PG Syllabus

Department of Mathematics
Assam University, Silchar
(Implemented from session 2015-16)

Structure of PG-Syllabus
Department of Mathematics
Assam University, Silchar

Semester-I

Paper No	Name of the Paper	Marks					L	T	C
		Internal		External		Total			
		M.M.	P.M.	M.M.	P.M.				
M-101	Algebra-I	30	12	70	28	100	4	2	6
M-102	Real Analysis-I	30	12	70	28	100	4	2	6
M-103	Ordinary Differential Equations	30	12	70	28	100	4	2	6
M-104	Numerical Analysis	30	12	70	28	100	4	2	6
M-105	Operations Research and Optimization Techniques-I	30	12	70	28	100	4	2	6
Total		150		350		500	20	10	30

Semester-II

Paper No	Name of the Paper	Marks					L	T	C	P
		Internal		External		Total				
		M.M.	P.M.	M.M.	P.M.					
M-201	Topology	30	12	70	28	100	4	2	6	-
M-202	Algebra-II	30	12	70	28	100	4	2	6	-
M-203	Mathematical Methods (Open-I)	30	12	70	28	100	4	2	6	-
M-204	Linear Algebra (Open -II)	30	12	70	28	100	4	2	6	-
M-205	Partial Differential Equations (Theory)	30	12	40	16	70	3	1	6	-
	Partial Differential Equations (Practical)	-	-	30	12	30	-	-	-	2
Total		150		350		500	19	9	30	2

Semester-III

Paper No	Name of the Paper	Marks					L	T	C
		Internal		External		Total			
		M.M.	P.M.	M.M.	P.M.				
M-301	Real Analysis-II	30	12	70	28	100	4	2	6
M-302	Discrete Mathematics	30	12	70	28	100	4	2	6
M-303	Complex Analysis	30	12	70	28	100	4	2	6
M-304	Operations Research and Optimization Techniques-II	30	12	70	28	100	4	2	6
M-305	Classical Mechanics and Electrodynamics	30	12	70	28	100	4	2	6
Total		150		350		500	20	10	30

Semester-IV

Paper No	Name of the Paper	Marks					L	T	C
		Internal		External		Total			
		M.M.	P.M.	M.M.	P.M.				
M-401	Functional Analysis	30	12	70	28	100	4	2	6
M-402	Integral Equations and Calculus of Variations	30	12	70	28	100	4	2	6
M-403	Fluid Dynamics	30	12	70	28	100	4	2	6
M-404	Optional Papers : a. Relativity b. Differential Geometry c. Mathematical Modeling d. CFD e. Operator Theory f. Groups and Representations g. Mathematical Statistics h. Algebraic Topology i. Fuzzy Sets and Applications	30	12	70	28	100	4	2	6
M-405	Project Work	30	12	70 (50+20)	28	100	4	2	6
Total		150		350		500	20	10	30

In external examinations, each unit of a paper containing 70 marks carries 14 marks.

L=Lecture, T=Tutorial, C=Credit, P=Practical, MM=Maximum Marks, PM=Pass Marks

M101

Algebra-I

Unit-I

Relation and function, equivalence relation, partition, binary operation, semigroups, groups, abelian and non-abelian groups, subgroups, cyclic subgroups, definition and example of cyclic groups, properties of a cyclic group (application in solving problems).

Unit-II

Permutation group, cycles and cycle notations, decomposition of a permutation as a product of disjoint cycles, even and odd permutations, alternating groups, conjugate elements in a group, conjugacy classes in S_n, left and right cosets, groups of cosets, Lagrange's theorem (application in solving problems).

Unit-III

Normal subgroups (normal subgroups of to be determined), automorphisms and inner automorphisms, factor groups, homomorphism of groups, kernel, fundamental theorem on group homomorphism, isomormorphism theorems and applications, simplicity of A_n, $n \geq 5$ commutator subgroups, Cayley's theorem (application in solving problems).

Unit-IV

Rings, integral domain, fields, characteristic of a ring, Fermat's and Euler's theorems, ring homomorphism and isomorphism, kernel, quotient fields of an integral domain (thrust is on solving problems).

Unit-V

Subrings, ideals (left and right ideals), quotient rings, algebra of ideals, prime and maximal ideals, factorization in rings (associates, irreducible, prime elements, gcd etc.), Euclidean domain, principal ideal domain, unique factorization domain (thrust is on solving problems).

Recommended Texts:

1. Gallien, J.: Contemporary Abstract Algebra, Narosa Publishers
2. Herstein, I.N.: Topics in Algebra, New Age International Publishers

References:

1. Hungerford, T.W.: Algebra, Sringer (Unit I-III)
2. Fraleigh, J.B.: A First Course in Abstract Algebra (Unit-I-V), Narosa Publishers
3. Dumit, D.S. and Foote, R.M.: Algebra, Jhon Wiley and Sons

M102

Real Analysis-I

Unit-I

Finite and infinite sets, countability, real number system, sequence and series of real numbers.

Unit-II

Open and closed sets, limit points, Bolzano-Weirestrass theorem for infinite sets, Heine-Borel theorem, continuity, uniform continuity, monotone and inverse functions.

Unit-III

Derivative of a function, mean value theorems, L'Hospital's rules, Taylor's theorem

Unit-IV

Riemann integration, sequence and series of functions, uniform convergence

Unit-V

Power series, functions of bounded variation, absolute continuity

Recommended Texts:

1. Sohrab, H.H.: Basic Real Analysis, Birkhauser (Springer International Edition)
2. Bartle, G., Sherbert, R.: Introduction to Real Analysis, Jhon Wiley and Sons

References:

1. Kumar, A., Kumaresan, S.: A Basic Course in Real Analysis, CRC Press
2. Carothers, N.L.: Real Analysis, Cambridge University Press
3. Ponnusamy, S.: Foundations of Mathematical Analysis, Birkhauser (Springer International Edition)

M103

Ordinary Differential Equations

Unit-I

Linear equations with constant coefficients.

