Shivaji University, Kolhapur

Name of Department: Mathematics

Name of Programme: M.Sc. Mathematics

Vision
The vision of the Department is to be a premier institute of higher learning and research in Mathematics at National and International levels.
Mission
To prepare excellent academicians and software developers to cater for the needs of academic institutes and industries.
Program Outcomes
1. To develop problem-solving skills and apply them independently to problems in pure and applied mathematics. 2. To develop abstract mathematical thinking. 3. To improve the abilities of students which will be helpful to qualify competitive examinations. 4. Apply knowledge of Mathematics, in all the fields of learning including higher research. 5. Work effectively as an individual, and also as a member or leader in multi-linguistic and multi-disciplinary teams. 6. To qualify lectureship and fellowship exams such as NET, GATE, SET etc. 7. Understand the basic concepts, fundamental principles and mathematical theories related to various courses and their relevance to other sciences.
Program Specific Outcomes
1. To solve the problems in mass and heat transfer by using the methods on partial differential equations. 2. To train the students to handle the differentiation and integration in higher dimensions. 3. To solve real-life problems using numerical and wavelet analysis. 4. To use mathematical software to analyse the dynamical systems. 5. To study abstract structures.

Course Outcomes		
Part-I Semester-I		
CC-101	Advanced Calculus	1. Analyze convergence of sequences and series of functions 2. check differentiability of functions of several variables 3. Apply inverse and implicit function theorems for functions of several variables 4. Use Green's theorem, Stoke's Theorem, Gauss divergence Theorem.
CC-102	Linear Algebra	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 3. construct Canonical forms and Bilinear forms. 4. apply knowledge of Vector space, Linear Transformations, Canonical Forms and Bilinear Transformations.
CC-103	Complex Analysis	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.
CC-104	Classical Mechanics	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.
CC-105	Ordinary Differential Equations	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
Part-I Semester-II		
CC-201	Functional Analysis	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.
CC-202	Algebra	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.
CC-203	General Topology	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.
CC-204	Numerical Analysis	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.
CC-205	Partial Differential Equations	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.
Part-II Semester-III		
CC- 301	Real Analysis	1. generalise the concept of length of interval. 2. analyse the properties of Lebesgue measurable sets. 3. demonstrate the measurable functions and their properties. 4. understand the concept of Lebesgue integration of measurable functions. 5. characterize Riemann and Lebesgue integrability.

		6. prove completeness of L ▪ Spaces.
DSE- 302	Advanced Discrete Mathematics	1. classify the graphs and apply to real world problems. 2. simplify the graphs using matrix. 3. study Binomial theorem and use to solve various combinatorial problems. 4. simplify the Boolean identities and apply to switching circuits. 5. locate and use information on discrete mathematics and its applications
DSE- 302	Topological Vector Spaces	1. Apply topological concepts on vector spaces. 2. Construct homeomorphisms on different topological vector spaces. 3. Understand and apply separation properties. 4. formulate compatible metric on topological vector spaces. 5. Study Frechet spaces.
CCS-303, CCS-304, CCS-305	Number Theory	1. learn more advanced properties of primes and pseudo primes. 2. apply Mobius Inversion formula to number theoretic functions. 3. explore basic idea of cryptography. 4. understand concept of primitive roots and index of an integer relative to a given primitive root. 5. derive Quadratic reciprocity law and its apply to solve quadratic congruences.
CCS-303, CCS-304, CCS-305	Operations Research I	1. identify Convex set and Convex functions. 2. Construct linear integer programming models and discuss the solution techniques, 3. Formulate the nonlinear programming models, 4. Propose the best strategy using decision making methods, 5. solve multi –level decision problems using dynamic programming method.
CCS-303, CCS-304, CCS-305	Fuzzy Mathematics-I	1. acquire the knowledge of notion of crisp sets and fuzzy sets, 2. understand the basic concepts of crisp set and fuzzy set,

