



PANSKURA BANAMALI COLLEGE(AUTONOMOUS)
DEPT. OF MATHEMATICS

PROGRAMME: *B.Sc. (Mathematics Hons.)*

PROGRAMME SPECIFIC OUTCOMES (PSO):

PSO1 Disciplinary knowledge:

Capability to demonstrate comprehensive knowledge of mathematics and understand one or more disciplines which form a part of an undergraduate programme of study.

PSO2 Communications skills:

- a) Ability to communicate various concepts of mathematics effectively using examples and their geometrical visualizations.
- b) Ability to use mathematics as a precise language of communication in other branches of human knowledge.
- c) Ability to communicate long standing unsolved problems in mathematics.
- d) Ability to show the importance of mathematics as precursor to various scientific developments since the beginning of the civilization.
- e) Ability to explain the development of mathematics in the civilizational context and its role as queen of all sciences.

PSO3 Critical thinking and analytical reasoning:

- a) Ability to employ critical thinking in understanding the concepts in every area of mathematics.
- b) Ability to analyze the results and apply them in various problems appearing in different branches of mathematics.

PSO4 Problem solving:

- a) Capability to solve problems in computer graphics using concepts of linear algebra.
- b) Capability to solve various models such as growth and decay models, radioactive decay model, drug assimilation, LCR circuits and population models using techniques of differential equations.
- c) Ability to solve linear system of equations, linear programming problems and network flow problems.
- d) Ability to provide new solutions using the domain knowledge of mathematics

PSO5 Research-related skills:

- a) Capability for inquiring about appropriate questions relating to the concepts in various fields of mathematics.
- b) To know about the advances in various branches of mathematics.

PSO6 Information/digital literacy:

- a) Capability to use appropriate softwares to solve system of equations and differential equations.
- b) Capability to understand and apply the programming concepts of C++ to mathematical investigations and problem solving.

PSO7 Self-directed learning:

Ability to work independently and do in-depth study of various notions of mathematics.

PSO8 Moral and ethical awareness/reasoning:

Ability to identify unethical behaviour such as fabrication, falsification or misrepresentation of data and adopting objective, unbiased and truthful actions in all aspects.

PSO9 Lifelong learning:

Ability to think, acquire knowledge and skills through logical reasoning and to inculcate the habit of self-learning.



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COURSE OUTCOMES (COS): B.Sc. (Mathematics Hons.)

SEMESTER – I

CORE - 1 : CALCULUS, GEOMETRY & DIFFERENTIAL EQUATION

Course Outcomes: This course will enable the students to

- CO1 State and prove Leibnitz rule and apply it to find higher order derivatives and can solve various type of problems.
- CO2 Calculate Envelope, asymptotes, Curvature of standard curves if exists and interpret point of inflexion.
- CO3 Apply L'Hospital rule to find limit of functions.
- CO4 Sketch curves in Cartesian and polar co-ordinate systems and classify the conics and conicoids using some standard methods and explain the properties of three dimensional shapes.
- CO5 Derive reduction formula and apply it in different situations.
- CO6 Calculate arc length of a curve, area under curve, area and volume of surface of revolution.
- CO7 Understand the genesis of ordinary differential equations and Picard's theorem and learn various techniques of getting exact solutions of solvable first order ODE and grasp concept of general, particular and singular solution.

CORE - 2 : ALGEBRA

Course Outcomes: This course will enable the students to

- CO1 understand the importance of roots of real and complex polynomials and learn various methods of obtaining roots.
- CO2 familiarize with inequality involving $A.M. > G.M. > H.M.$, Cauchy-Schwarz's inequality etc.
- CO3 familiarize with relations, equivalence relations and partitions.
- CO4 employ De-Moivre's theorem in a number of applications to solve numerical problems.
- CO5 recognize consistent and inconsistent system of linear equations by the row echelon form of the augmented matrix, using rank.
- CO6 understand the concepts of vector space, subspaces, bases, dimension and their properties.
- CO7 find eigen values and corresponding eigen vectors for a square matrix.
- CO8 relate matrices and linear transformations.

GE 1: CALCULUS & GEOMETRY

Course Outcomes: This course will enable the students to

- CO1 State and prove Leibnitz rule and apply it to find higher order derivatives and can solve various type of problems.
- CO2 Calculate Envelope, asymptotes, Curvature of standard curves if exists and interpret point of inflexion.
- CO3 Apply L'Hospital rule to find limit of functions.
- CO4 Sketch curves in Cartesian and polar co-ordinate systems and classify the conics and conicoids using some standard methods and explain the properties of three dimensional shapes.
- CO5 Derive reduction formula and apply it in different situations.



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CO6 Calculate arc length of a curve, area under curve, area and volume of surface of revolution.

SEMESTER – II

CORE - 3 : REAL ANALYSIS

Course Outcomes: This course will enable the students to

- CO1 The set of real numbers is an ordered field with supremum property.
- CO2 The set \mathbb{R} of real numbers possesses the Archimedian property which will be required to examine the convergence of a sequence and series in next unit.
- CO3 The concept of neighbourhood of a point in \mathbb{R} , open-ness, closed-ness, of a subset of \mathbb{R} , Limit point of a set and its various properties and to prove Bolzano – Weirstrass theorem along with its application.
- CO4 Notion of countability along with countability of \mathbb{Q} and uncountability of \mathbb{R} .
- CO5 Compactness of a set in \mathbb{R} along with Heine – Boral theorem.
- CO6 Assimilate the notions of limit of a sequence and convergence of a series of real numbers.
- CO7 Recognize bounded, convergent, divergent, Cauchy and monotonic sequence and to calculate their limit superior, limit inferior and the limit of a bounded sequence.
- CO8 Apply the ratio, root, alternating series and limit comparison testes for convergence and absolute convergence of an infinite series of real numbers.

