B.A./B.Sc. (Mathematics) Syllabus  
(Choice Based Credit System)  
H.N.B. Garhwal University Srinagar (Garhwal) U. K.  
With effect from session 2015-2016

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**Discipline Specific Electives (DSE)**

**DSE 1A (choose one)**
1. Matrices
2. Mechanics
3. Linear Algebra

**DSE 1B (choose one)**
1. Numerical Methods
2. Complex Analysis
3. Linear Programming

**Skill Enhancement Course (SEC)**

**SEC 1 (choose one)**
1. Logic and Sets
2. Analytical Geometry
3. Integral Calculus

**SEC 2 (choose one)**
1. Vector Calculus
2. Theory of Equations
3. Number Theory
**SEC 3 (choose one)**
1. Probability and Statistics
2. Mathematical Finance
3. Mathematical Modeling

**SEC 4 (choose one)**
1. Boolean Algebra
2. Transportation and Game Theory
3. Graph Theory

**Core 1.1: Differential Calculus**
Limit and Continuity ($\varepsilon$ and $\delta$ definition), Types of discontinuities, Differentiability of functions, Successive differentiation, Leibnitz's theorem, Partial differentiation, Euler's theorem on homogeneous functions.


Rolle's theorem, Mean Value theorems, Taylor's theorem with Lagrange's and Cauchy's forms of remainder, Taylor's series, Maclaurin's series of $\sin x$, $\cos x$, $e^x$, $\log(1+x)$, $(1+x)^m$, Maxima and Minima, Indeterminate forms.

**Books Recommended**

**Core 2.1: Differential Equations**


**Books Recommended**
**Core 3.1: Real Analysis**

Finite and infinite sets, examples of countable and uncountable sets. Real line, bounded sets, suprema and infima, completeness property of \( \mathbb{R} \), Archimedean property of \( \mathbb{R} \), intervals. Concept of cluster points and statement of Bolzano-Weierstrass theorem.

Real Sequence, Bounded sequence, Cauchy convergence criterion for sequences. Cauchy's theorem on limits, order preservation and squeeze theorem, monotone sequences and their convergence (monotone convergence theorem without proof).


**Books Recommended**

**Core 4.1: Algebra**

Definition and examples of groups, examples of abelian and non-abelian groups, the group \( \mathbb{Z}_n \) of integers under addition modulo \( n \) and the group \( \mathbb{U}(n) \) of units under multiplication modulo \( n \). Cyclic groups from number systems, complex roots of unity, circle group, the general linear group \( \text{GL}_n (\mathbb{R}) \), groups of symmetries of (i) an isosceles triangle, (ii) an equilateral triangle, (iii) a rectangle, and (iv) a square, the permutation group \( \text{Sym}(n) \), Group of quaternions.

Subgroups, cyclic subgroups, the concept of a subgroup generated by a subset and the commutator subgroup of group, examples of subgroups including the center of a group. Cosets, Index of subgroup, Lagrange's theorem, order of an element, Normal subgroups: their definition, examples, and characterizations, Quotient groups.

Definition and examples of rings, examples of commutative and non-commutative rings: rings from number systems, \( \mathbb{Z}_n \) the ring of integers modulo \( n \), ring of real quaternions, rings of matrices, polynomial rings, and rings of continuous functions. Subrings and ideals, Integral domains and fields, examples of fields: \( \mathbb{Z}_p \), \( \mathbb{Q} \), \( \mathbb{R} \), and \( \mathbb{C} \).

**Books Recommended**
**DSE 1A.1: Matrices**

R, R², R³ as vector spaces over R. Standard basis for each of them. Concept of Linear Independence and examples of different bases. Subspaces of R², R³.

Translation, Dilation, Rotation, Reflection in a point, line and plane. Matrix form of basic geometric transformations. Interpretation of eigen values and eigen vectors for such transformations and eigen spaces as invariant subspaces.

Types of matrices. Rank of a matrix. Invariance of rank under elementary transformations. Reduction to normal form, Solutions of linear homogeneous and non-homogeneous equations with number of equations and unknowns upto four.


**Books Recommended**

**DSE 1A.2: Mechanics**

Conditions of equilibrium of a particle and of coplanar forces acting on a rigid Body. Laws of friction, Problems of equilibrium under forces including friction, Centre of gravity, Work and potential energy. Velocity and acceleration of a particle along a curve: radial and transverse components (plane curve), tangential and normal components (space curve), Simple harmonic motion, Simple Pendululum.

**Books Recommended**
**DSE 1A.3: Linear Algebra**

Vector spaces, subspaces, algebra of subspaces, quotient spaces, linear combination of vectors, linear span, linear independence, basis and dimension, dimension of subspaces.

Linear transformations, null space, range, rank and nullity of a linear transformation, matrix representation of a linear transformation, algebra of linear transformations. Dual Space, Dual Basis, Double Dual, Eigen values and Eigen vectors, Characteristic Polynomial.

Isomorphisms, Isomorphism theorems, invertibility and isomorphisms, change of coordinate matrix.

**Books Recommended**


**DSE 1B.1: Numerical Methods**


Lagrange and Newton interpolation: linear and higher order, finite difference operators. Numerical differentiation: forward difference, backward difference and central difference. Integration: trapezoidal rule, Simpson’s rule, Euler’s method.

