Centre for Physical and Mathematical Sciences
Scheme of Programme M.Sc Mathematics

SEMESTER I

S.No	Paper Code	Course Title	L	T	P	Cr	% Weightage A	B	C	D	E
1	MAT.501	Algebra – I	4	-	-	4	25	25	25	25	100
2	MAT.502	Complex Analysis	4	-	-	4	25	25	25	25	100
3	MAT.503	Real Analysis	4	-	-	4	25	25	25	25	100
4	MAT.504	Mechanics – I	2	-	-	2	25	25	25	25	50
5	MAT.505	Differential Equations	4	-	-	4	25	25	25	25	100
6	MAT.506	Linear Algebra	4	-	-	4	25	25	25	25	100
7		Inter-Disciplinary Elective -1 (From Other Departments	2	-	-	2	10	15	15	10	50
Interdisciplinary courses offered by MAT Faculty (For students of other Centres)											
8	MAT.507	Basic Mathematics	2	-	-	2	25	25	25	25	50
			24	**-**	**-**	**24**	**-**	**-**	**-**	**-**	600

A: Continuous Assessment: Based on Objective Type Tests
B: Mid-Term Test-1: Based on Objective Type & Subjective Type Test
C: Mid-Term Test-2: Based on Objective Type & Subjective Type Test
D: End-Term Exam (Final): Based on Objective Type Tests
E: Total Marks
L: Lectures T: Tutorial P: Practical Cr: Credits

SEMESTER II

S.No	Paper Code	Course Title	L	T	P	Cr	% Weightage A	B	C	D	E
1	MAT.508	Algebra – II	4	-	-	4	25	25	25	25	100
2	MAT.509	Topology	4	-	-	4	25	25	25	25	100
3	MAT.510	Mechanics– II	2	-	-	2	25	25	25	25	50
4	MAT.511	Probability and Statistics	4	-	-	4	25	25	25	25	100
5	MAT.512	Fundaments of Computer science and programming in C and C++	3	-	-	3	25	25	25	25	75
6	MAT.554	Fundaments of Computer science and programming in C and C++ LAB	-	-	-	1	-	-	-	-	25
7		Inter-Disciplinary Elective -2 (From Other Departments	2	-	-	2	10	15	15	10	50
8	MAT.599	Seminar	-	-	-	2	-	-	-	-	50
Opt any one course from interdisciplinary course offered by other centres											
8	MAT.513	Linear Programming	2	-	-	2	25	25	25	25	50
	MAT.514	Numerical Methods	2	-	-	2	25	25	25	25	50
			19	**-**	**-**	**24**					600

A: Continuous Assessment: Based on Objective Type Tests
B: Mid-Term Test-1: Based on Objective Type & Subjective Type Test
C: Mid-Term Test-2: Based on Objective Type & Subjective Type Test
D: End-Term Exam (Final): Based on Objective Type Tests
E: Total Marks
L: Lectures T: Tutorial P: Practical Cr: Credits

Semester-III

S.No	Paper Code	Course Title	L	T	P	Cr	% Weightage				E
							A	B	C	D	
1	MAT.515	Functional Analysis	4	-	-	4	25	25	25	25	100
2	MAT.516	Numerical Analysis	3	-	-	3	25	25	25	25	75
3	MAT.517	Differential Geometry	4	-	-	4	25	25	25	25	100
4	MAT.518	Operations Research-I	4	-	-	4	25	25	25	25	100
5	MAT.519	Measure Theory	4	-	-	4	25	25	25	25	100
6	MAT.555	Numerical Analysis LAB	-	-	1	1	-	-	-	-	25
Opt any one course from following elective courses											
7	MAT.520 MAT.521 MAT.522	Discrete Mathematics Fluid Mechanics Number Theory	4	-	-	4	25	25	25	25	100
			23	**-**	**1**	**24**	**-**	**-**	**-**	**-**	600

A: <u>Continuous Assessment:</u> Based on Objective Type Tests
B: <u>Mid-Term Test-1:</u> Based on Objective Type & Subjective Type Test
C: <u>Mid-Term Test-2:</u> Based on Objective Type & Subjective Type Test
D: <u>End-Term Exam (Final):</u> Based on Objective Type Tests
E: Total Marks
L: Lectures T: Tutorial P: Practical Cr: Credits

Semester-IV

S.No	Paper Code	Course Title	L	T	P	Cr	% Weightage				E
							A	B	C	D	
1	MAT.523	Operations Research - II	4	-	-	4	25	25	25	25	100
2	MAT.524	Calculus of Variation and integral equations	4	-	-	4	25	25	25	25	100
3	MAT.525	Differential Geometry of Manifolds	4	-	-	4	25	25	25	25	100
4	MAT.500	Dissertation Research	-	-	-	8	-	-	-	-	200
Opt any one course from following elective courses											
5	MAT.526	Special Functions	4	-	-	4	25	25	25	25	100
	MAT.527	Fuzzy Sets and Logic									
			12	**-**	**-**	**24**	**-**	**-**	**-**	**-**	600

A: Continuous Assessment: Based on Objective Type Tests
B: Mid-Term Test-1: Based on Objective Type & Subjective Type Test
C: Mid-Term Test-2: Based on Objective Type & Subjective Type Test
D: End-Term Exam (Final): Based on Objective Type Tests
E: Total Marks
L: Lectures T: Tutorial P: Practical Cr: Credits

Semester I

MAT.501 **Algebra – I** **Credit Hours: 4**

Unit I **(14 Lecture Hours)**

Group Theory: Review of basic concepts of Groups, subgroups, normal subgroups, quotient groups, Homomorphisms, cyclic groups, permutation groups, Even and odd permutations, Conjugacy classes of permutations, Alternating groups, Simplicity of An, n > 4. Cayley's Theorem, class equations, Zassenhaus lemma, Direct products, Fundamental Theorem for finite abelian groups.

Unit II **(14 Lecture Hours)**

Sylow theorems and their applications, Finite Simple groups Survey of some finite groups, Groups of order p2 , pq (p and q primes). Solvable groups, Normal and subnormal series, composition series, Theorems of Schreier and Jordan Holder

Unit III **(13 Lecture Hours)**

Ring Theory: Review of Rings, Zero Divisors, Nilpotent Elements and idempotents, Matrices, Ring of endomorphisms, Ideals, Maximal and prime ideals, Nilpotent and nil ideals, Zorn's Lemma.

Unit IV **(14 Lecture Hours)**

Polynomial rings in many variables, Factorization of polynomials in one variable over a field. Unique factorization domains. Gauss Lemma, Eisenstein's Irreducibility Criterion, Unique Factorization in R[x], where R is a Unique Factorization Domain. Euclidean and Principal ideal domains..

Recommended Books:

1. Contemporary Abstract Algebra, J.A, Gallian, Narosa Publishing House, New Delhi.
2. Modern Algebra, Singh Surjeet and Qazi Zameeruddin, Vikas Publishing House, New Delhi (8^{th} Edition) 2006.
3. Basic Abstract Algebra, Bhattacharya P.B., Jain S.K., and Nagpal S.R., Cambridge University Press, New Delhi.
4. The Theory of Groups of Finite Order (2nd Ed.), Burnside W., Dover, New York, 1955.
5. Topics in Algebra (Second Edition), Herstein I.N., Wiley Eastern Limited, New Delhi.
6. Algebra, Hungerford T.W., Springer 1974.