CORE - 4 : DIFFERENTIAL EQUATIONS & VECTOR CALCULUS

Course Outcomes: This course will enable the students to

- CO1 Learn various techniques of getting general solution of homogeneous equation of second order, linear homogeneous and non-homogeneous equation of higher order with constant coefficients.
- CO2 Learn about systems of linear differential equation with constant coefficients of various types and solving various types of method.
- CO3 Learn about Equilibrium points giving interpretation of phase plane.
- CO4 Learn about power series solution of a differential equation and to solve various problem.
- CO5 Calculate triple product and test the continuity of vector function, differentiation and integration of vector functions.

GE 2: ALGEBRA - I

Course Outcomes: This course will enable the students to

- CO1 understand the importance of roots of real and complex polynomials and learn various methods of obtaining roots.
- CO2 familiarize with inequality involving $A.M. > G.M. > H.M.$, Cauchy-Schwarz's inequality etc.
- CO3 employ De-Moivre's theorem in a number of applications to solve numerical problems.
- CO4 recognize consistent and inconsistent system of linear equations by the row echelon form of the augmented matrix, using rank.
- CO5 understand the concepts of vector space, subspaces, bases, dimension and their properties.
- CO6 Find eigen values and corresponding eigen vectors for a square matrix.
- CO7 relate matrices and linear transformations.



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SEMESTER – III

CORE - 5: THEORY OF REAL FUNCTIONS

Course Outcomes: This course will enable the students to

- CO1 Learn concept of limits and calculate the limit of a function if exists.
- CO2 Examine the continuity and differentiability of a function at a point / on a given interval and understand the geometrical interpretation of differentiability.
- CO3 State and prove sign preserving property, Intermediate value theorem, Bolzano's theorem and learn the concept of uniform continuity.
- CO4 State, prove and apply mean value theorem in unfamiliar situations and understand the consequences of various mean value theorem. Find the infinite series of a function by using Taylors.
- CO5 Learn about Local, Global maximum and minimum of a function and find the extreme values if exists of a given function.

CORE - 6: GROUP THEORY - I

Course Outcomes: This course will enable the students to

- CO1 Recognize the mathematical objects called groups.
- CO2 Link the fundamental concepts of groups and symmetries of geometrical objects.
- CO3 Explain the significance of notions of Cosets, normal subgroups, and factor groups.
- CO4 Analyze consequences of Lagrange's theorem.
- CO5 Learn about structure preserving maps between groups and their consequences.
- CO6 State and prove Cayley's theorem, 1st, 2nd and 3rd isomorphism theorem.

CORE - 7: NUMERICAL METHODS

Course Outcomes: This course will enable the students to

- CO1 obtain numerical solutions of algebraic and transcendental equations.
- CO2 Find numerical solutions of system of linear equations and check the accuracy of the solutions.
- CO3 Learn about various interpolating methods, the formulas of numerical differentiation and to solve different types of problems.
- CO4 Learn about numerical integration and to apply it in various problems.
- CO5 Learn about algebraic eigen value problem and approximation and to solve various problems.
- CO6 Solve initial value problems in differential equations using numerical methods.

SEC1: LOGIC AND SETS

Course Outcomes: This course will enable the students to

- CO1 Learn about propositions, truth table and several types of logical operators and to apply it.
- CO2 Familiarize with propositional equivalence, predicates and quantifiers.



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- CO3 Learn about set theory, its laws and standard set operations and to apply it into real life problems.
- CO4 Learn about cartesian products of sets, relation, its several types and to apply in various problems.

GE 3: DIFFERENTIAL EQUATIONS & VECTOR CALCULUS

Course Outcomes: This course will enable the students to

- CO1 Understand the genesis of ordinary differential equations and Picard's theorem and learn various techniques of getting exact solutions of solvable first order ODE and grasp concept of general, particular and singular solution.
- CO2 Learn various techniques of getting general solution of homogeneous equation of second order, linear homogeneous and non-homogeneous equation of higher order with constant coefficients.
- CO3 Learn about systems of linear differential equation with constant coefficients of various types and solving various types of method.
- CO4 Calculate triple product and test the continuity of vector function, differentiation and integration of vector functions.

SEMESTER – IV

CORE - 8: RIEMANN INTEGRATION AND SERIES OF FUNCTIONS

Course Outcomes: This course will enable the students to

- CO1 Learn about Riemann integrality of bounded functions and algebra of R-integrable functions.
- CO2 Determine various applications of the fundamental theorem of integral calculus.
- CO3 Relate concepts of point-wise convergence and uniform convergence of sequence and series of functions.
- CO4 Determine Fourier expansions and summation results for series.
- CO5 Understand the convergence, term by term integration and differentiation of a power series.

CORE - 9: MULTIVARIATE CALCULUS

Course Outcomes: This course will enable the students to

- CO1 learn conceptual variations while advancing from one variable to several variables in calculus.
- CO2 Apply multivariate calculus in optimization problems.
- CO3 Calculate the line integral, double integral and triple integral formulations.
- CO4 Apply multivariate calculus tools in physics, economics, optimization and understanding the architecture of curves and surfaces in plane and space etc.
- CO5 Calculate gradient of a scalar function, divergence and curl of a vector function.
- CO6 Realize importance of Green's, Gauss and Stokes theorems in other branches of mathematics.



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CORE - 10: RING THEORY AND LINEAR ALGEBRA - I

Course Outcomes: This course will enable the students to

- CO1 Understand the concepts of ring, integral domain, field and their inter relationship.
- CO2 Recognize different kinds of ideal such as prime ideal, maximal ideal, principal ideal.
- CO3 Know about ring homomorphism and isomorphism.
- CO4 Learn the properties of vector spaces and can find the basis and dimension of vector spaces and subspaces.
- CO5 Know about linear transformation, find its matrix representation, nullity and rank.

