MATHEMATICS

B. Sc. Mathematics

Program Specific Outcomes

After the successful completion of this course, the student will:

- Be able to explain the core ideas and the techniques of mathematics at the college level.
- Be able to recognize the power of abstraction and generalization, and to carry out investigative mathematical work with independent judgment.
- Be able to setup mathematical models of real world problems and obtain solutions in structured and analytical approaches with independent judgement.
- Be able to carry out objective analysis and prediction of quantitative information with independent judgment.
- Be able to communicate effectively about mathematics to both lay and expert audiences utilizing appropriate information and communication technology.
- Be able to work independently, and to collaborate effectively in team work and team building.
- Be able to conduct self-evaluation, and continuously enrich themselves through lifelong learning.
- Be able to communicate to lay audiences and arouse their interest in the beauty and precision of mathematical arguments and science.
- Be able to recognize the importance of compliance with the ethics of science and being a responsible citizen towards their community and a sustainable environment.
- Be able to cultivate a mathematical attitude and nurture the interests.

Course Outcomes

First Semester

MM1CRT01: FOUNDATION OF MATHEMATICS

On completion of this course, successful students will be able to:

- prove statements about sets and functions;
- analyze statements using truth tables;
- Construct simple proofs.
- Identify mathematical Symbols and understand standard methods of proofs.

Second Semester

MM2CRT01: ANALYTIC GEOMETRY, TRIGONOMETRY AND MATRICES

On completion of this course, successful students will be able to:

- find the equation to tangent, normal at a point on a conic;
- find the polar equation of a line, circle, tangent and normal to conics
- recognise real and imaginary parts of a circular and hyperbolic functions of a complex variable
- solve a System of Linear equations using the inverse of a matrix
- find characteristic roots and characteristic vectors.
- find the inverse of a matrix by Cayley-Hamilton theorem

Third Semester

MM3CRT01: CALCULUS

After completing this course the learner should be able to

- Find the higher order derivative of the product of two functions.
- Expand a function using Taylor's and Maclaurin's series.
- Conceive the concept of asymptotes and obtain their equations.
- Learn about partial derivatives and its applications.
- Find the area under a given curve, length of an arc of a curve when the equations are given in parametric and polar form.
- Find the area and volume by applying the techniques of double and triple integrals

FOURTH SEMESTER

MM4CRT01 : Vector Calculus, Theory of Equations and Numerical Methods

After completing this course the learner should be able to

- Represent vectors analytically and geometrically, and compute dot and cross products for presentations of lines and planes,
- Analyze vector functions to find derivatives, tangent lines, integrals, arc length, and curvature,
- Compute limits and derivatives of functions of 2 and 3 variables,
- Apply derivative concepts to find tangent lines to level curves and to solve optimization problems,
- Evaluate double and triple integrals for area and volume,

    - Differentiate vector fields
    - Determine gradient vector fields and find potential functions
    - Analyze the fundamental theorem of calculus and see their relation to the fundamental theorems of calculus in calculus , leading to the more generalised version of Stokes' theorem in the setting of differential forms.
    - Evaluate line integrals directly and by the fundamental theorem
    - Analyze different forms of equations and finding their roots
    - Understand relation between roots and coefficients
- Derive numerical methods for approximating the solution of problems of continuous mathematics,
- Analyze the error incumbent in any such numerical approximation,
- Implement a variety of numerical algorithms using appropriate technology
- Compare the viability of different approaches to the numerical solution of problems arising in roots of solution of non-linear equations, interpolation and approximation, numerical differentiation and integration, solution of linear systems.

