# SHIVAJI UNIVERSITY, KOLHAPUR

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**Accredited By NAAC with 'A' Grade**

**CHOICE BASED CREDIT SYSTEM**

**Syllabus For**

# M.A. / M.Sc. Mathematics Part -I

## Semester I and II

**(Syllabus to be implemented from June, 2019 onwards.)**

# M. A. / M.Sc. (Mathematics) Programme structure (CBCS PATTERN) (2019-20)
## M.Sc. (Mathematics) Part – I

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **SEMESTER-I (Duration- Six Month)** | | | | | | | | | | | |
| | Sr. No. | Course Code | Teaching Scheme | | | Examination Scheme | | | | | |
| | | | Theory and Practical | | | University Assessment (UA) | | | Internal Assessment (IA) | | |
| | | | Lectures (Per week) | Hours (Per week) | Credit | Maximum Marks | Minimum Marks | Exam. Hours | Maximum Marks | Minimum Marks | Exam. Hours |
| **CGPA** | 1 | CC-101 | 5+1 | 6 | 5 | 90 | 36 | 3 | 30 | 12 | 1 |
| | 2 | CC-102 | 5+1 | 6 | 5 | 90 | 36 | 3 | 30 | 12 | 1 |
| | 3 | CC-103 | 5+1 | 6 | 5 | 90 | 36 | 3 | 30 | 12 | 1 |
| | 4 | CC-104 | 5+1 | 6 | 5 | 90 | 36 | 3 | 30 | 12 | 1 |
| | 5 | CC-105 | 5+1 | 6 | 5 | 90 | 36 | 3 | 30 | 12 | 1 |
| **Total (A)** | | | **--** | **--** | **25** | **450** | **--** | **--** | **150** | **--** | **--** |
| **Non-CGPA** | 1 | AEC-106 | 2 | 2 | 2 | -- | -- | -- | 50 | 20 | 2 |
| **SEMESTER-II (Duration- Six Month)** | | | | | | | | | | | |
| **CGPA** | 1 | CC-201 | 5+1 | 6 | 5 | 90 | 36 | 3 | 30 | 12 | 1 |
| | 2 | CC-202 | 5+1 | 6 | 5 | 90 | 36 | 3 | 30 | 12 | 1 |
| | 3 | CC-203 | 5+1 | 6 | 5 | 90 | 36 | 3 | 30 | 12 | 1 |
| | 4 | CC-204 | 5+1 | 6 | 5 | 90 | 36 | 3 | 30 | 12 | 1 |
| | 5 | CC-205 | 5+1 | 6 | 5 | 90 | 36 | 3 | 30 | 12 | 1 |
| **Total (B)** | | | **--** | **--** | **25** | **450** | **--** | **--** | **150** | **--** | **--** |
| **Non-CGPA** | 1 | SEC-206 | 2 | 2 | 2 | -- | -- | -- | 50 | 20 | 2 |
| **Total (A+B)** | | | | | **50** | **900** | **--** | **--** | **300** | **--** | **--** |

| | |
|---|---|
| • Student contact hours per week : **30** Hours (Min.) | • Total Marks for M.Sc.-I : **1200** |
| • Theory and Practical Lectures : **60** Minutes Each | • Total Credits for M.Sc.-I (Semester I & II) : **50** |
| • CC-Core Course<br>• CCPR-Core Course Practical<br>• AEC-Mandatory Non-CGPA compulsory Ability Enhancement Course<br>• SEC- Mandatory Non-CGPA compulsory Skill Enhancement Course | • Practical Examination is annual.<br>• Examination for CCPR-105 shall be based on Semester I Practicals.<br>• Examination for CCPR-205 shall be based on Semester II Practicals.<br>• Duration of Practical Examination as per respective BOS guidelines<br>• ***Separate passing is mandatory for Theory, Internal and Practical Examination*** |