Unit-II

Linear equations with variable coefficients.

Unit-III

Linear equations with Regular Singular Points.

Unit-IV

Existence and uniqueness of solutions of initial value problems for first order ordinary differential equations.

Unit-V

Adjoint equation, self-adjoint equation, Green's function, Strum-Liouville Theory.

Recommended Texts:

1. **Coddington, E. A.**, An Introduction to Ordinary Differential Equations, PHI, 1995 (for Unit I,II,III,IV)
2. **Agrawal, R.P., O'Regan, D.**, An Introduction to Ordinary Differential Equations, Springer, 2008 (for Unit V: Page Nos. -224,232-249,265-278)

References:

1. **Piaggio, H. T. H.**, Differential Equations, CBS Publishers & Distributors, 1985
2. **Ince, E. L.** Ordinary Differential Equations (Dover Books on Mathematics), 2003

M104

Numerical Analysis

Unit-I

Number systems and errors, types and sources of error, propagation of error, error in Numerical Analysis, Hermite interpolation, central difference interpolating formula, piecewise interpolation, inverse interpolation, estimation of error in different interpolation formulae, spline interpolation cubic splines ,least square approximation to discrete data,

Unit-II

Numerical differentiation, Error in numerical differentiation, Numerical integration- the Trapezoidal rule, Simpsons rules, Booles and Weddles rules, Romberg integration, Gauss quadrature rules ,singular integrals. Approximation of function : Chebyshev approximation , Lanczos economisation, least square approximation and orthogonal polynomials, min-max polynomial approximation.

Unit-III

Numerical solution of algebraic and transcendental equations in one unknown, bi-section method, regula-falsi method, fixed point iteration method, secant method, Newton-Raphson method, rate of convergence of iterative methods, generalized Newtons method, system of linear equations-Direct and iterative methods.

Unit-IV

Numerical solution of ordinary differential equations, Picards method, Eulers method, modified Eulers method, Runge-Kutta method, solution of boundary value problems for linear second order equations.

Unit-V

Difference equations-Definition of difference equation, order of difference equation, general and particular solution of difference equation, Linear difference equations, Homogeneous linear difference equations with constant coefficients, linear independent solutions, solution of non linear homogeneous difference equations by different methods, simultaneous difference equations, partial difference equations.

Recommended Texts:

1. **Atkinson, Kendall, E.**: An Introduction to Numerical Analysis(John Wiely Sons (Asia)
1. Pvt.Ltd.
2. **Acharya , B.P.** and **Das, R.N.**: A Course on Numerical Analysis, Kalyani Publishers
3. **Murray R Spiegel**, Theory and Problems of calculus of finite differences and difference equations

References:

1. **Sarborough, J.B.**, Numerical Mathematical Analysis, Oxford and Intl
2. **Conte Boor**, Elementary Numerical Analysis, McGraw Hill
3. **Boehm, W.**, Numerical Methods, University Press and Prautzsc
4. **Sastry, S.S.**, Introduction to Methods of Numerical Analysis, Prentice Hall of India
5. **Jain, M.K.**,Numerical Methods- Problems and Solutions, New Age Intl.

M105

Operations Research and Optimization Techniques-I

Unit-I

Revised simplex method, post-optimal analysis, job sequencing problem.

Unit-II

Game theory with and without saddle point, different methods of solving game theoretic problem

Unit-III

Theory of replacement problems and their applications, project management. PERT and CPM techniques, activities, network diagram, forward pass method, oat of activity and event, critical path.

Unit-IV

Deterministic inventory control models under different situation

Unit-V

Integer programming problems, Gomory's all integer cutting plane method, Gomory's mixed integer cutting plane method, Branch and bound technique.

Recommended Texts:

1. **Wagner, H.M.**, Principles of Operations Research, Prentice Hall
2. **Sharma. J.K.**, Operations Research : Theory and Application, Mcmillan
3. **Man Mohan, Gupta, P.K., Swarup Kanti**, Operation Research, S. Chand Sons

References:

1. **Shenoy, L.V.**, Linear Programming : Methods and Applications.
2. **Vohra, N.D.**, Quantitative Techniques in Management, (Tata McGraw Hill)

M 201

Topology

Unit-I

Metric spaces, examples, open and closed sets, neighbourhoods, closure, dense subsets, separable metric spaces, boundaries, interiors, sequence in metric spaces, convergence of sequences and continuity, homeomorphism.

Unit-II

Complete metric spaces, Cantor's intersection theorem, completion of a metric space, isometry, isometric isomorphism, Baires category theorem, compactness in metric spaces, Heine-Borel theorem.

Unit-III

Topological spaces, definition and examples, open and closed sets, metrizable spaces, neighbourhoods, basis, first countable spaces, closure, Kuratowski closure operation, dense subsets, separable spaces, boundary and interior, continuity and homeomorphism.

Unit-IV

Compactness, product topology, Tychonoff's theorem, local compactness, one-point compactification, path-connectedness, connectedness, intermediate value theorem, components, totally disconnected spaces, local connectedness.

Unit-V

Countability and separation axioms, Urysohn's metrization theorem, Tietze's extension theorem.

