KUMAUN UNIVERSITY, NAINITAL
Department of Mathematics
B. Sc. Mathematics

Semester system course structure:

1. *The course work shall be divided into six semesters with three papers in each semester.*
2. *Each paper in a semester will be of **80 marks** out of which **60 marks** for theory and **20 marks** are allotted for internal assessment (written test or assignments or both)*
3. *Each theory paper shall consists of **section (A):** 20% of total marks (objective, one word answer, fill in the blanks, true- false; all parts will be compulsory), **section (B)**: 40% of total marks (short answer) and **section (C)**: 40% of total marks (long answer).*
4. *Question paper shall cover the whole syllabus.*
5. *The duration of theory examination shall be **03 hrs.***

B.A./B. Sc. Mathematics
Course Structure (Semester System)

I Semester	II Semester	III Semester	IV Semester	V Semester	VI Semester
Elementary Algebra and Trigonometry	Group Theory	Advanced Algebra	Vector spaces and Matrices	Linear Algebra	Numerical Methods
Differential Calculus	Integral Calculus	Differential Equations	Real Analysis	Complex Analysis	Mathematical Statistics
Geometry and Vector Analysis	Analytical Geometry	Mechanics	Mathematical Methods	Functions of several variables and Partial Differential Equations	Operations Research

B. Sc. Semester I

PAPER I: Elementary Algebra and Trigonometry: MM 60

Numbers: Natural numbers, Integers, Rational and Irrational numbers, Real numbers, Complex numbers, Mappings, Equivalence relation and partitions, Congruence modulo n.

Roots of equations: Fundamental Theorem of Algebra, Relations between Roots and Coefficients, transformation of equations, Descartes rule of signs, Algebraic Solution of a Cubic equations (Carden method), Bi-quadratic Equation.

Elementary Matrices: Symmetric, skew-symmetric, Hermitian and skew-Hermitian matrices; Elementary operations on matrices, adjoint and inverse of a matrix.

Trigonometry: De Movire's Theorem and its applications, Exponential, Logarithmic, Circular and hyperbolic functions together with their inverses, Gregory's series, Summation of Trigonometric series.

Books Recommended:
1. Leonard E. Dickson: First Course in the Theory of Equations.
2. Burnside, William Snow,Panton and Arthur William: The Theory of Equations Vol I (1924).
3. John Bird: Engineering Mathematics, Fifth edition.
4. Rajendra Kumar Sharma, Sudesh Kumari Shah and Asha Gauri Shankar: Complex Numbers and the Theory of Equations, Anthom Press India

PAPER II: DIFFERENTIAL CALCULUS   MM 60

Limit, Continuity and Differentiability: Functions of one variable, Limit of a function (ε-δ Definition), Continuity of a function, Properties of continuous functions, Intermediate value theorem, Classification of Discontinuities, Differentiability of a function, Rolle's Theorem, Mean value theorems and their geometrical interpretations, Applications of mean value theorems.

Successive Differentiation, Expansions of functions and Indeterminate forms: Successive Differentiation, n^{th} Differential coefficient of functions, Leibnitz Theorem; Taylor's Theorem, Maclaurin's Theorem, Taylor's and Maclaurin's series expansions.

Tangents and Normals: Geometrical meaning of $\frac{dy}{dx}$, Definition and equation of Tangent, Tangent at origin, Angle of intersection of two curves, Definition and equation of Normal, Cartesian subtangent and subnormal, Tangents and Normals of polar curves, Angle between radius vector and tangent, Perpendicular from pole to tangent, Pedal equation of curve, Polar subtangent and polar subnormal, Derivatives of arc (Cartesian and polar formula).

Curvature and Asymptotes: Curvature, Radius of curvature; Cartesian, Polar and pedal formula for radius of curvature, Tangential polar form, Centre of curvature, Asymptotes of algebraic curves, Methods of finding asymptotes, Parallel asymptotes.

Singular Points and Curve Tracing: Regular points and Singular Points of a curve, Point of inflection, Double Points, Cusp, Node and conjugate points, Curve tracing.

