

UNIVERSITY OF DHAKA



**Syllabus of the
Department of Mathematics**

for

B.S. Honours Course

for the

Sessions : 2009-2010 to 2011-2012

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DEPARTMENT OF MATHEMATICS
Four-year B.S. Honours Programme

Sessions : 2009-2010 to 2011-2012

Degree Requirements: Successful completion of 132 Credits

Major Courses	114 credits
Lecture Courses	91 credits
Lab Courses	12 credits
Honours Project	3 credits
Viva Voce	8 credits
Minor Courses	18 credits

**(Minor Subjects : Computer Science, Statistics,
Physics/Economics)**

Year-wise Class-Load

First Year	31 credits
Minor Courses	10 credits
Major Courses	16 credits
Math Lab	3 credits
Viva-voce	2 credits
Second Year	30 credits
Minor Courses	8 credits
Major Courses	17 credits
Math Lab	3 credits
Viva-voce	2 credits
Third Year	36 credits
Major Courses	31 credits
Math Lab	3 credits
Viva-voce	2 credits
Fourth Year	35 credits
Major Courses	27 credits
Math Lab	3 credits
Honours Project	3 credits
Comprehensive Viva-voce	2 credits

List of Major Courses

First Year

MTH 101	Fundamentals of Mathematics	3 credits
MTH 102	Calculus I	4 credits
MTH 103	Analytic and Vector Geometry	3 credits
MTH 104	Linear Algebra I	3 credits
MTH 105	FORTTRAN Programming	3 credits
MTH 150	Math Lab I	3 credits
MTH 199	Viva-voce	2 credits

Second Year

MTH 201	Real Analysis I	4 credits
MTH 202	Calculus II	4 credits
MTH 203	Ordinary Differential Equations I	3 credits
MTH 204	Linear Algebra II	3 credits
MTH 205	Numerical Analysis I	3 credits
MTH 250	Math Lab II	3 credits
MTH 299	Viva-voce	2 credits

Third Year

MTH 301	Real Analysis II	3 credits
MTH 302	Complex Analysis	4 credits
MTH 303	Ordinary Differential Equations II	3 credits
MTH 304	Abstract Algebra	4 credits
MTH 305	Numerical Analysis II	3 credits
MTH 306	Mathematical Methods	4 credits
MTH 307	Mechanics	4 credits
MTH 308	Linear Programming	3 credits
MTH 309	Fundamentals of Topology	3 credits
MTH 350	Math Lab III	3 credits
MTH 399	Viva-voce	2 credits

Fourth Year

MTH 401	Introduction to Functional Analysis	3 credits
MTH 402	Tensor Analysis	3 credits
MTH 403	Partial Differential Equations	3 credits
MTH 404	Differential Geometry	3 credits
MTH 405	Theory of Numbers	3 credits
MTH 407	Hydrodynamics	3 credits

Three of the courses MTH 410 – MTH 420 to be offered by the Academic Committee

MTH 410	Astronomy	3 credits
MTH 411	Discrete Mathematics	3 credits
MTH 412	Fuzzy Mathematics	3 credits
MTH 413	Mathematical Modeling in Biology	3 credits
MTH 414	Mathematical Modeling in Finance and Business Management	3 credits
MTH 415	Difference Equations	3 credits
MTH 416	Topics in Scientific Computing	3 credits
MTH 417	Asymptotic and Perturbation Methods	3 credits
MTH 420	Special Topics	3 credits
MTH 450	Math Lab IV	3 credits
MTH 490	Honours Project	3 credits
MTH 499	Comprehensive Viva-voce	2 credits

Detailed Syllabi

MTH 101: Fundamentals of Mathematics **3 credits**

1. Elements of logic: Mathematical statements. Logical connectives. Conditional and biconditional statements. Truth tables and tautologies. Quantifications. Logical implication and equivalence. Deductive reasoning. Methods of proof (direct, indirect); method of induction.
2. Sets and subsets. Set operations. Family of Sets. De Morgan's laws.
3. Relations and functions: Cartesian product of sets. Relations. Order relation. Equivalence relations. Functions. Images and inverse images of sets. Injective, surjective, and bijective functions. Inverse functions.
4. The Real number system: Field and order properties. Natural numbers, integers and rational numbers. Absolute value. Basic inequalities. (Including inequalities involving means, powers; inequalities of Cauchy, Chebyshev, Weierstrass).

5. The Complex number system: Geometrical representation Polar form. De Moivre's theorem and its applications.
6. Elementary number theory: Divisibility. Fundamental theorem of arithmetic. Congruences (basic properties only).
7. Summation of finite series: Arithmetic-geometric series. Method of difference. Successive differences.
8. Theory of equations: Synthetic division. Number of roots of polynomial equations. Relations between roots and coefficients. Multiplicity of roots. Symmetric functions of roots. Transformation of equations.

Evaluation: Incourse Assessment : 30 Marks. Final examination (Theory, 3 hours): 70 Marks.

Eight questions of equal value will be set, of which any five are to be answered.

References

1. S. Lipschutz, Set Theory, Schaum's Outline Series.
2. S. Barnard & J. M. Child, Higher Algebra.
3. W.L. Ferrar, Algebra.
4. P.R. Halmos, Naive, Set Theory.

MTH 102: Calculus 1

4 credits

A. Differential Calculus

1. Functions and their graphs (polynomial and rational functions, logarithmic and exponential functions, trigonometric functions and their inverses, hyperbolic functions and their inverses, combination of such functions).
2. Limits of Functions: Definition. Basic limit theorems with proofs. Limit at infinity and infinite limits. Continuous functions. Algebra of continuous functions. Properties of Continuous functions on closed and boundary intervals (no proof required).

3. Differentiation: Tangent lines and rates of change. Definition of derivative. One-sided derivatives. Rules of differentiation (proofs and applications). Successive differentiation.
4. Leibnitz theorem. Related rates. Linear approximations and differentials.
5. Rolle's theorem, Lagrange's and Cauchy's mean value theorems. Extrema of functions, problems involving maxima and minima. Concavity and points of inflection.
6. Taylor's theorem with general form of the remainder. Lagrange's and Cauchy's forms of the remainder. Taylor's series. Differentiation and integration of series. Validity of Taylor expansions and computations with series. Indeterminate forms. L'Hospital's rules.

B. Integral Calculus

1. Integrals: Antiderivatives and indefinite integrals. Techniques of integration. Definite integration using antiderivatives. Definite integration using Riemann sums.
2. Fundamental theorems of calculus. Basic properties of integration. Integration by reduction.
3. Application of integration: Plane areas. Solids of revolution. Volumes by cylindrical shells. Volumes by cross-sections. Arc length and surface of revolution.
4. Improper integrals. Gamma and Beta functions.
5. Graphing in polar coordinates. Tangents to polar curves. Area and arc length in polar coordinates.

Evaluation: Incourse Assessment : 30 marks. Final examination (Theory, 4 hours): 70 Marks

Eight questions of equal value will be set, four from each group, of which five are to be answered, taking at least two questions from each group.

References

1. H. Anton et al, Calculus with Analytic Geometry.
2. E.W. Swokowski, Calculus with Analytic Geometry.
3. L. Bers & P. Karal, Calculus.
4. S. Lang, A First Course in Calculus.

MTH 103: Analytic and Vector Geometry **3 credits**

Two-dimensional geometry

1. Coordinates in two dimension. Transformations of coordinates.
2. Reduction of second degree equations to standard forms. Pairs of straight lines. Identifications of conics. Equations of conics in polar coordinates.

Three-dimensional geometry

3. Coordinates in three dimensions. Direction cosines, and direction ratios.
4. Planes, straight lines and conicoids (basic definitions and properties only)

Vector geometry

5. Vectors in plane and space. Algebra of vectors. Scalar and vector products. Triple scalar products. Applications to Geometry.

Evaluation: Incourse Assessment : 30 Marks.

Final examination (Theory, 3 hours): 70 Marks.

Eight questions of equal value will be set, of which any five are to be answered.