# M. A. / M.Sc. (Mathematics) Programme structure (CBCS PATTERN) (2020-21)
## M.Sc. (Mathematics) Part – II

| **SEMESTER-III (Duration- Six Month)** | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Sr. No. | Course Code | Teaching Scheme | | | Examination Scheme | | | | | |
| | | | Theory and Practical | | | University Assessment (UA) | | | Internal Assessment (IA) | | |
| | | | Lectures (Per week) | Hours (Per week) | Credit | Maximum Marks | Minimum Marks | Exam. Hours | Maximum Marks | Minimum Marks | Exam. Hours |
| **CGPA** | 1 | CC-301 | 5+1 | 6 | 5 | 90 | 36 | 3 | 30 | 12 | 1 |
| | 2 | DSE -302 | 5+1 | 6 | 5 | 90 | 36 | 3 | 30 | 12 | 1 |
| | 3 | CCS-303 | 5+1 | 6 | 5 | 90 | 36 | 3 | 30 | 12 | 1 |
| | 4 | CCS -304 | 5+1 | 6 | 5 | 90 | 36 | 3 | 30 | 12 | 1 |
| | 5 | CCS -305 | 5+1 | 6 | 5 | 90 | 36 | 3 | 30 | 12 | 1 |
| **Total (C)** | | | **--** | **--** | **25** | **450** | **--** | **--** | **150** | **--** | |
| **Non-CGPA** | 1 | AEC-306 | 2 | 2 | 2 | -- | -- | -- | 50 | 20 | 2 |
| | 2 | EC (SWM MOOC)-307 | Number of lectures and credit shall be as specified on SWAYAM MOOC | | | | | | | | |
| **SEMESTER-IV (Duration- Six Month)** | | | | | | | | | | | |
| **CGPA** | 1 | CC-401 | 5+1 | 6 | 5 | 90 | 36 | 3 | 30 | 12 | 1 |
| | 2 | DSE -402 | 5+1 | 6 | 5 | 90 | 36 | 3 | 30 | 12 | 1 |
| | 3 | CCS-403 | 5+1 | 6 | 5 | 90 | 36 | 3 | 30 | 12 | 1 |
| | 4 | CCS -404 | 5+1 | 6 | 5 | 90 | 36 | 3 | 30 | 12 | 1 |
| | 5 | CCS -405 | 5+1 | 6 | 5 | 90 | 36 | 3 | 30 | 12 | 1 |
| **Total (D)** | | | **--** | **--** | **25** | **450** | **--** | **--** | **150** | **--** | **--** |
| **Non-CGPA** | 1 | SEC-406 | 2 | 2 | 2 | -- | -- | -- | 50 | 20 | 2 |
| | 2 | GE-407 | 2 | 2 | 2 | -- | -- | -- | 50 | 20 | 2 |
| **Total (C+D)** | | | | | **50** | **900** | **--** | **--** | **300** | **--** | **--** |

| | |
|---|---|
| • Student contact hours per week : **30** Hours (Min.) | • Total Marks for M.Sc.-II : **1200** |
| • Theory and Practical Lectures : **60** Minutes Each | • Total Credits for M.Sc.-II (Semester III & IV) : **50** |
| • CC-Core Course<br>• CCS- Core Course Specialization<br>• CCPR-Core Course Practical<br>• DSE-Discipline Specific Elective<br>• AEC-Mandatory Non-CGPA compulsory Ability Enhancement Course<br>• SEC- Mandatory Non-CGPA compulsory Skill Enhancement Course<br>• EC (SWM MOOC) - Non-CGPA Elective Course<br>• GE-Generic Elective | • Practical Examination is annual.<br>• Examination for CCPR-305 shall be based on Semester III Practicals.<br>• Examination for CCPR-405 shall be based on Semester IV Practicals.<br>• Duration of Practical Examination as per respective BOS guidelines<br>• ***Separate passing is mandatory for Theory, Internal and Practical Examination*** |

| | **M.Sc.-I** | **M.Sc.-II** | **Total** |
|---|---|---|---|
| **Marks** | **1200** | **1200** | **2400** |
| **Credits** | **50** | **50** | **100** |

**I. CGPA course:**

1. There shall be 12 Core Courses (CC) of 60 credits per programme.
2. There shall be 06 Core Course Specialization (CCS)of 30 credits per programme.
3. There shall be 02 Discipline Specific Elective (DSE) courses of 10 credits per programme
4. Total credits for CGPA courses shall be of 100 credits per programme

**II. Mandatory Non-CGPA Courses:**

1. There shall be 02 Mandatory Non-CGPA compulsory Ability Enhancement Courses (AEC) of 02 credits each per programme.
2. There shall be o1 Mandatory Non-CGPA compulsory Skill Enhancement Course (SEC) of 02 credits per programme.
3. There shall be one Elective Course (EC) (SWAYAM MOOC). The credits of this course shall be as specified on SWAYAM MOOC.
4. There shall be one Generic Elective (GE) course of 02 credits per programme. Each student has to take generic elective from the department other than parent department.
5. The total credits for Non-CGPA course shall be of 08 credits + 2-4 credits of EC as per availability.
6. The credits assigned to the course and the programme are to be earned by the students and shall not have any relevance with the work load of the teacher.

# M.A. / M. Sc. (Mathematics) (Part I) (Semester I)

**M.A. / M. Sc. (Mathematics) (Part I) (Semester I)**
**(Choice Based Credit System)**
**(Introduced from June 2019 onwards)**

**Course Code** : CC-101
**Title of Course**: Advanced Calculus
**Course Outcomes** : Upon successful completion of this course, the student will be able to:
(i) Analyze convergence of sequences and series of functions
(ii) check differentiability of functions of several variables
(iii)Apply inverse and implicit function theorems for functions of several variables
(iv) Use Green's theorem, Stoke's Theorem, Gauss divergence Theorem.