MAT.502 **Complex Analysis** **Credit Hours: 4**

Unit I **(13 Lecture Hours)**

Review of Complex number system, Algebra of complex numbers, the comlax plane, Function of a complex variable, Limit, Continuity, Uniform continuity, Differentiability, Analytic function, Cauchy- Riemann equations, Harmonic functions and Harmonic conjugate, Construction of analytic functions.

Unit II **(14 Lecture Hours)**

Complex line integral, Cauchy's theorem, Cauchy-Goursat theorem, Cauchy's integral formula and its generalized form. Index of a point with respect to a closed curve, Cauchy's inequality. Poisson's integral formula, Morera's theorem. Liouville's theorem.Contour integral, Power series, Taylor's series, Higher order derivatives, Laurent's series.

Unit III **(13 Lecture Hours)**

Singularities of analytic functions, Casorati-Weierstrass theorem, Fundamental theorem of algebra, Zeroes of analytic function, Poles, Residues, Residue theorem and its applications to contour integrals, Branches of many valued functions with arg z, log z, and z^{a}. Maximum modulus principle, Schwarz lemma, Open mapping theorem.

Unit IV **(14 Lecture Hours)**

Meromorphic functions, The argument principle, Rouche's theorem, Inverse function theorem, Mobius transformations and their properties and classification, Definition and examples of conformal mappings, Analytic Continution.

Recommended books:

1. E. T. Copson, An Introduction to Theory of Functions of a Complex variable
2. L. V. Ahlfors, Complex Analysis, Tata McGraw Hill, 1979.
3. S. Ponnusamy, Foundations of Complex Analysis, Narosa Publishing House, 2007.
4. R. V. Churchill & J. W. Brown, Complex Variables and Applications, Tata McGraw Hill, 1996.
5. W. Tutschke and H.L. Vasudeva, An Introduction to complex analysis: Classical and Modern Approaches, CRC Publications.

MAT.503 **Real Analysis** **Credit Hours: 4**

Unit I **(15 Lecture Hours)**

Elementary set theory: Real number system as a complete ordered field, Archimedean property, supremum, infimum. Sequences and series, convergence, uniform convergence, Continuity, uniform continuity, differentiability, mean value theorem. Metric spaces: definition and examples, open and closed sets, Compact sets, elementary properties of compact sets, k- cells, compactness of k-cells, compact subsets of Euclidean space R^{k}, Perfect sets, Cantor set, Separated sets, connected sets in a metric space, connected subsets of real line.

Unit II **(14 Lecture Hours)**

Convergent sequences (in Metric spaces), Cauchy sequences, subsequences, Complete metric space, Cantor's intersection theorem, category of a set and Baire's category theorem. Examples of complete metric space, Banach contraction principle, Limits of functions (in Metric spaces), Continuous functions, continuity and compactness, Continuity and connectedness, Discontinuities, Monotonic functions, Uniform continuity.

Unit III **(13 Lecture Hours)**

Functions of several variables, linear transformation, Derivatives is an open subject, Chain rule, Partial derivatives, Jacobian, interchange of the order of differentiation, Derivation of higher order, inverse function theorem, implicit function theorem.

Unit IV **(14 Lecture Hours)**

Riemann Stieltje's Integral: definition and existence of Integral, Properties of integral, integration and differentiation, Riemann sums and Riemann integral, Improper Integrals. Fundamental theorem of Calculus, 1^{st} and 2^{nd} mean value theorems for Riemann Stieltje's integral, Integration of vector valued functions, Rectifiable curves.

Recommended Books:

1. Walter Rudin, Principles of Mathematical Analysis, 3^{rd} edition, McGraw Hill, Kogakusha, 1976, International student edition.
2. H. L. Royden , Real Analysis, 3^{rd} edition, Macmillan, New York & London 1988.
3. Malik, S.C. : Mathematical Analysis, Wiley Eastern Ltd.
4. Titchmarsh, E.C. *The Theory of functions, 2nd Edition*, U.K. Oxford University Press 1961.
5. Tom M. Apostol, Mathematical Analysis , Addition –Wesley.
6. G. F. Simmons, Introduction to Topology and Modern Analysis, McGraw-Hill Ltd.

MAT.504 **Mechanics – I** **Credit Hours: 2**

Unit I **(10 Lecture Hours)**

Velocity and acceleration of a particle along a curve, Radial & Transverse components (plane motion). Relative velocity and acceleration. Kinematics of a rigid body rotating about a fixed point. Vector angular velocity, Euler's dynamical equations for the motion of a rigid body about an axis, theory of small oscillations.

Unit II **(8 Lecture Hours)**

Newton's laws of motion, work, energy and power. Conservative forces, potential energy. Impulsive forces, Rectilinear particle motion:- (i) Uniform accelerated motion (ii) Resisted motion (iii) Simple harmonic motion (iv)Damped and forced vibrations.

Unit III **(8 Lecture Hours)**

Projectile motion under gravity, constrained particle motion, angular momentum of a particle. Moments and products of Inertia, Theorems of parallel and perpendicular axes, angular motion of a rigid body about a fixed point and about fixed axes.

Unit IV **(8 Lecture Hours)**

Moments and products of Inertia, Theorems of parallel and perpendicular axes, angular motion of a rigid body about a fixed point and about fixed axes.

Recommended books:

1. F. Gantmacher, Lectures in Analytic Mechanics, MIR Publishers, Moscow, 1975.
2. P.V. Panat, Classical Mechanics, Narosa Publishing House, New Delhi, 2005.
3. N.C. Rana and P.S. Joag, Classical Mechanics, Tata McGraw- Hill, New Delhi, 1991.
4. Louis N. Hand and Janet D. Finch , Analytical Mechanics, CUP, 1998.
5. K. Sankra Rao , Classical Mechanics, Prentice Hall of India, 2005.
6. M.R. Speigal, Theoretical Mechanics, Schaum Outline Series.
7. D.E Rutherford, Classical Mechanics.

MAT.505 **Differential Equations** **Credit Hours: 4**

Unit I **(14 Lecture Hours)**

Initial value problem, Existence of solutions of ordinary differential equations of first order, Existence and Uniqueness theorem, Regular and Singular points, Singular solutions for first order ODEs, System of first order ODEs, General theory of homogenous and non-homogeneous linear ODEs, variation of parameters, method of undetermined coefficients, reduction of the order of equation, method of Laplace's transform.

Unit II **(14 Lecture Hours)**

Lipchilz's condition and Gron Wall's inequality, Picards theorems, dependence of solution on initial conditions and on function, Continuation of solutions, Non local existence of solutions. Green's function and its applications.

Unit III **(13 Lecture Hours)**

Total differential equations. Simultaneous differential equations, orthogonal trajectories, Boundary value problems, Sturm Liouville's boundary value problems. Sturm comparison and Separation theorems, Orthogonality solution.