SEC2: GRAPH THEORY

Course Outcomes: This course will enable the students to

- CO1 Appreciate the definition and basics of graphs along with types and their examples.
- CO2 Understand the definition of a tree and learn its applications to fundamental circuits.
- CO3 Learn about the matrix representation of a graph and apply it into the shortest path problems and to understand various algorithms.

GE 4: PDE & NUMERICAL METHODS

Course Outcomes: This course will enable the students to

- CO1 Understand the basic concept of PDE, classify the first order PDE.
- CO2 Apply the various types of method to solve first order PDE.
- CO3 Derive the heat conduction, wave equation and Laplace equation, classify the 2nd order equations, and reduce the 2nd order PDE to canonical forms.
- CO4 Obtain numerical solutions of algebraic and transcendental equations.
- CO5 Find numerical solutions of system of linear equations and check the accuracy of the solutions.
- CO6 Learn about various interpolating methods, the formulas of numerical differentiation and solve initial value problems in differential equations using numerical methods.

SEMESTER – V

CORE - 11: PARTIAL DIFFERENTIAL EQUATIONS & APPLICATIONS

Course Outcomes: This course will enable the students to

- CO1 Understand the basic concept of PDE, classify the first order PDE.
- CO2 Apply the various methods to solve first order PDE.
- CO3 Derive the heat conduction, wave equation and Laplace equation, classify the 2nd order equations, and reduce the 2nd order PDE to canonical forms.
- CO4 Solve the Cauchy problem of an infinite string, IVP, Equation with non-homogeneous BC, non-homogeneous wave equations.
- CO5 Apply the method of separation of variables to solve heat and wave equation.
- CO6 Learn about a particle moving under central forces, constrained motion, the Kepler's laws of the planetary motion and motion of the particle when mass varies.



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CORE - 12: GROUP THEORY - II

Course Outcomes: This course will enable the students to

- CO1 Understand the fundamental concepts of group automorphism and class equation and apply it to solve order related problem of a group.
- CO2 Learn about direct product of groups, fundamental theorem of finite abelian groups.
- CO3 Know about the operation of group actions, Generalized Cayley's theorem of finite abelian group and index theorem.
- CO4 Learn in detail about Sylow's theorem and can test the non- simplicity of a finite group by using Sylow's theorem.
- CO5 Understand how groups act on themselves by conjugation, conjugacy in S_n and Cauchy's theorem.

DSE 1 : LINEAR PROGRAMMING & GAME THEORY

Course Outcomes: This course will enable the students to

- CO1 Analyze and solve linear programming models of real life situations.
- CO2 Provide graphical solutions of linear programming problems with two variables and illustrate the concept of convex set and extreme points.
- CO3 Understand the theory of the simplex method used to solve linear programming problems.
- CO4 Learn about two-phase and big-M methods to deal with problems involving artificial variables.
- CO5 Know about the relationships between the primal and dual problems, and to understand sensitivity analysis.
- CO6 Learn about the applications to transportation, assignment problems.
- CO7 Apply linear programming method to solve two-person zero-sum game problems.

DSE 2 : PROBABILITY & STATISTICS

Course Outcomes: This course will enable the students to

- CO1 Learn about probability density and moment generating functions.
- CO2 Know about various univariate distributions such as Bernoulli, Binomial, Poisson, gamma and exponential distributions.
- CO3 Learn about distributions to study the joint distribution of two random variables.
- CO4 Measure the scale of association between two variables, and to establish a formulation helping to predict one variable in terms of the other, i.e., correlation and linear regression.
- CO5 Understand central limit theorem, which helps to understand the remarkable fact that: the empirical frequencies of so many natural populations, exhibit a bell-shaped curve, i.e., a normal distribution.
- CO6 Learn about Random Samples, Sampling Distributions, Parameter and Statistics, estimator, good estimator, Consistent & Unbiased estimates.
- CO7 Learn about Testing of hypothesis, Probability of Type – I error, Probability of Type – II error, Best critical Region, Likelihood ratio testing, examples. Chi-square test of goodness of fit.



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SEMESTER – VI

CORE - 13: METRIC SPACES AND COMPLEX ANALYSIS

Course Outcomes: This course will enable the students to

- CO1 Learn basic concepts of metric spaces, like open ness, closed-ness, completeness, connectedness, compactness, Bolzano-weirstrass properties.
- CO2 Know about homomorphism in a metric space, Banach's fixed point theorem and can apply this theorem to solve partial differential equation.
- CO3 Learn about the fundamental concepts like limits, continuity, derivative of a complex function, Cauchy-Reimann equations.
- CO4 Understand the notion of analytic function with its various properties.
- CO5 Know about some important theorem such as Cauchy-Goursat theorem, Liouville's theorem, Cauchy's integral formula etc.
- CO6 Expand functions in Taylor series or Laurent series.

CORE - 14: RING THEORY AND LINEAR ALGEBRA - II

Course Outcomes: This course will enable the students to

- CO1 Know the fundamental concepts in ring theory such as the concepts of ideals, quotient rings, integral domains, and fields.
- CO2 Learn in detail about polynomial rings, fundamental properties of finite field extensions, and classification of finite fields.
- CO3 Appreciate the significance of unique factorization in rings and integral domains.
- CO4 Understand the concepts of Linear functional, Dual spaces, Dual bases, annihilators and their properties.
- CO5 Compute the characteristic polynomial, eigenvalues, eigenvectors, and eigenspaces, as well as the geometric and the algebraic multiplicities of an eigenvalue and apply the basic diagonalization result
- CO6 Learn properties of inner product spaces and determine orthogonality in inner product spaces.
- CO7 Realise importance of adjoint of a linear transformation and its canonical form.

