Tribhuvan University

Institute of Science and Technology

Three year B. Sc. Mathematics Course of Study

2052

In three years Bachelor Programme, students offering mathematics as major subject will have to study 8 papers, each carrying 75 marks. The duration of examination of each paper will be three hours. The distribution of the 8 papers (equivalent to 600 marks) will be in the pattern- 2+2+4 i.e., two papers in each of the first two years and 4 papers in the third year. The minimum number of periods per week per paper will be 6 (or full 4 hours theory) and 3 (or full 2 hours theory) for tutorial.

All questions will be compulsory and choices, if given, will be from the same unit. Full marks of each paper will be 75 and the pass marks will be 35%. of the full marks.

The yearwise courses distribution will be as follows:

First year	Course I (Math 311)	Calculus
	Course II (Math 312)	Analytic Geometry and Vector
Second year	Course III (math321)	Algebra I
	Course IV (Math322)	Mathematical Analysis I
Third year **(Four Papers)**	Course V (Math331)	Mathematical Analysis II
	Course VI (Math332)	Advanced Calculus
	Course VII (Math333)	Algebra
	Any one of the follows optional courses	
	Course VIII (Math334)	Mechanics
	Course IX (Math335)	Linear Programming
	Course X (Math336)	Mathematical Statistics
	Course XI (Math337)	Numerical Analysis and Computer Programming

Course Title: Calculus **Full Marks:** 75
Course No.: MATH 311 (Major/Minor) **Pass Marks:** 35%
Nature of the Course: Theory (Compulsory) **Year:** I

Unit 0. **Review of Elementary Calculus:** Functions, graphs, evaluation of limits, continuity, discontinuity, test of continuity and properties of continuous function, integration. **6 hrs.**

Unit 1. **Tangents and Normals:** Tangents and normals, subtangent, subnormal and their lengths, Derivative of arc length, Polar equations of subtangent and subnormal, Angle between radius vector and tangent, Length of perpendicular from pole on tangent, Pedal equations and Angle between two curves. **6 hrs.**

Unit 2. **Higher-order Derivatives and Mean Value Theorems:** Higher order derivatives, Leibnitz theorem, Rolle's theorem, Lagrange's theorem, Cauchy Mean Value theorem (without proof) and their applications, Maclaurin's and Taylor's theorems and their applications in expanding functions. **8 hrs.**

Unit 3. **Maxima, Minima and Indeterminate Forms:** Maxima and minima of function of one variable, concept of local and global maxima and minima, criterion of maxima and minima, indeterminate forms, L'Hospital's rule (statement only) **6 hrs.**

Unit 4. **Asymptotes and Curve Tracing:** Asymptotes, Types of asymptotes, asymptotes of algebraic

curves, curve tracing techniques, standard curves and their tracing. **6 hrs.**

Unit 5. **Curvature:** Concept of curvature, chord of curvature, curvature at origin, centre and circle of curvatures. **6 hrs.**

Unit 6. **Partial Differentiations and Maxima and Minima of functions of 2 or 3 Variables:** Basic ideas of limits and continuity of functions with 2 or 3 variables, partial derivatives and geometrical interpretation, higher order partial derivatives, homogeneous functions, Euler's theorems, (proof for 2 variables only), total differentials extremum values, stationary points, criterion for maxima and minima, subsidiary conditions, Lagrange's method of undetermined multipliers. **8 hrs.**

Unit 7. **Integration and Definite Integrals:** Integration concepts, integration techniques and standard formulae, integration of rational fractions and hyperbolic functions, integration as the limit of a sum, definite integral and fundamental theorem of integral calculus (without proof), properties of definite integral. **8 hrs.**

Unit 8. **Beta and Gamma Functions and Reduction Formulae:** Beta and Gamma functions and their properties, reduction formulae. **4 hrs.**

Unit 9. **Rectification and Quaderature, Volume and Surface of Solid of Revolution:** Rectification notion, length formula, Idea of quadrature and area-

formula, volume and surface area of solid of revolution **8 hrs.**

Unit 10. **Differential Equations of the First-order and First Degree:** Introduction, standard forms, variable-separable equations, homogeneous equations, equations reducible to homogenous equations, non-homogeneous equation of the first order, exact differential equation, condition for exactness, integrating factors and techniques, linear differential equations and equations reducible to linear forms. **6 hrs.**

Unit 11. **Differential Equations of the First-order but not of First Degree:** Equations solvable for p, equations solvable for y, equations solvable for x, equation solvable for x and y, equation homogeneous in x and y, Clairaut's equation. **6 hrs.**

Unit 12. **Linear Differential Equations with Constant Coefficients:** Linear equation with constant coefficients, linear equations solvable using symbolic operators, symbolic operation techniques, particular integral and complementary function, Homogeneous linear equations, equations reducible to homogeneous form. **6 hrs.**

Unit 13. **Applications of First Order and First Degree Differential Equations:** Formation of problems into differential equations, initial and boundary conditions, solution technique. **6 hrs.**

