B.A./B.Sc. Part I Mathematics

(For the Examination of 2012 and after)

Paper I: Algebra

Unit I

Equivalence relations and partitions, Congruence modulo n, Definition of a group with examples and simple properties, Subgroup, Generators of a group, Cyclic groups, Coset decomposition, Lagrange's theorem and its consequences, Fermat and Euler theorem, Normal subgroups, Quotient groups.

Unit II

Homomorphism and Isomorphism, fundamental theorem of homomorphism, isomorphism theorems, Permutation groups, Even and odd permutations, The alternating groups A_n, Cayley's theorem, direct product,

Unit III

Rings, Subrings, Integral domains and fields, Characteristic of a ring, Ideal and quotient rings, Ring homomorphism, Field of quotient of an integral domain.

Unit IV

Vector spaces, subspaces, linear independence and dependence, basis and dimension, coordinates, computation concerning subspaces.

Paper II: Calculus

Unit I

ε - δ Definition of the limit and continuity, classification of discontinuities, Differentiability, Chain rule, Successive differentiation, Leibnitz theorem, Rolle's theorem, Lagrange and Cauchy Mean value theorems, Maclaurin and Taylor series, Indeterminate forms.

Unit II

Partial differentiation, Change of variables, Euler's theorem on homogeneous functions, Tangents and Normals, Asymptotes.

Unit III

Curvature, Envelops and evolutes, tests for concavity and convexity, points of inexion, multiple points, tracing for curves in simple cartesian and polar curves.

Unit IV

Definite integrals as limit of the sum, Reduction Formulae, quadrature, rectification, volumes and surfaces of solid of revolution, Pappus theorem.

Paper III: Matrices, Vectors & Differential Equations

Unit I
Type of Matrices, Elementary operation on matrices, Inverse of a matrix by elementary operations, rank of a matrix, Echelon and normal form, Eigen values, eigenvectors and characteristic equation of a matrix, Cayley-Hamilton theorem and its use in finding inverse of a matrix, system of linear homogeneous and non homogeneous equations, theorems on consistency of a system of linear equations.

Unit II
Vector Differentiation, Gradient, Divergence and Curl, Vector Integration, Theorems of Gauss, Green, Stokes and related problems.

Unit III
Formation of a differential equation, geometrical meaning of a differential equation, Equation of first order and first degree, Equations in which the variables are separable, Homogeneous equation, Linear equations Exact differential equations and equations reducible to the exact form, First order higher degree equations solvable for x, y, p.

Unit IV
Clairaut's equation and singular solutions, orthogonal trajectories, linear differential equation with constant coefficients, homogeneous linear differential equations.

Paper IV: Geometry & Trigonometry

Unit I
General equation of second degree, systems of conics, tracing of conics, confocal conics, polar equation of conics and its properties.

Unit II
3-dimensional coordinates, projection and direction cosines. Plane and straight line in three dimensions, Sphere, Cone, Cylinder

Unit III
Central conicoids, paraboloids, plane section of conicoid, generating lines, confocal conicoids, reduction of second degree equations.

Unit IV
Complex functions and separation into real and imaginary parts, Exponential, direct and inverse trigonometric and hyperbolic functions, logarithmic function, Gregory’s series, Summation of series.

B.A./B.Sc. Part II Mathematics

(For the Examination of 2013 and after)

Paper I: Advanced Calculus

Unit I

Continuity, Sequential Continuity, properties of continuous functions, Uniform continuity, chain rule of differentiability, Mean value theorems and their geometrical interpretations, Darboux's intermediate value theorem for derivatives, Taylor's theorem with various forms of remainders.

Unit II

Limit and Continuity of functions of two variables, Taylor's theorem for functions of two variables, Envelops, Evolutes, Maxima and minima for function of two variables, Lagrange multiplier method, Jacobians.

Unit III

Beta and Gamma functions, Double and triple integrals, Dirichlet integral, change of order of integration in double integrals.

