POST GRADUATE DEPARTMENT OF MATHEMATICS

LEARNING OUTCOMES

B. Sc. Programme(Mathematics)

PROGRAM SPECIFIC OUTCOMES

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

- Demonstrate an understanding of the foundations and history of mathematics.
- Develop familiarity with the depth of modern mathematics, by successful completion of a range of advanced courses.
- Communicate mathematics effectively in writing.
- Utilize technology to address mathematical ideas.
- Understand the broad background of Mathematics and develop an appreciation of how its various sub disciplines are related.
- Recognize and appreciate the connections between theory and applications.
- Recognize the importance and value of mathematical and statistical thinking, training, and approach to problem solving.
- Develop an in-depth knowledge about topics chosen from those offered through the university.
- Engage in an independent mathematical project.
- Develop understanding of career opportunities in Mathematics and use mathematics in their careers.
- Build up strong foundations for higher studies in Mathematics.
- Formulate and analyze mathematical models of real life situations.
- Join teaching profession in primary and secondary schools.

COURSE OUTCOMES

FIRST SEMESTER

MM 1141 METHODS OF MATHEMATICS

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

- Take limits of algebraic and trigonometric expressions including limits that go to infinity, limits that don't exist and limits that are finite.

- Differentiate all polynomial, rational, radical, and trigonometric functions and compositions of those functions and apply it for optimization and for solving problems in Physics and economics
- Compute indefinite integrals and find antiderivatives, including finding constants of integration given initial conditions.
- Apply the definite integral to compute area between two curves, volumes of solids of revolutions, arc length, surface area for surfaces of revolution and work problems.

SECOND SEMESTER

MM 1221 FOUNDATIONS OF MATHEMATICS

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

- Understand the concept of complex numbers and hyperbolic functions
- Perform basic operations of complex numbers and to represent complex numbers in polar forms
- Develop understanding about the difference between total and partial derivatives and to perform both operations.
- Evaluate multiple integrals and apply it in relevant situations.
- Perform basic vector computations, as well as dot and cross products of two vectors and projection of one vector onto another vector.

THIRD SEMESTER

MM 1341 ELEMENTARY NUMBER THEORY AND CALCULUS-I

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

- Develop knowledge of basic concepts in Number Theory
- Analyze vector functions to find derivatives, tangent lines, integrals, arc length, and curvature etc.
- Apply derivative concepts to find tangent lines to level curves and to solve optimization problems.
- Find tangent lines to intersections of surfaces, extrema ofr multivariate functions and Lagrange multipliers to solve extremum problems with constrains.

FOURTH SEMESTER

MM 1441 ELEMENTARY NUMBER THEORY AND CALCULUS-II

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

- Gain knowledge in the fundamental facts in Elementary Number theory.
- Perform operations in connection with congruence relations and its properties.
- Understand about Mahavira's puzzle, modular inverses and polar Rho factoring method, Wilson's theorem, Fermat's little theorem and Euler's theorem.
- Evaluate double integrals and triple integrals in both Cartesian and polar coordinates and apply it to find areas and volumes under curves.
- Define and evaluate surface integrals and apply it to solve problems by making use of the divergence theorem, Gauss's law & Stoke's theorem.

FIFTH SEMESTER

MM 1541 REAL ANALYSIS-I

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

- Describe fundamental properties of the real numbers that lead to the formal development of Real Analysis.
- Interpret ideas in Real Analysis geometrically as well as algebraically.
- Approximate irrational numbers by rational numbers.
- Define neighborhood, absolute value, completeness of a set, countability etc.
- Develop an understanding of limits and how they are used in sequences, series, differentiation and integration.
- Illustrate Dedekind's property, Completeness property, Supremum property etc using examples.
- Use plotting softwares such as GeoGebra to plot various functions.

MM 1542 COMPLEX ANALYSIS-I

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

- Develop understanding of the basic concepts underlying complex analysis.
- Perform basic operations on complex numbers.

- Define uniform convergence, analyticity of functions, power series etc.
- Evaluate power series expansions of exponential functions and the sine and cosine functions.
- Describe integral of a function along a curve as a limit of Reimann sum.
- Illustrate the use of complex numbers in Number theory & Geometry.

MM 1543 DIFFERENTIAL EQUATIONS

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

- Recall the concepts in differential and integral calculus.
- Understand various methods to solve first order differential equations and second order linear equations.
- Solve various physical problems using differential equations.
- Find solutions of exact differential equations.
- Describe integration from the viewpoint of differential equations.

