

PROPOSED SCHEME FOR CHOICE BASED CREDIT SYSTEM IN
B.A. with Mathematics

Semester	Discipline Specific Core Course (DSC) (14)	Ability Enhancement Compulsory Course (AECC) (2)	Skill Enhancement Course (SEC) (2)	Discipline Specific Elective (DSE) (4)	Generic Elective (GE) (2)
1	DSC-101: Differential Calculus (Credit: 5+1) DSC-102: DSC-103:	AECC-101: English/MIL (Credit: 4)			
2	DSC-201: Differential Equations (Credit: 5+1) DSC-201: DSC-203:	AECC-201: Environmental Studies (Credit: 4)			
3	DSC-301: Real Analysis (Credit: 5+1) DSC-302: DSC-303		SEC-301 (I): Logic & Sets (Credit: 4) SEC-301(II): Classical Algebra & Trigonometry (Credit: 4)		
4	DSC-401: Abstract Algebra (Credit: 5+1) DSC-402: DSC-403:		SEC-401 (I): Vector calculus (Credit: 4) SEC-401(II): Mathematical Modelling (Credit: 4)		
5			SEC-501 (I): Probability & Statistics (Credit: 4) SEC-501(II): Number Theory (Credit: 4) SEC-501 (III): Integral Calculus (Credit: 4)	DSE-501(I): Linear Algebra (Credit: 5+1) DSE-501(II): Matrices (Credit: 5+1) DSE-502 : DSE-503:	GE-501(I): Numerical Methods (Credit: 5+1) GE-501(II): Statics (Credit: 5+1)
6			SEC-601 (I): Boolean Algebra (Credit: 4) SEC-601(II): Transportation and Game Theory (Credit: 4) SEC-601(III): Analytical Geometry (Credit: 4)	DSE-501(I): Linear Programming (Credit: 5+1) DSE-501(II): Complex Analysis (Credit: 5+1) DSE-502 : DSE-503:	GE-601(I): Programming in C (Credit: 5+1) GE-601(II): Dynamics (Credit: 5+1)

**B.A with MATHEMATICS
DISCIPLINE SPECIFIC CORE COURSES (DSC)**

Semester	Course No.	Name of the Course	Page No.
I	MATHEMATICS -DSC-101	Differential Calculus	3
II	MATHEMATICS - DSC-201	Differential Equations	4
III	MATHEMATICS - DSC-301	Real Analysis	5
IV	MATHEMATICS -DSC-401	Abstract Algebra	6

DISCIPLINE SPECIFIC ELECTIVES (DSE)

Semester	Course No.	Name of the Course	Page No.
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	MATHEMATICS -DSE-501(II)	Matrices	8
VI	MATHEMATICS -DSE-601(I)	Linear Programming	9
	MATHEMATICS -DSE-601(II)	Complex Analysis	10

SKILL ENHANCEMENT COURSES (SEC):

Semester	Course No.	Name of the Course	Page No.
III	MATHEMATICS -SEC-301(I)	Logic & Sets	11
	MATHEMATICS -SEC-301(II)	Classical Algebra & Trigonometry	12
IV	MATHEMATICS -SEC-401(I)	Vector Calculus	13
	MATHEMATICS -SEC-401(II)	Mathematical Modeling	14
V	MATHEMATICS -SEC-501(I)	Probability & Statistics	15
	MATHEMATICS -SEC-501(II)	Number Theory	16
	MATHEMATICS -SEC-501(III)	Integral Calculus	17
VI	MATHEMATICS -SEC-601(I)	Boolean Algebra	18
	MATHEMATICS -SEC-601(II)	Transportation & Game Theory	19
	MATHEMATICS -SEC-601(III)	Analytical Geometry	20

GENERIC ELECTIVES (GE)

Semester	Course No.	Name of the Course	Page No.
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	MATHEMATICS -GE-602(I)	Programming in C	23
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DISCIPLINE SPECIFIC CORE COURSES

MATHEMATICS -DSC-101

Differential Calculus

(Theory: 75 Lectures; 15 Tutorials; Credits: 5+1)

Full marks: 100 (ESE: 70; CCA: 30)

Pass marks: 40 (ESE: 28; CCA: 12)

(Each Unit carries equal weightage)

Unit-I

Limit of a function, algebra of limits, related results and problems

Unit-II

Continuity (ϵ and δ definition), related theorems and problems, types of discontinuities, differentiability of functions

Unit-III

Successive differentiation, Leibnitz's theorem, Partial differentiation, Euler's theorem on homogeneous functions

Unit-IV

Tangents and normals, curvature, asymptotes, singular points, tracing of curves, parametric representation of curves and tracing of parametric curves

Unit-V

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

1. Das, B.C. and B.N. Mukherjee, *Differential Calculus*, U.N. Dhur and Sons
2. S.C. Malik and S. Arora, *Mathematical Analysis*, New-Age International Publishers

MATHEMATICS -DSC-201
Differential Equations
(Theory: 75 Lectures; 15 Tutorials; Credits: 5+1)

Full marks: 100 (ESE: 70; CCA: 30)
Pass marks: 40 (ESE: 28; CCA: 12)
(Each Unit carries equal weightage)

Unit-I

First order exact differential equations, integrating factors, rules to find an integrating factor.
First order higher degree equations solvable for x, y, p

Unit-II

Methods for solving higher-order differential equations, basic theory of linear differential equations

Unit-III

Solving a differential equation by reducing its order linear homogenous equations with constant coefficients, linear non-homogenous equations, the method of variation of parameters

Unit-IV

The Cauchy-Euler equation, simultaneous differential equations, total differential equations

Unit-V

Order and degree of partial differential equations, concept of linear and non-linear partial differential equations, formation of first order partial differential equations,

Books Recommended

1. Shepley L. Ross, *Differential Equations*, 3rd Ed., John Wiley and Sons, 1984.
2. M.D. Raisinghania, *Advanced Differential Equations*, S. Chand and Sons

MATHEMATICS -DSC-301

Real Analysis

(Theory: 75 Lectures; 15 Tutorials; Credits: 5+1)

Full marks: 100 (ESE: 70; CCA: 30)

Pass marks: 40 (ESE: 28; CCA: 12)

(Each Unit carries equal weightage)

Unit-I

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}

Unit-II

Intervals, open and closed subsets of \mathbb{R} , their properties, nested interval theorem, concept of cluster points and Bolzano-Weierstrass theorem

Unit-III

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).

Unit-IV

Infinite series. Cauchy convergence criterion for series, positive term series, geometric series, comparison test, convergence of p-series, root test, ratio test, alternating series, Leibnitz's test (Tests of Convergence without proof), definition and examples of absolute and conditional convergence.

Unit-V

Sequential criterion of limit and continuity and the equivalence of sequential criterion with epsilon-delta definition, properties of continuous functions

Books Recommended:

1. R.G. Bartle and D. R Sherbert, *Introduction to Real Analysis*, John Wiley and Sons (Asia) Ltd., 2000.
2. S.C. Malik and S. Arora, *Mathematical Analysis*, New-Age International Publishers

MATHEMATICS -DSC-401

Abstract Algebra

(Theory: 75 Lectures; 15 Tutorials; Credits: 5+1)

Full marks: 100 (ESE: 70; CCA: 30)

Pass marks: 40 (ESE: 28; CCA: 12)

(Each Unit carries equal weightage)

Unit-I

Definition and examples of groups, examples of abelian and non-abelian groups, the group Z_n of integers under addition modulo n and the group $U(n)$ of units under multiplication modulo n , Cyclic groups from number systems, complex roots of unity, circle group, the general linear group $GL(n, \mathbb{R})$

Unit-II

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

Unit-III

Normal subgroups: their definition examples, and characterizations, Quotient groups, group homomorphism: definition, example and related problems

Unit-IV

Definition and examples of rings, examples of commutative and non-commutative rings: rings from number systems, Z_n the ring of integers modulo n , rings of matrices, polynomial rings, and rings of continuous functions.

Unit-V

Integral domains, division ring, and fields, examples of fields: Z_p , Q , R , and C , Subrings and ideals, prime, principal and maximal ideal

Books Recommended

1. Joseph A Gallian, *Contemporary Abstract Algebra*, 4th Ed., Narosa, 1999.
2. S. Singh and K. Zameeruddin, *Modern Algebra*, PHI

DISCIPLINE SPECIFIC ELECTIVE

MATHEMATICS -DSE-501(I)

Linear Algebra

(Theory: 75 Lectures; 15 Tutorials; Credits: 5+1)

Full marks: 100 (ESE: 70; CCA: 30)

Pass marks: 40 (ESE: 28; CCA: 12)

(Each Unit carries equal weightage)

Unit-I

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

Unit-II

Linear transformations, null space, range, rank and nullity of a linear transformation, matrix representation of a linear transformation,

Unit-III

Algebra of linear transformations, invertibility and isomorphisms, change of coordinate matrix

Unit-IV

Eigen space of a linear operator, diagonalisability, invariant subspaces and Cayley-Hamilton theorem, the minimal polynomial for a linear operator

Unit-V

Inner product spaces and norms, Gram Schimidt orthogonalisation process, orthogonal complements, Bessel's inequality, the adjoint of a linear operator, least square approximation

Books Recommended:

1. K. Hoffman and R. Kunze, *Linear Algebra*, PHI
2. S. Kumaresan, *Linear Algebra-A Geometric Approach*, PHI

MATHEMATICS -DSE-501(II)

Matrices

(Theory: 75 Lectures; 15 Tutorials; Credits: 5+1)

Full marks: 100 (ESE: 70; CCA: 30)

Pass marks: 40 (ESE: 28; CCA: 12)

(Each Unit carries equal weightage)

Unit-I

\mathbb{R} , \mathbb{R}^2 , \mathbb{R}^3 as vector spaces over \mathbb{R} , standard basis for each of them concept of linear independence and examples of different bases, subspaces of \mathbb{R}^2 , \mathbb{R}^3

Unit-II

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

Unit-III

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 up to four

Unit-IV

Matrices in diagonal form, reduction to diagonal form upto matrices of order 3, computation of matrix inverses using elementary row operations

Unit-V

Rank of matrix, solutions of a system of linear equations using matrices illustrative examples of above concepts from Geometry, Physics, Chemistry, Combinatorics and Statistics

Books Recommended

1. S. H. Friedberg, A. L. Insel and L. E. Spence, *Linear Algebra*, Prentice Hall of India Pvt. Ltd., New Delhi, 2004.
2. Richard Bronson, *Theory and Problems of Matrix Operations*, Tata McGraw Hill, 1989
3. Shanti Narayan, *Matrices*, S. Chand and Sons

MATHEMATICS -DSC-601(I)
Linear Programming
(Theory: 75 Lectures; 15 Tutorials; Credits: 5+1)
Full marks: 100 (ESE: 70; CCA: 30)
Pass marks: 40 (ESE: 28; CCA: 12)
(Each Unit carries equal weightage)

