

**101M Introduction to Differential Calculus (3+0) credit-hours**

Real numbers, inequalities, functions, injective function and its inverse. Limits,  $\epsilon - \delta$  definition, continuity, properties of a continuous function on an interval. Differentiability, techniques of differentiation, critical points, absolute and local extrema, mean value theorem. Intervals of increase and decrease, first derivative and second derivative tests for local extrema, concavity and inflection points, asymptote, curve sketching, applied extrema problems, related rates. Conic sections.

**102M Introduction to Integral Calculus (3+0) credit-hours.**

*Prerequisite: 101M*

Definition of Riemann integral by Riemann sums, properties of the definite integral. Mean value theorem for the integral, the fundamental theorem of calculus, indefinite integral, integration by substitution. Logarithmic and exponential functions, hyperbolic and inverse hyperbolic functions. Techniques of integration: integration by parts, trigonometric substitutions, integrals involving quadratic expressions, partial fractions, miscellaneous substitutions. Numerical integration (the trapezoidal rule). L'Hospital's rule, improper integrals. Evaluation of area, volume of revolution, arc length. Sketching of some elementary curves in polar coordinates, evaluation of area in polar coordinates.

**103M General Mathematics I (3+0) credit-hours.**

Inequalities, functions, limits and continuity. Differentiability, Differentiation techniques. Trigonometric, inverse trigonometric, logarithmic and exponential functions. Applications of differentiation (curve tracing, rates of change, maxima and minima).

**104M General Mathematics II (3+0) credit-hours.**

*Prerequisite: 103M*

Conic Sections. Polar coordinates. Anti-derivatives, indefinite integral. Definite integral and its properties, simple methods of integration (substitution, by parts). Applications of the definite integral. Integration of exponential, logarithmic and hyperbolic functions. Integration techniques. First order differential equations. Cramer's rule for solving systems of linear equations. Three dimensional coordinates, quadric surfaces, partial differentiation.

**105M Differential Calculus (3+0) credit-hours.**

*Language of instruction: English*

Real numbers, functions, Limits, continuity. Derivatives, differentials, chain rule, implicit differentiation. Higher order derivatives, local extrema, concavity, horizontal and vertical asymptotes, applications of extrema, related rates. Rolle's theorem, mean value theorem, inverse trigonometric functions. Conic sections.

**106M Integral Calculus (3+0) credit-hours.**

*Prerequisite: 105M*

*Language of instruction: English*

The definite integral, fundamental theorem of calculus, the indefinite integral, change of variable, numerical integration. Area, volume of revolution, work, arc length. Differentiation and integration of inverse trigonometric functions. The logarithmic, exponential, hyperbolic and inverse hyperbolic functions. Techniques of integration: substitution, by parts, trigonometric substitutions, partial fractions, miscellaneous substitutions. Indeterminate forms, improper integrals. Polar coordinates.

**107M Vectors and Matrices (3+0) credit-hours.**

*Prerequisite: 105M*

*Language of instruction: English*

Vectors in two and three dimensions, scalar and vector products, equations of lines and planes in space, surfaces, cylindrical and spherical coordinates. Vector valued functions, their limits, continuity, derivatives and integrals. Motion of a particle in space, tangential and normal components of acceleration. Functions in two or three variables, their limits, continuity, partial derivatives, differentials, chain rule, directional derivatives, tangent planes and normal lines to surfaces. Extrema of functions of several variables, Lagrange multipliers. Systems of linear equations, matrices, determinants, inverse of a matrix, Cramer's rule.

**109M Mathematics for Pharmacy Students (3+0) credit-hours.**

*Language of instruction: English*

Real numbers, functions, trigonometric functions. Limits, continuity. Derivatives, rules for differentiation, applications of differentiation (rates of change, extrema, curve sketching analysis). Exponential and Logarithmic functions,. Integration by substitution, by parts and using partial fractions. Functions of several variables, their partial derivatives, extrema. Introduction to differential equations, linear first order differential equations.