Recommended Texts:

1. **Runde, V.,** A Taste of Topology, Springer
2. **Colin ,A., Franzosa, R.**, Introduction to Topology, Pearson (LPE)

References:

1. **Munkres, J.K.**, Topology, Prentice Hall of India
2. **Kelley, J.**, Topology, Springer
3. **Willard, S**, General Topology, Dover Publications

M202

Algebra-II

Unit-I

Direct and semidirect product of groups, group actions, class equations, automotphism groups, inner automorphism groups

Unit-II

Sylow's theorems and applications, structure theorems for finite abelian groups, solvable groups

Unit-III

Polynomial rings, Euclidean algorithm, irreducible polynomials, Gauss' lemma, Eisenstein's irreducibility criterion and applications

Unit-IV

Field extension, degree of an extension, algebraic extension, splitting field, normal extensions

Unit-V

Separable extensions, finite field, perfect fields, Galois extension, fundamental theorem of Galois theory

Recommended Texts:

1. **Bhattacharjee, P.B., Jain, S.K.**, Nagpaul, S.R., Basic Abstract Algebra, Cambridge University Press

References:

1. **Hungerford, T.W.**, Algebra, Springer
2. **Dumit, D.S. and Foote, R.M.**, Algebra, John Wiley and Sons

M 203

Mathematical Methods (Open - I)

Unit – I

Real Analysis: Real number system, supremum, infimum in $\mathbb{R}$, Archimedian property, sequence of real numbers, subsequence, infinite series, continuity, differentiability.

Unit – II

Linear Algebra: Liner spaces, subspaces, linear dependence and independence, bases and dimension, linear transformations, change of basis, eigen values and eigen vectors of matrices, the Caley-Hamilton theorem.

Unit – III

Numerical Linear Algebra: Elementary row transformations-rank-echelon form, normal form – solution of linear systems – direct methods- LU decomposition- LU decomposition from Gauss elimination –Solution of tridiagonal systems – solution of linear systems.

Unit – IV

Interpolation: Introduction- errors in polynomial interpolation – finite differences- forward differences-backward differences – symbolic relations and separation of symbols-differences of a polynomial-Newton's formulae for interpolation –interpolation with unevenly spaced points - Lagrange's interpolation formula.

Unit – V

Integral Transforms:

Laplace transforms – definition, transformation of elementary functions, Inverse Laplace Transforms, Convolution theorem. Some related problems

Fourier transforms- Definition, Fourier sine and cosine transforms, properties, relation between Laplace and Fourier transforms with some practical problems.

Z-Transforms – definition, Standard Z-transforms, properties, initial and final value theorems, convolution theorem, inverse Z-transforms. Some related problems.

Recommended Texts:

1. **T. K. V. Iyengar, B. Krishna Gandhi and Others,** Mathematical Methods, S. Chand & Company.
2. **V. Ravindranath, A. Vijayalaxmi,** A text book of Mathematical MethodsHimalaya Publishers.
3. **B. V. Raman,** A text Book of Engineering Mathematics, Tata Mc Graw Hill.
4. **G. Sankara Rao,**Mathematical Methods, I.K. International Pvt. Ltd., 2009
5. **G. Bartle., R. Sherbert**: Introduction to Real Analysis, John Wiley and Sons

References:

1. **E. Kreyszig,** Advanced Engineering Mathematics, Willey India Pvt. Ltd.
2. **M. K. Jain, S. R. K. Iyengar, R. K. Jain,**Numerical Methods for Scientific and Engineering
3. Computation, New age international Publishers.
4. **Aitkinson & Han,** Elementary Numerical Analysis, Willey India, 3rd Edition, 2006
5. **C.M. Bender, S.A. Orszag,** Advanced Meathematical Methods for Scientists and Engineers, Springer, 1999.

M 204

Linear Algebra (Open - II)

Unit-I

Linear transformations, rank-nullity theorem, representation of linear transformations by matrices, change of basis matrices, algebra of linear transformations, algebra isomorphism between the algebra of linear transformations and algebra of matrices change of bases for linear transformations, equivalence of matrices, similarity of matrices, quotient spaces, isomorphism theorems, linear functionals, dual space, dual bases, annihilators.

Unit-II

Characteristic roots, characteristic vectors, characteristic polynomials, relation between characteristic polynomial and minimal polynomial of an operator, eigenvalues, Cayley-Hamilton theorem (proof to be given later), diagonalizablility, necessary and sufficient condition for diagonalizability, projections and their relation with direct sum decomposition of vector spaces, invariant subspaces, direct sum decompositions, invariant direct sums, the primary decomposition theorem, geometric and algebraic multiplicities.

Unit-III

Cyclic subspaces, companion matrices, a proof of Cayley-Hamilton theorem, triangulability, canonical forms of nilpotent transformations, diagonal forms, triangular forms, rational canonical forms.

Unit-IV

Trace and transpose, inner product spaces, linear functionals and adjoints, orthogonality, orthonormality, projection theorem, Gram-Schmidt orthogonalization, orthonormal basis, Riesz representation theorem, adjoint of operators, orthogonal diagonalizability, self-adjoint operators, unitary and normal operators, orthogonal diagonalization, orthogonal projection.

Unit-V

Bilinear Forms, correspondence between bilinear forms and matrices, rank of a bilinear form, nondegenerate bilinear form, quadratic forms, reduction and classifiication of quadratic forms, symmetric and skew-symmetric bilinear forms.

Recommended Texts:

1. **Herstein, I.N.**, Topics in Algebra,Wiley Eastern Limited/New Age International Second Edition.
2. **Hoffman and Kunze**, Linear Algebra, Prentice Hall of India Private Limited
3. **Roman, Steven**, Advanced Linear Algebra, Graduate Texts in Mathematics 135,Springer- Verlag

References:

1. **Bhattacharjee, Jain Nagpaul**, First Course in Linear Algebra,New Age International.
2. **Halmos, Paul R.**, Finite-Dimensional Vector Spaces, Sringer.

M205

Partial Differential Equations

Unit-I

Partial differential equations of first order

Unit -II

Partial differential equations of second order

Unit -III

Laplace's equation

Unit -IV

The wave equation

Unit -V

The diffusion equation

Recommended Text:

1. **I. N. Sneddon**, Elements of Partial Differential Equations, Dover Publication ,2006

References:

1. **E. T. Copson,** Partial Differential Equation , Oxford University Press
2. **Piaggio,** Differential Equation ,CBS. Publ.
3. **Forsyth,** Theory of differential equation.
4. **P. Prasad R. Ravindran,** Partial Differential Equations, New Age
5. **T. Amarnath,** An Elementary course in Partial Differential Equation, narosa Pub.
6. **Frank Ayres,** Theory and problems of Differential Equations, Schaum's Outline Series
7. **B. Epstein,** Partial Differential equations, McGraw Hill

M205

Partial Differential Equations (Practical)

Problems from M-205 (Theory) may be solved with the help of softwares like MATLAB/Mathematica.

