PG Syllabus

Department of Mathematics
Assam University, Silchar
(To be implemented from session 2019-20)

Course Structure for M.Sc. (Mathematics)

First semester

Paper No	Name of the Paper	Marks					L	T	C	P
		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(**Theory**)	30	12	40	16	70	3	1	6	-
	Numerical Analysis(**Practical**)	-	-	30	12	30	-	-	-	2
M-105	Operations Research - I	30	12	70	28	100	4	2	6	-
Total		150		350		500	19	9	30	2

Second semester

Paper No	Name of the Paper	Marks					L	T	C
		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	Discrete Mathematics (Open – II)	30	12	70	28	100	4	2	6
M-205	Partial Differential Equation	30	12	70	28	100	4	2	6
Total		150		350		500	20	10	30

Third semester

Paper No	Name of the Paper	Marks					L	T	C
		Internal		External		Total			
		M.M.	P.M.	M.M.	P.M.				
M-301	Integral Equations and Calculus of Variations	30	12	70	28	100	4	2	6
M-302	Linear Algebra	30	12	70	28	100	4	2	6
M-303	Mechanics	30	12	70	28	100	4	2	6
M-304	Operations Research - II	30	12	70	28	100	4	2	6
M-305	Complex Analysis	30	12	70	28	100	4	2	6
Total		150		350		500	20	10	30

Fourth semester

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	Real Analysis -II	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. Operator Theory e. Groups and Representations f. Commutative Algebra g. Operations Research - III	30	12	70	28	100	4	2	6
M-405	Project	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

M-101
Algebra-I

Unit-I

Definition of groups and simple properties, Lagrange theorem and applications, cyclic groups and their characterisations, Normal subgroup and group homomorphism, Quotient group, correspondence theorem.

Unit II

Conjugacy class, characterisation of normal subgroup in terms of conjugacy class, determination of conjugacy classes in Symmetric group , alternating group and dihedral group, External direct product, automorphism groups.

Unit-III

Internal direct product and semi direct product of groups, fundamental theorem of finite abelian groups (statement and applications only) , Group action, properties of group action, orbit-stabiler theorem, Cauchy's theorem using group action.

Unit-IV

Class equation of finite groups, Simplicity of A5using class equation, Sylow's theorems with proof, applications of Sylow's theorems, classification of groups of small order up to 15.

Unit-V

Sub normal, normal series, derived group, solvable groups, composition series, nilpotent groups, Jordan-Holder theorem, construction of free group.

Recommended Texts:

1. A Course in Group Theory, J.F. Humphreys, Oxford University Press.

References:

1. An introduction to the theory of groups, J.J Rotman, Springer.
2. Contemporary Abstract Algebra, J. Gallian, Narosa Publishers
3. Abstract Algebra , D.S. Dumit, D.S. and R.M Foote, John Wiley and Sons

M102

Real Analysis-I

Unit-I

Finite and infinite sets, countability, construction of real number system from natural numbers, Archimedean property of R, supremum, infimum of bounded subsets of R, density of rationals and irrationals in R, sequences in R^n

Unit-II

Topology of R^n: open and closed sets, limit points, Bolzano-Weiestrass theorem, Heine-Borel theorem, limit and continuity of real and vector-valued functions, sequential continuity, properties of continuous functions on compact sets

Unit-III

Uniform continuity, Monotone real valued functions, Derivative of a function in R, mean value theorems, L'Hospital's rules, Taylor's theorem and applications in R

Unit-IV

Derivative of a vector valued function in R^n, partial and directional derivatives, higher order partial derivatives, mean value theorem, equality of mixed partial derivatives

Unit-V

Taylor's theorem for functions of several variables, extremum problem with/ without constraints, implicit and inverse function theorem.

