INSTITUTE OF SCIENCE, NAGPUR

(An Autonomous Institute of Government of Maharashtra)

DEPARTMENT OF MATHEMATICS

Syllabus

Master of Science (M. Sc.) Semester Pattern

MATHEMATICS

(MTH/PG/2021/01)

(To be Implemented from 2021-2022)

M. Sc. (Semester Pattern) Syllabus

Semester wise Name of Papers

Subject – Mathematics

Semester	Paper	Name of the Paper	Paper Code
I	I	ALGEBRA I	MMFS11
	II	REAL ANALYSIS I	MMFS12
	III	TOPOLOGY I	MMFS13
	IV	ORDINARY DIFFERENTIAL EQUATIONS	MMFS14
	V	INTEGRAL EQUATIONS	MMFS15
II	I	ALGEBRA II	MMFS21
	II	REAL ANALYSIS II	MMFS22
	III	TOPOLOGY II	MMFS23
	IV	DIFFERENTIAL GEOMETRY	MMFS24
	V	CLASSICAL MECHANICS	MMFS25
III	I	COMPLEX ANALYSIS	MMSS31
	II	FUNCTIONAL ANALYSIS	MMSS32
	III	MATHEMATICAL METHODS	MMSS33
	IV*	FLUID DYNAMICS-I (OPTIONAL)	MMSS34
		GENERAL RELATIVITY (OPTIONAL)	MMSS35
		MEASURE AND INTEGRATION THEORY (OPTIONAL)	MMSS36
		NUMBER THEORY (OPTIONAL)	MMSS37
		ALGEBRAIC TOPOLOGY-I (OPTIONAL)	MMSS38
	V**	ELEMENTARY MATHEMATICS-I (FOUNDATION PAPER FOR OTHER THAN MATHEMATICS STUDENTS)	MMSS39
		OPERATION RESEARCH-I (SUBJECT CENTRIC)	MMSS310
IV	I	DYNAMICAL SYSTEMS	MMSS41
	II	PARTIAL DIFFERENTIAL EQUATIONS	MMSS42
	III	ADVANCE NUMERICAL METHODS	MMSS43
	IV*	FLUID DYNAMICS-II (OPTIONAL)	MMSS44
		COSMOLOGY (OPTIONAL)	MMSS45
		CRYPTOGRAPHY (OPTIONAL)	MMSS46
		ALGEBRAIC TOPOLOGY-II (OPTIONAL)	MMSS47

		OPERATOR THEORY (OPTIONAL)	MMSS48
	V**	ELEMENTARY DISCRETE MATHEMATICS-II (FOUNDATION PAPER FOR OTHER THAN MATHEMATICS STUDENTS)	MMSS49
		OPERATION RESEARCH-II (SUBJECT CENTRIC)	MMSS410
* Choose any one paper out of five optional papers. ** Mathematics Students may choose Subject centric Paper or foundation paper from PG syllabus of other Subjects.			

Marking Scheme of Syllabus

Faculty of Science M. Sc. Semester –I to IV (Mathematics)

Semester	Paper	Total Periods / Week	Marks			Total Marks
			Theory	Internal	Total	
I to IV	I	5	100	25	125	625
	II	5	100	25	125	
	III	5	100	25	125	
	IV	5	100	25	125	
	V	5	100	25	125	
Note : The Syllabus is based on 5 theory periods per paper per week. Theory paper is divided into four units. Each unit shall be covered in 15 hours. Fifteen periods (of 60 minutes) are allotted for each unit. The examination shall comprise five theory papers of 3 hours duration of 100 marks each. Two internal assessments of 25 marks each are based on Five theory papers.						

SUBJECT: **MATHEMATICS**

M. Sc. -I SEMESTER -I

MMFS11: PAPER-I

(ALGEBRA I)

OUTCOMES

1. Classify between permutation groups, dihedral group, commutator group and so on.
2. Use Sylows theorem.
3. Study groups of order 2^p and pq.
4. Find difference between quotient modules, completely reducible modules and free modules.

UNIT-I (15 hours)

Permutation Group. Normal subgroups, Quotient groups Dihedral group. Commutator group. Isomorphism Theorems. Automorphisms. Characteristic subgroup. Conjugacy and G-Sets, Cyclic Decomposition, Alternating group A_n, Simplicity of A_n.

UNIT-II (15 hours)

Normal Series. Solvable groups. Nilpotent groups. Cyclic decomposition of permutation group. Alternating groups. Simplicity of A_n.

UNIT-III (15 hours)

Direct product, semi-direct product of groups, finitely generated abelian groups, Invariants of a finite abelian group, Sylows theorems. Groups of order 2^p and pq

UNIT-IV (15 hours)

Ideals and Homomorphisms. Sum and direct sum of ideals. Maximal and prime ideals. Nilpotent and Nil ideals. Modules. Submodules. Direct sums. R-homomorphisms and quotient modules. Completely reducible modules. Free modules.

Text Books:

Basic Abstract Algebra : Bhattacharya, Jain, and Nagpal, Second Edition, Cambridge University Press.

Reference Books:

1. Topics in Algebra, I. N. Herstein, Second Edition, John Wiley.
2. Abstract Algebra: David S. Dummit and Richard M. Foote, John Wiley.

SUBJECT: **MATHEMATICS**

M. Sc. -I SEMESTER -I

MMFS12: PAPER-II

(REAL ANALYSIS I)

OUTCOMES

1. Understand uniform convergence of sequence of functions.
2. Study utility of uniform convergence in continuity, integration and differentiation.
3. Use inverse function theorem, implicit function theorem, and rank theorem in the advance course in mathematics.
4. Understand topological manifold and related concepts.

UNIT-I (15 hours)

Uniform convergence. Uniform convergence and continuity. Uniform convergence and integration. Uniform convergence and differentiation. Equicontinuous families of functions. The Stone-Weierstrass theorem.

UNIT-II (15 hours)

Differentiation. The Contraction Principle. The Inverse Function Theorem. The Implicit Function Theorem. The Rank Theorem. Partitions of unity.

UNIT-III (15 hours)

The space of tangent vectors at a point of Rn. Another definition of Ta (Rn). Vector fields on open subsets of Rn. Topological manifolds. Differentiable manifolds. Real Projective space. Grassman manifolds. Differentiable functions and mappings.

UNIT-IV (15 hours)

Rank of a mapping. Immersion. Sub manifolds. Lie groups. Examples of Lie groups.

Text Books:

1. Principles of Mathematical Analysis (Third Edition): Walter Rudin Mc GRAW – HILL Book Company.
2. An Introduction to Differentiable Manifolds and Riemannian geometry: W. Boothby, Academic Press, 1975.

Reference Books:

1. Methods of Real Analysis: R. R. Goldberg, John Wiley.
2. Calculus of Several Variables: C. Goffman, Harper and Row.

SUBJECT: **MATHEMATICS**

M. Sc. -I SEMESTER -I

MMFS13: PAPER-III

(TOPOLOGY I)

OUTCOMES

1. Determine countable, uncountable sets and cardinal numbers.
2. Describe open sets, derived sets, closed sets and connected set with illustrative examples.
3. Understand compact and countably compact spaces, regular and normal spaces.
4. Identify continuous functions and homeomorphisms.

UNIT-I (15 hours)

Countable and Uncountable sets. Examples and related Theorems. Cardinal Numbers and related Theorems. Topological Spaces and Examples.