DSE 3 : MECHANICS

Course Outcomes: This course will enable the students to

- CO1 Know about the concepts in statics such as moments, couples, equilibrium in both two and three dimensions.
- CO2 Understand the theory behind friction and center of gravity.
- CO3 Calculate moments of inertia of areas and rigid bodies.
- CO4 Know about conservation of mechanical energy and work-energy equations.



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CO5 Learn about translational and rotational motion of rigid bodies.

DSE 4 : MATHEMATICAL MODELLING

Course Outcomes: This course will enable the students to

- CO1 Know about power series solution of a differential equation and learn about Legendre's and Bessel's equations.
- CO2 Use of Laplace transform and inverse transform for solving initial value problems.
- CO3 Learn about various models such as Monte Carlo simulation models, queuing models, and linear programming models.
- CO4 Understand the basics of graph theory and learn about social networks, Eulerian and Hamiltonian graphs, diagram tracing puzzles and knight's tour problem.



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PROGRAMME: *B.Sc. (Mathematics GEN.)*

PROGRAMME SPECIFIC OUTCOMES (PSO):

- PSO1.** This programme is the culmination of knowledge of algebra, analysis, calculus, differential equations and other several branches of mathematics and other specific branches of physics & chemistry. Thus, this programme helps students in building a solid foundation for higher studies.
- PSO2.** This programme enable the students to communicate various concepts, ideas, notions or theories effectively using example and their geometrical visualizations. Also, the students will be able to present mathematics clearly and precisely, make vague ideas precise by formulating them in the language of mathematics, describe mathematical ideas from multiple perspectives and explain fundamental concepts of mathematics to non-mathematicians. Also, they represent the problems in nature in brief, concise logically by using mathematics.
- PSO3.** Students undergoing this programme learn to logically question assertions, to recognize patterns and to distinguish between essential and irrelevant aspects of problems. They also connect between theoretical and practical knowledge. This helps them to learn the pattern of rapidly changing the society.
- PSO4.** Students will be able to work independently and do in-depth study of various notions of mathematics, physics & chemistry.
- PSO5.** Students will be to identify unethical behaviour such as fabrication, falsification or misrepresentation of data and adopting objective, unbiased and truthful actions in all aspects.
- PSO6.** This programme will enable the students to think independently, acquire knowledge and skills through logical reasoning and to inculcate the habit of self-learning.
- PSO7.** Completion of this programme will also enable the learners to join teaching profession in primary and secondary schools.
- PSO8.** This programme will also help students to enhance their employability for government jobs, jobs in banking, insurance and investment sectors, jobs in various other public and private enterprises.



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DEPT. OF MATHEMATICS

COURSE OUTCOMES (COS): B.Sc. (Mathematics GEN.)

SEMESTER - I

DSC1: Differential Calculus

Course Outcomes:

Students will be able to

- CO1 Learn different types of limits.
- CO2 Calculate the limit and examine the continuity and understand the geometrical interpretation of differentiability.
- CO3 State and prove Leibnitz rule and apply it to find higher order derivatives and can solve various type of problems.
- CO4 Calculate Envelope, asymptotes, Curvature of standard curves if exists.
- CO5 Understand the consequences of various mean value theorem.

SEMESTER - II

DSC 2: Differential Equations

Course Outcomes:

Students will be able to

- CO1 Learn various techniques of getting general solution of homogeneous equation of second order linear homogeneous and non-homogeneous equation of higher order with constant coefficients.
- CO2 Learn about systems of linear differential equation with constant coefficients of various types and solving various types of method.
- CO3 Understand the basic concept of PDE, classify the first order PDE.
- CO4 Apply the various types of method to solve first order PDE.
- CO5 Classify the 2nd order equations and reduce the 2nd order PDE to canonical forms.

SEMESTER - III

DSC 3: Real Analysis

Course Outcomes:

Students will be able to

- CO1 understand that the set \mathbb{R} of real numbers possesses the Archimedian property which will be required to examine the convergence of a sequence and series in next unit.
- CO2 understand that the concept of neighbourhood of a point in \mathbb{R} , open-ness, closed-ness, of a subset of \mathbb{R} , Limit point of a set and its various properties and to prove Bolzano – Weirstrass



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theorem along with its application and Compactness of a set in \mathbb{R} along with Heine – Borel theorem.

- CO3 Assimilate the notions of limit of a sequence and convergence of a series of real numbers.
- CO4 Recognize bounded, convergent, divergent, Cauchy and monotonic sequence and to calculate their limit superior, limit inferior and the limit of a bounded sequence.
- CO5 Apply the ratio, root, alternating series and limit comparison tests for convergence and absolute convergence of an infinite series of real numbers.
- CO6 Relate concepts of point-wise convergence and uniform convergence of sequence and series of functions.
- CO7 Understand the convergence, term by term integration and differentiation of a power series.

SEC1: Integral Calculus

Course Outcomes:

Students will be able to

- CO1 Learn about integration by partial fraction and initialize with definite integrals.
- CO2 Derive reduction formula and apply it in different situations.
- CO3 Calculate arc length of a curve, area under curve, area and volume of surface of revolution.
- CO4 Calculate the line integral, double integral and triple integral formulations.

SEMESTER - IV

DSC- 4: Algebra

Course Outcomes:

Students will be able to

- CO1 Recognize the mathematical objects called groups.
- CO2 Link the fundamental concepts of groups and symmetries of geometrical objects.
- CO3 Explain the significance of notions of Cosets, normal subgroups, and factor groups.
- CO4 Analyze consequences of Lagrange's theorem.
- CO5 Understand the concepts of ring, integral domain, field and their inter relationship.

SEC 2: Theory of Equations

Course Outcomes:

Students will be able to

- CO1 Understand the importance of roots of real and complex polynomials and learn various methods of obtaining roots.
- CO2 Learn Descartes' rule of sign and apply it to demonstrate the roots of the equation.
- CO3 Find the relation between roots and coefficient of a equation and solve them.
- CO4 Understand symmetric function, to solve cubic and biquadratic equations.