		3. develop the skill of operation on fuzzy sets and fuzzy arithmetic, 4. demonstrate the techniques of fuzzy sets and fuzzy numbers. 5. apply the notion of fuzzy set, fuzzy number in various problems.
CCS-303, CCS-304, CCS-305	Fluid Dynamics	1) explain physical properties of fluids. 2) represent general motion of fluid element. 3) test possible fluid flows, classify rotational and irrotational fluid flows . 4) transform stress components from one co-ordinate system to another, establish relation between strain and stress tensor.. 5) develop constitutive equations for Newtonian fluids, conservation laws and Navier-Stokes equation. 6) determine the complex potential and images of a two dimensional source, sink and doublet.
CCS-303, CCS-304, CCS-305	Fractional Calculus	1. compare Grünwald-Letnikov,Riemann-Liouville,and Caputo fractional derivative. 2. evaluate fractional derivatives and fractional integral of power function and trigonometric functions 3. analyze the behaviour of fractional derivatives near and far from the lower terminal 4. derive important properties such as linearity, compositions, Commutatively and Leibnitz rule for fractional derivatives 5. evaluate transforms of fractional derivatives and integrals. 6. solve fractional differential equations using transform methods.
CCS-303, CCS-304, CCS-305	General Relativity I	1. understand Albert Einstein's special and general theory of relativity. 2. formulate fields of General Relativity. 3. relate the covariant derivative and geodesic curves

		4. calculate components of the Riemann curvature tensor form a line element. 5. derive Necessary and Sufficient condition for isometry
CCS-303, CCS-304, CCS-305	Lattice Theory –I	1. Students should acquire thorough knowledge of fundamental notions from lattice theory and properties of lattices 2. To learn Modular and Distributive lattice 3. To learn about Boolean algebra 4. To know Stone Algebra 5. Students should develop ability to solve individually and creatively advanced problems of lattice theory and also problems connected with its applications to mathematics 6. Describe Lattices and Posets and their use
CCS-303, CCS-304, CCS-305	Approximation Theory	1. Construct approximate polynomial for periodic function using Bernstein polynomials 2. Interpolate given function using finite interpolation. 3. determine error bounds in polynomial approximations and establish uniqueness of approximating polynomials. 4. prove convergence of Fourier series of a function of bounded variation. 5. establish orthogonality of Jacobi polynomials and predict zeros of orthogonal polynomials. 6. formulate recurrence relations of orthogonal polynomials.
CCS-303, CCS-304, CCS-305	Dynamical Systems- I	1. Classify equilibrium points of the dynamical system 2. Construct bifurcation diagrams and analyze the system for different values of parameter. 3. Relate the qualitative properties of the system with the eigen values of coefficient matrix. 4.Estimate the solution of the system using the canonical form of coefficient matrix 5.Construct the exponential of a matrix and

		apply it to solve the dynamical system. 6. Examine the discrete dynamical systems.
CCS-303, CCS-304, CCS-305	Graph Theory-I	1. classify the graphs and solve the related problems. 2. understand Euler Graph and Hamiltonian Graph to solve problems. 3. use matching's to solve optimal assignment problems. 4. solve network problems 5. solve graph theoretic problems and apply algorithms
CCS-303, CCS-304, CCS-305	Differential Geometry	1. find the directional derivatives of the functions. 2. compare the unit-speed and arbitrary-speed curves. 3. apply the Frenet formulas to analyze the curves. 4. examine whether the given set in R3 is a surface. 5. construct the parametrizations of different surfaces. 6. formulate different types of curvatures of given surface.
CCS-303, CCS-304, CCS-305	Combinatorics	1. describe Pigeonhole principle and use it to solve problems. 2. use definitions and theorems from memory to construct solutions to problems 3. use Burnside Frobenius Theorem in counting's. 4. use various counting techniques to solve various problems. 5. apply combinatorial ideas to practical problems. 6. improve mathematical verbal communication skills.
CCS-303, CCS-304, CCS-305	Commutative Algebra – I	1. classify the ideals to solve the related problems. 2. understand various radicals.