References

1. A.F.M. Abdur Rahman & P.K. Bhattacharjee, Analytic Geometry and Vector Analysis.
2. Khosh Mohammad, Analytic Geometry and Vector Analysis.
3. J. A. Hummel, Vector Geometry.

MTH 104: Linear Algebra I **3 credits**

1. Vectors in $\mathbb{R}^n$ and $\mathbb{C}^n$:
Review of geometric vectors in $\mathbb{R}^2$ and $\mathbb{R}^3$ space. Vectors in $\mathbb{R}^n$ and $\mathbb{C}^n$. Inner product. Norm and distance in $\mathbb{R}^n$ and $\mathbb{C}^n$.
2. Matrices and Determinants.
Notion of matrix. Types of matrices. Matrix operations, laws of matrix Algebra. Determinant

function. Properties of determinants. Minors, Cofactors, expansion and evaluation of determinants. Elementary row and column operations and row-reduced echelon matrices. Invertible matrices. Block matrices.

3. System of Linear Equations:

Linear equations. System of linear equations (homogeneous and non-homogeneous) and their solutions. Application of Matrices and determinants for solving system of linear equations.

4. Vector Spaces:

Notions of groups and fields. Abstract vector space, subspace. Sum and direct sum of subspaces. Linear independence of vectors; basis and dimension of vector spaces. Row and column space of a matrix, rank of matrices. Solution spaces of systems of linear equations.

5. Linear Transformations:

Linear transformations. Kernel and image of a linear transformation and their properties. Matrix representation of linear transformations. Change of bases.

6. Eigenvalues and Eigenvectors:

Eigenvalues and eigenvectors. Diagonalization. Cayley Hamiton theorem. Applications.

Evaluation: Incourse Assessment : 30 Marks. Final examination (Theory, 3 hours). 70 Marks.

Eight questions of equal value will be set, of which any five are to be answered.

References

1. H. Anton, and C. Rorres, Linear Algebra with Applications, 9th Edition,
2. S. Lipschutz, Linear Algebra, Schaum's Outline Series.
3. W. Greub, Linear Algebra.

MTH 105: FORTRAN Programming**3 credits**

1. Introduction to personal computers.
2. Disk Operating Systems: MS DOS, WINDOWS.
3. Problem-solving techniques using computers: Flowcharts, Algorithms, Pseudo code.
4. Programming in FORTRAN: Syntax and semantics, data types and structures, input/output, loops, decision statements, arrays, user-defined functions, subroutines and recursion.
5. Computing using FORTRAN: Construction and implementation of FORTRAN programs for solving problems in mathematics and sciences.

Classes: Theory (2 hours/week), Lab (At least 10 assignments).

Evaluation: Incourse Assessment (Laboratory work): 30 Marks

Final examination (Theory, 3 hours): 70 Marks.

Eight questions of equal value will be set, of which any five are to be answered.

References

1. Programming in Fortran, Schaum's Outline Series.
2. Gordon B. Davis & Thomas R. Hoffmann, FORTRAN 77: A Structured, Disciplined Style.

MTH 150: MATH LAB I**3 credits**

Introduction to the computer algebra package MATHEMATICA.

Problem solving in concurrent courses (e.g. Calculus, Linear Algebra, Geometry and Fundamentals of Mathematics) using MATHEMATICA.

Lab Assignments: There shall be at least 15 lab assignments

Evaluation: Internal Assessment (Laboratory works). 40 Marks
Final examination (Lab. 3 hours). 60 Marks.

MTH 199: Viva Voce**2 credits**

Viva Voce on courses taught in the First Year

MTH 201: Real Analysis I**4 credits**

1. Bounded sets of real numbers. Supremum and infimum. The completeness axiom and its consequences. Dedekind's theorems. Cluster (limit) points; Bolzano-Weierstrass theorem.
2. Infinite sequences. Convergence. Theorems on limits. Monotone sequences, subsequences. Cauchy's general principle of convergence. Cauchy's first and second theorems on limits.
3. Infinite series of real numbers: convergence and absolute convergence. Tests for convergence; Gauss's tests (simplified form). Alternating series (Leibnitz's test). Product of infinite series.
4. Properties of continuous functions (with proofs). Intermediate value theorem.
5. The derivative : Standard theorems including Darboux's theorem.
6. The Riemann integral; Definitions via Riemann's sums and Darboux's sums. Darboux's theorem (equivalence of the two definitions) Necessary and sufficient conditions for integrability. Classes of integrable functions. Fundamental theorem of calculus.
7. Uniform convergence: Interchangeability of limiting processes. Power series, differentiation and integration of power series. Abel's continuity theorem.
8. Improper integrals: Tests for convergence.
9. Integrals depending upon a parameter. Differentiation and integration under the integral sign.

Evaluation: Incourse Assessment : 30 Marks. Final examination (Theory, 4 hours). 70 Marks.

Eight questions of equal value will be set, of which any five are to be answered.

References

1. K. A. Ross : Elementary Analysis : The Theory of Calculus.
2. R. G. Bartle & D. R. Sherbert : Introduction to Real Analysis.
3. W. Rudin : Principles of Mathematical Analysis.
4. M. Ramzan Ali Sarder : Elements of Real Analysis.

MTH 202: Calculus II**4 credits****A. Differential Calculus**

1. Vector-valued functions of a single variable: Limits, derivatives and integrals of vector valued functions.
2. Tangent lines to graphs of vector-valued functions Arc length from vector view point. Arc length parametrization.
3. Curvature of plane and space curves: Curvature from intrinsic equations, Cartesian equations and parametric equations. Radius of curvature. Centre of curvature.
4. Partial Differentiation: Functions of several variables. Graphs of functions of two variables. Limits and continuity. Partial derivatives. Differentiability, linearization and differentials. The Chain rule. Partial derivatives with constrained variables. Directional derivatives, gradient vectors and tangent planes.
5. Extrema of functions of several variables, Lagrange multipliers. Taylor's formula.
6. Differentiation of Vectors, Gradient, Divergence and curl and their physical meanings.

B. Integral Calculus

1. Multiple integrals: Double integrals and iterated integrals. Area as a double integral. Double integrals in polar form.
2. Triple integrals and iterated integrals. Volume as a triple integral. Triple integral in cylindrical and spherical polar coordinates.
3. General multiple integrals. Change of variables in multiple integrals. Jacobians.
4. Integration of Vector, divergence, curl. Green's theorem, Gauss's theorem, Stoke's theorem.

Evaluation: Incourse Assessment 30 : Marks. Final examination (Theory, 4 hours): 70 Marks.

Eight questions of equal value will be set, of which any five are to be answered.

References

1. H. Anton et al, Calculus with Analytic Geometry.
2. E. Swokowski, Calculus with Analytic Geometry.
3. L. Bers & P. Karal, Calculus with Analytic Geometry.
4. S. Lang, Calculus of Several Variables.

MTH 203: Ordinary Differential Equations I 3 credits

1. Ordinary differential equations and their solutions: Classification of differential equations. Solutions. Implicit solutions. Singular solutions. Initial value problems. Boundary value problems. Basic existence and uniqueness theorems (statement and illustration only). Direction fields. Phase line.
2. Solution of first order differential equations: Separable equations and equations reducible to this form. Linear equations, Exact equations, Special integrating factors, Substitutions and transformations.
3. Modelling with first order differential equations: Construction of differential equations as mathematical models (exponential growth and decay, heating and cooling, mixture of solutions, series circuit, logistic growth, chemical reaction, falling bodies). Model solutions and interpretation of results. Orthogonal and oblique trajectories.
4. Solution of higher order linear differential equations: Linear differential operators. Basic theory of linear differential equations. Solution space of homogeneous linear equations. Fundamental solutions of homogeneous systems. Reduction of order. Homogeneous linear equations with constant coefficients. Non homogeneous equation. Method of undetermined coefficients. Variation of parameters. Euler-Cauchy differential equations.
5. Modelling with second-order differential equations: Vibration of a mass on a spring, free and undamped motion; free and damped motion; forced motion; resonance phenomena; electric circuit problems, motion of a rocket.