UNIT-II (15 hours)

Open sets and Limit points, Derived Sets. Closed sets and closure operators. Interior, Exterior and boundary operators. Neighbourhoods, bases and relative topologies.

UNIT-III (15 hours)

Connected sets and components. Compact and countably compact spaces, Continuous functions and homeomorphisms, Arc wise connectivity.

UNIT-IV (15 hours)

T0 and T1-spaces, T2-spaces and sequences. Axioms of countability, Separability, Regular and normal spaces.

Text Books:

Foundations of General Topology: W.J. Pervin, Academic press, 1964.

Reference Books:

1. Topology: J.R. Munkres, (second edition), Prentice Hall of India, 2002.
2. Introduction to Topology and Modern Analysis: G.F. Simmons, Mc Graw Hill 1963.
3. General Topology: J.L. Kelley, Van Nostrand, 1995.
4. Introduction to general Topology: K.D. Joshi, Wiley Eastern Ltd. 1983.

SUBJECT: **MATHEMATICS**

M. Sc. -I SEMESTER -I

MMFS14: PAPER-IV

(ORDINARY DIFFERENTIAL EQUATIONS)

OUTCOMES

1. The aim of this course is to study basic notions in Differential Equations and use the results in developing advanced mathematics.
2. After completion of this course students will able to solve application problems modeled by linear differential equations and will able to use power series methods to solve differential equations about ordinary points and regular singular points.

UNIT-I (15 hours)

Linear Equations with variable coefficients: Initial value problems for the homogeneous equations. Solutions of the homogeneous equations, The Wronskian and linear independence, Reduction of the order of a homogeneous equation, The non-homogenous equations, Homogeneous equations with analytic coefficients, The Legendre equations.

UNIT-II (15 hours)

Linear Equations with regular singular points: The Euler equations, Second order equations with regular singular points, The Bessel equation, Regular singular points at infinity.

UNIT-III (15 hours)

Existence and uniqueness of solutions to first order equations: The method of successive approximations, The Lipschitz condition of the successive approximation. Convergence of the successive approximation, Non-local existence of solutions, Approximations to solutions and uniqueness of solutions.

UNIT-IV (15 hours)

Existence and Uniqueness of Solutions to System of first order ordinary differential equations: An example- Central forces and planetary motion, Some special equations, Systems as vector equations , Existence and uniqueness of solutions to systems, Existence and uniqueness for linear systems, Green's function, Sturm Liouville theory.

Text Books:

1. E.A.Coddington: An introduction to ordinary differential equations (2012), Prentice Hall of India Pvt.Ltd. New Delhi.
2. G. Birkoff and G.G.Rota: Ordinary Differential equations, John Willey and Sons.
3. Mark Pinsky: Partial differential equations and boundary-value problems with applications, AMS, 3rd edition(2011).

Reference Books:

1. G.F. Simmons Differential Equations with Applications and Historical note, MeGraw Hill, Inc. New York. (1972)
2. E.A. Coddington and Levinson: Theory of ordinary differential equations McGraw Hill, New York(1955) 3.E.D. Rainvills :Elementary differential equations, The Macmillan company, New York. (1964)

SUBJECT: **MATHEMATICS**

M. Sc. -I SEMESTER -I

MMFS15: PAPER-V

(INTEGRAL EQUATIONS)

OUTCOMES

1. Convert ordinary differential equation into integral equation.
2. Classify linear integral equations.
3. Do Hermitization and symmetrization of kernels.
4. Solve integral equations.
5. Handle approximate methods of solutions for linear integral equations.

UNIT-I (15 hours)

Preliminary concepts of integral equations. Some problems which give rise to integral equations. Conversion of ordinary differential equations into integral equations. Classification of linear integral equations. Integro-differential equations.

UNIT-II (15 hours)

Fredholm equations. Degenerate kernels. Hermitian and symmetric kernels. The Hilbert- Schmidt theorem. Hermitization and symmetrization of kernels. Solutions of integral equations with Green's function type kernels.

UNIT-III (15 hours)

Types of Voltera equations. Resolvent kernel of Voltera equations, Convolution type kernels. Some miscellaneous types of Voltera equations. Non-linear Voltera equations. Fourier integral equations. Laplace integral equations.

UNIT-IV (15 hours)

Hilbert transform. Finite Hilbert transforms. Miscellaneous integral transforms. Approximate methods of solutions for linear integral equations. Approximate evaluation of Eigen values and Eigen functions.

Text Books:

Integral Equations: A short course: L. G. Chambers: International text book company Ltd, 1976.

Reference Books:

1. Integral equations by Shanti Swaroop, Shiv Raj Singh
2. Linear integral equation, Theory and techniques, Academic press, New York 1971
3. R.P. Kanwal, Linear Integral Equation, Theory and Techniques, Academic Press, N.Y. (1971).
4. S.G. Mikhlin, Linear Integral Equations, Hindustan Book Agency, (1960).
5. A.M. Viazwaz, A First Course in Integral Equations, World Scientific (1997).
6. L.I.G. Chambers, Integral Equation: A Short Course, International Text Book Company Ltd. (1976).
7. Larry Andrews, Bhimsen Shiramoggo, Integral Transform for Engineers, Prentice Hall of India (2003).
8. Integral equations and boundary value problems by M. D. Raisinghania, S. Chand publication

SUBJECT: **MATHEMATICS**

M. Sc. -I SEMESTER -II

MMFS21: PAPER-I

(ALGEBRA II)

OUTCOMES

1. Classify between unique factorization domains, principal ideal domains and Euclidean domains.
2. Understand Fundamental theorem of Galois theory and Fundamental theorem of algebra.
3. Study algebraically closed fields and splitting fields.
4. Apply Eisenstein criteria to polynomials.

UNIT-I (15 hours)

Unique factorization domains. Principal Ideal domains. Euclidean domains. Polynomial rings over unique factorization domains.

UNIT-II (15 hours)

Irreducible polynomials and Eisenstein criterion. Adjunction of roots. Algebraic extensions. Algebraically closed fields. Splitting fields. Normal extensions. Splitting fields, multiple roots.

UNIT-III (15 hours)

Finite fields. Separable extensions. Automorphism groups, and fixed fields. Fundamental theorem of Galois theory. Fundamental theorem of algebra.

UNIT-IV (15 hours)

Roots of unity and Cyclotomic polynomials. Cyclic extensions. Polynomials solvable by radicals. Ruler and compass constructions.

Text Books:

Basic Abstract Algebra: Bhattacharya, Jain, Nagpaul; Second Edition, Cambridge University Press.

Reference Books:

1. Topics in Algebra, I. N. Herstein, Second Edition, John Wiley.
2. Abstract Algebra, David S.Dummit and Richard M.Foote, John Wiley.

SUBJECT: **MATHEMATICS**

M. Sc. -I SEMESTER -II

MMFS22: PAPER-II

(REAL ANALYSIS II)

OUTCOMES

1. Differentiate between measurable and non measurable sets.
2. Understand general Lebesgue integral.
3. Classify between compact metric spaces, locally compact spaces and sigma compact spaces.
4. Use Holder and Minkowski inequalities.

UNIT-I (15 hours)

Outer measure. Measurable sets and Lebesgue measure. Anon-measurable set, Measurable functions, Littlewood's three principles.