MM 1544 VECTOR ANALYSIS

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

- Define directional derivatives, vector fields, del and Laplacian operators etc.
- Evaluate line integrals.
- Describe conservative vector field.
- Prove Green's theorem and apply the theorem in relevant situations.
- Use Gauss's theorem to evaluate surface integrals.
- Apply Stoke's theorem to interpret integrals as anti-derivatives.

MM 1545 ABSTRACT ALGEBRA-I

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

- Recall the basic concepts of set theory.
- Recognize the concept of binary operations.
- Understand the well-definedness and closedness of a set under a binary operation.
- Define group, subgroup, cyclic groups, permutations, direct products, cosets etc.
- Prove Lagrange's theorem and apply the theorem in relevant situations.
- Write proofs and do problems based on axioms.

MM 1551 OPEN COURSE- OPERATIONS RESEARCH

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

- Formulate linear programming models and the graphical solutions of linear programs in two variables.
- Express linear programs in standard forms.
- Find solution of a linear programming problem using simplex method.
- Solve transportations problems using Vogel's approximation method.
- Understand project management and assignment problems.

SIXTH SEMESTER

MM 1641 REAL ANALYSIS-II

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

- Recall the basic concepts in Real Analysis.
- Understand the History of development of calculus.
- Interpret the notion continuity geometrically as an unbroken curve.
- Explain the connection between continuity and existence of limits.
- View differentiation from a conceptual point of view.
- Understand the difference between anti-differentiation and Reimann's theory of integration.
- Apply Reimann's theory of integration.

MM 1642 LINEAR ALGEBRA

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

- Recall the basic concepts of matrices.
- Understand the geometrical aspects of linear algebra.
- Describe the two dimensional aspects of analytic geometry, solutions of simultaneous equations in two variables and the theory of 2X2 matrices.
- Extend the concepts in two dimension to three dimension.
- Extend the concepts in two & three dimensions into arbitrary dimensions.

MM 1643 COMPLEX ANALYSIS-II

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

- Recall the basic concepts in complex analysis
- Understand the properties of functions analytic i9n a disc or on a punctured disc.
- Define singularity, residues, contour integral etc.
- Apply contour integral methods to evaluate and estimate sums.
- Represent analytic functions as power series.
- Apply Residue theorem to evaluate integrals.

MM 1644 ABSTRACT ALGEBRA-II

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

- Recall the basic concepts in group theory.
- Familiarize with detailed study on group theory.
- Understand the basic concepts of ring theory.
- Assess properties implied by the definitions of groups and rings.
- Define homomorphism of groups, factor groups etc.
- Analyze examples of rings, factor groups etc.

MM 1645 COMPUTER PROGRAMMING (PRACTICAL)

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

- Prepare document in computers using the LATEX typesetting program
- Understand the basics of computer programming using Python.
- Understand the fundamentals of GNU/Linux operating system.
- Identify the Linux directory structure and the advantages of keeping their files in well structured directories.

MM 1651 ELECTIVE COURSE – GRAPH THEORY

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

- Understand the basic concepts of graphs, directed graphs etc
- Represent graphs by matrices
- Understand the properties of trees and to find the centre, radius and diameter of trees
- Determine whether a graph is planar or non planar

- Define walks, paths, circuits, connected graphs, bipartite graphs etc.
- Understand the concept of Euler graph and apply it to describe the Konigsberg problem, utility problem, seating problem etc.

MM 1646 PROJECT

After the successful completion of project, the student will be able to:

- Demonstrate library research skills in the area of Mathematics.
- Develop communication and teamwork skills.
- Produce a mature oral presentation of a non-trivial mathematical topic.

Complementary Mathematics For B.Sc Physics

FIRST SEMESTER

MM 1131.1: CALCULUS WITH APPLICATIONS IN PHYSICS-I

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

- Understand differentiation of product of functions, chain rule and various other methods of differentiation
- Familiarize with integration by parts, reduction formulae etc.
- Apply the techniques in Integral and Differential Calculus to solve problems in Physics.
- Solve problems related with limits of arithmetic, geometric and arithmetic geometric series.
- Perform vector operations.
- Use vectors to find distances.