Books Suggested:

1. M.B. Singh and B.C. Bajracharya,: ***Differential Calculus***, Sukunda Pustak Bhandar, Kath.
2. G.D. Pant and G.S. Shrestha, : ***Integral Calculus and Differential Equations***, Sunita Prakashan, Kath.
3. D.A. Murray, : ***Introductory Course in Differential Equations***, Orient Longman.
4. T.M. Apostal, : ***Calculus Vol. I & II***, Wiley Eastern Ltd. New Delhi.
5. Das and Mukherjee, : ***Differential Calculus***, U.N. Dhar and Sons, Calcutta.
6. Das, and Mukherjee, : ***Integral Calculus***, U.N. Dhar and Sons, Calcutta.

Course Title: Analytical Geometry and Vector Analysis **Full Marks:** 75
Course No.: MATH 312 (Major/Minor) **Pass Marks:** 35%
Nature of the Course: Theory (Compulsory) **Year:** I

Unit 1. **Transformation of Coordinates:** Transformation, rotation, process involving combination of Translation and rotation of axes, invariants in orthogonal transformation. **6 hrs.**

Unit 2. **Conic Sections and their Properties:** Introduction-Conic section as locus of a point and as a section of cone, central conic sections, ellipse and hyperbola, derivation of their equations in standard forms, Auxiliary circles and eccentric angle, equations of tangent and normal, chord of contact, pole and polar and their properties, diameter, conjugate diameter equi-conjugate diameter, Asymptotes of hyperbola, relations between the equation of hyperbola, its asymptotes and the conjugate hyperbola, equation of a hyperbola referred to the asymptotes as coordinate axes. **14 hrs.**

Unit 3. **Polar Equation of a Conic:** Polar equation of a conic section with focus being pole, equation of chord of conic, equation to the tangent, normal and chord of contact, equation of the polar to a conic and equation of the asymptotes. **6 hrs.**

Unit 4. **General Equation of the Second Degree:** General equation of the second degree and the conic representation by them, nature of the conic, centre of conic, equation of the tangent and condition of

tangency, equation of pair of tangents, director-circle. equation of the normal to a conic, equation of pole and polar with respect to a conic. diameter and conjugate diameter, intersection of conics, asymptotes to a conic. **6 hrs.**

Unit 5. **Co-ordinates in Space and Plane:** Review of co-ordinates in space, angle between two lines, general equation of the first degree representing a plane, angle between two planes, plane through three points, plane through the intersection of two planes, condition for representing a pair of planes by the homogeneous equation of the second degree. **6 hrs.**

Unit 6. **Straight Lines:** Representation of a line as the intersection of two planes, line in symmetric form, line through two points, reduction of the general form to the symmetrical form, perpendicular distance of a point from a line, condition for a line to lie in a plane, general equation of a plane containing a line, coplanar lines and condition for it, skew lines, magnitude and the equation of the line of shortest distance between two skew lines, intersection of three planes. **8 hrs.**

Unit 7. **Sphere:** Sphere and equation of a sphere, its representation by the general equation of the second degree, sphere through four given points, plane section of a sphere, intersection of two spheres, sphere with a give diameter, tangent plane and condition of tangency. **6 hrs.**

Unit 8. **Cone and Cylinder:** Definition and equation of a cone, condition that the general equation of the second degree to represent a cone, condition that a

cone has three mutually perpendicular generators, tangent lines and tangent plane, condition of tangency reciprocal cone, enveloping cone and right circular cone, cylinder and enveloping cylinder, right circular cylinder. **8 hrs.**

Unit 9. **Central Conicoids:** Conicoids and central conicoids, standard equation of central conicoid, intersection of a line with a conicoid, tangent and tangent planes, condition of tangency, director sphere, equation of the normal, cubic curve through the feet of the six normals, general equation of the conicoid through the six feet of the normals, polar plane and plane of contact, enveloping cone of the central conicoid and enveloping cylinder to a conicoid section of a conicoid, diametral plane, conjugate diameters and diametral planes of a ellipsoid, properties of conjugate semi-diameters. **10 hrs.**

Unit 10. **Product of three or more Vectors:** Multiplication of three vectors, scalar triple products, applications and geometrical meanings of scalar triple product, properties of scalar triple product, condition of coplanarity of these vectors, vector triple product, scalar product of four vectors and vector product of four vectors, reciprocal system of vectors. **6 hrs.**

Unit 11. **Differentiation of Vectors:** Vector function of a single variable, vector function and its expression in terms of unit vectors, limit and continuity of vector functions, differentiation of a vector function w.r.t. a scalar, partial derivatives of vectors, higher derivatives of a vector function w.r.t. a scalar, differentiation of the product of a scalar and a vector,

differentiation of scalar product and vector product of two and three vectors. **8 hrs.**

