Student Learning Outcomes of B.Sc. (Mathematics) Programme

★ Upon successful completion of B.Sc. (Mathematics) Programme the students will :

- have developed important analytical skills and problem solving strategies to solved various problems and issues in Mathematics and other related fields.
- be able to formulate mathematical reasoning to developed solutions in scientific fields.
- be prepared for any area of employment that requires peoples with clear and logical thinking.

Student Learning Outcomes Subject wise

★ Upon successful completion of Analytic Geometry and Complex Numbers (US01CMTH01) students will be able to

- Learn sketching of various curves.
- Concepts of Asymptotes and various types of Asymptotes
- Understand the application of Cycloid.
- Learn to find parametric equations of curves.
- Understand polar coordinates and its relationship with cartesian coordinates.
- Understand symmetry of various curves in polar coordinate system.
- Learns polar equations of straight lines and conics.
- Apply the concept of reciprocal curves.
- Learns concept of complex numbers.
- Learns De'Movire's theorem and its application in finding out n^{th} root of a complex number.
- Understand the Fundamental Theorem of Algebra and use it to find multiple roots of an equation and their multiplicity.

★ Upon successful completion of Calculus and Differential equations (US01CMTH02) students will be able to

- Calculate higher order derivatives and algebraic and trigonometric functions.
- Use Libnitz's theorem to find higher order derivatives of product functions.
- Understand the curvature and radius of curvature along with their relevance with derivatives.
- Rectify a curve in various coordinate systems.
- Find relation between the length of the arc measured from a fixed point and the angle between the tangent and the radius vector at a point on a curve.
- differentiate composite and implicit functions.
- understand partial derivatives.
- understand homogeneous function and prove Euler's theorem along useful corollaries.
- learn applications of Euler's theorems for two and three variables.
- understand limit and continuity of two variables.
- Understand linear differential equations with constant coefficients and solve them.
- learn to find orthogonal trajectories in cartesian coordinates.

★ Upon successful completion of Problems and Exercises in Mathematics (US01CMTH03) students will be able to :

- Understand the idea of limit by using L'Hospital's rule ,Angles between two curves ,Radius of curvature and Arc length of the curves ,Intrinsic equation and its Applications .
- Sketch Cartesian curve, parametric curves, polar curves and reciprocal curves .
- Verify Euler's theorem on homogeneous functions .
- Obtain Maxima and minima for a function of two variables
- Find Taylor's expansion of functions and Orthogonal trajectories of a family of curves
- Solve Exact Differential equations and Differential equations of the first order but not of first degree
- Understand Algebra of complex numbers and its properties

★ Upon successful completion of Analytic Solid Geometry (US02CMTH01) students will be able to :

• Find centre and radius of Sphere and circles
• Find family of spheres Passing through a circle , tangent planes and normal lines to a sphere.
• Identify different conicoids and sketch them
• Understand relationship between different coordinate systems and plot the curve in Spherical,cylindrical polar coordinates .
• Understand Jacobian and its importance in Mathematics .
• Obtain equation of Cone , enveloping cone ,cylinder ,right circular cylinder , enveloping cylinder and prove their results .
• Find equation of tangent plane, reciprocal cone of given cone .

★ Upon successful completion of Matrix Algebra and Differential Equations (US02CMTH02) students will be able to :

- perform algebraic operations on matrices.
- reversal laws (for products), distributive law and associative law for matrices.
- prove theorems on unique representations of square matrices in terms of symmetric and skew-symmetric matrices or Hermitian and Skew-Hermitian matrices and apply them to a given matrix for such representations.
- define characteristic equation of a matrix and find the equation for a given matrix.
- prove Cayley-Hamilton theorem and verify it for a given square matrix.
- define and find characteristic roots and corresponding vectors of of a square matrix and find them for a given square matrix.
- construct an orthogonal matrix with the help of a real skew symmetric matrix.
- define linear differential equation with constant coefficients and its complementary function and particular integral.
- prove the existence of general solution of linear differential equation with constant coefficients.
- find complementary function using auxiliary equation.
- derive formula for finding particular integrals of $f(D)y = X$, where X is a function of x.
- derive formula for finding particular integrals of $f(D)y = e^{mx}$
- solve linear differential equations $f(D)y = X$ where X involves e^{mx} only.
- derive working rules for finding particular integral of $f(D)y = X$ where $X = sinmx, cosmx, x^m , e^{ax}V, xV$ (where V is a function of x only)
- solve a linear differential equations of the form $f(D)y = X$, where X involves $\sin mx, \cos mx, e^m x, x^m, e^{ax}V$ or xV (where V is a function of x only).
- define homogeneous linear differential equation and solve such equations.

