PROSPECTUS

OF

MASTER OF SCIENCE EXAMINATION

Semester - I & III Winter 2010,
Semester - II & IV Summer 2011
IN
MATHEMATICS

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Syllabus Prescribed for
M.A./M.Sc. Part-I & Part-II
Semester I to IV (Mathematics)

M.A./M.Sc. Part-I (Mathematics)

Semester I:

Compulsory Papers:
1. MTH1 Real Analysis
2. MTH2 Advanced Abstract Algebra-I
3. MTH3 Complex Analysis-I
4. MTH4 Topology-I

Optional Papers (Choose Any One):
1. MTH5 i) Differential Geometry-I
2. MTH6 ii) Advanced Discrete Mathematics-I
3. MTH7 iii) Differential and Integral Equations-I

Semester II:

Compulsory Papers:
1. MTH1 Measure and Integration Theory
2. MTH2 Advanced Abstract Algebra-II
3. MTH3 Complex Analysis-II
4. MTH4 Topology-II

Optional Papers (Choose Any One):
1. MTH5 Riemannian Geometry
2. MTH6 Advanced Discrete Mathematics-II
3. MTH7 Differential and Integral Equations-II

M.A./M.Sc.-I (MATHEMATICS)
SEMESTER-I

1. MTH-1 : REAL ANALYSIS

UNIT-I:
Definition and existence of Riemann-Stieltjes integral, properties of the integral, Integration and differentiation. The fundamental theorem of calculas, integral of vector-valued function, rectifiable curves.

UNIT-II:
Rearrangement of terms of a series, Riemann's theorem, power series, uniform convergence of power series, Abel's theorem, Power series, uniform convergence of a series of functions, power series, Abel's theorem, properties of the integral, integration and differentiation, Weierstrass approximation theorem.

UNIT-III:
Functions of several variables, linear transformation, geometric and directional derivatives, chain rule, partial derivatives, interchange of order of differentiation. Derivatives of higher order, Taylor's expansion.

UNIT-IV:
Inverse function theorem, implicit function theorem, Jacobian, Extremum problems with constraints, Lagrange's multiplier method, differentiation of integrals.

Text Book:

References:
M.A./M.Sc.-I
SEMESTER-I

1MTH-2 : Advanced Abstract Algebra-1

Unit-I:
Automorphisms, conjugacy and G-Sets. Normal series, solvable groups, Nilpotent groups.

Unit-II:
Sylow's theorems, group of order $P^2$, $pq$, Canonical forms, similarity of linear transformations, invarient subspace, reduction to triangular forms, Nilpotent transformations, index of nilpotency, invarient of a nilpotent transformation.

Unit-III:
Cyclic modules, simple modules, Shur's lemma, free module.

Unit-IV:
Noetherian and Artiniann Module and rings.

Unit-V:
Hilbert basis theorem, Wedderburn Artiniann theorem, uniform modules, Noether Lasker theorem.

Text Book:

References:
Unit-IV: Separation and Countability Axioms (Contd.)

Regular and normal spaces, Urysohn Lemma, Tietze Extension Theorem.

Text Books:

(i) Foundations of General Topology by William J. Pervin
Publisher: Academic Press.

References:


S. Saks & A. Zygmund, Analytic Functions, Monografie, Matematyczne, 1952.


1MTH5: (ii) ADVANCED DISCRETE MATHEMATICS-I

**Unit-I:**

**Unit-II:**

**Unit-III:**
Lattice Theory: Lattices are partially ordered sets. Their properties. Lattices as algebraic systems. Sublattices. Direct products and Homomorphisms. Some special lattices, e.g. complete, distributive, boolean algebras.

**Unit-IV:**

**Unit-V:**

**References:**

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1MTH5: (iii) DIFFERENTIAL AND INTEGRAL EQUATIONS-I

**Unit-I:**
Existence theorems, Linear equations of arbitrary order, solutions of linear equations, linear system with constant coefficients, operational calculus and solutions of linear differential equations, infinite series solutions.

**Unit-II:**
Solutions of differential equations by definite integrals, Boundary value problems, Green's functions, expansion theorems, non-linear differential equations.

**Unit-III:**

**Unit-IV:**
Mellin Transform: Definition, properties and evaluation of transforms. Convolution theorem for Mellin transform, application to integral equation.