UNIT-II (15 hours)

The Riemann integral. Lebesgue integral of a bounded function over a set of finite measure. Integral of a non-negative function. General Lebesgue integral. Convergence in measure. Differentiation of monotone functions. Functions of bounded variation. Differentiation of an integral.

UNIT-III (15 hours)

Absolute continuity. Convex functions. Lp-spaces. Holder and Minkowski inequality. Riesz-Fischer theorem. Approximation in Lp. Bounded linear functionals on Lp-spaces.

UNIT-IV (15 hours)

Compact metric spaces. Baire category theorem. Arzela Ascoli theorem. Locally compact spaces. Sigma compact spaces.

Text Books:

Real Analysis, H.L. Royden, Third edition, Prentice Hall, 1988.

Reference Books:

1. Measure theory and Integration, G. de Barra Wiley Eastern Limited, 1981.
2. An introduction to Measure & Integration, Inder K. Rana, Narosa Publishing House.

SUBJECT: **MATHEMATICS**

M. Sc. -I SEMESTER -II

MMFS23: PAPER-III

(TOPOLOGY-II)

OUTCOMES

1. Understand metric topology and product topology.
2. Understand the concept of connectedness, compactness and completeness of topological spaces.
3. Use Urysohn's lemma and Urysohn's metrization theorem.

UNIT-I (15 hours)

Continuous Functions: Continuous functions - the product topology - The metric topology. Chapter 2 : Sections 18 to 21 [Omit Section 22]

UNIT-II (15 hours)

Connectedness: Connected spaces - connected subspaces of the Real line - Components and local connectedness. [Chapter 3 : Sections 23 to 25]

UNIT-III (15 hours)

Compactness: Compact spaces - compact subspaces of the Real line - Limit Point Compactness - Local Compactness. [Chapter 3 : Sections 26 to 29]

UNIT-IV (15 hours)

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]

Text Books:

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.

SUBJECT: **MATHEMATICS**

M. Sc. -I SEMESTER -II

MMFS25: PAPER-IV

(DIFFERENTIAL GEOMETRY)

OUTCOMES

1. Study canonical geodesic equations.
2. Use properties of geodesics.
3. Difference between Gaussian curvature, constant curvature and mean curvature.
4. Understand compact surfaces and complete surfaces.

UNIT-I (15 hours)

Definition of surface. Curves on a surface. Surfaces of revolution. Helicoids. Metric. Direction coefficients. Families of curves. Isometric correspondence. Intrinsic properties. Geodesics. Canonical geodesic equations.

UNIT-II (15 hours)

Normal property of geodesics. Existence theorems. Geodesic parallels. Geodesic curvature. Gauss Bonnet theorem. Gaussian curvature. Surfaces of constant curvature. Conformal mapping. Geodesic mapping.

UNIT-III (15 hours)

Second fundamental form. Principal curvatures. Lines of curvature. Developable. Developable associated with space curves. Developable associated with curves on surfaces. Minimal surfaces and ruled surfaces. Fundamental equations of Surface theory. Parallel surfaces.

UNIT-IV (15 hours)

Compact surfaces whose points are umbilics. Hilbert's lemma. Compact surfaces of constant Gaussian or mean curvature. Complete surfaces. Characterisation of complete surfaces. Hilbert's theorem. Conjugate points on geodesics. Intrinsically defined surfaces. Triangulation. Two dimensional Riemannian manifolds. Problem of metrization. Problem of continuation.

Text Books:

An introduction to Differential Geometry: T.J. Wilmore; Oxford University Press

Reference Books:

1. W . Klingenberg (Springer), A course in Differential Geometry
2. Geometry of curves and surfaces: do Carmo, Academic Press.
3. Weatherburn, C. Riemannian Geometry and Tensor Calculus
4. D. Somasundaram, Differential Geometry a first course, Narosa Publishing House, 2008

SUBJECT: **MATHEMATICS**

M. Sc. -I SEMESTER -II

MMFS25: PAPER-V

(CLASSICAL MECHANICS)

OUTCOMES

1. Derive Lagrange equations from Hamilton's principle.
2. Describe canonical transformations.
3. Study equations of motions.

UNIT-I (15 hours)

Variational principle and Lagranges Equations : Hamilton's principle, some techniques of the calculus of variations. Derivation of Lagrange' s Equations from Hamilton's Principle. Extension of principle to nonholonomic systems. Conservation theorems and symmetry properties.

UNIT-II (15 hours)

Legendre transformations and the Hamilton equations of motion, cyclic coordinates and conservation theorems, Routh's equations, Derivation of Hamilton's equations from a variational principle, the principle of least action.

UNIT-III (15 hours)

Canonical transformations : The equations of Canonical transformation, examples of canonical transformations. Symmetric approach to Canonical Transformation, Poisson's bracket & other canonical invariants.

UNIT-IV (15 hours)

Equations of motion. Infinitesimal canonical transformations and conservation theorems in the Poisson bracket formulation, the angular momentum poisson bracket relations, Hamilton-Jacobi theory for Hamilton's principle, and Hamilton-Jacobi theory for characteristic functions.

Text Books:

H.Goldstein, Classical Mechanics, Second edition, Narosa Publishing House, New Delhi

Reference Books:

1. T.M. Karade, G.S.Khadekar, Lectures on Advanced Mechanics, Sonu-Nilu publication
2. A.S.Ramsey Dynamics Part-II, the English Language Book Society and Cambridge University Press.
3. Gupta, Kumar and Sharma, Classical Mechanics
4. I.D. Landau and E.M. Lifchitz, Vol. I third edition, Perguman press, New Delhi
5. N. C. Rana & P .S. Joag ,Classical Mechanics ,Tata Mc Graw Hill
6. L. M. Katkar, Classical Mechanics(Mathematics), Shivaji University Kolhapur, 2007

SUBJECT: **MATHEMATICS**

M. Sc. -II SEMESTER -III

MMSS31: PAPER-I

(COMPLEX ANALYSIS)

OUTCOMES

1. Represent analytic function as power series.
2. Classify singularities, residues.
3. Apply Cauchy theorem and integral formula.
4. Use open mapping theorem and Goursat theorem.

UNIT-I (15 hours)

Impossibility of ordering Complex numbers. Extended complex plane and stereographic projection. Elementary properties and examples of analytic Functions: Power series, analytic functions.

UNIT-II (15 hours)

Analytic functions as mappings, Mobius transformations. Power series representation of analytic functions, zeros of an analytic function, index of a closed curve.

UNIT-III (15 hours)

Cauchy's theorem and integral formula, the homotopic version of cauchy's theorem and simple connectivity, counting zeros; the open mapping theorem, Goursat's theorem, Classification of singularities, residues, the argument principle.

UNIT-IV (15 hours)

The maximum principle. Schwarz's lemma. convex functions and Hadamards three circles theorem. Phragmen-Lindel of theorem.

Text Books:

Functions of one complex variable: John B. Conway, Second edition, Springer international Student Edition.

Reference Books:

Complex Analysis, L.V. Ahlfors. Mc-Graw Hill, 1966.

SUBJECT: **MATHEMATICS**

M. Sc. -II SEMESTER -III

MMSS32: PAPER-II

(FUNCTIONAL ANALYSIS)

OUTCOMES

1. Define norm on vector space.
2. Study completeness and compactness of normed space.
3. Use different versions of Hahn-Banach theorem.
4. Describe bounded linear operators and closed linear operators.