Recommended Texts:

1. **Rudin**, **W.**, Principles of Mathematical Analysis, McGraw-Hill International

References:

1. **Moskowitz, M, Paliogiannis, F**., Functions of Several Real Variables, World Scientific

2. **Bartle, R., G., Sherbert, D.R.,** Introduction to Real Analysis, John Wiley and Sons

M-103
Ordinary Differential Equations

Unit-I

Introduction, initial value problem, boundary value problem, linear dependence equations with constant as well as variable coefficient, Wronskian, variation of parameter, method of undetermined coefficients, reduction of the order of equation, method of Laplace's transform.

Unit-II

Lipchitz's condition and Gronwall's inequality, Picards theorems, dependence of solution on initial conditions and on function, Continuation of solutions, Nonlocal existence of solutions Systems as vector equations, existence and uniqueness of solution to systems and existence and uniqueness of solution for linear systems.

Unit-III

Introduction, Strum-Liouvilles system, Green's function and its applications to boundary value problems, some oscillation theorems such as Strum theorem, Strum comparison theorem and related results.

Unit –IV

Introduction, System of first order equation, fundamental matrix, Non homogeneous linear system, Linear system's with constant as well as periodic coefficients.

Unit –V

Linear equations with Regular Singular Points.

Books Recommended:

1. E.A. Coddington: An introduction to Ordinary Differential Equations, Prentice Hall of India, New Delhi, 1991.
2. S.C. Deo, Y. Lakshminathan and V. Raghavendra: Text Book of Ordinary Differential Equation Second Edition) Tata McGraw Hill, New Delhi (Chapters IV, VII and VIII).
Reference Books: 1. P. Haitman: Ordinary Differential Equations, Wiley, New York, 1964.
3. E.A. Coddington and H. Davinson: Theory of Ordinary Differential Equations, McGraw Hill, NY, 1955.

M- 104
NUMERICAL ANALYSIS (Theory)
Marks: 40

Unit-I

Error estimations in numerical analysis, central difference interpolation formulae, Lagrange interpolation formula, inverse interpolation formulae, Hermite interpolation, piecewise interpolation, spline interpolation, cubic Splines.

Unit-II

Numerical differentiation: Method of undetermined coefficient, extremum values, Numerical integration: formula for equidistant nodes, cases of singular integrals. Approximation of functions: Chebyshev approximation, least square approximation and orthogonal 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, system of linear equations: Direct and iterative methods.

Unit-IV

Numerical solution of ordinary differential equations: Picard's method, Euler's method, modified Euler's method, Runge-Kutta method, solution of initial value problems for linear and non-linear equations.

Unit-V

Difference equations: general and particular solution of difference equation, homogeneous linear difference equations with constant coefficients. Finite Difference Methods: derivation of finite difference methods, finite difference method to solve two-point BVP of linear and nonlinear ODEs.

Numerical Analysis (Practical)

Marks: 30

A list of practical problems related with the Units I-V, based on some numerical methods will be studied with the use of software programmes like MATLAB/ MATHEMATICA.

Recommended Texts:

1. **Atkinson, Kendall, E.**: An Introduction to Numerical Analysis (John Wiely Sons (Asia) 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 -I

Unit-I

Revised simplex method, post-optimal analysis.

Unit-II

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

Unit-III

Job sequencing problem, 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, neighborhoods , 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, neighborhoods, 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
4. **Mukharjee M.N.**, Elements of metric spaces, Academic publisher

M-202
Algebra-II

Unit-I

Definition of Rings and simple properties, subrings and ideals, integral domains fields, quotient rings, prime ideal and maximal ideals and their characterisation, ring homomorphism, field of fractions.

Unit II

Polynomial ring in one and many variables, Prime and irreducible elements, factorisation in integral domains, unique factorisation domain, principal ideal domain, Euclidean domain.

Unit-III

Irreducible polynomials, Gauss' lemma, Eisenstein's irreducibility criterion and applications, finite and algebraic extension, geometric constructions.

Unit-IV

Kroneker's theorem, existence and uniqueness of splitting field, characterisations of normal extensions and separable extensions**,** examples of inseparable and perfect fields**.**

Unit-V

Finite fields, Galois extension, fundamental theorem of Galois theory and its applications, cyclotomic extension, Galois group of a polynomial, solvability by radicals, inverse Galois problem.

