SHIVAJI UNIVERSITY, KOLHAPUR

New Syllabi of M.A./M.Sc. Mathematics (Part I) (CBCS) (To be implemented in the Department of Mathematics, Shivaji University and in P.G. Centers in Affiliated Colleges) (with effect from 2018-2019)

1) Title of the course: M.A./M.Sc. (Mathematics)

M. Sc. (Mathematics) program has semester pattern and Choice Based Credit System. The program consists of 100 credits.

2) Structure of the course

The following table gives the scheme of Examination at M.A./M.Sc. Mathematics (Part I) according to the New Syllabus and pattern of Examination.

M.A./M.Sc.(Mathematics) Semester - I (25 credits)

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Title of course</th>
<th>Instruction hrs/week</th>
<th>Duration of Term end Exam</th>
<th>Marks-Term end exam</th>
<th>Marks-(Internal) Continuous Assessment</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>MT 101</td>
<td>Advanced Calculus</td>
<td>5</td>
<td>3</td>
<td>90</td>
<td>30</td>
<td>5</td>
</tr>
<tr>
<td>MT 102</td>
<td>Linear Algebra</td>
<td>5</td>
<td>3</td>
<td>90</td>
<td>30</td>
<td>5</td>
</tr>
<tr>
<td>MT 103</td>
<td>Complex Analysis</td>
<td>5</td>
<td>3</td>
<td>90</td>
<td>30</td>
<td>5</td>
</tr>
<tr>
<td>MT 104</td>
<td>Classical Mechanics</td>
<td>5</td>
<td>3</td>
<td>90</td>
<td>30</td>
<td>5</td>
</tr>
<tr>
<td>MT 105</td>
<td>Ordinary Differential Equations</td>
<td>5</td>
<td>3</td>
<td>90</td>
<td>30</td>
<td>5</td>
</tr>
</tbody>
</table>

M.A./M.Sc.(Mathematics) Semester - II (25 credits)

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Title of course</th>
<th>Instruction hrs/week</th>
<th>Duration of Term end Exam</th>
<th>Marks-Term end exam</th>
<th>Marks-(Internal) Continuous Assessment</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>MT 201</td>
<td>Functional Analysis</td>
<td>5</td>
<td>3</td>
<td>90</td>
<td>30</td>
<td>5</td>
</tr>
<tr>
<td>MT 202</td>
<td>Algebra</td>
<td>5</td>
<td>3</td>
<td>90</td>
<td>30</td>
<td>5</td>
</tr>
<tr>
<td>MT 203</td>
<td>General Topology</td>
<td>5</td>
<td>3</td>
<td>90</td>
<td>30</td>
<td>5</td>
</tr>
<tr>
<td>MT 204</td>
<td>Numerical Analysis</td>
<td>5</td>
<td>3</td>
<td>90</td>
<td>30</td>
<td>5</td>
</tr>
<tr>
<td>MT 205</td>
<td>Partial Differential Equations</td>
<td>5</td>
<td>3</td>
<td>90</td>
<td>30</td>
<td>5</td>
</tr>
</tbody>
</table>

Open Electives for PG Students:

<table>
<thead>
<tr>
<th>Semester</th>
<th>Title of course</th>
<th>Instruction hrs/week</th>
<th>Intake Capacity</th>
<th>Eligibility</th>
<th>Marks and Exam</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>ODD</td>
<td>Classical Mechanics</td>
<td>5</td>
<td>15</td>
<td>Physics</td>
<td>As per MT 104</td>
<td>5</td>
</tr>
<tr>
<td>EVEN</td>
<td>Numerical Analysis</td>
<td>5</td>
<td>15</td>
<td>Science and Technology</td>
<td>As per MT 204</td>
<td>5</td>
</tr>
</tbody>
</table>
M.A./M. Sc. (Mathematics) (Part I) (Semester I)
Course Code: MT 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, Equi continuous 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:

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

Recommended books:
Reference books:
2) J.R. Munkres, Analysis on Manifolds.
Course Code: MT 102
Title of Course: Linear Algebra