Unit-I

Introduction to linear programming problem, theory of simplex method, optimality and unboundedness, the simplex algorithm, simplex method in tableau format

Unit-II

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

Unit-III

Transportation problem and its mathematical formulation, northwest-corner method least cost method and Vogel approximation method for determination of starting basic solution, algorithm for solving transportation problem

Unit-IV

Assignment problem and its mathematical formulation, Hungarian method for solving assignment problem

Unit-V

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

Books Recommended:

1. Hamdy A. Taha, *Operations Research, An Introduction*, 8th Ed., Prentice-Hall India, 2006.
2. R.K. Gupta, *Operations Research, Operations Research*, Krishna Prakashan Media

MATHEMATICS -DSC-601(II)
Complex Analysis
(Theory: 75 Lectures; 15 Tutorials; Credits: 5+1)
Full marks: 100 (ESE: 70; CCA: 30)
Pass marks: 40 (ESE: 28; CCA: 12)
(Each Unit carries equal weightage)

Unit-I

Limits, limits involving the point at infinity, continuity, properties of complex numbers, regions in the complex plane, functions of complex variable, mappings

Unit-II

Derivatives, differentiation formulas, Cauchy-Riemann equations, sufficient conditions for differentiability. Analytic functions, examples of analytic functions, exponential function, Logarithmic function, trigonometric function

Unit-III

Definite integrals of functions, Contours, Contour integrals and its examples, upper bounds for moduli of contour integrals. Cauchy Goursat theorem, Cauchy integral formula

Unit-IV

Liouville's theorem and the fundamental theorem of algebra, convergence of sequences and series, Taylor series and its examples

Unit-V

Laurent series and its examples, absolute and uniform convergence of power series

Books Recommended

1. James Ward Brown and Ruel V. Churchill, *Complex Variables and Applications*, 8th Ed., McGraw – Hill International Edition, 2009.
2. Joseph Bak and Donald J. Newman, *Complex Analysis*, 2nd Ed., Undergraduate Texts in Mathematics, Springer-Verlag New York, Inc., New York, 1997.
3. S. Ponnusamy, *Foundations of Complex Analysis*, Narosa Publications

MATHEMATICS -SEC-301 (I)
Logic & Sets
(Theory: 60 Lectures; Credits: 4)
Full marks: 100 (ESE: 70; CCA 30)
Pass marks: 40 (ESE: 28; CCA: 12)
(Each Unit carries equal weightage)

Unit-I

Introduction, propositions, truth table, negation, conjunction and disjunction. Implications, biconditional propositions, converse, contra positive and inverse propositions and precedence of logical operators.

Unit-II

Propositional equivalence: Logical equivalences. Predicates and quantifiers: Introduction, Quantifiers, Binding variables and Negations.

Unit-III

Sets, subsets, Set operations and the laws of set theory and Venn diagrams. Examples of finite and infinite sets, Finite sets and counting principle. Empty set, properties of empty set. Standard set operations.

Unit-IV

Classes of sets. Power set of a set. Difference and Symmetric difference of two sets. Set identities, Generalized union and intersections.

Unit-V

Relation: Product set, Composition of relations, Types of relations, Partitions, Equivalence Relations with example of congruence modulo relation, Partial ordering relations, n-ary relations.

Books Recommended

1. R.P. Grimaldi, *Discrete Mathematics and Combinatorial Mathematics*, Pearson Education, 1998.
2. P.R. Halmos, *Naive Set Theory*, Springer, 1974.
3. E. Kamke, *Theory of Sets*, Dover Publishers, 1950.

MATHEMATICS -SEC-301 (II)
Classical Algebra & Trigonometry
(Theory: 60 Lectures; Credits: 4)
Full marks: 100 (ESE: 70; CCA 30)
Pass marks: 40 (ESE: 28; CCA: 12)
(Each Unit carries equal weightage)

Unit-I

Solutions of linear equations by matrix and Gaussian elimination method, rank of a matrix, determination of rank from definition and by transforming to Echelon form, eigen values and eigenvectors, Cayley-Hamilton theorem

Unit-II

Relation between the roots and co-efficients of a polynomial equation of nth degree with special reference to cubic equations, symmetric functions of roots, solutions of cubic equations of the form $ax^3 + bx^2 + c = 0$, $a \neq 0$ by Cardan's method, inequalities involving A.M., G.M. and H.M., Cauchy-Schwarz inequality

Unit-III

Sequence and their convergence and divergence, Monotonic and bounded sequences, Cauchy sequence, subsequence, Cauchy's general principle of convergence and divergence (statements only), Simple problems, convergence of the series $\sum \frac{1}{n^p}$, where p is a real number, tests of convergence of the series with positive term with the help of comparison test, D'Alembert's ratio test, Raabe's test and Cauchy's root test, Alternating series-Leibnitz test

Unit-IV

De-Moivre's theorem with applications, expansion of trigonometric functions,

Unit-V

Gregory's series, complex arguments, hyperbolic functions and summation of series

Books Recommended:

1. J.G.Chakroborty and P.R.Ghosh, Advanced Higher Algebra, U.N. Dhur and sons
2. B.C. Das and B.N. Mukherjee, Higher Trigonometry, U.N. Dhur and sons

MATHEMATICS -SEC-401 (I)
Vector Calculus
(Theory: 60 Lectures; Credits: 4)
Full marks: 100 (ESE: 70; CCA 30)
Pass marks: 40 (ESE: 28; CCA: 12)
(Each Unit carries equal weightage)

Unit-I

Continuity and differentiability of vectors

Unit-II

Ordinary derivatives of vectors, their sum and product

Unit-III

Partial differentiation of vectors

Unit-IV

Gradient, divergence and curl of vectors

Unit-V

Vector integration, line integrals

Books Recommended

1. G.B. Thomas and R.L. Finney, *Calculus*, 9th Ed., Pearson Education, Delhi, 2005.
2. H. Anton, I. Bivens and S. Davis, *Calculus*, John Wiley and Sons (Asia) P. Ltd. 2002.
3. P.C. Matthew's, *Vector Calculus*, Springer Verlag London Limited, 1998.
3. M.R. Spiegel, *Vector Calculus*, McGraw Hill

MATHEMATICS -SEC-401 (II)
Mathematical Modelling
(Theory: 60 Lectures; Credits: 4)
Full marks: 100 (ESE: 70; CCA 30)
Pass marks: 40 (ESE: 28; CCA: 12)
(Each Unit carries equal weightage)

Unit-I

Introduction to mathematical modelling, types of mathematical modeling, types of different variables involved in mathematical modeling, simple examples of mathematical models

Unit-II

Applications of differential equations: the vibrations of a mass on a spring, mixture problem, free damped motion

Unit-III

Forced motion, resonance phenomena, electric circuit problem, mechanics of simultaneous differential equations.

Unit-IV

Applications to Traffic Flow, vibrating string, vibrating membrane, conduction of heat in solids, gravitational potential, conservation laws

Unit-V

Modelling of population dynamics, exponential population growth (Malthus model), logistic population growth (Verhulst model)

Books Recommended:

1. Shepley L. Ross, *Differential Equations*, 3rd Ed., John Wiley and Sons, 1984.
2. I. Sneddon, *Elements of Partial Differential Equations*, McGraw-Hill, International Edition, 1967.
3. E.S. Allma and J.A. Rhodes, *Mathematical Models in Biology*, Cambridge University Press
4. J.N. Kapoor, *Mathematical Modelling*, New Age International Publishers

MATHEMATICS -SEC-501 (I)
Probability & Statistics
(Theory: 60 Lectures; Credits: 4)
Full marks: 100 (ESE: 70; CCA 30)
Pass marks: 40 (ESE: 28; CCA: 12)
(Each Unit carries equal weightage)

Unit-I

Sample space, probability axioms, real random variables (discrete and continuous), cumulative distribution function

Unit-II

Probability mass/density functions, mathematical expectation, moments, moment generating function

Unit-III

Characteristic function, discrete distributions: uniform, binomial, Poisson, continuous distributions: uniform, normal, exponential

Unit-IV

Joint cumulative distribution function and its properties, joint probability density functions, marginal and conditional distributions

Unit-V

Expectation of function of two random variables, conditional expectations, independent random variables

Books Recommended:

1. Robert V. Hogg, Joseph W. McKean and Allen T. Craig, *Introduction to Mathematical Statistics*, Pearson Education, Asia, 2007.
2. Irwin Miller and Marylees Miller, John E. Freund, *Mathematical Statistics with Application*, 7th Ed., Pearson Education, Asia, 2006.
3. Sheldon Ross, *Introduction to Probability Model*, 9th Ed., Academic Press, Indian Reprint, 2007.
3. S.C. Gupta and V.K. Kapoor, *Fundamentals of Mathematical Statistics*, Sultan Chand and Sons

MATHEMATICS -SEC-501 (II)
Number Theory
(Theory: 60 Lectures; Credits: 4)
Full marks: 100 (ESE: 70; CCA 30)
Pass marks: 40 (ESE: 28; CCA: 12)
(Each Unit carries equal weightage)

Unit-I

Linear Diophantine equation, prime counting function, statement of prime number theorem, Goldbach conjecture, linear congruences, complete set of residues, Chinese Remainder theorem, Fermat's Little theorem, Wilson's theorem.

Unit-II

Number theoretic functions, sum and number of divisors, totally multiplicative functions, definition and properties of the Dirichlet product, the Mobius Inversion formula

Unit-III

The greatest integer function, Euler's phi-function, Euler's theorem, reduced set of residues, some properties of Euler's phi-function.