Recommended Texts:

1. Abstract Algebra , D.S. Dummit, D.S. and R.M Foote, John Wiley and Sons

R**eferences:**

1. Basic abstract algebra, P.B .Bhattacharya, S .K.Jain, S .R.Nagpaul, springer
2. Contemporary Abstract Algebra, J. Gallian, Narosa Publishers

M 203
Mathematical Methods (Open - I)

Unit – I

Ancient World Mathematics: A survey of the historical development of Mathematics: Early number systems and symbols, Mathematics in early civilization, the beginning of Greek Mathematics , Late Greek Mathematics: Diophantus, Fibonacci , Cardon and Tartaglia, ancient Mathematics in Egypt and Mesopotamia , China, Europe.

Unit – II

Ancient Indian Mathematics: A survey of the historical development of Indian Mathematics, Vedic Mathematics, Panini, Jaina Mathematics, Development of place value system, Aryabhatta1, Aryabatta2, Bhaskar1, Bhramagupta1, Bhramagupta2, Bhramagupta3, Bakshali Manuscript, Mahavira, Bhaskar2, Kerala school of Astronomy.

Unit – III

Numerical Linear Algebra: Linear spaces, subspaces, linear dependence and independence, bases and dimension, Elementary row transformations-rank-echelon form, normal form – solution of linear systems – direct methods- LU decomposition- LU decomposition from Gauss elimination –Solution of tri-diagonal 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 polynomialNewton'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. **Victor J. Katz**, A History of Mathematics, an introduction , Addison-Wesley, third edition 2009.
2. **Bharati Krishna Tirtaji Maharaja**, Vedic Mathematics, Matilal banarasi Dass
3. **T. K. V. Iyengar, B. Krishna Gandhi and Others,** Mathematical Methods, S. Chand & Company.
4. **B. V. Raman,** A text Book of Engineering Mathematics, Tata Mc Graw Hill.
5. **M. D. Rai Singhania**, Laplace and Fourier transforms, S. Chand & company Ltd.

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. **D. J. Struik**, A concise history of mathematics, Dover publication, INC. New York

M 204
Discrete Mathematics (Open - II)

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, Subgraph, Varities of graphs, degree and incidence, isormorphism, intersection graph, operations on graph, walks and connectedness, trees cycles and cocycles.

Unit – V

Traversability : Eulerian and Hamiltomian graphs, plane and planner graphs, Kuratowski's theorem.

Recommended texts:

1. Burton, D.M. : Elementary Number Theory (universal Book Stall)
2. Niven,l I.H.S. Zuckerman, H.L. Montgomery. An Introduction to the Theory of Numbers (John Wiley L PE)
3. Harvary, F. : Graph Theory (Narosa Publishing House)
4. Liu, C.L.: Elements Discrete Maths (Tata McGraw – Hill)

References :

1. Ireland, K&Rosen, M., A classical Introduction to Modern Number Theory. (Springer LPE)
2. West : Introduction to Graph Theory (Prentice Hall of India)
3. B. Kolman, Busby, R.C. & S. Ross : Discrete Mathematical Structures (Prentice –Hall of India)

M-205
Partial Differential Equations

Unit-I

Partial differential equations of first order.

Unit-II

Classification of second order partial differential equations to Hyperbolic, Elliptic and Parabolic types. Reduction of linear and quasi-linear equations in two independent variables to their canonical forms, characteristic curves.

Unit-III

Parabolic Equation : Conduction of heat in a bounded strip, First boundary value problem Maximum Minimum theorem and its consequences , uniqueness, continuous dependence of the solution and existence of the solution. Conduction of heat in a infinite strip (Cauchy problem), Problems.

