THIRUVALLUVAR UNIVERSITY

MASTER OF SCIENCE

DEGREE COURSE

M.Sc. MATHEMATICS

UNDER CBCS

(with effect from 2008-2009)

The Course of Study and the Scheme of Examinations

Year / Semester	Subject	Paper	Title of the Paper	Ins. Hrs/ Week	Credit	Exam hrs	Max.Marks		
							IA	Uni. Exam.	Total
I Year I Semester	Core	Paper I	Algebra I	6	5	3	25	75	100
	Core	Paper II	Real Analysis I	6	5	3	25	75	100
	Core	Paper III	Ordinary Differential Equations	6	4	3	25	75	100
	Core	Paper IV	Mechanics	6	4	3	25	75	100
	Elective I	Paper I	**(to choose 1 out of 3)** **1.** Differential Geometry **2.** Mathematical Programming **3.** Graph Theory	6	4	3	25	75	100
I Year II Semester	Core	Paper V	Algebra II	5	4	3	25	75	100
	Core	Paper VI	Real Analysis II	6	4	3	25	75	100
	Core	Paper VII	Partial Differential Equations	6	4	3	25	75	100
	Core	Paper VIII	Tensor Analysis and Relativity Theory	5	4	3	25	75	100
			Human Rights	2	2	3	25	75	100
	Elective II	Paper II	**(to choose 1 out of 3)** 1. * Programming in C++ and Numerical Analysis (With Practicals) 2. Algebraic Number Theory 3. Operations Research	6	4	3	25	75	100
II Year III Semester	Core	Paper IX	Complex Analysis I	5	4	3	25	75	100
	Core	Paper X	Topology	6	4	3	25	75	100
	Core	Paper XI	Probability Theory	5	4	3	25	75	100
	Core	Paper XII	Discrete Mathematics	5	4	3	25	75	100

Year / Semester	Subject	Paper	Title of the Paper	Ins. Hrs/ Week	Credit	Exam hrs	Max.Marks		
							IA	Uni. Exam.	Total
	Elective III	Paper III	**(to choose 1 out of 3)** 1. Fuzzy Logic 2. Analytic Number Theory 3. Fluid Dynamics	5	4	3	25	75	100
	Elective IV (Non-Major Subject)	Paper IV	**(to choose 1 out of 5)** 1. Mathematical Economics 2. Mathematical Biology 3. Mathematical Modelling 4. Principles of Operations Research 5. Mathematics for Biological Sciences (for M.Sc. Zoology, Botany, Bio-informatics and Microbiology students only)	4	4	3	25	75	100
II Year IV Semester	Core	Paper XIII	Complex Analysis II	6	5	3	25	75	100
	Core	Paper XIV	Functional Analysis	6	5	3	25	75	100
	Core	Paper XV	Mathematical Statistics	6	4	3	25	75	100
	Core	Paper XVI	Difference Equations	6	4	3	25	75	100
	Project with Viva-Voce (or) Elective V	Paper V	**(to choose 1 out of 3)** 1. Number Theory and Cryptography 2. Wavelets 3. Algebraic Topology	6	4	3	25	75	100
			Total	**120**	**90**				**2200**

*** Programming in C++ and Numerical Analysis (With Practicals)**

Theory 60 Marks - Internal 15 + External 45

Practical 40 marks - Internal 10 + External 30

The following guidelines / clarifications are offered for the Project with Vica-Voce:

1. The project should be valued for 75 marks by an external examiner and Viva-Voce should be conducted by the external examiner and the internal guide/teacher concerned.
2. The Project Report may consist of 40 to 50 pages.
3. The candidate has to submit the Project Report 15 days before the commencement of the IV Semester Examinations.
4. A candidate who fails in the Project / Dissertation may resubmit the report (on the same topic) with necessary modification / correction / improvements in the subsequent semester examination for evaluation.

THIRUVALLUVAR UNIVERSITY

M.Sc. MATHEMATICS

SYLLABUS

UNDER CBCS

(with effect from 2008-2009)

I SEMESTER

PAPER I

ALGEBRA I

Objectives

To introduce the concepts and to develop working knowledge on class equation, solvability of groups, finite abelian groups, linear transformations, real quadratic forms.

UNIT-I

Another counting principle - class equation for finite groups and its applications - Sylow's theorems (For theorem 2.12.1, Only First proof).

Chapter 2: Sections 2.11 and 2.12 (Omit Lemma 2.12.5)

UNIT-II

Solvable groups - Direct products - Finite abelian groups- Modules

Chapter 5 : Section 5.7 (Lemma 5.7.1, Lemma 5.7.2, Theorem 5.7.1)
Chapter 2: Sections 2.13 and 2.14 (Only Theorem 2.14.1)
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 Eastern Limited, New Delhi, 1975.

Reference Books

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, Narosa Publishing House , New Delhi, 1999
4. D.S.Malik, J.N. Mordeson and M.K.Sen, *Fundamental of Abstract Algebra*, McGraw Hill (International Edition), New York. 1997.
5. N.Jacobson, *Basic Algebra,* Vol. I & II W.H.Freeman ; also published by Hindustan Publishing Company, New Delhi, 1980.

PAPER II

REAL ANALYSIS I

Objectives

To work comfortably with functions of bounded variation, Riemann - Stieltjes Integration, convergence of infinite series, infinite product and uniform convergence and its interplay between various limiting operations.

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.

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

Chapter - 6 : Sections 6.1 to 6.8
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 criterion 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.

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 - 8 Sec, 8.20, 8.21 to 8.26
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, Addison-Wesley Publishing Company Inc. New York, 1974.

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.

PAPER III

ORDINARY DIFFERENTIAL EQUATIONS

Objectives

To develop strong background on finding solutions to linear differential equations with constant and variable coefficients and also with singular points, to study existence and uniqueness of the solutions of first order differential equations.

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 - Algebra of constant coefficient operators.

Chapter - 2 : Sections 7 to 12.

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

Euler equation - Second order equations with regular singular points -Exceptional cases - Bessel 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

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.Choudary and H.I. Freedman, *A Course in Ordinary Differential Equations,* Narosa Publishing House, New Delhi, 2002.

PAPER IV

MECHANICS

Objectives

To study mechanical systems under generalized coordinate systems, virtual work, energy and momentum, to study mechanics developed by Newton, Langrange, Hamilton Jacobi and Theory of Relativity due to Einstein.

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 principle.

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.

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.

ELECTIVE

(to choose any 1 out of the given 3)

PAPER I.1

DIFFERENTIAL GEOMETRY

Objectives

This course introduces space curves and their intrinsic properties of a surface and geodesics. Further the non-intrinsic properties of surface and the differential geometry 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 - Helics.

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 II: 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.

Chapter II: Sections 10 to 18

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 surface - Minimal surfaces - Ruled surfaces.

Chapter III: Sections 1 to 8

UNIT-V : DIFFERENTIAL GEOMETRY OF SURFACES

Fundamental Equations of Surface Theory - Fundamental Existence Theorem for surfaces - Compact surfaces whose points are umblics - Hilbert's lemma - Compact surface of constant curvature - Complete surfaces.

