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

<table>
<thead>
<tr>
<th>M. Sc. Mathematics Semester I</th>
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<tbody>
<tr>
<td><strong>Code</strong></td>
<td><strong>Teaching scheme (Hours / Week)</strong></td>
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<tr>
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<td>Theory / Practical</td>
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<tr>
<td>Core 1</td>
<td>1T1 Paper 1: Algebra-I</td>
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<tr>
<td>Core 2</td>
<td>1T2 Paper 2: Real Analysis-I</td>
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<tr>
<td>Core 3</td>
<td>1T3 Paper 3: Topology-I</td>
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<tr>
<td>Core 4</td>
<td>1T4 Paper 4: Linear Algebra and Differential Equations</td>
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<tr>
<td>Core 5</td>
<td>1T5 Paper 5: Integral Equations</td>
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### M. Sc. Mathematics Semester II

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<tr>
<td><strong>Code</strong></td>
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<td>Theory / Practical</td>
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<td>Code</td>
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<td>Core</td>
<td>Paper1:</td>
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<td>6 2T1</td>
<td>Algebra-II</td>
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<td>Paper 2:</td>
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<td>7 2T2</td>
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<td>8 2T3</td>
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<td>Core</td>
<td>Paper 4:</td>
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<td>10 2T5</td>
<td>Classical Mechanics</td>
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**M. Sc. Mathematics Semester III**

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<tr>
<th>Code</th>
<th>Paper</th>
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<th>Practical</th>
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<td>13 3T3</td>
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<td>3T4</td>
<td>Fluid Dynamics-I/General Relativity/Algebraic Topology-I/Non-Linear Programming-I/Operator Theory</td>
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### M. Sc. Mathematics Semester IV

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<td>Theory / Practical</td>
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<td>Paper 1: Dynamical System</td>
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<td>3 100 25 125 50</td>
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<tr>
<td>Core 15 4T2</td>
<td>Paper 2: Partial Differential Equation</td>
<td>5 5 4 1 5</td>
<td>3 100 25 125 50</td>
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<tr>
<td>Core 16 4T3</td>
<td>Paper 3: Advanced Numerical Method</td>
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<td>3 100 25 125 50</td>
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<td>Core Elective 4T4</td>
<td>Paper 4: Fluid Dynamics-II/ Cosmology/ Algebraic Topology- II / Non-Linear Programming-II/Advance Algebra</td>
<td>5 5 4 1 5</td>
<td>3 100 25 125 50</td>
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<td>Paper 5: Mathematics-I (Elementary Discrete Mathematics)/ (4T5) /Operation Research –II (4T5)</td>
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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 Mathematics)
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:

Unit 2:

Unit 3:
Direct product, semi-direct product of groups. Sylows theorems. Groups of order $2^p$ and $pq$.

Unit 4:

Text Book:

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

Unit 1:  

Unit 2:  

Unit 3:  

Unit 4:  
Rank of a mapping. Immersion. Sub manifolds. Lie groups. Examples of Lie groups.

Text Books:  

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

Topology-I  

Unit 1:  

Unit 2:  

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:  

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

Linear Algebra and Differential Equations

Unit 1:

Unit 2:

Unit 3:

Unit 4:

Text Book :

Reference Book :
Unit 1:

Unit 2:

Unit 3:

Unit 4:

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

Algebra-II

Unit 1:

Unit 2:

Unit 3:

Unit 4:

Text Book :

Reference Books :
Unit 1:

Unit 2:

Unit 3:

Unit 4:

Text Book:

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

Topology-II

Unit 1: 

Unit 2: 
Quotient topology. Nets and filters.

Unit 3:  
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:  

Reference books:  
Unit 1:

Unit 2:

Unit 3:


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

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

Classical Mechanics

Unit 1:  


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:  

References:  
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:

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

Functional Analysis  

Unit 1:  

Unit 2:  

Unit 3:  

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:

Unit 2:

Unit 3:

Unit 4:

Text Book:

References Books:
Unit 1:

Unit 2:

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:

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

General Relativity

Unit 1:

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 Schwarzschild’s solution and its isotropic form, Birkhoff’s theorem, Schwarzschild 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 Schwarzschild’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).
Unit 1:

Unit 2:

Unit 3:

Unit 4:

Text Book:

Reference Books:
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:

Unit 3:

Unit 4:

Text Book:

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

Unit 2:

Unit 3:

Unit 4:

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:

Reference books:
M. Sc. Mathematics  
Semester-IV  
Paper - XVI (Code: 4T1)  
Dynamical Systems

Unit 1:  

Unit 2:  

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:  

Text Book:  

Reference Book:  
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:

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

Advance Numerical Methods

Unit 1:

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.
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:

Text Books:
2. Fluid Mechanics: Joseph Spurk; Springer.

Reference Books:
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

References Books:
Unit 1:

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:

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:

Reference Books :
Unit 1:

Unit 2:

Unit 3:

Unit 4:

Text Book:

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

Unit 2:

Unit 3:

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

Text Book :

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:**  
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 :  
inc, New York