**Recommended Books**

DSE 1B.2: Complex Analysis

Limits, Limits involving the point at infinity, continuity. Properties of complex numbers, regions in the complex plane, functions of complex variable, mappings. Derivatives, differentiation formulas, Cauchy-Riemann equations, sufficient conditions for differentiability.


Liouville’s theorem and Taylor and Laurent series, and its examples.

Books Recommended

DSE 1B.3: Linear Programming

Linear Programming Problems, Graphical Approach for Solving some Linear Programs. Convex Sets, Supporting and Separating Hyperplanes. Theory of simplex method, optimality and unboundedness, the simplex algorithm, simplex method in tableau format, introduction to artificial variables, two-phase method, Big-M method and their comparison.

Duality, formulation of the dual problem, primal- dual relationships, economic interpretation of the dual.

Recommended Books
SEC 1.1: Logic and Sets
Introduction, propositions, truth table, negation, conjunction and disjunction. Implications, biconditional propositions, converse, contra positive and inverse propositions and precedence of logical operators. Propositional equivalence: Logical equivalences. Predicates and quantifiers: Introduction, Quantifiers, Binding variables and Negations.


Difference and Symmetric difference of two sets. Set identities, Generalized union and intersections. Relation: Product set, Composition of relations, Types of relations, Partitions, Equivalence Relations with example of congruence modulo relation.

Book Recommended

SEC 1.2: Analytical Geometry
Techniques for sketching parabola, ellipse and hyperbola. Sphere, Cone, Cylindrical Surfaces, Central Conicoids.

Books Recommended

SEC 1.3: Integral Calculus
Integration by Partial fractions, integration of rational and irrational functions. Properties of definite integrals. Reduction formulae for integrals of rational, trigonometric, exponential and logarithmic functions and of their combinations.

Areas and lengths of curves in the plane, volumes and surfaces of solids of revolution. Double and Triple integrals.

Books Recommended
SEC 2.1: Vector Calculus
Differentiation and partial differentiation of a vector function. Derivative of sum, dot product and cross product of two vectors.

Gradient, divergence and curl.

Books Recommended

SEC 2.2: Theory of Equations
General properties of polynomials, Graphical representation of a polynomials, maximum and minimum values of a polynomials, General properties of equations, Descarte’s rule of signs positive and negative rule, Relation between the roots and the coefficients of equations.


Books Recommended

SEC 2.3: Number Theory
Division algorithm, Lame’s theorem, linear Diophantine equation, fundamental theorem of arithmetic, prime counting function, statement of prime number theorem, Goldbach conjecture, binary and decimal representation of integers, linear congruences, complete set of residues.

Number theoretic functions, sum and number of divisors, totally multiplicative functions, definition and properties of the Dirichlet product, the Möbius inversion formula, the greatest integer function, Euler’s phi-function.

Books Recommended:
SEC 3.1: Probability and Statistics
Sample space, probability axioms, real random variables (discrete and continuous), cumulative distribution function, probability mass/density functions, mathematical expectation, moments, moment generating function, characteristic function, discrete distributions: uniform, binomial, Poisson, continuous distributions: uniform, normal, exponential.

Joint cumulative distribution function and its properties, joint probability density functions, marginal and conditional distributions, expectation of function of two random variables, conditional expectations, independent random variables.

Books Recommended:

SEC 3.2: Mathematical Finance
Basic principles: Comparison, arbitrage and risk aversion, Interest (simple and compound, discrete and continuous), time value of money, inflation, net present value, internal rate of return (calculation by bisection and Newton-Raphson methods), comparison of NPV and IRR. Bonds, bond prices and yields. Floating-rate bonds, immunization.

Asset return, short selling, portfolio return, (brief introduction to expectation, variance, covariance and correlation), random returns, portfolio mean return and variance, diversification, portfolio diagram, feasible set.

Books Recommended:
SEC 3.3: Mathematical Modeling
Applications of differential equations: the vibrations of a mass on a spring, mixture problem, free damped motion, forced motion, resonance phenomena, electric circuit problem, mechanics of simultaneous differential equations.


Books Recommended:

SEC 4.1: Boolean Algebra
Definition, examples and basic properties of ordered sets, maps between ordered sets, duality principle, maximal and minimal elements, lattices as ordered sets, complete lattices, lattices as algebraic structures, sublattices, products and homomorphisms.

Definition, examples and properties of modular and distributive lattices, Boolean algebras, Boolean polynomials, minimal forms of Boolean polynomials, Quinn-McCluskey method, Karnaugh diagrams, switching circuits and applications of switching circuits.

Books Recommended:

SEC 4.2: Transportation and Game Theory

Game theory: formulation of two person zero sum games, solving two person zero sum games, games with mixed strategies, graphical solution procedure.

Books Recommended:
**SEC4.3: Graph Theory**
Definition, examples and basic properties of graphs, pseudographs, complete graphs, bipartite graphs, isomorphism of graphs, paths and circuits, Eulerian circuits, Hamiltonian cycles, the adjacency matrix, weighted graph, travelling salesman’s problem, shortest path, Dijkstra’s algorithm, Floyd - Warshall algorithm.

**Books Recommended:**

**Note:**
(i) Each course will carry 100 marks.

(ii) In each course, sessional test will carry 30 marks, which includes; one test of 1 hour duration/assignment/paper/poster presentation etc. suitable for the course and shall carry 20 marks, 5 marks shall be given for participation in academic activities/discipline and 5 marks for attendance in the class.

(iii) In each course, the end semester examination shall be of 70 marks.