★ Upon successful completion of Problems and Exercises in Mathematics (US02CMTH03) students will be able to :

• Obtain Integration of rational function and linear surd .
• Evaluate integration of trigonometric functions of higher degree by Reduction formulae .
• Obtain Solution of System of linear homogeneous and non homogeneous algebraic equations.
• Application of Descarte's rule of sign.
• Find Solution of equations by Cardan's method , Ferarri's method.
• Find equation of conic section such as Spheres , Cone and Cylinder.
• Sketch Quadric surfaces .
• Find Rank and Normal form of matrix ,Inverse of a nonsingular matrix , Eigenvalue and Eigenvector of matrix .
• Find General solution of Linear differential equations .

★ Upon successful completion of Advanced Calculus (US03CMTH01),students will be able to:

- Evaluation of Line , Double integral ,Triple integrals and Change of variables in integral.
- Apply double and triple integral to find Area ,Volume , Total mass , Centre of gravity and Moment of inertia.
- Understand to the Change the order of integration in double integral.
- Prove Green's theorem and different forms of Green's theorem and apply it to find line integral.
- Express equation of Surface in Cartesian and Parametric forms .
- Obtain Tangent plane and Normal line to the surface.
- Evaluate Area of a surface , Surface integrals and Moment of inertia of surface.
- Prove Gauss and Stoke's theorem and apply them to find surface integral and line integral .

★ Upon successful completion of Numerical Analysis (US03CMTH02),students will be able to:

- Learn various numerical methods to solve algebraic and transcendental equations.
- Understands forward, backward and central differences and relationships between them.
- Learns interpolation with equally spaced points and applies various interpolation formulas to interpolate a given data.
- Learns interpolation with unequally spaced points and applies various interpolation formulas to interpolate a given data.
- Learns divided difference and its properties and uses Newton's formula to for interpolation.
- Learns numerical differentiation and able to use various numerical methods to find differentiation.
- Understands various methods of numerical integration.
- Able to solve ordinary differential equation using various numerical methods.

★ Upon successful completion of Mathematics Practical (US03CMTH03), students will be able to :

- Find Inherent Errors , truncated errors and Errors in a series approximation.
- Understand Interpolation by different methods and apply them properly.
- Find Numerical differentiation and integration by different methods .
- Find Solution of algebraic and transcendental equations by different methods.
- Find Numerical solution of ordinary differential equations by Solution by Taylor's series and other different methods .
- Analyze Boolean algebra ,Simplify Switching circuits.

★ Upon successful completion of Calculus (US03EMTH01), students will be able to :

- Prove result for Convergence of improper integrals and Comparison tests for convergence .
- Evaluate integrals by Beta and Gamma functions .
- Analyze Beta and Gamma functions and their properties
- Find Gradient and Directional derivatives of scalar field , divergence and curl of a vector field
- Prove important results of divergence and curl of a vector field.
- Analyze Fourier series and its applications
- Understand Euler formulae and it's evaluation .
- Find Half range expansions of Periodic functions .

★ Upon successful completion of Calculus and Algebra - 1 (US03EMTH05), students will be able to :

- Identify Indeterminate forms and evaluate limits by L'Hospital's rule .
- Find Partial derivatives of first and second order
- Prove Euler's theorem on homogeneous functions and its application
- Understand Different types of matrices and their properties .
- Prove Reversal law for the transpose of a product
- Prove Associative and Distributive law for matrix multiplication
- Find Characteristic matrix and characteristic equation of a matrix
- Prove Cayley- Hamilton theorem and its application .

★ Upon successful completion of Linear Algebra (US04CMTH01), students will be able to :

- Analyze Vector spaces and subspaces over a field and their properties
- Understand Span of a set and it's Properties .
- Analyze Linear dependence and independence of sets and their properties together with examples .
- Find Dimension and basis of a vector space and Prove their properties
- Analyze Linear Transformations and their properties .
- Determine Matrix associated with a linear map and Linear map associated with a Matrix .