Chapter III : Sections 9 and 10

Chapter IV : Only Section 1 to 5

Recommended Text

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. Kobayashi. S. and Nomizu. K. *Foundations of Differential Geometry,* Interscience Publishers, 1963.
3. Wilhelm Klingenberg: *A course in Differential Geometry*, Graduate Texts in Mathematics, Springer-Verlag 1978.
4. J.A. Thorpe *Elementary topics in Differential Geometry*, Under - graduate Texts in Mathematics, Springer - Verlag 1979.

PAPER I.2

MATHEMATICAL PROGRAMMING

Objectives

This course introduces advanced topics in Linear and non-linear Programming

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. - Zero-One Integer Programming.

Dynamic Programming: Characteristics of Dynamic Programming Problem - Developing Optimal Decision Policy - Dynamic Programming Under Certainty - DP approach to solve LPP.

Chapter-7: 7.1 - 7.7

Chapter-20: 20.1 - 20.5

UNIT-II : CLASSICAL OPTIMIZATION METHODS

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 Methods - Beale's Method

Chapter-23: 23.1 - 23.4

Chapter-24: 24.1 - 24.4

UNIT-III : THEORY OF SIMPLEX METHOD

Canonical and Standard form of LP - Slack and Surplus Variables - Reduction of any Feasible solution to a Basic Feasible solution - Alternative Optimal solution - Unbounded solution - Optimality conditions - Some complications and their resolutions - Degeneracy and its resolution

Chapter-25: 25.1 - 25.4, 25.6-25.9

UNIT-IV : REVISED SIMPLEX METHOD

Standard forms for Revised simplex Method - Computational procedure for Standard form I - comparison of simplex method and Revised simplex Method.

Bounded Variables LP problem: The simplex algorithm

Chapter-26: 26.1 - 26.4

Chapter-28: 28.1, 28.2

UNIT-V: PARAMETRIC LINEAR PROGRAMMING

Variation in the coefficients c_j , Variations in the Right hand side, b_i.

Goal Programming: Difference between LP and GP approach - Concept of Goal Programming - Goal Programming Model formulation - Graphical Solution Method of Goal Programming - Modified Simplex method of Goal Programming.

Chapter-29: 29.1 - 29.3.

Chapter-8: 8.1 - 8.4, 8.6 and 8.7.

Recommended Text

J.K.Sharma, *Operations Research*, Theory and Applications, Third Edition (2007) Macmillan India Ltd.

Reference Books

1. Hamdy A. Taha, *Operations Research,* (seventh edition) Prentice - Hall of India Private Limited, New Delhi, 1997.
2. F.S. Hillier & J.Lieberman *Introduction to Operation Research* (7th Edition) Tata-McGraw Hill ompany, 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

PAPER I.3

GRAPH THEORY

Objectives

To study and develop the concepts of graphs, subgraphs, trees, connectivity, Euler tours, Hamilton cycles, matching, coloring of graphs, independent sets, cliques, vertex coloring, and planar graphs

UNIT-I : GRAPHS, SUBGRAPHS AND TREES

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

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

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

Independent sets - Ramsey's Theorem - Chromatic Number - Brooks' Theorem - Chromatic Polynomials.

Chapter 7 (Section 7.1 – 7.2)
Chapter 8 (Section 8.1 – 8.2, 8.4)

UNIT-V: PLANAR GRAPHS

Plane and planar Graphs - Dual graphs - Euler's Formula - The Five-Colour Theorem and the Four-Colour Conjecture.

Chapter 9 (Section 9.1 - 9.3, 9.6)

Recommended Text

J.A.Bondy and U.S.R. Murthy, *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. S.A.Choudum, *A First Course in Graph Theory*, MacMillan India Ltd. 1987.

II SEMESTER

PAPER V

ALGEBRA II

Objectives

To study field extension, roots of polynomials, Galois Theory, finite fields, division rings, solvability by radicals and to develop computational skill in abstract algebra.

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 (Only Theorem 7.2.1)

UNIT-V

Solvability by radicals - A theorem of Frobenius - Integral Quaternions and the Four - Square theorem.

Chapter 5: Section 5.7 (omit Lemma 5.7.1, Lemma 5.7.2 and Theorem 5.7.1) Chapter 7 : Sections 7.3 and 7.4

Recommended Text

I.N. Herstein. *Topics in Algebra* (II Edition) Wiley Eastern Limited, New Delhi, 1975.

Reference Books

1. M.Artin, *Algebra,* Prentice Hall of India, 1991.
2. 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,* Narosa Publishing House , New Delhi, 1999
4. D.S.Malik, J.N. Mordeson and M.K.Sen, *Fundamental of Abstract Algebra*, McGraw Hill (International Edition), New York. 1997.
5. N.Jacobson, *Basic Algebra,* Vol. I & II Hindustan Publishing Company, New Delhi.

PAPER VI

REAL ANALYSIS II

Objectives

To introduce measure on the real line, Lebesgue measurability and integrability, Fourier Series and Integrals, in-depth study in multivariable calculus.

UNIT-I : MEASURE ON THE REAL LINE

Lebesgue Outer Measure - Measurable sets - Regularity - Measurable Functions - Borel and Lebesgue Measurability

Chapter - 2 Sec 2.1 to 2.5 (de Barra)

UNIT-II : INTEGRATION OF FUNCTIONS OF A REAL VARIABLE

Integration of Non- negative functions - The General Integral - Riemann and Lebesgue Integrals

Chapter - 3 Sec 3.1,3.2 and 3.4 (de Barra)

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 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 to 11.15 (Apostol)

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 to 12.14 (Apostol)

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 to 13.7 (Apostol)

Recommended Texts

1. G. de Barra, *Measure Theory and Integration*, Wiley Eastern Ltd., New Delhi, 1981. (for Units I and II)
2. Tom M.Apostol : *Mathematical Analysis*, 2nd Edition, Addison-Wesley Publishing Company Inc. New York, 1974. (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. Roydon,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. 6.Sanjay Arora and Bansi Lal, *Introduction to Real Analysis*, Satya Prakashan, New Delhi, 1991

PAPER VII

PARTIAL DIFFERENTIAL EQUATIONS

Objectives

This course aims to acquaint the students with various mathematical techniques viz. variable separable method, integral transform techniques and Green's function approach so as to solve various boundary value problems involving parabolic, elliptic and hyperbolic differential equations which arise in many physical situations.

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 0.1,0.2.0.3 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 and 3.9 (omit 3.8)

UNIT-IV : HYPERBOLIC DIFFERENTIAL EQUATIONS

Formation and solution of one-dimensional wave equation - canocical 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 4.12 (omit 4.6 & 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: only 6.13, 6.13.1 and 6.13.2 (omit 6.14)

Recommended Text

S, Sankar 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 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.

PAPER VIII

TENSOR ANALYSIS AND RELATIVITY THEORY

Objectives

The course aims to introduce vector algebra and vector calculus and special relativity and relativistic kinematics, dynamics and accelerated systems.

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 of 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

Riemannian Space - Christoffel Symbols and their properties

Chapter III: III.1 and III.2

UNIT-III : TENSOR CALCULUS (CONTD)

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

Chapter III: III.3 - III.5

UNIT-IV : SPECIAL THEORY OF RELATIVITY

Galilean Transformation - 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

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

Recommended Text

For Units I,II and III

U.C. De, Absos Ali Shaikh and Joydeep Sengupta, *Tensor Calculus*, Narosa Publishing House, New Delhi, 2004.