Unit IV

Improper integrals, convergence of $\int_a^\infty f(x)dx$, Comparison test, Convergence of $\int_a^\infty \frac{dx}{x^n}$, a > 0, Abel's test, Dirichlet's test, Convergence of $\int_a^\infty \frac{dx}{(x-a)^n}$, examples, Convergence of beta and gamma functions.

Paper II: Mathematical Methods

Unit I

Definition of a sequence, Theorems on limits of sequences, Bounded and Monotonic sequences, Cauchy's convergence criterion, Cauchy sequence, limit superior and limit inferior of a sequence, subsequence, Series of non-negative terms, Comparison tests, Cauchy's integral test, Ratio tests, Root test, Raabe's logarithmic, de Morgan and Bertrand's tests, Alternating series, Leibnitz's theorem, Absolute and conditional convergence.

Unit II

The concept of transform, Integral transform, Kernel, Laplace Transformation- Linearity of the Laplace transformation, Existence theorem for Laplace transforms, Laplace transforms of derivatives and integrals, Shifting theorems, Differentiation and Integration of Laplace transforms, Convolution theorem, Inverse Laplace transforms, Solution of

system of differential equations using the Laplace transformation. Fourier transforms (finite and infinite), Fourier integral, Applications of Fourier transform to boundary value problems, Fourier series.

Unit III
Calculus of variations-Variational problems with fixed boundaries- Euler's equation for functionals containing first order derivative and one independent variable, Extremals, Functionals dependent on higher order derivatives, Functionals dependent on more than one independent variable, Variational problems in parametric form, Invariance of Euler's equation under coordinates transformation.

Unit IV
Partial differential equations of the first order, Lagrange's solution, Some special types of equations which can solve easily by methods other than the general methods, Charpit's general method of solution, Partial differential equations of the second and higher orders, Classification of linear partial differential equations of second order, Homogeneous and non-homogeneous equations with constant coefficients, Partial differential equations reducible to equations with constant coefficients, Monge's method.

Paper III: Differential Equations

Unit I
Second order linear equations, general solution of homogeneous equation, use of known solution to find another, homogeneous equation with constant coefficients, method of undetermined coefficient, variation of parameters.

Unit II
Series solutions of differential equations, Power series method, Bessel, Legendre and hypergeometric equations, Bessel, Legendre and hypergeometric functions and their properties, convergence, recurrence and generating relations.

Unit III
Orthogonality of functions, Sturm Liouville Problem, Orthogonality of eigen functions, Reality of eigenvalues, Orthogonality of Bessel functions and Legendre polynomials, Oscillation theory and boundary value problems, Qualitative properties of solutions, Sturm-comparison theorem, regular Sturm- Liouville problem, examples.

Unit IV
Linear systems, Homogeneous linear system with constant coeficient, Volterra Prey-Predator equations, Non-linear equations, Autonomous system, critical points, stability of linear system, Liapunov direct method, Simple critical points of non linear systems. Recommended Text: GF Simmons: Differential Equations, Tata-McGraw Hill Company

Paper IV: Mechanics

Unit I

Basic concepts, Newton's Laws of motion, frame of reference, work energy principle, Forces in three dimensions, Poinsot's central axis, Wrenches, Null lines and planes.

Unit II

Virtual work, Stable and Unstable equilibrium, Catenary, Catenary of uniform strength, centre of gravity.

Unit III

Velocities and accelerations along radial and transverse directions, and along tangential and normal directions, Simple Harmonic motion, Motion under other law of forces. Elastic strings, Motion in resisting medium, Constrained motion, Motion on smooth and rough plane curves.

Unit IV

Motion of particles of varying mass, Rocket motion, Central orbit, Kepler's laws of motion,, Motion of particle in three dimensions, Rotating frame of reference, Rotating Earth, Acceleration in terms of different coordinates systems.

B.A./B.Sc. Part III Mathematics

(For the Examination of 2014 and after)

Paper I: Analysis

Unit I

Definition and examples of metric spaces, Neighbourhoods, Interior points, Limit points, Open and closed sets, Subspaces, Convergent and Cauchy sequences, Completeness, Cantor's intersection theorem.