M301

Real Analysis-II

Unit-I

Functions of several variables, total and directional derivatives, equality of mixed partial derivatives, Schwarz lemma, Taylor's theorem.

Unit-II

Extremum problem with/ without constraints, implicit and inverse function theorem.

Unit-III

Set functions (additive, countably additive), regular set function, construction of the Lebesgue measure, measurable sets.

Unit-IV

Measurable function, simple function, Lebesgue integration.

Unit-V

Lebesgue's monotone convergence theorem, Fatou's theorem, Lebesgue's dominated convergence theorem, comparison with Reimann integral.

Recommended Texts:

1. **Rudin**, **W.**, Principles of Mathematical Analysis, McGraw-Hill International
2. **Cohn, D.**, Measure Theory, Birkhauser, 2nd edition

References:

1. **Apostol, T.M.**, Mathematical Analysis, Narosa Publishers
2. **Ghodpade, S., Limaye, B.V.**, A Course in Multivariable Calculus and Analysis, Springer

M-302
Discrete Mathematics

Unit – I

Permutations, combinations, pigeon-hole principle, inclusion-exclusion principle, derangements. Divisibility in Z, gcd, lcm, Euclidean algorithm, Eulers Phi function, Diophantine equations ax+by = c.

Unit -II

Prime numbers, fundamental theorem of arithmetic, congruences, theorems of Euler, Fermat and Wilson, chinese remainder theorem, polynomial congruences; applications.

Unit -III

Primitive roots and indices, quadratic residues, Legendre symbol, Jacobi symbol, law of quadratic reciprocity, arithmetic functions, multiplicative arithmetic functions, Mobius inversion formula; applications.

Unit -IV

Graph, walks, paths, cycles and cocycles, connectivity.

Unit – V

Tree, Graph colorings, Ramsey Theory.

Recommended Texts:

1. **Burton, D.M.**, Elementary Number Theory (universal Book Stall) (Unit I,II,III)
2. **W. D. Wallis**, A Beginner's guide to Graph Theory, Birkhouser, 2nd Ed. 2007 (Unit IV,V)

References:

1. **Niven,l., H.S. Zuckerman, H.L. Montgomery**, An Introduction to the Theory of Numbers (John Wiley LPE)
2. **West**, Introduction to Graph Theory,Prentice Hall of India
3. **Harary, F.**, Graph Theory ,Narosa Publishing House
4. **Liu, C.L.,** Elements Discrete Mathematics ,Tata McGraw Hill
5. **Ireland, K. Rosen, M.**, A classical Introduction to Modern Number Theory, Springer LPE

M 303

Complex Analysis

Unit-I

Extended complex plane, stereographic projections, arguments, complex logarithms, power series, holomorphic and analytic functions, Cauchy-Riemann equations, the exponential functions, the logarithmic functions, complex trigonometric functions.

Unit-II

Line integrals, differential forms, homotopy and simple connectivity, winding number, Cauchys theorem, Goursats theorem, Cauchys integral formula, power series expansion of holomorphic functions, Moreras theorem, Cauchys inequalities, Liouvilles theorem, fundamental theorem of algebra, cycles and homology.

Unit-III

Counting zeros of holomorphic function, open mapping theorem, maximum modulus principle, Schwarzs lemma, singularities and their classification, Laurent series expansions, Casorati-Weierstrasss theorem, meromorphic functions.

Unit-IV

Residues, residue theorem, evaluation of definite integrals, argument principle, Rouches theorem, harmonic conjugates, Poissons formula.

Unit-V

Examples of images of regions under elementary holomorphic functions, conformal maps, Mobius transformation, cross-ratio, orientation and symmetry principles.

Recommended Texts:

1. **Gilman, Jane P., Kra, Irwin Rodriguez, Rubi E.** : Complex Analysis, In the Spirit of Lipman Bers, GMT 245, Springer - Verlag
2. **Conway, John B.**: Functions of One Complex Variable, Second Edition, Narosa Publishing House.

References:

1. **Cartan, H.**, Elementary Theory of Analytic Functions of One or Several Complex Variable, Dover Publishing House
2. **Shastri, Anant R.**, An Introduction to Complex Analysis, Macmillan India Limited.
3. **Ahlfors, L.V.**, Complex Analysis, McGraw-Hill Book Co.
4. **Choudhary,B.**, The Elements of Complex Analysis, New Age International (P) Limited, Publishers
5. **Ponnusamy, S.**, Foundations of Complex Analysis, Narosa Publishing House.

M304

Operations Research and Optimization Techniques-II

Unit-I

Basic concept of probability and probability distributions, simulation technique and their applications.

Unit –II

Queuing theory and its applications, introduction to the stochastic process with applications.

Unit –III

Probabilistic inventory control: Different models, decision theory under different situation.

Unit -IV

Introduction to multi-objective optimization (emphasis on goal programming with its different variants and solution procedures).

Unit -V

Classical and nonlinear optimization techniques with different methods of solution.

Recommended Texts:

1. **Wagner, H.M**., Principles of Operations Research, Prentice Hall
2. **Sharma, J.K.**, Operations Research : Theory and Application, Mcmillan
3. **Man Mohan, Gupta, P.K., Swarup Kanti** : Operations Research, S. Chand Sons

References:

1. **Shenoy, L.V.**, Linear Progarmming : Methods and Applications, New Age Int.
2. **Vohra, N.D.**, Quantitative Techniques in Management, Tata McGraw Hill

M 305

Classical Mechanics and Electrodynamics

Unit-I

Generalised coordinates, holonomic and non-holonomic systems, constraints, D'Alembert's principle, Lagrange's equations, Calculus of variations, Euler-Lagrange equation, application of calculus of variations in dynamical problems, Hamilton's principle, Lagrange's equations from Hamilton's principle, extension of Hamilton's principle to non-conservative and non-holonomic systems, conservation theorems and symmetry properties.