For Units IV and V

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

Reference Books

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

HUMAN RIGHTS

COMPULSORY PAPER

UNIT-I

Definition of Human Rights - Nature, Content, Legitimacy and Priority - Theories on Human Rights - Historical Development of Human Rights.

UNIT-II

International Human Rights - Prescription and Enforcement upto World War II - Human Rights and the U .N .O. - Universal Declaration of Human Rights - International Covenant on Civil and Political Rights - International Convenant on Economic, Social and Cultural Rights and Optional Protocol.

UNIT-III

Human Rights Declarations - U.N. Human Rights Declarations - U.N. Human Commissioner.

UNIT-IV

Amnesty International - Human Rights and Helsinki Process - Regional Developments - European Human Rights System - African Human Rights System - International Human Rights in Domestic courts.

UNIT-V

Contemporary Issues on Human Rights: Children's Rights - Women's Rights - Dalit's Rights - Bonded Labour and Wages - Refugees - Capital Punishment.

Fundamental Rights in the Indian Constitution - Directive Principles of State Policy - Fundamental Duties - National Human Rights Commission.

Books for Reference:

1. International Bill of Human Rights, Amnesty International Publication, 1988.
2. Human Rights, Questions and Answers, UNESCO, 1982

3. Mausice Cranston - What is Human Rights
4. Desai, A.R. - Violation of Democratic Rights in India
5. Pandey - Constitutional Law.
6. Timm. R.W. - Working for Justice and Human Rights.

7. Human Rights, A Selected Bibliography, USIS.
8. J.C.Johari - Human Rights and New World Order.
9. G.S. Bajwa - Human Rights in India.
10. Amnesty International, Human Rights in India.
11. P.C.Sinha & K. Cheous (Ed) - International Encyclopedia of Peace, Security Social Justice and Human Rights (Vols 1-7).
12. Devasia, V.V. - Human Rights and Victimology.

Magazines:

1. The Lawyer, Bombay
2. Human Rights Today, Columbia University
3. International Instruments of Human Rights, UN Publication
4. Human Rights Quarterly, John Hopkins University, U.S.A.

ELECTIVE II

(to choose any 1 out of the given 3)

PAPER II.1

PROGRAMMING IN C++ AND NUMERICAL ANALYSIS WITH PRACTICALS

(Theory 60 marks + Practical 40 Marks)

(Theory: Int.15+Ext.45) **(Practical:Int.10+Ext.30)**

Objectives

This courses introduces a higher level language C++ and numerical methods for hands-on experience on computers. Stress is also given on the error analysis.

UNIT-I

Principles of OOP-Tokens-Expressions, Control Structures-Functions-Classes and Objects-constructors and destructors.

Chapter 1 to 6 (Balagurusamy)

UNIT-II

Operator Overloading and type Conversions - Inheritance - Pointers, Virtual Functions and Polymorphism-Managing Console I/O Operations-Working with Files

Chapter 7 to 11 (Balagurusamy)

UNIT-III : FINITE DIGIT ARITHMETIC AND ERRORS

Floating point arithmetic - Propagated Error - Generated Error - Error in Evaluation of a function f(x). - Non-linear Equations: Bisection method- Secant Method - Regula Falsi Method - Newton's method - Muller's method - Fixed Point method -

Chapters 1,2 : Only 2.1 to 2.6 (Devi Prasad)

UNIT-IV : SYSTEM OF LINEAR EQUATIONS

Gauss- Elimination Method - Crout's method - Inverse of a matrix - Condition numbers and errors - Jacobi's method - Gauss-Seidel Method - Relaxation method. **Numerical Differentiation and Integration:** Numerical Differentiation - Numerical Integration - Newton-Cotes Formulas - Gaussian Quadrature - Double Integral

Chapter 3 and 5 : 5.1 to 5.5 and 5.7 (omit 5.6) (Devi Prasad)

UNIT-V : Ordinary Differential Equations: Difference equation - Differential Equations:Single Step method-Runge-Kutta Method-Multi-step methods

Chapter 6: 6.1 to 6.4 (omit 6.5) (Devi Prasad)

Recommended Text

1. E. Balagurusamy, *Object Oriented Programming with* C++, Tata McGraw Hill, New Delhi, 1999.
2. Devi Prasad, An *Introduction to Numerical Analysis* (3rd edn) Narosa Publishing House, New Delhi, 2006.

Reference Books

1. D. Ravichandran, *Programming with* C++, Tata McGraw Hill, New Delhi, 1996
2. Conte and de Boor, *Numerical Analysis,* McGraw Hill, New York, 1990
3. John H.Mathews, *Numerical Methods for Mathematics, Science and Engineering* (2nd Edn.), Prentice Hall, New Delhi, 2000

COMPUTER LABORATORY PRACTICE EXERCISES

SECTION I

COMPUTER LANGUAGE EXERCISES FOR PROGRAMMING IN C++

1. Write a class to represent a vector (a series of float values). Include member functions to perform the following tasks: To create the vector, To modify the value of a given element, To multiply by a scalar value, To display the vector in the form (10, 20, 30,…). Write a program to test your class.
2. Create a class FLOAT that contains one float data member. Overload all the four arithmetic operators so that they operate on the objects of FLOAT.
3. Write a program which shows the days from the start of year to date specified. Hold the number of days for each month in an array. Allow the user to enter the month and the day of the year. Then the program should display the total days till the day.
4. Write a program to include all possible binary operator overloading using friend function.
5. Write a program to read an array of integer numbers and sort it in descending order. Use readdata, putdata, and arraymax as member functions in a class.
6. Write a program to read two character strings and use the overloaded '+' operator to append the second string to the first.
7. Develop a program Railway Reservation System using Hybrid Inheritance and Virtual Function.
8. Using overloaded constructor in a class write a program to add two complex numbers.
9. Create a class MAT of size(m,n). Define all possible matrix operations for MAT type objects.
10. Write a program that determines whether a given number is a prime number or not and then prints the result using polymorphism.

SECTION II

NUMERICAL METHODS EXERCISES FOR PROGRAMMING IN C++

1. Non-Linear Equations : Bisection Method , Regula-falsi Method , Newton-Raphson Method , Secant Method, Fixed Point Iteration
2. System of Equations: Gaussian Elimination, Jacobi's Method, Gauss-Seidel Method
3. Numerical Differentiation and Integration: Differentiation and Newton-Cotes formula, Gaussian Quadrature, multiple integrals
4. Numerical Solution to Differential Equations: Euler's Method, Taylor's Method of order 4, Runge-Kutta Method of order 4, Milne-Simpson Method

PAPER II.2

ALGEBRAIC NUMBER THEORY

Objectives

The course aims to provide a study on modules over rings, finite fields, algebraic extensions, number fields and cyclotomic fields, Noetherian rings and modules and Dedekind rings.

UNIT-I : ALGEBRAIC BACKGROUND

Rings and Fields- Factorization of Polynomials - Field Extensions - Symmetric Polynomials - Modules - Free Abelian Groups.

Chapter 1: Sec. 1.1 to 1.6

UNIT-II : ALGEBRAIC NUMBERS

Algebraic numbers - Conjugates and Discriminants - Algebraic Integers - Integral Bases - Norms and Traces - Rings of Integers.