Books Recommended:
1. M. Ray: Differential Calculus, Shiva Lal Agarwal and Co., Agra
2. H. S. Dhami: Differential Calculus, New Age International, New Delhi
3. T. M. Apostol: Calculus, John Willey and Sons, New York
4. S. Lang: A First Course in Calculus, Addison Wesley Publishing Co., Philippines
5. Gorakh Prasad: Differential Calculus, Pothishala publication, Allahabad.

PAPER III: GEOMETRY AND VECTOR ANALYSIS   MM 60

Polar Equation of conics: Polar coordinate system, Distance between two points, Polar equation of a Straight line, Polar equation of a circle, Polar equation of a conic, Chords, Tangent and Normal to a conic, Chord of contact, Polar of a point.

Vector Algebra and its Applications to geometry (Plane and Straight Line):

Triple product, Reciprocal vectors, Product of four vectors. General equation of a Plane, Normal and Intercept forms, Two sides of a plane, Length of perpendicular from a point to a plane, Angle between two planes, System of planes.

Direction Cosines and Direction ratios of a line, Projection on a straight line, Equation of a line, Symmetrical and unsymmetrical forms, Angle between a line and a plane, Coplanar lines, Lines of shortest distance, Length of perpendicular from a point to a line, Intersection of three planes, Transformation of coordinates.

Vector Differentiation: Ordinary differentiation of vectors, Applications to mechanics, Velocity and Acceleration, Differential operator-Del, Gradient, Divergence and Curl,

Vector Integration: Line, Surface and volume integrals, Simple applications of Gauss divergence theorem, Green's theorem and Stokes theorem (without proof).

Books Recommended:
1. Murray R. Spiegel: Vector Analysis, Schaum's Outline Series, McGraw Hill.
2. N. Saran and S. N. Nigam: Introduction to vector analysis Pothishala Pvt. Ltd. Allahabad.
3. Shanti Narayan: A text book of vector calculus, S. Chand & co. New Delhi.
4. P. N. Pandey: Polar Coordinate Geometry, Sharda Academic Publishing House, Allahabad.
5. P. K. Jain and Khalil Ahmed: A textbook of Analytical Geometry,Wiley Eastern pub, New Age.

B. Sc. Semester II

PAPER I: GROUP THEORY   MM 60

Basic concepts: Sets, Subsets, Operations on sets, Index set and family of sets, Relations, Equivalence relations and partitions, Mappings.

Basic concepts Contd.: Infinite sets and cardinality, Congruence modulo-n., Laws of composition.

Groups: Binary operation and Algebraic structure, Groups, Subgroups, Generators of a group, Permutation groups, Cyclic groups, Coset decomposition, Lagrange theorem and its consequences, Homomorphism and Isomorphism, , Normal subgroups, Quotient group, Cayley's theorem.

Groups Contd.: Fundamental theorems on homomorphism and isomorphism, Automorphism and inner automorphism, Automorphism groups and their computation, Normaliser and center of group, Group actions, Stabilizers and orbits, Finite groups, Commutor subgroups.

Books Recommended:
1. I. N. Herstein: Topics in Algebra, Wiley Eastern Ltd, New Delhi.
2. S. Singh: Modern Algebra, Vikas Publishing House, India.

PAPER II: INTEGRAL CALCULUS   MM 60

Definite Integrals: Integral as a limit of sum, Properties of Definite integrals, Fundamental theorem of integral calculus, Summation of series by integration, Infinite integrals, Differentiation and integration under the integral sign.

Functions Defined by Infinite Integrals: Beta function, Properties and various forms, Gamma function, Recurrence formula and other relations, Relation between Beta and Gamma function, Evaluation of integrals using Beta and Gamma functions.

Multiple Integrals: Double integrals, Repeated integrals, Evaluation of Double integrals, Double integral in polar coordinates, Change of variables and Introduction to Jacobians, Change of order of integration in Double integrals, Triple integrals, Evaluation of Triple integrals, Drichlet's theorem and its Liovelle's extension.

Geometrical Applications of Definite Integrals: Area bounded by curves (quadrature), Rectification (length of curves), Volumes and Surfaces of Solids of revolution.