Riemann integral, Integrability of continuous and monotonic functions, Fundamental theorem of integral calculus, Mean value theorems of integral calculus, Improper integrals and their convergence, Comparison test, μ-test, Abel's test, Dirichlet's test, Integral as a function of a parameter and its differentiability and integrability.

Unit II

Series of arbitrary terms, Convergence divergence and oscillation, Uniform convergence of sequences and series of functions, Uniform convergence and continuity, Uniform convergence and integration, Uniform convergence and differentiation, Power series, Partial derivation and differentiability of real valued functions of two variables, Schwarz and Young's theorem, Implicit function theorem, Fourier series, Fourier expansion of piece wise monotonic functions.

Unit III

Complex numbers as ordered pairs, geometric representation of complex numbers, Stereographic projection, Continuity and Differentiability of complex functions, Analytic functions, Cauchy Riemann equations, Harmonic functions, complex integration, Cauchy-Goursat theorem, Cauchy's Integral formula, Formulae for first, second and nth derivatives, Cauchy's Inequality, Maximum Moduli theorem, Liouville's Theorem, Elementary functions, Mapping by elementary functions.

Unit IV

Series, Taylor and Laurent Series, Absolute and uniform convergence of Power series, Residues and Poles, Residue theorem, Zeros and Poles of order m, Evaluation of improper real integrals, Improper Integrals and definite integrals involving sines and cosines, conformal mapping, Analytic continuation.

Paper II: Abstract Algebra

Unit I

Automorphism, inner automorphism, automorphism groups and their computations. Conjugacy relations, Normaliser, Counting principle and the class equation of a finite group, Center of group of prime power order, Sylow's theorems, Sylow p-subgroup.

Unit II
Prime and maximal ideals, Euclidean Rings, Principal ideal rings, Polynomial Rings, Polynomial over the Rational Field, The Eisenstein Criterion, Polynomial Rings over Commutative Rings, unique factorization domain, R is unique factorization domain implies so is $R[x_1, x_2, \ldots, x_n]$.

Unit III
Direct sum, Quotient space, Linear transformations and their representation as matrices, The Algebra of linear transformations, rank nullity theorem, change of basis, linear functional, Dual space, Bidual space and natural isomorphism, transpose of a linear transformation, Characteristic values, annihilating polynomials, diagonalisation, Cayley Hamilton Theorem, Invariant subspaces, Primary decomposition theorem.

Unit IV
Inner product spaces, Cauchy-Schwarz inequality, orthogonal vectors, Orthogonal complements, Orthonormal sets and bases, Bessel's inequality for finite dimensional spaces, Gram-Schmidt orthogonalization process, Bilinear, Quadratic and Hermitian forms.

Paper III: Numerical Analysis & Programming in C

Unit I
Solution of equations: bisection, Secant, Regula Falsi, Newton Raphson's method, Roots of polynomials. Interpolation, Lagrange and Hermite interpolation, Divided differences, Difference schemes, Interpolation formula using differences, Numerical differentiation.

Unit II
Numerical Quadrature: Newton Cotes Formulas, Gauss Quadrature Formulas, Chebyehev's Formulas, Linear equations: Direct method for solving systems of linear equations (Gauss elimination, LU Decomposition, Cholesky Decomposition), Iterative methods (Jacobi, Gauss Seidel, Relaxation methods). The Algebraic Eigenvalue problem: Jacobi's method, Givens method' Householder's method, Power method, QR method, Lanczos' method.

Unit III
Numerical solution of Ordinary differential equations: Euler method, single step methods, Runge-Kutta method, Multi-step methods, Milne-Simpson method, Methods based on Numerical integration, Methods based on numerical differentiation, boundary value problems, Eigenvalue problems. Approximation: Different types of approximation, Least square polynomial approximation, Polynomial approximation using Orthogonal Polynomials, Approximation with Trigonometrical functions, Exponential functions, Chebychev Polynomials, Rational Functions.