Unit 12. Gradient, Divergence and Curl and Expansion Formulae: Scalar point function, vector point function, scalar field, vector field, vector operators, gradient scalar field, gradient in polar coordinates, condition for a scalar point function to be constant and conversely, total differential, directional derivatives, divergence of a vector field, solenoidal vector, curl of a vector field, expansion formulae, second order differential operators, expansion of formulae involving first order and second order differential operators. **8 hrs.**

Books Suggested:

1. Y.R. Sthapit and B.C. Bajracharya, : ***A Text Book of Three Dimensional Geometry***, Sukunda Pustak Bhawan, Kathmandu.
2. S.L. Loney, : ***Elements of Coordinate Geometry***, McMillan Book Co., N.Y. (1984).
3. J.T. Bell, : ***An Elementary Treatise of Coordinate Geometry of Three Dimensions***, McMillan Book Co., N.Y. (1986).
4. M.B. Singh and B.C. Bajracharya, : ***A Text Book of Vector Analysis***, Sukunda Pustak Bhandar.
5. S. Narayan, : ***Analytical Solid Geometry***, S. Chand and Co.
6. Lalji Prasad, : ***Vector Analysis***, Paramount Publication (1986).

Course Title: Algebra I **Full Marks:** 75
Course No.: MATH 321 (Major/Minor) **Pass Marks:** 35%
Nature of the Course: Theory (Compulsory) **Year:** II

Unit 1. **Sets, Mappings and Properties of Integers:** Review of sets and set operations, relations and mappings, properties of mappings and composite mappings, binary operations, equivalence relations and equivalence classes, properties of integers and prime numbers, divisors and greatest common divisors, prime factors and unique factorization theorem (no proof) congruencies and residue classes. **10 hrs.**

Unit 2. **Matrices and Determinants:** Matrices and entries, standard matrices, submatrices, equal matrices, algebra of matrices, transpose of a matrix and properties, symmetric and skew symmetric matrices, matrices of complex entries, Hermitian, skew Hermitian matrices. orthogonal and unitary matrices, determinant of a square matrix, properties of determinants, minors and co-factors, adjoint of a square matrix, inverse of a square matrix and their properties. **8 hrs.**

Unit 3. **System of Linear Equations:** System of linear equations, homogeneous and nonhomogeneous, rank of matrix, reduction of Echelon form, linear dependence and independence, properties of rank, row and rank column rank, rank of product of matrices, consistency conditions, solution of homogeneous and non-homogeneous systems of equations, elementary transformations of a matrix,

characteristic equation of a matrix and Cayley-Hamilton theorem (no proof). **10 hrs.**

Unit 4. **Groups:** Groups and semi-groups and their examples, elementary properties of groups, integral power of an element, cyclic groups, subgroups and their characterization, cosets, order of an element, Lagrange's theorem, normal subgroups, quotient group and their properties, homomorphism, kernel and image of homomerphism, isomerphism, permutation groups, cyclic-permutation, even and odd permutations. **10 hrs.**

Unit 5. **Rings and Fields:** Rings, special classes of rings, elementary properties of rings, zero divisor, division ring, integral domain, field and their properties, homomorphism of rings, ideals and quotient rings, maximal ideal of rings. **8 hrs.**

Unit 6. **Vector in n-Space:** Point in n-space, algebraic operations in n-space and their properties, scalar product, Norm distance, angle, scalar and vector projections, geometric interpretations, orthogonality. **8 hrs.**

Unit 7. **Vector Space and Subspaces:** Vector spaces and subspaces, elementary properties, linear combinations, linear dependence and independence, basis and dimension, idea of dual spaces, direct sum, homomorphism and isomorphism, inner product, orthogonality and orthonormality, orthogonal and orthonormal basis. **8 hrs.**

Unit 8. **Linear Transformations:** Transformations, linear tranformations, kernel and image of linear transformations, algebra of linear transformations, matrix as a linear transformation, eigenvalues and eigenvactors, Caley – Hamilton theorems (no proof). **8 hrs.**

Unit 9. **Theory of Polynomial Equations:** Polynomials over an integral domain, division algorithm, division of a polynomial, zeros of a polynomial, Rolle's theorem, properties of equations, Descartes rule of signs relation between roots and coefficients, application to solution of an equation, symmetric functions of the root, transformation of equations, transformation in general, equation of squared difference of a cubic, multiple roots, sum of powers of roots, reciprocal equations. **10 hrs.**

Unit 10. **Cubic and Biquadratic Equations:** Algebraic solutions, solution of the cubic, nature of roots of a cubic, nature of roots from Cardan's solution and applications to numerical examples, solution by symmetric functions of roots, solution of the biquadratic and solution by radical. **10 hrs.**

Books Suggested:

