs

Trees – Characterization of trees – Centers and Centroids – Block Cut points – Independent Cycles and Cocycles

Chapters: 3 and 4 (Omit: 3.5 Matroids)

Unit–III

Connectivity – Connectivity and line – Connectivity – Menger's Theorem – Point form – Further Variations of Mengers theorem

Chapter 5

Unit–IV

Coverings – Coverings and independent sets – Planarity – Plane and planar graphs – Outerplanar graph – Thickness – Crossing number

Chapters: 10 and 11

Unit–V

Colorability – The Chromatic number – The five color theorem – The chromatic polynomial.

Matrices – The adjacency matrix – the incidence matrix – the cycle matrix

Chapters: 12 and 13

Recommended Text :

Frank Harary , Graph Theory, Narosa Publishing House, New Delhi, 2001

Books for Reference:

1. J.A. Bondy and U.S.R Murty , Graph Theory with Applications , Macmillan, London 1976
2. K.R. Parthasarathy, Basic Graph Theory , Tata McGraw-Hill, New Delhi, 1994

3. Narsingh Deo , Graph Theory with Applications to Engineering and Computer Science , Prentice-Hall of India, 2007
4. Douglas B.West, Introduction to Graph Theory, Pearson Prentice Hall, 2006

Learning Outcomes

This course will enable the students to :

CO Number	CO Statement	Knowledge Level
CO1	understand basic concepts in Graph theory.	K2
CO2	apply the understanding and use it to model real life situations.	K3
CO3	apply the concepts of connectivity, Euler and Hamilton cycles in the real life situations.	K4
CO4	identify and develop the applications of planarity and colourability .	K1, K6
CO5	create graph models in network and computing.	K5

GROUP A: ELECTIVE-I

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="6">A1 . FORMAL LANGUAGES AND AUTOMATA THEORY</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="6"></td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">Elective-I</td><td>Year</td><td>I</td><td rowspan="2">Credits</td><td rowspan="2">4</td><td rowspan="2">Course Code</td><td rowspan="2"></td></tr>
<tr><td>Semester</td><td>I</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="6">Elementary algebra</td></tr>
<tr><td colspan="2" rowspan="5">Course Outline</td><td colspan="6">UNIT-I :

Finite automata, regular expressions and regular grammars
Finite state systems – Basic definitions – Nondeterministic finite automata – Finite automata with ε moves – Regular expressions – Regular grammars.
Chapter 2. Sections 2.1 to2.5
Chapter 9 Section 9.1</td></tr>
<tr><td colspan="6">UNIT-II :
Properties of regular sets.
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</td></tr>
<tr><td colspan="6">UNIT-III : Context-free grammars
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</td></tr>
<tr><td colspan="6">UNIT-IV : Pushdown automata
Informal description- Definitions-Pushdown automata and context-free languages – Normal forms for deterministic pushdown automat.
Chapter 5 : Sections 5.1 to 5.3</td></tr>
<tr><td colspan="6">UNIT-V : Properties of context-free languages
The pumping lemma for CFL’s – Closure properties for CFL’s – Decision algorithms for CFL’s.

Chapter 6 : Sections 6.1 to 6.3</td></tr>
<tr><td colspan="2">Recommended Text</td><td colspan="6">John E.Hopcraft and Jeffrey D.Ullman, Introduction to Automata Theory, Languages and Computation, Narosa Publishing House, New Delhi, 1987.</td></tr>
<tr><td colspan="2">Reference Books</td><td colspan="6">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.</td></tr>
</table>

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="6">A2: DISCRETE MATHEMATICS</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="6"></td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">Elective-II</td><td>Year</td><td>I</td><td rowspan="2">Credits</td><td rowspan="2">4</td><td rowspan="2">Course Code</td><td rowspan="2"></td></tr>
<tr><td>Semester</td><td>I</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="6">Elementary algebra</td></tr>
<tr><td colspan="2" rowspan="5">Course Outline</td><td colspan="6">UNIT-I : Lattices: Properties of Lattices: Lattice definitions – Modular and distributive lattice; Boolean algebras: Basic properties – Boolean polynomials, Ideals; Minimal forms of Boolean polynomials.
Chapter 1: § 1 A and B § 2A and B. § 3.</td></tr>
<tr><td colspan="6">UNIT-II : Applications of Lattices: Switching Circuits: Basic Definitions - Applications
Chapter 2: § 1 A and B</td></tr>
<tr><td colspan="6">UNIT-III : Finite Fields

Chapter 3: § 2</td></tr>
<tr><td colspan="6">UNIT-IV : Polynomials : Irreducible Polynomials over Finite fields – Factorization of Polynomials

Chapter 3: § 3 and §4.</td></tr>
<tr><td colspan="6">UNIT-V: Coding Theory : Linear Codes and Cyclic Codes
Chapter 4 § 1 and 2</td></tr>
<tr><td colspan="2">Recommended Text</td><td colspan="6">Rudolf Lidl and Gunter Pilz, Applied Abstract Algebra, Spinger-Verlag, New York, 1984.</td></tr>
<tr><td colspan="2">Reference Books</td><td colspan="6">1. A.Gill, Applied Algebra for Computer Science, Prentice Hall Inc., New Jersey.
2. J.L.Gersting, Mathematical Structures for Computer Science(3rd Edn.), Computer Science Press, New York.
3. S.Wiitala, Discrete Mathematics- A Unified Approach, McGraw Hill Book Co.</td></tr>
</table>

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="6">A3. FUZZY SETS AND APPLICATIONS</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="6"></td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">Elective-II</td><td>Year</td><td>I</td><td rowspan="2">Credits</td><td rowspan="2">4</td><td rowspan="2">Course Code</td><td rowspan="2"></td></tr>
<tr><td>Semester</td><td>I</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="6">Knowledge of graphs, relations, composition</td></tr>
<tr><td colspan="2" rowspan="5">Course Outline</td><td colspan="6">UNIT-I : Fundamental Notions: Chapter I: Sec. 1 to 8</td></tr>
<tr><td colspan="6">UNIT-II : Fuzzy Graphs: Chapter II: Sec. 10 to 18</td></tr>
<tr><td colspan="6">UNIT-III : Fuzzy Relations: Chapter II: Sec. 19 to 29</td></tr>
<tr><td colspan="6">UNIT-IV : Fuzzy Logic: Chapter III: Sec.31 to 40 (omit Sec. 37, 38, 41)</td></tr>
<tr><td colspan="6">UNIT-V : The Laws of Fuzzy Composition: Chapter IV: Sec.43 to 49</td></tr>
<tr><td colspan="2">Recommended Text</td><td colspan="6">A.Kaufman, Introduction to the theory of Fuzzy subsets, Vol.I,
Academic Press, New York, 1975.</td></tr>
<tr><td colspan="2">Reference Books</td><td colspan="6">1. H.J.Zimmermann, Fuzzy Set Theory and its Applications, Allied Publishers, Chennai, 1996
2. George J.Klir and Bo Yuan, Fuzzy sets and Fuzzy Logic-Theory and Applications, Prentice Hall India, New Delhi, 2001.</td></tr>
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SEMESTER- II

<table>
<tr><td>Title of the Course</td><td colspan="7">Core Paper : V ALGEBRA-II</td></tr>
<tr><td>Paper Number</td><td colspan="7">V</td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">Core</td><td>Year</td><td>I</td><td rowspan="2">Credits</td><td rowspan="2">4</td><td rowspan="2">Course Code</td><td rowspan="2"></td></tr>
<tr><td>Semester</td><td>II</td></tr>
<tr><td>Pre-requisite</td><td colspan="7">Basic notions of fields</td></tr>
</table>

Objective : To study the transformations, Extension Fields and algebraic extensions, Finite Fields and Sylow's theorems, Finite Simple groups, Summetry groups and Cayley digraphs of groups and Galois Theory in Vector Space..

UNIT I - Extension fields - Transcendence of e.
Chapter 5: Section 5.1 and 5.2

UNIT II - Roots or Polynomials.- More about roots
Chapter 5: Sections 5.3 and 5.5

UNIT III - Elements of Galois theory.
Chapter 5 : Section 5.6

UNIT IV - Finite fields - Wedderburn's theorem on finite division rings
Chapter 7: Sections 7.1 and 7.2 (Theorem 7.2.1 only)

UNIT V - Solvability by radicals – Galois groups over the rationals -— A theorem of Frobenius.

Chapter 5: Sections 5.7 and 5.8
Chapter 7: Sections 7.3

<u>Recommended Text :</u>
I.N. Herstein. Topics in Algebra (II Edition) Wiley 2002

<u>Reference Books :</u>

1. M.Artin, *Algebra*, Prentice Hall of India, 1991.
2. P.B.Bhattacharya, S.K.Jain, and S.R.Nagpaul, *Basic Abstract Algebra* (II Edition) Cambridge University Press, 1997. (Indian Edition)
3. I.S.Luther and I.B.S.Passi, *Algebra*, Vol. I - Groups(1996); Vol. II Rings, (1999) Narosa Publishing House , New Delhi.
4. K.Thirusangu and K.Balasangu, An Invitation to Field Theory, KTM Publications, 2021.
5. D.S.Dummit and R.M.Foote, *Abstract Algebra*, 2nd edition, Wiley, 2002.
6. N.Jacobson, *Basic Algebra*, Vol. I & II Hindustan Publishing Company, New Delhi.