Books Recommended:
1. M. Ray: Integral Calculus, Shiva Lal Agarwal and Co., Agra
2. H. S. Dhami: Integral Calculus, New Age International, New Delhi
3. T. M. Apostol: Calculus, John Willey and Sons, New York
4. S. Lang: A First Course in Calculus, Addison Wesley Publishing Co., Philippines
5. Gorakh Prasad: Integral Calculus, Pothishala Publication, Allahabad

PAPER III: ANALYTICAL GEOMETRY   MM 60

System of co-ordinates: Curvilinear coordinates, Spherical and Cylindrical coordinates.

The Sphere: Definition and equation of a sphere, Plane section of a sphere, Intersection of two spheres, Intersection of a sphere and a line, Power of a point, tangent plane, Plane of contact, Polar plane, Pole, Angle of Intersection of two spheres, Radical plane, Co-axial system of spheres.

Cone and Cylinder: Definition and equation of a cone, Vertex , Guiding curve, Generators, Three mutually perpendicular generators, Intersection of a line with a cone, Tangent line and tangent plane, Reciprocal cone, Right circular cone, Definition and equation of a cylinder, Right circular cylinder, Enveloping cylinder.

Conicoids: General equation of second degree, Central conicoids, Tangent plane, Director sphere, Normal, Plane of contact, Polar plane, Conjugate plane and conjugate points.

Books Recommended:
1. Shanti Narayan: A Text book of Analytical Geometry, S. Chand, & company, New Delhi.
2. H. Burchared Fine and E. D. Thompson: Coordinate Geometry, The Macmillan company.
3. P. K. Jain and Khalil Ahmed: A textbook of Analytical Geometry, New Age, Delhi.

B. Sc. Semester III

PAPER I: ADVANCED ALGEBRA   MM 60

Rings: Rings, Various types of rings, Rings with unity, Rings without zero divisors, Properties of rings, Sub rings.

Ideals: Ideals, Quotient rings, Principal ideals, Maximal ideals, Prime ideals, Principal ideal domains, Characteristic of a ring.

Integral domains and Fields: Integral domain, Field, Skew field etc., Field of quotients of an integral domain, Embedding of an integral domain in a field, Factorization in an integral domain, Divisibility, Units, Associates, Prime and irreducible elements, Unique Factorisation Domain, Euclidean rings.

Polynomial rings: Polynomials over a ring, Degree of a polynomial, Zero, Constant and monic polynomials, Equality of polynomials, Addition and multiplication of polynomials, Polynomial rings, Embedding of a ring R into R[x], Division algorithm, Euclidean algorithm, Units and associates in polynomials, Irreducible polynomials.

Books recommended
1. I. N. Herstein: Topics in Algebra. Wiley Eastern Ltd.
2. N. Jacobson: Basic Algebra Vol I & II . Hindustan Publishing Co.
3. Joseph A. Gallian: Contemporary Abstract Algebra. Narosa Publishing House.
4. Shanti Narayan: Textbook of Modern Abstract Algebra . S Chand & Co.
5. R. S. Aggarwal: A Textbook on Modern Algebra. S Chand & Co.

PAPER II: DIFFERENTIAL EQUATIONS   MM 60

Differential equations: Introduction of Differential equations, Order and Degree of Differential Equations, Complete primitive (general solution, particular solution and singular solutions), Existence and uniqueness of the solution dy/dx= f(x,y).

First Order Differential Equations: Differential equations of first order and first degree, Separation of variables, Homogeneous Equations, Exact Equations, Integrating Factor, Linear Equation, Equation of First order but not of first degree, Various methods of solution, Clairaut's form, Singular solutions, Trajectory, Orthogonal Trajectory, Self-Orthogonal family of Curves.

Linear Differential Equations: Linear equations with constant coefficients, Complementary function, Particular integral, Working rule for finding solution, Homogeneous linear equations.

Miscellaneous Equations: Simultaneous differential equations, Differential equations of the form dx/P= dy/Q= dz/R where P, Q, R are functions of x, y, z. Exact differential equations, Total differential equations, Series solutions of differential equations, Linear differential equations of second order with variable coefficients.

Applications: Initial and boundary value problems, Simple applications of differential equations of first order.