UNIT-I (15 hours)

Normed spaces, Banach spaces, Further properties of normed spaces. Finite dimensional normed spaces and subspaces. Compactness and finite dimension. Bounded and continuous linear operators.

UNIT-II (15 hours)

Linear functionals. Normed spaces of operators. Dual spaces. Inner product space. Hilbert space. Further properties of inner product spaces. Orthogonal complements and direct sums. Orthonormal sets and sequences. Total orthonormal sets and sequences.

UNIT-III (15 hours)

Representation of functionals on Hilbert spaces. Hilbert adjoint operators, self adjoint, unitary and normal operators. Hahn-Banach Theorem, Hahn-Banach Theorem for complex vector spaces and normed spaces. Reflexive spaces.

UNIT-IV (15 hours)

Category theorem, Uniform boundedness theorem, strong and weak convergence, Convergence of sequences of operators and functionals. Open mapping theorem, Closed linear operators and closed graph theorem.

Text Books:

Introductory Functional Analysis with Applications by E. Kreyszig, John Wiley and Sons.

Reference Books:

1. Introduction to Functional Analysis by A.E. Taylor and D.C. Lay, John Wiley and Sons.
2. Introduction to Topology and Modern Analysis: G.F. Simmons, Mc Graw Hill.

SUBJECT: **MATHEMATICS**

M. Sc. -II SEMESTER -III

MMSS33: PAPER-III

(MATHEMATICAL METHODS)

OUTCOMES

1. Understand Fourier transform, Fourier sine and cosine transform and their applications to solve pde and boundary value problems.
2. Understand Laplace transform and its applications to solve ode and boundary value problems.
3. Understand Finite Hankel, Finite Legendre and Finite Mellin transform and their applications to solve boundary value problems.

UNIT-I (15 hours)

Fourier integral theorem. Fourier transforms. Fourier cosine and sine transform. The convolution integral. Multiple Fourier transform. Solution of partial differential equation by means of Fourier transform.

UNIT-II (15 hours)

Calculations of the Laplace transform of some elementary functions. Laplace transform of derivatives. The convolution of two functions. Inverse formula for the Laplace transform. Solutions of ordinary differential equations by Laplace transform.

UNIT-III (15 hours)

Finite Fourier transform. Finite Sturm-Liouville transforms. Generalized finite Fourier transform.

UNIT-IV (15 hours)

Finite Hankel transform. Finite Legendre transform. Finite Mellin transform.

Text Books:

The use of integral transforms: I N. Sneddon, Tata Mc Graw Hill Publishing Company Ltd.

Reference Books:

Modern Mathematics For Engineers: Edwin F Beckenbach, Second series, Mc Graw Hill Book Company.

SUBJECT: **MATHEMATICS**

M. Sc. -II SEMESTER -III

MMSS34: PAPER-IV

FLUID DYNAMICS-I (OPTIONAL)

OUTCOMES

1. Distinguish between real and ideal fluids, Steady and unsteady fluids.
2. Analyze source, sink and doublets.
3. Understand entropy, Maxwell's thermodynamic relation, Isothermal Adiabatic and Isentropic processes.
4. Understand the equation of motion of a gas. Sonic, subsonic, supersonic flows; isentropic gas flow.

UNIT-I (15 hours)

Real fluids and ideal fluids. Velocity of a fluid at a point. Stream lines and path lines. Steady and unsteady flows. Velocity potential. Velocity vector. Local and particle rate of change. Equation of continuity. Acceleration of a fluid. Condition at a rigid boundary. General analysis of fluid motion. Euler's equation of motion. Bernoulli's equation. Worked examples. Discussion of the case of steady motion under conservative body forces. Some further aspects of vortex motion.

UNIT-II (15 hours)

Sources, sinks and doublets. Images in a rigid infinite plane. Images in solid spheres. Axisymmetric flows. Stokes' stream function. The complex potential for two-dimensional irrotational, incompressible flow. Complex velocity potential for standard two dimensional flow. Uniform stream. Line source and line sink. Line doublets. Line vortices. Two dimensional image systems. The Milne-Thomson circle theorem. Circle Theorem. Some applications of circle theorem. Extension of circle theorem. The theorem of Blasius.

UNIT-III (15 hours)

The equations of state of a substance, the first law of thermodynamics, internal energy of a gas, functions of state, entropy, Maxwell's thermodynamic relation, Isothermal Adiabatic and Isentropic processes. Compressibility effects in real fluids, the elements of wave motion. One dimensional wave equation, wave equation in two and three dimensions, spherical waves, progressive and stationary waves.

UNIT-IV (15 hours)

The speed of sound in a gas, equation of motion of a gas. Sonic, subsonic, supersonic flows; isentropic gas flow. Reservoir discharge through a channel of varying section, investigation of maximum mass flow through a nozzle, shock waves, formation of shock waves, elementary analysis of normal shock waves.

Text Books:

F. Chorlton, Text book of Fluid Dynamics, CBS Publishers, Delhi 1985.

Reference Books:

1. G.K. Batchelor, An Introduction to fluid Mechanics, Foundation Books, New Delhi 1994.
2. M.D. Raisinghania, fluid Mechanics, S. Chand and Company, Delhi.

SUBJECT: **MATHEMATICS**

M. Sc. -II SEMESTER -III

MMSS35: PAPER-IV

GENERAL RELATIVITY (OPTIONAL)

OUTCOMES

1. Classify tensors.
2. Apply principles of covariance, equivalence and geodesic.
3. Study gravitational field equations.
4. Linearization of field equations.

UNIT-I (15 hours)

Tensor Algebra, Riemannian geometry, Curvature Tensor: Covariant Curvature tensor, Ricci tensor, Einstein Tensor, The Bianchi identity.

UNIT-II (15 hours)

The principle of covariance, The principle of equivalence, Geodesic principle, Newton's equations of motion as an approximation of geodesic equations, Poisson's equations as an approximation to Einstein field equations.

UNIT-III (15 hours)

Gravitational field equations in free space, Exterior Schwarzchild's solution and its isotropic form, Birkhoff's theorem, Schwarzchild singularity, planetary orbit, Advance of Perihelion of a planet, Bending of light rays in the gravitational filed, Gravitational Red shift in the spectral lines.

UNIT-IV (15 hours)

Newtonian Incompressible star, The pressure contribution mass of static, spherically symmetric System, The Tolman-Oppenheimer-Volkoff Equation, Schwarzchild's Interior solution.

Text Books:

1. Introduction to General Relativity: Ronald Adler, Maurice Bezin and Manamen Schiffer, McGraw-Hill Kogakusha Ltd.
2. Lecture Notes on General Theory of Relativity, **Øyvind Gron** (Oyvind Gron) , Springer publication Unit 4 : Chapter 10 , articles [10.1, 10.2,10.3, 10.4]

Reference Books:

1. Introduction to theory of relativity, Rosser W.G.V., ELBS(1972).
2. Lecture on General Relativity, T M Karade, G S Khadekar and Maya S Bendre, Sonu Nilu Publication (2004)
3. Relativity Special, General and Cosmology, Rindler W., Pub. Oxford University Press (2003).
4. The Classical Theory of Fields By Landau I.D. and Lifshitz E.M., Pub. Pergamon Press (1978).