Unit IV **(15 Lecture Hours)**

Classification of first order PDE, Classification of second order PDE, Lagrange's linear PDE, Charpit's method. Well posed and Ill-posed problems, Monge's method, General solution of higher order PDEs with constant Coefficients, Separation of variables method for parabolic, hyperbolic, elliptic, Laplace, heat and wave equations.

Recommended books:

1. Williams, E. B. and Richard, C. DI Prima, Elementary differential equations and boundary value problems, New York: John Wiley and sons, 1967.
2. George, F Simmons, Differential equations with applications and historical notes, New Delhi: Tata McGraw Hill, 1974
3. Reid, W.T. Ordinary Differential Equations, New York: John Wiley and Sons, 1971.
4. Raisinghania, M.D. Advanced Differential Equations, New Delhi: S.Chand & Company Ltd. 2001.
5. E.A. Codington and N. Levinson, Theorey of Differential Equations, McGraw Hill
6. I.N. Sneddon, Elements of Partial Differential Equations, McGraw-Hill.
7. S.L. Ross, Differential Equations, Wiley.
8. Elements of Partial Differential Equations by I.N. Sneddon, McGraw Hill Book Company, 1957.
9. Partial Differential Equations by Phoolan Prasad and Renuka Ravindran, Wiley Eastern Limited, 1987.

MAT.506 **Linear Algebra** **Credit Hours: 4**

Unit I **(14 Lecture Hours)**

Vector Space: vector spaces, subspaces, direct sum of subspaces, linear dependence and independence, basis and dimensions, linear transformations, quotient spaces, algebra of linear transformations, linear functions, dual spaces, matrix representation of a linear transformation, rank and nullity of a linear transformation, invariant subspaces.

Unit II **(15 Lecture Hours)**

Characteristic polynomial and minimal polynomial of a linear transformation, eigenvalues and eigenvectors of a linear transformation, diagonalization and triangularization of a matrix, companion matrix, Cayley Hamilton Theorem, Matrix representation of Linear Transformation, Change of Basis, Canonical forms, Diagonal forms, triangular forms, Jordan Canonical Forms and Rational canonical forms.

Unit III **(14 Lecture Hours)**

Bilinear forms, symmetric bilinear forms, Sylvester's theorem, quadratic forms, Hermitian forms. Inner product spaces. Norms and Distances, Orthonormal basis, Orthogonality, Schwartz inequality, The Gram-Schmidt Orthogonalization process, Orthogonal complements.

Unit IV **(13 Lecture Hours)**

The Adjoint of a Linear operator on an inner product space, Normal and self-Adjoint Operators, Unitary and Normal Operators, Spectral Theorem, Bilinear and Quadratic forms, reduction and lassification of quadratic forms.

Recommended books:

1. P.B. Bhattacharya, S.K. Jain and S.R. Nagpaul, First Course in Linear Algebra (Wiley Eastern , Delhi).
2. J. Gilbert and L. Gilbert: Linear Algebra and Matrix Theory (Academic Press).
3. I.N. Herstein, Topics in Algebra (Delhi Vikas).
4. V.Bist and V. Sahai, Linear Algebra (Narosa, Delhi).

MAT.507 **Basic Mathematics** **Credit Hours: 2**

Unit I **(10 Lecture Hours)**

Ordered pairs, Cartesian product of sets. Number of elements in the Cartesian product of two finite sets. Cartesian product of the reals with itself (upto R × R ×R).
Definition of relation, pictorial diagrams, domain, co-domain and range of a relation. Function as a special kind of relation from one set to another. Pictorial representation of a function, domain, co-domain and range of a function. Real valued function of the real variable, domain and range of these functions, constant, identity, polynomial, rational, functions.

Unit II **(10 Lecture Hours)**

Sequence and series, Sequence and Series , Arithmetic Progression (A.P), Arithmetic Mean (A.M) , Geometric Progression (G.P), general term of a G.P, sum of n terms of a G.P . Arithmetic and Geometric series, infinite G.P. and its sum. Geometric mean (G .M), relation between A.M and G.M.

Unit III **(8 Lecture Hours)**

Need for complex numbers, especially √-1, to be motivated by inability to solve every quadratic equation. Brief description of algebraic properties of complex numbers. Argand plane and polar representation of complex numbers. Statement of Fundamental Theorem of Algebra,

Unit IV **(8 Lecture Hours)**

Matrix and determinants, properties of determinants, eigen values and eigen vectos, Derivatives, differential equations, order and degree of differential equations, solution of first order differential equations.

Recommended books:

1. R.K. Jain, S.R.K. Iyengar, Advanced Engineering Mathematics .
2. Raisinghania, M.D. Advanced Differential Equations, New Delhi: S.Chand & Company Ltd. 2001.
3. E. T. Copson, An Introduction to Theory of Functions of a Complex variable

Semester II

MAT.508 **Algebra – II** **Credit Hours: 4**

Unit I **(13 Lecture Hours)**

Field Theory: Basic concepts of Field theory, Extension of fields, algebraic and transcendental extensions. Splitting fields, Separable and inseparable extensions, Algebraically closed fields, Perfect fields.

Unit II **(14 Lecture Hours)**

Galios Theory: Galois extensions, the fundamental theorem of Galois theory, Cyclotomic extensions, and Cyclic extensions, Applications of cyclotomic extensions and Galois theory to the constructability of regular polygons, Solvability of polynomials by radicals.

Unit III **(15 Lecture Hours)**

Modules: Difference between Modules and Vector Spaces, Module Homomorphisms, Quotient Module, Completely reducible or Semi simple Modules, Free Modules, Representation and Rank of Linear Mappings, Smith normal Form over a PID, Finitely generated modules over a PID, Rational Canonical Form, Applications to finitely generated abelian groups.

Unit IV **(14 Lecture Hours)**

Canonical forms: Similarity of linear transformations, Invariant subspaces, Reduction to triangular form, Nilpotent transformations, Index of nilpotency, Invariants of nilpotent transformations, The primary decomposition theorem, Rational canonical forms, Jordan blocks and Jordan forms.

Recommended Books:

1. First Course in Linear Algebra, P.B. Bhattacharya, S.K. Jain and S.R. Nagpaul, (Wiley Eastern ,Delhi).
2. Linear Algebra and Matrix Theory, J. Gilbert and L. Gilbert, (Academic Press).
3. Topics in Algebra, I.N. Herstein, (Delhi Vikas).
4. V.Bist and V. Sahai, Linear Algebra (Narosa, Delhi).
5. J-P. Escofier, Galois Theory, Springer-Verlag.
6. I. Stewart, Galois Theory, Chapman and Hall.
7. Hartley, B and Hawkes T.O., Rings, Modules and Linear Algebra, Chapman and Hall.
8. Musili C, Rings and Modules (Second Revised Edition), Narosa Publishing House, New Delhi, 1994.

MAT.509 **Topology** **Credit Hours: 4**

Unit I **(14 Lecture Hours)**

Countable and uncountable sets, infinite sets and Axiom of choice, limsup, liminf. Bolzano Weierstrass theorem, Cardinal numbers and their arithmetic. Schroeder-Bernstein Theorem, Cantor's theorem and the continuum hypothesis, Zorn's Lemma, Well-ordering theorem.