**Unit-V:**
Hankel Transform: Definition, properties and evaluation of Hankel transforms. Application to integral equation.

**Text Book:**
SYLLABUS PRESCRIBED FOR M.A./M.Sc.-II SEMESTER-II

2MTH-1 : MEASURE AND INTEGRATION THEORY

Unit-I :
Lebesgue outer measure, measurable sets, Regularity, Measurable functions, Borel and Lesbesgue measurability.

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

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

Unit-IV :
Measures and outer measures, Extension of a measure, uniqueness of Extension, completion of a measure, measurespaces, integration with respect to a measure.

Unit-V :

Text Book :

References :

SEMESTER-II

2MTH-2 : ADVANCED ABSTRACT ALGEBRA-II

Unit-I :
Extension fields, Algebraic and transcendental extensions, separable and inseparable extensions, normal extensions.

Unit-II :

Unit-III :
Roots of Unity and cyclotomic polynomials, cyclic extensions, solution of polynomial equations by radicals, Insolvability of the general equation of degree 5 by radicals, Ruler and Compass construction.

Unit-IV :
Smith Normal Form over a PID and Rank : Preliminaries, row module, column module and rank, Smith normal form.

Unit-V :
Fundamental structure theorem for finitely generated modules over a PID and its applications to finitely generated abelian groups.

Text Book :
Basic Abstract Algebra, P.B.Bhattacharya, S.K.Jani, S.R.Nagpaul

References :

Relevant Books :

Text Book :

References :
(11) Vivek Sahai and Vikas Bist, Algebra, Narosa Publishing House,
SEMESTER-II

2MTH-3 : COMPLEX ANALYSIS-II

Unit-I:
The Gamma function and its properties, the Riemann Zeta Function, Remann’s Functional Equation, Euler’s theorem, Mittag-Leffler’s Theorem.

Unit-II:
Analytic Continuation, uniqueness of direct analytic continuation, uniqueness of analytic continuation along a curve, power series method of analytic continuation.

Unit-III:
Schwarz Reflection Principle, monodromy theorem and its consequences, Harmonic functions on a disk, Harnack’s inequality, Dirichlet’s problem, Green’s function.

Unit-IV:
Canonical products, Jensen’s formula, Poisson-Jensen formula, The genus and order of an entire function, exponent of convergence, Hadamard’s factorization theorem.

Unit-V:
The range of an analytic function, Bloch theorem, Little Picard theorem, Schottky’s theorem, univalent functions, Bieberbach’s conjecture (Statement only), Coble’s “1/4” theorem.

Text Book:

References:
4) S.Lang, Complex Analysis, Addison Wesley, 1977.
7) E.Hille, Analytic Function Theory (2 Vols), Gonn & co. 1959.
14) S.Zaremba, A Zwrotnica, Analytic Functions, Monografie Matematyczne, 1927.
SEMESTER-II

(1) RIEMANNIAN GEOMETRY

Unit-I:
- Riemannian metric, metric tensor, christoffel symbol, christoffel symbol of first kind, second kind, properties of christoffel symbols, transformation of christoffel symbols, derivatives of tensor, absolute derivative. Covariant derivatives, divergence, gradient, laplacian.

Unit-II:
- Parallel Vector Fields: Parallel vector field of constant magnitude, parallel displacement of covariant vector field, parallelism of a vector field of variable magnitude.
- Geodesic: Differential equations of a geodesic, special coordinate system: Local cartesian, Riemannian coordinates, normal coordinates, geodesic normal coordinates.

Unit-III:
- Curvature Tensor: Covariant curvature tensor of Riemann tensor, curvature tensor in Riemannian coordinates, properties of curvature tensors, on a cyclic property, number of independent components of Riemannian curvature.

Unit-IV:
- Ricci tensor and Einstein tensor, Ricci tensor, curvature invariant, Einstein tensor, the Bianchi identity. Geodesic deviation: Equations of Geodesic deviation.

Unit-V:
- Riemannian curvature, space of constant curvature, flat space, cartesian tensor.

References:
3. (3) Tensor Calculus - Schild, J.L. Synge.

SEMESTER-II

(2) ADVANCED DISCRETE MATHEMATICS-II

Unit-I:
- Graph Theory: Definition of (undirected) graphs, paths, circuits, cycles and subgraphs. Induced subgraphs. Degree of a vertex. Connectivity planar graphs and their applications. Planarity testing for connected planar graphs. Complete and complete bipartite graphs. Kuratowski's theorem (statement only) and its use.