1. I.N. Herstein, : ***Topics in Algebra***, Vikas Publishing House Pvt. Ltd.
2. R.M. Shrestha & S. Bajracharya, : ***Linear Algebra with Group Rings***, Sukunda Pustak Bhavan, Kathmandu.
3. S. Lang : ***Linear Algebra***, Addison-Wesley Publishing Company.
4. N.S. Gopal Krishna, : ***University – Algebra***, Orient Longman.
5. Chandtrika Prasad, : ***A Text Book Algebra & theory of Equations***, Pothisala Private Ltd.
6. P.B. Bhattacharya S.K. Jain & S.R. Nagpaul, : ***First Course in Linear Algebra***, Wiley Eastern Ltd.
7. P.R. Halmos: ***Finite Dimensional Vector Space***, D. Van Nostard Co., Princeten.
8. B.S. Vatssa, : ***Theory of Matrices***, Wiley Eastern Ltd.
9. P.B. Bhattacharya, S.K. Jain & S.R. Nagpaul, : ***Basic Abstract Algebra***, Cambridge, 1986.

Course Title: Mathematical Analysis I **Full Marks:** 75
Course No.: MATH 322 (Major/Minor) **Pass Marks:** 35%
Nature of the Course: Theory (Compulsory) **Year:** II

Unit 1. **Basic Concepts:** Elementary logic, sets and sets operations, relation and functions, one-to-one and onto mappings, one-to-one correspondence, cordinality of a set. **6 hrs.**

Unit 2. **Real Numbers System:** Field axioms, order axioms, bounded and unbounded sets, supermum and infimum completeness axioms, Archemedean property, extended real number systems, countable and uncountable sets. **10 hrs.**

Unit 3. **Points Set Topology of the Real Line:** Neighbourhood, interior points and limit points of a set, open and closed sets and their properties, Bolzano – Weierstrass theorem, closure of a set, dense and derived sets, real line as a topological space. **10 hrs.**

Unit 4. **Sequences of Real Numbers:** Sequences and subsequences, convergent sequences, Bolzano – Weierstrss theorem for sequence, Cauchy sequence, convergence criteria, operations of convergent sequences, Monotonic sequences and convergences, nested intervals theorem. **10 hrs.**

Unit 5. **Series of Real Numbers:** Series and sequence, convergence and divergence, Cauchy's criteria for convergence, different tests for convergence, alternating series, absolute and conditional convergences. **8 hrs.**

Unit 6. **Limit and Continuity:** Limit, left hand and right hand limits, properties of limits, intermediate value theorem, continuity of functions discontinuities, fonctions continuous on closed intervals, continuity and inverse images of open and closed sets, uniform continuity. **12 hrs.**

Unit 7. **Differentiations:** Derivative of a real-valued functions of a single variable, differentiability at a point and in an interval, differentiability and continuity, monotonic functions, Rolle's theorem, Lagrange's mean value theorem, Cauchy's mean value theorem and their geometric interpretations, higher order derivatives, Taylor's theorem, Maclaurin's Theorem and their infinite series forms, applications of Taylor's theorem in extreme values problems and in indeterminate forms, proof of L'Hospital rule. **12 hrs.**

Unit 8. **Riemann Integration:** Partition and refinement of partitions, upper and lower integrals, Riemann integrable functions and Riemann integrals, conditions of integrability, properties of Riemann integrals. **10 hrs.**

Unit 9. **Fundamental Theorems of Integral Calculus:** Primitives, fundamental theorem of calculus, first mean value theorem, generalized first mean value theorem, integration by parts, change of variable in an interval, second mean value theorem. **12 hrs.**

Books Suggested:

1. S.C. Malik & Savita Arora, : ***Mathematical Analysis (Second Edition)***, Wiley Eastern Limited.
2. R.M. Shrestha, : ***Mathematical Analysis***, Sukunda Pustak Bhandar, Kathmandu.
3. Shanti Narayan, : ***Mathematical Analysis***, S. Chand and Co., New Delhi.

Course Title: Mathematical Analysis II **Full Marks:** 75
Course No.: MATH 331 (Major/Minor) **Pass Marks:** 35%
Nature of the Course: Theory (Compulsory) **Year:** III

Unit 1. **Infinite Series and Infinite Products:** Sequence of real numbers, limit superior, limit inferior, infinite series, inserting and removing parenthesis, Rearrangement of series, Riemann's theorem on conditional convergent series, subseries, double sequences, double series and rearrangement theorem for it, sufficient condition for iterated series, multiplication of series and Merten's theorem. **15 hrs.**

Unit 2. **Sequences and Series of Functions:** Pointwise convergence, uniform convergence, Cauchy condition for uniform convergence, Tests for uniform convergence, uniform convergence and continuity, uniform convergence and Riemann integration, uniform convergence and differentiation, power series, multiplication of power series, Taylor's series generated by functions. **12 hrs.**

Unit 3. **Improper Integrals:** Convergence, Divergence, Application of fundamental theorem of calculus, simple properties, conditions and tests for convergence, absolute convergence, Abel's test and Dirichlet's test. **10 hrs.**

Unit 4. **Point Set Topology:** Euclidean space R^n. Open balls and open sets in R^n, Closed sets and adherent points, Bolozono-Weierstrass theorem, Cantor intersection theorem, Metric spaces, point set topology in metric spaces. **11 hrs.**