Unit-IV

Elliptic Equations : Occurrence of Laplace's equation. Fundamental solutions of Laplace's equation in two and three independent variables. Laplace equation in polar, Spherical polar and in cylindrical polar coordinates, Minimum – Maximum theorem and its consequences. Boundary value problems, Dirichlets and Neumann's interior and exterior problems uniqueness and continuous dependence of the solution on the boundary conditions. Use of the separation of variables method for the solution of Laplace's equations in two and three dimensions interior and exterior Dirichlet's problem for a circle, and a semi circle, steady-state heat flow equation Problems, Higher dimensional problems, Dirichlet's problem for a cube, cylinder and sphere, Green's function for the Laplace equation, in two and three dimensions.

Unit-V

Hyperbolic Equations: The equation of vibration of s string. Formulation of mixed initial and boundary value problem. Existence, uniqueness and continuous dependence of the solution to the initial conditions. D'Alembert's formula for the vibration of an infinite string. The domain of dependence, the domain of influence use of the method of separation of variables for the solution of the problem of vibration of a string. Investigation of the conditions under which the infinite series solution convergence and represents the solution. Riemann method of solution, Problems, Transverse vibration of membrane. Rectangular and circular membranes problems.

Recommended Texts:

1. Sneddon I.N. : Elements of Partial Differential Equations, Mcgraw Hill.
2. Miller F.H. : Partial Differential Equations

References:

1. Sankara Rao,K:Introduction to Partial Differential Equations,PHI
2. Amarnath,T:An Elementary Course in Partial Differential Equations,Narosa Publishing House.

M 301
Integral Equation and Calculus of variations

Unit-I

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

Unit-II

Integral equations of the first, second and third kinds, examples, finite difference approximations, Fredholm integral equation, the Fredholm alternative.

Unit-III

Volterra Integral equations, kernels with weak singularities, degenerate kernels, Volterra equations of the first kind.

Unit – IV

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

Unit – V

Hankel Transforms and their inverse with applications.

Recommended Texts:

1. Calculus of variations, I.M.Gelfanf and S.V. Fomin, Dover.
2. Integral Equations, Shanti Swarup, Krishna Prakashan Media

References:

1. Calculus of variations with Applications, A.S. Gupta,PHI(2004)
2. A First Course in Integral Equations, Abdul-Mazid Wazwaz
3. R. P. Kanwal: Linear Integral Equations, Academic press, New York (1998)
4. S. G. Mikhlin: Linear Integral Equations (translated from Russian) Hudson Book Agency(1980)
5. D. Porter and D. S. G. Stirling: Integral equations, Cambridge University Press (1998)

M 302

Linear Algebra

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.

M – 303

Mechanics

Unit-I

Generalised coordinates, constraints and constrained motion, principal of virtual work, 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, conservation theorems and symmetry properties.

Unit-II

Hamiltonian function, physical significance of Hamiltonian, Hamilton's canonical system of equations, Hamilton's equations from variatioinal principle, equations of canonical transformations, integral invariants of Poincare, Lagrange and Poisson's brackets as canonical invariants, equations of motion in Poisson bracket form.

Unit-III

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-IV

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

Unit-V

Classical (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, variation of mass with velocity, equivalence of mass and energy, transformation formulae for mass, momentum and energy problems, Minkowski space, four vectors.

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. **Robert Resnick** , Introduction to special relativity (New Age)
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. **Satya Prakash**, Relativistic Mechanics – (Pragati Prakashan Meerut; U.P)

M - 304
Operations Research -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.

Unit –IV

Goal programming problem – formulation, solution and application.

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
Complex Analysis

Unit-I

Algebra and topology of the complex plane, stereographic projections, continuity of complex functions, power series, Analytic functions, Elementary functions, Mobius transformation.

Unit-II

Power series representation of analytic functions, zeros of analytic functions, Definition and simple properties of complex integral, Cauchy's theorem and integral formula, Morera's theorem, Cauchy's inequalities, Liouvilles theorem.

Unit-III

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

Unit-IV

Calculus of residues, Cauchy's residue theorem, evaluation of definite integrals using residue, argument principle, Rouche's theorem, Complex analytic proofs of fundamental theorem of algebra.

Unit-V

Spaces of continuous, analytic and meromorphic functions, Riemann mapping theorem, infinite products, Weierstrass factorisation theorem.