Learning Outcomes

This course will enable the students to :

CO Number	CO Statement	Knowledge Level
CO1	prove theorems applying algebraic ways of thinking.	K3, K5
CO2	connect groups with graphs and understanding about Hamiltonian graphs.	K4
CO3	compose clear and accurate proofs using the concepts of Galois Theory.	K6
CO4	bringout insight into Abstract Algebra with focus on axiomatic theories.	K1
CO5	Demonstrate knowledge and understanding of fundamental concepts including extension fields, Algebraic extensions, Finite fields, Class equations and Sylow's theorem.	K2

<table>
<tr><td>Title of the Course</td><td colspan="6">Core Paper : VI REAL ANALYSIS – II</td></tr>
<tr><td>Paper Number</td><td colspan="6">VI</td></tr>
<tr><td rowspan="2">Category Core</td><td>Year</td><td>I</td><td rowspan="2">Credits</td><td rowspan="2">4</td><td rowspan="2">Course Code</td><td rowspan="2"></td></tr>
<tr><td>Semester</td><td>II</td></tr>
<tr><td>Pre-requisite</td><td colspan="6">Real Analysis-I</td></tr>
</table>

Objective : To study and analyze the real number system, Lebesgue Integral, Fourier series, Fourier Integral, multivariable calculus, Implicit functions and Extremum problems.

UNIT - I

The Lebesgue Integral - Introduction - The integral of a step function - Monotonic sequences of step functions - Upper functions and their integrals - Riemann- integrable functions as examples of upper functions - The class of Lebesgue – integrable functions on a general interval - Basic properties of the Lebesgue integral - Lebesgue integration and sets of measure zero - The Levi monotone convergence theorems - The Lebesgue dominated convergence theorem.

Chapter : 10 Sections : 10. 1 - 10. 10

UNIT - II

The Lebesgue Integral - Measurable functions - Continuity of functions defined by Lebesgue integrals - Differentiation under the integral sign - Interchanging the order of integration - Measurable sets on the Real line - The Lebesgue integral over arbitrary subsets of R - Lebesgue integrals of complex – valued functions - Inner products and norms - The set $L^2 (I)$ of square – integrable functions - The set $L^2 (I)$ as a semi metric space - A convergence theorem for series of functions in $L^2 (I)$ - The Riesz – Fischer theorem.

Chapter : 10 Sections : 10. 14 - 10 . 25

UNIT-III : Fourier Series and Fourier Integrals - 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 Thorem - The convergence and representation problems in for trigonometric series - The Riemann - Lebesgue Lemma - The Dirichlet Integrals - An integral representation for the partial sums of Fourier series - Riemann's localization theorem - Sufficient conditions for convergence of a Fourier series at a particular point - Cesaro summability of Fourier series- Consequences of Fejes's theorem - The Weierstrass approximation theorem

Chapter 11 : Sections 11.1 - 11.15

UNIT-IV : Multivariable Differential Calculus - 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 - Matrix form of chain rule - The mean - value theorem for differentiable functions - A sufficient condition for differentiability - A sufficient condition for equality of mixed partial derivatives - Taylor's theorem for functions of R^n to R^1

Chapter 12 : Section 12.1 - 12.14

UNIT-V : Implicit Functions and Extremum Problems **:** Functions with non-zero Jacobian determinants – The inverse function theorem-The Implicit function theorem-Extrema of real valued functions of severable variables-Extremum problems with side conditions.

Chapter 13 : Sections 13.1 - 13.7

Recommended Text:

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

Books for Reference:

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.
6. G. de Barra, *Measure Theory and Integration*, New Age International, 2003

Learning Outcomes

This course will enable the students to :

CO Number	CO Statement	Knowledge Level
CO1	understand and describe the basic concepts of Fourier series and Fourier integrals with respect to orthogonal system.	K1, K2
CO2	analyze the representation and convergence problems of Fourier series.	K4
CO3	analyze and evaluate the difference between transforms of various functions.	K4, K5
CO4	formulate and evaluate complex contour integrals directly and by the fundamental theorem.	K5, K6
CO5	apply the Cauchy integral theorem in its various versions to compute contour integration.	K3

Title of the Course		Core Paper – VII PARTIAL DIFFERENTIAL EQUATIONS					
Paper Number		VII					
Category	Core	**Year**	I	**Credits**	4	**Course Code**	
		Semester	II				
Pre-requisite		UG level differential equations					

Objective : To develop skills in solving partial differential equations.

UNIT-I : Partial Differential Equations of First Order: Formation and solution of PDE- Integral surfaces – Cauchy Problem order eqn- Orthogonal surfaces – First order non-linear – Characteristics – Csmpatible system – Charpit method. Fundamentals: Classification and canonical forms of PDE.
Chapter 0: 0.4 to 0.11 (omit .1,0.2.0.3 and 0.11.1) and Chapter 1: 1.1 to 1.5

UNIT-II : Elliptic Differential Equations: Derivation of Laplace and Poisson equation – BVP – Separation of Variables – Dirichlet's Problem and Newmann Problem for a rectangle – Interior and Exterior Dirichlets's problems for a circle – Interior Newmann problem for a circle – Solution of Laplace equation in Cylindrical and spherical coordinates – Examples.

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

UNIT-III : Parabolic Differential Equations: Formation and solution of Diffusion equation – Dirac-Delta function – Separation of variables method – Solution of Diffusion Equation in Cylindrical and spherical coordinates Examples.

Chapter 3: 3.1 to 3.7 (omit 3.8 & 3.9)

UNIT-IV : Hyperbolic Differential equations: Formation and solution of one-dimensional wave equation – canonical reduction – IVP- d'Alembert's solution – Vibrating string – Forced Vibration – IVP and BVP for two-dimensional wave equation – Periodic solution of one-dimensional wave equation in cylindrical and spherical coordinate systems – vibration of circular membrane – Uniqueness of the solution for the wave equation – Duhamel's Principle – Examples
Chapter 4: 4.1 to 4.11(omit 4.12&4.13)

UNIT-V: Green's Function: Green's function for laplace Equation – methods of Images – Eigen function Method – Green's function for the wave and Diffusion equations.
Laplace Transform method: Solution of Diffusion and Wave equation by Laplace Transform.

Chapter 5: 5.1 to 5.6 Chapter 6: 6.13.1 and 6.13.2 only (omit (6.14)

Recommended Text:

S, Sankar Rao, *Introduction to Partial Differential Equations,* 2^{nd} Edition, Prentice Hall of India, New Delhi. 2005

Books for Reference:

1. R.C.McOwen, *Partial Differential Equations*, 2^{nd} Edn. Pearson Eduction, 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.

Learning Outcomes

This course will enable the students to :

CO Number	CO Statement	Knowledge Level
CO1	recognize the major classification of PDEs and the qualitative differences between the classes of equations.	K1
CO2	demonstrate modeling assumptions and derivations that lead to PDEs.	K2
CO3	be critically competent in solving linear PDEs using classical solution methods.	K4
CO4	use knowledge of partial differential equations for modeling the general structure of solutions and using analytic methods for solutions.	K6
CO5	investigate and solve boundary values problems and point out its significance.	K3, K5

Title of the Course		Core Paper – VIII **Probability Theory**					
Paper Number		**VIII**					
Category	Core	**Year**	**I**	**Credits**	4	**Course Code**	
		Semester	**II**				
Pre-requisite		Probability at UG level					

Objective : To study the fundamental concepts of measure theory, probability measures, Law of large numbers, Central Limit Theorems and its ramifications.

Unit–I

Fundamental concepts – Measure Theory-Classes of sets –Probability measures and their Distribution Functions

Chapter 2: Sections 2.1,2.2

Unit- II

Random variables – Expectation – Properties of Mathematical Expectations-Independence-Simple problems

Chapter-3 : Sections 3.1,3.2,3.3

Unit–III

Convergence concepts – Various modes of convergence – Borel-Cantelli Lemma-Vague convergence

Chapter-4 : Sections 4.1,4.2,4.3

Unit–IV

Law of large numbers-Random series – Impel theorems-Weak law of large numbers-Convergence series –Strong

Law of large numbers –Simple problems

Characteristic Functions : General properties-Convolutions &Uniqueness – Convergence theorems-Simple applications

Chapter -5 : Sections 5.1 – 5.4 , Omit 5.5
Chapter-6 : Sections 6.1-6.4

Unit-V
Central Limit Theorems and its Ramifications

Liapounov's theorem – Lindeberg Feller Theorem-Ramification of Feller Limit theorems

Conditioning – Markovian property – Martingale – Basic properties of conditional expectations-Conditional

Independence –Markov property-Basic properties of Smartingales.