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SEMESTER - V

DSE 1: Linear Algebra

Course Outcomes:

Students will be able to

- CO1 Learn the properties of vector spaces and can find the basis and dimension of vector spaces and subspaces.
- CO2 Know about linear transformation, find its matrix representation, nullity and rank.
- CO3 Understand the concepts of Linear functional, Dual spaces, Dual bases, annihilators and their properties.
- CO4 Compute the characteristic polynomial, eigenvalues, eigenvectors, and eigen spaces, as well as the geometric and the algebraic multiplicities of an eigen value and apply the basic diagonalization result.

SEC 3: Probability and Statistics

Course Outcomes:

Students will be able to

- CO1 Know about sample space and probability axioms.
- CO2 Learn about probability density and moment generating functions.
- CO3 Know about various univariate distributions such as Bernoulli, Binomial, Poisson, gamma and exponential distributions.
- CO4 Learn about distributions to study the joint behavior of two random variables.
- CO5 Learn and apply about moment generating function and characteristic function

SEMESTER - VI

DSE 2 : Numerical Methods

Course Outcomes:

Students will be able to

- CO1 Obtain numerical solutions of algebraic and transcendental equations.
- CO2 Find numerical solutions of system of linear equations and check the accuracy of the solutions.
- CO3 Learn about various interpolating methods, the formulas of numerical differentiation and to solve different types of problems.
- CO4 Learn about numerical integration and to apply it in various problems.
- CO5 Solve initial value problems in differential equations using numerical methods.

SEC 4: Transportation and Game Theory

Course Outcomes:

Students will be able to

- CO1 Learn about the applications to transportation, assignment problems.
- CO2 Apply linear programming method to solve two-person zero-sum game with mixed strategies problems.



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DEPT. OF MATHEMATICS

PROGRAMME: M.Sc. (*Mathematics*)

PROGRAMME SPECIFIC OUTCOMES (PSO):

This programme enables the students to

- PSO1.** Inculcate critical thinking to carry out scientific investigation objectively. Formulate coherent arguments; critically evaluate practices, policies and theories by following scientific approach to knowledge development. Critically evaluate ideas, evidence and experiences from an open-minded and reasoned perspective.
- PSO2.** Equip the student with skills to analyse problems, formulate a hypothesis, evaluate and validate results, and draw reasonable conclusions. Acquire the capacity to extrapolate from what one has learned and apply their competencies to solve different kinds of non-familiar problems, rather than replicate curriculum content knowledge.
- PSO3.** Imbibe effective scientific and / or technical communication in both oral and writing. Ability to show the importance of the subject as precursor to various scientific developments since the beginning of the civilization.
- PSO4.** Continue to acquire relevant knowledge and skills appropriate to professional activities and demonstrate highest standards of ethical issues in the subject concerned. Ability to identify unethical behaviour such as fabrication, falsification or misrepresentation of data and adoptive objective, unbiased and truthful actions in all aspects.
- PSO5.** Create awareness to become an enlightened citizen with commitment to deliver one's responsibilities within the scope of bestowed rights and privileges
- PSO6.** Evaluate the reliability and relevance of evidence; identify logical flaws and holes in the arguments of others; analyse and synthesise data from a variety of sources; draw valid conclusions and support them with evidence and examples and addressing opposing viewpoints.
- PSO7.** Think, acquire knowledge and skills through logical reasoning and to inculcate the habit of self-learning throughout life, through self- paced and self- directed learning aimed at personal development, and adapting to changing academic demands of work place through knowledge/ skill development/ reskilling.
- PSO8.** Prepare students for pursuing research or careers in industry in concerned subject and allied fields. Capability to use appropriate software to solve various problems and to apply programming concepts of C++ and Mathematica/ Matlab to various scientific investigations, problem solving and interpretation



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COURSE OUTCOMES (COS): M.Sc. (Mathematics)

SEMESTER – I

MTM-101

Real Analysis

Course outcomes: The students will be able to

- CO1 be familiar with abstract concept of functions in the parlance of set theory.
- CO2 analyze various critical properties of functions.
- CO3 perform integration for functions defined on set, having discrete nature.
- CO4 judge that whether we can get success or not by assigning a routine work to a computer.
- CO5 apply measure concept on abstract sets.

MTM-102

Complex Analysis

Course outcomes: The students will be able to

- CO1 Construct analytic function, using Cauchy-Riemann equation.
- CO2 Know about Cauchy's theorem, Cauchy's Integral formula, Morer's theorem, Lowville's theorem, Taylor's and Laurent's series and maximum modulus principle.
- CO3 Learn about singularities of a complex function with their classification, zeroes of an analytic function and find the residue of a function at its pole.
- CO4 Integrate improper integral of various kinds using Cauchy's integral formula.
- CO5 Know about different kinds of transformation like mobius transformation, conformal mapping, Schwartz-Christoffel transformation and solve mapping related problems.

MTM-103

Ordinary Differential Equations and Special Functions

Course outcomes: The students will be able to

- CO1 Understand the technique of series solution of Fuchsian type differential equation near about ordinary or singular points by any method or by Frobenius method.
- CO2 Solve the hypergeometric and confluent hypergeometric equation, also find the integral representation of both type differential equation.
- CO3 Solve Legendre differential equation, find the general form of Legendre function and generating function, prove the orthogonal property of Legendre polynomials and apply this knowledge in unfamiliar situation.
- CO4 Solve Bessel differential equation, define Bessel functions of different kinds and generating function, prove the orthogonal property of Bessel polynomials and apply this knowledge in unfamiliar situation.
- CO5 Construct the Green's function for solving ODE.
- CO6 Define S – L type ODE, find the eigen functions and eigen values of a S – L problem.
- CO7 Represent a system of linear differential equation in matrix form and solve the system by matrix method.