		3. know Hilbert basis theorem and apply it to other development. 4. use Nakayama Lemma for further development in Noetherion Rings. 5. Derive The Krull intersection theorem
CCS-303, CCS-304, CCS-305	Space dynamics- I	1. formulate trajectory equations and classify trajectories 2. Calculate flight path angle 3. determine orbit from position vectors and from one ground based observation 4. Calculate time of flight and orbit propagation 5. use perturbation methods 6. calculate atmospheric drag.
CCS-303, CCS-304, CCS-305	Theory of Computation	1. derive The Myhill Nerode theorem . 2. understand context free grammars. 3. explain The pumping Lemma for context free Languages. 4. describe Churchs hypothesis.
CCS-303, CCS-304, CCS-305	Algebraic Topology	(i) develop the concept of homotopy of paths (ii) combine the group theory and topology to define fundamental groups of curves and surfaces (iii) determine the fundamental groups of various curves (iv) build the concept of retraction and use to study homotopy (v) evaluate the fundamental group of compact 2-manifolds by applying Seifert-van Kampen theorem.
CCS-303, CCS-304, CCS-305	Probability and Stochastic Processes	1. Apply the specialised knowledge in probability theory and random processes to solve practical problems. 2. Gain advanced and integrated understanding of the fundamentals of and interrelationship between

		discrete and continuous random variables and between deterministic and stochastic processes. 3. Create mathematical models for practical design problems and determine theoretical solutions to the created models.
Part-II semester-IV		
CC- 401	Field Theory	1) determine the basis and degree of a field over its subfield. 2) construct splitting field for the given polynomial over the given field. 3) find primitive nth roots of unity and nth cyclotomic polynomial. 4) make use of Fundamental Theorem of Galois Theory and Fundamental Theorem of Algebra to solve problems in Algebra. 5) apply Galois Theory to constructions with straight edge and compass.
DSE- 402	Integral Equations	1. classify the linear integral equations and demonstrate the techniques of converting the initial and boundary value problem to integral equations and vice versa. 2. develop the technique to solve the Fredholm integral equations with separable kernel. 3. develop and demonstrate the technique of solving integral equations by successive approximations, using Laplace and Fourier transforms 4. to analyze the properties of symmetric kernel. 5. toprove Hilbert Schmidt Theorem and solve the integral equation by applying it.
DSE- 402	Measure and Integration	1. generalise the concept of measure. 2. appreciate the properties of Lebesgue measurable sets. 3. demonstrate the measurable functions and their properties. 4. understand the concept of Lebesgue integration of general measurable functions. 5. apply Fubini and Tonelli theorem to

		interchange order of the integration.
CCS-403, CCS-404, CCS-405	Algebraic Number Theory	1. deal with algebraic numbers , algebraic integers and its applications, 2. concept of lattices and geometric representation of algebraic numbers. 3. Understand the concept of fractional ideals. 4. relate Finitely generated abelian groups and modules 5. derive Minkowski's theorem. 6. compute class groups and class numbers.
CCS-403, CCS-404, CCS-405	Operations Research – II	1.decide policy for replacement. 2.calculate economic lot size. 3.derivePoission distribution theorem and compute attributes of distribution model. 4.construct Shannon Fano codes. 5.identify optimal path by using CPM and PERT.
CCS-403, CCS-404, CCS-405	Fuzzy Mathematics-II	1. acquire the concept of fuzzy relations. 2. understand the basic concepts of fuzzy logic and fuzzy algebra. 3. develop the skills of solving fuzzy relation equations. 4. construct approximate solutions of fuzzy relation equations. 5.solve problems in Engineering and medicine.
CCS-403, CCS-404, CCS-405	Computational Fluid Dynamics	1. classify partial differential equations (PDEs) mathematically and physically. 2. apply separation of variables method for solving initial boundary value problems. 3. construct forward, backward and centered difference formulae. 4. test stability, convergence & consistency of finite difference schemes. 5. solve problems in CFD using computer software.
CCS-403, CCS-404, CCS-405	Fractional Differential Equations	1. analyze existence and uniqueness of solution of fractional differential equations. 2. apply Mittag-Leffler functions to derive the solution of fractional differential equations.

