SYLLABUS for M. Sc. MATHEMATICS
Choice Based Credit System (Semester Pattern)
Rashtrasant Tukadoji Maharaj Nagpur University, Nagpur
Effective from 2018-2019

Candidates opting for this course are advised to go through the direction relating to the course "DIRECTION RELATING TO THE EXAMINATION LEADING TO THE DEGREE OF MASTER OF SCIENCE, SEMESTER PATTERN (CHOICE BASED CREDIT SYSTEM) AND DEGREE OF MASTER OF SCIENCE AND TECHNOLOGY (APPLIED GEOLOGY). SEMESTER PATTERN, (CHOICE BASED CREDIT SYSTEM) (FACULTY OF SCIENCE & TECHNOLOGY)" which is available on R. T. M. Nagpur University website.

The direction will provide details on admission criteria, rules for ATKT, scheme of examination, absorption scheme for CBS students into CBCS pattern, elective papers, foundation course papers, subject centric papers, coding pattern, pattern of question papers, practicals, distribution of marks, seminars, project work, internal assessment, calculation of SGPA and CGPA, etc.

Scheme of teaching and examination under semester pattern Choice Based Credit System (CBCS) for M.Sc. Program in Mathematics

M. Sc. Mathematics Semester I												
Code	Theory / Practical	Teaching scheme (Hours / Week)		Credits		Total	Examination Scheme					
		Th	Total	Theory	Internal Assessment		Duration in hrs.	Max. Marks		Total Marks	Minimum Passing Marks (40%)	
								External Marks	Internal Ass		Theory External	Internal Ass.
Core 1 1T1	Paper1: **Algebra-I**	5	5	4	1	5	3	100	25	125	50	
Core 2 1T2	Paper 2: **Real Analysis - I**	5	5	4	1	5	3	100	25	125	50	
Core3 1T3	Paper 3: **Topology-I**	5	5	4	1	5	3	100	25	125	50	
Core4 1T4	Paper 4: **Linear Algebra and Differential Equations**	5	5	4	1	5	3	100	25	125	50	
Core 5 1T5	Paper 5: **Integral Equations**	5	5	4		5	3	100	25	125	50	
	TOTAL	**25**	**25**	**20**	**5**	**25**		**500**	**125**	**625**	**250**	

M. Sc. Mathematics Semester II										
Code	/ Theory Practical	Teaching scheme (Hours / Week)		Credits		Total	Examination Scheme			
		Th	Total	Theo ry	Inter nal .		Durat ion in	Max. Marks	Total Mark	Minimum Passing Marks (40%)

								External Marks	Internal Ass		Theory External	Internal Ass.
Core 6 2T1	Paper1: **Algebra-II**	5	5	4	1	5	3	100	25	125	50	
Core 7 2T2	Paper 2: **Real Analysis - II**	5	5	4	1	5	3	100	25	125	50	
Core 8 2T3	Paper 3: **Topology-II**	5	5	4	1	5	3	100	25	125	50	
Core 9 2T4	Paper 4: **Differential Geometry**	5	5	4	1	5	3	100	25	125	50	
Core10 2T5	Paper 5: **Classical Mechanics**	5	5	4		5	3	100	25	125	50	
	TOTAL	**25**	**25**	**20**	**5**	**25**		**500**	**125**	**625**	**250**	

M. Sc. Mathematics Semester III												
Code	Theory / Practical	Teaching scheme (Hours / Week)		Credits		Total	Examination Scheme					
							Duration in hrs.	Max. Marks		Total Marks	Minimum Passing Marks (40%)	
		Th	Total	Theory	Internal Assessment			External Marks	Internal Ass		Theory External	Internal Ass.
Core 11 3T1	Paper1: **Complex Analysis**	5	5	4	1	5	3	100	25	125	50	
Core 12 3T2	Paper 2: **Functional Analysis**	5	5	4	1	5	3	100	25	125	50	
Core 13 3T3	Paper 3: **Mathematical Method**	5	5	4	1	5	3	100	25	125	50	
Core Elective 3T4	Paper 4: **Fluid Dynamics-I/ General Relativity/ Algebraic Topology- I / Non-Linear Programming-I/Operator Theory**	5	5	4	1	5	3	100	25	125	50	
Foundation	Paper 5: **Mathematics-I**	5	5	4		5	3	100	25	125	50	