**Unit 1 :**
Sequences and series of functions: Pointwise convergence of sequences of functions, Examples of sequences of real valued functions, Definition of uniform convergence, Uniform convergence and continuity, Cauchy condition for uniform convergence, Uniform convergence and Riemann integration, Uniform convergence and differentiation, Equicontinuous family of functions.[1,2] **15 Lectures**

**Unit 2:**
Multivariable differential Calculus: The Directional derivatives, directional derivatives and continuity, total derivative, total derivatives expressed in terms of partial derivatives, The matrix of linear function, mean value theorem for differentiable functions, A sufficient condition for differentiability, sufficient condition for equality of mixed partial derivatives, Taylor's formula for functions from $R^n$ to $R^1$.[2,1]
**15 Lectures**

**Unit 3:**
Implicit functions: Functions of several variables, Linear transformations, Differentiation, Contraction principle, The inverse function theorem, The implicit function theorem and their applications.[1]
**15 Lectures**

**Unit 4:**
Integral Calculus: Path and line integrals, Multiple integrals Double integral (Theorems without proof) Application to area and volume.( Theorems without proof )Greens theorem in the plane. Application of Green's Theorem. Change of variables, special cases of transformation formula. Surface integral, change of parametric representation. Other notations for surface integrals, Stoke's Theorem Curl and divergence of a Vector field. Gauss divergence Theorem. [3] **15 Lectures**

**Unit 5:** Problems, Seminars, assignments, Examples etc. on units 1-4 **15 Lectures**

Recommended books :

1) Principles of mathematical Analysis, Walter Rudin, third Edition, McGraw Hill book company
2) Mathematical Analysis, Apostal, Second Edition, Narosa Publishing House.

3) Calculus Vol. II , Tom M. Apostol, Second EditionWiley India Pvt. Ltd.
Reference books:
1) W.Fleming, Functions of several Variables,2nd Edition ,Springer Verlag, 1977.
2)J.R.Munkres, Analysis on Manifolds.

**M.A./M. Sc. (Mathematics) (Part I) (Semester I)**
**(Choice Based Credit System)**
**(Introduced from June 2019 onwards)**

**Course Code :** CC-102
**Title of Course:** Linear Algebra
**Course Outcomes:** Upon successful completion of this course, the student will be able to:
1. understand basic notions in Linear Algebra and use the results in developing advanced mathematics.
2. study the properties of Vector Spaces, Linear Transformations, Algebra of Linear Transformations and Inner product space in some details.
3. construct Canonical forms and Bilinear forms.
4. apply knowledge of Vector space, Linear Transformations, Canonical Forms and Bilinear Transformations.

**Unit I**:Basic concepts of vector space, Dual Spaces, Annihilator of a subspace, Quotient Spaces. Inner product spaces, Algebra of Linear transformations. **15 Lectures**

**Unit II:** Eigen values and eigenvectors of a linear transformation. Diagonalization. Invariant subspaces, Similarity of linear transformations. **15 Lectures**

**Unit III:** Triangular form, Nilpotent transformations, Primary decomposition theorem, Jordan blocks and Jordan forms, Rational Canonical Form, Trace and transpose, Determinants, Real Quadratic forms. **15 Lectures**

**Unit IV**: Hermitian, Self adjoint, Unitary and normal linear transformation, Symmetric bilinear forms, skew symmetric bilinear forms, Group preserving bilinear forms. **15 Lectures**

**Unit V**: Examples, seminars, group discussions on above four units. **15 Lectures**

**Recommended Book(s):**

1. Herstein I. N. : Topics in Algebra, 2nd Edition, Willey Eastern Limited.
2. Hoffman, Kenneth and Kunze R: Linear Algebra, Prentice Hill of India Private Limited., 1984.

**Reference Books:**

1. A. R. Rao and P. Bhimashankaran, Linear Algebra, Hidustan Book Agency.
2. Surjit Singh, Linear Algebra, Vikas publishing House (1997).
3. Gilbert Strang: Introduction to Linear Algebra, Wellesley-Cambridge Press

**M.A./M. Sc. (Mathematics) (Part I) (Semester I)**
**(Choice Based Credit System)**
**(Introduced from June 2019 onwards)**

**Course Code :** CC-103
**Title of Course:** Complex Analysis
**Course Outcomes:** Upon successful completion of this course, the student will be able to:
1. understand fundamental concepts of complex analysis.
2. identify analytic functions, Conformal maps.
3. construct Taylor and Laurent series.
4. classify singularity and apply Residue Theorem to evaluate real integrals.
5. enjoy the beauty of analytic functions and related concepts.