Chapter- 7 : Sections 7.1 – 7.3
Chapter-9 : Sections 9.1-9.3

Recommended Text:

Kai Lai Chung , A Course in Probability Theory, Third edition – Academic Press, New York , 1974

Books for Reference:

1. R.B.Ash , Real Analysis and Probability , Academic Press , New York , 1972
2. R.Durrett , Probability : Theory and Examples, [2nd Edition] , Duxpury Press , New York, 1996
3. V.K.Rohatgi , An Introduction to Probability : Theory and Mathematical Statistics , Weiley 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.
6. M.Fisz , Probability Theory and Mathematical Statistics, John Wiley and Sons, New York, 1963 .

Learning Outcomes

This course will enable the students to :

CO Number	CO Statement	Knowledge Level
CO1	analyze and describe various modes of convergence concepts.	K4, K5
CO2	classify the concept of law of large numbers and weak law of large numbers.	K1
CO3	Illustrate the simple problems.	K2
CO4	construct various mathematical proofs using the properties of mathematical expectations.	K3
CO5	explain the concept of markovian property and martingale.	K6

Group –B (Elective Paper-II)

<table>
<tr><td>Title of the course</td><td colspan="7">MATHEMATICAL PROGRAMMING</td></tr>
<tr><td>Paper Number</td><td colspan="7"></td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">Elective</td><td>Year</td><td>I</td><td rowspan="2">Credits</td><td rowspan="2">3</td><td rowspan="2">Course Code</td><td rowspan="2"></td></tr>
<tr><td>Semester</td><td>II</td></tr>
<tr><td>Pre-requisite</td><td colspan="7">Basic mathematical programming techniques</td></tr>
<tr><td>Course outline</td><td colspan="7">UNIT – I : Integer Linear Programming : Types of Integer Linear Programming Problems – Concept of Cutting Plane – Gomory’s All Integer Cutting Plane Method – Gomory’s Mixed Integer Cutting Plane Method- Branch and Bound Method
Chapter 7</td></tr>
<tr><td></td><td colspan="7">UNIT – II : Dynamic Programming : Characteristics of Dynamic Programming Problem - Developing Optimal Decision Policy- Dynamic Programming under Certainty – DP approach to solve LPP
Chapter 22</td></tr>
<tr><td></td><td colspan="7">UNIT – III: Classical Optimization Method : Unconstrained Optimization – Constrained Multi- variable Optimization with Equality Constraints – Constrained Multi-variable Optimization with inequality Constraints
Non-linear Programming Methods : Examples of NLPP – General NLPP – Graphical Solution – Quadratic Programming – Wolfe’s modified simplex method
Chapter 23 and Chapter 24: Sections 24.1 to 24.4 (Omit Beale’s method)</td></tr>
<tr><td></td><td colspan="7">UNIT – IV : Linear Programming Problem – Simple problems.
Parametric Linear Programming : Variation in the coefficients c_j, Variations in the Right hand side, b_i
Chapter 4 : Section 4.1 to 4.3 and Chapter 29</td></tr>
<tr><td></td><td colspan="7">UNIT – V: Goal Programming : Difference between LP and GP approach – Concept of Goal Programming – Goal Programming Model formulation – Graphical solution method of Goal Programming.
Chapter 8 : Section 8.1 to 8.5</td></tr>
<tr><td>Recommended Text</td><td colspan="7">J.K.Sharma, Operations Research,(fourth edition) Macmillan, New Delhi, 2009</td></tr>
<tr><td>Reference Books</td><td colspan="7">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 Operations Research (7th edition) Tata – McGraw Hill Company , New Delhi, 2001.
3. Beightler. C, D.phillips, B. Wilde, Foundations of Optomization (2nd edition) Prentice Hall Pvt Ltd., New York, 1979
4. S.S. Rao – Optimization Theory and Applications, Wiley Eastern, New Delhi. 1990</td></tr>
</table>

Group –B (Elective Paper-II)

<table>
<tr><td colspan="2">Title of the course</td><td colspan="6">WAVELETS</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="6"></td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">Elective</td><td>Year</td><td>I</td><td rowspan="2">Credits</td><td rowspan="2">3</td><td rowspan="2">Course Code</td><td rowspan="2"></td></tr>
<tr><td>Semester</td><td>II</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="6">Basic Analysis and Linear Algebra</td></tr>
<tr><td colspan="2">Course Outline</td><td colspan="6">UNIT – I : The Discrete Fourier Transforms
Chapter 2 : Sections 2.1 to 2.3</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT - II : Wavelets on Z _n
Chapter 3 : Sections 3.1 and 3.2</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT – III : Wavelets on Z
Chapter 4 : Sections 4.1 to 4.3</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT – IV : Wavelets on z (Continued)
Chapter 4 : Sections 4.4 to 4.6</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT - V : Wavelets on R
Chapter 5 : Sections 5.1 to 5.5</td></tr>
<tr><td colspan="2">Recommended Text</td><td colspan="6">Michael W Fraier, An Introduction to Wavelets through Linear Algebra, Springer verlag, Berlin, 1999</td></tr>
<tr><td colspan="2">Reference Books</td><td colspan="6">1. C.K. Chui, An Introduction to Wavelets, Academic Press, 1992
2. E. Hernande and G.Weiss, A First Course in Wavelets, CRC Press, NY 1996
3. D.F. Walnut, Introduction to Wavelet Analysis, Birkhauser, 2004</td></tr>
</table>

Group –B (Elective Paper-II)

<table>
<tr><td colspan="2">Title of the course</td><td colspan="6">COMBINATORICS</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="6"></td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">Elective</td><td>Year</td><td>I</td><td rowspan="2">Credits</td><td rowspan="2">3</td><td rowspan="2">Course
Code</td><td rowspan="2"></td></tr>
<tr><td>Semester</td><td>II</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="6"></td></tr>
<tr><td colspan="2">Course Outline</td><td colspan="6">UNIT – I : Basic Combinatorial numbers
Chapter 1 : Section 1</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT - II : Generator Functions and Recurrence Relations – Symmetric functions
Chapter 1 : Sections 2 and 3</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT – III : Multinomials – Inclusion and Exclusion Principle
Chapter 1 : Sections 4 and 5</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT – IV : Necklace Problem and Burnside's Lemma – Cycle Index of Permutation Group – Polya's Theorems and their Applications
Chapter 2 : Sections 1, 2 and 3.</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT - V : Binary Operations on Permutation Groups
Chapter 2 : Section 4</td></tr>
<tr><td colspan="2">Recommended Text</td><td colspan="6">V.Krishnamoorthy, Combinatorics – Theory and Applications , Affiliated East – West Press Pvt Ltd, New Delhi , 1985</td></tr>
<tr><td colspan="2">Reference Books</td><td colspan="6">4. Aigner, M.Combinatorial Theory, Springer Verlag, Berlin 1979
5. Liu, C.L. Introduction to Combinatorial Mathematics. MC
6. Grimaldi, R.P. Discrete and combinatorial Mathematics : An applied introduction (4th Edition). Pearson, (8th Indian Print)</td></tr>
</table>

Extra Disciplinary-I

Title of the course	MATHEMATICAL ECONOMICS						
Paper Number							
Category	Elective	Year	I	Credits	3	Course Code	
		Semester	II				
Pre-requisite	U.G. Level Modern Algebra and Calculus						
Objectives of the Course	To initiate the study on consumer behavior, Theory of Firms, Markets Equilibrium, Welfare Economics						
Course Outline	UNIT – I : The THEORY OF CONSUMER BEHAVIOUR : Utility function – Indifference Curves – Rate of Commodity Substitution – Existence of Utility Function – maximization of Utility – Choice of a Utility Index						
	UNIT - II : Demand function – Income and Leisure – Substitution and Income effects – Generalisation to n variables – Theory of Revealed Preference – Problem of Choice in Risk. Chapter 2: Sections 2.1 to 2.10 for Unit I and II						
	UNIT – III : The Theory of Firm : Production Function – Productivity Curves – isoquents – Optimization behavior – Input Demand Functions – Cost Functions (short – run and long –run) – Homogeneous Production functions and their properties – CES Production Function and their properties – Joint products – Generalisation to m variables						
	UNIT – IV : Market Equilibrium : Assumption of Perfect Competition – Demand Functions – Supply Functions – Commodity Equilibrium – Applications of the Analysis – factor Market Equilibrium – Existence of Existence Equilibrium – Stability of Equilibrium – Dynamic Equilibrium with lagged adjustment.						
	UNIT - V : Imperfect Competition : Monopoly and its applications – Duopoly and Oligopoly – Monopolistic Composition – Monopsony, Duopsony and Oligopsony – Bilateral Monopoly Chapter 6 : Sections 6.1 to 6.7						
Recommended Text	J.M. Henderson and R.E. Quandt, Micro Economic Theory – A mathematical Approach (2^{nd} Edn) McGraw Hill ,New York , 1971						
Reference Books	1. W.J. Baumol, Economic Theory and Operation Analysis, Prentice Hall of India, New Delhi, 1978 2. A.C. Chiang, Fundamental Methods of Mathematical Economics, McGraw Hill, New York, 1984 3. M.D. Intriligator, Mathematical Optimization and Economic Theory, Prentice hall, New York, 191 4. A. Kautsoyiannis, Modern Microeconomics (2^{nd} Edn) McMillan, New York, 1979.						