Course 1/ Core Subject Centric 3T5	(*Elementary Mathematics*)/ **(3T5) /Operation Research –I (3T5)**										
	TOTAL	**25**	**25**	**20**	**5**	**25**		**500**	**125**	**625**	**250**

M. Sc. Mathematics Semester IV												
Code	Theory / Practical	Teaching scheme (Hours / Week)		Credits		Total	Examination Scheme					
							Duration in hrs.	Max. Marks		Total Marks	Minimum Passing Marks (40%)	
		Th	Total	Theory	Internal Assessment			External Marks	Internal Ass		Theory External	Internal Ass.
Core 14 4T1	Paper1: D**ynamical System**	5	5	4	1	5	3	100	25	125	50	
Core 15 4T2	Paper 2: **Partial Differential Equation**	5	5	4	1	5	3	100	25	125	50	
Core 16 4T3	Paper 3: **Advanced Numerical Method**	5	5	4	1	5	3	100	25	125	50	
Core Elective 4T4	Paper 4: **Fluid Dynamics-II/ Cosmology/ Algebraic Topology- II / Non-Linear Programming-II/Advance Algebra**	5	5	4	1	5	3	100	25	125	50	
Foundation Course 1/ Core Subject Centric 4T5	Paper 5: **Mathematics-I** (*Elementary Discrete Mathematics*)/ **(4T5) /Operation Research –II (4T5)**	5	5	4		5	3	100	25	125	50	
	TOTAL	**25**	**25**	**20**	**5**	**25**		**500**	**125**	**625**	**250**	

M. Sc. Mathematics
Choice Base Credit Semester wise Syllabus (CBCS)
Total Marks: 2500
Each Paper: 100 marks theory + 25 marks (Internal assessment)
Periods Allotted per week per paper: 05 Hrs.

M. SC. SEMESTER-I

COMPULSORY PAPERS
Paper I 1T1-Algebra I
Paper II 1T2-Real Analysis I
Paper III 1T3-Topology I
Paper IV 1T4-Linear Algebra and Differential Equations
Paper V 1T5-Integral Equations

M. SC. SEMESTER-II

COMPULSORY PAPERS

Paper VI 2T1-Algebra II
Paper VII 2T2-Real Analysis II
Paper VIII 2T3-Topology II
Paper IX 2T4-Differential geometry
Paper X 2T5- Classical Mechanics

M. SC. SEMESTER-III

COMPULSORY PAPERS

Paper XI 3T1-Complex Analysis
Paper XII 3T2-Functional Analysis
Paper XIII 3T3-Mathematical Methods

CORE ELECTIVE PAPER XIV (Opt any one of the following)

Paper XIV - 3T4

(i) Fluid Dynamics-I
(ii) General Relativity
(iii) Algebraic Topology- I
(iv) Non-Linear Programming-I
(v) Operator Theory

(FONDATION/SUBJECT CETRIC) PAPER XV (3T5)

PAPER XV : FOUNDATION (For Students other than Mathematics)

3T5 MATHEMATICS PAPER-I (Elementary Mathematics)

PAPER XV : CORE SUBJECT CENTRIC (Only for Students of Mathematic)

3T5 Operation Research-I

M. SC. SEMESTER-IV

Paper-XVI 4T1-Dynamical Systems
Paper-XVII 4T2-Partial Differential Equations
Papers XVIII 4T3-Advanced Numerical Methods

CORE ELECTIVE PAPER XIX (Opt any one of the following)
PAPER XIX - 4T4

(i) Fluid Dynamics II
(ii) Cosmology
(iii) Algebraic Topology- II
(iv) Non-Linear Programming-II
(v) Advance Algebra

(FONDATION/SUBJECT CETRIC) PAPER XX - 4T5

PAPER XX : FOUNDATION (For Students other than Mathematics)

4T5 MATHEMATICS PAPER-II (Elementary Discrete Mathematics)

PAPER XX : CORE SUBJECT CENTRIC (Only for Students of Mathematic)

4T5 Operation Research-II

Detailed Syllabus

M. Sc. Mathematics

Semester-I

Paper – I (Code: 1T1)

Algebra -I

Unit 1:

Permutation Group. Group of Symmetry. Dihedral group. Commutator group. Isomorphism Theorems. Automorphisms. Characteristic subgroup. Conjugacy and G-Sets.

Unit 2:

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

Unit 3:

Direct product, semi-direct product of groups. Sylows theorems. Groups of order 2 p and pq.