Unit – II

Hamiltonian – Jacobi equation from Hamilton's principle function, Harmonic oscillator problem as an example of the Hamiltonian – Jacobi method, Hamiltonian – Jacobi equation for characteristic function, Separation of variables in the Hamiltonian – Jacobi equation.

Unit-III

Two dimensional motion of rigid bodies, Euler's dynamical equations of motion for a rigid body, Motion of a rigid body about an axis, motion about revolving axis, Eulerian angles, Eulers theorem on the motion of a rigid body, infinitesimal rotations, rate of change of a vector, Coriolis force, Euler's equations of motion, force free motion of a rigid body.

Unit-IV

Hamilton canonical equations, Hamilton's equations of motion, conservation theorems and physical significance of Hamiltonian, Hamilton's equations from variatioinal principle, principle of least action, Equations of canonical transformation, integral invariants of Poincare, Lagrange and Poisson brackets as canonical invariants, equations of motion in Poisson bracket notation.

Unit – V

Electric charge, charge density, Coulomb's law, electrostatic potential, current density, displacement Current, transformation of charge and current densities, the electromagnetic field equations of Maxwell, electromagnetic wave equation, vector and scalar potentials, Gauge transformation, Lorentz – gauge conditions, transformation of electric and magnetic field components, invariance of Maxwell's equations, Biot - Savart law and its applications.

Recommended Texts:

1. **Herbert Goldstein,** Classical Mechanics, Narosa Publishng House
2. **A. S. Gupta,** Calculus of Variation with Application, Prentice-Hall of India Pvt. Ltd.
3. **D.J. Griffith,** Introduction to Electrodynamics, Prentice Hall, New Jersey
4. **M. M. Schwartz,** Principles of electrodynamics, Dover Publications Inc., 1988.

References:

1. **J.R.Taylor,** Classical Mechanics, University Science Books, 2004.
2. **G. Aruldhas,** Classical Mechanics, Prentice-Hall of India Pvt. Ltd., 2013.
3. **N.C. Rana, P.S. Jog,** Classical Mechanics
4. **Gupta, Kumar, Singh,** Electrodynamics, Pragati prakashan.

M-401
Functional Analysis

Unit-I

Normed linear spaces, Banach spaces, subspaces, continuity of linear map, finite and infinite dimensional normed linear spaces, compactness, equivalent norms, Riesz's lemma

Unit-II

Hahn Banach theorem, consequences of Hahn-Banach theorem, natural embedding into second topological dual spaces, topologically reflexive spaces

Unit-III

Uniform boundedness theorem, Banach Steinhaus theorem, open mapping theorem, closed graph theorem and their applications.

Unit-IV

Hilbert spaces, orthogonal complements and direct sums, orthonormal sets and sequences, series related to orthonormal sequences and sets, total orthonormal sets and sequences, Parsevals identity, Riesz representation theorem, adjoint operator, normal, unitary, self-adjoint operators.

Unit-V

Spectra of bounded linear operators, compact operators and their spectra.

Recommended Texts:

1. **Limaye, B.V.**,Functional Analysis, New Age International
2. **Kreyszig, E.**, Introduction to Functional Analysis with Applications, John-Wiley and Sons

References:

1. **Conway, J. B.**, A Course in Functional Analysis, Springer

M-402

Integral Equations and Calculus of Variations

Unit-I

Integral equations of the first, second and third kinds, examples, finite difference approximations, the Fredholm alternative, Hadamards inequality, Hilbert spaces.

Unit-II

Fixed point theorem, elementary existence theorems, Volterra equations, kernels with weak singularities, degenerate kernels, Volterra equations of the first kind.

Unit-III

Compact operators, self-adjoint compact operators.

Unit-IV

Fourier transforms, applications of Fourier transforms, Laplace transforms, application of Laplace transforms.

Unit-V

Function spaces, functionals, variations, the fundamental lemmas, Euler's equation, related results (theorems and applications)

Recommended Texts:

1. **Harry Hochstadt**, Integral Equations, a Wiley Inter-science publications, 1973 (Unit I,II,III,IV)
2. **I.M. Gelfand, S.V. Fomin**, A Calculus of Variations, Dover Publications (Unit V)

References:

1. **Kikhlin, S.G.**, Linear Integral Equations, Hudson Book Agency
2. **Kanwal, R.P.**, Linear Integral Equations, Academic Press, New York, 1998
3. **Gupta, A.S.,** Calculus of Variations with Applications

M 403

Fluid Dynamics

Unit-I

Governing equations of fluid motion : Lagrangian and Eulerian methods of description, stream line, path line, vorticity and circulation, equation of continuity in fluid motion (in Lagrangian and Eulerian methods). Equivalence of the two forms of equations of continuity, boundary conditions, Eulers equations of motion, for perfect fluids, integrals of Eulers equations of motion. Lagranges equations of motion, Cauchys integrals, equation of energy.

Unit-II

Motion in two dimensions : Two-dimensional motions, stream function, complex potential, source, sink and doublet; image, Image in two-dimensions ; Images of a source with regard to a plane, a circle and a sphere; image of a doublet, Milne-Thomson circle theorem, theorem of Blasius.

Unit-III

Motions in three-dimensions : (a) Uniform motion of a sphere in a liquid, axisymmetric motion (b) Vortex motion : Helmholtz properties of vortices, velocity in a vortex field, Motion of a circular vortex, Infinite rows of vortices, Karmans vortex street.