Unit-II:

Unit-III:

Unit-IV:

References:
1. (1) N. Deo, Graph Theory with Applications to Engineering and Computer Sciences, Prentice Hall of India.
3. (3) J. E. Hopcroft and J. D. Ullman, Introduction to Automata Theory, Languages, and Computation, Addison-Wesley.

SEMESTER-II

(3) DIFFERENTIAL AND INTEGRAL EQUATIONS-II

Unit-I:
- Fredholm Equations: Some problems which give rise to integral equations, conversion of ordinary differential equations into integral equations, integro-differential equations.

Unit-II:
- Degenerated Kernels, Hermitian and symmetric kernels, the Hilbert-Schmidt theorem, the Fredholm alternative, the Hilbert-Schmidt theorem.

Unit-III:
- The Hilbert-Schmidt theorem, the Fredholm alternative, the Hilbert-Schmidt theorem.

References:
Unit-III: Volterra Integral Equation: Types of Volterra equations, Resolvent Kernel of Volterra equations, Convolution type Kernel, Some Miscellaneous type of Volterra equations.

Unit-IV: Non-linear Volterra equations, Approximate methods, Application to Volterra equations with Convolution type Kernels.

Unit-V: Existence and Uniqueness of Solution using Fixed Point Theorem in case of Linear and Non-linear Volterra and Fredholm Integral Equations.

References:

SYLLABUS PRESCRIBED FOR M.A./M.Sc. Part-II (Mathematics)

Semester III: Compulsory Papers

Unit-I: Functional Analysis-I

Text Book:

References:

Unit-II: Classical Mechanics

References:

Unit-III: Fluid Dynamics-I

References:

Unit-IV: Operations Research-I

References:

Unit-V: Difference Equations-I

References:


B.V.Limaye, Functional Analysis, Wiley Eastern Ltd.


SEMESTER-III

3MTH-2 : CLASSICAL MECHANICS

Unit-I:
Variational principle and Lagranges Equations : Hamilton's principle, some techniques of the calculus of variations. Derivation of Lagrange's Equations from Hamilton's principle, some techniques of the calculus of variations.

Unit-II:

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

Unit-IV:
Canonical transformations : The equations of Canonical transformation, examples of canonical transformations, Poisson's bracket & other canonical invariants (Lagranges Bracket), Poisson's identity.

Unit-V:
The Hamilton-Jacobi Equation for Hamilton's principle function, The harmonic Oscillator problem as an example of the Hamilton-Jacobi method. The Hamilton-Jacobi Equation for Hamilton's characteristic function, Separation of variables in the Hamilton-Jacobi equation.

Text Book:

References:
(1) A.S.Ramsey Dynamics Part-II, the English Language Book Society.


SEMESTER-III

(ii) FLUID DYNAMICS-I (OPTIONAL)

Unit-I:

Unit-II:
Pressure of motion of a fluid: Pressure at a point in a fluid at rest. Pressure at a point in a moving fluid, conditions at a boundary of two inviscid immiscible fluids. Euler's integral of the first kind, the complex potential, complex flow, and conservative body forces. Some potential theorems, some special two-dimensional flow. Some further aspects of vortex motion.

Unit-III:

Unit-IV:
The Milne-Thompson circle theorem, some applications of the circle theorem, extension of the circle theorem, the theorem of Wasignon, the use of conformal transformation. Vortices, single infinite row of line vortices. The Kármán vortex street.

Unit-V:
Elements of Thermodynamics: The equation of state of a substance, the first law of thermodynamics, internal energy, entropy, the equation of state of an ideal gas, the equation of state of a real gas. The second law of thermodynamics, the Carnot cycle, and the Carnot engine.

Textbook:
(1) F. Chorlton, Textbook of Fluid Dynamics, CBS Publishers, Delhi, 1996.

References:

SEMESTER-III

(III) OPERATION RESEARCH-I (OPTIONAL)

Unit-I:

Unit-II:
Other algorithms for linear programming - dual simplex method, parametric linear programming, upper bound technique, interior point algorithm, linear goal programming.