Unit 4:

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

Text Book:

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

Reference Books:

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

M. Sc. Mathematics
Semester-I
Paper – II (Code: 1T2)

Real Analysis-I

Unit 1:

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

Unit 2:

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

Unit 3:

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

Unit 4:

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

Text Books:

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

Reference Books:

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

M. Sc. Mathematics
Semester-I
Paper – III (Code: 1T3)

Topology-I

Unit 1:

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

Unit 2:

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

Unit 3:

Connected sets and components. Compact and countably compact spaces. Continuous functions and homeomorphisms.

Unit 4:

T_0 and T_1-spaces, T_2-spaces and sequences. Axioms of countability. Separability. Regular and normal spaces.

Text Book:

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

Reference Books:

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

M. Sc. Mathematics
Semester-I
Paper – IV (Code: 1T4)

Linear Algebra and Differential Equations

Unit 1:

Matrices and operators, Subspaces, Bases and Dimension. Determinants, trace, and Rank. Direct sum decomposition. Real Eigen Values. Differential equations with Real Distinct Eigen values. Complex Eigen values.

Unit 2:

Complex vector spaces. Real operators with Complex Eigen values. Application of complex linear algebra to differential equations. Review of topology in Rn. New norms for old. Exponential of operators.

Unit 3:.

Homogeneous linear systems. A non-homogeneous equation. Higher order systems. The primary decomposition. The S+N decomposition. Nilpotent canonical forms.

Unit 4:

Jordan and real canonical forms. Canonical forms and differential equations. Higher order linear equations on function spaces. Sinks and sources. Hyperbolic flows. Generic properties of operators. Significance of genericity.

Text Book :

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

Reference Book :

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

M. Sc. Mathematics
Semester-I
Paper – V (Code: 1T5)

Integral Equations

Unit 1:

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

Unit 2:

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

Unit 3:

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

Unit 4:

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

Text Book:

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

M. Sc. Mathematics
Semester-II
Paper – VI (Code: 2T1)

Algebra-II

Unit 1:

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

Unit 2:

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

Unit 3:

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

Unit 4:

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

Text Book :

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

Reference Books :

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

M. Sc. Mathematics
Semester-II
Paper – VII (Code: 2T2)

Real Analysis -II

Unit 1:

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

Unit 2:

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

Unit 3:

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

Unit 4:

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

Text Book :

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

Reference Books :

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

M. Sc. Mathematics
Semester-II
Paper – VIII (Code: 2T3)

Topology-II

Unit 1:

Urysohn's lemma. Tietze extension theorem. Completely regular spaces.Completely normal spaces. Compactness for metric spaces. Properties of metric spaces.

Unit 2:

Quotient topology. Nets and filters.

Unit3:

Product topology : Finite products, product invariant properties, metric products, Tichonov topology, Tichonov theorem.

Unit 4:

Locally finite and discrete families in topological spaces. Paracompact spaces, Urysohn's metrization theorem.

Text books:

1. Foundations of General Topology: W.J. Pervin, Academic press, 1964.
2. Introduction to general Topology: K.D. Joshi, Wiley Eastern Ltd. 1983.

Reference books:

1. Topology: J.R.. Munkres, second edition, Prentice Hall of India, 2002.
2. Introduction to topology and modern analysis :G.F. Simmons, Mc Graw Hill 1963.
3. General Topology: J.L. Kelley, Van Nostrand, 1995.

M. Sc. Mathematics
Semester-II
Paper – IX (Code: 2T4)

Differential Geometry

Unit 1:

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

Unit2:

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

Unit 3:

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

Unit 4: Compact surfaces whose points are umbilics. Hilbert's lemma. Compact surfaces of constant Gaussian or mean curvature. Complete surfaces.

Characterisation of complete surfaces. Hilbert's theorem. Conjugate points on geodesics. Intrinsically defined surfaces. Triangulation. Two dimensional Riemannian manifolds. Problem of metrization. Problem of continuation.

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

Reference Book:
Geometry of curves and surfaces: do Carmo, Academic Press.

M. Sc. Mathematics
Semester-II
Paper – X (Code: 2T5)

Classical Mechanics

Unit 1:

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

Unit 2: Legendre transformations and the Hamilton equations of motion. Cyclic coordinates and conservation theorems. Routh's procedure and oscillations about steady motion, The Hamiltonian formulation of relativistic mechanics, The Principle of least action.