SECOND SEMESTER

MM 1231.1: CALCULUS WITH APPLICATIONS IN PHYSICS-II

- Understand basic operations of complex numbers.
- Familiarize with hyperbolic functions.
- Find partial derivatives using chain rule and by changing variables
- Distinguish between exact and inexact differentials.

- Use multiple integrals to find areas and volumes.
- Perform differential operations on vectors.

THIRD SEMESTER

MM 1331.1: CALCULUS AND LINEAR ALGEBRA

- Solve differential equations of various orders.
- Find Laplace transforms solution of linear differential equation with constant coefficients
- Evaluate Line integrals by applying Green's Theorem.
- Calculate vector areas of surfaces using Surface integrals.
- Evaluate volumes of three dimensional regions using volume integrals.
- Represent a function as a Fourier Series.
- Understand the concept of linear operators
- Perform various matrix operations.

FOURTH SEMESTER

MM 1431.1: COMPEX ANALYSIS, SPECIAL FUNC TIONS AND PROBABILITY THEORY

- Understand the concept of analytic functions.
- Identify analytic functions using Cauchy- Reimann equations
- Understand various special functions namely, factorial function, Gamma function etc
- Apply the theory of probability for solving various problems in Chemistry

Complementary Mathematics For B.Sc Chemistry

FIRST SEMESTER

MM 1131.2: CALCULUS WITH APPLICATIONS IN CHEMISTRY-I

- Understand differentiation of product of functions, chain rule and various other methods of differentiation
- Familiarize with integration by parts, reduction formulae etc.
- Apply the techniques in Integral and Differential Calculus to solve problems in Chemistry.
- Perform vector operations.

- Use vectors to find distances.
- Understand basic operations of complex numbers.
- Familiarize with hyperbolic functions.

SECOND SEMESTER

MM 1231.2: CALCULUS WITH APPLICATIONS IN CHEMISTRY-II

- Solve problems related with limits of arithmetic, geometric and arithmetic geometric series.
- Find partial derivatives using chain rule and by changing variables
- Distinguish between exact and inexact differentials.
- Perform differential operations on vectors.
- Use multiple integrals to find areas and volumes.

THIRD SEMESTER

MM 1331.1: LINEAR ALGEBRA, PROBABILITY THEORY AND NUMERICAL METHODS

- Understand the concept of linear operators
- Perform various matrix operations.
- Apply the theory of probability for solving various problems in Chemistry.
- Distinguish between algebraic and transcendental equations.
- Solve equations using linear interpolation, binary chopping and Newton- Raphson method.
- Solve differential equations using Taylor series.

FOURTH SEMESTER

MM 1431.2: DIFFERENTIAL EQUATIONS, VECTOR CALCULUS AND ABSTRACT ALGEBRA

- Solve differential equations of various orders.
- Find Laplace transforms solution of linear differential equation with constant coefficients
- Evaluate Line integrals by applying Green's Theorem.
- Calculate vector areas of surfaces using Surface integrals.
- Evaluate volumes of three dimensional regions using volume integrals.

- Represent a function as a Fourier Series.
- Understand basics of Abstract Algebra.
- Apply representation theory in Chemistry.

STATISTICS COMPLEMENTARY COURSE

FIRST SEMESTER

ST 1131.1: DESCRIPTIVE STATISTICS

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

- Understand the characteristics of data and will get acquainted with describing data through illustrating examples and exercises.
- Collect, organize and summarize data.
- Create and interpret simple graphs.
- Compute appropriate summary statistics.

SECOND SEMESTER

ST 1231.1: PROBABILITY AND RANDOM VARIABLES

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

- Understand the ideas of probability and random variables in both univariate and bivariate cases.

THIRD SEMESTER

ST 1331.1: STATISTICAL DISTRIBUTIONS

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

- Understand the ideas of standard probability distributions, limit theorems and sampling distributions and its applications.

FOURTH SEMESTER

ST 1431.1: STATISTICAL INFERENCE

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

- Understand point estimation, interval estimation, testing of hypothesis and design of experiments.

ST 1432.1: PRACTICAL USING EXCEL

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

- Use statistical tools available in Excel
- Have hands on training in data analysis.