**Unit 1:** Power series, Radius of convergence, analytic functions, Cauchy-Riemann equations, Harmonic functions, Conformal mappings, Mobius Transformations, line integral.
15 Lectures

**Unit 2:** Power series representation of analytic functions, zeros of an analytic function, Liouville's Theorem, Fundamental theorem of algebra, maximum modulus theorem, the index of a closed curve, Cauchy's theorem and integral formula, Morera's Theorem.
15 Lectures

**Unit 3**: Counting zeros, open Mapping theorem, Goursat's Theorem, classification of singularities, Laurent series development, Casorati–Weierstrass theorem, residues, residue theorem, evaluation of real integrals.
15 Lectures

**Unit 4**: The argument principle, Rouche's theorem, the maximum principle, Schwarz's lemma and its application to characterize conformal maps, Riemann mapping theorem.
15 Lectures

**Unit 5**: Examples seminars, group discussions on above four units. 15 Lectures

**Recommended Book :**
1. J. B. Conway: Functions of One Complex Variable (3rd Edition) Narosa Publishing House.

**References :**

1. S.Ponnusamy, Foundations of Complex Analysis, Narosa Publishing House.
2. Alfors L. V.: Complex Analysis, McGraw 1979.
3. Churchill and Brown, Complex Variables and applications, MacGraw Hill(India). ($8^{th}$ Edition, 2014)
4. Serge Lang, Complex Analysis, Springer
5. Steven G. Krantz, Complex Analysis, A Geometric view Point, The Carus Mathematical Monographs.
6. T. W. Gamelin, Complex Analysis, Springer.

**M.A./M. Sc. (Mathematics) (Part I) (Semester I)**
**(Choice Based Credit System)**
**(Introduced from June 2019 onwards)**

**Course Code :** CC-104

**Title of Course:** Classical Mechanics

**Course Outcomes:** Upon successful completion of this course, the student will be able to:

1. discuss the motion of system of particles using Lagrangian and Hamiltonian approach.
2. solve extremization problems using variational calculus.
3. discuss the motion of rigid body.
4. construct Hamiltonian using Routh process.
5. use infinitesimal and finite rotations to analyze motion of rigid body.

**UNIT – I:** Mechanics of a particle, Mechanics of a system of particles, conservation theorems, constraints, Generalized coordinates, D' Alembert's Principle, Lagrange's equations of motion, Simple applications of Lagrangian formulation, Cyclic co-ordinates and generalised momentum, conservation theorems **15 Lectures**

**UNIT – II:** Functionals, basic lemma in calculus of variations, Euler- Lagrange's equations, first integrals of Euler- Lagrange's equations, Geodesics in a plane and space, the minimum surface of revolution, the case of several dependent variables Undetermined end conditions, the problem of Brachistochrone, Isoperimetric problems, problem of maximum enclosed area.
Hamilton's Principle, Derivation of Hamilton's principle from D'Alembert's principle, Lagrange's equations from Hamilton's principle. Lagrange's equations of motion for nonconservative systems (Method of Langrange's undetermined multipliers) **15 Lectures**

**UNIT – III:** Hamiltonian function, Hamilton's canonical equations of motion, cyclic co-ordinates and Routh's procedure, Derivation of Hamilton's equations from variational principle, Physical significance of Hamiltonian, The principle of least action.
Orthogonal transformations, Properties of transformation matrix, infinitesimal rotations.
**15 Lectures**

**UNIT – IV:** The Kinematics of rigid body motion: The independent co-ordinates of a rigid body, the Eulerian angles, Euler's theorem on motion of rigid body, Angular momentum and kinetic energy of a rigid body with one point fixed, the inertia tensor and moment of inertia, Euler's equations of motion, Cayley- Klein parameters, Matrix of transformation in Cayley- Klein parameters, Relations between Eulerian angles and Cayley- Klein parameters. **15 Lectures**

**Unit V:** Examples, seminars, group discussions on above four units. **15 Lectures**

**Recommended Books :**

1) Goldstein, H. Classical Mechanics. (1980), Narosa Publishing House, New Delhi.
2) Weinstock: Calculus of Variations with Applications to Physics and Engineering (International Series in Pure and Applied Mathematics). (1952), Mc Graw Hill Book Company, New York.

**Reference Books :-** 1) Whittaker, E. T. A treatise on the Analytical Dynamics of particles and rigid bodies. (1965), Cambridge University Press.
2) Gupta, A. S. Calculus of Variations with Applications (1997), Prentice Hall of India.
3) Gelfand, I. M. and Fomin, S. V. Calculus of Variations (1963), Prentice Hall of India.
4) Rana, N.C. and Joag, P. S. Classical Mechanics. (1991) Tata McGraw Hill, New Delhi.