Fifth Semester

MM5CRT01: MATHEMATICAL ANALYSIS

After completing this course the learner should be able to

- Describe the real line as a complete, ordered field
- Determine the basic topological properties of subsets of the real numbers
- Use the definitions of convergence as they apply to sequences, and functions,
- Determine the continuity, differentiability, and integrability of functions defined on subsets of the real line
- Apply the Mean Value Theorem and the Fundamental Theorem of

Calculus to problems in the context of real analysis

- Produce rigorous proofs of results that arise in the context of real analysis.
- Write solutions to problems and proofs of theorems that meet rigorous standards based on content, organization and coherence, argument and support, and style

MM5CRT02: DIFFERENTIAL EQUATIONS

After studying this course the students should be able to

- Obtain an integrating factor which may reduce a given differential equation into an exact one and eventually provide its solution.
- Identify and obtain the solution of Clairaut's equation.
- Fine the complementary function and particular integrals of linear differential equation.
- Familiarize the orthogonal trajectory of the system of curves on a given surface.
- Method of solution of the differential equation $\frac{dx}{P} = \frac{dy}{Q} = \frac{dz}{R}$
- Describe the origin of partial differential equation and distinguish the integrals of first order linear partial differential equation into complete, general and singular integrals.
- Use Lagrange's method for solving the first order linear partial differential equation
- Solve differential equations of first order using graphical, numerical, and analytical methods,
- Solve and apply linear differential equations of second order (and higher),
- Solve linear differential equations using the Laplace transform technique,
- Find power series solutions of differential equations, and
- Develop the ability to apply differential equations to significant applied and/or theoretical problems.
- Demonstrate their ability to write coherent mathematical proofs and scientific arguments needed to communicate the results obtained from

differential equation models

- Demonstrate their understanding of how physical phenomena are modeled by differential equations and dynamical systems
- Implement solution methods using appropriate technology.

MM5CRT03: ABSTRACT ALGEBRA

After completing this course the learner should be able to

- Assess properties implied by the definitions of groups and rings,
- Use various canonical types of groups (including cyclic groups and groups of permutations) and canonical types of rings (including polynomial rings and modular rings),
- Analyze and demonstrate examples of subgroups, normal subgroups and quotient groups,
- Analyze and demonstrate examples of ideals and quotient rings,
- Use the concepts of isomorphism and homomorphism for groups and rings
- Produce rigorous proofs of propositions arising in the context of abstract algebra.

MM5CRT04 : ENVIRONMENTAL MATHEMATICS AND HUMAN RIGHTS

After the completion of this course the student will be able to:

- Develop awareness about natural resources and the role of individuals in conservation of natural resources.
- Understand the causes, effects and control measures of various types of pollution
- Understand the relation between Fibonacci numbers and nature.
- Realize the presence of the Golden ratio in different spheres of life.

- Acquire basic knowledge about various human rights

Open course

MM5OPT02: APPLICABLE MATHEMATICS

After the completion of this course the student will be able to

- Understanding the basic operations of Mathematics
- Applies shortcut methods for solving problems
- Apply mathematical concepts and principles to perform computations
- Apply mathematics to solve real life problems
- Create, use and analyze graphical representations of mathematical relationships
- Communicate mathematical knowledge and understanding
- Apply technology tools to solve problems
- Perform abstract mathematical reasoning
- Learn independently
- Compute limits, derivatives, and definite & indefinite integrals of algebraic, logarithmic and exponential functions
- Analyze functions and their graphs as informed by limits and derivatives
- Familiarize with basic operations on real numbers, logarithms and quadratic equations
- Identify the definitions of trigonometric ratios and their applications to problems involving heights and distance
- Get basic ideas of two dimensional geometry and graphing straight lines
- Use various methods to compute the probabilities of events
- Acquires basic ideas of derivatives, standard results and various rules for finding the derivatives of functions
- Differentiate integration from differentiation and integration of simple functions
- Acquires the basic arithmetic skills involving percentages, averages, time and rates, elementary algebra and geometry

SIXTH SEMESTER

MM6CRT01: REAL ANALYSIS

After the completion of this course the student will be able to:

- Identify Continuity and Discontinuity of various functions in different contexts
- Distinguish Uniform continuity from continuity and related theorems
- Understand partitions and their refinement
- Understand Integrability and theorems on integrability
- Recognize the difference between pointwise and uniform convergence of a sequence of functions
- Illustrate the effect of uniform convergence on the limit function with respect to continuity, differentiability, and integrability
- Develops a knowledge about Riemann Integration and applies into problems
- Determine the Riemann integrability and the Riemann Stieltjes integrability of a bounded function and prove a selection of theorems concerning integration