SUBJECT: **MATHEMATICS**

M. Sc. -II SEMESTER -III

MMSS36: PAPER-IV

MEASURE AND INTEGRATION THEORY (OPTIONAL)

OUTCOMES

1. Classify measurable and non-measurable sets, Measurable funs.
2. Understand Riemann and Lebesgue integrals.
3. Find Four derivatives.
4. Understand the concept of measure space and integration with respect to a measure.
5. Concept of convex functions and its role in Jensen's inequality.

UNIT-I (15 hours)

Lebesgue outer measure, measurable sets, Regularity,Measurable functions, Borel and Lesbesgue measurability.

UNIT-II (15 hours)

Integration of Non-negative function, the general integral, integration of series, Riemann and Lebesgue integrals.

UNIT-III (15 hours)

The Four derivatives, continuous non-differentiable functions, functions of bounded variation, Lebesgue differentiation theorem, differentiation and integration.

UNIT-IV (15 hours)

Measures and outer measures, Extension of a measure,: The uniqueness of Extension, completion of a measure, measure spaces, integration with respect to a measure. spaces, convex functions, Jensen's inequality.

Text Books:

Bartle R. G ., The Elements of Integration, John Wiley & Sons, Inc., New York, 1966.

Reference Books:

1. Bartle R.G ., The Elements of Integration, John Wiley & Sons, Inc., New York, 1966.
2. G .de Barra, Measure Theory and Integration. Wiley Eastern Limited,1981.
3. Halmos P .R. Measure Theory, Van Nostrand Princeton, 1950.
4. Hawkins T. G., Lebesgue' s Theory of Integration, its origins and Development, Chelsea, New York, 1979.
5. Inder K. Rana, An Introduction to Measure and Integration, Narosa Publishing House, Delhi, 1997.
6. Karade T .M., Salunke J.N., Lectures on Advanced Real Analysis, Sonu Nilu Publication, Nagpur, 2004.
7. Royden H.L., Real Analysis, Macmillan Pub. Co. Inc., 4th Edition, New York, 1993
8. P.K. Jain and V.K.Gupta, Lebesgue Measure and integration, June-2010.

SUBJECT: **MATHEMATICS**

M. Sc. -II SEMESTER -III

MMSS37: PAPER-IV

NUMBER THEORY (OPTIONAL)

OUTCOMES

1. Understand the concept of Mobius function u(n), Euler totient function φ(n).
2. Understand Euler's summation formula, asymptotic formulas, the average order of d(n), the average order of divisor functions (n), the average order of φ(n).
3. Understand Chebyshev's functions Ψ(x) and v(x) and their relations.
4. Understand reduced residue systems and Euler-Format theorem, Polynomial congruences modulo-*p*.

UNIT-I (15 hours)

Introduction, The Mobius function u(n), The Euler totient function φ(n), A relation connecting φ and μ. A product formula for φ (n),The Dirichlet product of arithmetical functions, Dirichlet inverses and Mobius Inversions formula. The Mangoldt function π(n), Multiplicative functions. Multiplicative functions and Dirichlet multiplication, The inverse of a completely multiplicative function, Liouville's function (n), The divisor function (n). Generalised convolutions.

UNIT-II (15 hours)

Introduction, The big oh notation Asymptotic equality of functions, Euler's summation formula, some elementary asymptotic formulas, the average order of d(n), the average order of divisor functions (n), the average order of φ(n), An application to the distribution of lattice points visible from the origin. The average order of μ(n) and π(n), The partial sums of a Dirichlet product, Applications to μ(n) and π(n), Another identity for the partial sums of a Dirichlet product.

UNIT-III (15 hours)

Introduction, Chebyshev's functions Ψ(x)and v(x). Relations connecting Ψ (x)and v(x), some equivalent forms of the prime number theorem, Inequlities of π(n) and Pn Shapiro's Tauberian theorem. Application of Shapiro's theorem. An asymptotic formulae for the partial sums Σ (1/p).

UNIT-IV (15 hours)

Definition and basic properties of congruences. Residue classes and complete residue systems. Linear congruences. Reduced residue systems and Euler - Format theorem, Polynomial congruences modulo p, Lagrange's theorem. Simultaneous linear congruences, the Chinese remainder theorem. Applications of the Chinese remainder theorem. Polynomial congruences with prime power moduli.

Text Books:

Introduction to analytic number theory - by Tom M-Apostol, Narosa Publishing House, New Delhi. Sections: 2.2 to 2.14 3.1 to 3.12 4.1 to 4.9 5.1 to 5.9

Reference Books:

SUBJECT: **MATHEMATICS**

M. Sc. -II SEMESTER -III

MMSS38: PAPER-IV

ALGEBRAIC TOPOLOGY-I (OPTIONAL)

OUTCOMES

1. Understand the concept of Homotopic mappings, Essential & inessential mappings.
2. Understand Higher homotopy groups. Covering spaces.
3. Understand geometrical complexes and polytopes, Barycentric subdivision.
4. Understand embedding theorem for polytopes, Simplicial homology theory (Oriented complexes, Incidence numbers).
5. Understand Betti numbers and torsion coefficients.

UNIT-I (15 hours)

The Elements of Homotopy theory: Introduction. Homotopic mappings. Essential and inessential mappings. Homotopically equivalent spaces. Fundamental group. Knots and related embedding problems. Higher homotopy groups. Covering spaces.

UNIT-II (15 hours)

Polytopes and triangulated spaces: En as a vector space over E1.Barycentric coordinates. Geometrical complexes and polytopes. Barycentric subdivision. Simplicial mappings and simplicial approximation theorem.

UNIT-III (15 hours)

Abstract simplicial complexes. Embedding theorem for polytopes. Simplicial homology theory: Introduction. Oriented complexes. Incidence numbers. Chains, cycles and groups.

UNIT-IV (15 hours)

Decomposition theorem for abelian groups. Betti numbers and torsion coefficients. Zero dimensional homology groups. Universal coefficients. Euler Poincare formula. Universal coefficients.

Text Books:

Topology : J.G. Hocking and G.S. Young : Addison Wesley, 1961

Reference Books:

1. Topology : J.R.Munkres, Prentice Hall, Second Edition, 2000.
2. Basic Concepts of Algebraic Topology : Fred H.Croom , Springer Verlag 1978.

SUBJECT: **MATHEMATICS**

M. Sc. -II SEMESTER -III

MMSS39: PAPER-V

ELEMENTARY MATHEMATICS-I

(FOUNDATION PAPER FOR OTHER THAN MATHEMATICS STUDENTS)

OUTCOMES

1. Understand the concept differentiation and integration of real valued functions.
2. Understand the concepts of matrices and determinants and their related theories.
3. Understand basic concepts of Complex numbers.

UNIT-I (15 hours)

Differentiation: Derivative of a constant function, derivative of trigonometric functions, derivative of inverse trigonometric functions, derivative of hyperbolic function, derivation of parametrically defined functions, logarithmic differentiation.

UNIT-II (15 hours)

Integration: Methods of integration, integration by substitution, three important forms of integrals, six important integrals, integration by parts, definite integrals, reduction formulae.

UNIT-III (15 hours)

Matrices & Determinant: Transpose of matrix, orthogonal matrices, unitary matrices, Hermitian and Skew-Hermitian matrices, idempotent matrix, Involutory matrix, minors and factors, properties of determinants, determinants-general treatment, symmetric & Skew-symmetric determinant.