Extra Disciplinary-I

<table>
<tr><td colspan="2">Title of the course</td><td colspan="6">PROGRAMMING IN C^{++}</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="6"></td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">Elective</td><td>Year</td><td>I</td><td rowspan="2">Credits</td><td rowspan="2">3</td><td rowspan="2">Course Code</td><td rowspan="2"></td></tr>
<tr><td>Semester</td><td>II</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="6">Basics of Computer Programming</td></tr>
<tr><td colspan="2">Course Outline</td><td colspan="6">UNIT – I : Tokens, Expressions and Control Structures
Chapter 3 : Sections 3.1 – 3.25</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT – II : Functions in C^{++}
Chapter 4 : Sections 4.1 to 4.12</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT – III : Classes and Objects
Chapter 5 : Sections 5.1 to 5.19</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT – IV : Constructors and Destructors
Chapter 6 : Sections 6.1 – 6.11</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT – V: Operator overloading and Type Conversions
Chapter 7 : Sections 7.1 to 7.9</td></tr>
<tr><td colspan="2">Recommended Text</td><td colspan="6">E. Balaguruswamy, Object Oriented Programming with C^{++}, Tata McGraw Hill, New Delhi, 1999</td></tr>
<tr><td colspan="2">Reference Books</td><td colspan="6">D.Ravichandran, Programming with C^{++}, Tata McGraw Hill, New Delhi, 1996</td></tr>
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Extra Disciplinary-I

<table>
<tr><td colspan="2">Title of the course</td><td colspan="6">Financial Mathematics</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="6"></td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">Elective</td><td>Year</td><td>I</td><td rowspan="2">Credits</td><td rowspan="2">3</td><td rowspan="2">Course Code</td><td rowspan="2"></td></tr>
<tr><td>Semester</td><td>II</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="6">Stochastic Processes</td></tr>
<tr><td colspan="2">Course Outline</td><td colspan="6">UNIT – I : Single Period Models: Definitions from Finance – Pricing of a Forward – One – step Binary Model
Chapter 1 : Sections 1.1 to 1.3</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT – II : Single Period Models ; A characterization of no arbitrage – Risk – Neutral Probability Measure
Chapter 1 : Sections 1.5 and 1.6</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT – III : Binomial trees and Discrete parameter Martingales: Multi period Binary Model – American options
Chapter 2: Sections 2. 1 and 2.2</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT – IV : Binomial trees and Discrete parameter Martingales: Discrete parameter martingales and Markov processes – Martingale theorems
Chapter 2 : Sections 2.3 and 2.4</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT – V: Brownian Motion : Definition of the process – Levy's construction of Brownian Motion
Chapter 3 : Sections 3.1 and 3.2</td></tr>
<tr><td colspan="2">Recommended Text</td><td colspan="6">A.Etheridge, A course in Financial Calculus, Cambridge University Press, 2002</td></tr>
<tr><td colspan="2">Reference Books</td><td colspan="6">1. M. Boxter and A. Rennie, Financial calculus: An Introduction to Derivatives Pricing, Cambridge University Press, 1996
2. D. Lamberton and B. Lapeyre, Introduction to Stocahstic calculus Applied to Finance, Chapman and hall, 1966
3. M. Musiela and M. Rutkowski, Martingale Methods in Financial Modeling, Springer, New York, 1988
4. R.J. Elliott and P.Ekkehard Kopp, Mathematics of Financial Markets, Springer, New York, 2001 (3rd Printing)</td></tr>
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SEMESTER III

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="7">Core Paper – IX COMPLEX ANALYSIS-I</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="7">IX</td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">Core</td><td>Year</td><td>II</td><td rowspan="2">Credits</td><td rowspan="2">4</td><td rowspan="2">Course Code</td><td rowspan="2"></td></tr>
<tr><td>Semester</td><td>III</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="7">Basics at UG level</td></tr>
</table>

Objective : To study the Cauchy's Integral formula, Analytical functions, Harmonic functions and Entire functions.

UNIT I - Cauchy's Integral Formula: The Index of a point with respect to a closed curve - The Integral formula - Higher derivatives.
Local Properties of Analytical Functions : Removable Singularities-Taylors's Theorem-Zeros and poles-The local Mapping - The Maximum Principle .
Chapter 4 : Section 2 : 2.1 to 2.3, Section 3 : 3.1 to 3.4

UNIT II - The general form of Cauchy's Theorem : Chains and cycles- Simple Connnectivity -Homology - The General statement of Cauchy's Theorem - Proof of Cauchy's theorem – Locally exact differentials-Multilply connected regions – Residue theorem - The argument principle.
Chapter 4 : Section 4 : 4.1 to 4.7, Section 5: 5.1 and 5.2

UNIT III - Evaluation of Definite Integrals and Harmonic Functions:
Evaluation of definite integrals - Definition of Harmonic functions and basic properties - Mean value property - Poisson formula.
Chapter 4 : Section 5 : 5.3, Section 6 : 6.1 to 6.3

UNIT IV - Harmonic Functions and Power Series Expansions:
Schwarz theorem - The reflection principle - Weierstrass theorem - Taylor Series - Laurent series .
Chapter 4 : Sections 6.4 and 6.5
Chapter 5 : Sections 1.1 to 1.3

UNIT V - Partial Fractions and Entire Functions: Partial fractions – Infinite products - Canonical products - Gamma Function - Jensen's formula
Chapter 5 : Sections 2.1 to 2.4, Section 3.1

Recommended Text :

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

Books for Reference:

1. H.A. Priestly, *Introduction to Complex Analysis,* Clarendon Press,Oxford, 2003.

2. J.B.Conway, *Functions of one complex variable*, Springer International Edition, 2003

3. T.W Gamelin, *Complex Analysis,* Springer International Edition, 2004.

4. D.Sarason, *Notes on complex function Theory*, Hindustan Book Agency, 1998

Learning Outcomes

This course will enable the students to :

CO Number	CO Statement	Knowledge Level
CO1	analyze and evaluate local properties of analytical functions and definite integrals.	K4, K5
CO2	describe the concept of definite integral and harmonic functions.	K1
CO3	demonstrate the concept of the general form of Cauchy's theorem.	K2
CO4	develop Taylor and Laurent series .	K3
CO5	explain the infinite products, canonical products and jensen's formula .	K6

Title of the Course		Core Paper – X TOPOLOGY					
Paper Number		X					
Category	Core	Year	II	Credits	4	Course Code	
		Semester	III				
Pre-requisite		Concepts in Real analysis					

Objective : To develop student's topological and proof writing skills which are essential in the study of advanced mathematics, understand the concepts of topological spaces, analyze and synthesize proofs, understanding the concepts of connectedness and compactness.

Unit I - Topological spaces, Basis for a topology, Product topology on X x Y, Subspace topology, Closed sets and Limit points, Continuous functions.
Chapter 2 - Sections 12, 13, 15, 16, 17, 18.

Unit II - Connected spaces, Connected subspaces of the real line, Components and Local connectedness, Compact spaces, Compact subspaces of the real line.
Chapter 3 - Sections 23, 24, 25, 26, 27.

Unit III - Countability axioms, Separation axioms, Normal spaces, Urysohn Lemma, Urysohn metrization theorem, Tietze extension theorem.
Chapter 4 - Sections 30, 31, 32, 33, 34, 35.

Unit IV - Product topology, Tychonoff theorem.
Chapter 2 - Sections 19.
Chapter 5 - Section 37.

Unit V - Homotopy of paths, Fundamental group.
Chapter 9 - Sections 51, 52.

Recommended Text :

James R. Munkres *"Topology"* (Second edition) PHI, 2015.

Books for Reference:

1. T.W. Gamelin and R.E. Greene, *Introduction to Topology*, The Saunders Series, 1983.
2. G.F. Simmons, *Introduction to Topology and Modern Analysis*, Mcgraw-Hill
3. J. Dugundji, *Topology*, Prentice Hall of India.
4. J.L. Kelly, *General Topology, Springer*.
5. S. Willard, *General Topology*, Addison-Wesley.

Learning Outcomes

This course will enable the students to :

CO Number	CO Statement	Knowledge Level
CO1	define and illustrate the concept of topological spaces and the basic definitions of open sets, neighbourhood, interior, exterior, closure and their axioms for defining topological space.	K1, K2
CO2	understand continuity, compactness, connectedness, homeomorphism and topological properties.	K2
CO3	analyze and apply the topological concepts in Functional Analysis.	K3, K4
CO4	ability to determine that a given point in a topological space is either a limit point or not for a given subset of a topological space.	K5
CO5	develop qualitative tools to characterize connectedness, compactness, second countable, Hausdorff and develop tools to identify when two are equivalent(homeomorphic).	K6

<table>
<tr><td>Title of the Course</td><td colspan="7">Core Paper – XI : OPERATIONS RESEARCH</td></tr>
<tr><td>Paper Number</td><td colspan="7">XI</td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">Core</td><td>Year</td><td>II</td><td rowspan="2">Credits</td><td rowspan="2">4</td><td rowspan="2">Course Code</td><td rowspan="2"></td></tr>
<tr><td>Semester</td><td>III</td></tr>
<tr><td>Pre-requisite</td><td colspan="7">UG Level Operations Research</td></tr>
</table>

Objective : To study the decision theory, network models, queueing theory and replacement and maintenance models.