Unit 5. **Compactness:** Lindel of covering theorem, Heine-Borel covering theorem, compactness in R^n, compact subsets of a metric space **8 hrs.**

Unit 6. **Limits and Continuity:** Convergent sequence in a metric space, Cauchy sequences, complete metric space, Limit of a function, continuous functions, continuity of composite functions, continuity and inverse images of open or close sets, functions continuous on compact sets, topological mappings (homomorphism), Bolzano's theorem and intermediate value theorem, uniform continuity, uniform continuity and compact sets. **12 hrs.**

Unit 7. **Multivariable Differential Calculus:** Directional derivatives, directional derivative and continuity, total derivative, total derivative expressed in terms of partial derivatives, Matrix of linear function, Jacobian Matrix, Chain rule and its matrix form, mean value theorems, sufficient conditions for differentiability and for equality of mixed partial derivatives, Taylor's formula for functions for R^n to R^1. **12 hrs.**

Unit 8. **Functions of Bounded Variation:** Properties of monotinic functions, functions of bounded variation, total variation, its additive property, total variation on {a, x} as function of x, function of bounded variation expressed as the difference of increasing functions, continuous functions of bounded variation. **12 hrs.**

Unit 9. **Riemann-Stieltjes Integration:** Riemann- Stieltjes integrals, Linear properties, integration by parts, change of variables, reduction to a Riemann integral, step – functions as integrators, reduction to a finite

sum, increasing integrators, upper and lower integrals, Riemann's condition, comparison theorems, integrators of bounded variation. **11 hrs.**

Unit 10. Riemann – Stieltjes Integration (Continued): Necessary and sufficient conditions for existence of Riemann – Stieltjes integrals, mean value theorem, integral as a function of the interval, second fundamental theorem, second mean value theorem, Riemann – Stieltjes integrals depending on a parameter, differentiation under the integral sign, interchanging the order of integrations. **12 hrs.**

Books Suggested:

1. Apostal M. : ***Mathematical Analysis***, Addison, Wesly Naroso Publishing House.
2. Robert G. Bartle, : ***The Elements of Real Analysis***, John Wiley and Sons.
3. David V. Widder, : ***Advanced Calculus***, Prentice Hall.

Course Title: Advanced Calculus **Full Marks:** 75
Course No.: MATH 332 **Pass Marks:** 35%
Nature of the Course: Theory (Compulsory) **Year:** III

Unit 1. **Curves in Space:** Tangent line, principle normal and binormal at a point on a space curve, osculating plane, Normal plane and rectifying plane at a point on a curve, Torsion, Curvature, Radius of curvature, Serrect-Frenet formula, circle of curvature, Properties of locus of center of curvature. **15 hrs.**

Unit 2. **Exact Differential Equations:** Exact differential equations, condition for exactness, integration of an exact equation, equations of the form $y^{(n)} = f(x)$, solutions of equations not containing x or y directly and of equations containing x or y in derivatives.**12 hrs.**

Unit 3. **Second Order Linear Differential Equations:** Solutions of homogeneous and non-homogeneous equations, transformations of equations by removing first derivative, by changing dependent variable and independent variable and method of variation of parameter. **12 hrs.**

Unit 4. **Simultaneous and Total Differential Equations:** Simultaneous equations of the first order and of the first degree, simultaneous equations of second order and of first degree, single integrable differential equations, condition of integrability, single non-integrable differential equations. **12 hrs.**

Unit 5. **Partial Differential Equations of First Order:** Singular integral, general integral, integral of linear equations, Lagrange's solutions, solution of equations of four standard forms, Charpit's method. **10 hrs.**

Unit 6. **Partial Differential Equations of Second Order:** Homogeneous and non-homogeneous equations with constant coefficients, Monge's equations. **10 hrs.**

Unit 7. **Vector Integration:** Line, Surface and Volume integrals. **10 hrs.**

Unit 8. **Integral Transformation Theory:** Green's theorem in the plane, Gauss's divergence theorem and Stoke's theorem. **10 hrs.**

Unit 9. **Functions of Complex Variable:** Limit and continuity, Derivatives and differentials, Cauchy-Riemann equations, necessary and sufficient conditions, analytic functions, harmonic functions.**12 hrs.**

Unit 10. **Fourier Series:** Trgonometric series, Fourier series, Fundamental theorem, Fourier-cosine and sine-series, Uniqueness theorem, Fourier series of orthogonal functions, convergence of Fourier series. **12 hrs.**

Books Suggested:

1. weatherbern, : ***Differential Geometry***.
2. Murray, Daniel A., : ***Differential Equations***.
3. Churchill and Brown, : ***Complex Variable and its Applications***.
4. G.D. Pant and G.S. Shrestha, : ***Integral Calculus and Differential Equations***.
5. M.B. Singh and B.C. Bajracharya, : ***Text Book of Vector Analysis***.
6. L. Prasad: ***Vector analysis***.
7. Badri Luxmi Baidya,: ***Vector Analysis***.
8. Apostal, T.M., : ***Mathematical Analysis***.