Evaluation: Incourse Assessment : 30 Marks. Final examination (Theory, 3 hours): 70 Marks.

Eight questions of equal value will be set, of which any five are to be answered.

References

1. S. L. Ross, Differential Equation.
2. D. G. Zill, A First Course in Differential Equations with Applications.
3. F. Brauer & J. A. Nohel, Differential Equations.
4. H.J.H. Piaggio, An Elementary Treatise on Differential Equations.

MTH 204: Linear Algebra II

3 credits

1. Similar Matrices: Canonical forms of matrices, Symmetric, orthogonal and Hermitian matrices.
2. Linear Functional and dual Space: Linear functional and the dual space. Dual basis, Second dual space, Annihilators. Transpose of a linear transformation.
3. Inner Product Space: Inner products. Inner product spaces, Orthogonality and orthonormal sets. Linear functions and adjoints. Positive operators, unitary operators and normal operators. The spectral theorem.
4. Bilinear, quadratic & hermitian forms: Matrix form, transformations, canonical forms, reduction form, definite and semi-definite forms, principal minors, and factorable forms.
5. Application of linear algebra in solving problems in Mathematics and applied sciences.

Evaluation: Incourse Assessment : 30 Marks. Final examination (Theory, 3 hours): 70 Marks.

Eight questions of equal value will be set, of which any five are to be answered.

References

1. H. Anton, and C. Rorres, Linear Algebra with Applications, 9th Edition,
2. S. Lipschutz, Linear Algebra, Schaum's Outline Series.
3. W. Greub, Linear Algebra.

MTH 205: Numerical Analysis I

3 credits

1. Solution of equation in one variable: Bisection algorithm, Method of false position. Fixed point iteration, Newton-Raphson method, Error Analysis for iterative method, Accelerating limit of convergence.
2. Interpolation and polynomial approximation: Taylor polynomials, Interpolation and Lagrange polynomial, Iterated interpolation, Extrapolation.
3. Differentiation and Integration: Numerical differentiation, Richardson's extrapolation, Elements of Numerical Integration, Adaptive quadrature method, Romberg's integration, Gaussian quadrature.
4. Solutions of linear systems: Gaussian elimination and backward substitution, pivoting strategies, LU decomposition method.

Evaluation: Incourse Assessment : 30 Marks. Final examination (Theory, 3 hours): 70 Marks.

Eight questions of equal value will be set, of which any five are to be answered.

References :

1. R.L. Burden & J.D. Faires, Numerical Analysis.
2. M.A. Celia & W.G. Gray, Numerical Methods for Differential Equations.
3. L.W. Johson & R.D. Riess, Numerical Analysis.

MTH 250: Math Lab II**3 credits**

Problem solving in concurrent courses (e.g; Calculus, Linear Algebra, Differential Equations and Numerical Analysis) using FORTRAN.

Lab Assignments: There shall be at least 15 lab assignments.

Evaluation: Internal Assessment (Laboratory works): 40 marks. Final Examination (Lab, 3 hours): 60 marks.

MTH 299: Viva Voce**2 credits**

Viva Voce courses taught in the Second Year

MTH 301: Real Analysis II**3 credits**

1. Metric Spaces. Metric : Definition and examples. g - neighbourhood, open and closed sets in metric spaces. Interior, exterior and boundary of a set. Bounded sets. Equivalent metrics.
2. Cluster points of sets in metric spaces. Derive set, closure of a set.
3. Infinite sequences in metric spaces and their convergence. Cauchy sequences. Complete metric spaces.
4. Continuity and uniform continuity of functions on metric spaces.
5. Compactness in metric spaces. Necessary and sufficient condition or compactness. Heine-Borel theorem.
6. Differentiation in R^n :Jacobian, implicit and inverse function theorems.
7. Integration in R^n : Fubini's theorem. Change of variables.

Evaluation: Incourse Assessment : 30 Marks. Final examination (Theory, 3 hours): 70 Marks.

Eight questions of equal value will be set, of which any five are to be answered.

References

1. C.G.C. Pitts, Introduction to Metric Spaces,
2. R. G. Bartle, & D. R. Sherbert, Introduction to Real Analysis.
3. W. Rudin, Principles of Mathematical Analysis.
4. T.M. Apostol, Advanced Calculus.

MTH 302: Complex Analysis

4 credits

1. Metric properties and geometry of the complex plane. The point at infinity; stereographic projection.
2. Functions of a complex variable.
3. Differentiability of a complex function. Analytic functions and their properties. Harmonic functions.
4. Power series of complex terms.
5. Complex integration: Line integration over rectifiable curves, Winding number, Cauchy's theorem, Cauchy's integral formula, Liouville's theorem, fundamental theorem of Algebra.
6. Singularities, residues, Taylor's and Laurent's expansion. Cauchy's residue theorem. Evaluation of integrals by contour integration. Branch points and cuts.
7. Rouché's theorem. The maximum modulus principle.
8. Conformal mappings, especially bilinear transformations.
9. Meromorphic functions.
10. Infinite product decomposition of entire functions.

Evaluation: Incourse Assessment : 30 Marks. Final examination (Theory, 4 hours): 70 Marks.

Eight questions of equal value will be set, of which any five are to be answered.

References

1. R.V. Churchill & J.W. Brown, Complex Variables and Applications.
2. L. Penniri, Elements of Complex Variables.
3. U. P. Palka, An Introduction to Complex Function Theory
4. L.V. Ahlfors, Complex Analysis, McGraw-Hill

MTH 303: Ordinary Differential Equations II 3 credits

1. Existence and uniqueness theory: Fundamental existence and uniqueness theorem. Dependence of solutions on initial conditions and equation parameters. Existence and uniqueness theorems for systems of equations and higher-order equations.
2. Series solutions of second order linear equations: Taylor series solutions about an ordinary point. Frobenius series solutions about regular singular points. Series solutions of Legendre, Bessel, Laguerre and Hermite differential equations, Hypergeometric equations.
3. Systems of linear first order differential equations: Elimination method. Matrix method for homogeneous linear systems with constant coefficients. Variation of parameters. Matrix exponential.
4. Eigenvalue problems and Sturm-Liouville boundary value problems: Regular Sturm-Liouville boundary value problems. Non-homogeneous boundary value problems and the Fredholm alternative. Solution by eigenfunction expansion. Green's functions. Singular Sturm Liouville boundary value problems. Oscillation and comparison theory.

Evaluation: Incourse Assessment : 30 Marks. Final examination (Theory, 3 hours): 70 Marks.

Eight questions of equal value will be set, of which any five are to be answered.

References

1. S. L. Ross, Differential Equation
2. D. G. Zill, A First Course in Differential Equations with Applications.
3. F. Brauer & J. A. Nohel, Differential Equations.
4. H.J.H. Piaggio, An Elementary Treatise on Differential Equations

MTH 304: Abstract Algebra**4 credits**

1. Groups and subgroups. Groups of symmetry. Permutation groups. The symmetric group on n letters. Cyclic groups.
2. Left and right congruence modulo a sub group. Cosets. Lagrange's theorem, Product of cosets. Frobenius's counting formula.
3. Normal subgroups, quotient (factor) groups. Homomorphisms and automorphisms. The isomorphism theorems. Conjugacy: the class equation. Direct product. Groups of small orders.
4. Rings, ideals and quotient rings, prime and maximal ideals.
5. Integral domain. Field of fractions.
6. Principal ideal domains. Euclidean domains. Unique factorization domains.
7. Polynomial rings. Primitive polynomials (Gauss's theorem). Eisenstein's irreducibility criterion.
8. Characteristic of a ring or integral domain. Prime Fields; structure of prime fields.

Evaluation : Incourse Assessment : 30 Marks. Final examination (Theory, 4 hours): 70 Marks.

Eight questions of equal value will be set, of which any five are to be answered.

References

1. P.B. Bhattacharya, S.K. Jain & S.R. Nagpaul, Basic Abstract Algebra.
2. W.K. Nicholson, Introduction to Abstract Algebra.
3. J.B. Fraleigh, Introduction to Abstract Algebra.
4. M. Artin, Algebra.