Chapters 2: Sec. 2.1 to 2.6

UNIT-III : QUADRATIC AND CYCLOTOMIC FIELDS

Quadratic fields and cyclotomatic fields : Factorization into Irreducibles : Trivial factorization - Factroization into irreducibles - Examples of non-unique factorization into irreducibles.

Chapter 3: Sec. 3.1 and 3.2 ; Chapter 4: Sec. 4.2 to 4.4

UNIT-IV

Prime Factroization - Euclidean Domains - Euclidean Quadratic fields - Consequences of unique factorization - The Ramanujan -Nagell Theorem.

Chapter 4: Sec. 4.5 to 4.9

UNIT-V : IDEALS

Prime Factorization of Ideals - The norms of an Ideal - Non-unique Factorization in Cyclotomic Fields..

Chapter 5 : Sec. 5.2 to 5.4

Recommended Text

I. Steward and D.Tall. *Algebraic Number Theory and Fermat's Last Theorem* (3rd Edition) A.K.Peters Ltd., Natrick, Mass. 2002.

Reference Books

1. Z.I.Bosevic and I.R.Safarevic, *Number Theory*, Academic Press, New York, 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.
5. A.Weil. *Basic Number Theory*, Springer, New York, 1967.

PAPER II.3

OPERATIONS RESEARCH

Objectives

This course aims to introduce decision theory, PERT, CPM, deterministic and probabilistic inventory systems, queues, replacement and maintenance problems.

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-11 : 11.1 - 11.8

UNIT-II : PROJECT MANAGEMENT : PERT AND CPM

Basic Differences between PERT and CPM - Steps in PERT/CPM Techniques - PERT/CPM Network Components and Precedence Relationships - Critical Path Analysis - Probability in PERT Analysis - Project time-cost Trade Off - Updating the Project - Resource Allocation

Chapter-13 : 13.1 - 13.9

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-14 : 14.1 - 14.8

Chapter-15 : 15.1 - 15.4

UNIT-IV : QUEUES 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-16 : 16.1 - 16.9

Appendix 16.A (PP 774-781)

UNIT-V : REPLACEMENT AND MAINTENANCE MODELS

Failure Mechanism of items - Replacement of Items Deteriorates with Time - Replacement of items that fail completely - other Replacement Problems.

Chapter-17 : 17.1 - 17.5

Recommended Text

J.K.Sharma, *Operations Research* Theory and Applications, Third Edition (2007), Macmillan India Ltd.

Reference Books

1. F.S. Hillier and J.Lieberman -,*Introduction to Operations Research* (8th Edition), Tata McGraw Hill Publishing Company, New Delhi, 2006.
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.
5. Hamdy A. Taha , *Operations Research* (sixth edition), Prentice - Hall of India Private Limited, New Delhi.

III SEMESTER

PAPER IX

COMPLEX ANALYSIS I

Objectives

To Study Cauchy integral formula, local properties of analytic functions, general form of Cauchy's theorem and evaluation of definite integral and harmonic 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 Analytic Functions: Removable Singularities - Taylors's Theorem - Zeros and poles - The local Mapping - The Maximum Principle.

Chapter 4 : Section 2 : 2.1 to 2.3
Chapter 4 : Section 3 : 3.1 to 3.4

UNIT-II : THE GENERAL FORM OF CAUCHY'S THEOREM

Chains and cycles- Simple Continuity - 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
Chapter 4 : Section 5: 5.1 and 5.2

UNIT-III : EVALUATION OF DEFINITE INTEGRALS AND HARMONIC FUNCTIONS

Evaluation of definite integrals - Definition of Harmonic function and basic properties - Mean value property - Poisson formula.

Chapter 4 : Section 5 : 5.3
Chapter 4 : Sections 6 : 6.1 to 6.3

UNIT-IV : HARMONIC FUNCTIONS AND POWER SERIES EXPANSIONS

Schwarz theorem - The reflection principle - Weierstrass theorem - Taylor's 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 - Hadamard's Theorem

Chapter 5 : Sections 2.1 to 2.4
Chapter 5 : Sections 3.1 and 3.2

Recommended Text

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

Reference Books

1. H.A. Presfly, *Introduction to complex Analysis*, Clarendon Press, oxford, 1990.
2. J.B. Conway, *Functions of one complex variables* Springer - Verlag, International student Edition, Naroser Publishing Co.1978
3. E. Hille, *Analytic function Thorey* (2 vols.), Gonm & Co, 1959.
4. M.Heins, *Complex function Theory*, Academic Press, New York,1968.

PAPER X

TOPOLOGY

Objectives

To study topological spaces, continuous functions, connectedness, compactness, countability and separation axioms.

UNIT-I : TOPOLOGICAL SPACES

Topological spaces - Basis for a topology - The order topology - The product topology on X x Y - The subspace topology - Closed sets and limit points.

Chapter 2 : Sections 12 to 17

UNIT-II : CONTINUOUS FUNCTIONS

Continuous functions - the product topology - The metric topology.

Chapter 2 : Sections 18 to 21 (Omit Section 22)

UNIT-III : CONNECTEDNESS

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

Chapter 3 : Sections 23 to 25

UNIT-IV : COMPACTNESS

Compact spaces - compact subspaces of the Real line - Limit Point Compactness - Local Compactness.

Chapter 3 : Sections 26 to 29

UNIT-V: COUNTABILITY AND SEPARATION AXIOM

The Countability Axioms - The separation Axioms - Normal spaces - The Urysohn Lemma - The Urysohn metrization Theorem - The Tietz extension theorem.

Chapter 4 : Sections 30 to 35

Recommended Text

James R. Munkres, *Topology* (2nd Edition) Pearson Education Pve. Ltd., Delhi-2002 (Third Indian Reprint)

Reference Books

1. J. Dugundji , *Topology* , Prentice Hall of India, New Delhi, 1975.
2. George F.Sinmons, *Introduction to Topology and Modern Analysis*, McGraw Hill Book Co., 1963
3. J.L. Kelly, *General Topology*, Van Nostrand, Reinhold Co., New York
4. L.Steen and J.Subhash, Counter Examples in Topology, Holt, Rinehart and Winston, New York, 1970.
5. S.Willard, *General Topology*, Addison - Wesley, Mass., 1970

PAPER XI
PROBABILITY THEORY

Objectives

To introduce axiomatic approach to probability theory, to study some statistical characteristics, discrete and continuous distribution functions and their properties, characteristic function and basic limit theorems of probability.

UNIT-I : RANDOM EVENTS AND RANDOM VARIABLES

Random events - Probability axioms - Combinatorial formulae - conditional probability - Bayes Theorem - Independent events - Random Variables - Distribution Function - Joint Distribution - Marginal Distribution - Conditional Distribution - Independent random variables - Functions of random variables.

Chapter 1: Sections 1.1 to 1.7
Chapter 2 : Sections 2.1 to 2.9

UNIT-II : PARAMETERS OF THE DISTRIBUTION

Expectation- Moments - The Chebyshev Inequality - Absolute moments - Order parameters - Moments of random vectors - Regression of the first and second types.

Chapter 3 : Sections 3.1 to 3.8

UNIT-III: CHARACTERISTIC FUNCTIONS

Properties of characteristic functions - Characteristic functions and moments - semi-invariants - characteristic function of the sum of the independent random variables - Determination of distribution function by the Characteristic function - Characteristic function of multidimensional random vectors - Probability generating functions.