Recommended Texts:

1. **Conway, J. B.**, Functions of One Complex Variable, Second Edition, Narosa Publishing House.

References:

1. **Ponnusamy, S.**, Foundations of Complex Analysis, Narosa Publishing House
2. **Bak J, Newman D.J.**, Complex Analysis, third edition, springer.

M-401
Functional Analysis

Unit-I

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

Unit-II

Continuity of linear maps, Hahn Banach theorem, consequences of Hahn-Banach theorem, topological dual of normed linear spaces, natural embedding, reflexive spaces

Unit-III

Applications of Baire category theorem, Uniform boundedness principle, Banach Steinhaus theorem, open mapping theorem, closed graph theorem and their applications

Unit-IV

Inner product spaces, 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

Unit-V

Projection, Riesz representation theorem, adjoint operators, normal operators, unitary operators and self-adjoint operators on Hilbert spaces, compact operators on Banach and Hilbert spaces

Recommended Texts:

1. **Limaye, B.V.**,Functional Analysis, New Age International

References:

1. **Conway, J. B.**, A Course in Functional Analysis, Springer
2. **Kreyszig, E.**, Introduction to Functional Analysis with Applications, John-Wiley and Sons

M 402

Real Analysis-II

Unit-I

Sequence and series of real valued functions, Weierstrass approximation theorem, power series, Riemann integration, improper integrals, drawbacks of Riemann integration

Unit-II

Extended real number system, Lebesgue outer measure, Lebesgue measurable sets, Lebesgue measure and properties, Borel and Lebesgue sigma-algebras, measurable functions, Lusin's theorem

Unit-III

Simple functions, Lebesgue integration and properties, Lebesgue's monotone convergence theorem, Fatou's lemma, Lebesgue's dominated convergence theorem, comparison with Riemann integration

Unit-IV

Uniform integrability and tightness, Vitali convergence theorem, functions of bounded variations, absolute continuity

Unit-V

Convergence in Lebesgue measure, L^p-spaces over R: completeness, approximations and separability of L^p-spaces

Recommended Texts:

1. **Royden, H.L. Fitzpatrick, P.M.,** Real Analysis, Prentice Hall of India
   (**Chapter-II, III, IV, V**)
2. **Rudin**, **W.**, Principles of Mathematical Analysis, McGraw-Hill International
   (**Chapter-I**)

References:

1. **Rana, I.K.,** An Introduction to Measure and Integration, Second Edition, American Mathematical Society
2. **Sohrab, H.H.,** Basic Real Analysis, Birkhauser

M- 403
Fluid Dynamics

Unit-I

Fluid and its continuum hypothesis, Lagrangian and Eulerian methods of description, streamline and path line, equation of continuity in fluid motion (Lagrangian and Eulerian forms), equivalence of two forms of equations of continuity, boundary surface conditions, Euler's equations of motion for perfect fluids, integrals of Euler's equations of motion. Lagrange's equations of motion, flow and circulation, Kelvins circulation theorem, equation of energy for perfect fluid.

Unit-II

Motion in two dimensions, Lagranges stream function, complex potential, sources, sinks and doublets; image, images of a source with regard to a plane and a circle; image of a doublet, Milne-Thomson circle theorem, theorem of Blasius.

Unit-III

Motions in three-dimensions: Uniform motion of a sphere in a liquid, axisymmetric motion; Vortex motion: Helmholtz properties of vortices, velocity in a vortex field, motion of a circular vortex, infinite rows of vortices, Karman's vortex street.

Unit-IV

Viscosity and viscous fluid, Newton's law of viscosity, Navier - Stokes equations, some exact solutions of Navier- Stokes equations: steady motion of a viscous fluid between two parallel plates, steady flow through circular cylindrical pipe and annulus, dissipation of energy.

Unit-V

Dynamical similarity of flows, Reynolds number, Parandtl's boundary layer theory and boundary layer equations, Blasius solution, Von-Karman's integral equations, momentum boundary layer thickness, displacement thickness, energy thickness.