M. Sc. Mathematics

PROGRAM SPECIFIC OUTCOMES

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

- Write professional quality mathematics.
- Produce and judge the validity of rigorous mathematical arguments.
- Motivate for research in mathematical sciences.
- Develop a strong foundation that leads to success in subsequent careers and educational programs.
- Develop superior educational quality for students by promoting all aspects of teaching, learning, and researching mathematics.
- Deliver important skills for a successful transition to a research career or the industrial workplace.
- Develop familiarity with the depth of modern mathematics, by successful completion of a range of advanced courses.
- Engage in complex mathematical problems, clarify issues and find suitable solution methods.
- Formulate a theoretical or practical problem in a mathematical language, and work towards a solution of the problem within a formally correct framework.
- Develop the curiosity and give him or her understanding and respect for scientific values such as openness, precision, punctuality and the importance of distinguishing between knowledge and opinions.
- Obtain a deeper insight into modern mathematical theory and into how its general and powerful methods and techniques can be used within mathematics and its areas of application.
- Apply rigorous, analytic, highly numerate approach to analyze, execute tasks and solve problems in daily life and at work.
- Engage in an independent mathematical project.

COURSE OUTCOMES

FIRST SEMESTER

MM 211 LINEAR ALGEBRA

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

- Recall the basic concepts of matrix theory
- Define vector space, subspaces, basis, dimension etc. and illustrate them with examples.
- Verify whether a subset of a vector space is a subspace or not.
- Understand dimension theorems and apply them to calculate the dimension of a vector space.
- Define linear map, nullspace of a linear map, nullity, rank, invertibility etc of a linear map.
- Define Eigen values, Eigen vectors, linear operator, invariant subspaces, upper triangular matrices, diagonal matrices etc.
- Find out the Eigen values & Eigen vectors of an operator by applying theorems.
- Describe a linear operator on a complex vector space in terms of its generalized eigenvectors.
- Define characteristic polynomial, minimal polynomial, Jordan form of an operator, trace of an operator etc.

MM 212 REAL ANALYSIS I

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

- Recall the basic concepts of real analysis.
- Define functions of bounded variation, total variation, rectifiable curves, equivalence of paths etc.
- Describe the properties of functions of bounded variation, total variation etc
- Understand the definition, properties and applications and conditions for existence of Reimann-Steiltjles integrals.
- Illustrate the convergence, uniform convergence and pointwise convergence of sequences of functions.
- Analyze the sufficient conditions for the uniform convergence of series.
- Characterize continuity, boundedness, convexity etc.
- Define subsequences, Cauchy sequences etc.

MM213 DIFFERENTIAL EQUATIONS

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

- Recall the basic concepts of integral & differential calculus.
- Solve second order linear equations using the method of undetermined coefficients, variation of parameters, successive approximation etc.
- Evaluate series solutions of first order equations.
- Recognize the major classification of PDEs and the qualitative differences between the Classes of equations.
- Use partial differential equations to solve one dimensional wave equations, laplace equations, boundary value problems etc.
- Solve Pfaffian differential equations, Charpit's equations etc.

MM214 TOPOLOGY I

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

- Define and illustrate metric spaces, open set, closed sets etc.
- Explain the equivalence of metric spaces, complete metric spaces etc.
- Define and illustrate topological spaces, interior, boundary, base, subbase etc.
- Describe connected and disconnected spaces, compact spaces and related theorems.

SECOND SEMESTER

MM221 ABSTRACT ALGEBRA

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

- Recall basic concepts of Abstract Algebra
- Define and illustrate groups, cyclic groupos, cosets, rings, fields, UFD's, PID's, extensions, splitting fields etc.
- Develop knowledge of conjugates, the Class Equation and Sylow theorems and apply these in relevant situations.
- Apply mod p test, Eisenstein criterion etc to verify the irreducibility of polynomials.
- Understand Galois group and Galois theory.
- Analyze the solvability of polynomials by radicals.
- Prove and apply isomorphism theorems, Fermat's last theorem, Sylow theorems etc

MM222 REAL ANALYSIS II

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

- Understand the fundamental concepts of Mathematical Analysis.
- Familiarize with measurable sets and functions.
- Integrate a measurable function.
- Prove and apply Jensen's inequality, Holder's inequality and Minkowski's inequality
- Understand the applications of Radon- Nikodym theorem.
- Define signed measures and prove Hahn decomposition & Jordan decomposition theorems.

MM 223 TOPOLOGY II

After the successful completion of this course, the student will 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.
- Understand the concept of separation axioms and explain the properties of T0, T1& T2 spaces.
- Explain convergence and Tychonoff theorem.