**M.A./M. Sc. (Mathematics) (Part I) (Semester I)**
**(Choice Based Credit System)**
**(Introduced from June 2019 onwards)**

**Course Code :** CC-105
**Title of Course:** Ordinary Differential Equations
**Course Outcomes:** Upon successful completion of this course, the student will be able to:
1. study basic notions in Differential Equations and use the results in developing advanced mathematics.
2. solve problems modeled by linear differential equations
3. use power series methods to solve differential equations about ordinary points and regular singular points.
4. construct approximate solutions using method of successive approximation.
5. establish uniqueness of solutions.

**Unit – I : Linear Equations with variable coefficients:** Initial value problems for the homogeneous equations. Solutions of the homogeneous equations, The Wronskian and linear independence, Reduction of the order of a homogeneous equation, The non-homogenous equations, Homogeneous equations with analytic coefficients, The Legendre equations. **15 Lectures**

**Unit - II: Linear Equations with regular singular points:** The Euler equations, Second order equations with regular singular points, The Bessel equation, Regular singular points at infinity. **15 Lectures**

**Unit - III: Existence and uniqueness of solutions to first order equations:** The method of successive approximations, The Lipschitz condition of the successive approximation. Convergence of the successive approximation, Non-local existence of solutions, Approximations to solutions and uniqueness of solutions. **15 Lectures**

**Unit – IV: Existence and Uniqueness of Solutions to System of first order ordinary differential equations:** An example- Central forces and planetary motion, Some special equations, Systems as vector equations , Existence and uniqueness of solutions to systems, Existence and uniqueness for linear systems, Green's function, Sturm Liouville theory. **15 Lectures**

**Unit -V:** **15 Lectures**

Examples, Problems, assignments, seminars etc. based on Units 1-4 above.

**Recommended books:**
**1)** E.A.Coddington: An introduction to ordinary differential equations. (2012) Prentice Hall of India Pvt.Ltd. New Delhi.
**2)** G. Birkoff and G.G.Rota: Ordinary Differential equations, John Willey and Sons
3) Mark Pinsky: Partial differential equations and boundary-value problems with applications, AMS,3$^{rd}$ edition(2011).

**Reference books:**
**1.** G.F. Simmons Differential Equations with Applications and Historical note, MeGraw Hill, Inc. New York. (1972)
**2.** E.A. Coddington and Levinson: Theory of ordinary differential equations McGraw Hill, New York(1955)
3.E.D. Rainvills :Elementary differential equations, The Macmillan company, New York. (1964)

# M.A./M. Sc. (Mathematics) (Part I) (Semester II)

| Course code | Title of course |
|---|---|
| CC-201 | Functional Analysis |
| CC-202 | Algebra |
| CC-203 | General Topology |
| CC-204 | Numerical Analysis |
| CC-205 | Partial Differential Equations |
| SEC-206 | Fundamentals of Information Technology (FIT)-I |

**M.A./M. Sc. (Mathematics) (Part I) (Semester II)**
**(Choice Based Credit System)**
**(Introduced from June 2019 onwards)**

**Course Code:** CC-**201**
**Title of Course: Functional Analysis**
**Course Outcomes:** Upon successful completion of this course, the student will be able to:
1. understand the fundamental topics, principles and methods of functional analysis.
2. demonstrate the knowledge of normed spaces, Banach spaces, Hilbert space.
3. define continuous linear transformations between linear spaces, bounded linear functionals.
4. apply finite dimensional spectral theorem.
5. identify normal, self adjoint, unitary, Hermit ion operators.

**Unit I**: Normed linear spaces, Banach spaces, Quotient spaces, Continuous linear transformations, Equivalent norms, Finite dimensional normed spaces and properties, Conjugate space and separability, The Hahn-Banach theorem and its consequences. **15 Lectures**

**Unit II:** Second conjugate space, the natural embedding of the normed linear space in its second conjugate space, Reflexivity of normed spaces, The open mapping theorem, Projection on Banach space, the closed graph theorem, the conjugate of an operator, the uniform boundedness principle. **15 Lectures**

**Unit III:** Hilbert spaces: examples and elementary properties, Orthogonal complements, The projection theorem, Orthogonal sets, The Bessel's inequality, Fourier expansion and Perseval's equation, separable Hilbert spaces, The conjugate of Hilbert space, Riesz's theorem, The adjoint of an operator. **15 Lectures**

**Unit IV**: Self adjoint operators, Normal and Unitary operators, Projections, Eigen values and eigenvectors of an operator on a Hilbert space, The determinants and spectrum of an operator, The spectral theorem on a finite dimensional Hilbert space. **15 Lectures**

**Unit V**: Examples, seminars, group discussions on above four units. **15 Lectures**

**Recommended Book(s):**

1. G. F. Simmons, Introduction to Topology and Modern Analysis, Tata McGraw Hill, 1963.

**Reference Books:**

4. Erwin Kreyszig, Introductory Functional Analysis with Applications, John Wiley and Sons, 1978
5. A. E. Taylor, Introduction to Functional analysis, John Wiley and sons,1958.
6. J. B. Convey, A course in Functional Analysis, Springer-Verlag, 1985.
7. G. Bachman and L. Narici, Functional Analysis, Academic Press, 1972.
8. B. V. Limaye, Functioned Analysis, New age international, 1996.