Unit-IV

Order of an integer modulo n , primitive roots for primes, composite numbers having primitive roots, Euler's criterion, the Legendre symbol and its properties, quadratic reciprocity, quadratic congruences with composite moduli

Unit-V

Mersenne primes, perfect numbers, amicable numbers, Fermat's number, the equation $x^2 + y^2 = z^2$, Fermat's Last theorem.(statement only)

Books Recommended

1. David M. Burton, *Elementary Number Theory*, 6th Ed., Tata McGraw-Hill, Indian reprint, 2007
2. K.C. Choudhury, *A First Course in Theory of Numbers*, Assian Books

MATHEMATICS -SEC-501 (III)
Integral Calculus
(Theory: 60 Lectures; Credits: 4)
Full marks: 100 (ESE: 70; CCA 30)
Pass marks: 40 (ESE: 28; CCA: 12)
(Each Unit carries equal weightage)

Unit-I

Integration as the reverse of differentiation, integration by substitution, integration of rational functions

Unit-II

Definite integrals and their properties, definite integral as the limit of a sum

Unit-III

Reduction formulae for integrals of rational, trigonometric, exponential and logarithmic functions and of their combinations

Unit-IV

Areas and lengths of curves in the plane

Unit-V

Volumes and surfaces of solids of revolution, double and triple integrals

Books Recommended

1. G.B. Thomas and R.L. Finney, *Calculus*, 9th Ed., Pearson Education, Delhi, 2005.
2. H. Anton, I. Bivens and S. Davis, *Calculus*, John Wiley and Sons (Asia) P. Ltd., 2002.
3. B.C. Das and B.N. Mukherjee, *Integral Calculus*, U.N. Dhur and Sons

MATHEMATICS -SEC-601 (I)
Boolean Algebra
(Theory: 60 Lectures; Credits: 4)
Full marks: 100 (ESE: 70; CCA 30)
Pass marks: 40 (ESE: 28; CCA: 12)
(Each Unit carries equal weightage)

Unit-I

Definition, examples and basic properties of ordered sets, maps between ordered sets, duality principle, maximal and minimal elements

Unit-II

Lattices as ordered sets, complete lattices, lattices as algebraic structures, sublattices, products and homomorphisms

Unit-III

Definition, examples and properties of modular and distributive lattices

Unit-IV

Boolean algebras, Boolean polynomials, minimal forms of Boolean polynomials, disjunctive and conjunctive normal functions

Unit-V

Quinn-McCluskey method, Karnaugh diagrams, switching circuits and applications of switching circuits

Books Recommended:

1. B A. Davey and H. A. Priestley, *Introduction to Lattices and Order*, Cambridge University Press, Cambridge, 1990.
2. V.K. Khanna, *Lattice and Boolean Algebra*, Vikash Publishing House

MATHEMATICS -SEC-601 (II)
Transportation and Game Theory
(Theory: 60 Lectures; Credits: 4)
Full marks: 100 (ESE: 70; CCA 30)
Pass marks: 40 (ESE: 28; CCA: 12)
(Each Unit carries equal weightage)

Unit-I

Transportation problem and its mathematical formulation, matrix formulation, degenerate and non-degenerate basic feasible solution, existence of feasible solution, loops in transportation problem, initial basic feasible solution by north-west corner method, least cost method and Vogel's approximation method

Unit-II

Optimal solution of transportation problems, resolution of degeneracy in transportation problems, unbalanced transportation problems and their solution

Unit-III

Assignment problem and its mathematical formulation, Hungarian method for solving assignment problem, unbalanced assignment problems

Unit-IV

Game theory: formulation of two person zero sum games, maxi-min, mini-max principle, solving two person zero sum games, saddle point, games with mixed strategies and related results

Unit-V

Graphical solution procedure in game theory, solution of 2×2 games, $2 \times n$ games and $m \times 2$ games, dominance property and related problems.

Books Recommended:

1. Hamdy A. Taha, *Operations Research, An Introduction*, 8th Ed., Prentice-Hall India, 2006.
2. D.C. Sanyal and K. Das, *Introduction to Linear Programming*, U.N. Dhur and Sons

MATHEMATICS -SEC-601 (III)
Analytical Geometry
(Theory: 60 Lectures; Credits: 4)
Full marks: 100 (ESE: 70; CCA 30)
Pass marks: 40 (ESE: 28; CCA: 12)
(Each Unit carries equal weightage)

Unit-I

Change of origin, invariants in orthogonal transformation, pair of straight lines, bisector of angles between pair of straight lines

Unit-II

Orthogonal circles, radical axis, radical centre of three circles, circles through intersection of two circles, circles through intersection of a circle and a straight line, condition of tangency of a straight line to a circle, parabola, ellipse and hyperbola

Unit-III

Definition, equation of polar of a point with respect to a circle, parabola, ellipse and hyperbola, determination of the pole of a straight line with respect to a circle, parabola, ellipse and hyperbola,

Unit-IV

Shortest distance and equation of shortest distance line, general equation of a sphere, sphere through origin and having intercepts on the axes, section of a sphere by a plane, great circle, sphere through a given circle, the curve of intersection of two spheres, tangent plane to a sphere at a given point on it

Unit-V

Classification of quadratic equations representing lines, parabola, ellipse and hyperbola, spheres, cylindrical surfaces, illustrations of graphing standard quadric surfaces like cone, ellipsoid

Books Recommended

1. G.B. Thomas and R.L. Finney, *Calculus*, 9th Ed., Pearson Education, Delhi, 2005.
2. B.Das, *Coordinate Geometry*
3. S.L. Loney, *The Elements of Coordinate Geometry*, McMillan and Company, London.

4. R.J.T. Bill, *Elementary Treatise on Coordinate Geometry of Three Dimensions*, McMillan India Ltd., 1994.

MATHEMATICS -GE-601 (I)

Numerical Methods

(Theory: 75 Lectures; 15 Tutorials; Credit: 4)

Full marks: 100 (ESE: 70; CCA 30)

Pass marks: 40 (ESE: 28; CCA: 12)

Use of Scientific Calculator is allowed

(Each Unit carries equal weightage)

Unit-I

Algorithms, convergence, error analysis: relative, absolute, round off, truncation.

Unit-II

Transcendental and polynomial equations: bisection method, regula-falsi method, Newton's method, secant method, rate of convergence of these methods, related problems

Unit-III

System of linear algebraic equations: Gaussian Elimination and Gauss -Jordan methods. Gauss- Jacobi method, Gauss- Seidel method and their convergence analysis, related problems

Unit-IV

Interpolation: Lagrange and Newton's methods, error bounds, finite difference operators, Gregory forward and backward difference interpolation, related problems

Unit-V

Numerical integration: Trapezoidal rule, Simpson's 1/3 rule, Simpson's 3/8th rule, Boole's Rule, midpoint rule, composite Trapezoidal rule, composite Simpson's rule, numerical ordinary differential equations: Euler's method, Modified Euler's method

Books Recommended

1. M.K. Jain, S.R.K. Iyengar and R.K. Jain, *Numerical Methods for Scientific and Engineering Computation*, 6th Ed., New age International Publisher, India, 2007.
2. P.P. Gupta and G.S. Malik, *Calculus of Finite Differences and Numerical Analysis*, Krishna Prakashan Media.

MATHEMATICS -GE-601 (II)

Statics

(Theory: 75 Lectures; 15 Tutorials; Credit: 4)

Full marks: 100 (ESE: 70; CCA 30)

Pass marks: 40 (ESE: 28; CCA: 12)

(Each Unit carries equal weightage)

Unit-I

Coplanar forces – their resultant, condition of equilibrium and example involving contact with smooth planes, Friction – Laws of statical friction, equilibrium on rough planes and spheres

Unit-II

Centre of gravity – C.G of a triangle formed by three rods, C.G. of an arc and a sector of circle, of a quadrant of an ellipse, of a cardioid, of an astroid, and of a lamina bounded by a parabola and a line. C.G. of solid and surfaces of revolution, three systems of pulleys

Unit-III

Virtual work – Virtual displacement and virtual work, principle of virtual works for a system of coplanar forces, forces which can be omitted in the equation of a virtual work, simple problems

Unit-IV

Equilibrium - Stable and unstable equilibrium, condition of stability and instability, Energy tests for stability, simple problems

Unit-V

Catenary – the common catenary, important relation for the common catenary, Equilibrium of a string under any given force in a plane

Books Recommended:

1. B.C. Das and B.N. Mukherjee, *Statics*, U.N. Dhur and Sons
2. S.L. Loney, *Statics*,

MATHEMATICS -GE-602 (I)

Programming in C

(Theory: 75 Lectures; 15 Tutorials; Credit: 4)

Full marks: 100 (ESE: 70; CCA 30)

Pass marks: 40 (ESE: 28; CCA: 12)

(Each Unit carries equal weightage)

Unit-I

Introduction to C language, C characters, C constants and variables, Arithmetic expression and statements. Input/Output, statements, Assignment statements, printf and scanf statements, declaration statements.

Unit-II

Simple computer program, Logical expression and statements, logical and relational operators

Unit-III

Decision control structures, loops, if statements if-else statements, for statements, while statements, Do-while loop, Switch statements, break statements, continue statements, command operator, go to statements.

Unit-IV

Functions-defining a function, function prototypes, passing arguments to a function.

Unit-V

Return statements Arrays, defining an array, multi dimensional arrays.

Books Recommended

1. Y. Kanitkar, *Let us C*, PHI
2. B.W Kernighan and D.M.Ritchie, *The C Programming Language*, PHI

MATHEMATICS -GE-602 (II)

Dynamics

(Theory: 75 Lectures; 15 Tutorials; Credit: 4)

Full marks: 100 (ESE: 70; CCA 30)

Pass marks: 40 (ESE: 28; CCA: 12)

(Each Unit carries equal weightage)

Unit-I

Motion in a line with variable acceleration (under some law of velocity ,inverse square law and other laws of acceleration) , Simple Harmonic motion , Angular velocity , Tangential and normal components of velocity and acceleration in a plane.

Unit-II

Motion in a plane – Projectile , Range of projection on horizontal & on an inclined plane , Central Orbits(polar and pedal forms), Apses and apsidal distances.

Unit-III

Uniplanar motion – Motion under inverse square law, planetary motion, Kepler's laws (Statement and geometrical implication only), Motion in resisting medium under gravit (only upward and downward motions).

Unit-IV

Impulse, Work, Energy – Impulse of a force, work, power, energy, principle of energy, conservation of linear momentum and energy.

Impact – Direct impact of two elastic bodies, Direct impact of an elastic body on a smooth fixed plane, oblique impact of two perfectly smooth spheres(Direction and magnitudes of velocity components , impulse of blow)

Unit-V

Dynamics of a rigid body – Moments and product of inertia, theorems of parallel and perpendicular axes, M I about any line in terms of M I and P I about any three mutual perpendicular lines, Principal axes, Principal moments, d' Alembert's principle.