Course Title: Algebra II **Full Marks:** 75
Course No.: MATH 333 **Pass Marks:** 35%
Nature of the Course: Theory (Compulsory) **Year:** III

Unit 1. **Vector Spaces and Linear Maps:** Vector spaces and subspaces, basis, dimension, sum and direct sum, linear maps, dimensions of kernel and image. **10 hrs.**

Unit 2. **Matrices and Linear Maps:** Matrix algebra (general treatment), matrix as a linear map, representation of a linear map by matrix, effect of change of basis on matrix representation and coordinates of vector. **8 hrs.**

Unit 3. **Scalar Products on Vector Spaces:** Scalar and Hermitian products, positive difiniteness, orthogonality, Schwarz and Bessel inequalities, Gram-Schmidt orthogonalization, orthogonal complement, applications to linear equations, bilinear maps and matrices, general orthogonal basis, the dual spaces. **15 hrs.**

Unit 4. **Bilinear Forms and Standard Operators:** Bilinear forms, Quadratic forms; symmetric, Hermitian and unitary operators, Sylvester's theorem. **12 hrs.**

Unit 5. **Polynomials and Matrices:** Polynomials of matrices and linear maps, Eigen vector and Eigen values, Characteristic polynomial, Minimal polynomial, Decomposition of a vector space w.r.t. a linear map, Jordan normal form (no proof). **12 hrs.**

Unit 6. **Triangulation of Matrices and Linear Maps:** Existence of triangulation, Hamilton-Cayley theorem, diagonalisation of unitary maps. **8 hrs.**

Unit 7. **Groups:** Review of groups, subgroups, quotient groups and homomorphisms, homomorphism theorems, automorphisms and inner automorphism, permutation groups, representation of groups by matrices, Cayley's theorem, conjugacy and conjugate classes, normalizer and centralizer, class equations and applications, Cauchy's theorem, external and internal direct products, Sylow's theorems (no proof). **20 hrs.**

Unit 8. **Rings:** Rings, ideal, homomorphisms, the field of quotient of an integral domain, Divisors and greatest common divisors, prime elements, units, Euclidean rings, unique factorization theorem, Gaussian integers, polynomial rings, polynomical over rational fields. **15 hrs.**

Unit 9. **Fields:** Finite and Infinite fields, field extensions, finite and algebraic extensions, Roots of polynomial, splitting fields, uniqueness (no proof), derivative and multiple roots. **15 hrs.**

Books Suggested:

1. I.N. Herstein, : ***Topic in Algebra***, Vikash Publication.
2. S. Lang, : ***Linear Algebra***, Addision- Wesley Publication.
3. N.S. Gopal Krishnan, : ***University Algebra***, Orient Longman.
4. K. Hoffman and R. Kunz, : ***Linear Algebra***, Prentice Hall.
5. P.B. Bhattacharya et all, : ***First Course in Linear Algebra***, Wiley Eastern.

Course Title: Mechanics **Full Marks:** 75
Course No.: MATH 334 **Pass Marks:** 35%
Nature of the Course: Theory (Optional) **Year:** III

Unit 1. **Coplanar Forces:** Resultant of coplanar forces, Equation to the resultant, Equivalent force and couple, General condition of equilibrium. **15 hrs.**

Unit 2. **Virtual Work:** Work done by the resultant, Virtual displacement, Virtual work, Principles of virtual work for a system of coplanar forces acting on a particle and for a system coplanar forces acting at different point of a rigid body (without proof). **15 hrs.**

Unit 3. **Catenary:** Definition, equation of the common catenary in the intrinsic and Cartesion forms, properties of common catenery, approximations to the common catenary, sag of a tightly stretched wire. **15 hrs.**

Unit 4. **Center of Gravity:** Center of mass, Center of gravity, Center of gravity by integration, Center of gravity of an arc, Center of gravity of a plane area, Center of gravity of a solid of revolution, Center of gravity of a surface of revolution, Center of gravity of the sum or difference of two bodies. **15 hrs.**

Dynamics:

Unit 5. **Rectilinear Motion:** Simple harmonic motion, motion under inverse square law, motion under laws of force. **10 hrs.**

Unit 6. **Kinematics in Two Dimensions:** Motion in plane-velocity and acceleration, radial and transverse components of velocity and acceleration, angular velocity and acceleration, tangential and normal components of acceleration. **15 hrs.**

Unit 7. **Constrained Motion:** Conical pendulum, motion on a smooth curve in a vertical plane (circle and cycloid). **10 hrs.**

Unit 8. **Central Orbits:** Motion of a particle in a plane with an acceleration which is always directed to a fixed point in the plane and applications. **10 hrs.**

Unit 9. **Moments and Products of Inertia:** Definition, motion of inertia in some simple case, theorem of parallel axis, moments of inertia about any axis, momental ellipsoid. **10 hrs.**

Books Suggested:

1. R.S. Verma, : ***Text Book on Statics***, Pothishala, Pvt. Ltd., Allhabad.
2. M.Ray, : ***Text Book on Dynamics***, S. Chand and Co., Delhi.