Unit II **(14 Lecture Hours)**

Topological Spaces, Subspaces and relative topology. **Examples of topological spaces:** the product topology, the metric topology, the quotient topology. Bases for a topology, the order topology, the product topology on X ×Y, the subspace topology. Open sets, closed sets and limit points, closures, interiors, continuous functions, homeomorphisms..

Unit III **(14 Lecture Hours)**

Sequence, Connected spaces, connected subspaces of the real line, components and local connectedness. **Connectedness and Compactness:** Connected spaces, Connected subspaces of the real line, Components and local connectedness, Compact spaces, Compact space of the real line, limit point compactness, Heine-Borel Theorem, Local -compactness.

Unit IV **(14 Lecture Hours)**

Separation Axioms: The Countability Axioms, The Separation Axioms, T_0 , T_1, and T_2 spaces, examples and basic properties, Hausdorff spaces, Regularity, Complete Regularity, Normal Spaces, Normality, Urysohn Lemma, Tychonoff embedding and Urysohn Metrization Theorem, Tietze Extension Theorem. Tychnoff Theorem, One-point Compactification.

Recommended Books:

1. G.F.Simmons: Topology and Modern Analysis, McGraw Hill (1963)
2. W. J. Pervin, Foundations of General Topology
3. Willard, Topology, Academic press
4. Vicker , Topology via logic (School of Computing, Imperial College, London)
5. Topology, A First Course By: J. R. Munkers Prentice Hall of India Pvt. Ltd.
6. Copson, E.T. *Metric Spaces*, New York: Cambridge University Press, 1963.
7. Willord, S. *General Topology,* Philippines: Addison Wesley Publishing Company, 1970.
8. Joshi, K. D. *Introduction to General Topology*, New Delhi: New Age International, 1983.

MAT.510 **Mechanics – II** **Credit Hours: 2**

Unit I **(10 Lecture Hours)**

General motion of a rigid body, linear momentum of a system of particles. Angular momentum of a system, use of centroid, moving origins, impulsive forces. Problems in two-dimensional rigid body motion, law of conservation of Angular momentum, illustrating the laws of motion, law of conservation of energy, impulsive motion.

Unit II **(8 Lecture Hours)**

Euler's dynamical equations for the motion of a rigid body about a fixed point. Problems on general three-dimensional rigid body motion.

Unit III **(8 Lecture Hours)**

. Moving frames of references and frames in general motion, Euler's dynamical equations, Motion of a rigid body with a fixed point under no force, Method of pointset Constraints, Generalized coordinates and velocities, D'Alembert's principle and Lagrange's equations, Applications of Lagrangian formulation.

Unit IV **(8 Lecture Hours)**

Generalised co-ordinates and velocities Virtual work, generalized forces. Lagrange's equations for a holonomic system and their applications to small oscillation. Lagrange's equations for impulsive forces.

Recommended books:

1. F. Gantmacher, Lectures in Analytic Mechanics, MIR Publishers, Moscow, 1975.
2. P.V. Panat, Classical Mechanics, Narosa Publishing House, New Delhi, 2005.
3. N.C. Rana and P.S. Joag, Classical Mechanics, Tata McGraw- Hill, New Delhi, 1991.
4. Louis N. Hand and Janet D. Finch , Analytical Mechanics, CUP, 1998.
5. K. Sankra Rao , Classical Mechanics, Prentice Hall of India, 2005.
6. M.R. Speigal, Theoretical Mechanics, Schaum Outline Series.

MAT.511 **Probability and Statistics** **Credit Hours: 4**

Unit I **(13 Lecture Hours)**

Probability: Definition of probability-classical, relative frequency, statistical and axiomatic approach, Addition theorem, Boole’s inequality, Conditional probability and multiplication theorem, Independent events, Mutual and pairwise independence of events, Bayes’ theorem and its applications.

Unit II **(14 Lecture Hours)**

Random Variable and Probability Functions: Definition and properties of random variables, discrete and continuous random variables, probability mass and density functions, distribution function. Concepts of bivariate random variable: joint, marginal and conditional distributions.

Mathematical Expectation: Definition and its properties. Variance, Covariance, Moment generating function- Definitions and their properties. Chebychev’s inequality.

Unit III **(14 Lecture Hours)**

Discrete distributions: Uniform, Bernoulli, binomial, Poisson and geometric distributions with their properties.

Continuous distributions: Uniform, Exponential, Gamma and Normal distributions with their properties. Central Limit Theorem (Statement only).

Statistical estimation: Parameter and statistic, sampling distribution and standard error of estimate. Point and interval estimation, Unbiasedness, Efficiency.

Unit IV **(15 Lecture Hours)**

Testing of Hypothesis: Null and alternative hypotheses, Simple and composite hypotheses, Critical region, Level of significance, One tailed and two tailed tests, Two types of errors.

Tests of significance: Large sample tests for single mean, single proportion, difference between two means and two proportions; Definition of Chi-square statistic, Chi-square tests for goodness of fit and independence of attributes; Definition of Student’s ‘t’ and Snedcor’s F-statistics, Testing for the mean and variance of univariate normal distributions, Testing of equality of two means and two variances of two univariate normal distributions

Recommended books:

1. Mood, A.M., Graybill, F.A. and Boes, D.C., Mc Graw Hill Book Company.
2. Freund,J.E., Mathematical Statistics, Prentice Hall of India.
3. Gupta S.C. and Kapoor V.K., Fundamentals of Mathematical Statistics, S. Chand Pub., New Delhi.
4. Speigel, M., Probability and Statistics, Schaum Outline Series.
5. Ross, Sheldon M. (2003) Introductory Statistics
6. Hogg, R. V. and Craig, T. T. (1978) Introduction to Mathematical Statistics (Fourth Edition) (Collier-McMillan)

MAT.512 **Fundaments of Computer science and programming in C and C++** **Credit Hours: 3**

Unit I **(11 Lecture Hours)**

Basic Concepts: Historical development of C, Primary memory, Secondary storage devices, Input and Output devices, Significance of software in computer system, Categories of software – System software, Application software, Compiler, Interpreter, Utility program, Binary arithmetic for integer and fractional numbers, Operating System and its significance.

Unit II **(12 Lecture Hours)**

C Programming: Introduction to algorithm, Flow charts, Problem solving methods, Need of programming languages. C character set, Identifiers and keywords, Data types, Declarations, Statement and symbolic constants, Input-output statements, Preprocessor commands, Operators, expressions and library functions, decision making and loop control statements, Functions, Storage Classes, Arrays, Strings, Pointers, Structure and union, File handling.

Unit III **(11 Lecture Hours)**

Basic concepts of Object-Oriented Programming (OOP). Advantages and applications of OOP. Object-oriented languages. Introduction to C++. Structure of a C++ program. Creating the source files. Compiling and linking, **C++ programming basics**: Input/Output, Data types, Operators, Expressions, Control structures, Library functions.