Unit 3:

The equations of canonical transformation. Examples of canonical transformation. The symplectic approach to canonical transformations. Poisson brackets and other canonical invariants.

Unit 4:

Equations of motion. Infinitesimal canonical transformations and conservation theorems in the Poisson bracket formulation, the angular momentum, Poisson bracket relations, symmetry groups of mechanical systems. Liouville's theorem.

Text Book:

Classical Mechanics: By H. Goldstein, Second Edition Narosa publishing house, New Delhi.

References:

1. Lectures in Analytic Mechanics: F. Gantmacher, MIR Publishers, Moscow, 1975.
2. Classical Mechanics: Narayan Chandra Rana and Pramod Sharad Chandra Jog, Tata Mc Graw Hill.
3. Lecture on Advanced Mechanics, Sonu Nilu Publication (2004) by T M Karade and G S Khadekar

M. Sc. Mathematics
Semester-III
Paper – XI (Code: 3T1)

Complex Analysis

Unit 1:

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

Unit 2:

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

Unit 3:

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

Unit 4:

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

Text Book:

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

Reference Book:

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

M. Sc. Mathematics
Semester-III
Paper – XII (Code: 3T2)

Functional Analysis

Unit 1:

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

Unit 2:

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

Unit 3:

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

Unit 4:

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

Text Book:

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

Reference Books:

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

M. Sc. Mathematics
Semester-III
Paper – XIII (Code: 3T3)

Mathematical Methods

Unit 1:

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

Unit 2:

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

Unit 3:

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

Unit 4:

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

Text Book:

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

References Books:

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

M. Sc. Mathematics
Semester-III
Core Elective*
Paper – XIV (Code: 3T4)

Fluid Dynamics-I

Unit 1:

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

Unit 2:

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

Unit 3:

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

Unit 4:

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

Text Book:

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

Reference Books:

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

M. Sc. Mathematics
Semester-III
Core Elective
Paper – XIV (Code: 3T4)

General Relativity

Unit 1:

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

Unit 2:

The principle of covariance, The principle of equivalence, Geodesic principle,

Newton's equations of motion as an approximation of geodesic equations, Poisson's equations as an approximation to Einstein field equations.

Unit 3:

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

Unit 4:

Gravitational field equations for non empty space, Linearization of the field equations, The Weyl's solution of linearized Field equations, Interior Schwarzchild's solution.

Text Book:

Introduction to General Relativity: Ronald Adler, Maurice Bezin and Manamen Schiffer, McGraw-Hill Kogakusha Ltd.

References Books:

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

M. Sc. Mathematics
Semester-III
Core Elective

Paper – XIV (Code: 3T4)

Algebraic Topology- I

Unit 1:

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

Unit 2:

Polytopes and triangulated spaces: E^n as a vector space over E^1.Barycentric coordinates. Geometrical complexes and polytopes. Barycentric subdivision. Simplicial mappings and simplicial approximation theorem.

Unit 3:

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

Unit 4:

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

Text Book :

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

Reference Books :

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

M. Sc. Mathematics
Semester-III
Core Elective

Paper – XIV (Code: 3T4)

Non-linear Programming-I

Unit 1 :

The non-linear programming problem and its fundamental ingredients. Linear inequalities and the theorem of the alternative. The optimality criteria of linear programming. Tucker's lemma and existence theorems.

Unit 2:

Theorems of the alternative Convex sets – Separation theorems. Convex and concave functions - basic properties and some fundamental theorems for convex functions. Generalised Gordan theorem. Bohnenblust – Karlin – Shapley theorem. Saddle point optimality criteria without differentiability – The minimization and the local minimization problems and some basic results.

Unit 3:

Sufficient optimality theorem. Fritz John Saddle point necessary optimality theorem. Slater's and Karlin's constraint qualifications and their equivalence. The strict constraint qualification. Kuhn – Tucker saddle point optimality theorems. Differentiable concave and convex functions - Some basic properties. Twice differentiable convex and concave functions. Theorems in cases of strict convexity and concavity of functions.

Unit 4:

Optimality criteria with differentiability- Optimality theorems, Fritz John stationary point necessary optimality theorem. The Arrow – Hurwicz – Uzawa constraint qualification. Kuhn – Tucker stationary – point necessary optimality theorem.

Text Book :

O.L. Mangasarian, Non- linear programming. Mc Graw Hill, New York.