Unit-IV

Viscous Fluids : Navier Stokes equations for viscous flows-some solutions, diffusion of vorticity, dissipation of energy, Reynolds number, steady motion of a viscous fluid between two parallel plates, steady flow through circular cylindrical pipe and annulus.

Unit-V

Boundary layer theory: Dynamical similarity, parandtl's boundary layer equations in two dimensions, Blasius solution. Boundary layer thickness, displacement thickness, Karman integral equations.

Recommended Texts:

1. **F. Chorlton,** Text book of Fluid Dynamics (Van Nostrand Reinhold Co)
2. **D.E. Rutherford,** Fluid Dynamics (oliver Boyd)
3. **L.M. Milne Thomson,**Theoretical Hydrodynamics
4. **W.H. Besant and A.S. Ramsey**, A treatise of Hydromechanics.
5. **M.E. DNeill and F. Chorlton,** Ideal and Incompressible Fluid Dynamics.

References:

1. **Shantiswarup** ,Hydrodynamics (Krishna Prakashan)
2. **Bansilal,** Theoratical Hydrodynamics
3. **H. Lamb,** Hydrodynamics
4. **N. Curle H.J. Davies,** Modern Fluid Dynamics. (Van Nostrand Reinhold Co,)
5. **Karmacheti Krishna Murti,** Principles of Ideal Fluid Aerodynamics. (John Wiley Sons)

M 404 (a)
Relativity

Unit – I

Inertial frame, Galilean theory and transformations, need for special theory, postulates of special theory of relativity, Lorentz transformations, time dilation, consequences of time dilation, relativistic formulae for composition of velocities, transformation of Lorentz contraction factor, Lorentz transformation of force and density, geometrical interpretation of Lorentz transformations, variation of mass with velocity, equivalence of mass and energy, transformation formulae for mass, momentum and energy problems, Minkowski space, four vectors.

Unit – II

Summation convention, dummy and free suffix, Kroneeker delta, definition of tensor, Invariance of tensor equation, covariant and contravariant tensors, addition, subtraction, outer product, inner product of tensors, line element, the fundamental tensor in cartesian, cylindrical and spherical coordinates, Christoffel symbols of the first and second kind, transformation of Christoffel symbols, formula for second-order partial derivative in terms of Christoffel symbols.

Unit – III

The covariant derivative of a covariant vector, contravariant vector a mixed tensor of second order, rule of covariant differentiation and velocity gradient tensor in cylindrical and spherical co-ordinates. Curvature tensor, Riemmann – Christoffel tensor, Ricci tensor, equation of geodesic, geodesic coordinates, Bianchi identities, Einstein tensor.

Unit – IV

Need for generalization of the special theory, fundamental concept of general theory of relativity, inertial and gravitational masses, principles of covariance and equivalence, energy -momentum tensor, field equations of general relativity, Poisson's equation as an approximation of the field equations.

Unit – V

Schwarzschild's exterior solution, planetary orbits, crucial tests in relativity - advance of perihelion, gravitational shift of spectral lines and bending of light rays in a gravitational field, Schwarzschild's interior solution, cosmological models, Einstein's model, De-sitters model.

Recommended Texts:

1. **Robert Resnick** , Introduction to special relativity (New Age)
2. **A.P. French**, Special Relativity – (ELBS/Van Nostrand Reinhold (UN)
3. **P.G. Bergman**, Introduction to the Theory of Relativity – (Prentice Hall)
4. **M. Ray**, Theory of Relativity (Special and General) – (S. Chand & Co. Delhi)
5. **A.S. Eddington**, The Mathematical Theory of Relativity
6. **C. Moller,** The Theory of Relativity

References:

1. **Satya Prakash**, Relativistic Mechanics – (Pragati Prakashan Meerut; U.P)
2. **R. Latz**, An Introduction to the Special Theory of Relativity – (Van Nostran Princeton, N.J.)
3. **R.K. Pathria**, The Theory of Relativity – (Hindustan Publishing Co., Delhi)
4. **R.C. Tolman**, Relativity, Thermodynamics and Cosmology –
5. **Barry Spain**, Tensor Analysis –

M 404 (b)
Differential Geometry

Unit-I

Curves with Torsion : Space curves, their curvature and torsion, fundamental theorem of space curves, tangent, principal normal, curvature, bi-normal, torsion, Serret-Frenet formulae, locus of center of curvature, spherical curvature, locus of center of spherical curvature, theorem of curve determined by its intrinsic equations, helices, spherical indicatrix of tangent etc., involutes, evolutes, Bertrand curves.

Unit-II

Envelopes developable surfaces : Surface, tangent plane, normal; one-parameter family of surfaces; envelope, characteristics, edge of regression; developable surfaces; osculating developable; polar developable, rectifying developable; two parameter family of surfaces, envelope, characteristic points

Unit-III

Curvilinear co-ordinates on a surface, fundamental magnitudes, curves on surfaces, first and second fundamental forms, Gaussian curvature, curvilinear coordinates : first order magnitudes ; directions of a surface, the second order magnitudes, derivatives of N, curvature of normal section, Mausniers theorem.

Unit-IV

Curves on a surface and lines of curvature : Principal directions and curvatures, first and second curvatures, Eulers theorem, Dupins indicatrix, the surface $Z=f(x,y)$, surface of revolution, examples of asymptotic lines, curvature and torsion.

Unit-V

Geodesics, fundamental equations of surface theory, geodesic property, equation of geodesics, surface of revolution, torsion of a geodesic.

Recommended Texts:

1. **Weather burn ,C.E.**, Differential Geometry of three Dimensions, Cambridge University Press
2. **Guggenheimer ,H.**, Differential Geometry, McGraw Hill

References:

1. **Somasubdaram, D**., Differential Geometry: A First Course, Narosa Book Distributors Pvt. Ltd.