MTH 305: Numerical Analysis II**3 credits**

1. Iterative techniques in matrix algebra: Linear systems of equations, error estimations and iterative refinement, eigenvalues and eigenvectors, the power method, Householder's method, Q-R method.

2. Nonlinear system of equations: Fixed point for functions of several variables, Newton's method, Quasi-Newton's method, Steepest Descent techniques.
3. Initial value problems for ODE : Euler's and modified Euler's method, Higher order Taylor's method, Single-step methods (Runge-Kutta methods, extrapolation methods-higher order differential equations and systems of differential equations), Multi-step methods (Adams-Bashforth, Adams-Moulton, Predictor-Corrector and Hybrid methods), variable step-size multistep methods, error and stability analysis.
4. Boundary value problem for ODE: Shooting method for linear and nonlinear problems, Finite difference methods for linear and nonlinear problems.

Evaluation: Incourse Assessment : 30 Marks. Final examination (Theory, 3 hours): 70 Marks.

Eight questions of equal value will be set, of which any five are to be answered.

References

1. R.L. Burden & J.D. Faires, Numerical Analysis.
2. M.A. Celia & W.G. Gray, Numerical Methods for Differential Equations.
3. L.W. Johson & R.D. Riess, Numerical Analysis.

MTH 306: Methods of Applied Mathematics 4 credits

1. Fourier Series: Fourier series and its convergence. Fourier sine and cosine series. Properties of Fourier series. Operations on Fourier series. Complex form. Applications of Fourier series.
2. Special functions: Gamma function. Error function. Hypergeometric function (Hypergeometric equation, special hypergeometric function, Generalized hypergeometric function, special confluent hypergeometric functions).
3. Legendre functions (Generating function, recurrence relations and other properties of Legendre polynomials, Expansion theorem, Legendre differential equation,

- Legendre function of first kind, Legendre function of second kind, associated Legendre functions).
4. Bessel functions (Generating function, recurrence relations, Bessel differential equation, Integral representations, Orthogonality relations, Modified Bessel functions).
 5. Hermite polynomials, Laguerre polynomials (Generating function, Rodrigue's formula, orthogonal properties, Hermite and Laguerre differential equation, recurrence relations, expansion theorems). Laplace transforms: Basic definitions and properties, Existence theorem. Transforms of derivatives. Relations involving integrals. Transforms of Bessel functions.
 6. Laplace transforms of periodic functions. Transforms of convolutions. Inverse transform. Calculation of inverse transforms. Use of contour integration. Applications to boundary differential equations.
 7. Fourier transforms: Fourier transforms. Inversion theorem. Sine and cosine transforms. Transform of derivatives. Transforms of rational function. Convolution theorem. Parseval's theorem. Applications to boundary value problems and integral equation.

Evaluation: Incourse Assessment : 30 Marks. Final examination (Theory, 4 hours): 70 Marks.

Eight questions of equal value will be set, of which any five are to be answered.

References

1. R.V. Churchill & J. W. Brown, Fourier Series and Boundary value problems.
2. W.N. Lebedev & R.A. Silverman, Special Functions and their Applications.
3. E. Kreyszig, Advanced Engineering Mathematics.
4. M. R. Spiegel, Laplace Transforms, Schaum's Outline Series.

MTH 307: Mechanics**4 credits**

1. General conditions of equilibrium. Principle of virtual work. Stable and unstable equilibrium. Centre of gravity.
2. Rectilinear motion.
3. Motion in a plane. Motion of a particle under a central force.
4. Motion of a particle in space.
5. Motion of rigid bodies. Moment of inertia. D'Alembert's principle.
6. Motion about fixed axes.
7. Motion in two dimensions.

References :

1. S.L. Loney : Statics.
2. L.A. Pars : Introduction to Dynamics.
3. S.L. Loney : Analytical Dynamics of a Particle.

Evaluation : Incourse Assessment : 30 Marks. Final examination (Theory, 4 hours): 70 Marks.

Eight questions of equal value will be set, of which any five are to be answered.

MTH 308: Linear Programming**3 credits**

1. Convex sets and related theorems.
2. Introduction to linear programming.
3. Formulation of linear programming problems.
4. Graphical solutions.
5. Simplex method. Two phase and Big-M simplex methods.
6. Duality of linear programming and related theorems. Dual simplex method.
7. Sensitivity analysis.

Evaluation : Incourse Assessment : 30 Marks. Final examination (Theory, 3 hours): 70 Marks.

Eight questions will be set, of which any five are to be answered.

References

1. S.I. Gass, Linear Programming .
2. G. Hadley, Linear Programming.
3. N.S. Kambo, Mathematical Programming Techniques.
4. Ravindran, Phillips & Solberg, Operations Research.

MTH 309: Fundamentals of Topology **3 credits**

1. Topological Spaces : Definition and examples (discrete, indiscrete, cofinite, cocountable topologies). Metric topology. Cluster point of a set. Neighbourhood system: base and subbase.
2. Convergence of sequences in topological spaces. Continuity of functions on topological, Sequential continuity, Uniform continuity.
3. Separation axioms. Properties of Hausdorff spaces. Product spaces.
4. Countability of topological spaces: First and second countable spaces. Countability and separability properties, Lindelof's theorem.
5. Compactness properties: Tychonoff's theorem. Equivalence of sequential compactness, BolzanoWeierstrass property, Totally boundeness, Lebesgue number and compactness in a metric spaces.
6. Connectedness: Connected spaces, totally disconnected spaces, components of space, locally and pathwise connected spaces.

Evaluation: Incourse Assessment : 30 Marks. Final examination (Theory, 3 hours): 70 Marks.

Eight questions will be set of which any Five are to be answered.

References :

1. G.F. Simmons, Introduction to Topology and Modern Analysis
2. S.Lipschutz, General Topology.
3. J. Kelly, General Topology.

MTH 350: Math Lab III **3 credits**

Problem Solving in concurrent courses (Complex Analysis, Numerical Analysis and Applied Mathematics, Linear Programming) using FORTRAN.

Lab Assignments: There shall be at least 15 lab assignments

Evaluation: Internal Assessment (Laboratory works). 40 Marks
 Final Examination (Lab, 3 hours): 60 Marks

MTH 399: Viva Voce

2 credits

Viva Voce on courses taught in the Third Year.

MTH 401: Introduction to Functional Analysis **3 credits**

1. General Linear space: Linear functional, basis and its dual on finite dimensional space, Zorn's lemma, Extension of linear functions, sublinear functional.
2. Inner product and norm (on a vector space over $\mathbb{R}$)
 Definitions and examples, Cauchy-Schwarz inequality. Norm derived from inner product. Parallelogram law. Metric derived from a norm. Inner product space, orthogonality. Bessel's inequality.
3. Normed linear space: Sequence space, separability, Riesz's lemma, Linear mappings, boundedness and continuity. Quotient space.
4. Linear operators. Elementary properties of linear operators. Linear operators in finite dimensional spaces. Spaces of bounded linear operators.
5. Banach spaces. Open mapping theorem, closed graph theorem, and their applications, Baire's category theorem, Uniform boundedness principle, normed conjugates of a NLS (Hahn-Banach theorem)
6. Fixed point theorems : Contraction mapping, Banach fixed point theorem, Applications of fixed point theorems.
7. Hilbert Spaces: Basic properties, Riesz's representation theorems. Adjoint of a linear operator.

Evaluation: Incourse Assessment : 30 Marks. Final examination (Theory, 3 hours): 70 Marks.

Eight questions of equal value will be set of which any Five are to be answered.

References :

1. A.E. Taylor, Introduction to Functional Analysis
2. E. Kreyszig, Introduction to Functional Analysis with Applications

- solutions.
2. Second order equations: Classifications. Reduction to canonical forms. Characteristic curves.
 3. Boundary value problems related to linear equations. Applications of Fourier methods (Coordinate systems and separability. Homogeneous equations. Nonhomogeneous boundary conditions. Inhomogeneous equations.)
 4. Problems involving cylindrical and spherical symmetry. Boundary value problems involving special functions.
 5. Transform methods for boundary value problems (applications of the Laplace transforms; applications of Fourier sine and cosine transforms). Inhomogeneous equations.