**M.A./M. Sc. (Mathematics) (Part I) (Semester II)**
**(Choice Based Credit System)**
**(Introduced from June 2019 onwards)**

**Course Code:** CC-**202**
**Title of Course: Algebra**
**Course Outcomes:** Upon successful completion of this course, the student will be able to:
1. study group theory and ring theory in some details.
2. introduce and discuss module structure over a ring.
3. apply Sylow theorems.
4. use homomorphism and isomorphism theorems.
5. check irreducibility of polynomials over Q using Eisenstein criteria.

**Unit I**: Groups of permutations, Simple groups, simplicity of $A_n$ (n > 5), Commutator subgroups, normal and subnormal series, Jordan-Holder theorem, Solvable groups, isomorphism theorems, Zassenhaus Lemma, Schreier refinement theorem. **15 Lectures**

**Unit II:** Group action on a set, fixed sets and isotropy subgroups, Burnside theorem, Sylow theorems, p-groups, Applications of the Sylow theory and Class equation. **15 Lectures**

**Unit III:** Rings of polynomials, factorization of polynomials over fields, the division algorithm in F[x], irreducible polynomials, Eisenstein criteria, ideals in F[x], uniqueness of factorization in F[x], unique factorization domains, principal ideal domain, Gauss lemma, Euclidean Domains. **15 Lectures**

**Unit IV**: Modules, sub-modules, quotient modules, homomorphism and isomorphism theorems, fundamental theorem for modules, Simple modules, Schur's lemma, Artinian and Noetherian modules. **15 Lectures**

**Unit V**: Examples, seminars, group discussions on above four units. **15 Lectures**

**Recommended Book(s):**

3. John B. Fraleigh , A first course in Abstract Algebra (Third Edition), Narosa publishing house, New Delhi.
4. C. Musili, Introduction to Rings and Modules (Second Revised Edition), Narosa Publishing house, New Delhi.

**Reference Books:**

9. Joseph A. Gallian, Contemporary Abstract Algebra (Fourth Edition), Narosa Publishing house, New Delhi.
10. Bhattacharya, Jain and Nagpal, Basic Abstract Algebra, 2nd edition, Narosa Publishing House, New Delhi.
11. I. N. Herstein, Topics in Algebra, Vikas Publishing House.
12. N. Jacobson, Basic Algebra, Hind Publishing Corporation, 1984.

**M. A. / M. Sc. Mathematics (Part I) (Semester II)**

**(Choice Based Credit System)**

**(Introduced from June 2019 onwards)**

**Course Code:** CC-**203**
**Title of Course**: **General Topology**
**Course Outcomes:** Upon successful completion of this course, the student will be able to:
1. built foundations for future study in analysis, in geometry, and in algebraic topology.
2. introduce the fundamental concepts in topological spaces.
3. acquire demonstrable knowledge of topological spaces, product spaces, and continuous functions on topological spaces.
4. identify compact and connected sets in topological spaces.
5. use Separation and countability axioms, Urysohn lemma, Urysohn metrization theorem and the Tychonoff theorem.

**Unit I:** Topological Spaces, Basis for a Topology, The Order Topology, The Product Topology on $X \times Y$, The Subspace Topology, Closed Sets and Limit Points, Continuous Functions.
**15 Lectures**

**Unit II:** The Product Topology, The Metric Topology, Connected Spaces, Connected Subspaces of the Real Line, Components and Local Connectedness. **15 Lectures**

**Unit III:** Compact Spaces, Compact Subspaces of the Real Line, Limit Point Compactness, Local Compactness, The Countability Axioms. **15 Lectures**

**Unit IV:**, The Separation Axioms, Normal Spaces, The Urysohn Lemma, The Urysohn Metrization Theorem (Only statement and its importance), The Tietze Extension Theorem (Only statement and its importance), The Tychonoff Theorem.
**15 Lectures**

**Unit V**: Examples, seminars, group discussions on above four units. **15 Lectures**

**Recommended Book:**

1. J. R. Munkers, Topology, Second Edition, Pearson Education (Singapore), 2000.

**Reference Books:**

1. W. J. Pervin, Foundations of General Topology, Academic Press, New York, 1964.
2. J. L. Kelley, General Topology, Springer-Verlag, New York, 1955.
3. S. Willard, General Topology, Addison-Wesley Publishing Company, 1970.
4. K. D. Joshi, Introduction to General Topology, New Age International, 1983.
5. G. F. Simmons, Introduction to Topology and Modern Analysis, McGraw Hill Book Company, New Delhi, 1963.