MM6CRT02: GRAPH THEORY AND METRIC SPACES

After the completion of this course the student will be able to

- Understand the new topics Graph Theory
- Understand the basic concepts of graphs, directed graphs, and weighted graphs and able to present a graph by matrices
- Understand the properties of trees and able to find a minimal spanning tree for a given weighted graph
- Understand Eulerian and Hamiltonian graphs

MM6CRT03: COMPLEX ANALYSIS

On completion of this course, the students will be able to

- Compute sums, products, quotients, conjugate, modulus, and argument of complex numbers
- Define and analyze limits and continuity for complex functions as well as consequences of continuity
- Conceive the concepts of analytic functions and will be familiar with the elementary complex functions and their properties
- Determine whether a given function is differentiable, and if so find its derivative
- Use differentiation rules to compute derivatives
- Write complex numbers in polar form
- Evaluate exponentials and integral powers of complex numbers
- Find all integral roots and all logarithms of nonzero complex numbers
- Apply the concept and consequences of analyticity and the Cauchy Riemann equations and of results on harmonic and entire functions including the fundamental theorem of algebra
- Find parametrizations of curves, and compute complex line integrals directly
- Understand the theory and techniques of complex integration
- Applies the theory into application of the power series expansion of analytic functions
- Understand the basic methods of complex integration and its application in contour integration.
- Analyze sequences and series of analytic functions and types of convergence,
- Evaluate complex contour integrals directly and by the fundamental theorem, apply the Cauchy integral theorem in its various versions, and the Cauchy integral formula
- Represent functions as Taylor, power and Laurent series, classify singularities and poles, find residues and evaluate complex

integrals using the residue theorem

- Use the Cauchy Residue Theorem to evaluate integrals and sum series
- Identify the isolated singularities of a function and determine whether they are removable, poles, or essential
- Compute Laurent series at an isolated singularity, and determine the residue
- Understand uses of improper integrals in various situations
- Use the residue theorem to compute complex line integrals and real integrals

MM6CRT04: LINEAR ALGEBRA

Upon completion of this course, students should be able to:

- Understand the idea about vector space and metric space
- Analyze finite and infinite dimensional vector spaces and subspaces over a field and their properties, including the basis structure of vector spaces
- Use the definition and properties of linear transformations and matrices of linear transformations and change of basis, including kernel, range and isomorphism
- Compute with the characteristic polynomial, eigenvectors, eigenvalues and Eigen spaces, as well as the geometric and the algebraic multiplicities of an eigen value and apply the basic diagonalization result
- Recall the defining properties of a metric space, and determine whether a given function defines a metric
- Determine how that a function is or is not a metric
- Show that a set in a metric space is or is not open and/or closed
- Show that a function between metric spaces is or is not continuous
- Show that a sequence in a metric space is or is not convergent
- Show that a metric space is or is not complete

- Familiarize with open sets, closed sets and Cantor set

MM6CBT01 : OPERATIONS RESEARCH

Upon completion of this course, students should be able to:

- Understand the new term LPP
- Applies the theory into different types of problems

- Understand Transportation Problem, Assignment problem and Queuing models
- Solving problems using different methods
- Formulate and model a linear programming problem from a word problem and solve them graphically in 2 and 3 dimensions, while employing some convex analysis
- Place a Primal linear programming problem into standard form and use the Simplex Method or Revised Simplex Method to solve it
- Find the dual, and identify and interpret the solution of the Dual Problem from the final tableau of the Primal problem
- Be able to modify a Primal Problem, and use the Fundamental Insight of Linear Programming to identify the new solution, or use the Dual Simplex Method to restore feasibility
- Interpret the dual variables and perform sensitivity analysis in the context of economics problems as shadow prices, input values, marginal values, or replacement values
- Explain the concept of complementary slackness and its role in solving primal/dual problem pairs
- Classify and formulate integer programming problems and solve them with cutting plane methods, or branch and bound methods
- Formulate and solve a number of classical linear programming problems and such as the minimum spanning tree problem, the

assignment problem, (deterministic) dynamic programming problem, the knapsack problem, the XOR problem, the transportation problem, the maximal flow problem, or the shortest path problem, while taking advantage of the special structures of certain problems

- Understands duality theorems and dual simplex method
- Uses dual simplex method to find optimal solutions
- Explains the Transportation Problem and formulate it as an LPP and hence solve the problem
- Determine that an Assignment Problem is a special case of LPP and hence solve by Hungarian method
- Identifies the Queuing models, their various forms and methods of solutions

Project

- Demonstrate library research skills in the area of mathematics,
- Critique mathematical presentations, and
- Produce a mature oral presentation of a non-trivial mathematical topic.