UNIT-IV (15 hours)

Complex Number: Definition, conjugate, modulus and argument, Algebra of complex number (Addition, Subtraction, Multiplication and Division), power and square root of complex number, properties of complex number, Argand diagram, solution of quadratic equation in complex number system.

Text Books:

1. Differential Calculus by Shanti Narayan (Unit 1 & Unit 2)
2. An Introduction to Matrices by S.C. Gupta (Unit 3 & Unit 4).

Reference Books:

SUBJECT: **MATHEMATICS**

M. Sc. -II SEMESTER -III

MMSS310: PAPER-V

OPERATION RESEARCH-I

(SUBJECT CENTRIC)

OUTCOMES

1. Use Simplex method.
2. Study transportation and assignment problem.
3. Study game theory.
4. To solve game theory problems by using graphical and linear programming methods.
5. Understand basic concept of inventory control.

UNIT-I (15 hours)

Revised simplex method (with and without artificial variables). Post Optimality Analysis: changes in (i) objective function, (ii) requirement vector, (iii) coefficient matrix; Addition and deletion of variables, Addition of constraints.

UNIT-II (15 hours)

Integer Programming: Gomory's cutting plane algorithm (All integer and mixed integer algorithms), Branch and Bound method.

UNIT-III (15 hours)

Bounded variable technique for L.P.P. Unconstrained optimization, Constrained optimization with equality constraints- Lagrange's multiplier method, Interpretation of Lagrange multiplier.

UNIT-IV (15 hours)

Inventory control: Deterministic inventory models including price breaks. Multi-item inventory model with constraints. Queueing Theory: Basic features of queueing systems, operating characteristics of a queueing system, arrival and departure (birth & death) distributions, inter-arrival and service times distributions, transient, steady state conditions in queueing process. Poisson queueing models- M/M/1, M/M/C for finite and infinite queue length.

Text Books:

Operations Research: Kanti Swarup P.K. Gupta and Man Mohan: Sultan Chand and Sons New Delhi.

Reference Books:

1. H. A. Taha, Operations Research – An Introduction, Prentice-Hall, 1997.
2. J. K. Sharma, Operations Research: Theory and Applications, Macmillan, 1997.
3. S. D. Sharma, H. Sharma, Operations Research: Theory, Methods and Applications, Kedar Nath Ram Nath, 1972 .
4. S. S. Rao, Optimization-Theory and Applications, Wiley Eastern Ltd., 1977.
5. F. S. Hillier, G. J. Lieberman, Introduction to Operations Research, McGraw-Hill, 2001
6. M. S. Bazaraa, H. D. Sherali, C. M. Shetty, Nonlinear Programming-Theory and Algorithms, Wiley-Interscience, 2006
7. A. K. Bhunia and L. Sahoo, Advanced Operations Research, Asian Books Private Limited, New Delhi, 2011.
8. M. Aokie, Introduction to Optimization Techniques: Fundamentals and Applications of Nonlinear Programming, The Macmillan Company, 1971.

SUBJECT: **MATHEMATICS**

M. Sc. -II SEMESTER -IV

MMSS41: PAPER-I

(DYNAMICAL SYSTEMS)

OUTCOMES

1. Study various dynamical systems.
2. Apply Poincare-Bendixson theorem.
3. Use Liapunov function.
4. Study gradient systems.

UNIT-I (15 hours)

Dynamical systems and vector fields. The fundamental theorem. Existence and uniqueness. Continuity of solutions in initial conditions. On extending solutions. Global solutions. The flow of a differential equation.

UNIT-II (15 hours)

Nonlinear sinks. Stability. Liapunov function. Gradient systems. Gradients and inner products.

UNIT-III (15 hours)

Limit sets, local sections and flow boxes, monotone sequences in planar dynamical systems. The Poincare Bendixson theorem, Applications of Poincare-Bendixson theorem; one species, predator and prey, competing species.

UNIT-IV (15 hours)

Asymptotic stability of closed orbits, discrete dynamical systems. Stability and closed orbits. Non Autonomous equations and differentiability of flows. Persistence of equilibria, persistence of closed orbits. Structural stability.

Text Books:

Differential equations, dynamical systems & linear algebra: M.W. Hirsch & S. Smale, Academic Press, 1975.

Reference Books:

Dynamical systems: V.I. Arnold, Springer Verlag, 1992.

SUBJECT: **MATHEMATICS**

M. Sc. -II SEMESTER -IV

MMSS42: PAPER-II

(PARTIAL DIFFERENTIAL EQUATIONS)

OUTCOMES

1. Classify partial differential equations and transform into canonical form.
2. Solve linear partial differential equations of both first and second order.
3. Solve boundary value problems for Laplace's equation, the heat equation, the wave equation by separation of variables, in Cartesian, polar, spherical and cylindrical coordinates.

UNIT-I (15 hours)

Curves and surfaces, First order Partial Differential Equations, classification of first order partial differential equations, classifications of Integrals, Linear equations of first order. Pfaffian differential equations, Criteria of Integrability of a Pfaffian differential equation. Compatible systems of first order partial differential equations.

UNIT-II (15 hours)

Charpits method, Jacobi method of solving partial differential equations, Integral surfaces through a given curve for a linear partial differential equations: Cauchy Problem, Quasi Linear Equations: Geometry of Solutions, Non-linear First Order partial differential equations.

UNIT-III (15 hours)

Second order Partial Differential Equations, Classification of second order partial differential equation, Vibration of an infinite string (both ends are not fixed), Physical Meaning of the solution of the wave equation. Vibration of an semi infinite string, Vibration of a string of finite length:(Method of separation of variables), Uniqueness of solution of wave equation. Heat conduction Problems with finite rod and infinite rod.

UNIT-IV (15 hours)

Laplace equation, Boundary Value Problems: Dirichlets problems and Neumann problems, Maximum and minimum principles . Dirichlet Problems and Neumann problems for a circle, for a rectangle and for a upper half plane, Families to 32 equipotential surfaces, Solution of Laplace equation, Laplace equation in polar form, Laplace equation in spherical polar coordinates. Kelvin’s inversion theorem, Stability theorem, Duhamel's Principle.

Text Books:

T. Amarnath: An elementary course in Partial differential equations, 2nd edition, Narosa publishing House (2012).

Reference Books:

1. Mark Pinsky: Partial differential equations and boundary-value problems with applications, AMS,3rd edition(2011).
2. I. N. Sneddon: Elements of Partial Differential Equations, McGraw Hill Int.
3. Fritz John: Partial Differential Equations, Springer(1952).

SUBJECT: **MATHEMATICS**

M. Sc. -II SEMESTER -IV

MMSS43: PAPER-III

(ADVANCE NUMERICAL METHODS)

OUTCOMES

1. Apply various methods in numerical analysis to solve algebraic and transcendental equations.
2. Identify roots of the polynomials.
3. Use Newton's method for non- linear systems.
4. Understand Polynomial interpolation.
5. Study approximation problems.

UNIT-I (15 hours)

Simple enclosure methods, Secant method, Newton's method, general theory for one point iteration methods. Aitken extrapolation for linearly convergent sequences, Error tests, Numerical evaluation of multiple roots, roots of polynomials, Mullers method, Non-linear systems of equations, Newton's method for non- linear systems.