MM224 SCIENTIFIC PROGRAMMING WITH PYTHON

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

- Visualize data with graphs using computer program.
- Describe Algebra Symbolic math with SymPy and solve Calculus problems.
- Design and program Python applications.
- Write functions and pass arguments in Python.
- Write programs to find out roots of equations.
- Use Lagrange's method, Newton's method etc with a computer program.

THIRD SEMESTER

MM 231 COMPLEX ANALYSIS I

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

- Understand elementary properties and examples of analytic functions.
- Define Reimann Steiltjes integral and describe its properties.
- Represent analytic functions as power series and find the zeroes of an analytic function.
- Prove Cauchy's theorem and integral formula and derive homotopic version of Cauchy's theorem.
- Prove open mapping theorem and Goursat's theorem.
- Define and classify the singularities of a function.
- Represent the extended plane spherically.

M232 FUNCTIONAL ANALYSIS I

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

- Recall the basic concepts regarding sets, linear spaces, linear maps etc
- Understand and apply the concepts of normed spaces.
- Describe the continuity of linear maps .
- Analyze the proofs of Hahn Banach theorems and apply it.
- Define and illustrate Banach spaces.
- Explain the fundamental concepts of functional analysis and their role in modern mathematics and applied contexts.
- Understand open mapping, closed graph & bounded inverse theorems.

MM233 ELECTIVE I – OPERATIONS RESEARCH

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

- Formulate linear programming models and the graphical solutions of linear programs in two variables.
- Express linear programs in standard forms.
- Find solution of a linear programming problem using simplex method.
- Solve transportations problems using Vogel's approximation method.
- Understand project management and assignment problems.
- Explain Kuhn Tucker theory and non linear programming.

MM 234 ELECTIVE II – GRAPH THEORY

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

- Understand the basic concepts of graphs, directed graphs etc
- Determine whether a graph is planar or non planar
- Define walks, paths, circuits, connected graphs, bipartite graphs etc.
- Understand the concept of Eulerian and Hamiltonian graphs and apply it to describe the Konigsberg problem, utility problem, seating problem etc.
- Understand the concept of graph coloring
- Define and explain strong digraphs, Ramsey number and Turan's theorem.

FOURTH SEMESTER

MM241 COMPLEX ANALYSIS II

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

- Recall the basic concepts in complex analysis
- Understand the concepts of compactness and convergence in space of analytic functions.
- Prove Reimann Mapping theorem & Wierstrass factorization theorem.
- Define Gamma function, Reimann zeta function etc.
- Analyze and apply Runge,s theorem, Mittag- Leffler theorem, Monodromy theorem Hadamard factorization theorem.
- Describe basic properties of harmonic functions.
- Understand genus & order of an entire function

MM242 FUNCTIONAL ANALYSIS II

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

- Explain the fundamental concepts of functional analysis.
- Define self-adjoint and unitary linear operators.
- Demonstrate capacity for mathematical reasoning through analyzing, proving and explaining concepts from functional analysis.
- Analyze and apply projection and Riesz representation theorems.
- Distinguish between spectrum and resolvent set of a linear operator.
- Define compact linear operators and apply definition to prove theorems.

MM243 ELECTIVE III – FIELD THEORY

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

- Recall the basic concepts of abstract algebra
- Prove isomorphism theorems and correspondence theorem.
- Define Sylow p-subgroups, commutator subgroup and higher subgroups.
- Apply Sylow theorems to prove that S_5 is not simple.
- Describe the definitions and properties of polynomial rings over fields.
- Explain the characteristics of splitting fields.
- Evaluate roots of unity and analyze the solvability of polynomials by radicals.
- Prove and apply fundamental theorem of Galois theory.

MM244 ELECTIVE IV – ANALYTIC NUMBER THEORY

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

- Study the prime numbers using the famous Reimann zeta function
- Prove and apply fundamental theorem of arithmetic.
- Define congruences and prove Chinese remainder theorem to solve simultaneous congruences.
- Explain quadratic residues, reciprocity law and Jacobi symbol.
- Describe the existence and number of primitive roots.

MM245 DISSERTATION/ PROJECT & COMPREHENSIVE VIVA

After the successful completion of project and viva, the student will be able to:

- Demonstrate library research skills in the area of Mathematics.
- Engage in an independent mathematical project.
- Produce a mature oral presentation of a non-trivial mathematical topic.
- Evaluate his own understanding from his performance in viva.