**M.A./M. Sc. (Mathematics) (Part I) (Semester II)**
**(Choice Based Credit System)**
**(Introduced from June 2019 onwards)**

**Course Code** CC-**204**

**Title of Paper: Numerical Analysis**

**Course Outcomes:** Upon successful completion of this course, the student will be able to:

1. apply the methods to solve linear and nonlinear equations.
2. find numerical integration and analyze error in computation.
3. solve differential equations using various numerical methods.
4. determine eigen values and eigen vectors of a square matrix.
5. construct LU decomposition of a square matrix.

**Unit I** **15 Lectures**

**Algebraic and transcendental equations:**
Rate of Convergence of Secant method, Regula Falsi method and Newton-Raphson method. Bairstow method.
**System of linear equations**: Matrix factorization methods (Doo little reduction, Crout reduction), Eigen values and eigenvectors, Gerschgorin theorem, Brauer theorem, Jacobi method for symmetric matrices.

**Unit II** **15 Lectures**

**Numerical Integration**: Error estimates of trapezoidal and Simpson's numerical integration rule. Gauss-Legendre integration methods (n=1, 2), Lobatto integration method (n=2), Radau integration method (n=2) and their error estimates.

**Unit III** **15 Lectures**

Runge–Kutta Methods: Second order methods, The coefficient tableau, Third order methods (without proof), order conditions, Fourth order methods (without proof), Implicit Runge–Kutta methods, Stability characteristics.
Taylor Series Methods: Introduction to Taylor series methods, Manipulation of power series, An example of a Taylor series solution.

**Unit IV** **15 Lectures**

**Linear Multistep Methods**: Adams methods, General form of linear multistep methods, Predictor–corrector Adams methods, Starting methods.
**Analysis of Linear Multistep Methods**: Convergence, Consistency, Sufficient conditions for convergence, Stability Characteristics.

**Unit V** **15 Lectures**
Problems, assignments, seminars etc. based on Units 1-4 above.

**Recommended Books :**
**1.** Numerical methods for scientific and Engineering Computation, M.
K. Jain, S. R. K. Iyengar, R. K. Jain, New Age International Limited Publishers, 6th edition.
(For Units 1 and 2)
2. Numerical methods for ordinary differential equations, J.C. Butcher, John Wiley & Sons Ltd, 2nd edition. (For Units 3 and 4)
**Reference Books :-**
1. Discrete variable methods in ordinary differential equations, P. Henrici, John Wiley &Sons Ltd.
**2.** Introductory methods of Numerical Analysis' S. S. Sastry, Prentice Hall of India New Delhi.
3.Numerical solutions of Differential Equations by M. K. Jain

**M.A./M. Sc. (Mathematics) (Part I) (Semester II)**
**(Choice Based Credit System)**
**(Introduced from June 2019 onwards)**

**Course Code:** CC-**205**
**Title of Course: Partial Differential Equations**
**Course Outcomes:** Upon successful completion of this course, the student will be able to:
1. classify partial differential equations and transform into canonical form
2. solve linear partial differential equations of both first and second order.
3. solve boundary value problems for Laplace's equation, the heat equation, the wave equation by separation of variables, in Cartesian, polar, spherical and cylindrical coordinates.
4. apply method of characteristics to find the integral surface of a quasi linear partial differential equations.
5. establish uniqueness of solutions of partial differential equations.

**Unit I:** **15 Lectures**
Curves and surfaces, First order Partial Differential Equations, classification of first order partial differential equations, classifications of Integrals, Linear equations of first order. Pfaffian differential equations, Criteria of Integrability of a Pfaffian differential equation. Compatible systems of first order partial differential equations.

**Unit II:** **15 Lectures**
Charpits method, Jacobi method of solving partial differential equations, Cauchy Problem, Integral surfaces through a given curve for a linear partial differential equations, for a non-linear partial differential equations. Method of characteristics to find the integral surface of a quasi linear partial differential equations.

**Unit III:** **15 Lectures**
Second order Partial Differential Equations. Origin of Partial differential equation, wave equations, Heat equation. Classification of second order partial differential equation, Vibration of an infinite string (both ends are not fixed), Physical Meaning of the solution of the wave equation. Vibration of an semi infinite

string, Vibration of a string of finite length, Method of separation of variables, Uniqueness of solution of wave equation. Heat conduction Problems with finite rod and infinite rod.