References

1. H.T.H. Piaggio : Differential Equations,
2. B. Epstein : Partial Differential Equations
3. I.N.Sneddon : Introduction to Partial Differential Equations
4. J.M. Kar : Partial Differential Equations

Evaluation: Incourse Assessment : 30 Marks. Final examination (Theory, 3 hours): 70 Marks.

Eight questions of equal value will be set, of which any five are to be answered.

MTH 404: Differential Geometry 3 credits

1. Curves in space: Vector functions of one variable, space curves, unit tangent to a space curve, equation of a tangent line to a curve, Osculating plane (or Plane of curvature).
2. Vector functions of two variables. Tangent and normal plane to the surface $f(x,y,z)=0$. Principal normal, binormal and Fundamental planes, equation of principal normal and binormal line, curvature and torsion, Serret-Frenet's formulae, theorems on curvature and torsion.
3. Helices and their properties, Circular helix. Spherical indicatrix of tangent, normal and binormal, curvature and torsion of spherical indicatrices, Involute and evolutes, Bertrand curves.
4. Surface: Curvilinear coordinates, parametric curves, Analytical representation, Monge's form of the surface, first fundamental form or metric geometrical representation

of metric, relation between coefficients E, F, G ; properties of metric, angle between any two directions and parametric curves, condition of orthogonality of parametric curves, elements of area, unit surface normal, tangent plane, Weingarten equations (or derivatives of surface normal).

5. Second fundamental form, Normal curvature, Meusnier's theorem, curvature directions, condition of orthogonality of curvature direction, Principal curvatures, lines of curvature, first curvature, mean curvature, Gaussian curvature, centre of curvature, Rodrigues's formula.
6. Euler's Theorem, Elliptic, hyperbolic and parabolic points, Dupin Indicatrix, asymptotic lines, Third Fundamental form, Theorem of Beltrami-Enneper.

Evaluation: Incourse Assessment : 30 Marks. Final examination (Theory, 3 hours): 70 Marks.

Eight questions of equal value will be set, of which any five are to be answered.

References

1. M.L. Khanna, Differential Geometry.
2. M.M. Lipschutz, Theory and Problems of Differential Geometry.
3. D.J. Struik, Lecturer on Classical Differential Geometry.
4. C.E. Weatherburn, Differential Geometry of Three Dimensions.

MTH 405: Theory of Numbers 3 credits

1. Arithmetic in $\mathbb{Z}$. Euclidean algorithm. Continued fractions.
2. The ring $\mathbb{Z}$, and its group of units. Chinese remainder theorem. Linear diophantine equations.
3. Arithmetical functions. Dirichlet convolution. Multiplicative function.
4. Representation by sum of two and four squares.
5. Arithmetic of quadratic fields. Euclidean quadratic Fields.

Evaluation : Incourse Assessment : 30 Marks. Final examination (Theory, 3 hours): 70 Marks.

Eight questions of equal value will be set, of which any five are to be answered.

References

1. G.H. Hardy & E.M. Wright, An Introduction to Theory of Number
2. I.S. Niven and H.S. Zuckermann, An Introduction to Theory of Number
3. W.J. LeVeque, Fundamentals of Number Theory.

MTH 407: Hydrodynamics

3 credits

1. Velocity and acceleration of fluid particles; relation between local and individual rates; steady and unsteady flows; uniform and nonuniform flows; stream lines; path lines; vortex lines; velocity potential. Bernoulli's equations and its application.
2. Rotational and irrotational flows; equations of continuity; equations of continuity in spherical and cylindrical polar coordinates; boundary surfaces.
2. Euler's equation of motion, conservative field of force; Lamb's hydrodynamical equations of motion; motion under conservative body force; vorticity equations (Helmholtz's vorticity equation)
3. Motion in two-dimensions; stream function, physical meaning of stream function; velocity in polar-coordinates; relation between stream function and velocity.
4. Circulation and vorticity; relation between circulation and vorticity; Kelvin's circulation theorem, Kelvin's minimum energy theorem. Generalized Joukowski's transformation, Elliptic coordinates and its application.
5. The circle's theorem, motion of a circular cylinder; pressure at points on a circular cylinder; application of circle theorem. Blasius theorem.
6. Sources, sinks and doublets, complex potential and complex velocity, stagnation points; complex potential due to a source and a doublet, image in two and three dimensions; Stoke's stream function.
7. Vortex motion; vortex tube; strength of a vortex; vortex pair; complex potential due to vortex motion; vortex rows; Free vortex, Forced vortex, spireal vortex.
8. Wave motion, mathematical representation of wave, surface wave, Canal wave, long wave.

Evaluation: Incourse Assessment : 30 Marks. Final exam (Theory, 3 hours): 70 Marks.

Eight questions of equal value will be set, of which any five are to be answered.

References

1. F. Chorlton, A Text Book of Fluid dynamics.
2. L.M. Mine Thomosn, Theoretical Hydrodynamics.
3. P.P. Gupta, Hydrodynamics.

MTH 410: Astronomy 3 credits

1. Sphere and spherical triangles, the celestial sphere, problems conncted with diurnal motion.
2. Astronomical refraction, Astronomical instruments. Finding the latitude of a place. Conversion of coordinates fixing . The ecliptic and the first point of Aries.
3. Kepler's laws: Equations of time, unit of time,
4. Geocentric parallax, The moon, Local line, Eclipses.
5. The Solar System.
6. Precession and mutation, Annual parallax. Aberration of light.
7. The stellar universe.
8. Modern finding of astronomical objects. Working process of the Hubble telescope and its finding.

Evaluation: Incourse Assessment: 30 Marks. Final examination (Theory, 3 hours): 70 Marks.

Eight questions of equal value will be set, of which any **five** are to be answered.

References

1. A.F.M. Abdur Rahman, A Text Book of Modern Astronomy.
2. K.R. Khan & A.Z. Sikder, Astronomy.
3. W.R. Smart, Spheical Astronomy.
4. G.V. Ramnchandran, A Text Book of Astronomy.

MTH 411 Discrete Mathematics 3 credits

1. Mathematical reasoning: Inference and fallacies. Methods of proof. Recursive definitions. Program verification.
2. Combinatorics: Counting principles. Inclusion-exclusion principle. Pigeonhole principle. Generating functions. Recurrence relations, Applications to computer operations.
3. Graphs, structure and symmetry of graphs, Trees and connectivity, Eulerian and Hamiltonian graphs and diagraphs, Directed graphs, planar graphs.

4. Algorithms on graphs: Introduction to graphs, paths and trees. Shortest path problems: Dijkstra's algorithm, Floyd-Warshall algorithm and their comparisons. Spanning tree problems. Kruskal's greedy algorithm, Prim's greedy algorithm and their comparison.

Evaluation : Incourse Assessment : 30 Marks.

Final examination (Theory, 3 hours): 70 Marks

Eight questions of equal value will be set, of which any five are to be answered.

References

1. K. H. Rosen, An Introduction to Discrete Mathematics and Its Applications.
2. C.L Liu, Elements of Discrete Mathematics.
3. R. Kolman, R. C. Bushy, S. Ross, Discrete Mathematical Structures.

MTH 412 Fuzzy Mathematics

3 credits

1. Crisp sets and fuzzy sets; An overview of crisps sets; the notion of fuzzy sets; basic concepts of fuzzy sets. An overview of classical logic; fuzzy logic.
2. Operations of fuzzy sets; General discussion; fuzzy complement; fuzzy union; fuzzy intersection combinations of operations ; general aggregation operations.
3. Fuzzy arithmetic : fuzzy numbers, linguistic variables, arithmetic operations on intervals and fuzzy numbers, lattice of fuzzy numbers, fuzzy equations.
4. Fuzzy relations : Crisp and fuzzy relations ; binary relations on a set; equivalence and similarity relations; compatibility or tolerance relations; orderings; morphisms; fuzzy relational equations.