Unit IV **(12 Lecture Hours)**

Functions in C++ : Passing arguments to and returning values from functions. **Classes and objects** : Specifying and using class and object, Arrays within a class, Arrays of objects, Object as a function arguments. **Operator Overloading and Type Conversions**: Overloading unary, binary operators. **Inheritance**: General concepts of Inheritance, Types of derivation-public, private, protected. **Files and Streams**: Streams, Stream classes for console operations, Unformatted I/O operations, Formatted console I/O operations.

Recommended books:

1. Norton, P., Introduction to Computers, Tata McGraw Hill (2008).
3. Kerninghan, B. W. and Ritchie D.M., The C Programming Language, PHI (1989)
4. Kanetkar, Y., Let Us C, BPB (2007).
5. Deitel and Deitel , C++ How to Program, Pearson Education (2004).
6. Balaguruswamy, E., Objected Oriented Programming with C++, Tata McGraw Hill (2008).
7. Kanetkar Y. Let Uc C++, BPB, (1999).

MAT.554 **Fundaments of Computer science and programming in C and C++ LAB** **Credit Hours: 1**

Laboratory experiments will be set in context with the materials covered in theory.

MAT.513 Linear Programming Credit Hours: 2

Unit I (8 Lecture Hours)

Formulation of linear programming problems (LPP). Graphical solution to LPPs. Cases of unique and multiple optimal solutions. Unbounded solutions and infeasibility, and redundant constraints.

Unit II (8 Lecture Hours)

Feasible Solution, Basic feasible solutions, Optimal solution, convex sets, solution of LPP with simplex methods. The dual problem. Formulation of the Dual.

Unit III (6 Lecture Hours)

Transportation problems, formulation of transportation problem, Feasibile and optimal solution of transportation Poblems. Assignment problems.

Unit IV (5 Lecture Hours)

Theory of Games: Introduction to basic concepts of game theory including strategic Games.

Recommended books:

1. Taha, H. A. Operations Research - An Introduction, New York: Macmillan Publishing Company Inc., 2006.
2. Swarup, K., Gupta, P. K., and Mohan, Man: Operations Research, New Delhi: Sultan Chand & Sons, 2001.

MAT.514 Numerical Methods Credit Hours: 2

Unit I (6 Lecture Hours)

Error Analysis : Relative error, Truncation error, Roundoff error, order of approximation, order of convergence, Propagation,.

Unit II (6 Lecture Hours)

Bisection method of Balzeno, Method of false position and convergence, Newton Raphson Method, Order of Convergence.

Unit III (4 Lecture Hours)

Interpolation and Polynomial Approximation, Lagrange's Method, Newton's polynomials.

Unit IV (5 Lecture Hours)

Solution of differential equations: Euler's method, Henn's method, Taylor Series method, Runge Kutta method.

Recommended books:

1. K.E. Atkinson: An Introduction to Numerical Analysis.
2. J. I. Buchaman and P. R. Turner: Numerical Methods and Analysis..

3. S. S. Sastry, Introduction Methods of Numerical Analysis (4th Edition) Prentice-Hall.

Semester III

MAT.515 **Functional Analysis** **Credit Hours: 4**

Unit I **(13 Lecture Hours)**

Fundamentals of Normed Linear spaces: Normed Linear spaces, Banach spaces and examples, Characterization of finite dimensional spaces , Quotient space of normed linear spaces and its completeness, Equivalent norms, Riesz Lemma, Basic properties of finite dimensional normed linear spaces and compactness.

Unit II **(14 Lecture Hours)**

Weak convergence and bounded linear transformations, Normed linear spaces of bounded linear transformations, Dual spaces with examples. **Three main theorems on Banach space:** Uniform boundedness theorem and some of its consequences, Open mapping and closed graph theorems.

Unit III **(14 Lecture Hours)**

Hahn-Banach theorem for real linear spaces, Complex linear spaces and normed linear spaces, Reflexive spaces, Weak sequential compactness, Compact operators, Solvability of linear equations in Banach spaces, the closed Range Theorem.

Unit IV **(15 Lecture Hours)**

Inner product spaces. Hilbert spaces, Orthonormal Sets, Bessel's Inequality, Complete orthonormal sets and Parseval's Identity, Structure of Hilbert Spaces, Projection Theorem, Riesz Representation Theroem, Adjoint of an operator on a Hilbert space, Reflexivity of Hilbert Spaces, Self-adjoint operators, Positive, projection, normal and Unitary operators, Abstract variational boundary-value problem, The Generalized Lax-Milgram Theorem.

Recommended books:

1. Limaye, B. V. *Functional Analysis,* New Delhi: New Age International (P) Ltd, 1996.
2. Berberian, S. K. *Introduction to Hilbert Spaces,* Rhode Island: AMS Chelsea Publishing, 1996.
3. Goffman, C., and Pedrick, G. *First Course in Functional Analysis,* New Delhi: Prentice Hall of India, 1983.
4. Riesz, F. K., and Nagy, B. S. *Functional Analysis,* Dover Publications, 1990.
5. Siddiqui, A. H. *Functional Analysis*, New Delhi: Tata-McGraw Hill, 1987.
6. Erwin Kreyszig, Introductory functional analysis with application, Willey.

PHY.516 **Numerical Analysis** **Credit Hours: 3**

Unit I **(12 Lecture Hours)**

Approximate numbers, Significant figures, rounding off numbers. Error Absolute, Relative and percentage.

Numerical solutions of algebraic equations. Iterative solutions of nonlinear equation: bisection method. Fixed-point interation, Newton's method, secant method, rate of convergence, Newton's method for two non linear equations, polynomial equation methods, Polynomial interpolation: interpolation polynomial, divided difference, interpolation, Aitken's formula, finite difference formulas, Hermite's interpolation, double interpolation. Interpolation with cubic splines, End Conditions, Minimizing Property, Error Analysis.

Unit II **(11 Lecture Hours)**

Linear systems of Equations: Gauss Elimination, Gauss-Jordan method, LU decomposition, iterative methods, and Gauss- Seidel iteration, Numerical Calculus : Numerical differentiation, Errors in numerical differentiation, Numerical Integration, Trapezoidal rule, Simpson's 1/3 - rule, Simpson's 3/8 rule, error estimates for Trapezoidal rule and Simpson's rule.

Unit III **(11 Lecture Hours)**

Numerical Solution of Ordinary differential Equations : Solution by Taylor series, Picard Method of successive approximations, Euler's Method, Modified Eular Method, Runge-Kutta Methods, Predicator-Corrector Methods, Eigenvalue Problem : Power method, Jacobi method, Householder method, Mupad Computer practicals.

Unit IV **(11 Lecture Hours)**

Finite Element Method: Shooting method, Rayleigh Ritz method, the collocation and Galerkin’s method, finite element methods for ODE’s and finite element for one dimensional & two dimensional Columns, Finite element method for Elliptic, Parabolic and Hyperbolic partial differential equations.

Recommended books:

1. K.E. Atkinson: An Introduction to Numerical Analysis.
2. J. I. Buchaman and P. R. Turner: Numerical Methods and Analysis..
3. S. S. Sastry, Introduction Methods of Numerical Analysis (4th Edition) Prentice-Hall.