MTM-104

Advanced Programming in C and MATLAB

Course outcomes: The students will be able to

- CO1 Learn various types of keywords which are used in C-language.
- CO2 Write some mathematical programs in C-language using pointer, structure and array etc
- CO3 Understand and apply the programming concepts of MATLAB which is important for mathematical investigation and problem solving.
- CO4 Use mathematical libraries for computational objects.



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CO5 Represent the outputs of programs visually in terms of well formulated text and plots.

MTM-105 Classical Mechanics and Non-linear Dynamics

Course outcomes: The students will be able to

- CO1 Know about Motion of a system of particles, Constraints, Generalized coordinates, holonomic and non-holonomic system, principles of virtual work, D'Alembert's principle, Lagrange equations, plane and spherical pendulum, cyclic coordinates, Coriolis force and motion relative to rotating earth.
- CO2 Learn about principle of stationary action, Hamilton's principle, Brachitochrone problem, invariance transformations, Infinitesimal transformations, space-time transformation.
- CO3 Become familiar with small oscillation about equilibrium.
- CO4 Learn about Orientation and displacement of a rigid body.
- CO5 Know about special theory of relativity in classical mechanics.
- CO6 Learn about non-linear dynamics.

MTM-106 Graph Theory

Course outcomes: The students will be able to

- CO1 Understand the graph theoretical concepts like paths, cycles, connectivity, trees, spanning sub graphs, bipartite graphs.
- CO2 Know about Hamiltonian and Euler circles, distance and centre, cut sets and cut vertices.
- CO3 Do colouring and matching of graph.
- CO4 Learn about various kinds of graph like directed graphs, weighted graphs, intersection graph.
- CO5 Apply graph theory in operations research.

MTM-107 Lab.1:(Computational Methods: Using MATLAB) 25

Course outcomes: The students will be able to

- CO1 Apply MATLAB in various problems of matrix algebra.
- CO2 Use this software for graph plotting.
- CO3 Apply this software in various problems of linear algebra.
- CO4 represent polynomial function in the MATLAB® environment, Evaluate Polynomials, Roots, Derivatives, Convolution, Partial Fraction Expansions, Polynomial Curve Fitting, Characteristic Polynomials etc.

SEMESTER – II

MTM-201 Fluid Mechanics

Course Outcomes: Students will be able to

- CO1 Learn about viscous Flow with real and ideal fluids.
- CO2 Know about derivation of continuity equation, momentum equation, and energy equation.
- CO3 Understand the boundary layer theory.
- CO4 Learn about Exact / Analytical solution of Navier-Stokes equation.
- CO5 Learn about incompressible viscous flows via finite difference methods.



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MTM-202

Numerical Analysis

Course outcomes: The students will be able to

- CO1 Differentiate between problem of interpolation and problem of approximation, find cubic spline function over a specified interval using end conditions.
- CO2 Understand the different types of method for evaluating an integration by numerically and apply this knowledge in unfamiliar situations.
- CO3 Find the roots of polynomial equation by Bairstow method and also solve a system of nonlinear equations.
- CO4 Solve the system of linear equations by matrix method, LU decomposition method and also solve tri-diagonal system and Ill-conditioned system by efficient method.
- CO5 Find eigen function and eigen values of a matrix by power or Jacobi's method.
- CO6 Solve a system of ODE by R-K method. Understand the predictor & corrector method and stability of different methods used.
- CO7 Solve ODE and PDE by finite difference method.

MTM-203

Unit-1: Abstract Algebra

Course outcomes: The students will be able to

- CO1 Know about the abstract concepts like quotient groups, fundamental theorem on homomorphism, isomorphism theorems and solvable groups.
- CO2 Learn direct product of groups, class equation, Cauchy's theorem, permutation groups, Cayley theorem and group action.
- CO3 Apply Sylow's theorem to test non-simplicity of a finite group.
- CO4 Understand the concepts of ring, Euclidean domain, ideals.
- CO5 Know about field extensions splitting fields, algebraic closures, separable and inseparable extensions

Unit-2: Linear Algebra

Course outcomes: The students will be able to

- CO1 Find matrix representation of a linear transformation and diagonalize a matrix.
- CO2 Know about linear operators, dual space, minimal polynomial.
- CO3 Learn about various canonical forms such as triangular canonical form, Jordan canonical form and rational canonical form.
- CO4 Understand the properties of an inner product space along with unitary, normal transformation, symmetric and skew-symmetric bilinear forms and Sylvester's Law of inertia.

C-MTM-204A

Statistical and Numerical Methods

Course outcomes: The students will be able to

- CO1 Understand different types of statistical tools and their uses in other branch of science.
- CO2 Find Lagrange's and Newton's interpolating polynomials, Find the roots of algebraic and transcendental equations by various method. Solve the system of linear equations by Cramer rule and Gauss-elimination method. Integrate by trapezoidal and Simpson 1/3 methods. Solve ODE by Euler's method, Runge-Kutta methods.



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C-MTM-204B

History of Mathematics

Course outcomes: The students will be able to

- CO1 Know about the Mathematics in ancient Mesopotamia, the numerical system, arithmetic operation, geometric and algebraic problems and astronomy.
- CO2 Learn about Egyptian geometry, development of pure mathematics, pre- Euclidean geometry.
- CO3 Understand the advancement of geometry, Greek Trigonometry, mensuration, number theory.
- CO4 Know about the contribution of Archemedes, Appolonius, Omar Khayyam in Mathematics.
- CO5 Learn about the introduction of calculus, mathematical Platonism, traditional, nontraditional Platonism etc.