Evaluation: Incourse Assessment : 30 Marks. Final examination (Theory, 3 hours): 70 Marks.

Eight questions of equal value will be set, of which any five are to be answered.

References

1. G. J. Klir & U. Clair, Fuzzy Set Theory.
2. G. J. Klir & Bo Yuan. Fuzzy Sets & Fuzzy Logic Theory and Applications.

3. R. Lowen, Basic concepts, Techniques and Bibliography.
4. H.J. Zimmermann, Fuzzy Sets Theory and Its Applications.

MTH 413 Mathematical Modeling in Biology 3 credits

1. **Continuous population models for single species:** Simple models, Continuous growth models, Malthusian models, logistic models, delay models, harvesting models.
2. **Continuous Models for Interacting Population :** Two species population models, Prey-Predator models, Lotka-Volterra models, multi-spaces population models, War models, competition models, cooperation model, mutualism.
3. **Discrete population models:** Simple discrete models, Malthusian discrete models, logistic discrete models, Stability, discrete delay models, discrete growth models for interacting populations Fishery management models.
4. **Epidemic Models and Dynamics of Infectious Diseases :** Simple epidemic models SI model, SIS model, SIR model, some practical applications (HIV/AIDS model, etc), control of epidemic model.

References

1. J.N. Kapur, Mathematical model in Biology and medicine.
2. H.I. Freedfman, Deterministic Mathematical model in Population Ekokogy.
3. J.D. Murray, Mathematical Biology.

Evaluation: Incourse Assessment : 30 Marks.

Final examination (Theory, 3 hours): 70 Marks.

Eight questions of equal value will be set, of which any **five** are to be answered.

MTH 414 Mathematical Modeling in Finance and Business Management 3 credits

1. Mathematics for data processing: Binary number system. Computations in binary system.
2. Consumer Mathematics: Consumer loans. Other consumer computations.

3. Marketing Mathematics: Markup and markdown. Merchandise and profit. Trade discounts and cash discounts.
4. Mathematics for accounting: Pay roll accounting, financial statement, Inventory and depreciation Distribution of netincome.
5. Mathematics for Finance: Simple and compound interest and discounts. Investments in stocks and bonds. Mathematics of real estates. Mathematics of insurance. Elements of actuarial science.
6. Mathematics for management: Analysis of statements. Other business computations.

Evaluation: Incourse Assessment : 30 Marks. Final examination (Theory, 3 hours): 70 Marks.

Eight questions of equal value will be set, of which any **five** are to be answered.

References:

1. L. L. Smail, Mathematics of Finance.
2. P. H. Charles Seebeck, Mathematics of Finance.
3. Business Mathematics - L.W.T. Stafford.

MTH 415 Difference Equations

3 credits

1. Review of calculus of differences. Difference equations: Basic terminology, definition and simple examples, Formation of difference equations, Discrete analogy to differential equations, order and degree of a difference equation.
2. Homogeneous Linear difference equations (constant coefficient equations and their solutions, linear dependence and independence, initial value and boundary value problems, reduction of order, Euler equation, generating functions, eigenvalue problems)
3. Inhomogeneous linear difference equations (operator methods, variation of parameters, reduction of order, method of undetermined coefficients)
4. Linear difference equations with variable coefficients and their solutions.
5. Simple nonlinear difference equations; pseudo-nonlinear

equations. The Z - transform and its use in solving difference equations.

6. Differential-difference equations. Extension of difference equation to functions of a continuous variable. Partial difference equations.
7. Modelling with difference equations. Simple applications (application to vibrating systems, electrical networks, beams, collisions, probability, the Fibonacci numbers, integration, geometry, determinants, power series solutions, investigation of special functions, biology). Commercial applications (simple interest, compound interest, annuities). Application to chaos, Julia sets and the Mandelbrot set.

Evaluation : Incourse Assessment : 30 Marks. Final examination (Theory, 3 hours): 70 Marks.

Eight questions of equal value will be set, of which any **five** are to be answered.

References

1. H. Levy & F. Lessman , Finite Difference Equations.
2. N. Finizio & G. Ladas, An Introduction to Differential Equations with Difference Equations.
3. Murray R. Spiegel, Theory and Problems of Calculus of Finite Differences and Difference Equations.
4. Frank Chorlton, Ordinary Differential and Difference Equations Theory and Applications.

MTH 416 Topics in Scientific Computing **3 credits**

1. Error Analysis: Errors and propagation of errors, process graph.
2. *Computational Complexity of algorithms*: Algorithms and their efficiency: Searching algorithms. Sorting algorithms and their computational complexities. Algorithms on integer operations. Recursive algorithms.
3. Summation and recursion: Recursion and summation, different techniques of summation.
4. Simulation: Monte Carlo simulation, Evaluation of multi-dimensional integrals.
5. Percolation Theory: Introduction to percolation theory.

Evaluation : Incourse Assessment: 30 Marks. Final examination (Theory, 3 hours): 70 Marks

Eight questions of equal value will be set, of which any five are to be answered.

References

1. Knuth D, Concrete Mathematics,
2. H. Rosen, An Introduction to Discrete Mathematics and Its Applications.
3. Perren H, Introduction to Percolation Theory.

MTH 417: Asymptotic and Perturbation Methods 3 credits

1. Asymptotics: Asymptotic equivalence. Asymptotic expansions. Properties of asymptotic series. Watson's lemma.
2. Asymptotic solutions of second-order linear equations (expansions near an irregular singularity, expansion for large arguments, equations containing a large parameter, equations involving a small parameter).
3. Perturbation methods: Method of strained coordinates. Method of matched asymptotic expansions. Method of composite expansions. Method of averaging. Method of multiple scales.

Evaluation : Incourse Assessment: 30 Marks. Final exam (Theory, 3 hours): 70 Marks

Eight questions of equal value will be set, of which any five are to be answered.

References:

1. C. M. Bender and S.A. Orzag, Advanced Mathematical Methods for Scientists and Engineers.
2. J.D. Murry, Asymptotic Analysis
3. F. W. J. Olver, Asymptotics and Special Functions
4. Ali Hassan Nayfeh, Introduction to Perturbation Techniques.

MTH 420 Special Topics

3 credits

Any mathematical topic not covered in other courses may be offered under this title. The course-teacher will prepare an outline of the course and obtain the approval of

the departmental academic committee.

Evaluation : Incourse Assessment : 30 marks. Final examination (Theory, 3 hours): 70 Marks.

Eight questions of equal value will be set, of which any five are to be answered.

MTH 450 Math Lab

3 credits

Problem-solving in concurrent courses using MATHEMATICA and FORTRAN.

Lab Assignments: There shall be at least 15 lab assignments.

Evaluation: Internal Assessment (Laboratory works): 40 Marks.

Final Examination (Lab, 3 hours): 60 Marks.

MTH 490 Honours Project

3 credits

Each student is required to work on a project and present a project report for evaluation. Such projects should be extensions or applications of materials included in different honours courses and may involve field work and use of technology. There may be group projects as well as individual projects.

Evaluation: Project implementation and evaluation rules are given in the appendix.

MTH 499 Viva Voce (Comprehensive)

2 credits

Viva Voce on all the courses taught from First Year to Fourth Year.

N.B. In the grading system the evaluation of any course (irrespective of its credit hours) should be carried out of 100 marks. In each theoretical course 30% will be reserved for internal assessment; in each Lab course 40% will be reserved for internal assessment.

Appendix

Implementation and Evaluation of MTH 490 Honours Project

Implementation

The Academic Committee shall appoint a Project Implementation and Coordination Committee (PICC) well before the session begins. The PICC shall consist of a project Coordinator (PC) and such other members as the Academic Committee considers appropriate.

The PC shall invite projects from the teachers before the class start. Each teacher should submit three project proposal should include a short description of the project. Such projects should be extension or applications of materials included in different honors courses, and may involve fieldwork and use of technology.