M Sc. Mathematics

After the successful completion of this course, the student will be able

- To motivate for research in mathematical sciences.
- To train computational scientists who can work on real life challenging problem
- To have an in-depth knowledge of a broad range of methods and techniques for analysing and solving problems within applicable fields.
- To have a Good theoretical insight and the ability to apply theory to the development of methods and techniques for solving a problem.
- To have an in-depth knowledge within a specific mathematical primary field.
- To tackle complex problems, reveal structures and clarify problems, discover suitable analytical and/or numerical methods and interpret solutions.
- To communicate clearly in writing and orally knowledge, ideas and conclusions about mathematics, including formulating complex mathematical arguments, using abstract

mathematical thinking synthesising intuition about mathematical ideas and their applications.

- To demonstrate an advanced knowledge and fundamental understanding of a number of specialist mathematical topics, including the ability to solve problems related to those topics using appropriate tools and techniques.
- To produce a mature oral presentation of a non-trivial mathematical topic
- To apply rigorous, analytic, highly numerate approach to analyze, execute tasks and solve problems in daily life and at work.

Course Outcomes

Semester – 1

MT01C01 LINEAR ALGEBRA

Upon the completion of the course the students will be able to:

- Analyze finite and infinite dimensional vector spaces and subspaces over a field and their properties, including the basis structure of vector spaces,
- Use the definition and properties of linear transformations and matrices of linear transformations and change of basis, including kernel, range and isomorphism,
- To describe the properties of determinants and its relation to matrix transpose,inverse etc
- Compute with the characteristic polynomial, eigenvectors, eigenvalues and Eigen spaces,
- Compute inner products and determine orthogonality on vector spaces, including Gram-Schmidt orthogonalization
- Identify self-adjoint transformations and apply the spectral theorem and orthogonal decomposition of inner product spaces, the Jordan canonical form to solving systems of ordinary differential equations.

MT01C02 BASIC TOPOLOGY

Upon completion of this course, students should be able to:

- Define and illustrate the concept of topological spaces and continuous functions,
- Define and illustrate the concept of product topology and quotient topology,
- Prove a selection of theorems concerning topological spaces, continuous functions, product topologies, and quotient topologies,

- Define and illustrate the concepts of the separation axioms,
- Define connectedness and compactness, and prove a selection of related theorems, and
- Describe different examples distinguishing general, geometric, and algebraic topology.

MT01C03 MEASURE THEORY AND INTEGRATION

Upon completion of this course, students should be able to:

- To understand the fundamental concepts of Mathematical Analysis.
- To state some of the classical theorems in of Advanced Real Analysis.
- To be familiar with measurable sets and functions.
- To integrate a measurable function.
- To understand the properties of Classical Banach Spaces.

MT01C04 GRAPH THEORY

Upon completion of this course, students should be able to:

- Students will understand the language of graphs and trees.
- Students will understand the use of graphs as modes
- Students will understand various types of trees and methods for traversing trees
- Solve problems using basic graph theory
- Identify induced subgraphs, cliques, matchings, covers in graphs
- Determine whether graphs are Hamiltonian and/or Eulerian
- Solve problems involving vertex and edge connectivity, planarity and crossing numbers
- Solve problems involving vertex and edge coloring
- Model real world problems using graph theory

MT01C05 COMPLEX ANALYSIS

Upon completion of this course, students should be able to:

- Represent complex numbers algebraically and geometrically,
- Define and analyze limits and continuity for complex functions as well as consequences of continuity,

- Apply the concept and consequences of analyticity and the Cauchy-Riemann equations and of results on harmonic and entire functions including the fundamental theorem of algebra,
- Analyze sequences and series of analytic functions and types of convergence,
- Evaluate complex contour integrals directly and by the fundamental theorem, apply the Cauchy integral theorem in its various versions, and the Cauchy integral formula, and
- Represent functions as Taylor, power and Laurent series, classify singularities and poles, find residues and evaluate complex integrals using the residue theorem.