Unit IV

Programming in C

Programmer's model of computer, Algorithms, Data type, Arithmetic and input/out instruction, Decisions, Control structures, Decision statements, Logical and conditional operators, Loop case control structures, Functions, Recursion, Preprocessors, Arrays, Puppetting of strings Structures, Pointers, File formatting.

OPTIONAL PAPERS

Any one of the following papers

Paper IV(*a*): Number theory & Cryptography

Unit I

Divisibility: gcd, lcm, prime numbers, fundamental theorem of arithmetic, perfect numbers, floor and ceiling functions, Congruence : properties, complete and reduced residue systems, Fermat's theorem, Euler functions, Chinese remainder theorem.

Primality testing and factorization algorithms, Pseudo-primes, Fermat's pseudo-primes, Pollard's rho method for factorization.

Unit II

Introduction to cryptography : Attacks, services and mechanisms, Security services, Conventional encryption - Classical techniques : Model, Stegnanography, Classical encryption technique, Modern techniques : DES, cryptanalysis, block cipher principles and design, Key distribution problem, Random number generation.

Unit III

Hash functions, Public key cryptography, Diffie-Hellmann key exchange, Discrete logarithm-based crypto-systems, RSA crypto-system, Signature schemes, Digital signature standard (DSA), RSA signature schemes, Knapsack problem.

Unit IV

Elliptic curve cryptography: Introduction to elliptic curves, Group structure, Rational points on elliptic curves, Elliptic curve cryptography, Applications in cryptography and factorization, Known attacks.

Paper IV(*b*) : Linear Programming

Unit I

Linear programming problems, Statement and formation of general linear programming problems, Graphical method, Slack, and surplus variables, Standard and matrix forms of

linear programming problem, Basic feasible solution.

Unit II

Convex sets, Fundamental theorem of linear programming, Simplex method, Artificial variables, Big-*M* method, Two phase method.

Unit III

Resolution of degeneracy, Revised simplex method, Sensitivity Analysis.

Unit IV

Duality in linear programming problems, Dual simplex method, Primal-dual method Integer programming, Transportation problems, Assignment problems.

Paper IV(*c*): Differential Geometry & Tensor Analysis

Unit I

Local theory of curves- Space curves, Examples, Plane curves, tangent and normal and binormal, Osculating plane, normal plane and rectifying plane, Helices, Serret-Frenet apparatus, contact between curve and surfaces, tangent surfaces, involutes and evolutes of curves, Intrinsic equations, fundamental existence theorem for space curves, Local theory of surfaces- Parametric patches on surface curve of a surface, surfaces of revolutions, Helicoids, metric-first fundamental form and arc length.

Unit II

Local theory of surfaces (Contd.), Direction coefficients, families of curves, intrinsic properties, geodesics, canonical geodesic equations, normal properties of geodesics, geodesics curvature, geodesics polars, Gauss-Bonnet theorem, Gaussian curvature, normal curvature, Meusneir's theorem, mean curvature, Gaussian curvature, umbilic points, lines of curvature, Rodrigue's formula, Euler's theorem.

The fundamental equation of surface theory – The equation of Gauss, the equation of Weingarten, the Mainardi-Codazzi equation,

Unit III

Tensor algebra : Vector spaces, the dual spaces, tensor product of vector spaces, transformation formulae, contraction, special tensor, inner product, associated tensor.

Tensor Analysis: Contravariant and covariant vectors and tensors, Mixed tensors, Symmetric and skew-symmetric tensors, Algebra of tensors, Contraction and inner product, Quotient theorem, Reciprocal tensors, Christoffel's symbols, Covariant differentiation, Gradient, divergence and curl in tensor notation.

Unit IV

Differential Manifold-examples, tangent vectors, connexions, covariant differentiation. Elements of general Riemannian geometry-Riemannian metric, the fundamental theorem of local Riemannian Geometry, Differential parameters, curvature tensor, Geodesics, geodesics curvature, geometrical interpretation of the curvature tensor and special Riemannian spaces.

Paper IV(*d*) : Principles of Computer Science

Unit I

Data Storage

Storage of bits, main memory, mass storage, Information of storage, The binary system, Storing integers, storing fractions, communication errors.