Books Recommended:
1. Earl A. Coddington and Norman Levinson: Theory of Ordinary Differential Equations, Tata McGraw-Hill Publishing Company (1998).
2. Shepley L. Ross: Differential Equations, Wiley (1984).
3. Ravi P. Agarwal: Ordinary and Partial Differential Equations.
4. L. Elsgolts: Differential Equations and Calculus of Variations, Mir Publishers, 1970.
5. M D Raisinghania: Ordinary & Partial Differential Equation.

PAPER III: MECHANICS   MM 60

Rectilinear motion: Newton's Laws of Motion, velocity and acceleration, motion under constant acceleration, motion under inverse square law, rectilinear motion with variable acceleration, Simple Harmonic Motion.

Kinematics in two dimension: Angular velocity and angular acceleration, Components of velocity and acceleration along coordinate axes, Radial and transverse components of velocity and acceleration, tangential and normal components of velocity and acceleration.

Motion in resisting medium, constrained motion and Central orbits: Terminal Velocity, Motion in resisting medium in a straight line, Motion on vertical circle, Cycloidal motion, Central Force, Central orbit, intrinsic equation, Pedal form, apse and apsidal distance.

Statics: Coplaner Forces, Equilibrium of forces in three dimensions, Common catenary, Catenary of uniform strength, Virtual work.

Books Recommended:
1. M. Ray: A Textbook on Dynamics, S. Chand.
2. M. Ray: A Textbook on Statics, S. Chand.
3. A. S. Ramsay: Dynamics, Cambridge University Press.
4. S. L. Loney: Dynamics of a particle and of rigid bodies, Cambridge University Press.

B. Sc. Semester IV

PAPER I: VECTOR SPACES AND MATRICES   MM 60

Vector spaces: Vector space, sub spaces, Linear combinations, linear spans, Sums and direct sums.

Bases and Dimensions: Linear dependence and independence, Bases and dimensions, Dimensions and subspaces, Coordinates and change of bases.

Matrices: Idempotent, nilpotent, involutary, orthogonal and unitary matrices, singular and nonsingular matrices, negative integral powers of a nonsingular matrix; Trace of a matrix.

Rank of a matrix: Rank of a matrix, linear dependence of rows and columns of a matrix, row rank, column rank, equivalence of row rank and column rank, elementary transformations of a matrix and invariance of rank through elementary transformations, normal form of a matrix, elementary matrices, rank of the sum and product of two matrices, inverse of a non-singular matrix through elementary row transformations; equivalence of matrices.

Applications of Matrices: Solutions of a system of linear homogeneous equations, condition of consistency and nature of the general solution of a system of linear non-homogeneous equations, matrices of rotation and reflection.

Books Recommended:
1. Hadley: Linear Algebra.
2. Hoffman and Kunz: Linear Algebra, Prentice Hall of India, New Delhi, 1972.
3. S. Lang: Linear Algebra, springer.
4. K. B. Dutta: Matrix and Linear Algebra, Prentice Hall of India.
5. Shanti Narayan: Matrices, S. Chand and Co., New Delhi.

PAPER II: REAL ANALYSIS   MM 60

Continuity and Differentiability of functions: Continuity of functions, Uniform continuity, Differentiability, Taylor's theorem with various forms of remainders.

Integration: Riemann integral-definition and properties, integrability of continuous and monotonic functions, Fundamental theorem of integral calculus, Mean value theorems of integral calculus.

Improper Integrals: Improper integrals and their convergence, Comparison test, Dritchlet's test,

Absolute and uniform convergence, Weierstrass M-Test, Infinite integral depending on a parameter.

Sequence and Series: Sequences, theorems on limit of sequences, Cauchy's convergence criterion, infinite series, series of non-negative terms, Absolute convergence, tests for convergence, comparison test, Cauchy's root Test, ratio Test, Rabbe's, Logarithmic test, De Morgan's Test, Alternating series, Leibnitz's theorem.

Uniform Convergence: Point wise convergence, Uniform convergence, Test of uniform convergence, Weierstrass M-Test, Abel's and Dritchlet's test, Convergence and uniform convergence of sequences and series of functions.

Books Recommended:
1. Walter Rudin: Principle of Mathematical Analysis (3rd edition) McGraw-Hill Kogakusha, 1976, International Student Edition.
2. K. Knopp: Theory and Application of Infinite Series.
3. T. M. Apostol: Mathematical Analysis, Narosa Publishing House, New Delhi, 1985.