UNIT-I : Decision Theory **:** Steps in Decision theory Approach – Types of Decision-Making Environments – Decision Making Under Uncertainty – Decision Making under Risk – Posterior Probabilities and Bayesian Analysis – Decision Tree Analysis – Decision Making with Utilities.
Chapter 10 : Sec. 10.1 to 10.8

UNIT-II : Network Models : Scope of Network Applications – Network Definition – Minimal spanning true Algorithm – Shortest Route problem – Maximum flow model – Minimum cost capacitated flow problem - Network representation – Linear Programming formulation – Capacitated Network simplex Algorithm.

Chapter 6 : Sections 6.1 to 6.6 from **H.A.Taha :** Operations Research

UNIT-III : Deterministic Inventory Control Models: Meaning of Inventory Control – Functional Classification – Advantage of Carrying Inventory – Features of Inventory System – Inventory Model building - Deterministic Inventory Models with no shortage – Deterministic Inventory with Shortages
Probabilistic Inventory Control Models:
Single Period Probabilistic Models without Setup cost – Single Period Probabilities Model with Setup cost.
Chapter 13: Sec. 13.1 to 13.8
Chapter 14: Sec. 14.1 to 14.3

UNIT-IV : Queueing Theory : Essential Features of Queueing System – Operating Characteristic of Queueing System – Probabilistic Distribution in Queueing Systems – Classification of Queueing Models – Solution of Queueing Models – Probability Distribution of Arrivals and Departures – Erlangian Service times Distribution with k-Phases.
Chapter 15 : Sec. 15.1 to 15.8

UNIT-V : Replacement and Maintenance Models: Failure Mechanism of items – Replacement of Items that deteriorate with Time – Replacement of items that fail completely – other Replacement Problems.

Chapter 16: Sec. 16.1 to 16.5

Recommended Texts :

1. (For Unit 2) : H.A. Taha, *Operations Research*, 6th edition, Prentice Hall of India
2. (For all other Units): J.K.Sharma, *Operations Research* , MacMillan India, New Delhi, 2001.

Reference Books :

1. F.S. Hiller and J.Lieberman -,*Introduction to Operations Research* (7th Edition), Tata McGraw Hill Publishing Company, New Delhui, 2001.
2. Beightler. C, D.Phillips, B. Wilde ,*Foundations of Optimization* (2nd Edition) Prentice Hall Pvt Ltd., New York, 1979

3. Bazaraa, M.S; J.J.Jarvis, H.D.Sharall ,*Linear Programming and Network flow*, John Wiley and sons, New York 1990.
4. Gross, D and C.M.Harris, *Fundamentals of Queueing Theory*, (3rd Edition), Wiley and Sons, New York, 1998.

Learning Outcomes

This course will enable the students to :

CO Number	CO Statement	Knowledge Level
CO1	analyze and evaluate deterministic inventory control model.	K4, K5
CO2	describe the concept of Queueing theory.	K1
CO3	demonstrate the concept of network models.	K2
CO4	construct deterministic inventory control model and probabilistic inventory control model.	K3
CO5	explain the concept of replacement and maintenance models.	K6

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="6">Core Paper – XII MECHANICS</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="6">XII</td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">Core</td><td>Year</td><td>II</td><td rowspan="2">Credits</td><td rowspan="2">4</td><td rowspan="2">Course Code</td><td rowspan="2"></td></tr>
<tr><td>Semester</td><td>III</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="6">Calculus and Differential equations.</td></tr>
</table>

Objective : To study mechanical systems under generalized coordinate, virtual work, energy and momentum, also to study the mechanics developed by Newton, Lagrange, Hamilton and Jacobi.

UNIT-I : Mechanical Systems : The Mechanical system- Generalised coordinates – Constraints - Virtual work - Energy and Momentum

Chapter 1 : Sections 1.1 to 1.5

UNIT-II : Lagrange's Equations: Derivation of Lagrange's equations- Examples- Integrals of motion.

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

UNIT-III : Hamilton's Equations : Hamilton's Principle - Hamilton's Equation - Other variational principles.

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

UNIT – IV : Hamilton-Jacobi Theory - Hamilton Principle function – Hamilton-Jacobi Equation - Separability

Chapter 5 : Sections 5.1 to 5.3

UNIT-V : Canonical Transformation- 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)

Recommended Text :

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

Books for Reference:

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.

Learning Outcomes

This course will enable the students to :

CO Number	CO Statement	Knowledge Level
CO1	demonstrate the knowledge of core principles in mechanics.	K2
CO2	interpret and consider complex problems of classical dynamics in a systematic way.	K3, K5
CO3	apply the variation principle for real physical situations.	K4
CO4	explore different applications of these concepts in the mechanical and electromagnetic fields.	K6
CO5	describe and apply the concept of Angular momentum, Kinetic energy and Moment of inertia of a particle.	K1

Group – C (Elective Paper-III)

<table>
<tr><td colspan="2">Title of the course</td><td colspan="7">ALGEBRAIC THEORY OF NUMBERS</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="7"></td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">Elective</td><td>Year</td><td>II</td><td rowspan="2">Credits</td><td rowspan="2">3</td><td rowspan="2">Course code</td><td rowspan="2"></td></tr>
<tr><td>Semester</td><td>III</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="7">Algebra and Linear Algebra</td></tr>
<tr><td colspan="2">Course Outline</td><td colspan="7">UNIT – I : Algebraic back ground : Rings and Fields – Factorization of
Polynomials – Field extensions – Symmetric polynomials – Modules –
Free Abelian groups.
Chapter 1 : Sections – 1.1 to 1.6</td></tr>
<tr><td colspan="2"></td><td colspan="7">UNIT – II : Algebraic numbers – Conjugate and Discriminant – Algebraic integers.
Chapter 2 : Sections – 2.1 – 2.3</td></tr>
<tr><td colspan="2"></td><td colspan="7">UNIT – III : Integral bases – Norms and traces – Rings of integers
Chapter 2 : Sections – 2.4 to 2.6</td></tr>
<tr><td colspan="2"></td><td colspan="7">UNIT – IV : Quadratic fields – Cyclotomic fields
Chapter 3 : Sections – 3.1 – 3.2</td></tr>
<tr><td colspan="2"></td><td colspan="7">UNIT – V : Historical background – trivial factorization – factorization into irreducibles
Chapter 4 : Sections – 4.1 – 4.3</td></tr>
<tr><td colspan="2">Recommended Text</td><td colspan="7">I.Stewart and D.Tall. Algebraic number theory and Fermat's Last theorem (3rd edition) A.K Peters Ltd,Natrick, Mass. 2002</td></tr>
<tr><td colspan="2">Reference Books</td><td colspan="7">1. Z. I. Borevic and I.R.Safarevic, Number theory, Academic Press, NY, 1966.
2. J.W.S.cassels and A.Frohlich, Algebraic , Number theory, Academic Press, New York, 1967.
3. P. Ribenboim, Algebraic numbers, Wiley, New York, 1972.
4. P.Samuel, Algebraic Theory of Numbers, Houghton Mifflin company, Boston, 1970</td></tr>
</table>

Group –C (Elective Paper-III)

Title of the course		NUMBER THEORY AND CRYPTOGRAPHY					
Paper Number							
Category	Elective	Year	II	Credits	3	Course Code	
		Semester	III				
Pre-requisite		Elementary number theory and calculus					
Course Outline		UNIT – I : Elementary Number Theory : Time estimates for doing arithmetic – divisibility and the Euclidean algorithm Chapter 1 : Sections 1 and 2					
		UNIT - II : Elementary Number Theory :Congruences – Some applications to factoring Chapter 1 : Sections 3 and 4					
		UNIT – III : Finite Fields and Quadratic Residues: Finite Fields, Quadratic residues and reciprocity Chapter 2 : Sections 1 and 2					
		UNIT – IV : Cryptography : Some simple cryptosystems – Enciphering matrices Chapter 3 : Sections 1 and 2.					
		UNIT - V : Public Key : Public Key Cryptography - RSA Chapter 4 : Sections 1 and 2					
Recommended Text		Neal Koblit, A course in Number Theory and Cryptography, Springer – Verlag, New York, 1987					
Reference Books		1. I. Niven and H.S.uckermann, An Introduction to Theory of Numbers (Edition 3), Wiley Eastern Ltd, New Delhi 1976 2. D.M.Burton, Elementary Number Theory, Brown Publishers, Iowa, 1989 3. K.Ireland and M.Rosen, A classic Introduction to Modern Number Theory, Springer – Verlag, 1972 4. N.Koblit, Algebraic Aspects of Cryptography, Springer-Verlag, 1998					

Group –C (Elective Paper-III)