Chapter 4 : Sections 4.1 to 4.7

UNIT-IV : SOME PROBABILITY DISTRIBUTIONS

One point , two point , Binomial - Polya - Hypergeometric - Poisson (discrete) distributions - Uniform - normal gamma - Beta - Cauchy and Laplace (continuous) distributions.

Chapter 5 : Section 5.1 to 5.10 (Omit Section 5.11)

UNIT-V: LIMIT THEOREMS

Stochastic convergence - Bernoulli law of large numbers - Convergence of sequence of distribution functions - Levy-Cramer Theorems - de Moivre-Laplace Theorem - Poisson, Chebyshev, Khintchine Weak law of large numbers - Lindberg Theorem - Lyapunov Theroem - Borel-Cantelli Lemma - Kolmogorov Inequality and Kolmogorov Strong Law of large numbers.

Chapter 6 : Sections 6.1 to 6.4, 6.6 to 6.9 , 6.11 and 6.12. (Omit Sections 6.5, 6.10,6.13 to 6.15)

Recommended Text

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

Reference Books

R.B. Ash, Real Analysis and Probability, Academic Press, New York, 1972

K.L.Chung, A course in Probability, Academic Press, New York, 1974.

R.Durrett, Probability : Theory and Examples, (2nd Edition) Duxbury Press, New York, 1996.

V.K.Rohatgi An Introduction to Probability Theory and Mathematical Statistics, Wiley Eastern Ltd., New Delhi, 1988(3rd Print).

S.I.Resnick, A Probability Path, Birhauser, Berlin,1999.

B.R.Bhat , Modern Probability Theory (3rd Edition), New Age International (P)Ltd, New Delhi, 1999

PAPER XII

DISCRETE MATHEMATICS

Objectives

This course aims to explore the topics like lattices and their applications in switching circuits, finite fields, polynomials and coding theory.

UNIT-I : LATTICES

1. Properties and examples of Lattices
2. Distributive lattices
3. Boolean algebras
4. Boolean polynomials
6. Minimal Forms of Boolean Polynomials.

(5-excluded)

UNIT-II : 2. APPLICATIONS OF LATTICES

7. Switching Circuits
8. Applications of Switching Circuits

(9-excluded)

UNIT-III : 3. FINITE FIELDS AND POLYNOMIALS

13. Finite fields

(10,11,12-excluded)

UNIT-IV : 3. FINITE FIELDS AND POLYNOMIALS

14. Irreducible Polynomials over Finite fields
15. Factorization of Polynomials over Finite fields

UNIT-V: 4. CODING THEORY

17. Linear Codes

18. Cyclic Codes

(16-excluded)

Recommended Text

RUDOLF LIDL & GUNTER PILZ. APPLIED ABSTRACT ALGEBRA, Second Indian Reprint 2006, Springer Verlag, NewYork.

Reference Books

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.

ELECTIVE

(to choose any 1 out of the given 3)

PAPER III.1

FUZZY LOGIC

Objectives

This course aims to offer fuzzy graphs, fuzzy relations, fuzzy logic and fuzzy composition.

UNIT-I

Fundamental Notions

Chapter I: Sections 1 to 8

UNIT-II

Fuzzy Graphs

Chapter II: Sections 10 to 18

UNIT-III

Fuzzy Relations

Chapter II: Sections 19 to 29

UNIT-IV

Fuzzy Logic:

Chapter III: Sec.31 to 40 (omit Sec. 37, 38, 41)

UNIT-V

The Laws of Fuzzy Composition:

Chapter IV: Sec.43 to 49

Recommended Text

A.Kaufman, *Introduction to the theory of Fuzzy subsets,* Vol.I, Academic Press, New York, 1975.

Reference Books

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.

PAPER III.2

ANALYTIC NUMBER THEORY

Objectives

This course introduces arithmetic function and Dirichlet multiplication, averages of arithmetic function, congruence and quadratic residues

UNIT-I

Arithmetical function and Dirichlet multiplication.

Chapter 2

UNIT-II

Averages of Arithmetical function.

Chapter 3

UNIT-III

Congruence - Finite Abelian Groups and their characters

Chapter 5 [Omit 5.10 and 5.11]

Chapter 6: 6.1 to 6.4

UNIT-IV

Finite Abelian Groups and their characters (contd)

Chapter 6: 6.5 to 6.10

Dirichlet's theorem on Primes in Arithmetic Progressions

Chapter 7: All sections except 7.9

UNIT-V

Quadratic residues and quadratic reciprocity law.

Chapter 9 (Omit 9.10 and 9.11)

Recommended Text

Tom Apostol, *Introduction to Analytic Number theory*, Narosa Publications, New Delhi,

Reference Books

1. I. Niven and Zuckermann H.S. : *An Introduction to the theory of numbers,* Wiley Eastern Ltd. 1972
2. C.Y. Hsiung : *Elementary Theory of Numbers*, Allied Publishers.
3. W.W. Adams and L. J. Goldstein, *Introduction to Number Theory*, Prentice Hall Inc.
4. S.G. Telang, *Number Theory*.

PAPER III.3

FLUID DYNAMICS

Objectives

This course aims to discuss kinematics of fluids in motion, Equations of motion of a fluid, three dimensional flows, two dimensional flows and viscous flows.

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. Sections 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. Sections 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 Sections 4.1, 4.2, 4.3, 4.5.

UNIT-IV : SOME TWO DIMENSIONAL FLOWS

Meaning of two dimensional flow - Use of Cylindrical polar coordinate - 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. Sections 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 principal 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. Sections 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.

ELECTIVE

NON MAJOR SUBJECTS

(to choose any 1 out of the given 5)

PAPER IV.1

MATHEMATICAL ECONOMICS

UNIT-I: THE THEORY OF FIRM:

Basic Concepts - Optimizing Behavior - Input Demands - Cost Functions - Joint Products - Generalization to m variables - Homogeneous Production functions - CES Production Function.

Chapter 4: Sections 4.1 to 4.6

Chapter 5: Sections5.1 and 5.2

UNIT-II: PERFECT COMPETITION:

Assumptions of Perfect Competition - Demand Functions - Supply Functions - Commodity - Market Equilibrium - An application to Taxation.

Chapter 6: Sections 6.1 to 6.5

UNIT-III: MARKET EQUILIBRIUM:

Factor-Market Equilibrium - Existence and Uniqueness of Equilibrium - Stability of Equilibrium - Dynamic Equilibrium with Lagged Adjustment.

Chapter 6: Sections 6.6 to 6.9

UNIT-V: WELFARE ECONOMICS:

Pareto Optimality - the efficiency of Perfect competition - The efficiency of Imperfect competition - External Effects in consumption and Production - Taxes and Subsidies - Social Welfare functions - The theory of Second Best.

Chapter 11 : Sections 11.1 to 11.7

Recommended Text

James M. Henderson and Richard E. Quandt, Micro Economic Theory - A Mathematical Approach, (3rd Edn.) Tata McGraw Hill, New Delhi, 2003.