MTM-205

General Theory of Continuum Mechanics

Course outcomes: The students will be able to

- CO1 Calculate strain, tensor (Lagrangian and Eulerian), stress-tensor, different compatibility equation for linear strain etc and relate the strain-tensor with strain-vector.
- CO2 Learn about strain energy function, Hooks law, saint-venant's principle.
- CO3 Understand and calculate moduli of elasticity of isotropic bodies and their relations.
- CO4 Understand waves in isotropic elastic media.
- CO5 Learn Euler's equation of motion of an in-viscid fluid and also stream function and complex potential for perfect fluid.

MTM-206

General Topology

Course outcomes: The students will be able to

- CO1 learn about the concept of General topology, basis, sub-basis of a topological space and closure and interior of a set and relate these notion with similar notion of real analysis.
- CO2 Know about different types of topological spaces like subspace topology, metric topology, product topology etc.
- CO3 Understand the concepts of compactness, connectedness along with local compactness and local connectedness.
- CO4 Know about the separation axioms in a topological space and apply it to separate two points or sets.
- CO5 Learn some important theorems like Urysohn lemma, Urysohn Metrization theorem and Tietze extension theorem.

MTM-207 Lab. 2: (Language: C- Programming with Numerical Methods)

Course outcomes: The students will be able to

- CO1 Write programmes related searching and sorting problems by using C – programming.
- CO2 Write programmes related numerical problems (MTM 202) and solve these problems by using this language.
- CO3 Write programmes related statistical problem (i.e. on bivariate distribution: Correlation



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coefficient, Regression lines, Curve fitting, Multiple regression, Simple hypothesis testing) and solve these problems by using this language.

SEMESTER – III

MTM-301 Partial Differential Equations and Generalized Functions

Course outcomes: The students will be able to

- CO1 Understand the first order PDE in two independent variables with their classification and Cauchy problem. Reduce the second order PDE into canonical forms and find the nature of PDE.
- CO2 Understand the different methods for solving Hyperbolic equations and nature of solution. Find the D'Alembert's solution for homogeneous and non-homogeneous Cauchy problem.
- CO3 Solve Laplace's equations by method of separation variables and also solve this problem in case of Dirichlet and Neumann's BC. Find the solution of Dirichlet's and Neumann's problem for some typical problems like a disk and Sphere. Find Poisson's general solution. Construct Green's function for solving above mentioned problem.
- CO4 Solve heat conduction equation by efficient method.
- CO5 Understand generalized functions and their applications. Also find Fourier transform of generalized function.

MTM-302 Transforms and Integral Equations

Course outcomes: The students will be able to

- CO1 Find Fourier transform of a function and inverse Fourier transform of a function.
- CO2 Solve problems related to Fourier transform using convolution theorem and Parseval's identity.
- CO3 Find Laplace transform of a function and its inverse transform applying several methods.
- CO4 Solve partial differential equation by Fourier transform and both ordinary and partial differential equation by Laplace transform.
- CO5 Know about wavelet transform and apply it to signal and image processing.
- CO6 Learn about various methods to solve different kinds of integral equation and apply it to find eigen values, eigen function and solution of an integral equation.

MTM-303 Unit-1: Dynamical Oceanology and Meteorology

Course outcomes: The students will be able to

- CO1 Know the properties of Sea water relevant to Physical oceanography.
- CO2 Understand the basic physical laws used in Oceanography and classifications of forces and motions in the sea.
- CO3 Know the equation of continuity of volume and the equation of motion in oceanography.
- CO4 Know the composition of atmosphere and the basic thermodynamics of atmosphere.
- CO5 Understand different equations in dynamical meteorology

Unit-2: Operations Research



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Course outcomes: The students will be able to

- CO1 Know to solve the deterministic Inventory Control including price breaks and Multi-item with constraints.
- CO2 Understand the basic structures of Queuing models and apply it to solve real life problems.
- CO3 Know Poisson queues – MM/1, M/M/C for finite and infinite queue length and also Non Poisson queue – M/G/1.
- CO4 Understand Machine maintenance with steady state.
- CO5 Know the classical optimization techniques.

C-MTM-304 **Discrete Mathematics**

Course outcomes: The students will be able to

- CO1 Understand the notion of ordered sets and maps between ordered sets.
- CO2 Learn about lattices, modular and distributive lattices, sub lattices and homomorphisms between lattices.
- CO3 Become familiar with Boolean algebra.
- CO4 Learn about basics of graph theory, including Eulerian graphs, Hamiltonian graphs.
- CO5 Learn about the applications of graph theory in the study of shortest path algorithms.

MTM-305A **Special Paper-OM: Dynamical Oceanology**

Course outcomes: The students will be able to

- CO1 Know the different numbers like Reynolds number, Rossby number, Ekman number and also know the non-linear terms in the equation of motion.
- CO2 Understand about currents without Friction i.e. Geostrophic Flow.
- CO3 Understand about currents with Friction i.e. Wind-driven Circulation.
- CO4 Learn about vorticity and Circulation.
- CO5 Learn about Vortex motion.

MTM-306A **Special Paper-OM: Dynamical Meteorology -I**

Course outcomes: The students will be able to

- CO1 Learn about the Thermodynamics of the atmosphere.
- CO2 Know the effect of Ascent and descent on lapse rate and stability.
- CO3 Understand about the adiabatic motion, saturation by adiabatic ascent, Pseudoadiabatic change, wet bulb temperature, wet bulb potential temperature etc.
- CO4 Know the purpose and use of Aerological diagrams.
- CO5 Learn about equation of momentum of an air parcel in spherical coordinates, natural coordinates and isobaric coordinates.

MTM-305B **Special Paper-OR: Advanced Optimization and Operations Research**

Course outcomes: The students will be able to

- CO1 Apply revised simplex method and Modified dual simplex method to solve LPP.



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- CO2 Know about Parametric and Post optimal analysis.
- CO3 Understand the one-dimensional search technique like Fibonacci and Golden section method.
- CO4 Learn about Gradient methods like Method of conjugate directions, Steepest descent method and Davidon- Fletcher-Powell method.
- CO5 Learn about integer programming problem to obtain an integer solution of an LPP.
- CO6 Know about Goal programming problem.