Data Manipulations

The central processing unit, The stored program concept, Programme execution, Other Architectures, arithmetic/logic instructions, Computer – peripheral communication.

Unit II

Operating System and Network – The evolution of operating system, Operating system architecture, Coordinating the machine's activates, Handling competition among process, networks, network protocol.

Unit III

Algorithms - The concept of an algorithm, Algorithm representation, Algorithm, Discovery, Iterative structure, Recursive structures, Efficiency and correctness, (algorithm to be implemented in C++).

Unit IV

Programming Languages - Historical perspective, Traditional programming Concepts, Program units, Languages implementation, Parallel computing, Declarative computing.

Software Engineering - The software engineering discipline, The software life cycle, Modularity, Development, Tools and techniques, Documentation, Software ownership and liability. **Data Structures -** Array, Lists, Stack, Queues, Trees, Customised data types, Object-oriented.

Paper IV(*e*): Discrete Mathematics

Unit I

Propositional Logic - Proposition logic, basic logic, logical connectives, truth tables, tautologies, contradiction, normal forms (conjunctive and disjunctive), modus ponens and modus tollens, validity, predicate logic, universal and existential quantification.

Method of Proof - Mathematical induction, proof by implication, converse, inverse, contrapositive, negation, and contradiction, direct proof by using truth table, proof by counter example.

Relation - Definition, types of relation, composition of relations, domain and range of a relation, pictorial representation of relation, properties of relation, partial ordering relation.

Posets, Hasse Diagram and Lattices - Introduction, ordered set, Hasse diagram of partially ordered set, isomorphic ordered set, well ordered set, properties of lattices, and complemented lattices.

Unit II

Boolean Algebra - Basic definitions, Sum of products and product of sums, Logic gates and Karnaugh maps.

Graphs - Simple graph, multi graph, graph terminology, representation of graphs, Bipartite, regular, planar and connected graphs, connected components in a graph, Euler graphs, Hamiltonian path and circuits, Graph colouring, chromatic number, isomorphism and homomorphism of graphs.

Tree - Definition, Rooted tree, properties of trees, binary search tree, tree traversal.

Unit III

Combinatorics - Basics of counting, permutations, combinations, inclusion-exclusion, recurrence relations (n^{th} order recurrence relation with constant coefficients, Homogeneous recurrence relations, Inhomogeneous recurrence relations), generating function (closed form expression, properties of G.F., solution of recurrence relation using, G.F, solution of combinatorial problem using G.F.).

Unit IV

Finite Automata - Basic concepts of automation theory, Deterministic finite automation (DFA), transition function, transition table, Non deterministic finite automata (NDFA), Mealy and Moore machine, Minimization of finite automation.

Paper IV(*f*): Mathematical Statistics

Unit I

Probability Theory: Three definitions of probability (Mathematical, Empirical & axiomatic). Dependent, independent and compound events.

Addition and multiplication theorems of probability, conditional probability. Bionomial and multinomial theorems of probability, Baye's theorem, Mathematical expectation and its properties, Moment generating functions (m.g.f.) and cumulants.

Unit II

Discrete distributions – Binomial & Poisson distributions and their properties.

Continuous distributions – Distribution function, Probability density function (Pdf), Cauchy's distribution, rectangular distribution, exponential distribution, Beta, Gamma Normal distributions and their properties.

Fitting of the Curves by method of least square – Straight line, parabola and exponential curves.

Unit III

Correlation and Regression

Bivariate population, Meaning of correlation & regression. Coefficient of Correlation, rank correlation, lines of regression. Properties of regression coefficients, Partial and multiple correlation and their simple Properties.

Unit IV

Sampling Theory

Types of population, Parameters & Statistics, Null Hypothesis, Level of Significance, critical region. Procedure for testing Hypothesis. Type I & Type II error, χ^2 - distribution and its properties.

Simple and random sampling. Test of significance for large samples. Sampling distribution of Mean. Standard error, Test of significance based on χ^2. Test of significance based on t,F & Z distribution, ANOVA.