**131M Foundations of Mathematics (3+1) credit-hours.**

*Prerequisite: 101M*

Introduction to logic, methods of proof, mathematical induction. Sets, operations, on sets, cartesian product, binary relation, partition of a set, equivalence relation, equivalence classes, mappings, equivalence of sets, finite sets, countable sets, cardinal numbers. Binary operations, morphisms. Definition and examples of groups, definition and examples of rings and fields.

**151M Discrete Mathematics (3+0) credit-hours.**

*Prerequisite: 101M or 105M*

Propositional Calculus, logical equivalence, arguments, methods of proof. Relations, equivalence relations, order relations. Boolean algebras, logic circuits, simplification of circuits. Graphs, connectedness, isomorphisms, planar graphs, trees, applications.

**200M Differential and Integral Calculus (for Physics Students) (3+0) credit-hours.**

*Prerequisite: 102M*

Cartesian, cylindrical, spherical and curvilinear coordinates. Functions of two and three variables, limits and continuity, partial derivatives, the chain rule, extrema of functions of two variables, Lagrange multipliers. Double integrals, areas and volumes, double integrals in polar coordinates, triple integral in Cartesian cylindrical and spherical coordinates, surface area, change of variables. Sequences limit of a sequence (definition and theorems), infinite series, geometric series, convergent and divergent series, tests for convergence (integral, comparison and ratio tests), alternating series, absolute convergence, conditional convergence, representation of functions by power series, Taylor and Maclaurin series, the binomial series.

**201M Differential and Integral Calculus (3+1) credit-hours.**

*Prerequisite: 102M*

Cartesian, cylindrical and spherical coordinate systems. Functions of two and three variables, limits and continuity, partial derivatives, the chain rule, extrema of functions of two variables, Lagrange multipliers. Double integrals, moments and center of mass, double integrals in polar coordinates, triple integrals, application of triple integrals, triple integrals in cylindrical and spherical coordinates, surface area. Sequences, infinite series, convergence tests, representation of functions by power series, Taylor and Maclaurin series, the binomial series.

**202M Vector Calculus (3+1) credit-hours.**

*Corequisite: 201M*

Vectors in two and three dimensions, scalar and vector products, equations of lines and planes in 3-dimensional space. Surfaces of revolution an their equations in cylindrical and spherical coordinates. Vector valued functions of a real variable, curves in space, curvature. Rates of change in tangent and normal directions, directional derivatives. Gradient of a function, equations of normal and tangent space to a surface at a point. Vector fields, divergence, curl of a vector, line and surface integrals. Green's theorem, Gauss' divergence theorem, Stockers' theorem.

**203M Differential and Integral Calculus (3+0) credit-hours.**

*Prerequisite: 106M and 107M*

*Language of instruction: English*

Infinite series, convergence and divergence of infinite series, integral test, ratio test, root test and comparison test. Conditional convergence and absolute convergence, alternating series test. Power series, Taylor and Maclaurin series. Double integral and its applications to area, volume, moments and centre of mass. Double integrals in polar coordinates. Triple integral in rectangular, cylindrical and spherical coordinates and applications to volume moment and centre of mass. Vector fields, line integrals, surface integrals, Green's theorem, the divergence theorem, Stoke' theorem.

**204M Differential Equations (3+0) credit-hours.**

*Prerequisite: 201M or 203M*

Various types of first order equations and their applications. Linear equations of higher order. Systems of linear equations with constant coefficients, reduction of order. Power series methods for solving second order equations with polynomial coefficients. Fourier series, Fourier series for even and odd functions. Complex Fourier series. The Fourier integral.

**224M Introduction to Ordinary Differential Equations (3+1) credit-hours.**

*Prerequisite: 201M*

Classification of Differential equations and their origins. Methods of solution of first order differential equations, orthogonal trajectories. Linear equations with constant coefficients and variable coefficients. Linear system of equations, power series solutions of linear differential equation of the second order with polynomial coefficients, Laplace transform and the convolution. Fourier's series.