PAPER III: MATHEMATICAL METHODS   MM 60
Integral Transforms: Definition, Kernel.

Laplace Transforms: Definition, Existence theorem, Linearity property, Laplace transforms of elementary functions, Heaviside Step and Dirac Delta Functions, First Shifting Theorem, Second Shifting Theorem, Initial-Value Theorem, Final-Value Theorem, The Laplace Transform of derivatives, integrals and Periodic functions.

Inverse Laplace transforms: Inverse Laplace transforms of simple functions, Inverse Laplace transforms using partial fractions, Convolution, Solutions of differential and integro-differential equations using Laplace transforms. Dirichlet's condition,

Fourier Transforms: Fourier Complex Transforms, Fourier sine and cosine transforms, Properties of FourierTransforms, Inverse Fourier transforms.

Books Recommended:
1. Murry R. Spiegal: Laplace Transform (SCHAUM Outline Series), McGraw-Hill
2. J. F. James: A student's guide to Fourier transforms, Cambridge University Press.
3. Ronald N. Bracewell: The Fourier transforms and its applications, Mcgraw Hill.
4. J. H. Davis: Methods of Applied Mathematics with a MATLAB Overview, Birkhäuser, Inc.,Boston, MA, 2004.

B. Sc. Semester V

PAPER I: LINEAR ALGEBRA   MM 60
Linear Transformations: Linear transformations, rank and nullity, Linear operators, Algebra of linear transformations, Invertible linear transformations, isomorphism; Matrix of a linear transformation, Matrix of the sum and product of linear transformations, Change of basis, similarity of matrices.

Linear Functionals: Linear functional, Dual space and dual basis, Double dual space, Annihilators, hyperspace; Transpose of a linear transformation.

Eigen vectors and Eigen values: Eigen vectors and Eigen values of a matrix, product of characteristic roots of a matrix and basic results on characteristic roots, nature of the characteristic roots of Hermitian, skew-Hermitian, unitary and orthogonal matrices, characteristic equation of a matrix, Cayley-Hamilton theorem and its use in finding inverse of a matrix.

Bilinear forms: Bilinear forms, symmetric and skew-symmetric bilinear forms, quadratic form associated with a bilinear form.

Books Recommended:
1. Hadley: Linear Algebra.
2. Hoffman and Kunze: Linear Algebra, Prentice Hall of India, New Delhi, 1972.
3. H. Helson: Linear Algebra, Hindustan Book Agency, New Delhi, 1994.
4. K. B. Dutta: Matrix and Linear Algebra, Prentice Hall of India.
5. S. Lang: Linear Algebra, Springer

PAPER II: COMPLEX ANALYSIS   MM 60
Complex Variables: Functions of a complex variable; Limit, continuity and differentiability.
Analytic functions: Analytic functions, Cauchy and Riemann equations, Harmonic functions.
Complex Integration: Complex integrals, Cauchy's theorem, Cauchy's integral formula, Morera's Theorem, Liouville's Theorem, Taylor's series, Laurent's series, Poles and singularities.
Residues: Residues, the Residue theorem, the principle part of a function, Evaluation of Improper real integrals.

Books Recommended:
1. J. B. Conway: Functions of One Complex Variable, Narosa Publishing House, 1980.
2. E. T. Copson: Complex Variables, Oxford University Press.
3. L. V. Ahlfors: Complex Analysis, McGraw-Hill, 1977.
4. D. Sarason: Complex Function Theory, Hindustan Book Agency, Delhi, 1994..
5. P. R. Halmos: Naive Set Theory, Van Nostrand, 1960.

PAPER III: FUNCTIONS OF SEVERAL VARIABLES AND PARTIAL
DIFFERENTIAL EQUATIONS   MM 60
Functions of several variables: Limit, continuity and differentiability of functions of several variables.
Partial Derivatives: Partial derivatives and their geometrical interpretation, differentials, derivatives of composite and implicit functions, Jacobians, Chain rule, Euler's theorem on homogeneous functions, harmonic functions, Taylor's expansion of functions of several variables.
Maxima and Minima: Maxima and minima of functions of several variables – Lagrange's method of multipliers.
Partial differential equations: Partial differential equations of first order, Charpit's method, Linear partial differential equations with constant coefficients. First-order linear, quasi-linear PDE's using the method of characteristics.
Partial differential equations of 2nd-order: Classification of 2nd-order linear equations in two independent variables: hyperbolic, parabolic and elliptic types (with examples).