Reference Books

1. William J. Baumol. Economic Theory and Operations Analysis, Prentice Hall of India, New Delhi, 1978
2. A.C.Chiang, Fundamental Methods of Mathematical Economics, McGraw Hill, New York, 1984
3. Michael D. Intriligator, Mathematical Optimization and Economic Theory, Prentice Hall, New York, 1971.
4. A. Kautsoyiannis, Modern Microeconomics (2nd edn) MacMillan, New York, 1979

PAPER IV.2

MATHEMATICAL BIOLOGY

UNIT-I: Discrete Population Growth Models (Chapter 2: 2.2 to 2.5)

Arithmetic Growth Model - Geometric Growth Model - Generalizations - Age Structured Populations.

UNIT-II: Continuous Growth Models (Chapter 3: 3.2 to 3.5)

The Linear Model - The Exponential Model - Model for the Distribution of drugs in the body - Coalition Models.

UNIT-III: Continuous Growth Models (contd.) (Chapter 3: 3.8 to 3.11)

Environmental Resistance - A Model for the Spread of Technological Innovations - The Gomertz Model - Bertalanffy Growth Model.

UNIT-IV: Qualitative behavior of Populations (Chapter 5: 5.2 to 5.7)

Autonomous Equations - Steady and Equilibrium State - Stability of Equilibrium State - Logistic Model with Harvesting - Fixed Points and their stability - The Logistic Map.

UNIT-V: Mathematical Models in Epidemiology (Chapter 7: 7.2 to 7.5)

Plant Epidemics - Some features of Human Epidemics - A Simple Deterministic Epidemic Model - A more General Epidemic: SIR Disease.

Recommended Text:

C. R. Ranganathan, A First Course in Mathematical Models of Population Growth (with MATLAB Program), Associated Publishing Company, New Delhi, 2006.

Reference Books:

1. Pundir, Bio Mathematics, A Pragati Edition, 2006.
2. J.N. Kapur, Mathematical Models in Biology and Medicine, Affiliated East-West Press Pvt. Ltd., New Delhi, 1985.
3. Nicolas F. Britton, Essential Mathematical Biology, Springer International Edition, First Indian reprint, 2004.
4. Murray, Mathematical Biology, Springer International Edition, First Indian reprint, 2004.

PAPER IV.3
MATHEMATICAL MODELLING

UNIT-I:

Mathematical Modelling through Systems of Ordinary differential Equations of the First Order (Chapter 3: 3.1, 3.2, 3.5, and 3.6)

Mathematical modelling in population dynamics, Mathematical modelling of epidemics through systems of ordinary differential equations of first order - Mathematical Models in Medicine, Arms Race, Battles and international Trade in terms of Systems of ordinary differential equations - Mathematical modelling in dynamics through systems of ordinary differential equations of first order.

UNIT-II:

Mathematical Modelling through difference equations (Chapter 5: 5.1 to 5.3)

The need for Mathematical modelling through difference equations - some simple models - Basic theory of linear difference equations with constant coefficients - Mathematical modelling through difference equations in economics and finance

UNIT-III:

Mathematical Modelling through difference equations (contd.) (Chapter 5: 5.4 to 5.6)

Mathematical modelling through difference equations in population dynamics and genetics. Mathematical Modelling through difference equations in probability theory. Miscellaneous examples of Mathematical modelling through difference equations

UNIT-IV:

Mathematical modelling through Graphs (Chapter 7: 7.1 to 7.4)

Situations that can be modeled through graphs - Mathematical models in terms of directed graphs - Mathematical models in terms of signed graphs - Mathematical models in terms of weighted graphs.

UNIT-V:

Mathematical Modelling through calculus of Variations and Dynamic Programming (Chapter 9: 9.1 to 9.3)

Optimization principles and techniques - Mathematical modelling through calculus of variations - Mathematical Modelling through dynamic programming.

Recommended Text:

J. N. Kapur, Mathematical Modelling, Willey Eastern Limited, Reprint, 2000.

Reference Books:

1. D. J. G. James and J. J. Macdonald, Case studies in Mathematical Modelling, Stanly Thames, Cheltonham.
2. J.N. Kapur, Mathematical entropy Models.
3. M. Crossand A. O. Moscrcadini, The art of Mathematical Modelling, Ellis Harwood and John Wiley.
4. C. Dyson, Elvery, Principles of Mathematical Modelling, Academic Press, New York.
5. D. N. Burghes, Modelling with Difference Equations, Ellis Harwood and John Wiley.

PAPER IV.4
PRINCIPLES OF OPERATIONS RESEARCH

UNIT-I:

Linear programming problems (LPP)- Formulation - graphical solution - simplex method (UNIT-2:Chapter-1: 1.1 to 1.6; Chapter-3: 3.1 to 3.4)

UNIT-II:

Assignment models - Formulation - Hungarian method - unbalanced assignment problem - traveling salesman problem. (UNIT-2: Chapter-9: 9.1 - 9.2, 9.4 - 9.6, and 9.9)

UNIT-III:

Theory of games - Two-person zero sum games - Maximin (minimax) principle - solution of games with and without saddle points - mixed strategies - Dominance - graphical solution of 2xn and mx2 games (UNIT-4: Chapter-1: 1.1 to 1.7and 1.13 to 1.15).

UNIT-IV: Job sequencing. Solution of sequencing problems - processing of n jobs through 2 machines - n jobs through 3 machines - 2 jobs through m machines - graphical method. (UNIT-4: Chapter 6: 6.1 to 6.7)

UNIT-V:

Project Management by PERT/CPM. Network diagram - Rules of construction - Time estimate and critical path analysis - PERT. (UNIT-4: Chapter 7: 7.1 to 7.10)

Recommended text:

S.D Sharma, Operations Research, Kedar Nath Ram & Co. Meerut, 12th Edition, 1999.

Reference Books:

1. Kanti Swarup, P.K. Gupta, Manmohan, Operations Research, Sultan chand & Sons, New Delhi, 9th Edn.
2. Hamdy A. Taha, Operations Research An Introduction. Phi Learning Private Ltd. New Delhi, 8th Edn.
3. P.R. Vittal, Introduction to Operations Research, Margham Publications, Chennai, 2nd Edn.
4. P.K. Gupta, D.S. Hira, Problems in Operations Research, Principles and Solutions, S. Chand & company Ltd., New Delhi

PAPER IV.5

MATHEMATICS FOR BIOLOGICAL SCIENCES

(For M.Sc. Zoology, Botany, Bio-Informatics and Micro Biology students only)

UNIT-I: REAL NUMBERS, SETS AND LOGIC.

Classification and Measurement - A problem with percentages - proper and improper use of percentages - Algebraic Laws - Relative numbers - Inequalities - Mean values - Summation - Powers - Fractionional Powers - Calculations with Approximate Numbers - An Application - Survey - "New Mathematics" - Sets - Notations and Symbols - Variable Members - Complementary Sets - The Union - The Intersection - Symbolic Logic - Negation and Implication - Boolean Algebra.

UNIT-II: RELATIONS, FUNCTIONS, THE POWER FUNCTION AND RELATED FUNCTION.

Product Sets - Relations - Functions - A special function -The General Linear Function - linear relations - definitions of Power Function - examples of Power Functions - Polynomial - Differences - an application - quadratic equations.

UNIT-III: PERIODIC, EXPONENTIAL AND LOGARITHMIC FUNCTIONS.