M 404 (c)
Mathematical Modeling

Unit-I

Mathematical modelling introduction, techniques, classifications, some illustrations: mathematical modelling through geometry/algebra/trigonometry/calculus, mathematical modelling through ODE of first order: linear growth and decay model, non-linear growth and decay model, compartment models mathematical modelling of dynamics, geometrical problem.

Unit-II

Mathematical modeling through systems of ordinary differential equations of first order: in population dynamics, epidemics, economics, medicine, dynamics, mathematical modelling through ODE of second order : of planetary motions and motion of satellites, modelling through linear ordinary differential equations of second order in electrical circuits, catenary.

Unit-III

Mathematical modelling through difference equations with constant coefficients : in population dynamics and genetics, mathematical modelling through PDE : mass-balance equations, momentum balance equations, variational principles, model for traffic on a highway.

Unit-IV

Mathematical modelling through graphs : in terms of directed graphs in terms of signed graphs, in terms of weighted diagraphs and in terms of unoriented graphs.

Unit-V

Mathematical modelling through linear programming : of different industrial oriented problems, mathematical modelling through calculus of variations : on geometrical problems, problems of mechanics/ bioeconomics.

Recommended Text:

1. **Kapur, J.N.**, Mathematical modelling, New Age International

References:

1. **Burghes, D.N.**, Mathematical modelling in social, management and life sciences, Ellios
2. Horwood and John Wiley
3. **Giordano, F.R.,and Weir, M.D.**, A first course in Mathematical Modelling, Brooks Cole
4. **Kapur, J.N.**, Insight into mathematical modeling, Indian National Science academy
5. **Bellomo and Preziosi**, Modelling Mathematical methods and Scientific computation, CRC

M 404 (d)
Computational Fluid Mechanics

Unit-I

Irrotational flow, Potential function, Full potential equation, 2-D incompressible fluid flow, Stream function, conservation principles, Steady and unsteady fluid flow, vortex motion, vorticity equation, vorticity transport equations, viscous fluid flow, boundary layer approximation to viscous fluid motions.

Unit-II

Nature of problems, Finite difference formulations for elliptic problems. Simple, general and higher order derivative, mixed derivatives. Higher order accuracy schemes, accuracy of F.D. solutions. Iterative solution method, FD methods for 2-D and 3-D elliptic BVP with 2nd and 4th order and their application. FD approximations to Poissons equation in cylindrical and spherical co-ordinates, Alternation direction method.

Unit-III

Two and three level explicit and implicit F.D. approximations to parabolic equations. Stability analysis (matrix and Von-Neumann method). The method of factorization, fractional step methods, solution of 1-D non-linear parabolic equations. compatibility, consistency and convergence of the difference method, FD approximations to heat conduction equation in cylindrical and spherical co- ordinates.

Unit-IV

Explicit and implicit schemes, Von-Neumann stability analysis, Multi step methods, solution of 1-D non-linear hyperbolic problems, solution of non-linear wave equation, explicit and implicit schemes for Bungers equation.

Unit-V

Finite element formulations, the construction of finite elements, convergence rates for FEM, stability of FEM, Galerpins method, elementary ideas of finite volume method, one-dimensional computations by FVM, conversion of FVM to FDM, simple problem.

Recommended Texts:

1. **C.A.J. Eletcher**, Computational techniques for Fluid Dynamics,Springer-Verleg
2. **C.Y. Chow**, Introduction to Computation Fluid Dynamics, John Willey
1. **D.A. Anderson, J.C. Tasnechill, R.H. Pletcher**, Computational Fluid Dynamics and Heat Transformation,McGraw Hill

References:

1. **T.J. Chung** , Computational Fluid Dynamics, Cambridge University Press
2. **Peyret and T.D. Taylor**, Computational Fluid Dynamics, Springer-Verleg
3. **P. Wesseling**, Principles of Computational Fluid Dynamics, Springer-Verleg

M 404 (e)

Operator Theory

Unit-I

Banach algebras, inverse of an element, spectrum and resolvent, compact linear operators on normed linear spaces. The ideal of compact operators, the separability of the range and spectral properties of a compact linear operator, operator equations involving compact linear operators.

Unit-II

Fredholm type theorems, the Fredholm alternative, spectral properties of bounded self-adjoint linear operators. Positive operators. Square roots of a positive operator, projection operators, Spectral families, spectral family of a bounded self-adjoint linear operators.

Unit-III

Extension of the spectral theorem to continuous functions, properties of the spectral family of a bounded self-adjoint linear operator, unbounded linear operators and their Hilbert-adjoint operators, symmetric and self adjoint linear operators. closed linear operators closable operators and their closures.

Unit-IV

Spectral properties of self-adjoint linear operators. Spectral representation of unitary and self-adjoint linear operators. Multiplication operator and differentiation operator. Functional calculus and spectral mapping theorem for analytic function, the Riesz decomposition theorem.

Unit-V

Semigroups of bounded linear operators, exponential growth property and the resolvent, generation of semigroups, dissipative semigroups and compact semigroups, elementary examples of semigroups :Cauchy problem.

Recommended Texts:

1. **Kreyszig,E.**, Introductory Functional Analysis with Applications, John Filey and Sons
2. **Rajdavi, H. and Rosenmthal, P.**, Invarian subspaces, Springer-Verlag (Chapter 2)
3. **Balakrishnan,A.V.**, Applied Functional Analysis, Springer-Verlag

References:

1. **Lahiri,B.K.**, Elements of Functional Analysis by , World Press, Kolkata
2. **Limayce, B.V.**, Functional Analysis, New Age Int
3. **Dunford N., Schwartz, J.P.**, Linear Operators, Pt-I II : Intesciences Publishers
4. **Taylor A.E.,Ley,D.C.**, Introduction to Functional Analysis by John Wiley and Sons

M 404 (f)
Groups and Representations

Unit-I

Isomorphism theorems, group presentations, symmetric groups, dihedral groups, general linear groups, group actions, Sylows theorems.