Books Recommended:
1. W. Fleming: Functions of several variables, Springer
2. R P Agrawal: Ordinary and Partial Differential Equations, Springer
3. K Sankar Rao: Partial Diffrential Equations, PHI

B. Sc. Semester VI

PAPER I: NUMERICAL METHODS   MM 60

Errors in numerical Calculations: Absolute, Relative and Percentage errors, General Error, Error in series approximation.

Solutions of Algebraic and Transcendental Equations: Bisection method, False position method, Newton-Raphson Method, Picard's iteration method.

Linear systems of equations: Consistency of Linear System of equations, Solutions of Linear Systems by direct method: Guassian elimination and computation of inverse of a matrix, Method of Factorization,. Solutions of linear systems by iterative methods: Jacobi method, Gauss-Siedel method.

Interpolation and curve fitting: Errors in Polynomial interpolation, Finite differences, Differences of a polynomial, Newton's forward and backward interpolation, Central differences, Gauss, Stirling, Bessel's and Everett's Formulae, Lagrange's Interpolation formula.

Numerical differentiation and integration: Numerical differentation, Newton-Cotes Integration formula, Numerical integration by Trapezoidal rule, Simpson'1/3, Simpson's 3/8, and Romberg Integration.

Books Recommended:
1.   S. S. Sastry: Introductory Methods Numerical Analysis, Prentice- Hall of India.
2.   C.F. Gerald and P. O. Wheatley: Applied Numerical Analysis, Addison- Wesley, 1998.
3.   Konte and Debour: Numerical Analysis.

PAPER II: MATHEMATICAL STATISTICS   MM 60

Descriptive Statistics and Exploratory Data Analysis: Frequency distribution, Graphical representation of a frequency distribution, Measures of central tendency, Measures of dispersion, Moments, skewness and kurtosis.

Correlation and regression: Scatter diagram, Karl Pearson's coefficient of correlation and its calculation, Regression and equations of lines of regression, Rank correlation coefficient, Concept of Partial and Multiple correlation in case of distribution of three variables.

Probability: Notion of Probability, Random experiment, sample space, Mathematical and statistical definitions of Probability of an event, Axiom of probability, elementary properties of probability; equally likely, mutually exclusive, independent and compound events, Conditional probability, Additive law of probability and Multiplicative law of probability, Mathematical expectation, Inverse probability, Baye's Theorem, Concept of random variable.

Books Recommended:
1. S. C. Gupta & V. K. Kapoor: Mathematical Statistics, Sultan Chand & co. Ltd New Delhi.
2. J. N. Kapoor & H. C. Saxena: Mathematical Statistics, S. Chand & co. Ltd, New Delhi.
3. M. Ray & H. S. Sharma: A text book of Statistics, S. Chand & co. Pvt. Ltd New Delhi.

Paper III: Operations Research   MM 60

Basics of OR and LPP: Development of OR, Definition, characteristics, scope, objectives and limitations of OR, convex sets, Basic feasible solutions, Formulation of LPP, Graphical Method to solve LPP, General LPP, Canonical and Standard forms, Properties of Solutions and Theory of Simplex

method, Big M Method and Two phase simplex method, Degeneracy in LPP. Duality in LPP, Duality and simplex method, Dual simplex method.

Transportation and assignment Models: Formulation of TP, Transportation Table, Finding initial basic feasible solution, Test of optimality, Degeneracy, MODI method, Stepping Stone method, Solutions of Assignment problems, Hungarian method.

Recommended Books:
1. G. Hadley, Linear Programming, Narosa Publishing House, 1995.
2. S. I. Gass, Linear Programming: Methods and Applications (4th edition) McGraw-Hill, New York, 1975.
3. KantiSwaroop, P.K. Gupta and Man Mohan, Operations Research, Sultan Chand & Sons, New Delhi, 1998.
4. Hamdy A. Taha, Operations Research, Prentice-Hall of India, 1997.