Definition - angles - polar coordinates - sine and cosine - conversion of polar coordinates - right triangles - trigonometric relations - polar graphs - trigonometric polynomials - sequences - the exponential function - inverse functions the logarithmic functions - applications - scaling - spirals.

UNIT-IV: DIFFERENTIATION AND INTEGRATION.

Growth rates - differentiation - the anti-derivative - integrals - integration - the second derivative - extremes - mean of a continuous function - small changes - techniques of integration.

UNIT - V: ORDINARY DIFFERENTIAL EQUATIONS.

Geometric interpretation - The differential equation $y' = ay$, the differential equation $y'=ay + b$, the differential equation $y'=ay^2 + by + c$, the differential equation $dy/dx = ky/x$, a system of linear differential equations, a system of nonlinear differential equations, classification of differential equations.

Recommended text:

E. Batschelet, Introduction to Mathematics for Life Scientist, Springer Verlag, 2003.

Reference Books:

1. B. Ackerman, Biophysical Science, Englewood Cliffs, N.J., Prentice Hall, 1962.
2. S. I. Grossman and J. E. Turner, Mathematics for Biological Sciences, Macmillan Publishing Company, New York, 1974.

IV SEMESTER

PAPER XIII

COMPLEX ANALYSIS II

Objectives

To study Riemann Theta Function and normal families, Riemann mapping theorem, Conformal mapping of polygons, harmonic functions, elliptic functions and Weierstrass Theory of analytic continuation.

UNIT-I : RIEMANN THETA FUNCTION AND NORMAL FAMILIES

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
Chapter 5 : Sections 5.1 to 5.5

UNIT-II : RIEMANN MAPPING THEOREM

Statement and Proof - Boundary Behavior - Use of the Reflection Principle.

Conformal mappings of polygons : Behavior at an angle

Schwarz-Christoffel formula - Mapping on a rectangle.

Harmonic Functions : Functions with mean value property - Harnack's principle.

Chapter 6 : Sections 1.1 to 1.3 (Omit Section1.4)
Chapter 6 : Sections 2.1 to 2.3 (Omit section 2.4)
Chapter 6 : Section 3.1 and 3.2

UNIT-III : ELLIPTIC FUNCTIONS

Simply periodic functions - Doubly periodic functions

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

UNIT-IV : WEIRSTRASS THEORY

The Weierstrass - p-function - The functionsζζ (z) and - The differential equation - The modular equation - The Conformal mapping by .

Chapter 8 : Sections 1.1 to1.7

UNIT-V: ANALYTIC CONTINUATION

The Weiertrass Theory - Germs and Sheaves - Sections and Riemann surfaces - Analytic continuation along Arcs - Homotopic curves - The Monodromy Theorem - Branch points.

Chapter 7 : Sections 3.1 to 3.5

Recommended Text

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

Reference Books

1. H.A. Presfly, *Introduction to complex Analysis*, Clarendon Press, oxford, 1990.
2. J.B. Corway, *Functions of one complex variables*, Springer - Verlag, International student Edition, Narosa Publishing Co.
3. E. Hille, *Analytic function Thorey* (2 vols.), Gonm & Co, 1959.
4. M.Heins, *Complex function Theory*, Academic Press, New York,1968.

PAPER XIV

FUNCTIONAL ANALYSIS

Objectives

To study the details of Banach and Hilbert Spaces and to introduce Banach algebras.

UNIT-I : BANACH SPACES

Definition - Some examples - Continuous Linear Transformations - The Hahn -Banach Theorem - The natural embedding of N in N**

Chapter 9 : Sections 46 to 49

UNIT-II : BANACH SPACES AND HILBERT SPACES

Open mapping theorem - conjugate of an operator - Definition and some simple properties - Orthogonal complements - Orthonormal sets

Chapter 9 : Sections 50 and 51
Chapter 10 : Sections 52, 53 and 54

UNIT-III : HILBERT SPACE

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

Chapter 10 : Sections 55, 56,57,58 and 59

UNIT-IV : PRELIMINARIES ON BANACH ALGEBRAS

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

Chapter 12 : Sections 64 to 69

UNIT-V: STRUCTURE OF COMMUTATIVE BANACH ALGEBRAS

Gelfand mapping - Applications of the formula $r(x) = \lim \| x^n \|^{1/n}$ - Involutions in Banach Algebras - Gelfand-Neumark Theorem.

Chapter 13 : Sections 70 to 73

Recommended Text

G.F.Simmons , *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. H.C. Goffman and G.Fedrick, *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.

PAPER XV
MATHEMATICAL STATISTICS

Objectives

This course introduces sampling theory, significance tests ,estimation, testing of hypotheses, ANOVA and sequential analysis with rigorous mathematical treatment.

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

UNIT-II : SIGNIFICANCE TEST

Concept of a statistical test - Parametric tests for small samples and large samples - χ^2 test - Kolmogorov Theorem 10.11.1 - Smirnov Theorem 10.11.2 - 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

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)

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)

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)

Recommended Text

M. Fisz , *Probability Theory and Mathematical Statistics,* John Wiley and sons, New Your, 1963.

Reference Books

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.Vander Waerden, *Mathematical Statistics,* G.Allen & Unwin Ltd., London, 1968.

PAPER XVI

DIFFERENCE EQUATIONS

Objectives

To introduce the process of discretization, Discrete version of Differential Equations, Discrete oscillation and the asymptotic behaviour of solutions of certain class of difference equations for linear cases only. Solution of difference equations using z-transforms is stressed.

UNIT-I : LINEAR DIFFERENCE EQUATIONS OF HIGHER ORDER

Difference Calculus - General Theory of Linear Difference Equations - Linear Homogeneous Equations with Constant coefficients - Linear non-homogeneous equations - Method of Undetermined coefficients, the method of variation of constants - Limiting behavior of solutions.

Chapter 2: Sections 2.1 to 2.5

UNIT-II : SYSTEM OF DIFFERENCE EQUATIONS

Autonomous System - The Basic Theory - The Jordan form - Linear periodic system.

Chapter 3: Section 3.1 to 3.4

UNIT-III : THE Z-TRANSFORM METHOD

Definition, Example and properties of Z-transform - The Inverse Z-transform and solution of Difference Equations: Power series method, partial fraction method, the inverse integral method - Volterra Difference Equation of convolution types - Volterra systems.

Chapter 5: Sections 5.1 to 5.3, 5.5 (omit 5.4)

UNIT-IV : ASYMPTOTIC BEHAVIOUR OF DIFFERENCE EQUATION

Tools and Approximations - Poincare's Theorem - Second order difference equations - Asymptotic diagonal systems - Higher order Difference Equations.

Chapter 8 : Sections 8.1 to 8.5

UNIT-V : OSCILLATION THEORY

Three-term difference Equation - Non-linear Difference Equations - Self-Adjoint second order equations.

Chapter 7 : Sections 7.1 to 7.3

Recommended Text

Saber N. Elaydi, *An Introduction to Difference Equations*, Springer Verlag, New York, 1996.

Reference Books

1. R.P.Agarwal., *Difference Equations and Inequalities*, Marcel Dekker, 1999.
2. S. Goldberg, *Introduction to Difference Equations*, Dover Publications, 1986
3. V. Lakshmi kantham and Trigiante, *Theory of Difference Equations*, Academic Press, New York, 1988.
4. Peterson, A *Difference Equations, An Introduction with Applications,* Academic Press, New York, 1991.