MAT.517 Differential Geometry Credit Hours: 4

Unit I (14 Lecture Hours)

Tangent, Principal normal, Curvature, Binormal, Torsion, Serret Frenet formulae, Locus of center of curvature, Spherical curvature, Locus of center of spherical curvature. Theorem: Curve determined by its intrinsic equations, Helices, Involutes & Evolutes.

Unit II (14 Lecture Hours)

Surfaces, Tangent plane, Normal, Curvilinear co-ordinates First order magnitudes, Directions on a surface, The normal, second order magnitudes, Derivatives of n, Curvature of normal section. Meunier's theorem, Principal directions and curvatures, first and second curvatures, Euler's theorem. Surface of revolution.

Unit III (14 Lecture Hours)

Conjugate directions, Asymptotic lines, Curvature and torsion of Asymptotic lines, Gauss's formulae, Gauss characteristic equation, Mainardi – Codazzi relations, Derivalives of angle

Unit IV (14 Lecture Hours)

Introduction to Geodesics, Canonical Geodesic Equation, Normal property of Geodesic, Equations of geodesics, Surface of revolution, Torsion of Geodesic, Bonnet's theorem, vector curvature, Geodesic curvature.

Recommended books:

1. Weatherburn, C.E. Differential Geometry of Three Dimension, New Delhi: Khosla Publishing House 2003.
2. Willmore, T.J. Introduction to Differential Geometry, Dover Publication Inc. 2012.
3. Do Carmo, Manifredo P. Riemannian Geometry, Birkhauser 2011.
4. Berger, M. A Panoramic View of Riemannian Geometry, Springer 2003.

MAT.518 Operational Research –I Credit Hours: 4

Unit I (14 Lecture Hours)

Operations Research and its Scope. Necessity of Operations Research in industry Mathematical formulation of linear programming problem Linear Programming and examples, Convex Sets, Hyper plane, Open and Closed half-spaces, Feasible, Basic Feasible and Optimal Solutions, Extreme Point & graphical methods. Simple method, Charnes-M method, two phase method, Determination of Optimal solutions, unrestricted variables.

Unit II (14 Lecture Hours)

Duality theory, Dual linear Programming Problems, fundamental properties of dual Problems, Complementary slackness, unbounded solution in Primal. Dual Simplex Algorithm, Sensitivity analysis. Integer Programming- Branch and Bound Technique.

Unit III (14 Lecture Hours)

The General transportation problem, transportation table, duality in transportation problem, loops in transportation tables, linear programming formulation, solution of transportation problem, test for optimality, degeneracy, transportation algorithm(MODI method), time minimization transportation problem. Assignment Problems: Mathematical formulation of assignment problem, the assignment method, typical assignment problem, the traveling salesman problem.

Unit IV (14 Lecture Hours)

Game Theory: Two-person zero sum games, maximin-minimax principle, games without saddle points (Mixed strategies), graphical solution of $2 \times n$ and $m \times 2$ games, dominance property, arithmetic method of $n \times n$ games, general solution of $m \times n$ rectangular games.

Recommended books:

1. Taha, H. A. Operations Research - An Introduction, New York: Macmillan Publishing Company Inc., 2006.
2. Swarup, K., Gupta, P. K., and Mohan, Man: Operations Research, New Delhi: Sultan Chand & Sons, 2001.
3. Bazaraa, M. S., and Shetty, C. M. Nonlinear Programming, Theory & Algorithms, New York: Wiley, 2004.
4. Sinha, S. M. Mathematical Programming, Theory and Methods, Delhi: Elsevier, 2006.
5. Mangasarian, O. L. Nonlinear Programming, Delhi: TATA McGraw Hill Company Ltd., 1969.
6. Hadley, G. Linear Programming, New Delhi: Narosa Publishing House, 1987.
7. Kambo, N. S. Mathematical Programming Techniques, New Delhi: Affiliated East- West Press Pvt. Ltd., 1984, Revised Edition, Reprint 2005.

MAT.519 **Measure Theory** **Credit Hours: 4**

Unit I **(13 Lecture Hours)**

Lebesgue Measure: Introduction, Lebesgue outer measure, Measurable sets, Regularity, Measurable functions, Borel and Lebsegue measurability, Non-measurable sets. Littlewood's three principles.

Unit II **(14 Lecture Hours)**

Measurable functions. Borel and Lebesgue measurability. Housdorff measures on the real line, Integration of non negative functions. The general Integral, Integration of series, Riemann and Lebesgue integrals, The Lebesgue integral of a bounded function over a set of finite measure.

Unit III **(14 Lecture Hours)**

Differentiation and Integration: Differentiation of monotone functions, Monotonic functions, types of discontinuity, Functions of bounded variation, differentiation of an integral The Four derivatives, Lebsegue Differentiation Theorem, Absolute continuity, The Lebesgue set.

Unit IV **(15 Lecture Hours)**

The L_P-spaces, Minkowski and Holder inequalities, Convergence and Completeness of L_P spaces, Approximations in L_P spaces, Bounded linear functional on the L_P spaces, convex functions, Jensen's inequality, Completeness of L_p, Convergence in Measure. Almost uniform convergence.

Recommended Books:

1. H.L. Royden, Real Analysis, Macmillan, New York, 1988.
2. G.de Bara, Measure Theory and Integration, Ellis Horwood Limited, England
3. G.B. Folland, Real Analysis, second edition, John Wiley, New York, 1999.
4. E. Kreyszig Introductory Functional Analysis with Applications, John Wiley, 1989

MAT.555 Numerical Analysis Laboratory Credit Hours: 1

Writing Programs in C for the Problems based on the methods studied in theory paper and to run the Program on PC

1. WAP on Numerical solutions of algebraic equations.
2. WAP on Interpolation methods.
3. WAP on Numerical Integration
4. WAP on Trapezoidal and Simpson's rule
5. WAP on on Gaussian Quadrature.
6. WAP on Taylor Series method.
7. WAP on Picard method.
8. WAP on Euler's method.
9. WAP on Runge-Kutta Methods
10. WAP on Finite Difference Methods
11. WAP on Predictor-Corrector Methods
12. WAP on Approximations of Functions

MAT.520 **Discrete Mathematics** **Credit Hours: 4**

Unit I **(13 Lecture Hours)**

Basic logical operations, conditional and bi-conditional statements, tautologies, contradiction, Quantifiers, prepositional calculus. Recursively Defined Sequences. Solving Recurrence Relations. The Characteristic Polynomial. Solving Recurrence Relations: Generating Functions. Basics of Counting and the Pigeon-hole Principle.

Unit II **(14 Lecture Hours)**

Language and Grammars: Computability and Formal Languages. Ordered sets, . Phrase structure grammars. Types of grammars and languages. Finite state machines- equivalent machines. Finite state machines as language recognizers. Analysis of algorithm- Time complexity. Complexity of problems.

Unit III **(15 Lecture Hours)**

Graphs and Planar Graphs: Basic Terminology, Special types of Graphs. The Handshaking Theorem, Paths and Circuits Shortest paths. Connectivity of Graphs. Isomorphism of Graphs. Homeomorphic Graphs. Eulerianand Hamiltonian Graphs. Planar and Non Planar Graphs. Euler's formula. Graph Coloring. Adjacency and Incidence Matrices. Travelling Salesman Problem.