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, Riccei 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 Books:

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

Reference Books:

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

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, examples I , spherical curvature, locus of center of spherical curvature, theorem of curve determined by its intrinsic equations, helices, spherical indicatrix of tangent etc., involutes, evolutes, Betrand curves, examples II.

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., examples III.

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 X=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 Text:

1. **Weather burn ,C.E.**, Differential Geometry of three Dimensions, Cambridge University Press
2. **Bansi Lal**, Three Dimentional Di_erential Geometry ,S. Chand

References:

1. **Guggenheimer ,H.**, Differential Geometry, McGraw Hill

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

404 (d)
Operator Theory

Unit-I

Hilbert space and its properties, adjoint operators, normal operators, unitary operators, self-adjoint operators, projection operators on Hilbert spaces

Unit-II

Finite rank operators on normed linear spaces, compact operators, completely continuous operators, convergence in strong and weak operator topology, cyclic vectors, invariant subspaces

Unit-III

Spectrum and resolvent, spectral mapping theorem for polynomials, spectral radius, subdivision of spectrum, spectrum of compact operators, numerical range, Toeplitz-Hausdorff theorem, Spectral theorems for compact operators on Hilbert spaces

Unit-IV

Definition and examples of Banach algebra, regular and singular elements, topological divisors of zero, radical and semi-simplicity, Gelfand mapping

Unit-V

Involutions in Banach algebras, the Gelfand-Neumark theorem, Banach-Stone theorem, the stone-chech compactification, introduction to commutative C*-algebras.

Recommended Texts:

1. **Conway, J. B.**, A Course in Functional Analysis, Springer
2. **Simmons, G.**F., Introduction to Topology and Modern Analysis, Tata McGrow Hill (Unit-IV, Unit-V)

References:

1. **Halmos, P.R**., A Hilbert Space Problem Book, Springer
2. **Rudin, W**., Functional Analysis, Tata McGrow Hill
3. **Limaye, B.V.**,Functional Analysis, New Age International

M 404 (e)

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 (f)

Commutative Algebra

Unit-I

Rings and ring homomorphism, prime and maximal ideals, nil radical, Jacobson radical, operation on ideals, prime avoidance lemma, extension and contraction of ideals, units, zero divisors and nilpotent elements in polynomial ring and power series ring.

Unit-II

Modules and module homomorphism, submodules and quotient modules, operation on submodules, direct sum and product, finitely generated modules, Nakayama's lemma, exact sequences, tensor product of modules and simple properties.

Unit-III

Rings and modules of fraction, localisation at a prime ideal, extended and contracted ideals in Ring of fractions, Primary ideals, primary decomposition theorems and uniqueness of primary decomposition.

Unit-IV

Integral dependence, the going-up theorem, integrally closed integral domains, the going-down theorem, discrete valuation rings and Dedekind domain.

Unit-V

Chain conditions, Noetherian rings, Artinian rings, Noether normalisation, Hilbert nullstellansatz.

Recommended Text:

1. Introduction to Commutative Algebra, M.F. Atiyah, I.G. MacDonald, I.G, CRC Press (Chapter 1-9)

Reference Book:

1. Steps in Commutative Algebra, R.Y. Sharp, Cambridge University Press.
2. Commutative Algebra, N.S. Gopal Krishnan, Orient Blackswan Pvt. Ltd.
3. Undergraduate Commutative Algebra, Miles Reid, LMS Students text 29.

M – 404 (g)
Operations Research -III

Unit – I

Goal Programming: Some advanced topics (Variants of goal programming with different methodologies)

Unit – II

Theory of replacement problems and their applications

Unit - III

Decision theory under different situation.

Unit – IV

Separable programming, Geometric Programming.

Unit - V

Fractional Programming, Dynamic Programming.
(Introduction, mathematical formulation and some basic results)

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
4. **Sharma, S. D., Operations Research Theory, Methods and Applications:** Kedar Nath Ram Nath and Co. Meerut

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 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.).