There may group projects as well as individual projects. For group projects, students will sign up with the PICC in groups of three. These may not be changed later on without approval of the PICC.

The PICC shall assign each group a project. The members of each group shall work independently on the assigned project under the supervision of the concerned teacher.

The PICC shall monitor with the supervisors the progress of different projects and arrange weekly discussions on projects and materials.

Completion

The project must be completed the before the termination of the classes. Each student is required to prepare a separate report on the project. Each report should be of around 40 pages typed on one side of A4 size white paper preferably using word processors. Graphs and figures should be clearly drawn preferably using computers. Reports of different students working on the same group project should differ in some details and illustrations.

The Academic Committee will fix a date for the submission of the project reports to the PICC. Each student must submit three typed copies of her/his project report to the PICC on or before the date fixed for such submission.

The PICC, on receiving the reports will arrange the presentation of reports by individual students before the PICC, This presentation should take place soon after the completion of the written examination.

Any student who fails to submit the report on the due date or to present the thesis on the fixed date will not get any credit for this course.

Evaluation

The distribution of marks for each project shall be as follows:

Project Report	50 marks.
Project Presentation	50 marks.

Each project report shall be examined by two examiners, one of whom shall be the project supervisor and the other appointed from amongst the teachers of the department on the recommendation of the PCCC. In case the marks of the two examiners of a project report differ by more than 20% a third examiner for that report shall be appointed from amongst the teachers of the department on the recommendation of the PCCC. In such cases the final marks shall be determined according to the usual procedure.

Each student is required to present her/his work on the project before the PCCC who will evaluate the presentation.

The Academic Committee may prepare additional guidelines for evaluation of the projects.

All marks on the projects shall be submitted to the Examination Committee for tabulation with copies to the Controller of Examinations. The project reports shall be returned to the PCCC for preservation.

Mathematics Minor Courses For Honours Students of Departments other than Mathematics

The minor courses in Mathematics is open to Honours students of other departments in the faculty of science. Each students will pursue such courses as are required by her/his parent department

First Year

MTM 101	Fundamentals of Mathematics	2 credits
MTM 102	Calculus I	2 credits
MTM 103	Analytic and Vector Geometry	2 credits
MTM 104	Linear Algebra	2 credits
MTM 105	Calculus	4 credits

Second Year

MTM 201	Mathematical Analysis	2 credits
MTM 202	Calculus II	2 credits
MTM 203	Ordinary Differential Equations	2 credits
MTM 204	Numerical Analysis	2 credits
MTM 205	Mathematical Methods	2 credits

Detailed Syllabi

MTM 101: Fundamentals of Mathematics 2 credits

1. Sets and subsets. Set operations. Family of Sets. De Morgan's laws. Relations and functions: Cartesian product of sets. Relations. Equivalence relations. Functions. Images and inverse images of sets. Injective, surjective, and bijective functions. Inverse functions.
2. The Real number system: Field and order properties. Natural numbers, integers and rational numbers. Absolute value. Basic inequalities. (including inequalities involving means, powers; inequalities of Cauchy, Chebyshev, Weierstrass).
3. The Complex number system: Geometrical representation. Polar form. De Moivre's theorem and its applications. Elementary number theory: Divisibility. Fundamental theorem of arithmetic. Congruences (basic properties only).

4. Summation of finite series: Arithmetic-geometric series. Method of difference. Successive differences.
5. Theory of equations: Synthetic division. Number of roots of polynomial equations. Relations between roots and coefficients. Multiplicity of roots. Symmetric functions of roots. Transformation of equations.

Evaluation: Incourse Assessment: 30 Marks. Final examination (Theory, 2½ hours): 70 Marks

Eight questions of equal value will be set, of which any five are to be answered.

References

1. S. Lipschutz, Set Theory, Schaum's Outline Series.
2. S. Barnard & J. M. Child, Higher Algebra.
3. W.L. Ferrar, Algebra.
4. P.R. Halmos, Naive Set Theory.

MTM 102: Calculus I

2 credits

A. Differential Calculus

1. Functions and their graphs (polynomial and rational functions, logarithmic and exponential functions, trigonometric functions and their inverses, hyperbolic functions and their inverses, combination of such functions).
2. Limits of Functions: definition. Basic limit theorems (without proofs). Limit at infinity and infinite limits. Continuous functions. Properties of Continuous functions on closed and boundary intervals (no proofs required).
3. Differentiation: Tangent lines and rates of change. Definition of derivative. One-sided derivatives. Rules of differentiation (with applications). Linear approximations and differentials. Successive differentiation. Leibnitz theorem. Rolle's theorem: Lagrange's mean value theorems. Extrema of functions, problems involving maxima and minima.

B. Integral Calculus

4. Integrals: Antiderivatives and indefinite integrals.

Techniques of integration. Definite integration using anti derivatives.

5. Definite integral as a limit of a sum. The fundamental theorem of calculus. Integration by reduction.
6. Application of integration: Plane areas. Solids of revolution. Volumes by cylindrical shells. Volumes by cross-sections. Arc length and surface of revolution.

Evaluation: Incourse Assessment: 30 Marks. Final examination (Theory, 2½ hours): 70 Marks

Eight questions of equal value will be set, of which any **five** are to be answered.

References

1. H. Anton et al, Calculus with Analytic Geometry.
2. E.W. Swokowski, Calculus with Analytic Geometry.
3. L. Bers & P. Karal, Calculus.
4. S. Lang, A First Course in Calculus.

MTM 103: Analytic and Vector Geometry 2 credits

Two-dimensional geometry

1. Coordinates in two dimension. Transformations of coordinates.
2. Reduction of second degree equations to standard forms. Pairs of straight lines. Identifications of conics. Equations of conics in polar coordinates.

Three-dimensional geometry

3. Coordinates in three dimensions. Direction cosines, and direction ratios.
4. Planes, straight lines and conicoids (basic definitions and properties only)

Vector geometry

5. Vectors in plane and space. Algebra of vectors. Scalar and vector products. Triple scalar products. Applications to Geometry.

Evaluation: Incourse Assessment: 30 Marks. Final examination (Theory, 2½ hours): 70 Marks

Eight questions of equal value will be set, of which any **five** are to be answered.

References

1. A.F.M. Abdur Rahman & P.K. Bhattacharjee, Analytic Geometry and Vector Analysis.
2. Khosh Mohammad, Analytic Geometry and Vector Analysis.
3. J. A. Hummel, Vector Geometry.

MTM 104: Linear Algebra

2 credits

1. Matrices and Determinants:
Notion of matrix. Types of matrices. Matrix operations, laws of matrix Algebra. Determinant function. Properties of determinants. Minors, Cofactors, expansion and evaluation of determinants. Elementary row and column operations and row-reduced echelon matrices. Invertible matrices. Block matrices.
3. System of Linear Equations:
Linear equations. System of linear equations (homogeneous and non-homogeneous)and their solutions. Application of matrices and determinants for solving system of linear equations.
4. Vector Spaces:
Vectors in R^n and C^n :
Review of geometric vectors in R^2 and R^3 space. Vectors in R^n and C^n . Inner product. Norm and distance in R^n and C^n . Abstract vector space over R^n and C . Subspace. Sum and direct sum of sub spaces. Linear independence of vectors; basis and dimension of vector spaces. Row and column space of a matrix; rank of matrices. Solution spaces of systems of linear equation.
5. Linear transformations. Kernel and image of a linear transformation and their properties. Matrix representation of linear transformations. Change of bases.
6. Eigenvalues and eigenvectors. Diagonalization. Cayley Hamiton theorem. Applications.

Evaluation: Incourse Assessment : 30 Marks. Final examination (Theory, 2½ hours): 70 Marks

Eight questions of equal value will be set, of which any five are to be answered.

References

1. H. Anton, and C. Rorres, Linear Algebra with Applications, 9th Edition,
2. S. Lipschutz, Linear Algebra, Schaum's Outline Series.
3. W. Greub, Linear Algebra.