Course Title: Linear Programming **Full Marks:** 75
Course No.: MATH 335 **Pass Marks:** 35%
Nature of the Course: Theory (Optional) **Year:** III

Unit 1. **Linear Programming (LP):** Introduction to linear programming, problems, examples, mathematical formulation of L.P/, applications and limitations of L.P.**6 hrs.**

Unit 2. **Geometry in R^n and Graphic Solution of L.P.:** Vectors in n-space, n-dimensional Euclidean space, vector inequalities, hyper –plane, half –spaces, line and line segment, half –line, convex combination, extreme point of convex set, convex hull of a set, convex polytope, convex polyhedron, statement of fundamental theorem of L.P.P., solution of L.P. by graphical method. **10 hrs.**

Unit 3. **Simplex Method:** General linear programming problem, slack and surplus variables, standard form of L.P.P., basic solutions, basic feasible solutions, optimal basic feasible solution of L.P.P., characteristics solutions of L.P.P., relation between extreme points of the set of feasible solutions and basic feasible solutions of L.P.P. (including proofs), fundamental theorem of standard L.P.P., fundamental properties of solutions to an L.P.P. (without proofs), optimality criterion (without proofs), simplex tableau, computational procedure of the simplex method for L.P.P., artificial variable technique, method of penalties (Big M method), two phase method and degeneracy. **17 hrs.**

Unit 4. **Duality Problems:** Duality in L.P.P, Symmetric and unsymmetric primal dual problems, Algorithm for

primal dual construction, Fundamental theorems of duality and complementary slackness theorem, Reading solutions to the dual from the simplex table and conversely. **13 hrs.**

Unit 5. **Transportation Problems:** Introduction, examples of transportation problem (T.P.), matrix form of T.P., transportation table, methods of obtaining a first feasible solution (north west corner rule, lowest cost entry and Vogel's approximation method), Modi-method (u-v method) of solving T.P., degeneracy in the T.P., unblanced transportation problems. **13 hrs.**

Unit 6. **Assignment Problems and Routine Problems:** Introduction, need and utility, solution of assignment problems, unablanced assignment problem, travelling-salesman (routine) problem and its solution. **10 hrs.**

Unit 7. **Sequencing Problem (S.P.):** Introduction, scope and significance of S.P., problems with n jobs and 2 machines, problem with n jobs and 3 machines, problem with n jobs and m machines, optimal sequencing algorithm, graphical solution of S.P.**10 hrs.**

Unit 8. **Game Theory:** Basic concept of game theory, zero sum and non-zero sum game, two persons zero sum games, minimax and maximin criterion, a two persons -zero –sum game with mixed strategies, dominated strategies and principle of dominiance graphical method for the solution of $(2\times n)$ and $(m\times 2)$ games, transformation of a rectangular matrix game into a linear programming problem. **13 hrs.**

Unit 9. **Non-linear Programming Problem:** Introduction, Multivariable optimization-without constraints, with equality constraints and inequality constraints (upto three and two constraints), criterion for extremum using Hessian metrix, using Hessian matrix, solution by the methods of Lagrange's multipliers, Kuhn-Tucker conditions, Graphical solution method. **10 hrs.**

Unit 10. **Difference Equations:** Finite difference, difference formula, Difference table shift operator E, relation between operator E and difference operator, factorial function, anti- difference, different equations, various types of linear difference equations, homogeneous linear difference equations with constant coefficient, solution of linear first order difference equations and linear second order difference equation with constant coefficients, particular solutions to non-homogeneous linear difference equations (method of undetermined coefficient and operators method). **13 hrs.**

Books Suggested:

1. P.K. Gupta and Man Mohan : ***Linear Programming and Game Theory***, Sultan Chand and Sons (Revised Edition).
2. G. Hadley : ***Linear Programming***, Narosa Publishing House.
3. M. Upadhyaya: ***Linear Programming***. Sukunda Publication, Kathmandu.
4. P.K. Gupta, Man Mohan and Kanti Sworup: ***Operational Research***, Sultan Chand and Sons, Revised and Enlarged Edition.
5. Tana, Hamby, A. : ***Operational Research***.
6. H.C. Saxena: ***Finite Difference Calculus & Numerical Analysis***, S. Chand.

Course Title: Mathematical Statistics **Full Marks:** 75
Course No.: MATH 336 **Pass Marks:** 35%
Nature of the Course: Theory (Optional) **Year:** III

(*Those student who have offered statistics in 1st and 2nd year will not be permitted to take up this course.)