Books Recommended

1. S.L. Loney, Dynamics of a Particle

2. B.C. Das and B.N. Mukerjee, Dynamics, U.N. Dhur and Sons
3. R.K. Gupta, Rigid Dynamics

PROPOSED SCHEME FOR CHOICE BASED CREDIT SYSTEM IN
B.Sc. with Mathematics

Semester	Discipline Specific Core Course (DSC) (14)	Ability Enhancement Compulsory Course (AECC) (2)	Skill Enhancement Course (SEC) (2)	Discipline Specific Elective (DSE) (4)
1	DSC-101: Differential Calculus (Credit: 5+1) DSC-102: DSC-103:	AECC-101 : English/MIL (Credit: 4)		
2	DSC-201: Differential Equations (Credit: 5+1) DSC-201: DSC-203:	AECC-201 : Environmental Studies (Credit: 4)		
3	DSC-301: Real Analysis (Credit: 5+1) DSC-302: DSC-303		SEC-301 (I) : Logic & Sets (Credit: 4) SEC-301(II) : Classical Algebra & Trigonometry (Credit: 4)	
4	DSC-401: Abstract Algebra (Credit: 5+1) DSC-402: DSC-403:		SEC-401 (I) : Vector calculus (Credit: 4) SEC-401(II) : Mathematical Modelling (Credit: 4)	
5			SEC-501 (I) : Probability & Statistics (Credit: 4) SEC-501(II) : Number Theory (Credit: 4) SEC-501 (III) : Integral Calculus (Credit: 4)	DSE-501(I) : Linear Algebra(Credit: 5+1) DSE-501(II) : Matrices (Credit: 5+1) DSE-502 : DSE-503:
6			SEC-601 (I) : Boolean Algebra (Credit: 4) SEC-601(II) : Transportation and Game Theory (Credit: 4) SEC-601(III) : Analytical Geometry (Credit: 4)	DSE-501(I) : Linear Programming (Credit: 5+1) DSE-501(II) : Complex Analysis (Credit: 5+1) DSE-502 : DSE-503:

B.Sc. with MATHEMATICS
DISCIPLINE SPECIFIC CORE COURSES (DSC)

Semester	Course No.	Name of the Course	Page No.
I	MATHEMATICS -DSC-101	Differential Calculus	2
II	MATHEMATICS - DSC-201	Differential Equations	3
III	MATHEMATICS - DSC-301	Real Analysis	4
IV	MATHEMATICS -DSC-401	Abstract Algebra	5

DISCIPLINE SPECIFIC ELECTIVES (DSE)

Semester	Course No.	Name of the Course	Page No.
V	MATHEMATICS -DSE-501(I)	Linear Algebra	6
	MATHEMATICS -DSE-501(II)	Matrices	7
VI	MATHEMATICS -DSE-601(I)	Linear Programming	8
	MATHEMATICS -DSE-601(II)	Complex Analysis	9

SKILL ENHANCEMENT COURSES (SEC):

Semester	Course No.	Name of the Course	Page No.
III	MATHEMATICS -SEC-301(I)	Logic & Sets	10
	MATHEMATICS -SEC-301(II)	Classical Algebra & Trigonometry	11
IV	MATHEMATICS -SEC-401(I)	Vector Calculus	12
	MATHEMATICS -SEC-401(II)	Mathematical Modeling	13
V	MATHEMATICS -SEC-501(I)	Probability & Statistics	14
	MATHEMATICS -SEC-501(II)	Number Theory	15
	MATHEMATICS -SEC-501(III)	Integral Calculus	16
VI	MATHEMATICS -SEC-601(I)	Boolean Algebra	17
	MATHEMATICS -SEC-601(II)	Transportation & Game Theory	18
	MATHEMATICS -SEC-601(III)	Analytical Geometry	19

DISCIPLINE SPECIFIC CORE COURSES
MATHEMATICS -DSC-101
Differential Calculus
(Theory: 75 Lectures; 15 Tutorials; Credits: 5+1)
Full marks: 100 (ESE: 70; CCA: 30)
Pass marks: 40 (ESE: 28; CCA: 12)
(Each Unit carries equal weightage)

Unit-I

Limit of a function, algebra of limits, related results and problems

Unit-II

Continuity (ϵ - δ definition), related theorems and problems, types of discontinuities, differentiability of functions

Unit-III

Successive differentiation, Leibnitz's theorem, Partial differentiation, Euler's theorem on homogeneous functions

Unit-IV

Tangents and normals, curvature, asymptotes, singular points, tracing of curves, parametric representation of curves and tracing of parametric curves

Unit-V

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

1. Das, B.C. and B.N. Mukherjee, *Differential Calculus*, U.N. Dhur and Sons
2. S.C. Malik and S. Arora, *Mathematical Analysis*, New-Age International Publishers

MATHEMATICS -DSC-201
Differential Equations
(Theory: 75 Lectures; 15 Tutorials; Credits: 5+1)

Full marks: 100 (ESE: 70; CCA: 30)
Pass marks: 40 (ESE: 28; CCA: 12)
(Each Unit carries equal weightage)

Unit-I

First order exact differential equations, integrating factors, rules to find an integrating factor.
First order higher degree equations solvable for x, y, p

Unit-II

Methods for solving higher-order differential equations, basic theory of linear differential equations

Unit-III

Solving a differential equation by reducing its order linear homogenous equations with constant coefficients, linear non-homogenous equations, the method of variation of parameters

Unit-IV

The Cauchy-Euler equation, simultaneous differential equations, total differential equations

Unit-V

Order and degree of partial differential equations, concept of linear and non-linear partial differential equations, formation of first order partial differential equations,

Books Recommended

1. Shepley L. Ross, *Differential Equations*, 3rd Ed., John Wiley and Sons, 1984.
2. M.D. Raisinghania, *Advanced Differential Equations*, S. Chand and Sons

MATHEMATICS -DSC-301

Real Analysis

(Theory: 75 Lectures; 15 Tutorials; Credits: 5+1)

Full marks: 100 (ESE: 70; CCA: 30)

Pass marks: 40 (ESE: 28; CCA: 12)

(Each Unit carries equal weightage)

Unit-I

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}

Unit-II

Intervals, open and closed subsets of \mathbb{R} , their properties, nested interval theorem, concept of cluster points and Bolzano-Weierstrass theorem

Unit-III

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).

Unit-IV

Infinite series. Cauchy convergence criterion for series, positive term series, geometric series, comparison test, convergence of p-series, root test, ratio test, alternating series, Leibnitz's test (Tests of Convergence without proof), definition and examples of absolute and conditional convergence.

Unit-V

Sequential criterion of limit and continuity and the equivalence of sequential criterion with epsilon-delta definition, properties of continuous functions

Books Recommended:

1. R.G. Bartle and D. R Sherbert, *Introduction to Real Analysis*, John Wiley and Sons (Asia) Ltd., 2000.
2. S.C. Malik and S. Arora, *Mathematical Analysis*, New-Age International Publishers

MATHEMATICS -DSC-401

Abstract Algebra

(Theory: 75 Lectures; 15 Tutorials; Credits: 5+1)

Full marks: 100 (ESE: 70; CCA: 30)

Pass marks: 40 (ESE: 28; CCA: 12)

(Each Unit carries equal weightage)

Unit-I

Definition and examples of groups, examples of abelian and non-abelian groups, the group Z_n of integers under addition modulo n and the group $U(n)$ of units under multiplication modulo n , Cyclic groups from number systems, complex roots of unity, circle group, the general linear group $GL(n, \mathbb{R})$

Unit-II

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

Unit-III

Normal subgroups: their definition examples, and characterizations, Quotient groups, group homomorphism: definition, example and related problems

Unit-IV

Definition and examples of rings, examples of commutative and non-commutative rings: rings from number systems, Z_n the ring of integers modulo n , rings of matrices, polynomial rings, and rings of continuous functions.

Unit-V

Integral domains, division ring, and fields, examples of fields: Z_p , Q , R , and C , Subrings and ideals, prime, principal and maximal ideal

Books Recommended

1. Joseph A Gallian, *Contemporary Abstract Algebra*, 4th Ed., Narosa, 1999.
2. S. Singh and K. Zameeruddin, *Modern Algebra*, PHI

DISCIPLINE SPECIFIC ELECTIVE

MATHEMATICS -DSE-501(I)

Linear Algebra

(Theory: 75 Lectures; 15 Tutorials; Credits: 5+1)

Full marks: 100 (ESE: 70; CCA: 30)

Pass marks: 40 (ESE: 28; CCA: 12)

(Each Unit carries equal weightage)

Unit-I

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

Unit-II

Linear transformations, null space, range, rank and nullity of a linear transformation, matrix representation of a linear transformation,

Unit-III

Algebra of linear transformations, isomorphisms, isomorphism theorems, invertibility and isomorphisms, change of coordinate matrix

Unit-IV

Eigen space of a linear operator, diagonalisability, invariant subspaces and Cayley-Hamilton theorem, the minimal polynomial for a linear operator

Unit-V

Inner product spaces and norms, orthogonal complements, Bessel's inequality, the adjoint of a linear operator, least square approximation

Books Recommended:

1. K. Hoffman and R. Kunze, *Linear Algebra*, PHI
2. S. Kumaresan, *Linear Algebra-A Geometric Approach*, PHI

MATHEMATICS -DSE-501(II)

Matrices

(Theory: 75 Lectures; 15 Tutorials; Credits: 5+1)

Full marks: 100 (ESE: 70; CCA: 30)

Pass marks: 40 (ESE: 28; CCA: 12)

(Each Unit carries equal weightage)

Unit-I

\mathbb{R} , \mathbb{R}^2 , \mathbb{R}^3 as vector spaces over \mathbb{R} , standard basis for each of them concept of linear independence and examples of different bases, subspaces of \mathbb{R}^2 , \mathbb{R}^3

Unit-II

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

Unit-III

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 up to four

Unit-IV

Matrices in diagonal form, reduction to diagonal form upto matrices of order 3, computation of matrix inverses using elementary row operations

Unit-V

Rank of matrix, solutions of a system of linear equations using matrices illustrative examples of above concepts from Geometry, Physics, Chemistry, Combinatorics and Statistics

Books Recommended

1. S. H. Friedberg, A. L. Insel and L. E. Spence, *Linear Algebra*, Prentice Hall of India Pvt. Ltd., New Delhi, 2004.
2. Richard Bronson, *Theory and Problems of Matrix Operations*, Tata McGraw Hill, 1989
3. Shanti Narayan, *Matrices*, S. Chand and Sons

MATHEMATICS -DSC-601(I)
Linear Programming
(Theory: 75 Lectures; 15 Tutorials; Credits: 5+1)
Full marks: 100 (ESE: 70; CCA: 30)
Pass marks: 40 (ESE: 28; CCA: 12)
(Each Unit carries equal weightage)

Unit-I

Introduction to linear programming problem, theory of simplex method, optimality and unboundedness, the simplex algorithm, simplex method in tableau format

Unit-II

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

Unit-III

Transportation problem and its mathematical formulation, northwest-corner method least cost method and Vogel approximation method for determination of initial basic solution, algorithm for solving transportation problem

Unit-IV

Assignment problem and its mathematical formulation, Hungarian method for solving assignment problem

Unit-V

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

Books Recommended:

1. Hamdy A. Taha, *Operations Research, An Introduction*, 8th Ed., Prentice-Hall India, 2006.
2. R.K. Gupta, *Operations Research, Operations Research*, Krishna Prakashan Media

MATHEMATICS -DSC-601(II)
Complex Analysis
(Theory: 75 Lectures; 15 Tutorials; Credits: 5+1)
Full marks: 100 (ESE: 70; CCA: 30)
Pass marks: 40 (ESE: 28; CCA: 12)
(Each Unit carries equal weightage)

Unit-I

Limits, limits involving the point at infinity, continuity, properties of complex numbers, regions in the complex plane, functions of complex variable, mappings

Unit-II

Derivatives, differentiation formulas, Cauchy-Riemann equations, sufficient conditions for differentiability. Analytic functions, examples of analytic functions, exponential function, Logarithmic function, trigonometric function

Unit-III

Definite integrals of functions, Contours, Contour integrals and its examples, upper bounds for moduli of contour integrals. Cauchy Goursat theorem, Cauchy integral formula

Unit-IV

Liouville's theorem and the fundamental theorem of algebra, convergence of sequences and series, Taylor series and its examples

Unit-V

Laurent series and its examples, absolute and uniform convergence of power series

Books Recommended

1. James Ward Brown and Ruel V. Churchill, *Complex Variables and Applications*, 8th Ed., McGraw – Hill International Edition, 2009.
2. Joseph Bak and Donald J. Newman, *Complex Analysis*, 2nd Ed., Undergraduate Texts in Mathematics, Springer-Verlag New York, Inc., New York, 1997.
3. S. Ponnusamy, *Foundations of Complex Analysis*, Narosa Publications

MATHEMATICS -SEC-301 (I)
Logic & Sets
(Theory: 60 Lectures; Credits: 4)
Full marks: 100 (ESE: 70; CCA 30)
Pass marks: 40 (ESE: 28; CCA: 12)
(Each Unit carries equal weightage)

Unit-I

Introduction, propositions, truth table, negation, conjunction and disjunction. Implications, biconditional propositions, converse, contra positive and inverse propositions and precedence of logical operators.