MTM-306B Special Paper-OR: Operational Research Modelling-I

Course outcomes: The students will be able to

- CO1 Know about Dynamic Programming and its application in production scheduling and routing problems.
- CO2 Learn about Probabilistic inventory control and Basic concept of supply-chain management.
- CO3 Learn about Network like PERT and CPM and its application in real life problems.
- CO4 Understand about Replacement and Maintenance Models and use it to calculate the optimal replacement time of a machine.
- CO5 Become familiar with the steps of simulation process and know about different type of simulation.

SEMESTER – IV

MTM-401 Functional Analysis

Course outcomes: The students will be able to

- CO1 Know about normed linear spaces, spaces of bounded linear operators and quotients of normed linear spaces, conjugate spaces and reflexive spaces.
- CO2 Understand that every normed linear space is a metric space but not conversely.
- CO3 Know about some important Banach spaces.
- CO4 Apply uniform boundedness principle, closed graph theorem and open mapping theorem.
- CO5 Know about Hilbert spaces and some important inequality like Schwartz inequality, Bessel's inequality.
- CO6 Know about the operators like adjoint, normal, unitary and positive operators.

MTM-402 Unit-1: Fuzzy Mathematics with Applications

Course outcomes: The students will be able to

- CO1 Learn about basic concept and definition of fuzzy sets, standard fuzzy set operations and its properties.
- CO2 Know about fuzzy relations, properties of α -Cut.
- CO3 Define Zadeh's extension principle and fuzzy numbers and their properties.
- CO4 Learn about basic concept of fuzzy matrices and fuzzy differential equations.
- CO5 Apply in LPP with fuzzy resources by various approached.



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Unit-2: Soft Computing

Course outcomes: The students will be able to

- CO1 Understand soft computing, fuzzy logic, genetic algorithm and neural network.
- CO2 Apply these knowledge in scientific problem and interpret significantly.
- CO3 Solve the optimization problems by using genetic algorithm.
- CO4 Use effectively neural network in design & scientific analysis of problems.

MTM-403

Unit-1: Magneto Hydro-Dynamics

Course outcomes: The students will be able to

- CO1 Know and understand Maxwell's equation. Define Lorentz's force.
- CO2 Derive The equations of motion of a conducting fluid and understand Reynolds number and its significance.
- CO3 Understand Laminar Flow of a viscous conducting liquid between parallel walls in transverse magnetic fields.
- CO4 Understand M.H.D in different boundary conditions.

Unit-2: Stochastic Process and Regression

Course outcomes: The students will be able to

- CO1 learn stochastic process, random walk and advanced theory of linear estimation.
- CO2 Know Markov chains with finite and countable state space and Gambler's ruin problem, Markov processes in continuous time. Poisson's process
- CO3 Calculate partial and multiple correlation.

MTM-404A

Special Paper-OM: Computational Oceanology

Course outcomes: The students will be able to

- CO1 Apply the theories of incompressible fluid to describe the currents of the oceans.
- CO2 Identify the nature of various types of waves including the very famous Rossby waves.
- CO3 Apply the rules of numerical methods for the purpose of prediction.
- CO4 Use various miniature mathematical models to handle convection and diffusion problems.

MTM-405A

Special Paper-OM: Dynamical Meteorology –II

Course outcomes: The students will be able to

- CO1 Study the fluctuation of weather.
- CO2 Describe the reason behind various patterns of flow of atmosphere.
- CO3 Get the idea of regular circulation of air throughout the globe.
- CO4 Know the catastrophic weather condition like hurricane, tornado, cyclones etc.



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CO5 Predict some parameters linked with variable weather.

MTM-407A Special Paper-OM: Lab.(Dynamical Meteorology)

Course outcomes: The students will be able to

- CO1 Calculate Surface temperature, pressure, humidity, Wind speed and direction measurements, rainfall.
- CO2 Understand and analyze TD charts and T – diagram.
- CO3 Know the numerical method and computer techniques related to Meteorological problems. Handle and analyze the Meteorological data effectively.

MTM-404B Special Paper-OR: Nonlinear Optimization

Course outcomes: The students will be able to

- CO1 Know the nature & scope of optimization, optimality criterion.
- CO2 Understand the theories of non-linear programming.
- CO3 Learn about bi-matrix game problem and apply it to real life problems.
- CO4 Learn Kuhn-tucker conditions for non-linear programming problems and apply it in various problems.
- CO5 Describe the solution techniques of Quadratic programming by various methods and also solve it by using these methods.
- CO6 Learn about Stochastic and Geometric programming problems.
- CO7 Learn about Multi-Objective Non-linear Programming.

MTM-405B Special Paper-OR: Operational Research Modelling-II

Course outcomes: The students will be able to

- CO1 Learn about Optimal Control like as Methods of calculus of variations, Transversally condition, Bang–bang Controls etc.
- CO2 Know the concept of reliability.
- CO3 Understand Communication Processes— memory less channel, the channel matrix, Probability relation in a channel, noiseless channel.
- CO4 Learn the axiom for an entropy function, process of Encoding and Decoding.

MTM-407B Special Paper-OR: Lab. (OR methods using MATLAB and LINGO)

Course outcomes: The students will be able to

- CO1 Write a programme on optimization problems on real life by using MATLAB or LINGO.
- CO2 Solve problems related optimization by using these software.

MTM-406 Dissertation Project Work

Course outcomes: The students will be able to

- CO1 Choose a problem from any branch of mathematics.



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- CO2 Formulate hypothesis for solving this problem.
- CO3 Collect data if required for testing hypothesis or collect all relevant concept/ ideas/ theories or tools for verifying the hypothesis.
- CO4 Write the project report in specified format.
- CO5 Represent the project report effectively by using ICT.