Unit-III:
Transportation and assignment problems, network analysis, shortest path problem, minimum spanning tree problem, maximum flow problem.

Unit-IV:
Minimum cost flow problem, network simplex method, product planning, control with PERT-CPM.

Unit-V:
Deterministic and probabilistic dynamic programming.

Textbook:

References:

References:
SEMESTER-III

(IV) : DIFFERENCE EQUATIONS-I

Unit-I :
Introduction : Difference calculus. The difference operator. Generating function and approximate summation.

Unit-II :

Unit-III :
The Z-transform : Properties, initial and final value theorems, partial sum theorem, convolution theorem. Inverse Z-transforms, solution of difference equation with constant coefficients by Z-transforms.

Unit-IV :

Unit-V :

Text Book :

Reference Books :

SEMESTER-III

(V) : FUZZY SETS AND APPLICATIONS-I (OPTIONAL)

Unit-I :
Fuzzy sets - basic definitions, a-level sets. Convex fuzzy sets, basic operations on fuzzy sets, cartesian products. Algebraic products, bounded sums and difference t-norms, t-conorms.

Unit-II :
The Extension Principle - The Zadeh’s extension principle, image and inverse image of fuzzy sets, Fuzzy numbers and elements of fuzzy arithmetic.

Unit-III :
Fuzzy relations and fuzzy graphs - Fuzzy relations, fuzzy sets, composition of fuzzy relations. Min-Max composition and its properties, fuzzy equivalence relations, fuzzy computability relations, fuzzy relations equations, fuzzy graphs, similarity relations.

Unit-IV :
Possibility theory - fuzzy measures, evidence theory, possibility theory and fuzzy sets.

Unit-V :
Fuzzy Logic - An Overview of classical logic, multivalued logics, fuzzy propositions, fuzzy quantifiers.

Text Books :

Reference Books :
Unit-III : Continuous Wavelet Transforms - Motivation and definition of Wavelet Transforms, the constructions formula, frequency localization. [Cha.3 (3.1-3.3)]

Unit-IV : Generalized Frames - From resolution of unity to frames, reconstruction formula and consistancy condition, Recursive construction. [Cha.4 (4.1, 4.2, 4.4)]

Unit-V : Discrete Time - Frequency analysis, Shannon sampling theorem, sampling in the time frequency domain, timesampling verses frequency sampling. [Cha.5 (5.1-5.3)]


SEMESTER-III (VII) : BANACH ALGEBRAS-I (OPTIONAL)

Unit-I : Definition of Banach Algebra and Examples. Singular and non-singular elements. The abstract index. The spectrum of an element.


Unit-IV : C* - algebras : Definition and examples, self-adjoint, unitary, normal, positive and projection elements in C* - algebras.

Unit-V : Commutative C* algebras. C* - homomorphisms.


SEMESTER-III (VIII) : NON COMMUTATIVE RINGS-I  (OPTIONAL)

Unit-I : Basic Terminology and examples. Semi simple rings. (x1, x2 of [1]).

Unit-II : Structure of Semi simple rings. (x3 of [1]).

Unit-III : The Jacobson Radical (x4 of [1]).

Unit-IV : The prime radical; prime and semi prime rings. Structure of primitive rings; the Density Theorem (x10, x11 of [1]).

Unit-V : Sub-direct products and commutativity theorems. (x12 of [1]).

(2) N.Jacobson, Basic Algebra II, WH Freeman, 1989.

SEMESTER-IV 4MTH-1 : FUNCTIONAL ANALYSIS-II

Unit-I : Riesz Representation theorem, adjoint of an operator on a Hilbert space, Reflexivity of Hilbert spaces, self adjoint operators, positive, projection, normal and unitary operators.

Unit-II : Spectral properties of bounded linear operators, basic concepts, Uniform boundedness principle,

Unit-III : Compact linear operators on normed spaces, further properties of compact linear operators, spectral properties of compact linear operators on normed spaces.

Unit-IV : Spectral properties of bounded self-adjoint linear operators, further spectral properties.

Unit-V : Positive operator, square root of positive operator, projection operators, spectral family.

(2) G.Frazer, Introduction to Functional Analysis, 1959.

References :
4) C. W. Gear : Numerical Analysis, John Wiley.
Cosmology, Critical density, Closed and open universe, Age of the Universe.