Unit-II

Propositional equivalence: Logical equivalences. Predicates and quantifiers: Introduction, Quantifiers, Binding variables and Negations.

Unit-III

Sets, subsets, Set operations and the laws of set theory and Venn diagrams. Examples of finite and infinite sets, Finite sets and counting principle. Empty set, properties of empty set. Standard set operations.

Unit-IV

Classes of sets. Power set of a set. Difference and Symmetric difference of two sets. Set identities, Generalized union and intersections.

Unit-V

Relation: Product set, Composition of relations, Types of relations, Partitions, Equivalence Relations with example of congruence modulo relation, Partial ordering relations, n-ary relations.

Books Recommended

1. R.P. Grimaldi, *Discrete Mathematics and Combinatorial Mathematics*, Pearson Education, 1998.
2. P.R. Halmos, *Naive Set Theory*, Springer, 1974.
3. E. Kamke, *Theory of Sets*, Dover Publishers, 1950.

MATHEMATICS -SEC-301 (II)
Classical Algebra & Trigonometry
(Theory: 60 Lectures; Credits: 4)
Full marks: 100 (ESE: 70; CCA 30)
Pass marks: 40 (ESE: 28; CCA: 12)
(Each Unit carries equal weightage)

Unit-I

Solutions of linear equations by matrix and Gaussian elimination method, rank of a matrix, determination of rank from definition and by transforming to Echelon form, eigen values and eigenvectors, Cayley-Hamilton theorem

Unit-II

Relation between the roots and co-efficients of a polynomial equation of nth degree with special reference to cubic equations, symmetric functions of roots, solutions of cubic equations of the form $ax^3 + bx^2 + c = 0$, $a \neq 0$ by Cardan's method, inequalities involving A.M., G.M. and H.M., Cauchy-Schwarz inequality

Unit-III

Sequence and their convergence and divergence, Monotonic and bounded sequences, Cauchy sequence, subsequence, Cauchy's general principle of convergence and divergence (statements only), Simple problems, convergence of the series $\sum \frac{1}{n^p}$, where p is a real number, tests of convergence of the series with positive term with the help of comparison test, D'Alembert's ratio test, Raabe's test and Cauchy's root test, Alternating series-Leibnitz test

Unit-IV

De-Moivre's theorem with applications, expansion of trigonometric functions,

Unit-V

Gregory's series, complex arguments, hyperbolic functions and summation of series

Books Recommended:

1. J.G.Chakroborty and P.R.Ghosh, Advanced Higher Algebra, U.N. Dhur and sons
2. B.C. Das and B.N. Mukherjee, Higher Trigonometry, U.N. Dhur and sons

MATHEMATICS -SEC-401 (I)
Vector Calculus
(Theory: 60 Lectures; Credits: 4)
Full marks: 100 (ESE: 70; CCA 30)
Pass marks: 40 (ESE: 28; CCA: 12)
(Each Unit carries equal weightage)

Unit-I

Continuity and differentiability of vectors

Unit-II

Ordinary derivatives of vectors, their sum and product

Unit-III

Partial differentiation of vectors

Unit-IV

Gradient, divergence and curl of vectors

Unit-V

Vector integration, line integrals

Books Recommended

1. G.B. Thomas and R.L. Finney, *Calculus*, 9th Ed., Pearson Education, Delhi, 2005.
2. H. Anton, I. Bivens and S. Davis, *Calculus*, John Wiley and Sons (Asia) P. Ltd. 2002.
3. P.C. Matthew's, *Vector Calculus*, Springer Verlag London Limited, 1998.
3. M.R. Spiegel, *Vector Calculus*, McGraw Hill

MATHEMATICS -SEC-401 (II)
Mathematical Modelling
(Theory: 60 Lectures; Credits: 4)
Full marks: 100 (ESE: 70; CCA 30)
Pass marks: 40 (ESE: 28; CCA: 12)
(Each Unit carries equal weightage)

Unit-I

Introduction to mathematical modelling, types of mathematical modeling, types of different variables involved in mathematical modeling, simple examples of mathematical models

Unit-II

Applications of differential equations: the vibrations of a mass on a spring, mixture problem, free damped motion

Unit-III

Forced motion, resonance phenomena, electric circuit problem, mechanics of simultaneous differential equations.

Unit-IV

Applications to Traffic Flow, vibrating string, vibrating membrane, conduction of heat in solids, gravitational potential, conservation laws

Unit-V

Modeling of population dynamics, exponential population growth (Malthus model), logistic population growth (Verhulst model)

Books Recommended:

1. Shepley L. Ross, *Differential Equations*, 3rd Ed., John Wiley and Sons, 1984.
2. I. Sneddon, *Elements of Partial Differential Equations*, McGraw-Hill, International Edition, 1967.
3. E.S. Allma and J.A. Rhodes, *Mathematical Models in Biology*, Cambridge University Press
4. J.N. Kapoor, *Mathematical Modelling*, New Age International Publishers

MATHEMATICS -SEC-501 (I)
Probability & Statistics
(Theory: 60 Lectures; Credits: 4)
Full marks: 100 (ESE: 70; CCA 30)
Pass marks: 40 (ESE: 28; CCA: 12)
(Each Unit carries equal weightage)

Unit-I

Sample space, probability axioms, real random variables (discrete and continuous), cumulative distribution function

Unit-II

Probability mass/density functions, mathematical expectation, moments, moment generating function

Unit-III

Characteristic function, discrete distributions: uniform, binomial, Poisson, continuous distributions: uniform, normal, exponential

Unit-IV

Joint cumulative distribution function and its properties, joint probability density functions, marginal and conditional distributions

Unit-V

Expectation of function of two random variables, conditional expectations, independent random variables

Books Recommended:

1. Robert V. Hogg, Joseph W. McKean and Allen T. Craig, *Introduction to Mathematical Statistics*, Pearson Education, Asia, 2007.
2. Irwin Miller and Marylees Miller, John E. Freund, *Mathematical Statistics with Application*, 7th Ed., Pearson Education, Asia, 2006.
3. Sheldon Ross, *Introduction to Probability Model*, 9th Ed., Academic Press, Indian Reprint, 2007.
4. S.C. Gupta and V.K. Kapoor, *Fundamentals of Mathematical Statistics*, Sultan Chand and Sons

MATHEMATICS -SEC-501 (II)
Number Theory
(Theory: 60 Lectures; Credits: 4)
Full marks: 100 (ESE: 70; CCA 30)
Pass marks: 40 (ESE: 28; CCA: 12)
(Each Unit carries equal weightage)

Unit-I

Linear Diophantine equation, prime counting function, statement of prime number theorem, Goldbach conjecture, linear congruences, complete set of residues, Chinese Remainder theorem, Fermat's Little theorem, Wilson's theorem.

Unit-II

Number theoretic functions, sum and number of divisors, totally multiplicative functions, definition and properties of the Dirichlet product, the Mobius Inversion formula

Unit-III

The greatest integer function, Euler's phi-function, Euler's theorem, reduced set of residues, some properties of Euler's phi-function.

Unit-IV

Order of an integer modulo n, primitive roots for primes, composite numbers having primitive roots, Euler's criterion, the Legendre symbol and its properties, quadratic reciprocity, quadratic congruences with composite moduli

Unit-V

Mersenne primes, perfect numbers, amicable numbers, Fermat's number, the equation $x^2 + y^2 = z^2$, Fermat's Last theorem(statement only)

Books Recommended

1. David M. Burton, *Elementary Number Theory*, 6th Ed., Tata McGraw-Hill, Indian reprint, 2007
2. K.C. Choudhury, *A First Course in Theory of Numbers*, Assian Books

MATHEMATICS -SEC-501 (III)
Integral Calculus
(Theory: 60 Lectures; Credits: 4)
Full marks: 100 (ESE: 70; CCA 30)
Pass marks: 40 (ESE: 28; CCA: 12)
(Each Unit carries equal weightage)

Unit-I

Integration as the reverse of differentiation, integration by substitution, integration of rational functions

Unit-II

Definite integrals and their properties, definite integral as the limit of a sum

Unit-III

Reduction formulae for integrals of rational, trigonometric, exponential and logarithmic functions and of their combinations

Unit-IV

Areas and lengths of curves in the plane

Unit-V

Volumes and surfaces of solids of revolution, double and triple integrals

Books Recommended

1. G.B. Thomas and R.L. Finney, *Calculus*, 9th Ed., Pearson Education, Delhi, 2005.
2. H. Anton, I. Bivens and S. Davis, *Calculus*, John Wiley and Sons (Asia) P. Ltd., 2002.
3. B.C. Das and B.N. Mukherjee, *Integral Calculus*, U.N. Dhur and Sons

MATHEMATICS -SEC-601 (I)
Boolean Algebra
(Theory: 60 Lectures; Credits: 4)
Full marks: 100 (ESE: 70; CCA 30)
Pass marks: 40 (ESE: 28; CCA: 12)
(Each Unit carries equal weightage)

Unit-I

Definition, examples and basic properties of ordered sets, maps between ordered sets, duality principle, maximal and minimal elements

Unit-II

Lattices as ordered sets, complete lattices, lattices as algebraic structures, sublattices, products and homomorphisms

Unit-III

Definition, examples and properties of modular and distributive lattices

Unit-IV

Boolean algebras, Boolean polynomials, minimal forms of Boolean polynomials, disjunctive and conjunctive normal forms

Unit-V

Quinn-McCluskey method, Karnaugh diagrams, switching circuits and applications of switching circuits

Books Recommended:

1. B A. Davey and H. A. Priestley, *Introduction to Lattices and Order*, Cambridge University Press, Cambridge, 1990.
2. V.K. Khanna, *Lattice and Boolean Algebra*, Vikash Publishing House

MATHEMATICS -SEC-601 (II)
Transportation and Game Theory
(Theory: 60 Lectures; Credits: 4)
Full marks: 100 (ESE: 70; CCA 30)
Pass marks: 40 (ESE: 28; CCA: 12)
(Each Unit carries equal weightage)