SEMESTER 2

MT02C05 ABSTRACT ALGEBRA

Upon completion of this course, students should be able to:

- Demonstrate knowledge of group homomorphism, isomorphism and automorphisim.
- Derive and apply the First Isomorphism Theorem.
- Demonstrate knowledge of conjugates, the Class Equation and Sylow theorems.
- Derive and apply Sylow Theorems.
- Solvable groups and associated properties, finite abelian groups.
- Demonstrate knowledge of polynomial rings and associated properties.
- Derive and apply Gauss Lemma, Eisenstein criterion for irreducibility of rationals.
- Understand the characteristic of a field and the prime subfield.
- Understand Factorization and ideal theory in the polynomial ring; the structure of a primitive polynomials
- Understand Field extensions and characterization of finite normal extensions as splitting fields.
- Understand the structure and construction of finite fields.
- Understand radical field extensions.
- Understand Galois group and Galois theory.

MT02C07 ADVANCED TOPOLOGY

Upon completion of this course, students should be able to:

- Understand product topology

- Understand Tietze Characterisation of Normality.
- Able to Evaluate Functions in to Products
- Use The Urysohn Metrisation Theorem.
- Familiar with Nets and Filters
- Familiar with compactness
- Students will understand the concept of derivative in n dimensions and the implicit and inverse function theorems which give a bridge between suitably nondegenerate infinitesimal information about mappings and local information.
- They will understand the concept of manifold and see some examples such as matrix groups.

MT02C08 ADVANCED COMPLEX ANALYSIS

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

- Manipulate complex numbers in various representations, define fundamental topological concepts in the context of the complex plane, and define and calculate limits and derivatives of functions of a complex variable.
- Use fundamental results, including: Cauchy's Theorem and Cauchy's Integral Formula, the Fundamental Theorem of Algebra, Morera's Theorem and Liouville's Theorem.
- Represent analytic functions as power series on their domains and verify that they are well-defined.
- Define a branch of the complex logarithm.Classify singularities and find Laurent series for meromorphic functions

MT02C09 PARTIAL DIFFERENTIAL EQUATIONS

Upon completion of this course, students should be able to:

- Classify PDE and transform into canonical form
- Solve linear PDE of both first and second order
- Derive heat and wave equations in 2D and 3D
- Apply technique of separation of variables to solve PDEs and analyse the behaviour of solutions in terms of eigen function expansion

- Find the solutions of PDE determined by conditions at the boundary of the spatial domain and initial conditions at time zero.

MT02C10 REAL ANALYSIS

On completion of this unit successful students will be able to:

- evaluate the limits of a wide class of real sequences;
- determine whether or not real series are convergent by comparison with standard series or using the Ratio Test;
- understand the concept of continuity and be familiar with the statements and some proofs of the standard results about continuous real functions;
- understand the concept of the differentiability of a real valued function and be familiar with the statements of the standard results about differentiable real functions.

MT03C11 MULTIVARIATE CALCULUS AND INTEGRAL TRANSFORMS

On completion of this unit successful students will be able to:

- Understand the basic results in the analysis of functions of several variables.
- Understand the fundamental transforms,convolutions.
- Recognise vector valued functions and relate directional derivatives and partial derivatives to total derivative.
- Understand implicit functions and extremum problems.
- Recognise primitive mappings and differential forms.

MT03C12 FUNCTIONAL ANALYSIS

On completion of this unit successful students will be able to:

- Discuss various problems in different space: vector space, inner product space and Hilbert Spaces.
- Explain the fundamental concepts of functional analysis.
- Understand the approximation of continuous functions.
- Understand concepts of Hilbert and Banach spaces with l2 and lp spaces serving as examples.

- Understand the definitions of linear functional and prove the Hahn-Banach theorem, open mapping theorem, uniform boundedness theorem, etc.
- Define linear operators, self adjoint, isometric and unitary operators on Hilbert spaces.