**242M Linear Algebra I (3+1) credit-hours.**

*Prerequisite: 131M*

Matrices and their operations., types of matrices. Elementary transformations. Determinants, elementary properties. Inverse of a matrix. Linear systems of equations. Vector spaces, linear independence, finite dimensional spaces, linear subspaces. Inner product spaces. Linear transformations, kernel and image of a linear transformation. Eigen values and Eigen vectors of a matrix and of a linear operator.

**243M Number Theory (3+1) credit-hours.**

*Prerequisite: 131M*

First and second principles of Mathematical Induction. Well-ordering principle. Divisibility, Euclidean Algorithm. Prime numbers and their properties. Linear Diophantine equations. Congruences and their properties, linear Congruences. The Chinese remainder theorem. Fermat's little theorem. Euler's theorem. Wilson's theorem. Arithmetic functions,. Pythagorean triples. Some cases of Fermat's last theorem.

**244M Linear Algebra (3+0) credit-hours.**

*Prerequisite: 102M or 106M or 107M*

Matrices and their operations., types of matrices. Elementary transformations. Determinants, elementary properties. Inverse of a matrix. Linear systems of equations. Vector spaces, linear independence, finite dimensional spaces, linear subspaces. Inner product spaces. Linear transformations, kernel and image of a linear transformation. Eigen values and Eigen vectors of a matrix and of a linear operator.

**253M Numerical Analysis (3+1) credit-hours.**

*Prerequisite: 242M*

Numerical techniques for solving nonlinear equations including the study of error analysis and rate of convergence. Solving systems of linear equations by direct and iterative methods. The error estimate for numerical solutions in matrix algebra. Interpolation and approximation with error analysis. Numerical methods for differentiation and integration with the discussion of the accuracy and error estimate.

**254M Numerical Methods (3+1) credit-hours.**

*Prerequisite: (107M or 202M or 244M) plus (101 Comp. Science or 206 Comp. Science or 207 Comp. Science)*

Various numerical methods for solving nonlinear equations. Direct and iterative methods for solving systems of linear equations along with error estimate. Polynomial interpolation with error formula. Numerical differentiation and integration with error terms. An introduction to numerical solution of ordinary differential equations.

**282M Real Analysis I (3+1) credit-hours.**

*Prerequisite: 201M*

Basic properties of the field of real numbers, completeness axiom, countable sets, Sequences and their convergence, monotone sequence, Bolzano-Weierstrass theorem, Cauchy criterion. Basic topological properties of the real numbers. Limit of a function, continuous functions and properties of continuity, uniform continuity, compact sets. The derivative of a function, mean value theorem, L'Hospital rule, Taylor theorem.

**316M Mathematical Methods (3+1) credit-hours.**

*Prerequisite: 202M, 224M.*

Ordinary differential equations with variable coefficients, solution by power series. Inner product space of functions, self-adjoint operator, Sturm-Liouville theory. Orthogonal polynomials and special functions (Legendre, Hermite, gamma, beta, Bessel). Generalized theory of Fourier series. Fourier integral and Laplace transform. Some applications.

**343M Group Theory (3+1) credit-hours.**

*Prerequisite: 242M, 243M*

Definitions and examples, subgroups, Lagrange's theorem, normal subgroups, Factor groups, homomorphisms, isomorphism theorems, automorphisms, Cayley's theorem and its generalization. Simple groups, permutation groups. Class equation. Group action on a set. p-groups, Cauchy's theorem, Sylow theorems. External and internal direct products of groups. Burnside's theorem. Dihedral groups. Quaternions. Groups of automorphisms on finite cyclic subgroups.

**344M Rings and Fields (3+1) credit-hours.**

*Prerequisite: 343M*

Rings, group of units and group of automorphisms of a ring. Ideals and factor rings. Principal ring. Prime and maximal ideals. Field of quotients of integral domain. Characteristic of a ring. Direct sum of rings. Modules. Euclidean rings. Ring of polynomials. Roots of polynomials over a field. Field extensions. Finite and simple extensions of fields. Algebraic closure of a field. Splitting fields. Finite fields.