Unit-I

Transportation problem and its mathematical formulation, matrix formulation, degenerate and non-degenerate basic feasible solution, existence of feasible solution, loops in transportation problem, initial basic feasible solution by north-west corner method, least cost method and Vogel's approximation method

Unit-II

Optimal solution of transportation problems, resolution of degeneracy in transportation problems, unbalanced transportation problems and their solution

Unit-III

Assignment problem and its mathematical formulation, Hungarian method for solving assignment problem, unbalanced assignment problems

Unit-IV

Game theory: formulation of two person zero sum games, maximin- minimax principle, solving two person zero sum games, saddle point, games with mixed strategies and related results

Unit-V

Graphical solution procedure in game theory, solution of 2×2 games, $2 \times n$ games and $m \times 2$ games, dominance property and related problems

Books Recommended:

1. Hamdy A. Taha, *Operations Research, An Introduction*, 8th Ed., Prentice-Hall India, 2006.
2. D.C. Sanyal and K. Das, *Introduction to Linear Programming*, U.N. Dhur and Sons

MATHEMATICS -SEC-601 (III)
Analytical Geometry
(Theory: 60 Lectures; Credits: 4)
Full marks: 100 (ESE: 70; CCA 30)
Pass marks: 40 (ESE: 28; CCA: 12)
(Each Unit carries equal weightage)

Unit-I

Change of origin, invariants in orthogonal transformation, pair of straight lines, bisector of angles between pair of straight lines

Unit-II

Orthogonal circles, radical axis, radical centre of three circles, circles through intersection of two circles, circles through intersection of a circle and a straight line, condition of tangency of a straight line to a circle, parabola, ellipse and hyperbola

Unit-III

Definition, equation of polar of a point with respect to a circle, parabola, ellipse and hyperbola, determination of the pole of a straight line with respect to a circle, parabola, ellipse and hyperbola,

Unit-IV

Shortest distance and equation of shortest distance line, general equation of a sphere, sphere through origin and having intercepts on the axes, section of a sphere by a plane, great circle, sphere through a given circle, the curve of intersection of two spheres, tangent plane to a sphere at a given point on it

Unit-V

Classification of quadratic equations representing lines, parabola, ellipse and hyperbola, spheres, cylindrical surfaces, illustrations of graphing standard quadric surfaces like cone, ellipsoid

Books Recommended

1. G.B. Thomas and R.L. Finney, *Calculus*, 9th Ed., Pearson Education, Delhi, 2005.
2. B.Das, *Coordinate Geometry*
3. S.L. Loney, *The Elements of Coordinate Geometry*, McMillan and Company, London.

4. R.J.T. Bill, *Elementary Treatise on Coordinate Geometry of Three Dimensions*, McMillan India Ltd., 1994.

PROPOSED SCHEME FOR CHOICE BASED CREDIT SYSTEM IN
B.Sc. Honours (Mathematics)

Semester	Core Course (14)	Ability Enhancement Compulsory Course (AECC) (2)	Skill Enhancement Course (SEC) (2)	Discipline Specific Elective (DSE) (4)	Generic Elective (GE) (4)
1	C-101: Calculus (Credit: 4+2) C-102: Higher Algebra (Credit: 5+1)	AECC-101: English/MIL (Credit: 4)			GE-101(I): Differential Calculus (Credit: 5+1) GE-101 (II): Finite Element Method (Credit: 4+2)
2	C-201: Real Analysis (Credit: 5+1) C-202: Differential Equations (Credit: 4+2)	AECC-201: Environmental Studies (Credit: 4)			GE-201(I): Differential Equations (Credit: 5+1) GE-201 (II): Econometrics (Credit: 5+1)
3	C-301: Theory of Real Functions (Credit: 5+1) C-302: Group Theory (Credit: 5+1) C-303: PDE & Systems of ODE (Credit: 4+2)		SEC-301 (I): Logic & Sets (Credit: 4) SEC-301(II): Computer Graphics (Credit: 4) SCE-301(III): Programming in C (Credit: 4)		GE-301(I): Real Analysis (Credit: 5+1) GE-301 (II): Mathematical Finance (Credit: 5+1)
4	C-401: Numerical Methods (Credit: 4+2) C-402: Riemann Integration & Series of Functions (Credit: 5+1) C-403: Ring Theory (Credit: 5+1)		SEC-401 (I): Graph Theory (Credit: 4) SEC-401(II): Operating System: Linux (Credit: 4) SCE-401(III): Special Functions (Credit: 4)		GE-401(I): Abstract Algebra (Credit: 5+1) GE-401 (II): Combinatorial Mathematics (Credit: 5+1)
5	C-501: Topology (Credit: 5+1) C-502: Multivariate Calculus (Credit: 5+1)			DSE-501: (I) Number Theory (Credit: 5+1)/ (II) Probability & Statistics (Credit: 5+1) (III) Mechanics (Credit: 5+1) DSE-502: (I) Analytical Geometry (Credit: 5+1)/ (II) Industrial Mathematics (Credit: 5+1)/ (III) Boolean Algebra & Automata Theory (Credit: 5+1)	
6	C-601: Complex Analysis (Credit: 5+1) C-102: Linear Algebra (Credit: 5+1)			DSE-601:(I) Linear Programming (Credit: 5+1)/ (II) Biomathematics (Credit: 5+1)/ (III): Object Oriented Programming in C++ (Credit: 4+2) DSE-602: (I) Hydrodynamics (Credit: 5+1)/ (II) Mathematical Modelling (Credit: 4+2)/ (III) Theory of Equations (Credit: 5+1)/ (IV) Project Work	

CORE COURSES (C): MATHEMATICS (HONOURS)

Semester	Course No.	Name of the Course	Page No.
I	MATHEMATICS -C-101	Calculus	4
	MATHEMATICS -C-101-LAB	Calculus (Practical)	5
	MATHEMATICS -C-102	Higher Algebra	6
II	MATHEMATICS - C-201	Real Analysis	7
	MATHEMATICS -C-202	Differential Equations	8
	MATHEMATICS -C-202-LAB	Differential Equations (Practical)	9
III	MATHEMATICS -C-301	Theory of Real Functions	10
	MATHEMATICS -C-302	Group Theory	11
	MATHEMATICS -C-303	PDE and Systems of ODE	12
	MATHEMATICS -C-303-LAB	PDE and Systems of ODE (Practical)	13
IV	MATHEMATICS -C-401	Numerical Methods	14
	MATHEMATICS -C-401-LAB	Numerical Methods (Practical)	15
	MATHEMATICS -C-402	Riemann Integrations & Series of Functions	16
	MATHEMATICS -C-403	Ring Theory	17
V	MATHEMATICS -C-501	Topology	18
	MATHEMATICS -C-502	Multivariate Calculus	19
VI	MATHEMATICS -C-601	Complex Analysis	20
	MATHEMATICS -C-602	Linear Algebra	21

**DISCIPLINE SPECIFIC ELECTIVES (DSE):
MATHEMATICS HONOURS**

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V	MATHEMATICS -DSE-501(I)	Number Theory	22
	MATHEMATICS -DSE-501(II)	Probability & Statistics	23
	MATHEMATICS -DSE-501(III)	Mechanics	24
	MATHEMATICS -DSE-502(I)	Analytical Geometry	25
	MATHEMATICS -DSE-502(II)	Industrial Mathematics	26
	MATHEMATICS -DSE-502(III)	Boolean Algebra & Automata Theory	27
VI	MATHEMATICS -DSE-601(I)	Linear Programming	28
	MATHEMATICS -DSE-601(II)	Biomathematics	29
	MATHEMATICS -DSE-601(II)	Object Oriented Programming in C++	30
	MATHEMATICS -DSE-601(II)-LAB	Object Oriented Programming in C++(Practical)	31
	MATHEMATICS -DSE-602(I)	Hydrodynamics	32
	MATHEMATICS -DSE-602(II)	Mathematical Modeling	33
	MATHEMATICS -DSE-602(II)-LAB	Mathematical Modeling (Practical)	34
	MATHEMATICS -DSE-602(III)	Theory of Equations	35
	MATHEMATICS -DSE-602(IV)	Project Work	36

**SKILL ENHANCEMENT COURSES (SEC):
MATHEMATICS HONOURS**

Semester	Course No.	Name of the Course	Page No.
III	MATHEMATICS -SEC-301(I)	Logic & Sets	37
	MATHEMATICS -SEC-301(II)	Computer Graphics	38
	MATHEMATICS -SEC-301(III)	Programming in C	39
IV	MATHEMATICS -SEC-401(I)	Graph Theory	40
	MATHEMATICS -SEC-401(II)	Operating System: Linux	41
	MATHEMATICS -SEC-401(III)	Special Functions	42

GENERIC ELECTIVES (GE): FOR OTHER DISCIPLINES

Semester	Course No.	Name of the Course	Page No.
I	MATHEMATICS -GE-101(I)	Differential Calculus	43
	MATHEMATICS -GE-101(II)	Finite Element Method	44
	MATHEMATICS-GE-101(II)-LAB	Finite Element Method (Practical)	45
II	MATHEMATICS -GE-201(I)	Differential Equations	46
	MATHEMATICS -GE-201(II)	Econometrics	47
III	MATHEMATICS -GE-301(I)	Real Analysis	48
	MATHEMATICS -GE-301(II)	Mathematical Finance	49
IV	MATHEMATICS -GE-401(I)	Abstract Algebra	50
	MATHEMATICS -GE-401(II)	Combinatorial Mathematics	51

CORE COURSES

MATHEMATICS -C-101

Calculus

(Theory: 60 Lectures; Credit: 4)

Full marks: 70 (ESE: 50; CCA: 20)

Pass marks: 28 (ESE: 20; CCA: 8)

(Each Unit carries equal weightage)

Unit-I

Differentiation of hyperbolic functions, higher order derivatives, Leibniz rule and its applications to problems of the type $e^{ax+b} \sin x$, $e^{ax+b} \cos x$, $(ax+b)^n \sin x$, $(ax+b)^n \cos x$.

Unit-II

Concavity and inflection points, asymptotes, curve tracing in Cartesian coordinates, tracing in polar coordinates of standard curves, L'Hospital's rule.

Unit-III

Reduction formulae, derivations and illustrations of reduction formulae of the type $\int \sin nx dx$, $\int \cos nx dx$, $\int \tan nx dx$, $\int \sec nx dx$, $\int (\log x)^n dx$, $\int \sin^n x \cos^m x dx$, $\int \sin mx \cos nx dx$.

Unit-IV

Parametric equations, parameterizing a curve, arc length, arc length of parametric curves, area of surface of revolution.

Unit-V

Triple product, introduction to vector functions, operations with vector-valued functions, limits and continuity of vector functions, differentiation and integration of vector functions, tangent and normal components of acceleration.