Unit-IV: Relativistic Stellar Structure, A Simple Stellar model - The interior Schwarzschild solution, stellar models and stability.

Unit-V: The field of a charged mass point, Weyl's generalization of Riemannian geometry, Weyl's theory of electromagnetism.

References:
2. Introduction to General Relativity - Ronald Ader, Maurice Bazin, Menahem, Schiffer.

SEMESTER-IV

4MTH-3/4/5 (ii) : FLUID DYNAMICS-II (OPTIONAL)

Unit-I: Gas Dynamics - Compressibility effects in real fluids, the elements of wave motion, one dimensional wave equation, wave equation in two and in three dimensions, spherical waves, ... of maximum mass flow through a nozzle. Shockwaves, formation of shockwaves, elementary analysis of normal shock waves.

Unit-II: Viscous Flow - Stress components in a real fluid, relation between cartesian components of stress, translation motion of fluid element, the rate of strain quadric and ... stress analysis in fluid motion, relation between stress and rate of strain, the coefficient of viscosity and Laminar flow.

Unit-III: The Navier-Stokes equations of motion of a viscous fluid, some solvable problem in viscous flow, steady, flow between parallel plates, steady flow through tube of some specified geometry, in viscous flow. stead states and the concept of diffusion, viscous flow between parallel and prescribed fluxes, stress and mass in laminar, and turbulent flow of a viscous fluid. the role of boundary layers, the concept of laminar and turbulent flow.

Unit-IV: Magnetohydrodynamics - Nature of Magnetohydrodynamics, Maxwell's equations, medium at rest, medium in motion, the equation of motion of a fluid in the presence of a magnetic field, discharges in a magnetic field of varying strength, some problems of stray current, magnetic force, reversal of current, the magnetic Reynolds number, Alfven's theorem, the magnetic body force, Ferraro's laws of isorotation.

Unit-V: Dynamical similarity, Buckingham p-theorem, Reynold's number, Prandtl's boundary layer, Boundary layer equations in two dimensions, Blasius solutions, boundary layer thickness, displacement thickness, Karmarkar integral conditions, separation of boundary layer flow.

Textbook:

References:
Unit-II:
Integer Programming: Branch and Bound technique, Queueing theory and its applications, Industrial problems, Optimal product mix and activity levels, Petroleum refinery operations, Blending problems.

Unit-III:
Economic interpretation of dual linear programming problems, Input-output analysis, Leontief system, Indecomposable and decomposable economics.

Unit-IV:

Unit-V:
Quadratic Programming, separable programming, Convex programming, Non-convex programming.

Textbook:

Reference Books:
(2) G. Hadley, Nonlinear and Dynamic Programming, Addison-Wesley, Reading Mass.

SEMESTER-IV

(IV) Difference Equations-II

Unit-I:

Unit-II:

Unit-III:
Discrete calculation of variation: Introduction, Necessary conditions, Sufficient conditions and disconjugacy.

Unit-IV:

Unit-V:

Textbook:

Reference Books:

(IV) Fuzzy Sets and Applications-II (optional)

Unit-I:
Possibility theory: Fuzzy sets and possibility distributions, Possibility and necessity measures, Possibility vs probability.

Unit-II:
Linguistic variables and hedges: Inference from conditional fuzzy propositions, The compositional rule for inference.

Unit-III:
Approximate reasoning: An overview of fuzzy expert systems, Approximate reasoning and fuzzy conjunctions, Fuzzy logic and fuzzy inference.

Unit-IV:
Fuzzy control: Fuzzy controllers, Fuzzy rule base, Fuzzy inferences, Defuzzification and the various defuzzification methods.

Unit-V:
Decision making in fuzzy environment: Individual decision making, Multi-person decision making, Fuzzy ranking methods, Fuzzy linear programming.