Course Outcomes: To introduce basic notions in Linear Algebra and use the results in developing advanced mathematics. To study the properties of Vector Spaces, Linear Transformations, Algebra of Linear Transformations and Inner product space in some details. To introduce and discuss Canonical forms and Bilinear forms. After studying this course, students will have a demonstrable 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):

Reference Books:
Course Code: MT 103
Title of Course: Complex Analysis
Course Outcomes: The course is designed to familiarize fundamental concepts of complex analysis. This course includes topics such as analytic functions, Conformal maps, Taylor and Laurent series, singularity, Residue Theorem, Riemann mapping theorem. After completion of this course students will be able to enjoy the beauty of analytic functions and related concepts, use residue theorems to evaluate real integrals.

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

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.

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.

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

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

Recommended Book:

References:
4. Serge Lang, Complex Analysis, Springer
Course Code: MT 104
Title of Course: Classical Mechanics
Course Outcomes: Having successfully completed this course, the students will be able to-

- Discuss the motion of system of particles using Lagrangian and Hamiltonian approach.
- Solve extremization problems using variational calculus.
- Discuss the 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 – 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:
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.
Course Code : MT 105
Title of Course: Ordinary Differential Equations
Course Outcomes: The aim of this course is to study basic notions in Differential Equations and use the results in developing advanced mathematics. After completion of this course students will able to solve application problems modeled by linear differential equations and will able to use power series methods to solve differential equations about ordinary points and regular singular points.

(v) UNIT


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 – 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:
2) G. Birkoff and G.G.Rota: Ordinary Differential equations, John Willey and Sons

Reference books:
M.A./M. Sc. (Mathematics) (Part I) (Semester II)
(i)Course Code: MT201  
(ii) Title of Course: Functional Analysis  
(iii) Course Outcomes: The course is designed to familiarize the students with the fundamental topics, principles and methods of functional analysis. After studying this course, students will have a demonstrable knowledge of normed spaces, Banach spaces, Hilbert space, continuous linear transformations between such spaces, bounded linear functionals and finite dimensional spectral theorem.

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

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): 

Reference Books: 
M.A./M. Sc. (Mathematics) (Part I) (Semester II)
(Choice Based Credit System)
(Introduced from June 2018 onwards)

(i) Course Code: 202
(ii) Title of Course: Algebra

(iii) Course Outcomes: To study group theory and ring theory in some details. To introduce and discuss module structure over a ring. After studying this course, students will have a demonstrable knowledge of groups, polynomial rings and modules.

**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):**

**Reference Books:**
(Choice Based Credit System)
(Introduced from June 2018 onwards)

(i) Course Code: 203
(ii) Title of Course: General Topology
(iii) Course Outcomes: The Subject of topology serves to lay the foundations for future study in analysis, in geometry, and in algebraic topology. The objective of this course is to introduce the fundamental concepts in topological spaces. After studying this course, students will have a demonstrable knowledge of topological spaces, product spaces, and continuous functions on topological spaces, compact and connected sets in topological spaces, Separation and countability axioms, Urysohn lemma, Urysohn metrization theorem and the Tychonoff theorem.


15 Lectures


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:


Reference Books:

(i) Course Code  MT  204  
(ii) Title of Paper: Numerical Analysis  
(iii) Course Outcomes:  
Having successfully completed this course, the students will be able to--  
- Discuss the methods to solve linear and nonlinear equations.  
- Find numerical integration and analyze error in computation.  
- Solve differential equations using various numerical methods.

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 (Doolittle reduction, Crout reduction), Eigen values and eigenvectors, Gershgorin 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  
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 :  
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.  
M.A./M. Sc. (Mathematics) (Part I) (Semester II)
(Choice Based Credit System)
(Introduced from June 2018 onwards)

Course Code: MT 205
Title of Course: Partial Differential Equations

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

i. Classify partial differential equations and transform into canonical form
ii. Solve linear partial differential equations of both first and second order.
iii. 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.

Unit I: 15 Lectures

Unit II: 15 Lectures

Unit III: 15 Lectures

Unit IV: 15 Lectures

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

Recommended Book:

Reference Books:
1. **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.