Books Recommended

1. G.B. Thomas and R.L. Finney, *Calculus*, 9th Ed., Pearson Education, Delhi, 2005.
2. B.C. Das and B.N. Mukherjee, *Differential Calculus*, U.N. Dhur and Sons
3. B.C. Das and B.N. Mukherjee, *Integral Calculus*, U.N. Dhur and Sons
4. M.R. Spiegel, *Vector Calculus*, McGraw Hill

MATHEMATICS -C-101-LAB

Calculus

(Practical: Credit: 2)

Full marks: 30

Pass marks: 20

List of Experiments (using any software)

1. Plotting of graphs of function e^{ax+b} , $\log(ax+b)$, $1/(ax+b)$, $\sin(ax+b)$, $\cos(ax+b)$, $|ax+b|$ and to illustrate the effect of a and b on the graph.
2. Plotting the graphs of polynomial of degree 4 and 5, the derivative graph, the second derivative graph and comparing them.
3. Sketching parametric curves (Eg. Trochoid, cycloid, epicycloids, hypocycloid).
4. Obtaining surface of revolution of curves.
5. Tracing of conics in cartesian coordinates/ polar coordinates.
6. Sketching ellipsoid, hyperboloid of one and two sheets, elliptic cone, elliptic, paraboloid, hyperbolic paraboloid using cartesian coordinates.

MATHEMATICS -C-102
Higher Algebra
(Theory: 75 Lectures; 15 Tutorials; Credit: 5+1)

Full marks: 100 (ESE: 70; CCA: 30)
Pass marks: 40 (ESE: 28; CCA: 12)
(Each Unit carries equal weightage)

Unit-I

Polar representation of complex numbers, n th roots of unity, De Moivre's theorem for rational indices and its applications (expansion of $\sin nx$, $\cos nx$, $\sin^n x$, $\cos^n x$ upto Gregory series)

Unit-II

Equivalence relations, Functions, Composition of functions, Invertible functions, One to one correspondence and cardinality of a set

Unit-III

Well-ordering property of positive integers, Division algorithm, Divisibility and Euclidean algorithm, Congruence relation between integers, Principles of Mathematical Induction, statement of Fundamental Theorem of Arithmetic

Unit-V

Introduction to linear transformations on \mathbb{R}^n , matrix of a linear transformation, inverse of a matrix, characterizations of invertible matrices, subspaces of \mathbb{R}^n , dimension of subspaces of \mathbb{R}^n and rank of a matrix.

Unit-IV

Systems of linear equations, row reduction and echelon forms, vector equations, the matrix equation $Ax=b$, solution sets of linear systems, applications of linear systems, linear independence.

Books Recommended

1. B.C. Das and B.N. Mukherjee, Higher Trigonometry, U.N. Dhur and Sons
2. Edgar G. Goodaire and Michael M. Parmenter, *Discrete Mathematics with Graph Theory*, 3rd Ed., Pearson Education (Singapore) P. Ltd., Indian Reprint, 2005.
3. David C. Lay, *Linear Algebra and its Applications*, 3rd Ed., Pearson Education Asia, Indian Reprint, 2007.
4. D.M. Burton, Elementary Number Theory, McGraw Hill

MATHEMATICS -C-201

Real Analysis

(Theory: 75 Lectures; 15 Tutorials; Credit: 5+1)

Full marks: 100 (ESE: 70; CCA: 30)

Pass marks: 40 (ESE: 28; CCA: 12)

(Each Unit carries equal weightage)

Unit-I

Review of algebraic and order properties of \mathcal{R} , δ -neighborhood of a point in \mathcal{R} , idea of countable sets, uncountable sets and uncountability of \mathcal{R} . bounded above sets, bounded below sets, bounded sets, unbounded sets, suprema and infima, the completeness property of \mathcal{R} , the Archimedean property, density of rational (and irrational) numbers in \mathcal{R} , intervals in \mathcal{R} .

Unit-II

Limit points of a set, isolated points, derived sets, open and closed sets, closure of a set, illustrations of Bolzano-Weierstrass theorem for sets.

Unit-III

Sequences, bounded sequence, convergent sequence, limit of a sequence, limit theorems, monotone sequences, monotone convergence theorem.

Unit-IV

Subsequences, divergence criteria, monotone subsequence theorem (statement only), Bolzano Weierstrass theorem for sequences, Cauchy sequence, Cauchy's convergence criterion

Unit-V

Infinite series, convergence and divergence of infinite series, Cauchy criterion, tests for convergence: comparison test, limit comparison test, ratio test, Cauchy's n th root test, integral test, alternating series, Leibniz test, absolute and conditional convergence.

Books Recommended

1. R.G. Bartle and D. R. Sherbert, *Introduction to Real Analysis*, 3rd Ed., John Wiley and Sons (Asia) Pvt. Ltd., Singapore, 2002.
2. S.C. Malik and S. Arora, *Mathematical Analysis*, New Age International Publications

MATHEMATICS -C-202

Differential Equations

(Theory: 60 Lectures; Credit: 4)

Full marks: 70 (ESE: 50; CCA: 20)

Pass marks: 28 (ESE: 20; CCA: 8)

(Each Unit carries equal weightage)

Unit-I

Differential equation and its formulation, general, particular, explicit, implicit and singular solutions of a differential equation, wronskian: its properties

Unit-II

Exact differential equations and integrating factors, separable equations and equations reducible to this form, linear equation and Bernoulli equations, special integrating factors and transformations

Unit-III

Introduction to compartmental model, exponential decay model, lake pollution model (case study of lake burley griffin), drug assimilation into the blood (case of a single cold pill, case of a course of cold pills), exponential growth of population, limited growth of population, limited growth with harvesting.

Unit-IV

Simultaneous differential equations and total differential equations

Unit-V

Solutions of linear equations of higher order with constant coefficients, general solution of homogeneous equation of second order, linear homogeneous and non-homogeneous equations, principle of superposition for linear homogeneous equation, method of variation of parameters

Books Recommended

1. S.L. Ross, *Differential Equations*, 3rd Ed., John Wiley and Sons, India, 2004.
2. Z. Ahsan, *Differential Equations & their applications*, Prentice Hall of India
3. Kapur, J.N., *Mathematical Modeling*, New Age International Publishers

MATHEMATICS -C-202-LAB

Differential Equations

(Practical: Credits: 2)

Full marks: 30

Pass marks: 12

List of Experiments (using any software)

1. Plotting of second order solution family of differential equation.
2. Plotting of third order solution family of differential equation.
3. Growth model (exponential case only).
4. Decay model (exponential case only).
5. Lake pollution model (with constant/seasonal flow and pollution concentration).
6. Case of single cold pill and a course of cold pills.
7. Limited growth of population (with and without harvesting).
8. Pre-predatory model (basic volterra model, with density dependence, effect of DDT, two prey one predator).
9. Epidemic model of influenza (basic epidemic model, contagious for life, disease with carriers).
10. Battle model (basic battle model, jungle warfare, long range weapons).
11. Plotting of recursive sequences.
12. Study the convergence of sequences through plotting.
13. Verify Bolzano-Weierstrass theorem through plotting of sequences and hence identify convergent subsequences from the plot.
14. Study the convergence/divergence of infinite series by plotting their sequences of partial sum.
15. Cauchy's root test by plotting n^{th} roots.
16. Ratio test by plotting the ratio of n^{th} and $(n+1)^{\text{th}}$ term.

MATHEMATICS -C-301
Theory of Real Functions
(Theory: 75 Lectures; 15 Tutorials; Credit: 5+1)
Full marks: 100 (ESE: 70; CCA: 30)
Pass marks: 40 (ESE: 28; CCA: 12)
(Each Unit carries equal weightage)

Unit-I

Limits of functions ($\varepsilon - \delta$ approach), sequential criterion for limits, divergence criteria, limit theorems, one sided limits, infinite limits and limits at infinity

Unit-II

Continuous functions, sequential criterion for continuity and discontinuity, algebra of continuous functions, continuous functions on an interval, intermediate value theorem, location of roots theorem, preservation of intervals theorem

Unit-III

Differentiability of a function at a point and in an interval, Caratheodory's theorem, algebra of differentiable functions, relative extrema, interior extremum theorem, Rolle's theorem, mean value theorem, intermediate value property of derivatives, Darboux's theorem

Unit-IV

Uniform continuity, non-uniform continuity criteria via sequences, algebra of uniformly continuous functions, uniform continuity theorems, sufficient condition for uniform continuity using derivative, Lipchitz's continuity

Unit-V

Applications of mean value theorem to inequalities and approximation of polynomials, Taylor's theorem to inequalities, Cauchy's mean value theorem, Taylor's theorem with Lagrange's form of remainder, Taylor's theorem with Cauchy's form of remainder, application of Taylor's theorem to convex functions, relative extrema. Taylor's series and Maclaurin's series expansions of exponential and trigonometric functions, $\ln(1+x)$, $1/ax+b$ and $(1+x)^n$.

Books Recommended

1. R. Bartle and D.R. Sherbert, *Introduction to Real Analysis*, John Wiley and Sons, 2003.
2. K.A. Ross, *Elementary Analysis: The Theory of Calculus*, Springer, 2004.
3. S.C. Malik and S. Arora, *Real Analysis*, New Age International Publishers

MATHEMATICS -C-302
Group Theory
(Theory: 75 Lectures; 15 Tutorials; Credit: 5+1)
Full marks: 100 (ESE: 70; CCA: 30)
Pass marks: 40 (ESE: 28; CCA: 12)
(Each Unit carries equal weightage)

Unit-I

Symmetries of a square, dihedral groups, definition and examples of groups including permutation groups and quaternion groups (illustration through matrices), elementary properties of groups

Unit-II

Subgroups and examples of subgroups, centralizer, normalizer, center of a group, product of two subgroups

Unit-III

properties of cyclic groups, classification of subgroups of cyclic groups, cycle notation for permutations, properties of permutations, even and odd permutations, alternating group

Unit-IV

Cosets, properties of cosets, Lagrange's theorem and consequences including Fermat's Little theorem, external direct product of a finite number of groups, normal subgroups, factor groups.

Unit-V

Group homomorphisms, properties of homomorphisms, Cayley's theorem, properties of isomorphisms, first, second and third isomorphism theorems

Books Recommended

1. John B. Fraleigh, *A First Course in Abstract Algebra*, 7th Ed., Pearson, 2002.
3. Joseph A. Gallian, *Contemporary Abstract Algebra*, 4th Ed., Narosa Publishing House, New Delhi, 1999.

MATHEMATICS -C-303
PDE and Systems of ODE
(Theory: 60 Lectures; Credit: 4)
Full marks: 70 (ESE: 50; CCA: 20)
Pass marks: 28 (ESE: 20; CCA: 8)
(Each Unit carries equal weightage)

Unit-I

Partial differential equations – basic concepts and definitions, mathematical problems, first order equations, classification, construction and geometrical interpretation, some exact solutions of lower order non-linear PDE (method of inspection)

Unit-II

Canonical forms of first-order linear equations, method of separation of variables for solving first order partial differential equations, Lagrange's equation and its solutions

Unit-III

Classification of second order linear equations as hyperbolic, parabolic or elliptic, reduction of second order linear equations to canonical forms, Solution of linear PDE with constant coefficients upto order two.