Unit IV **(14 Lecture Hours)**

Trees: Basic Terminology. Binary Trees. Tree Traversing: Preorder, Postorder and Inorder Traversals. Minimum Spanning Trees, Prim's and Kruskal's Alogrithm. Boolean AIgebras: Boolean Functions, Logic Gates, Lattices and Algebraic Structures.

Recommended books:

1. Rosen, K. H. Discrete Mathematics and its Applications, Delhi: McGraw Hill, 2007.
2. Joshi , K. D. Foundation of Discrete Mathematics, Delhi: J. Wiley & Son's, 1989
3. Malik, D. S., and Sen, M. K. Discrete Mathematical Structures Theory and Applications, Thomson/Course Technology, 2004.
4. Liu, C. L. Elements of Discrete Mathematics, Delhi: McGraw Hill, 1986.

MAT.521 **Fluid Mechanics** **Credit Hours: 4**

Unit I **(15 Lecture Hours)**

Real fluids and ideal fluids, velocity of fluid at a point, streamlines, path lines, streak lines, velocity potential, vorticity vector, local and particle rate of change, equation of continuity, irrigational and rotational motion, acceleration of fluid, conditions at rigid boundary.

Unit II **(14 Lecture Hours)**

Euler's equation of motion, Bernoulli's equation, their applications, Potential theorems, axially symmetric flows, impulsive motion, Kelvin's Theorem of circulation, equation of vorticity.

Unit III **(13 Lecture Hours)**

Some three dimensional flows: sources, sinks and doublets, images in rigid planes, images in solid sphere, Stoke's stream function.

Unit IV **(13 Lecture Hours)**

Two dimensional flows: complex velocity potential, Milne Thomson Circle Theorem and applications, Theorem of Blasius, vortex rows, Karman Vortex Street.

Recommended books:

1. Charlton, F. Text Book of Fluid Dynamics, Delhi: CBS Publishers, Indian Edition, 2004
2. Landau, and Lipschitz, E. N. Fluid Mechanics, London: Pergamon Press Ltd., 1987.
3. Batchelor, G. K. An Introduction to Fluid Mechanics, New York: Cambridge University Press, 1967.
4. Kundu, and Cohen. Fluid Mechanics, Delhi: Harcourt (India) Pvt.Ltd., 2003.

MAT.522 **Number Theory** **Credit Hours: 4**

Unit I **(14 Lecture Hours)**

Divisibility of Integers, Greatest common divisor, Euclidean algorithm. The Fundamental theorem of Arithmetic, Congruences, Residue classes and reduced residue classes.

Unit II **(14 Lecture Hours)**

Chinese remainder theorem, Fermat's little theorem, Wilson's theorem, Euler's theorem. Arithmetic functions σ(n), d(n), τ(n), μ(n), Order of an integer modulo n, primitive roots for primes, composite numbers having primitive roots, theory of indices.

Unit III **(14 Lecture Hours)**

Quadratic residues, Legendre symbol, Euler's criterion, Gauss's lemma, Quadratic reciprocity law, Jacobi symbol. Perfect numbers, Characterization of even perfect numbers, Elementary results on the distribution of primes, Twin primes, Mersenne primes and Fermat numbers.

Unit IV **(14 Lecture Hours)**

Representation of an integer as a sum of two and four squares. Diophantine equations ax +by =c, x2+y2=z2, x4+y4=z4. Farey sequences, continued Fractions, Farey dissection of a circle and its applications to approximations of irrationals by rationals. Finite and Infinite simple continued fractions, periodic and purely periodic continued fractions, Lagrange's Theorem on periodic continued fractions. Applications to Pell's equation. The fundamental solution of Pell's equation.

Recommended books:

1. David, M. Burton Elementary Number Theory, 7th Edition New Delhi: Tata McGraw-Hill 2012.
2. Niven, I., Zuckeman, S. and Montgomery, H.L. Introduction to Number Theory, Wiley Eastern 1991.
3. Apostal, T.N. Introduction to Analytic Number Theory, Springer Verlag 1976.
4. Hardy, G.H. and Wright, E. M. An Introduction to the Theory of Number, U.K.:Oxford Univ. Press 2008.

Semester IV

MAT.523 **Operations Research-II** **Credit Hours: 4**

Unit I **(15 Lecture Hours)**

Queuing Theory: Introduction, Queuing System, elements of queuing system, distributions of Arrivals, inter arrivals, departure service times and waiting times. Classification of queuing models, Queuing Models: (M/M/1): (∞/FIFO), (M/M/1): (N/FIFO), Generalized Model: Birth-Death Process, (M/M/C): (∞/FIFO), (M/M/C) (N/FIFO).

Unit II **(14 Lecture Hours)**

Inventory Control: The inventory decisions, costs associated with inventories, factors affecting Inventory control, Significance of Inventory control, economic order quantity (EOQ), and Deterministic inventory problems with-out shortage and with shortages, EOQ problems with Price breaks, Multi item deterministic problems. Processing of n jobs through two machines, The Algorithm, Processing of n jobs through m machines, Processing of two jobs through m machines.

Unit III **(13 Lecture Hours)**

Network Analysis-Shortest Path Problem, Minimum Spanning Tree Problem, Maximum Flow Problem, Minimum Cost Flow Problem, Network Simplex Method, Project scheduling by PERT/CPM: Introduction, Basic differences between PERT and CPM, Steps of PERT/CPM Techniques, PERT/CPM network Components and Precedence Relationships, Critical Path analysis, Probability in PERT analysis, Project Crashing, Time cost Trade-off procedure, Updating of the Project, Resource Allocation.

Unit IV **(14 Lecture Hours)**

Non Linear Programming –One and Multi Variable Unconstrained Optimization, Kuhn-Tucker Conditions for Constrained Optimization, Quadratic Programming ,Separable Programming Convex programming. Non Convex Programming.

Recommended books:

1. Taha, H. A. Operations Research - An Introduction (8th edition), New York: Macmillan Publishing Co. 2006.
2. Gupta, Swarup, and Manmohan. Operations Research. New Delhi: Sultan Chand & Sons.
3. Hadly, G. Non-Linear and Dynamic Programming. New Delhi: Addision Wesley, Reading Mass. 1967.
4. Hadly, G. Linear Programming. New Delhi: Narosa Publishing House. 1963.
5. Rao, S. S. Optimization theory and Applications (4th edition). New Delhi: Wiley Eastern Ltd. 2009.

MAT.524 Calculus of variation and integral equations Credit Hours: 4

Unit I (14 Lecture Hours)

Linear Functional, Euler's - Lagrange's equations of single independent and single dependent variable and application. Necessary and sufficient conditions for extrema. Brachistochrone problem, approximate solution of boundary value problems by Rayleigh-Ritz method. Functional involving higher order derivatives. Variational methods for boundary value problems in ordinary and partial differentioal eqauation.