MT03C13 DIFFERENTIAL GEOMETRY

On satisfying the requirements of this course, students will have the knowledge and skills to

- Explain the concepts and language of differential geometry and its role in modern mathematics
- Analyze and solve complex problems using appropriate techniques from differential geometry
- Apply problem-solving with differential geometry to diverse situations in physics, engineering or other mathematical contexts
- Apply differential geometry techniques to specific research problems in mathematics or other fields
- To obtain sound knowledge in understanding the basic concepts in geometry of curves and surfaces in Euclidean space, especially.
- To acquire mastery in solving typical problems associated with the theory.
- To gain sufficient knowledge for generalizing these concepts to higher dimensions.

MT03C14 NUMBER THEORY AND CRYPTOGRAPHY

On completion of this unit successful students will be able to:

- Learn the foundational Number Theory required for encryption and decryption.
- Encrypt and Decrypt message.
- Know the difference between private key and public key cryptographies.
- Understand a number of privacy mechanisms.

MT03C15 OPTIMIZATION TECHNIQUES

On completion of this unit successful students will be able to:

- Formulate optimization problems;
- Understand the importance of linear programming problems in which the variables are being restricted to integers;

- Solve integer programming problems as well as mixed integer linear programming problems;
- Apply the methods of optimization in real life situation.
- Identify strategic situations and represent them as games
- Solve simple games using various techniques
- Identify the methods and solve programming problems when the objective function or constraints are non linear.

Semester – 4

MT04C16 SPECTRAL THEORY

On satisfying the requirements of this course, students will have the knowledge and skills to:

- Explain the fundamental concepts of functional analysis and their role in modern mathematics and applied contexts.
- Demonstrate accurate and efficient use of functional analysis techniques.
- Demonstrate capacity for mathematical reasoning through analyzing, proving and explaining concepts from functional analysis.
- Apply problem-solving using functional analysis techniques applied to diverse situations in physics, engineering and other mathematical contexts.

MT04E01ANALYTIC NUMBER THEORY

- The aim of this course is to study the prime numbers using the famous Riemann ζ-function. In particular, we will study the connection between the primes and the zeros of the ζ-function.
- In addition to the highlights mentioned above, students will gain experience with different types of Fourier transform.
- The course aims to introduce students to the theory of prime numbers, showing how the irregularities in this elusive sequence can be tamed by the power of complex analysis.
- Students will learn to handle multiplicative functions, to deal with Dirichlet series as functions of a complex variable, and to prove the Prime Number Theorem and simple variants.

MT04E05 MATHEMATICAL ECONOMICS

On completion of this unit successful students will be able to:

- Possess a solid grasp of essential mathematical tools required for the further studies in economic theory.
- Use and explain the underlying principles, terminology, methods, techniques and conventions used in the subject.
- Develop an understanding of optimization techniques used in economic theory.
- Encourage students to think about applying these mathematical tools in their own research, if necessary, with suitable modifications.
- Solve economic problems using the mathematical methods described in the course.
- Use the mathematical methods described in the course to analyze and solve problems in tutorials in a group discovery setting.

MT04E07 OPERATIONS RESEARCH

On completion of this unit successful students will be able to:

- To apply the notions of linear programming in solving transportation problems.
- To understand the theory of games for solving simple games.
- To acquire knowledge in formulating Tax planning problem and use goal programming algorithms.
- To use linear programming in the formulation of shortest route problem and use algorithmic approach in solving various types of network problem.
- To know the use of dynamic programming in various applications.

MT04E14 CODING THEORY

After the completion of this course, students will able to

- Comprehend various error control code properties, error detection and correction.
- Understand various methods of generating and detecting different types of error correcting codes
- Understands the fundamentals of coding theory
- The student has knowledge of properties of and algorithms for coding and decoding of linear block codes, cyclic codes and convolution codes. The student has an overview of arithmetic in finite fields, linear algebra over finite fields, and rings of power series.

- Apply various algorithms and techniques for coding
- Understands binary symmetric channel

PROJECT

- Engage in the study or research of a topic that is beyond the regular math department offerings in both rigor and content, and
- Produce a document (paper or thesis) that exhibits both the background and the conclusions reached as a result such study or research