<table>
<tr><td colspan="2">Title of the course</td><td colspan="6">STOCHASTIC PROCESSES</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="6"></td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">Elective</td><td>Year</td><td>II</td><td rowspan="2">Credits</td><td rowspan="2">3</td><td rowspan="2">Course Code</td><td rowspan="2"></td></tr>
<tr><td>Semester</td><td>III</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="6">Probability Theory</td></tr>
<tr><td colspan="2">Course Outline</td><td colspan="6">UNIT – I : Markov Chains : Classification of general stochastic processes – markov chain – Examples – Transition probability matrix – Classification of states - Recurrence
Chapter 1 : Section 3 only and Chapter 2 : sections 1 to 5.</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT - II : Limit theorems of Markov chains : Discrete renewal equation and its proof – Absorption probabilities – criteria for recurrence – Queuing models
Chapter 3 : Sections 1 to 7</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT – III : Continuous time Markov Chains : Poisson process – Pure Birth process – Birth and Death process - Birth and Death process with absorbing states
Chapter 1 : Section 2 (Poisson process)
Chapter 4 : Sections 1, 2 and 4to 7 (omit sections 3 and 8)</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT – IV : Renewal processes : Definition and related concepts – Some special renewal processes
Chapter 5 : sections 1 - 3</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT - V : Brownian Motion : Definition – Joint probabilities for Brownian Motion – Continuity of paths and the maximum variables – Variations and extensions
Chapter 1 : Section 2 (Brownian Motion)
Chapter 6 : sections 1 to 4 and 7A only</td></tr>
<tr><td colspan="2">Recommended Text</td><td colspan="6">S.Karlin and H.M. taylor, A first course in stochastic processes (2nd edition) Academic Press, New York, 1975</td></tr>
<tr><td colspan="2">Reference Books</td><td colspan="6">1. E. Cinler, Introduction to stochastic processes, Prentice Hall Inc, New Delhi, 1975
2. D.R.Cox and H.D.Miller, Theory of stochastic processes (3rd Edition) Chapman and hall, London, 1983
3. D.Kannan, An introduction to stochastic processes, North-Holland, New York, 1979
4. S.M. Ross, Stochastic processes, John Wiley and Sons, New York, 1983
5. H.W. Taylor nd S.Karlin, An introduction to stochastic modeling (3rd Edition), Academic Press, New York, 1998</td></tr>
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Extra Disciplinary-II

<table>
<tr><td colspan="2">Title of the course</td><td colspan="6">JAVA PROGRAMMING</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="6"></td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">Elective</td><td>Year</td><td></td><td rowspan="2">Credits</td><td rowspan="2">3</td><td rowspan="2">Course Code</td><td rowspan="2"></td></tr>
<tr><td>Semester</td><td></td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="6">Knowledge in Programming in C / C^{++}</td></tr>
<tr><td colspan="2">Course Outline</td><td colspan="6">UNIT – I : Overview of Java Language: Java Tokens – Java Statements.
Chapter 3 : Section 3.1 to 3.12</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT – II : Constants – Variables – Data Types
Chapter 4 : Section 4.1 to 4.12</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT – III : Operators - Expressions
Chapter 5 : Section 5.1 to 5.16</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT – IV : Decision making and Branching
Chapter 6 : Section 6.1 – 6.9</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT – V : Classes – Objects – Methods – Arrays – Strings
Chapter 8 : Section 8.1 to 8.19
Chapter 9 : Section 9.1 to 9.5</td></tr>
<tr><td colspan="2">Recommended Text</td><td colspan="6">E. Balaguruswamy, Programming with Java – A primer, Tata McGraw Hill Publishing Company Limited, New Delhi, 1998</td></tr>
<tr><td colspan="2">Reference Books</td><td colspan="6">1. Mitchell Waite and Robert Lafore, Data Structure and Algorithms in Java, Tech media (Indian Edition) New Delhi, 1999
2. Adam Drozdek, Data Structures and Algorithms in Java (Brown /Cole) Vikas Publishing House, New Delhi 2001.</td></tr>
</table>

Extra Disciplinary-II

<table>
<tr><td>Title of the course</td><td colspan="7">DATA STRUCTURES AND ALGORITHMS</td></tr>
<tr><td>Paper Number</td><td colspan="7"></td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">Elective</td><td>Year</td><td></td><td rowspan="2">Credits</td><td rowspan="2">3</td><td rowspan="2">Course Code</td><td rowspan="2"></td></tr>
<tr><td>Semester</td><td></td></tr>
<tr><td>Pre-requisite</td><td colspan="7"></td></tr>
<tr><td>Course Outline</td><td colspan="7">UNIT – I : Algorithms – Structures Programs – Analysis of Algorithms
Chapter 1 : Sections 1.1 to 1.4</td></tr>
<tr><td></td><td colspan="7">UNIT – II: Stacks and Queues – Trees – Heaps and Heapsort
Chapter 2 : Sections 2.1 to 2.3</td></tr>
<tr><td></td><td colspan="7">UNIT – III : Sets and disjoint set Union – graphs – Hashing
Chapter 2 : Sections 2.4 to 2.6</td></tr>
<tr><td></td><td colspan="7">UNIT – IV : The General – Binary Search – Finding the Maximum and Minimum
Chapter 3 : Sections 3.1 to 3.3</td></tr>
<tr><td></td><td colspan="7">UNIT – V: Merge sort – Quick sort – Selection sort
Chapter 3 : Section 3.4 to 3.6</td></tr>
<tr><td>Recommended Text</td><td colspan="7">E. Horowitz and S. Shani. Fundamentals of Computer Algorithm, Galgotia publications, New Delhi, 1984.</td></tr>
<tr><td>Reference Books</td><td colspan="7">1. D.E. Knuth, The Art of Computer Programming Sorting and Searching Vol. 3. Addism tresher mass, 1973
2. A. NiJenhuis and H.S. Wilf, Combinatorial Algorithms, Academic Press. New York, 1975.
3. A.V. Aho, J.E. Hoperoft, J.D. Ullman, The Design and Analysis of Computer Algorithms. Addision – Wesley Reading , Mass, 1974.</td></tr>
</table>

SEMESTER IV

Title of the Course		Core Paper XIII : COMPLEX ANALYSIS- II					
Paper Number		XIII					
Category	Core	Year	II	Credits	4	Course Code	
		Semester	IV				
Pre-requisite		Complex Analysis-I and Real Analysis					

Objective : To study the Riemann Zeta Function, Riemann mapping theorem, Weierstrass theory and Analytic Continuation.

UNIT-I : Riemann Zeta Function and Normal Famalies :
Product development – Extension of $\zeta(s)$ to the whole plane – The zeros of zeta function – Equicontinuity – Normality and compactness – Arzela's theorem – Families of analytic functions – The Classcial Definition

Chapter 5 : Sections 4.1 to 4.4, Sections 5.1 to 5.5

UNIT-II : Riemann mapping Theorem : Statement and Proof – Boundary Behaviour – Use of the Reflection Principle.
Conformal mappings of polygons : Behaviour at an angle - Schwarz-Christoffel formula Mapping of a rectangle.
Harmonic Functions : Functions with mean value property – Harnack's principle.

Chapter 6 : Sections 1.1 to 1.3 (Omit Section 1.4)
Sections 2.1 to 2.3 (Omit section 2.4), Section 3.1 and 3.2

UNIT-III : Elliptic functions **:** Simply periodic functions – Doubly periodic functions

Chapter 7 : Sections 1.1 to 1.3, Sections 2.1 to 2.4

UNIT-IV : Weierstrass Theory : The Weierstrass $\wp$-function – The functions $\zeta(s)$ and $\sigma(s)$ – The differential equation – The modular equation $\lambda(\tau)$ – The Conformal mapping by $\lambda(\tau)$.

Chapter 7 : Sections 3.1 to 3.5

UNIT-V: Analytic Continuation : The Weiesrtrass Theory – Germs and Sheaves – Sections and Riemann surfaces – Analytic continuation along Arcs – Homotopic curves – The Monodromy Theorem – Branch points.

Chapter 8 : Sections 1.1 to 1.7

Recommended Text:

Lars V. Ahlfors, *Complex Analysis*, (3rd Edition) McGraw Hill Book Company, New York, 1979.

Books for Reference:

1.H.A. Priestly, *Introduction to Complex Analysis*, Clarendon Press,Oxford, 2003.
2.J.B.Conway, *Functions of one complex variable*, Springer International Edition, 2003

3.T.W Gamelin, *Complex Analysis*, Springer International Edition, 2004.
4.D.Sarason, *Notes on Complex function Theory*, Hindustan Book Agency, 1998

Learning Outcomes

This course will enable the students to :

CO Number	CO Statement	Knowledge Level
CO1	analyze and evaluate Riemann Zeta Function and Normal Famalies.	K4, K5
CO2	describe the concept of Riemann mapping Theorem .	K1
CO3	demonstrate the concept of Simply periodic functions and Doubly periodic functions.	K2
CO4	explain the families of analytic functions.	K3
CO5	develop the concept analytic continuation.	K6

Title of the Course	Core Paper – XIV DIFFERENTIAL GEOMETRY						
Paper Number	XIV						
Category	Core	Year	II	Credits	4	Course Code	
		Semester	IV				
Pre-requisite	Linear Algebra and Calculus						

Objective : This course introduce space curves and their intrinsic properties of a surface and geodesics. Further the non-intrinsic properties of surfaces are explored.