MTM 105: Calculus

4 Credits

A. Differential Calculus

1. **Functions:** Functions and their graphs, polynomial and rational functions, logarithmic and exponential functions, trigonometric functions and their inverses, hyperbolic functions and their inverses, combination of functions.
2. **Limits of Functions:** Basic limit theorems with proofs, limit at infinity and infinite limits, continuous functions, algebra of continuous functions, extreme values and intermediate values of continuous functions on compact intervals (no proof required).
3. **Differentiation:** Tangent lines and rates of change, definition of derivative, one-sided derivatives, rules of differentiation (proofs and applications), successive differentiation, Leibnitz theorem (proof and application), related rates, linear approximations and differentials.
4. **Applications of the derivative:** Rolle's theorem, Mean value theorem, Taylor's theorem, increasing and decreasing functions, extrema of functions, concavity and points of inflection Optimization problems.

B. Integral Calculus

5. **Integrals:** Antiderivatives and indefinite integrals, definite integration using antiderivatives, definite integration using Riemann sums, fundamental theorem of calculus, basic properties of integration, integration by reduction.
6. **Application of integration:** Plane areas, solids of revolution, volumes by cylindrical shells, volumes by cross-sections, arc length and surface of revolution. Graphing in polar coordinates, tangents to polar curves,

areas in polar coordinates, arc length in polar coordinates.

7. **Improper integrals:** Gamma and Beta functions, indeterminate forms, L'Hospital's rules.
8. **Approximations and Series:** Taylor polynomials and series, convergence of series, Taylor's series, Taylor's theorem with remainder, differentiation and integration of series, validity of Taylor expansions and computations with series.

Evaluation: Incourse Assessment : 30 Marks. Final examination (Theory, 4 hours): 70 Marks.

Eight questions will be set of which any **Five** are to be answered.

References:

1. H. Anton et al, Calculus with Analytic Geometry.
2. E.W. Swokowski, Calculus with Analytic Geometry.
3. L. Bers & P. Karal, Calculus.
4. S. Lang, A First Course in Calculus.

MTM 201: Mathematical Analysis **2 credits**

1. Bounded sets of real numbers. Supremum and infimum. The completeness axiom and its consequences. Dedekind's theorems. Cluster (limit) points; Bolzano-Weierstrass theorem.
2. Infinite sequences. Convergence. Theorems on limits. Monotone sequences, subsequences. Cauchy's general principle of convergence.
3. Infinite series of real numbers: convergence and absolute convergence. Tests for convergence; Gauss's tests (simplified form). Alternating series (Leibnitz's test). Product of infinite series.
4. Properties of continuous functions. Intermediate value theorem.
5. The derivative : standard theorems (with proofs)
6. The Riemann integral; definitions via Riemann's sums and Darboux's sums. Darboux's theorem. (equivalence of the two definitions) Necessary and sufficient conditions

for integrability. Classes of integrable functions. Fundamental theorem of calculus. Improper integrals: Tests for convergence.

Evaluation: Incourse Assessment : 30 Marks. Final examination (Theory, 2½ hours): 70 Marks.

Eight questions of equal value will be set, of which any five are to be answered.

References

1. K. A. Ross : Elementary Analysis : The Theory of Calculus.
2. R. G. Bartle, & D. R. Sherbert : Introduction to Real Analysis.
3. W. Rudin : Principles of Mathematical Analysis.
4. M. Ramzan Ali Sarder : Elements of Real Analysis.

MTM 202: Calculus II

2 credits

A. Differential Calculus

1. Vector-valued functions of a single variable: Limits, derivatives and integrals of vector valued functions. Tangent lines to graphs of vector-valued functions. Curvature of plane and space curves.
2. Partial Differentiation: Functions of several variables. Limits and continuity. Partial derivatives. Differentiability, linearization and differentials. The Chain rule. Partial derivatives with constrained variables. Directional derivatives; gradient vectors and tangent planes.
3. Taylor's formula (in one and in several variables). Extrema of functions of several variables, Lagrange multiplier.

B. Integral Calculus

4. Multiple integrals: Double and triple integrals; and iterated integrals. Area as a double integral. Double integrals in polar form. Volume as a triple integral. Triple integral in cylindrical and spherical polar coordinates.

5. General multiple integrals. Change of variables in multiple integrals. Jacobians.
6. Gradient, divergence, curl. Green's theorem, Gauss's theorem, Stoke's theorem.

Evaluation: Incourse Assessment : 30 Marks. Final examination (Theory, 2½ hour): 70 Marks.

Eight questions of equal value will be set, of which any **five** are to be answered.

References

1. H. Anton et al, Calculus with Analytic Geometry.
2. E. Swokowski, Calculus with Analytic Geometry.
3. L. Bers & P. Karal, Calculus with Analytic Geometry.
4. S. Lang, Calculus of Several Variables.

MTM 203: Ordinary Differential Equations 2 credits

1. Ordinary differential equations and their solutions: Initial value problems. Boundary value problems. Basic existence and uniqueness theorems (statement and illustration only).
2. Solution of first order equations: Separable equations and equations reducible to this form. Linear equations, Exact equations, Special integrating factors, Substitutions and transformations,
3. Solution of higher order linear differential equations: Solution space of homogeneous linear equations. Fundamental solutions of homogeneous systems. Reduction of order. Homogeneous linear equations with constant coefficients. Non homogeneous equations.
5. Method of undetermined coefficients. variation of parameters. Cauchy-Euler differential equations.
6. Systems of differential equations, Linear system, Fundamental matrix. Solutions of linear systems, with constant coefficients.

Evaluation: Incourse Assessment : 30 Marks. Final examination (Theory, 2½ hours): 70 Marks

Eight questions of equal value will be set, of which any **five** are to be answered.

References

1. S. L. Ross, Differential Equation.
2. D. G. Zill, A First Course in Differential Equations with Applications.
3. F. Brauer & J. A. Nohel, Differential Equations.
4. H.J.H. Piaggio, An Elementary Treatise on Differential Equations.

MTM 204: Numerical Analysis

2 credits

1. Solution of equation in one variable: Bisection algorithm, Method of false position. Fixed point iteration, Newton-Raphson method, Error Analysis for iterative method, Acceleration of convergence.
2. Interpolation and polynomial approximation: Taylor polynomials, Interpolation and Lagrange polynomial, Iterated interpolation, Extrapolation.
3. Differentiation and Integration: Numerical differentiation, Richardson's extrapolation, Elements of Numerical Integration, Adaptive quadrature method, Romberg's integration, Gaussian quadrature.
4. Solutions of linear systems: Gaussian elimination and backward substitution, pivoting strategies, Matrix inversion; LU decomposition method.

Evaluation: Incourse Assessment : 30 Marks. Final examination (Theory, 2½ hours): 70 Marks

Eight questions of equal value will be set, of which any **five** are to be answered.

References :

1. R.L. Burden & J.D. Faires, Numerical Analysis.
2. M.A.Celia & W.G. Gray, Numerical Methods for Differential Equations.
3. L.W. Johson & R.D. Riess, Numerical Analysis.

MTM 205: Mathematical Methods 2 credits

1. **Fourier Series:** Fourier Series, Fourier sine and cosine series. Properties of Fourier series. Operations on Fourier series. Complex form.
2. Solution of differential equations in infinite series. Equations of Legendre, Bessel, Hermite and Laguerre. Special functions: Legendre, Hermite and Laguerre polynomials; Bessel functions. Generating functions and recurrent relations.
3. Beta and Gamma functions.
4. **Laplace transforms:** Basic definitions and properties, Existence theorem. Laplace transforms of periodic functions. Transforms of convolutions. Inverse transform. Use of Laplace transforms in solving initial value problems.
5. Functions of a complex variable, analytic functions. Complex integration; Cauchy's theorem and Cauchy's integral formula. Singularities and residues. Cauchy's residue theorem. Evaluation of real integrals using contour integration.

Evaluation: Incourse Assessment : 30 Marks. Final examination (Theory, 2½ hours): 70 Marks.

Eight questions of equal value will be set, of which any five are to be answered.

References

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