Reference Book :

Mokhtar S. Bazaraa and C.M.Shetty, Non- linear programming, Theory and Algorithms, Wiley, New York.

M. Sc. Mathematics
Semester-III
Core Elective

Paper – XIV (Code: 3T4)

Operator Theory

Unit 1:
Basic concepts about spectrum. Spactral properties of bounded linear operators. Further properties of resolvent and spectrum. Use of complex analysis in spectral theory.

Unit 2:
Banach Algebras. Further properties of Banach Algebras. Compact linear operators on normed spaces. Further properties of Compact linear operators. Spectral properties of compact linear operators.

Unit 3:
Further spectral properties of Compact linear operators. Operator equations involving compact linear operators. Further theorems of Fredholm type. Fredholm alternative.

Unit 4:
Spectral properties of bounded self adjoint linear operators. Further Spectral properties of bounded self adjoint linear operators. Positive operators. Square roots of a positive operator. Projection operator. Further properties of projections. Spectral family. Statement of spectral representation theorem.

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

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

NOTE*: Candidates can choose any one paper from Core elective.

M. Sc. Mathematics

Semester-III

PAPER XV : FOUNDATION (For Students other than Mathematics)

Paper – XV (Code: 3T5)

MATHEMATICS-I

Elementary Mathematics

Unit 1:

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

Unit 2:

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

Unit 3:

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

Unit 4:

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

Text Books:

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

M. Sc. Mathematics
Semester-III
CORE SUBJECT CENTRIC (Only Students of Mathematics)
Paper – XV (Code: 3T5)

Operational Research-I

Unit 1:
Simplex method, Theory of Simplex method, duality, dual simplex method.

Unit 2:
Transportation and Assignment problems.

Unit 3:
Two-person Zero-sum games. Games with mixed strategies, graphical solution, solution by linear programming.

Unit 4:
Dynamic programming

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

Reference books :

1. Linear programming: G. Hadley, Narosa Publishing House1995.
2. Introduction to operations Research: F.S. Hillier and G.J.Lieberman (Sixth Edition), Mc Graw Hill
3. International Edition 1995.
4. Operations Research – In Introduction: H.A Taha, Macmillan publishing company inc, New York

M. Sc. Mathematics
Semester-IV
Paper – XVI (Code: 4T1)

Dynamical Systems

Unit 1:

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

Unit 2:

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

Unit 3:

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

Unit 4:

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

Text Book:

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

Reference Book:

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

M. Sc. Mathematics
Semester-IV
Paper – XVII (Code: 4T2)

Partial Differential Equations

Unit 1:

First order partial differential equations in two independent variables and the Cauchy problem. Semilinear and quasi linear equations in two independent variables. First order non linear equations in two independent variables. Complete integral.

Unit 2:

Classification of second order partial differential equations. Potential theory and elliptic differential equations (sections 2.1-2.5).

Unit 3:

The diffusion equation and parabolic differential equations (sections 3.1-3.4).

Unit 4:

The Wave equation (sections 4.1, 4.2, 4.4, 4.8, 4.9)

Text Book:

Partial Differential Equations: Phoolan Prasad and Renuka Ravindran; New Age International (P) Limited.

M. Sc. Mathematics
Semester-IV
Paper – XVIII (Code: 4T3)

Advance Numerical Methods

Unit 1:

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

Unit 2:

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

Unit 3: The Weierstrass theorem and Taylor's theorem. The minimax approximation problem, the least square approximation problem, orthogonal polynomial, economisation of Taylor series, minimax approximation.

Unit 4:

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

Text book:

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

M. Sc. Mathematics
Semester-IV
Core Elective*

Paper – XIX (Code: 4T4)

Fluid Dynamics-II

Unit 1:

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

Unit 2:

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

Unit 3:

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

Unit 4:

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

Text Books:

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

Reference Books:

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

M. Sc. Mathematics
Semester-IV
Core Elective
Paper – XIX (Code: 4T4)

Cosmology

Unit 1:

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

Unit 2:

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

Unit 3:

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

Unit 4:

Steady state cosmology, Distance measure in cosmology, Comoving distance, Apparent luminosity and luminosity distance, Angular diameter and Lookback time, Galaxy count

Text Books:

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

References Books:

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

M. Sc. Mathematics
Semester-IV
Core Elective
Paper – XIX (Code: 4T4)

Algebraic Topology- II

Unit 1:
Simplicial mappings. Chain mappings. Barycentric Subdivision. The Brouwer Degree. The fundamental theorem of algebra.