**373M Introduction to Topology (3+1) credit-hours.**

*Prerequisite: 282M*

Topological spaces, examples, closure of a set, derived set, subspace, topology. Bases, finite product topology, subbases. Metric spaces, examples, metrizable,  $\mathbb{R}^n$  as a metrizable space. Continuous functions, characterization of continuous functions on topological and metric spaces, homeomorphisms, examples, topological property. Compact spaces, compactness in  $\mathbb{R}^n$ , limit point and sequentially compact spaces.

**374M Introduction to Differential Geometry (3+1) credit-hours.**

*Prerequisite: 202M and 242M*

Theory of curves in  $\mathbb{R}^3$ . Regular curves and reparametrization, Serret-Frenet apparatus and theorem, existence and uniqueness theorems for space curves. Local theory of surfaces: Simple surfaces, coordinate transformations, tangent vectors and tangent spaces, first and second fundamental forms, normal and geodesic curvatures, Weingarten map, principal, Gaussian and mean curvatures. Geodesics, equations of Gauss and Codazzi-Mainardi.

**384M Real Analysis II (3+1) credit-hours.**

*Prerequisite: 282M*

Riemann Integral: Definition, Darboux's theorem, Riemann sums, fundamental theorem. Uniform convergence of sequences and series of functions, power series. Lebesgue Measure: Borel  $\sigma$ -algebra, outer measure, Lebesgue measurable sets, Lebesgue measure and its properties. Lebesgue integration: simple functions, measurable functions, definition of integral. Monotone convergence theorem, dominated convergence theorem, relation between Lebesgue and Riemann integrals.

**385M Complex Analysis I (3+1) credit-hours.**

*Prerequisite: 282M*

Complex numbers, Cartesian and polar representation of complex numbers, powers and roots of complex numbers. Limits and continuity of a complex function. Analytic functions, Cauchy-Riemann equations, harmonic functions. Exponential, trigonometric, hyperbolic functions and logarithmic functions. Complex integration, contour integrals, Cauchy's theorem, Cauchy's formula. Bounds on analytic functions. Series representation of analytic functions, Taylor and Laurent series, power series, Zeros and singularities. Residue theory. Applications to real and improper integrals.

**423M Introduction to Partial Differential Equations (3+1) credit-hours.**

*Prerequisite: 316M*

First order equations, Lagrange's method for quasilinear equations, Cauchy's problem. Linear second order equations in 2 and 3 variables, elliptic, hyperbolic and parabolic types. Solution by separation of variables. Poisson's equation, boundary-value problems with Dirichlet, Neumann and mixed conditions. Green's function. The wave equation and the heat equation, physical interpretation, initial conditions, solution methods.

**434M Introduction to Graphs and Combinatorics 4(3+1) credit-hours**

Basic concepts. Eulerian graphs. Hamiltonian graphs. Planar graphs. Coloring. Minimal spanning trees. Orientation of graphs. Matching. Ordered sets. Dilworth's theorem. Applications. Permutations and combinations. Inclusion-exclusion. Recurrence relations. Generating functions. Analyzing algorithms and problems. Sorting. Algorithms in graphs and digraphs.

**442M Applications of Algebra 4(3+1) credit-hours**

Classical ciphers. Introduction to stream ciphers. Introduction to Shannon's information theory. Public-key cryptography. Elements of cryptanalysis. Basic concepts in coding theory. Error-detection codes. Error-correcting codes. Linear codes. Bose-Chaudhuri-Hocquengham (BCH) codes.

**456M Introduction to Mathematical Programming 3(2+1) credit-hours**

The geometric method for solving a linear program. Simplex method. Two-phase method. Degenerate solution. Revised simplex method. Dual linear optimization problems and sensitivity analysis. Applications in transportation and network analysis.

**482M Analysis in Several Variables 3(2+1) credit-hours**

$\mathbb{R}^n$  as a vector space. Inner product. Norm. Continuity. Differentiation and its properties. Critical points. Inverse function and implicit function theorems. Integration in several variables.

**499M Research Project.**

*Prerequisite: Successful completion of minimum of 90 credit hours.*