★ Upon successful completion of Differential Equations (US04CMTH02), students will be able to :

- Understand the curves and surfaces in three dimensions.
- Solve simultaneous equation using various methods.
- able to find orthogonal trajectories of a system of curves.
- solve Paffian differential equation in two and three variables.
- understand the formation of partial differential equation and able to solve a linear differential equation of first order.
- able to find surfaces orthogonal to a given system of surfaces and integral surfaces to a given curve.
- understand first order non-liner partial differential equation.
- Understands compatible equations and find their solutions.
- Learn the Chrarpit's method to solve a given non-linear partial differential equation.
- Solve partial differential equations with variable coefficients.

★ Upon successful completion of Mathematics Practical (US04CMTH03), students will be able to :

- Recognition of the properties of functions from their graphs and converse .
- Prove some important theorem with a ruler and compass only .
- Verify different geometric results .
- Analyze different properties of Conics , Polyhedra,Cylinder and Cone .
- Make Model of Regular Polyhedra from drawing sheet and String Construction .
- Analyze properties of Solid surfaces and other models.

★ Upon successful completion of Boolean Algebra and Laplace Transforms (US04EMTH01), students will be able to :

• Understand Boolean algebra , its Properties and its to switching circuits.
• Find Solution of algebraic and transcendental equations by different methods .
• Understand Laplace transform and Inverse transforms of elementary functions and Prove their Properties .
• Find differentiation and integration of Laplace transform and converse .
• Prove Shifting Property for inverse Laplace transforms.
• Evaluate integral by convolution theorem .

★ Upon successful completion of Calculus and Algebra - 2 (US04EMTH05), students will be able to :

• Evaluate Maxima and Minima for a function of two variables .
• Evaluate Gradient and Directional derivative of scalar field ,Divergence and Curl of vectors fields and Prove their Properties .
• Find Tangent and normal plane to a surface
• Understand Boolean algebra and Simplify Boolean function
• Analyze Application of Boolean algebra to switching circuits.

★ Upon successful completion of Real Analysis - I (US05CMTH01), students will be able to :
- understand fundamentals like bounded sets,supremum, infimum, Order Completeness of a field and Archimedean property.
- accept the existence of irrational number with logical proof and Order incompleteness of the field of rational numbers.
- learn properties absolute values and apply the same in various situations.
- understand fundamental properties of exponential and logarithmic functions.
- understand fundamental properties of trigonometric and inverse trigonometric functions.
- understand concepts like neighbourhood of a point, interior point, interior of a set, open set and prove various theorems regarding properties of open sets.
- understand limit point of a set, adherent point, closure of a set and closed set and prove various theorems regarding closed sets and their relation with open sets.
- recognize interior points, limit points, open sets and closed sets.
- define limit of a function and prove theorems on limits.
- apply definition and theorems to evaluate limits.
- define continuous functions and various theorem on continuity.
- understand continuous functions on closed and bounded intervals and their properties.
- Define uniformly continuous functions and identify such functions.
- Learn about derivable functions and their properties.
- Conceptualize relation of monotonic functions with the signs of their derivatives.
- Prove Darboux's theorem for derivable functions.

★ Upon successful completion of Real Analysis-II (US05CMTH02) students will be able to
- define sequence, convergence, limit of a sequence,limit point of a sequence and evaluate limits of certain class of sequences.
- prove Bolzano-Weierstrass theorem for existence of limit point of a sequence.
- prove Cauchy's general principle of convergence of a sequence and algebra of sequences.
- apply Cauchy's general principle to determine whether a sequence is convergent or not.
- define monotonic sequence and prove theorem for their convergence.
- understand various types of divergence of sequence.
- define infinite series, its convergence and divergence and prove various theorems on their convergence.
- prove theorems on Comparison tests, Cauchy's root test and D'Alembert ratio test for positive term series and apply the tests.
- Define function of several variables and understand their explicit and implicit forms.
- Define simultaneous limit and repeated limits and continuity of a function.
- Define and evaluate partial derivatives of functions of several variables.
- prove Taylor's theorem and Maclaurin's theorem for function of two variables
- define extreme values and prove theorems on extreme values.
- evaluate maxima and minima of functions of two variables.