Unit 2:
No retraction theorem and Brouwer fixed point theorem. Mappings into spheres. Relative homology groups. The exact homology sequence. Homomorphisms of exact sequences

Unit 3:
The excision theorem. The Mayer-Vietoris sequence. Eilenberg-Steenrod axioms for homology theory. Relative homotopy theory. Cohomology groups. Relations between chain and cochain groups.

Unit 4:
Simplicial and chain mappings. The cohomology product. The cap product. Exact sequences in cohomology theory. Relations between homology and cohomology groups.

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

Reference Books :

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

M. Sc. Mathematics
Semester-IV
Core Elective
Paper – XIX (Code: 4T4)

Non-linear Programming-II

Unit 1 :

Duality in non-linear programming – Weak duality theorem. Wolfe's duality theorem. Strict converse duality theorem. The Hanson – Huard strict converse duality theorem. Unbounded dual theorem. Duality in quadratic and linear programming.

Unit 2 :

Quasi convex, strictly quasi convex and strictly quasi concave functions. Karamardian theorem. Global minimum (maximum). Pseudo convex and pseudo concave functions. Relationship between pseudo convex functions and strictly quasi convex functions. Differentiable convex functions and pseudo convex functions.

Unit 3 :

Optimality and duality for generalized convex and concave functions – Sufficient optimality theorem. Generalized Kuhn – Tucker sufficient optimality theorem. Generalized Fritz John stationary point necessary optimality theorem, Kuhn-Tucker necessary optimality conditions under the weak constraint qualifications.

Unit 4 :

Duality. Optimality and duality in the presence of nonlinear equality constraints – Sufficient optimality criteria. Minimum principle necessary optimality criteria. Minimum principle necessary optimality theorem. Fritz John and Kuhn-Tucker stationary point necessary optimality criteria. Duality with nonlinear equality constraints.

Text Book :

O.L. Mangasarian, Non- linear programming. Mc Graw Hill, New York.

Reference Book :

Mokhtar S. Bazaraa and C.M.Shetty, Non- linear programming, Theory and Algorithms, Wiley, New York.

M. Sc. Mathematics
Semester-IV
Core Elective
Paper – XIX (Code: 4T4)

Advanced Algebra

Unit 1:
Tensor product of modules. Exact sequences – Projective, Injective, and Flat Modules.

Unit 2:
Noetherian Rings and Affine Algebraic sets. Radicals and Affine varieties. Integral Extensions and Hilbert's Nullstellensatz. Localisation. The prime spectrum of a ring.

Unit 3:
Artinian Rings . Discrete valuation rings. Dedekind domains. Introduction to Homological Algebra- Ext and Tor. The Cohomology of Groups. Crossed homomorphisms and $H^1(G,A)$. Group Extensions, Factor Sets and $H^2(G,A)$.

Unit 4:
Linear Actions and Modules over Group Rings. Wedderburn's theorem and some consequences. Character Theory and orthogonality Relations.

Text Book :
Abstract Algebra: David S. Dummit & Richard M. Foote (Second Edition) John Wiley & Sons Inc.

NOTE*: Candidates can choose any one paper from Core elective

M. Sc. Mathematics
Semester-IV
PAPER XX : FOUNDATION (For Students other than Mathematics)
Paper – XX (Code: 4T5)

MATHEMATICS-II

Elementary Discrete Mathematics

Unit 1:

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

Unit 2:

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

Unit 3:

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

Unit 4:

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

Text Book:

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

M. Sc. Mathematics
Semester-IV
CORE SUBJECT CENTRIC (Only Students of Mathematics)
Paper – XX (Code: 4T5)

Operations Research–II

Unit 1:
Integer programming.

Unit 2:
Queuing theory and sequencing.

Unit 3:
Non- Linear programming- one and multi- Variable unconstrained optimization, Kuhn-Tucker conditions for constrained optimization.

Unit 4:
Quadratic programming, fraction programming and goal programming.

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

Reference books :

1. G. Hadley: Linear programming, Narosa Publishing House 1995.
2. G. J. Lieberman: Introduction to operations Research (Sixth Edition) Mc Graw Hill International Edition 1995.
3. H.A Taha: Operations Research – In Introduction, Macmillan publishing company inc, New York