Unit-II

Minimal and maximal normal subgroups, automorphism groups, commutators, composition series, solvable groups, Jordan-Hölder, theorem, nilpotent groups, supersolvable groups, Fitting and Frattini subgroups.

Unit-III

Semidirect product, central product, wreath product, p-groups, extra-special p-groups, complements of subgroups, the Schur- Zassenhaus theorem.

Unit-IV

Modules and representations, Maschkes theorem, Wedderburn theory.

Unit-V

Characters, character table, theorems of Burnside and Hall, induced characters.

Recommended Text:

1. **J. L. Alperin Rowen B. Bell**, Gropus and Representations, GTM 162, Springer (1995)

References:

1. **Derik J. S. Robinson**, A course in the theory of Groups, GTM 80, Springer (1996)
2. **David S. Dummit Richard M. Foote**, Abstract Algebra, John Wiley Sons, Inc (1999)
3. **Joseph J. Rotman**, An Introduction to the Theory of Groups, third edition, Allyn Bacon, Inc (1984)
4. **M. J. Collins**, Representations and characters of finite groups, Cambridge Studies in Advanced Mathematics 22, Cambridge University Press (1990)

M 404 (g)
Mathematical Statistics

Unit-I

The postulates of probability, Some elementary theorems, addition and multiplication rules, Bayes rule and future Bayes theorem, random variables, mathematical expectation, probability mass functions and probability density function, distribution function and its properties.

Unit-II

Uniform, Bernoulli and binomial distribution, hypergeometric and geometric distribution, negative binomial and Poisson distribution, uniform and exponential distribution, gamma and beta distributions, normal distribution, log-normal distribution.

Unit-III

Moments and moment generating functions, probability generating functions and characteristic function Moments of binomial, hypergeometric, Poisson, gamma, beta and normal distributions, transformation of variables: one variable, Several variables.

Unit-IV

The distribution of sample moments, the distribution of differences of means and variances, the Chi-Square distribution, the t distribution and the F distribution.

Unit-V

Multiple linear regression, estimation of parameters using method of least square, use of dummy variables, binomial logestic regression and multinomial logestic regression- estimation of the regression coefficients and their interpretation.

Recommended Text:

1. **J. E. Freund**, Mathematical Statistics, (Prentice Hall Inc., 1992)
2. **Bhattacharjee D. and Das K. K.**, A Treatise on Statistical Inference and Distributions, (Asian Books, 2010)

References:

1. **Hogg and Craig**, Introduction to Mathematical Statistics, (Collier Macmillan, 1958)
2. **Mood, Greyill and Boes**, Introduction to the Theory of Statistics, (McGraw Hill)
3. **R. E. Walpole**, Introduction to Statistics, (Macmillan Publishing Company, 1982)
4. **M. R. Spiegel and L. J. Stephens**, Statistics, (McGraw Hill Book Company, 1984)

M 404 (h)

Algebraic Topology

Unit-I

Homotopy of paths, fundamental groups, fundamental group functor, homotopy of maps, homotopy equivalence, contractible and simply connected spaces, fundamental groups of the circle, torus etc., degree of maps of the circle.

Unit-II

Van-Kempen's theorem, application to cell complexes, calculation of fundamental groups of n-sphere, n> 1, fundamental group of topological group, Brouwer's fixed point theoremin dimension two, fundamental theorem of algebra, vector fields, Frobenius theorem on eigen values of a 3×3 matrix.

Unit-III

Covering space, unique lifting theorem, path-lifting theorem, covering homotopy theorem, application, universal covering and its existence.

Unit-IV

Simplicial and singular homology, reduced homology, Eilenberg- Steenrod axioms(without proof), relation between π_1 and H_1, relative homology.

Unit-V

Calculation of homology of n- spheres, Brouwer's fixed point theorem of dimension n > 2 and its applications to spheres and vector fields, Meyer – Vietoris sequences and its application.

Recommended Texts:

1. **M.J. Greenberg & J. R. Harper**, A First Course in Algebraic Topology (Second Edition), Addition-Wesley Publishing Co., 1997.
2. **Czes Kosnioski**, A First Course in Algebraic Topology, Cambridge University Press (1980)

References:

1. **Allen Hatcher**,Algebraic topology , Cambridge University Press (2002)
2. **William S. Massey**, A Basic Course in Algebraic Topology, Springer (Indian Edition)
3. **J.K. Munkres**, A First Course in Topology, Second Edition, Prentice-Hall of India Ltd, New Delhi.

M 404 (i)

Fuzzy Sets and Applications

Unit-I

Fuzzy sets: basic definitions and operations on fuzzy sets, types of fuzzy sets, cartesian products, algebraic products, bounded sum and difference, t- norms, t- conorms

Unit-II

Fuzzy numbers, linguistic variables, fuzzy numbers describing 'Large', fuzzy numbers in the set of integers, arithmetic operations on intervals and fuzzy numbers, lattice of fuzzy numbers, fuzzy equations.

Unit-III

Fuzzy relations, fuzzy graph, fuzzy order, fuzzy functions, fuzzy matrix, fuzzy logic: an overview of classical logic, fuzzy proposition, fuzzy quantifiers, linguistic hedges, inferences from conditional quantified fuzzy propositions.

Unit-IV

Belief and plausibility measures, probability, possibility and necessity measures, uncertainty and information

Unit-V

Different methods of defuzzification, decision making in fuzzy environment and some mathematical models in fuzzy environment.

Recommended Texts:

1. **G. J. Klir, U. S. Clair and B. Yuan**, Fuzzy Sets and Fuzzy Logic, Theory and Applications, Prentice Hall, 1995
2. **H. J. Zimmermann**: Fuzzy Set Theory and its Applications, Allied Publishers Ltd. 1991

M 405 (Project Work)

Here each student has to prepare a project report under a supervisor and to present his/her work before external expert. The work may be a survey based report or may be a new finding or may be solving exercises from any standard text / questions of competitive examinations (NET/GATE/NBHM etc.).