★ Upon successful completion of Metric Spaces (US05CMTH03) students will be able to
- define a metric space and various special metric spaces and determine whether a function is a metric or not.
- define limit and continuity of a function and prove corresponding theorems.
- define open balls, interior points, open sets and closed sets.
- prove theorems on open and closed sets and various conditions for continuity of a function.
- define subspace and their open and closed sets.
- define connectedness of a space and prove its relation with Heine-Borel property.
- define bounded and totally bounded sets and understand their relations.
- define complete metric and compact metric space and prove corresponding theorems.
- prove theorems on continuous functions on compact spaces.
- define uniform continuity and prove theorem on uniform continuity and compact spaces.

★ Upon successful completion of Abstract Algebra - 1 (USO5CMTH04), students will be able to :

• Analyze Group , Cyclic group ,Normal subgroup ,Quotient groups , Simple group , Commutator subgroup , Isomorphism , Automorphism , Homomorphism and their properties .
• Understand Lagrange's , Euler's , Fermat's , Cayley's ,First ,second and third isomorphism theorem and its application .
• Understand Direct products and prove its properties .
• Analyze Permutation groups and its properties .

★ Upon successful completion of Number Theory (USO5CMTH05), students will be able to :

• Analyze Divisibility ,GCD , LCM and Prime numbers and their Properties
• Prove Fundamental theorem of divisibility and Unique factorization theorem .
• Identify Perfect numbers ,Mersenne numbers ,Fermat numbers ,Gauss function , Mobius function ,Euler's function and prove their Properties .
• Analyze Congruences ,Complete residue system , Reduced residue system and their Properties.
• Solve indeterminate equation , Linear congruence in one unknown and two unknown.
• Understand Chinese theorem and its applications .

★ Upon successful completion of Mechanics - 1 (USO5CMTH06), students will be able to :

• Understand Ingredients of mechanics and their properties
• Understand Fundamental laws of Newtonian mechanics
• Analyze equilibrium of a particle , systems of particles and their properties
• Understand Couples , work and potential energy , principle of virtual work , mass center and center of gravity , gravitational potential and their results .
• Understand Flexible cables in contact with smooth and rough curve , kinematics of a particle , motion of a rigid body parallel to a plane and their results .

★ Upon successful completion of Maths Practical-I (US05CMTH07) students will be able to :

  • download and install Scilab.
  • understand the commandline computing environment of SCILAB and use some of its most basic commands.
  • perform arithmetic operations and inbuilt functions and interpret their output mathematically.
  • use operations on matrices and verify some theoretically established results.
  • apply matric operations to solve a system of linear equations.

★ Upon successful completion of Mathematics Practical-II (US05CMTH08) students will be able to :

  • use commands to draw graphs in two and three dimensions.
  • draw graphs of functions and determine their asymptotes.
  • draw statistical charts for a given set of data and interpret it.
  • draw multiple graphs on same page for comparative study.

★ Upon successful completion of Mathematics Practical-III (US05CMTH09) students will be able to :

  • find eigen values and corresponding vectors of a given matrix.
  • solve equations using builtin commands.
  • solve a system of equations.
  • solve simple ordinary and partial differential equations using builtin commands.

★ Upon successful completion of Real Analysis-III (US06CMTH01) students will be able to :

- prove Rolle's theorem, Langrange's mean value theorem and Cauchy's Mean Value theorem.
- apply Rolle's theorem, Langrange's mean value theorem and Cauchy's Mean Value theorems to functions satisfying their respective conditions.
- prove Taylor's and Maclaurin's theorems and apply them to functions satisfying their respective conditions.
- define extreme values and prove theorems related to conditions for extreme values.
- investigate a given function for extreme values and evaluate them for extreme values.
- define and evaluate Upper Integral,Lower Integral and Riemann Integrals
- define refinement of a partition and prove results showing its consequences on lower and upper sums.
- prove Darboux's theorem for integrals.
- prove various necessary and sufficient conditions for Riemann Integrability of a function.
- prove and apply results related to sum,difference,product,quotient and modulus of integrable functions.
- define Riemann Integral as a limit of Riemann Sum and prove necessary and sufficient condition for integrability.
- prove theorems on integrability of continuous functions, monotonic functions and functions having only a finite number of limit points of set of points of discontinuities.

★ Upon successful completion of Complex Analysis (USO6CMTH02) students will be able to :

• Understand Limits , Continuity , Differentiability , Cauchy-Riemann equations and their properties .
• Prove Sufficient conditions for analyticity of function .
• Analyze Analytic , harmonic ,exponential,Trigonometric , hyperbolic , Logarithmic ,Inverse trigonometric ,Inverse hyperbolic functions and prove their properties .
• Understand Linear , 1/z , Linear fractional , exponential , Trigonometric transformations and their properties .