Unit II (15 Lecture Hours)

Galerkin's method Kanturovich and Treffiz method, Isoperimetric problems, Geodesics, Geodesics on a sphere of radius 'a', variational problem with several variables,

Hamilton's principle, Hamiltonian variable and Hamiltonian function $H(t, q_i, p_i)$, Techniques of calculus of variations, Lagrange's equations through Hamilton's principle, Cyclic coordinates and conservation theorems, Canonical equations of Hamilton, Hamilton's equations from variational principle, Principle of least action.

Unit III (13 Lecture Hours)

Volterra Equations: Integral equations and algebraic system of linear equations. Volterra equation L2 Kernels and functions. Volterra equations of first and second kind. Volterra integral equation and linear differential equation.

Unit IV (14 Lecture Hours)

Fredholm Equations: Solution by the method of successive approximations. Solution of Fredholm integral equation for degenerate kernel; Examples, Faltung type(closed cycle type) integral equation, Singular integral equation; Solution of Abel's integral equation Neumann's series. Fredholm's equation with Pincherte-Goursat Kernel's.

Recommended books:

1. J.L. Synge and B.A. Griffith: Principle of Mechanics, McGraw-Hill Book Company (1970) (relevant portion only).
2. H. Goldstein: Classical Mechanics: Second Edition, Narosa Publishing House (1980), (relevant portion only).
3. Zafar Ahsan: Lecture Notes on Mechanics, Department of Mathematics, AMU, (1999), (Chapters III-VI).
4. Kanwal, R. P. Linear Integral Equations, Boston: Birkhauser Boslon, 1996.
5. Pinckus, A, and Zafrany, S. Fourier Series and Integral Transform, New York: Cambridge University Press, 1997.
6. Mikhlin, S. G. Integral equations and their applications to certain problems in Mechanics, Mathematical Physics and Technology, Oxford: Pergamon Press, 1964.

MAT.525 **Differential Geometry of Manifolds** **Credit Hours: 4**

Unit I **(15 Lecture Hours)**

Charts, Atlases, Manifolds, Differentiable structure on a manifold, Smooth maps, Tangent vectors and Tangent space.

Topological groups, Lie groups and lie algebras. Product of two Lie-groups, One parameter subgroups and exponential maps. Examples of Lie groups, Homomorphism and Isomorphism, Lie transformation groups, General Linear groups.

Unit II **(14 Lecture Hours)**

Principal fiber bundle, Linear frame bundle, Associated fiber bundle, Vector bundle, Tangent bundle, Induced bundle, Bundle homomorphism.

Unit III **(14 Lecture Hours)**

Sub-manifolds, induced connection and second fundamental form. Normals, Gauss formulae, Weingarten equations, Lines of curvature, Generalized Gauss and Mainardi–Codazzi equations.

Unit IV **(13 Lecture Hours)**

Almost Complex manifolds, Nijenhuis tensor, Contravariant and covariant almost analytic vector fields, F-connection.

Recommended books:

1. Sinha, B. B. An Introduction to Modem Differential Geometry, New Delhi: Kalyani Publishers, 1982.
2. Yano, K., and Kon, M. Structure of Manifolds, Chennai: World. Scientific Publishing Co. Pvt. Ltd., 1984.
3. Matsushima, Y. Differentiable Manifolds, Dekker, 1972.

MAT.526 Special Functions Credit Hours: 4

Unit I (13 Lecture Hours)

Hypergeometric Functions: The hypergeometric series, An integral formula for the hypergeometric series, The hypergeometric equation, Linear relations between the solutions of the hypergeometric equation, Relations of contiguity, The confluent hypergeometric function, Generalised hypergeometric series.

Unit II (15 Lecture Hours)

Legendre Functions: Legendre polynomials, Recurrence relations for the Legendre polynomials, The formulae of Murphy and Roderigues, Series of Legendre polynomials, Legendre's differential equation, Neumann's formula for the Legendre functions, Recurrence relations for the functions Qn (μ), The use of Legendre functions in potential theory, Legendre's associated functions, Integral expression for the associated Legendre function, Surface spherical harmonics, Use of associated Legendre functions in wave mechanics.

Unit III (14 Lecture Hours)

Bessel Functions: The origin of Bessel functions, Recurrence relations for the Bessel coefficients, Series expansions for the Bessel coefficients, Integral expressions for the Bessel coefficients, The addition formula for the Bessel coefficients, Bessel's differential equation, Spherical Bessel functions, Integrals involving Bessel functions, The modified Bessel functions, The Ber and Bei functions, Expansions in series of Bessel functions, The use of Bessel functions in potential theory, Asymptotic expansion of Bessel functions.

Unit IV (14 Lecture Hours)

The Functions of Hermite And Laguerre: The Hermite polynomials, Hermite's differential equation, Hermite functions, the occurrence of Hermite functions in wave mechanics, The Laguerre polynomials, Laguerre's differential equation, The associated Laguerre polynomials and functions, The wave functions for the hydrogen atom.

Recommended books:

1. I. N. Sneddon: Special Functions of Mathematical Physics and Chemistry, Edinburg, Oliver & Boyd, 1956.
2. G. Andrews, R. Askey & R. Roy, Special Functions, Cambridge, 1999.
3. L. Andrews, Special Functions for Engineers and Applied Scientists, Macmillan, 1985.
4. N. N. Lebedev, Special Functions & Their Applications, Revised Edition, Dover, 1976.
5. W. W. Bell, Special Functions for Scientists and Engineers, Dover, 1968.

MAT.527 **Fuzzy Sets and Fuzzy Logic** **Credit Hours: 4**

Unit I **(15 Lecture Hours)**

Fuzzy Sets-Basic definitions. α-level sets. Convex fuzzy sets. Basic operations on fuzzy sets. Types of fuzzy sets. Cartesian products. Algebraic products. Bounded sum and difference. T-norms and t-conorms. The Extensions Principle- The Zadeh's extension principle. Image and inverse image of fuzzy sets. Fuzzy Numbers. Elements of fuzzy arithmetic.

Unit II **(14 Lecture Hours)**

Fuzzy Relations and Fuzzy Graphs-Fuzzy, relations on fuzzy sets. Composition of fuzzy relations. Min-Max composition and its properties. Fuzzy Equivalence relations. Fuzzy compatibility relations. Fuzzy relation equations. Fuzzy graph. Similarity relations.

Unit III **(13 Lecture Hours)**

Possibility Theory-Fuzzy measures. Evidence theory. Necessity measures. Possibility measures. Possibility distribution. Possibility theory and fuzzy sets.

Unit IV **(14 Lecture Hours)**

Fuzzy logic- An overview of classical logic, Multivalued logics. Fuzzy propositions. Fuzzy Quantifiers. Linguistic variables and hedges. Inference from conditional fuzzy propositions, the compositional rule of inference.

Recommended books:

1. Zimmermann, H. J. Fuzzy set theory and its Applications, New Delhi: Allied Publishers Ltd., 1991.
2. Klir G. J., and Yuan, B. Fuzzy sets and fuzzy logic, New Delhi: Prentice-Hall of India, 1995.

MAT.500: Dissertation Research **Credit Hours: 8**