UNIT-II (15 hours)

Polynomial interpolation theory, Newton's divided differences, finite difference and table oriented interpolation formulas. Forward-differences. Hermite interpolation.

UNIT-III (15 hours)

The Weierstrass theorem and Taylor's theorem. The minimax approximation problem, the least square approximation problem, orthogonal polynomial, economisation of Taylor series, minimax approximation.

UNIT-IV (15 hours)

The trapezoidal rule and Simpson's rule, Newton- Cotes integration formulas.

Text Books:

An Introduction to Numerical Analysis by K. E. Atkinson, Johan Wiley and sons, Inc.

Reference Books:

SUBJECT: **MATHEMATICS**

M. Sc. -II SEMESTER -IV

MMSS44: PAPER-IV

FLUID DYNAMICS-II (OPTIONAL)

OUTCOMES

1. Understand Stress components in a real fluid.
2. Understand Navier-Stokes equations of motion of a viscous fluid.
3. Understand Maxwell electromagnetic field equations.
4. Understand dynamical similarity, Buckingham Theorem, Renold number.
5. Understand turbulence theory.

UNIT-I (15 hours)

Stress components in a real fluid, relation between Cartesian components of stress translation motion of fluid elements, the rate of strain quadric and principal stresses, some further properties of the rate of the 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, some solvable problems in viscous flow, diffusion of vorticity, energy dissipation due to viscosity, steady flow past a fixed sphere.

UNIT-II (15 hours)

Nature of magneto-hydrodynamics, Maxwell electromagnetic field equations; Motion at rest, Motion in medium , Equation of motion of conducting fluid, Rate of flow of charge, Simplification of electromagnetic field equation. Magnetic Reynold number; Alfven's theorem, The magnetic body force. Ferraro's Law of Isorotation.

UNIT-III (15 hours)

Dynamical similarity, Buckingham Theorem. Renold number. Prandtl's boundary layer, Boundary layer equation in two dimensions, Blasius solutions, Boundary layer thickness, Displacement thickness. Karman integral conditions, Separation of boundary layer flow.

UNIT-IV (15 hours)

Turbulence: Definition of turbulence and introductory concepts. Equations of motion for turbulent flow. Reynolds Stresses Cylindrical coordinates. Equation for the conservation of a transferable scalar quantity in a turbulent flow. Double correlations between turbulence-velocity components. Change in double velocity correlation with time. Introduction to triple velocity correlations. Features of the double longitudinal and lateral correlations in a homogeneous turbulence. Integral scale of turbulence.

Text Books:

1. Text book of Fluid Dynamics: F. Chorlton; CBS Publishers, Delhi 1985.
2. Fluid Mechanics: Joseph Spurk; Springer.
3. Turbulence by J.O. Hinze, 2nd edition, Mc Graw-Hill, chapter 1 sections 1.1 to 1.7
4. Fluid Mechanics by M.D. Raisinghania, S. Chand and Company, Delhi.

Reference Books:

1. An Introduction to fluid Mechanics: G.K. Batchelor; Foundation Books, New Delhi, 1994.
2. Boundary Layer Theory: H. Schichting; Mc Graw Hill Book Company, New York 1971.

SUBJECT: **MATHEMATICS**

M. Sc. -II SEMESTER -IV

MMSS45: PAPER-IV

COSMOLOGY (OPTIONAL)

OUTCOMES

1. Compare cosmological models of Einstein and de Sitter.
2. Derive Robertson Walker metric and its properties.
3. Study fundamental theorem of dynamical cosmology.
4. Study cosmological principle.

UNIT-I (15 hours)

Static cosmological models of Einstein and de Sitter and their derivation and its Properties: (i) The geometry of the Universe (ii) Density and pressure (iii) Motion of test particle (iv) Doppler shift (v) comparison with actual universe, Comparison between Einstein and de-Sitter models.

UNIT-II (15 hours)

Cosmological principle, Hubble law, Weyl's postulate, Derivation of Robertson Walker Metric and its properties, Motion of a particle and light rays in FRW model, Red shift, Deceleration parameter and Hubble's constant, Matter Dominated era.

UNIT-III (15 hours)

Friedman Model, Fundamental equation of dynamical cosmology, density and pressure of the present universe, Matter dominated era of the universe, critical density, flat, closed and open universe, age of the universe.

UNIT-IV (15 hours)

Steady state cosmology, Distance measure in cosmology, Comoving distance, Apparent luminosity and luminosity distance, Angular diameter and Lookback time, Horizons and the Hubble radius; Galaxy count**,** the Particle horizons, the Event Horizon.

Text Books:

1. Relativity, Thermodynamics and Cosmology: Richard C. Tolman, Oxford Press
2. Gravitation and Cosmology : Principles and Applications of the General Theory of Relativity by Steven Weinberg.

Reference Books:

1. The Classical Theory of Fields, By Landau I.D. and Lifshitz E.M., Pub. Pergamon Press (1978).
2. Lecture on General Relativity , Sonu Nilu Publication (2004) by T M Karade, G S Khadekar and Maya S Bendre
3. The Theory of Relativity Moller C, Pub. Oxford University Press (1982).
4. Introduction to theory of relativity, Rosser W.G.V., ELBS (1972).
5. Relativity Special, General and Cosmology, Rindler W., Pub. Oxford University Press (2003).
6. Relativity: The General Theory, Synge J.L., North Holland Pub. Comp. (1971).

SUBJECT: **MATHEMATICS**

M. Sc. -II SEMESTER -IV

MMSS46: PAPER-IV

CRYPTOGRAPHY (OPTIONAL)

OUTCOMES

1. Understand Euclidean algorithm, congruence's, quadratic residues and reciprocity, Fermat's little theorem.
2. Understand Classical cryptosystems.
3. Understand algorithms for discrete logarithm problems.
4. Understand Elliptic curves, Elliptic curve primality test.

UNIT-I (15 hours)

Time estimates for doing arithmetic, divisibility and Euclidean algorithm, congruence's, quadratic residues and reciprocity, Fermat's little theorem, applications to factoring, finite fields.

UNIT-II (15 hours)

Classical cryptosystems, Public key cryptography, Hash function, Probabilistic encryption, RSA cryptosystem, Pseudo primes, Pollard's P-1 method, The Rho method.

UNIT-III (15 hours)

The El Gamal cryptosystem, discrete logarithm, Diffee-Hellman key exchange system, Algorithms for discrete logarithm problem-Shank's algorithm, the Pollard Rhoalgorithm, the Pohlig-Hellman Algorithm, security of ElGamal systems, the ElGamal signature scheme.

UNIT-IV (15 hours)

Elliptic curves, Elliptic curve cryptosystems, Elliptic curve primality test, Elliptic curve factorization.

Text Books:

1. Neal Koblitz, A Course in Number Theory and Cryptography (second edition), SpringerVerleg.
2. Douglas R. Stinson, Cryptography: Theory and practice (Third Edition), CRC Press.

Scope :

Unit I- From Koblitz's book (Chapter 1 and Chapter 2 excluding Existence and uniqueness of finite fields with prime power number of elements)

Unit II – From Koblitz's book (Chapter 4 –sections 1 and 2, Chapter 5- sections 1 and 2)

Unit III – From Stinson's book (Chapter 6- section 1and 2, Chapter 7- section 3) 39

Unit IV - From Koblitz's book (Chapter 6).