UNIT-I : Space curves: Definition of a space curve — Arc length — tangent — normal and binormal — curvature and torsion — contact between curves and surfaces- tangent surface- involutes and evolutes- Intrinsic equations — Fundamental Existence Theorem for space curves- Helices.
Chapter I : Sections 1 to 9.

UNIT-II : Intrinsic properties of a surface: Definition of a surface curves on a surface — Surface of revolution — Helicoids — Metric- Direction coefficients — families of curves- Isometric correspondence- Intrinsic properties.
Chapter Il: Sections 1 to 9.

UNIT-III : Geodesics: Geodesics — Canonical geodesic equations — Normal property of geodesics- Existence Theorems — Geodesic parallels — Geodesics curvature- Gauss- Bonnet Theorem — Gaussian curvature surface of constant curvature – Conformal mapping.
Chapter II: Sections 10 to 19.

UNIT-IV : Non-intrinsic properties of a surface: The second fundamental form- Principal curvature — Lines of curvature — Developable - Developable associated with space curves and with curves on surfaces - Minimal surfaces — Ruled surfaces.
Chapter III: Sections 1 to 8.

UNIT-V : Differential Geometry of Surfaces :
Compact surfaces whose points are umblics- Hilbert's lemma — Compact surface of constant curvature Complete surfaces and their characterization — Hilbert's Theorem — Conjugate points on geodesics.
Chapter IV : Sections 1 to 8

Recommended Text:

T.J. Willmore, An Introduction to Differential Geometry, Oxford University Press (26th impression) New Delhi 2002. (Indian Print)

Books for Reference:

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

Learning Outcomes

This course will enable the students to :

CO Number	CO Statement	Knowledge Level
CO1	explain space curves, Curves between surfaces, metrics on a surface, fundamental form of a surface and Geodesics.	K2
CO2	evaluate these concepts with related examples.	K5
CO3	compose problems on geodesics.	K6
CO4	recognize applicability of developable.	K1
CO5	construct and analyze the problems on curvature and minimal surfaces.	K3, K4

Title of the Course		Core Paper – XV FUNCTIONAL ANALYSIS					
Paper Number		XV					
Category	Core	Year	I	Credits	4	Course Code	
		Semester	II				
Pre-requisite		Linear Algebra and Calculus					

Objective : To provide students with a strong foundation in functional analysis, focusing on spaces, operators and fundamental theorems. To develop student's skills and confidence in mathematical analysis and proof techniques.

Unit I

Banach Spaces: The definition and some examples – Continuous linear transformations – The Hahn-Banach theorem – The natural imbedding of N in N^{**} - The open mapping theorem – The conjugate of an Operator.

Chapter 9: Sections 46-51

Unit II

Hilbert Spaces: The definition and some simple properties – Orthogonal complements – Orthonormal sets – The conjugate space H^* - The adjoint of an operator – self-adjoint operators - - Normal and unitary operators – Projections.

Chapter 10: Sections 52-59

Unit III

Finite-Dimensional Spectral Theory: Matrices – Determinants and the spectrum of an operator – The spectral theorem.

Chapter 11: Sections 60-62

Unit IV

General Preliminaries on Banach Algebras**:** The definition and some examples – Regular and singular elements – Topological divisors of zero – The spectrum – The formula for the spectral radius – The radical and semi-simplicity.

Chapter 12: Sections 64-69

Unit V

The Structure of Commutative Banach Algebras: The Gelfand mapping – Application of the formula $r(x) = \lim \|x^n\|^{1/n}$ – Involutions in Banach algebras - The Gelfand-Neumark theorem.

Chapter 13: Sections 70-73

Recommended Text:

G. F. Simmons, Introduction to Topology and Modern Analysis, McGraw Hill Education(India) Private Limited, New Delhi, 1963.

Books for Reference:

1. W. Rudin, Functional Analysis, McGraw Hill Education (India) Private Limited, New Delhi, 1973.
2. B.V. Limaye, Functional Analysis, New Age International, 1996.

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.

Learning Outcomes

This course will enable the students to :

CO Number	CO Statement	Knowledge Level
CO1	understand the Banach spaces and Transformations on Banach Spaces.	K2
CO2	prove Hahn Banach theorem and open mapping theorem.	K5
CO3	describe operators and fundamental theorems.	K1
CO4	validate orthogonal and orthonormal sets.	K6
CO5	analyze and establish the regular and singular elements.	K3, K4

Group D: Elective IV (Semester IV)

Title of the Course		**FLUID DYNAMICS**					
Paper Number		**I**					
Category	Elective-IV	**Year**	**II**	**Credits**	**4**	**Course Code**	
		Semester	**IV**				
Pre-requisite		**Basic Differential Equations, Vector Calculus and Complex Analysis**					
Course Outline		**UNIT-I : Kinematics of Fluids in motion.** 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 - Equations 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 : 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 - 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. Introduction- Sources, sinks and doublets - Images in a rigid infinite plane - Axis symmetric flows - Stokes stream function **Chapter 4 Sec 4.1, 4.2, 4.3, 4.5.**					
		UNIT-IV : Some two dimensional flows : 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. **Chapter 5. Sec 5.1 to 5.8**					
		UNIT-V Viscous flows: Stress components in a real fluid. - Relations between Cartesian components of stress- Translational motion of fluid elements - 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**					
Recommended Text		F. Chorlton, *Text Book of Fluid Dynamics* ,CBS Publications. Delhi ,1985.					
Reference Books		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 Yor, 2002. 5. T.Petrila, Basics of Fluid Mechanics and Introduction to Computational Fluid Dynamics, Springer, berlin, 2004.					

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="6">MATHEMATICAL STATISTICS</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="6">I</td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">Elective-IV</td><td>Year</td><td>II</td><td rowspan="2">Credits</td><td rowspan="2">4</td><td rowspan="2">Course Code</td><td rowspan="2"></td></tr>
<tr><td>Semester</td><td>IV</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="6">Basic Probability Theory</td></tr>
<tr><td colspan="2" rowspan="5">Course Outline</td><td colspan="6">UNIT-I : Sample Moments and their Functions: Notion of a sample and a statistic – Distribution functions of $\bar{X}$, S^2 and ($\bar{X}$, S^2) - χ^2 distribution – Student t-distribution – Fisher's Z-distribution – Snedecor's F- distribution – Distribution of sample mean from non-normal populations
Chapter 9 : Sections 9.1 to 9.8</td></tr>
<tr><td colspan="6">UNIT-II : Significance Test : Concept of a statistical test – Parametric tests for small samples and large samples - χ^2 test – Kolmogorov Theorem – Smirnov Theorem – Tests of Kolmogorov and Smirnov type – The Wald-Wolfovitz and Wilcoxon-Mann-Whitney tests – Independence Tests by contingency tables.
Chapter 10 : Sections 10.11
Chapter 11 : 12.1 to 12.7.</td></tr>
<tr><td colspan="6">UNIT-III : Estimation : Preliminary notion – Consistency estimation – Unbiased estimates – Sufficiency – Efficiency – Asymptotically most efficient estimates – methods of finding estimates – confidence Interval.
Chapter 13 : Sections 13.1 to 13.8 (Omit Section 13.9)</td></tr>
<tr><td colspan="6">UNIT-IV : Analysis of Variance : One way classification and two-way classification. Hypotheses Testing: Poser functions – OC function- Most Powerful test – Uniformly most powerful test – unbiased test.
Chapter 15 : Sections 15.1 and 15.2 (Omit Section 15.3)
Chapter 16 : Sections 16.1 to 16.5 (Omit Section 16.6 and 16.7)</td></tr>
<tr><td colspan="6">UNIT-V : Sequential Analysis : SPRT – Auxiliary Theorem – Wald's fundamental identity – OC function and SPRT – E(n) and Determination of A and B – Testing a hypothesis concerning p on 0-1 distribution and m in Normal distribution.
Chapter 17 : Sections 17.1 to 17.9 (Omit Section 17.10)</td></tr>
<tr><td colspan="2">Recommended Text</td><td colspan="6">M. Fisz , Probability Theory and Mathematical Statistics, John Wiley and sons, New Your, 1963.</td></tr>
<tr><td colspan="2">Reference Books</td><td colspan="6">1. E.J.Dudewicz and S.N.Mishra , Modern Mathematical Statistics, John Wiley and Sons, New York, 1988.
2. V.K.Rohatgi An Introduction to Probability Theory and Mathematical Statistics, Wiley Eastern New Delhi, 1988(3rd Edn)
3. G.G.Roussas, A First Course in Mathematical Statistics, Addison Wesley Publishing Company, 1973
4. B.L.Van der Waerden, Mathematical Statistics, G.Allen & Unwin Ltd., London, 1968.</td></tr>
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<table>
<tr><td colspan="2">Title of the Course</td><td colspan="6">ALGEBRAIC TOPOLOGY</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="6"></td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">Elective-IV</td><td>Year</td><td>II</td><td rowspan="2">Credits</td><td rowspan="2">4</td><td rowspan="2">Course Code</td><td rowspan="2"></td></tr>
<tr><td>Semester</td><td>IV</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="6">Algebra, Topology</td></tr>
<tr><td colspan="2" rowspan="5">Course Outline</td><td colspan="6">UNIT-I : Homotopy of paths - Fundamental Group – Covering space - The Fundamental Group of the circle – Retractions and Fixed points

Chapter 9: Sections 51 – 55.</td></tr>
<tr><td colspan="6">UNIT-II : The Fundamental Theorem of Algebra – Borsuk–Ulam Theorem – Deformation Retracts and Homotopy Type – The Fundamental Group of S^n - Fundamental Groups of some surfaces.