Unit 1. **Presentation of Data:** Tables and diagrams, construction of tables with one or more classifications, diagrammatic representations (various type of graphs), graphical representation of frequency distribution, cumulative frequency distribution and time, categorization of data. **7 hrs.**

Unit 2. **Measures of Location and Central Tendency:** Measures of location, central tendency, dispersion moments, skewness and kurtosis for grouped and ungrouped data, Shiphard's correction for grouped data, scatter diagram. **8 hrs.**

Unit 3. **Regression and Correlation:** Concepts of regression, linear regression and its properties, error in regression, properties of residuals, principles of least-squares ($1^{st} - 3^{rd}$ degree and exponential curves), correlation-definition and properties, rank correlation and skewness correlation formulae, intra-class correlation coefficient and various correlation coefficients. **20 hrs.**

Unit 4. **Probability and Types of Probability:** Definition and properties, classical and relative approach to probability; Van Mises, Cramer and Kologorov approaches, merits and demerits of each of the approaches, types of probability, space, trial and sample, events and their types, conditional probability

and its properties, geometric probability, Baye's theorem and its application. **20 hrs.**

Unit 5. Random Variables: Variables and continuous variables, properties of each type of variables with illustrations, Mgf and Pgf, cumulative distribution function of random variable, mathematical expectation, expectation of random variables and its properties, measures of location, measures of dispersion moment, skewness and kurtosis. **20 hrs.**

Unit 6. Probability Distributions: Standard univariate distribution and its properties, truncated distribution, Descrete distribution. introduction, Binomial distribution, Poisson distribution, Hypergeometric and geometric distributions, Negative binomial distribution. Cauchy, Laplace (Gauss distribution) Gamma and Betadistributions, comparative analysis of all distributions and their significance. **20 hrs.**

Unit 7. Sampling Distribution: Introduction, small sampling and large sampling and their properties, Students t-distribution, F-distribution, hypothesis testing, estimation and confidence intervals, analysis of variances. **20 hrs.**

Books Suggested:

1. Mendenhak, Scheaffer and Wackerly : Mathematical Statistics with Applications, Duxbury, Boston, U.S.A.
2. Kapoor and Saxena : Introduction to Mathematical Statistics.
3. Hridaya B. Shrestha : Elementary Statistical Methods, Orient Longman Ltd. 1989.
4. William Feller : Theory of Probability Vol I, John-Wiley @ Aous-Inc. 1968.

Course Title: Numerical Analysis and Computer Programming **Full Marks:** 75
Course No.: MATH 337 **Pass Marks:** 35%
Nature of the Course: Theory (Optional) **Year:** III

Unit 1. **Introduction to Computers:** Background, history, generation of computers, type of computers and its architecture, application areas and scope, micro-computers and important terminology, algorithms, definition, characteristics and examples, psuedocode, flowcharts, programs, execution process, low-level and high-level languages, description and examples, compliers, Operation system description and examples, binary representation and arithmetic, basic DOS commands. **15 hrs.**

Unit 2. **Programming in Fortran M. :** Introduction, Syntax (complete) for constant, variable type, floating point variable, I/O statements, assignment statement and Control statements, structure of program structures array etc., arithmetic library function, sub-programs, function and subroutines, writing small programs, Bugs, Syntax and logical errors, Run-time errors, characteristic of a good and efficient program, documentation of programs. **25 hrs.**

Unit 3. **Algebraic and Transcendental Equation:** Introduction, concept of numerical solution and its importance, tabulation methods, graphical methods, bisection method, fixed point iteration methods, Newton Ralphson method, Graeffs method (root square), rate of convergence of all iteration methods, formal programmalute algorithms, solution of

algebraic/transcendental equations by different methods. **15 hrs.**

Unit 4. **Solution of Algebraic Simultaneous Equations:** Introduction, direct methods of special matrices, Gauss elimination, Gauss-Seidel and Gauss-Jacobi methods, formal algorithms of each of the methods, comparison of all three methods w.r.t. efficiency of rate of convergence. **15 hrs.**

Unit 5. **Interpolation and Approximation:** Basic concepts, general form, Newton's interpolation formulae, difference tables, Lagrange's method of error estimation etc., interpolation of equally spaced prints, backward, forward and central differences, Newton's formulae, Sterling's central differences formulae, formal algorithms. **15 hrs.**

Unit 6. **Numerical Differentiation:** Introduction, techniques of numerical differentiation based on undetermined coefficients, finite-difference operations and interpolation, formal algorithm. **10 hrs.**

Unit 7. **Numerical Integration:** Basic concepts and significance, Quatrature formula, Simpson's rule, Newton's formula (interpolation), formal algorithms. **10 hrs.**

Unit 8. **Numerical Solution of O.D.E.:** Taylor's series method, Euler's method, Richardson interpolation method, Range Kutte (2^{nd} and 4^{th}) order methods, formal algorithms of each of them. **10 hrs.**

Books Suggested:

1. Searbrough: Numerical Analysis, IBH Publication.
2. Raja Raman: Programming in FORTRAN 77.