**Unit IV:** **15 Lectures**

Families to equipotential surfaces, Laplace equation, Solution of Laplace equation, Laplace equation in polar form, Laplace equation in spherical polar coordinates. Kelvin's inversion theorem. Boundary Value Problems: Dirichlets problems and Neumann problems, Maximum and minimum principles, Stability theorem. Dirichlet Problems and Neumann problems for a circle, for a rectangle and for a upper half plane, Duhamel's Principle.

**Unit V**: **15 Lectures**

Examples, seminars, group discussions on above four units.

**Recommended Book:**

1. T. Amarnath: An elementary course in Partial differential equations, 2nd edition, Narosa publishing House(2012).

**Reference Books:**

1. Mark Pinsky: Partial differential equations and boundary-value problems with applications, AMS,3rd edition(2011).
2. I. N. Sneddon: Elements of Partial Differential Equations, McGraw Hill Int.
3. Fritz John: Partial Differential Equations, Springer(1952).

## Nature of the Theory Question Papers:

1. There shall be 7 questions each carrying 18 marks
2. Question No.1 is compulsory. It consists of objective type questions.
3. Students have to attempt any four questions from Question No.2 to Question No.7.
4. Question No.2 shall consists of short-answer type sub-questions
5. Question No.2 to Question No.7 shall consists of descriptive-answer type questions /sub-questions.

Equivalence for M.Sc. -I (Semester-I) courses

| **Sr. No.** | **Old title** | **New title** |
|---|---|---|
| 1 | Algebra - I | Algebra |
| 2 | Advanced Calculus | Advanced Calculus |
| 3 | Real Analysis | Real Analysis (Part II, Sem III) |
| 4 | Differential Equations | Differential Equations |
| 5 | Classical Mechanics | Classical Mechanics |

Equivalence for M.Sc. Part-I (Semester-II) courses

| **Sr. No.** | **Old title** | **New title** |
|---|---|---|
| 1 | Linear Algebra | Linear Algebra |
| 2 | Topology | General Topology |
| 3 | Complex Analysis | Complex Analysis (Part I, Sem I) |
| 4 | Numerical Analysis | Numerical Analysis |
| 5 | Differential Geometry | Differential Geometry (Part II, Sem III) |

Equivalence for M.Sc. Part-II (Semester-III) courses

| **Sr. No.** | **Old title** | **New title** |
|---|---|---|
| 1 | Functional Analysis | Functional Analysis (Part I, Sem II) |
| 2 | Advanced Discrete Mathematics | Advanced Discrete Mathematics |
| 3 | Number Theory | Number Theory |
| 4 | Integral Equations | Integral Equations (Part II, Sem IV) |
| 5 | Riemannian geometry -I | Space Dynamics-I |
| 6 | General Relativity I | General Relativity - I |
| 7 | Operations Research I | Operations Research - I |
| 8 | Lattice Theory –I | Lattice Theory –I |
| 9 | Approximation Theory | Approximation Theory |
| 10 | Dynamical Systems- I | Dynamical Systems- I |
| 11 | Fluid Dynamics | Fluid Dynamics |
| 12 | Graph Theory-I | Graph Theory-I |
| 13 | Fuzzy Mathematics | Fuzzy Mathematics-I |
| 14 | Algebraic Topology | Fractional Calculus |
| 15 | Measure and Integration | Measure and Integration (Part II, Sem IV) |
| 16 | Topological Vector Spaces | Topological Vector Spaces |
| 17 | Commutative Algebra I | Commutative Algebra - I |

Equivalence for M.Sc. Part-II (Semester-IV) courses

| Sr. No. | Old title | New title |
|---|---|---|
| 1 | Field Theory | Field Theory (Part II, Sem III) |
| 2 | Partial Differential Equations | Partial Differential Equations (Part I, Sem II) |
| 3 | Algebraic Number Theory | Algebraic Number Theory |
| 4 | Fractional Differential Equations | Fractional Differential Equations |
| 5 | Riemannian Geometry -II | Space Dynamics-II |
| 6 | General Relativity II | General Relativity II |
| 7 | Operations Research –II | Operations Research –II |
| 8 | Lattice Theory –II | Lattice Theory –II |
| 9 | Wavelet Analysis | Wavelet Analysis |
| 10 | Dynamical Systems- II | Dynamical Systems- II |
| 11 | Computational Fluid Dynamics | Computational Fluid Dynamics |
| 12 | Graph Theory-II | Graph Theory-II |
| 13 | Fuzzy Relations and Logic | Fuzzy Mathematics- II |
| 14 | Analysis on Manifolds | Analysis on Manifolds |
| 15 | Combinatorics | Combinatorics |
| 16 | Theory of Distributions | Theory of Distributions |
| 17 | Commutative Algebra – II | Commutative Algebra – II |