		3. analyse data dependency of solution of fractional differential equations. 4. examine the properties of solution of fractional differential equations with initial boundary conditions. 5. derive stability results for fractional differential equations.
CCS-403, CCS-404, CCS-405	General Relativity – II	1. able to solve Einstein field equations under spherical symmetry. 2.understand calculating relativistic frequency shifts for the bending of light passing a spherical mass distribution. 3.understand energy moment tensor, stress energy moment tensor for perfect fluid. 4. understand exterior product, derivative and P-forms. 5. calculate Bianchi identities in tetrad form.
CCS-403, CCS-404, CCS-405	Lattice Theory -II	1. analyze Congrunces and Ideals 2. check Modularity and semimodularity in given lattice 3. apply geometric closure operator 4. use Kurosh – Ore replacement property
CCS-403, CCS-404, CCS-405	Wavelet Analysis	1. calculate Fourier transforms and wavelet transforms of functions. 2. carry out synthesis and analysis of time signal. 3. construct mother wavelets. 4. construct inverse of Gram operator in infinite dimensional space. 5. use orthogonal wavelets.
CCS-403, CCS-404, CCS-405	Dynamical Systems- II	1. test for the existence and uniqueness of solution of nonlinear system. 2. relate the stability of the system with its linearization. 3. distinguish between stable and unstable sets corresponding to the given system. 4. construct the local stable manifolds for the nonlinear system. 5. identify the chaotic behavior in the system by using Lyapunov exponents.

CCS-403, CCS-404, CCS-405	Graph Theory-II	1. understand properties of graphs in terms of matrices. 2. use of matching of bipartite graph to solve various problems 3.compute Laplacian eigen values. 3. find energy of graph using its matrix . 4. classification of trees using properties of matrix
CCS-403, CCS-404, CCS-405	Analysis on Manifolds	1. develop the concept of integration of functions in higher dimensions. 2. give a geometric interpretation of the determinant function. 3. build the concept of manifold using curves and surfaces. 4. determine the volume of a parameterized manifold. 5. evaluate the integration of differential forms on manifolds
CCS-403, CCS-404, CCS-405	Theory of Distributions	1.construct test functions, approximate identity, distributions. 2.differentiate a generalized function. 3.limit of sequence of generalized functions. 4.analyze properties of support of generalized functions. 5.define directional derivatives of generalized functions.
CCS-403, CCS-404, CCS-405	Commutative Algebra – II	1. understand Artirian and Noetherion modules. 2. study The Krull-Schmidt theorem. 3. know projective modules for further development in modules. 4. apply integral extensions for going up and going down theorem. 5. derive prime decomposition theorem.
CCS-403, CCS-404, CCS-405	Space dynamics II	1 construct Euler's momentum equations. 2. analyze stability of rotation about principle axes. 3. perform Spin stabilization of missiles and

		projectiles. 4. represent General Motion of a Symmetric Gyro and Rolling of a thin circular disk 5. calculate Inertial components of angle of attack and Attitude Drift of Space Vehicles.
CCS-403, CCS-404, CCS-405	Automata Theory	1. understand semigroup relation. 2. explain Mealy machine. 3. derive orthogonal partitions. 4. describe admissible subset system decomposition.
CCS-403, CCS-404, CCS-405	Dynamic Equations on Time Scales	Learning outcome: Upon successful completion of this course, students will be able to: 1. demonstrate the concepts of time scales calculus and dynamic equations on time scales. 2. develop sophisticated skill in understanding unification of continuous and discrete theory. 3. analyze the qualitative and quantitative aspects of solutions of dynamic equations. 4. develop various techniques and apply them to solve certain dynamic equations. 5. develop and demonstrate the techniques to solve self-adjoint equations. 6. unify and extend the traditional study of differential equations and difference equations
CCS-403, CCS-404, CCS-405	Automata, Languages and Computation	1. Model, compare and analyse different computational models using combinatorial methods. 2. Apply rigorously formal mathematical methods to prove properties of languages, grammars and automata. 3. Construct algorithms for different problems and argue formally about correctness on different restricted machine models of computation 4. Identify limitations of some computational models and possible methods of proving them.