Textbook:
SEMESTER-IV (VI): LIE GROUPS

Lie Groups

Topics for Review Only: (No question to be set on this topic)
- Charts and coordinates
- Analytic structures
- Real functions on a manifold
- Tangent vectors
- Dual vectorspace
- Differentials
- Infinitesimal transformations and differential forms
- Mappings of manifolds
- Submanifolds
- Product of manifolds

UNIT-1: Topological Groups
- The family of nuclei of a topological group
- Subgroups and homomorphic images
- Connected topological groups

UNIT-II: Local Groups
- Lie groups
- Local Lie groups
- Analytic subgroups of a Lie group
- One-dimensional Lie groups

UNIT-III: The Commutator of two infinitesimal transformations
- The algebra of infinitesimal right translations
- Lie groups of transformations

UNIT-IV: The Lie algebra of sub-group
- One-parameter subgroup
- Taylor's theorem for Lie groups
- The exponential mapping

UNIT-V: The exterior algebra of a vector space
- The algebra of differential forms
- Exterior differentiation
- Maurer-Chartan forms
- The Maurer Cartan relations
- Statement of the Lie fundamental theorems
- The converses of Lie's first and second theorems

TEXT BOOKS:

REFERENCE BOOKS:
1. Lie Groups and Compact Groups by John F. Price (Cambridge University Press)

SEMESTER-IV (VII) - BANACH ALGEBRAS-II (OPTIONAL)

UNIT-I: Sub algebras of C*-algebra and the spectrum
- The spectral theorem
- The continuous functional calculus
- Positive linear functionals and states in C*-algebras

UNIT-II: Strong and weak operator topologies on C*-algebras
- The GNS construction
- Dual algebras of C*-algebras and the GNS construction
- The spectral theorem

UNIT-III: The commutant
- The double commutant theorem
- The Kaplansky density theorem
- L^∞ as a C*-algebra
- Maximal Abelian algebras

UNIT-IV: Abelian C*-algebras
- Cyclic and separating vectors
- Representation of Abelian C*-algebras
- The L^∞ functional calculus
- Connectedness of the unitary group

UNIT-V: The projection lattice
- Kaplansky's formula
- The centre of a C*-algebra
- Various types of projections
- Centrally orthogonal projections and type decomposition

TEXT BOOK:

REFERENCE BOOKS:

SEMESTER-IV (VIII): NON-COMMUTATIVE RINGS-II (OPTIONAL)

UNIT-I: Division rings, tensor products and maximal subfields
- Local rings, semi-local rings

UNIT-II: Polynomials over division rings
- Local rings
- Polynomial algebras

UNIT-III: The theory of idempotents
- Central idempotents and block decomposition

UNIT-IV: Perfect and semiperfect rings
- The theory of idempotents

TEXT BOOK:
## INDEX

### M.A./M.Sc. Part-I & Part-II (Semester I to IV)

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| 6.      | 1MTH4 Topology-I | 5          |

#### Optional Papers: Choose Any One.

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| 8.      | 1MTH6 Advanced Discrete Mathematics-I | 7         |
| 9.      | 1MTH7 Differential and Integral Equations-I | 8         |

#### M.Sc. Part-I Semester-II: Compulsory Papers

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| 10.     | 2MTH3 Complex Analysis-II | 11         |
| 11.     | 2MTH4 Topology-II | 12         |

#### Optional Papers: Choose Any One.

| 12.     | 2MTH5 Riemannian Geometry | 11         |
| 13.     | 2MTH6 Advanced Discrete Mathematics-II | 10         |
| 14.     | 2MTH7 Differential and Integral Equations-II | 9         |

#### M.Sc. Part-I Semester-III: Compulsory Papers

| 13.     | 3MTH1 Functional Analysis-I | 16         |
| 14.     | 3MTH2 Classical Mechanics | 17         |

Choose Any three from the following optional papers

| 15.     | 3MTH3 General Relativity and Cosmology-I | 18         |
| 16.     | 3MTH4 Fluid Dynamics-I | 19         |
| 17.     | 3MTH5 Operations Research-I | 20         |
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| 19.     | 3MTH7 Fuzzy Sets and Applications-I | 22         |
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| 21.     | 3MTH9 Non-Commutative Rings-I | 24         |
| 22.     | 3MTH10 Lie Groups | 25         |

#### M.Sc. Part-II Semester-I: Compulsory Papers

| 16.     | 4MTH1 Functional Analysis-II | 24         |
| 17.     | 4MTH2 Partial Differential Equations | 26         |

Choose Any three from the following optional papers

| 18.     | 4MTH3 i) General Relativity and Cosmology-II | 26         |
| 19.     | 4MTH4 ii) Fluid Dynamics-II | 27         |
| 20.     | 4MTH5 iii) Operations Research-II | 28         |
| 21.     | 4MTH6 iv) Difference Equations-II | 29         |
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