ELECTIVE

(to choose any 1 out of the given 3)

PAPER V.1

NUMBER THEORY AND CRYPTOGRAPHY

Objectives

This course aims to give elementary ideas from number theory which will have applications in cryptology.

UNIT-I : Elementary Number Theory

Time Estimates for doing arithmetic - Divisibility and Euclidean algorithm - Congruences - Applications to factoring.

Chapter-I

UNIT-II : Cryptography

Some simple crypto systems - Enciphering matrices

Chapter-III

UNIT-III : Finite Fields and quadratic Residues

Finite fields - Quadratic residues and Reciprocity

Chapter-II

UNIT-IV : Public Key Cryptography

The idea of public key cryptography - RSA - Discrete log - Knapsack

Chapter-IV : Sections IV.1 to IV.4 (omit sec.5)

UNIT-V : Primality and Factoring

Pseudoprimes - The rho method - Fermat factorization and factor bases - The Continued fraction method - The quadratic sieve method.

Chapter-V

Recommended Text

Neal Koblitz, *A Course in Number Theory and Cryptography*, Springer-Verlag, New York, 2002, Second Edition.

Reference Books

1. Niven and Zuckermann, *An Introduction to Theory of Numbers* (Edn. 3), Wiley Eastern Ltd., New Delhi, 1976.
2. David M.Burton, *Elementary Number Theory*, Wm C.Brown Publishers, Dubuque, Iowa, 1989.
3. K.Ireland and M.Rosen, *A Classical Introduction to Modern Number Theory*, Springer Verlag, 1972.

PAPER V.2

WAVELETS

Objectives

To introduce the basic notions and techniques of Wavelets Theory.

UNIT-I : AN OVERVIEW

Fourier to Wavelets - Integral Wavelet Transform and Time-frequency analysis - Inversion formulas and duals - Classification of Wavelets - Multiresolution analysis - Splines and Wavelets.

Fourier Analysis : Fourier and Inverse Fourier Transforms - Continuous time convolution - The delta fnction - Fourier Transform of square integrable functions.

Chapter 1: Sections 1.1 to 1.6 Chapter 2: Sections 2.1 to 2.3

UNIT-II : FOURIER ANALYSIS (CONTD)

Fourier Series - Basic Convergence Theory - Poisson Summaton Formula.

Wavelet Tranforms and Time Frequency Analysis: The Gabor Transform - Short time Fourier Transforms and the uncertainty principle - The integral Wavelet Transform - Dyadic Wavelets - Inversions - Frames - Wavelet Series.

Chapter 2: 2.4 and 2.5 Chapter 3: Section 3.1 to 3.6

UNIT-III : CARDINAL SPLINE ANALYSIS

Cardinal Spline spaces. - B-Splines and their basic properties - The time scale relation and an interpolating graphical display algorithm - B-Net representations and computation of cardinal splines - Construction of cadrdinal splines - construction of spline aaplication formulas - Construction of Spline interpolation formulas.

Chapter 4: Sections 4.1 to 4.6

UNIT-IV : SCALING FUNCTIONS AND WAVELETS

Multiresolution analysis - Scaling functions with finite two scale relation - Direction sum Decompositions of $L^2(R)$ - Wavelets and their duals.

Chapter 5: Sections 5.1 to 5.4 (omit 5.5 and 5.6)

UNIT-V: CARDINAL SPLINE WAVELETS

Interpolating splines wavelets - Compactly supported spline - Wavelets - Computation of Cardinal spline Wavelets - Euler - Frebenious Polynomials.

Orthogonal Wavelets: Examples of orthogonal Wavelets - Identification of orthogonal two scale symbols - Construction of compactly supported orthogonal wavelets.

Chapter 6 : Sections 6.1 to 6.4 (omit 6.5 and 6.6)

Chapter 7: Sections 7.1 to 7.3 (omit 7.4 and 7.5)

Recommended Text

Charles K.Chui , *An Introduction to Wavelets*, Academic Press, New York, 1992.

Reference Books

1. Chui. C.K. (ed) *Approximation theory and Fourier Analysis,* Academic Press Boston, 1991.
2. Daribechies,I. *Wavelets,* CBMS-NSF Series in Appl.. math. SIAM. Philadelphia, 1992.
3. Schumaker,L.L. *Spline Functions: Basic Theory ,* Wiley, New York 1981.
4. Nurnberger, G. *Applicatins to Spline Functions*, Springer Verlag, New York. 1989.
5. Walnut,D.F. *Introduction to Wavelet Analysis,*Birhauser, 2004.

PAPER V.3

ALGEBRAIC TOPOLOGY

Objectives

To introduce the ideas of algebraic topology to other branches of Mathematics

UNIT-I : CALCULUS IN THE PLANE: PATH INTEGRALS

Angles and Deformations - Differential forms and path Integrals - Independence of Path - Criterion for exactness. **Angles and Deformations:** Angle functions and Winding numbers - Reparametrizing and Deforming the Paths. **Winding Numbers.** Definition - Homotopy and Reparametrization - Varying the Point - Degrees and Local Degrees.

Chapter 1 : (a) to (c); Chapter 2: only (a) and (b)
Chapter 3 : (a) to (d)

UNIT-II : COHOMOLOGY AND HOMOLOGY

De Rham Cohomology and the Jordan Curve Theorem. Definition of the De Rham Graphs - The Coboundary map - the Jordon Curve Theorem - Applications and Variations.

Homology: Chains, Cycles, and H_0U - Boundaries, H_1U , and Winding Numbers - Chains on Grids - Maps and Homology - The First Homology Group for General Spaces.

Chapter 5: (a) to (d) Chapter 6: (a) to (e)

UNIT-III : HOLES AND INTEGRALS

Multiply connected regions - Integrations over continuous Paths and Chains - Periods of Integrals - Complex Integration

Mayer-Victoris: The Boundary map - Mayer-Victoris for Homology - Variations and applications - Mayer-Victoris for Cohomology

Chapter 9: (a) to (d) Chapter 10: (a) to (d)

UNIT-IV : COVERING SPACES AND FUNDAMENTAL GROUPS

Covering Spaces: Definition - Lifting paths and Homotopies - G-coverings - Covering Transformations. **The Fundamental Groups:** Definitions and Basic Properties - Homotopy - Fundamental Group and Homology. **Fundamental Groups and Covering Spaces:** Fundamental Group and Coverings - Automorphisms of Coverings - The Universal Covering - Coverings and Subgroups of the Fundamental Group

Chapter 11 : (a) to (d) Chapter 12 : (a) to (c) Chapter 13: (a) to (d)

UNIT-V : THE VAN KAMPEN THEOREM

G-Coverings from the Universal Covering - Patching Coverings together - The Van Kampen Theorem

Cohomology: Patching Coverings and Cech cohomology - Cech Cohomology and Homology - De Rham Cohomology and Homology - Proof of Mayer -Victoris for De Rham Cohomology.

Chapter 14 : (a) to (d) ; Chapter 15: (a) to (d)

Recommended Text

William Fulton, *Algebraic Topology* - A First Course, Springer-Verlag, New York, 1995

Reference Books

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 Nastrand, New York, 1970
5. J.R. Mukres, *Topology*, Prentica Hall of India, New Delhi, 2002 (3rd Indian Print)

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