Chapter 9 : Sections 56 - 60</td></tr>
<tr><td colspan="6">UNIT-III : Direct sums of Abelian Groups – Free products of Groups – Free Groups – The Seifert–van Kampen Theorem – The Fundamental Group of a wedge of circles.

Chapter 11 : Sections 67 -71.</td></tr>
<tr><td colspan="6">UNIT-IV : Fundamental groups of surfaces – Homology of surfaces – cutting and pasting – The classification theorem – constructing compact surfaces.
Chapter 12 : Sections 74 - 78</td></tr>
<tr><td colspan="6">UNIT-V : Equivalence of covering spaces – The Universal covering space – covering transformations – Existence of covering spaces
Chapter 13 : Sections 79 - 82</td></tr>
<tr><td colspan="2">Recommended Text</td><td colspan="6">J.R.Munkres, Toplogy, Pearson Education Asia , Second Edition 2002.</td></tr>
<tr><td colspan="2"></td><td colspan="6">1. M.K.Agoston, Algebraic topology – A First Course, Marcel Dekker, 1962.
2. Satya Deo, Algebraic Topology , Hindustan Book Agency, New Delhi, 2003.
3. M.Greenberg and Harper, Algebraic Topology – A First course, Benjamin/Cummings, 1981.
4. C.F. Maunder, Algebraic topology, Van Nostrand, New York, 1970.
5. A.Hatcher, Algebraic Topology, Cambridge University Press, South Asian Edition 2002.
6. W.S.Massey, Algebrai Topology : An Introduction, Springer 1990</td></tr>
</table>

Group E: Elective V (Semester IV)

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="6">TENSOR ANALYSIS AND RELATIVITY</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="6"></td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">Elective - V</td><td>Year</td><td>II</td><td rowspan="2">Credits</td><td rowspan="2">4</td><td rowspan="2">Course Code</td><td rowspan="2"></td></tr>
<tr><td>Semester</td><td>IV</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="6">Vector Calculus and Mechanics</td></tr>
<tr><td colspan="2">Course Outline</td><td colspan="6">UNIT-I : Tensor Algebra : Systems of Different orders – Summation Convention – Kronecker Symbols - Transformation of coordinates in S_n - 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</td></tr>
<tr><td colspan="2" rowspan="4"></td><td colspan="6">UNIT-II : Tensor Calculus : Riemannian Space – Christoffel Symbols and their properties.
Chapter III: III.1 and III.2</td></tr>
<tr><td colspan="6">UNIT-III : Tensor Calculus(contd) : Covariant Differentiation of Tensors – Riemann–Christoffel Curvature Tensor – Intrinsic Differentiation
Chapter III:III.3 – III.5</td></tr>
<tr><td colspan="6">UNIT-IV : Special Theory of Relativity : 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</td></tr>
<tr><td colspan="6">UNIT-V : Relativistic Dynamics : 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</td></tr>
<tr><td colspan="2">Recommended Text For Units I,II and III

For Units IV and V</td><td colspan="6">U.C. De, Absos Ali Shaikh and Joydeep Sengupta, Tensor Calculus, Narosa Publishing House, New Delhi, 2004.

D.Greenwood, Classical Dynamics, Prentice Hall of India, New Delhi, 1985.</td></tr>
<tr><td colspan="2">Reference Books</td><td colspan="6">1. J.L.Synge and A.Schild, Tensor Calculus, Toronto, 1949.
2. A.S.Eddington. The Mathematical Theory of Relativitity, Cambridge University Press, 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.</td></tr>
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Title of the Course	**MATHEMATICAL PHYSICS**							
Paper Number								
Category	Elective - V	**Year**	**II**	**Credits**	**4**	**Course Code**		
		Semester	**IV**					
Pre-requisite								
Course Outline	**UNIT-I :** Integral Equations, Sturm–Liouville Theorem and Green's Functions **Chapter 4:** Sections 4.1 – 4.4 only.							
	UNIT-II : Methods of Non linear Dynamics – I : Phase Portraits . **Chapter 6 :** Sections 6.1 – 6.4 only.							
	UNIT-III : Methods of Non linear Dynamics **-** II : Stability and Bifurcation. **Chapter 7 :** Sections 7.1 -7.4 only .							
	UNIT-IV : Non linear Differential Equations and their solutions. **Chapter 8 :** Sections 8.1 **-** 8.3 only							
	UNIT-V : Non linear Integral Equations and their solutions. **Chapter 9 :** Sections 9.1 – 9.7 only.							
Recommended Text	R.S.Kaushal and D.Parashar, Advanced Methods of Mathematical Physics							
Reference Books	1. Arfken,G (1966) Mathematical Methods for Physicists, A.P.NY. 2. Butkor,E. (1968) Mathematical Physics, Addison –Wesley. 3. Strogatz,S.H.(1994) Non linear Dynamics and Chaos : With Applications to Physics, Biology, Chemistry and Engineering. Addison – Wesley 4. Tabor, M (1989) Chaos and integrability in Non linear systems: An Introduction, John Wiley & Sons,NY. 5. Lakshmanan, M (1988). Solitons : Introduction and Applications, Springer Verlag, Berlin 6. Debnath, Lokenath (1997). Introduction to Non linear PDE for Scientists and Engineers , Birkhauser , Boston							

<table>
<tr><td>Title of the Course</td><td colspan="7">CALCULUS OF VARIATIONS AND INTEGRAL EQUATIONS</td></tr>
<tr><td>Paper Number</td><td colspan="7"></td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">Elective-V</td><td>Year</td><td>II</td><td rowspan="2">Credits</td><td rowspan="2">4</td><td rowspan="2">Course Code</td><td rowspan="2"></td></tr>
<tr><td>Semester</td><td>IV</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="6">UG level Differential equations</td></tr>
<tr><td colspan="2" rowspan="5">Course Outline</td><td colspan="6">UNIT-I : The Method of Variations in Problems with Fixed Boundaries
Chapter 6 : Sections 1 to 7 (Elsgolts)</td></tr>
<tr><td colspan="6">UNIT-II : Variational Problems with Moving Boundaries and certain other problems and Sufficient conditions for an Extremum
Chapter 7 : Sections 1 to 4 (Elsgolts)
Chapter 8 : Sections 1to 3(Elsgolts)</td></tr>
<tr><td colspan="6">UNIT-III : Variational Problems Involving a conditional Extremum
Chapter 9 : Sections 1 to 3. (Elsgolts)</td></tr>
<tr><td colspan="6">UNIT-IV : Integral Equations with Separable Kernels and Method of successive approximations.
Chapter 1 : Sections 1.1 to 1.7 (Kanwal)
Chapter 2 : Sections 2.1 to 2.5 (Kanwal)
Chapter 3 : Sections 3.1 to 3.5 (Kanwal)</td></tr>
<tr><td colspan="6">UNIT-V: Classical Fredholm Theory , Symmetric Kernels and Singular Integral Equations
Chapter 4 : Sections 4.1 to 4.5 (Kanwal)
Chapter 7 : Sections 7.1 to 7.6 (Kanwal)
Chapter 8 : Sections 8.1 to 8.5 (Kanwal)</td></tr>
<tr><td colspan="2">Recommended Text</td><td colspan="6">For Units I,II and III : L. Elsgolts , Differential Equations and the Calculus of variations, Mir Publishers, Moscow, 1973 (2nd Edition)

For Units IV and V :Ram P.Kanwal,Linear Integral Equations, Academic Press, New York, 1971.</td></tr>
<tr><td colspan="2">Reference Books</td><td colspan="6">1. I.M.Gelfand and S.V.Fomin, Calculus of Variations, Prentice-Hall Inc. New Jersey, 1963.
2. A.S.Gupta, Calculus of Variations with Applications, Prentice-Hall of India, New Delhi, 1997.
3. M.Krasnov, A.Kiselev and G.Makarenko, Problems and Exercises in Integral Equations, Mir Publishers, Moscow, 1979.
4. S.G.Mikhlin, Linear Integral Equations, Hindustan Publishing Corp. Delhi,1960.
5. L.A.Pars, An Introduction to the Calculus of Variations, Heinemann, London, 1965.
6. R.Weinstock, Calculus of Variations with Applications to Physics and Engineering, McGraw-Hill Book Company Inc. New York, 1952.</td></tr>
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S.A.C. SEPT'2022