Reference Books:

1. William Stallings, Cryptography and Network Security, Prentice Hall.

SUBJECT: **MATHEMATICS**

M. Sc. -II SEMESTER -IV

MMSS47: PAPER-IV

ALGEBRAIC TOPOLOGY-II (OPTIONAL)

OUTCOMES

1. Understand the fundamental theorem of algebra.
2. Understand the concept of exact homology sequence and Homomorphisms of exact sequences.
3. Understand homotopy theory, Cohomology groups and relations between chain and cochain groups.

UNIT-I (15 hours)

Simplicial mappings. Chain mappings. Barycentric Subdivision. The Brouwer Degree.

The fundamental theorem of algebra.

UNIT-II (15 hours)

No retraction theorem and Brouwer fixed point theorem. Mappings into spheres. Relative homology groups. The exact homology sequence. Homomorphisms of exact sequences.

UNIT-III (15 hours)

The excision theorem. The Mayer-Vietoris sequence. Eilenberg-Steenrod axioms for homology theory. Relative homotopy theory. Cohomology groups. Relations between chain and cochain groups.

UNIT-IV (15 hours)

Simplicial and chain mappings. The cohomology product. The cap product. Exact sequences in cohomology theory. Relations between homology and cohomology groups.

Text Books:

Topology : J.G. Hocking and G.S. Young : Addison Wesley, 1961

Reference Books:

1. Topology : J.R.Munkres, Prentice Hall, Second Edition, 2000
2. Basic Concepts of Algebraic Topology : Fred H.Croom , Springer Verlag 1978.

SUBJECT: **MATHEMATICS**

M. Sc. -II SEMESTER -IV

MMSS48: PAPER-IV

OPERATOR THEORY (OPTIONAL)

OUTCOMES

1. Understand basic concepts about spectrum and Spectral properties of bounded linear operators.
2. Understand Banach Algebra.
3. Understand spectral properties of Compact linear operators.
4. Understand Spectral properties of bounded self adjoint linear operators.

UNIT-I (15 hours)

Basic concepts about spectrum. Spectral properties of bounded linear operators. Further properties of resolvent and spectrum. Use of complex analysis in spectral theory.

UNIT-II (15 hours)

Banach Algebras. Further properties of Banach Algebras. Compact linear operators on normed spaces. Further properties of Compact linear operators. Spectral properties of compact linear operators.

UNIT-III (15 hours)

Further spectral properties of Compact linear operators. Operator equations involving compact linear operators. Further theorems of Fredholm type. Fredholm alternative.

UNIT-IV (15 hours)

Spectral properties of bounded self adjoint linear operators. Further Spectral properties of bounded self adjoint linear operators. Positive operators. Square roots of a positive operator. Projection operator. Further properties of projections. Spectral family. Statement of spectral representation theorem.

Text Books:

Introductory Functional Analysis with Applications by E. Kreyszig, John Wiley and Sons.

Reference Books:

Introduction to Functional Analysis by A.E.Taylor and D.C.Lay, John Wiley and Sons.

SUBJECT: **MATHEMATICS**

M. Sc. -II SEMESTER -IV

MMSS49: PAPER-V

ELEMENTARY DISCRETE MATHEMATICS-II

(FOUNDATION PAPER FOR OTHER THAN MATHEMATICS STUDENTS)

OUTCOMES

1. Understand Mathematical Logic.
2. Understand partially ordered sets, their properties and lattices.
3. Understand Boolean algebra and Logic Circuits.
4. Understand basic concepts in graph theory.

UNIT-I (15 hours)

Mathematical Logic: Introduction, Proposition, compound Proposition, Proposition and truth tables, logical equivalence, algebra of Proposition, conditional Proposition, converse, contra positive & inverse, bi conditional statement, negation of compound statements, tautologies & contradictions, normal forms, logic in proof.

UNIT-II (15 hours)

Lattice: Lattice as partially ordered sets, their properties, lattices as algebraic system, sub lattices, and some special lattices eg. Complete, complemented and distributive lattices.

UNIT-III (15 hours)

Boolean algebra and Logic Circuits: Boolean algebra, basic operations, Boolean functions, De-Morgan's theorem, logic gate, sum of products and product of sum forms, normal form, expression of Boolean function as a canonical form, simplification of Boolean expression by algebraic method, Boolean expression form logic & switching network.

UNIT-IV (15 hours)

Graph Theory: Basic terminology, simple graph, multigraph, degree of a vertex, types of a graph, sub graphs of isomorphic graphs, matrix representation of graphs, Euler's theorem on the existence of Eulerian path & circuits, directed graph, weighted graphs, strong connectivity, chromatic number.

Text Books:

Discrete Mathematical structures with applications to computer science by J.P. Tremblay and R. Manohar, McGraw-Hill Book Company, 1997.

Reference Books:

SUBJECT: **MATHEMATICS**

M. Sc. -II SEMESTER -IV

MMSS410: PAPER-V

(OPERATIONS RESEARCH–II)

OUTCOMES

1. Identify and develop operations research model describing a real life problem.
2. Understand the mathematical tools that are needed to solve various optimization problems.
3. Solve various linear programming, transportation, assignment, queuing, inventory and game problems related to real life.

UNIT-I (15 hours)

Operations Research: Origin, Definition and scope. Linear Programming: Formulation and solution of linear programming problems by graphical and simplex methods, Big - M and two-phase methods, Degeneracy, Duality in linear programming.

UNIT-II (15 hours)

Transportation Problems: Basic feasible solutions, Optimum solution by stepping stone and modified distribution methods, Unbalanced and degenerate problems, Transhipment problem. Assignment problems: Hungarian method, Unbalanced problem, Case of maximization, Travelling salesman and crew assignment problems.

UNIT-III (15 hours)

Concepts of stochastic processes, Poisson process, Birth-death process, Queuing models: Basic components of a queuing system, Steady-state solution of Markovian queuing models with single and multiple servers (M/M/1. M/M/C, M/M/1/k, M/MC/k).

UNIT-IV (15 hours)

Inventory control models: Economic order quantity(EOQ) model with uniform demand, EOQ when shortages are allowed, EOQ with uniform replenishment, Inventory control with price breaks.

Text Books:

Operations Research: Kanti Swarup P.K. Gupta and Man Mohan: Sultan Chand and Sons New Delhi.

Reference Books:

1. H. A. Taha, Operations Research – An Introduction, Prentice-Hall, 1997.
2. J. K. Sharma, Operations Research: Theory and Applications, Macmillan, 1997
3. S. D. Sharma, H. Sharma, Operations Research: Theory, Methods and Applications, Kedar Nath Ram Nath, 1972
4. S. S. Rao, Optimization-Theory and Applications, Wiley Eastern Ltd., 1977.
5. F. S. Hillier, G. J. Lieberman, Introduction to Operations Research, McGraw-Hill, 2001
6. M. S. Bazaraa, H. D. Sherali, C. M. Shetty, Nonlinear Programming-Theory and Algorithms, Wiley-Interscience, 2006
7. A. K. Bhunia and L. Sahoo, Advanced Operations Research, Asian Books Private Limited, New Delhi, 2011.
8. M. Aokie, Introduction to Optimization Techniques: Fundamentals and Applications of Nonlinear Programming, The Macmillan Company, 1971.