★ Upon successful completion of Topology (US06CMTH03) students will be able to :

- define a topological space, a topology, open set and closed sets.
- verify whether a given collection is a topology or not.
- define trivial and non-trivial topologies and prove some results regarding their properties.
- define finer, coarser and door topologies and neighbourhood of a point.
- define a cluster point and closure of a set and prove results related to relation between closure and closed sets.
- define dense set,inter point and interior of a set and prove results related to interior and open sets.
- define continuity of a function and homeomorphism and prove related theorems.
- define connected and disconnected spaces and prove necessary and sufficient conditions for connectedness.
- define subspaces and respective open sets and prove the results for connectedness of subspaces.
- define Hausdorff space,open covering and compact space and prove theorems on compactness.
- prove a theorem related to compactness and Heine-Borel property.
- prove theorem on consequences of compact domain on continuous functions.
- define T_1-space, regular space, T_3-space and metric topology and prove theorems on them.

★ Upon successful completion of Abstract Algebra - 2 (USO6CMTH04) students will be able to :

• Analyze Rings , Integrals domains , Fields , Ideals , prime ideals , maximal ideals ,Quotient fields , quotient rings,Homomorphism , isomorphism and their properties .
• Understand Factorization , Associates elements ,Irreducible element , Euclidean domain , Principal ideal domain ,Unique Factorization domain , Polynomial rings and their properties .
• Prove First isomorphism theorem, Eisenstein's criterion and Gauss theorem .

★ Upon successful completion of Graph Theory (US06CMTH05) students will be able to :

- define a graph in general and understand its applications to various fields.
- define isomorphism between two graphs, connected graphs, disconnected graphs and components.
- prove results on maximum number of edges in a simple graph.
- define and apply various operations on a graph.
- define Euler line and Euler graph and prove necessary and sufficient conditions for a graph to be an Euler graph.
- define Hamiltonian paths,circuits and trees and results related to properties of a tree.
- define distance between two vertices in a tree, center, radius and diameter and prove that distance in a tree is a metric.
- define spanning tree and corresponding fundamental circuits and fundamental cut-sets and prove related theorems.
- define connectivity and separability of a graph and prove related results.
- understand first and second isomorphisms.
- define planar graphs and non-planar graphs and understand Kuratowski's two graphs.
- define and find geometric dual of a planar graph and prove results related to geometric duals.
- prove Euler's theorem for planar graphs and apply the theorem to show that Kuratowski's two graphs are non-planar.

★ Upon successful completion of Mechanics - 2 (USO6CMTH06) students will be able to :

• Understand Methods of plane dynamics , motion of a particle and system of particles and their properties .
• Analyze projectile with and without resistance , Motion under central force , planetary orbits and their properties .
• Find Kinetic energy , angular momentum , moment of inertia of a rigid body and prove their properties .
• Understand Rotational motion about a fixed line , impulsive motion , collision and their properties .

★ Upon successful completion of Mathematics Practical-I (US06CMTH07) students will be able to :

- download and install MAXIMA/SAGE and understand its computing environments.
- define symbolic variables and perform simple symbolic calculations.
- define symbolic functions and basic operations on them.
- find limit, derivative and integral of a given function.
- determine convergence and divergence of sequence and series.

★ Upon successful completion of Mathematics Practical-II (US06CMTH08) students will be able to :

- understand and use basic programing constructs and use them to program user defined functions.
- define and use functions to determine whether a given number is natural, prime or composite.
- define a function to evaluate e^x, **Cosine** and **Sine** functions using infinite series.

★ Upon successful completion of Mathematics Practical-III (US06CMTH09) students will be able to :

- determine logical flow for solving a simple mathematical problem.
- write programs to find primes between two numbers, to determine whether a number is palindrome or not, to find gcd and lcm, to find all the factors of a natural number, to determine whether a given number is perfect or not and to approximate a real root of an equation using bisection method.

★ Upon successful completion of B.Sc. (Mathematics) Programme the students will :

- have developed important analytical skills and problem solving strategies to solved various problems and issues in Mathematics and other related fields.
- be able to formulate mathematical reasoning to developed solutions in scientific fields.
- be prepared for any area of employment that requires peoples with clear and logical thinking.