Unit-IV

Initial-boundary value problems, semi-infinite string with a fixed end, semi-infinite string with a free end, equations with non-homogeneous boundary conditions, one dimensional homogeneous wave and heat conduction equation, solving by separation of variables

Unit-V

Systems of linear differential equations, types of linear systems, differential operators, an operator method for solving linear systems with constant coefficients, basic theory of linear systems in normal form, homogeneous linear systems with constant coefficients: two equations in two unknown functions

Books Recommended

1. S.L. Ross, *Differential equations*, 3rd Ed., John Wiley and Sons, India, 2004.
2. Martha L Abell, James P Braselton, *Differential equations with MATHEMATICA*, 3rd Ed., Elsevier Academic Press, 2004.
3. M.D. Raisinghania, *Advanced Differential Equations*, S. Chand and Sons

MATHEMATICS -C-303-LAB

PDE and Systems of ODE

(Practical: Credits: 02)

Full marks: 30

Pass marks: 12

List of Experiments (using any software)

1. Solution of Cauchy problem for first order PDE.
2. Finding the characteristics for the first order PDE.
3. Plot the integral surfaces of a given first order PDE with initial data.

MATHEMATICS -C-304
Numerical Methods
(Theory: 60 Lectures; Credit: 4)
Full marks: 70 (ESE: 50; CCA: 20)
Pass marks: 28 (ESE: 20; CCA: 8)
(Each Unit carries equal weightage)

Use of Scientific Calculator is allowed

Unit-I

Algorithms, convergence, error analysis: relative, absolute, round off, truncation.

Unit-II

Transcendental and polynomial equations: bisection method, regula-falsi method, Newton's method, secant method, rate of convergence of these methods, related problems

Unit-III

System of linear algebraic equations: Gaussian Elimination and Gauss -Jordan methods. Gauss- Jacobi method, Gauss- Seidel method and their convergence analysis, related problems

Unit-IV

Interpolation: Lagrange and Newton's methods, error bounds, finite difference operators, Gregory forward and backward difference interpolation, related problems

Unit-V

Numerical integration: Trapezoidal rule, Simpson's 1/3 rule, Simpson's 3/8th rule, Boole's Rule, midpoint rule, composite Trapezoidal rule, composite Simpson's rule, numerical ordinary differential equations: Euler's method, Modified Euler's method

Books Recommended

1. M.K. Jain, S.R.K. Iyengar and R.K. Jain, *Numerical Methods for Scientific and Engineering Computation*, 6th Ed., New age International Publisher, India, 2007.
2. P.P. Gupta and G.S. Malik, *Calculus of Finite Differences and Numerical Analysis*, Krishna Prakashan Media.

MATHEMATICS -C-304-LAB

Numerical Methods (Practical: Credit: 2)

Full marks: 30
Pass marks: 12

List of Experiments (using any software)

1. Calculate the sum $1/1 + 1/2 + 1/3 + 1/4 + \dots + 1/N$.
2. To find the absolute value of an integer.
3. Enter 100 integers into an array and sort them in an ascending order.
4. Bisection Method.
5. Newton-Raphson Method.
6. Secant Method.
7. Regula-Falsi Method.
8. LU decomposition Method.
9. Gauss-Jacobi Method.
10. SOR Method or Gauss-Siedel Method.
11. Lagrange Interpolation or Newton Interpolation.
12. Simpson's rule.
13. Euler's method

Note: For any of the CAS (Computer aided software) Data types-simple data types, floating data types, character data types, arithmetic operators and operator precedence, variables and constant declarations, expressions, input/output, relational operators, logical operators and logical expressions, control statements and loop statements, Arrays should be introduced to the students.

MATHEMATICS -C-401
Riemann Integration and Series of Functions
(Theory: 75 Lectures; 15 Tutorials; Credit: 5+1)

Full marks: 100 (ESE: 70; CCA: 30)

Pass marks: 40 (ESE: 28; CCA: 12)

(Each Unit carries equal weightage)

Unit-I

Riemann integration; inequalities of upper and lower sums; Riemann conditions of integrability. Riemann sum and definition of Riemann integral through Riemann sums; equivalence of two definitions; Riemann integrability of monotone and continuous functions

Unit-II

Properties of the Riemann integral; definition and integrability of piecewise continuous and monotone functions. Intermediate Value theorem for Integrals; Fundamental theorems of Calculus

Unit-III

Improper integrals of first and second kind; Convergence of Beta and Gamma functions

Unit-IV

Pointwise and uniform convergence of sequence and series of functions, definitions, examples, simple problems, Cauchy criterion for uniform convergence and Weierstrass M-Test

Unit-V

Limit superior and Limit inferior, power series, radius of convergence, Cauchy Hadamard theorem, differentiation and integration of power series

Books Recommended

1. K.A. Ross, *Elementary Analysis, The Theory of Calculus*, Undergraduate Texts in Mathematics, Springer (SIE), Indian reprint, 2004.
2. R.G. Bartle D.R. Sherbert, *Introduction to Real Analysis*, 3rd Ed., John Wiley and Sons (Asia) Pvt. Ltd., Singapore, 2002.
3. S.C. Malik and S. Arora, *Mathematical Analysis*, New Age International Publishers

MATHEMATICS -C-402

Ring Theory

(Theory: 75 Lectures; 15 Tutorials; Credit: 5+1)

Full marks: 100 (ESE: 70; CCA: 30)

Pass marks: 40 (ESE: 28; CCA: 12)

(Each Unit carries equal weightage)

Unit-I

Definition and examples of rings, properties of rings, subrings, nilpotent and idempotent elements, integral domains, division rings, fields, characteristic of a ring

Unit-II

Ideal, ideal generated by a subset of a ring, factor rings, operations on ideals, prime and maximal ideals.

Unit-III

Ring homomorphisms, properties of ring homomorphisms, Isomorphism theorems I, II and III and applications

Unit-IV

Polynomial rings over commutative rings, division algorithm and consequences, Euclidean domains, principal ideal domains

Unit-V

Factorization of polynomials, irreducibility tests, Eisenstein criterion, unique factorization in $\mathbb{Z}[x]$, prime and irreducibility elements

Books Recommended

1. John B. Fraleigh, *A First Course in Abstract Algebra*, 7th Ed., Pearson, 2002.
3. Joseph A. Gallian, *Contemporary Abstract Algebra*, 4th Ed., Narosa Publishing House, 1999.

MATHEMATICS -C-501

Topology

(Theory: 75 Lectures; 15 Tutorials; Credit: 5+1)

Full marks: 100 (ESE: 70; CCA: 30)

Pass marks: 40 (ESE: 28; CCA: 12)

(Each Unit carries equal weightage)

Unit-I

Metric spaces: definition and examples, open, closed sets and their properties, limit point of a set, diameter, interior, exterior, closure and boundary of a set

Unit-II

Sequences in metric spaces, complete metric spaces, continuity of functions in metric spaces

Unit-III

Topological spaces: definition and examples including usual, lower limit and upper limit topology in \mathbb{R} , cofinite and cocountable topology, discrete and indiscrete topologies, particular point topology, comparison of topologies, open, closed sets and their properties

Unit-IV

Union and intersection of topologies, metrizable spaces, Hausdorff spaces, limit point, neighbourhood of a point, interior, exterior, closure and boundary of a set

Unit-V

Sequences in topological spaces and their convergence, continuity of functions in topological spaces, non-uniqueness of limit in topological spaces

Books Recommended:

1. G.F. Simmons, Introduction to topology and modern analysis, McGraw Hill Education (India) Pvt. Ltd.
2. S. Kumaresan, Topology of metric spaces, Narosa Publishers

MATHEMATICS -C-502
Multivariate Calculus
(Theory: 75 Lectures; 15 Tutorials; Credit: 5+1)
Full marks: 100 (ESE: 70; CCA: 30)
Pass marks: 40 (ESE: 28; CCA: 12)
(Each Unit carries equal weightage)

Unit-I

Functions of several variables, limit and continuity of functions of two variables, repeated limits, partial differentiation, directional derivatives, the gradient, maximal and normal property of the gradient, tangent planes

Unit-II

Extrema of functions of two variables, method of Lagrange multipliers, constrained optimization problems

Unit-III

Definition of vector field, divergence and curl Double integration over rectangular region, double integration over non-rectangular region, Double integrals in polar co-ordinates

Unit-IV

Triple integrals, Triple integral over a parallelepiped and solid regions, volume by triple integrals, cylindrical and spherical co-ordinates. Change of variables in double integrals and triple integrals. Line integrals, Applications of line integrals: Mass and Work

Unit-V

Fundamental theorem for line integrals, conservative vector fields, independence of path, Green's theorem, surface integrals, integrals over parametrically defined surfaces, Stoke's theorem, the divergence theorem

Books Recommended

1. G.B. Thomas and R.L. Finney, *Calculus*, 9th Ed., Pearson Education, Delhi, 2005.
2. S.C. Malik and S. Arora, *Principles of Mathematical Analysis*, New Age International Publishers.

MATHEMATICS -C-601

Complex Analysis

(Theory: 75 Lectures; 15 Tutorials; Credit: 5+1)

Full marks: 100 (ESE: 70; CCA: 30)

Pass marks: 40 (ESE: 28; CCA: 12)

(Each Unit carries equal weightage)

Unit-I

Limits, limits involving the point at infinity, continuity, properties of complex numbers, regions in the complex plane, functions of complex variable, mappings

Unit-II

Derivatives, differentiation formulas, Cauchy-Riemann equations, sufficient conditions for differentiability, analytic functions, examples of analytic functions, exponential function, Logarithmic function, trigonometric function

Unit-III

Definite integrals of functions, contours, contour integrals and its examples, upper bounds for moduli of contour integrals, Cauchy-Goursat theorem, Cauchy's integral formula

Unit-IV

Liouville's theorem and the fundamental theorem of algebra, convergence of sequences and series, Taylor series and its examples

Unit-V

Laurent series and its examples, absolute and uniform convergence of power series

Books Recommended

1. James Ward Brown and Ruel V. Churchill, *Complex Variables and Applications*, 8th Ed., McGraw – Hill International Edition, 2009.
2. Joseph Bak and Donald J. Newman, *Complex Analysis*, 2nd Ed., Undergraduate Texts in Mathematics, Springer-Verlag New York, Inc., New York, 1997.
3. S. Ponnusamy, *Foundations of Complex Analysis*, Narosa Publishers
4. M.R. Spiegel, *Complex Analysis*, McGraw Hill Publications

MATHEMATICS -C-602

Linear Algebra

(Theory: 75 Lectures; 15 Tutorials; Credit: 5+1)

Full marks: 100 (ESE: 70; CCA: 30)

Pass marks: 40 (ESE: 28; CCA: 12)

(Each Unit carries equal weightage)

Unit-I

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

Unit-II

Linear transformations, null space, range, rank and nullity of a linear transformation, matrix representation of a linear transformation

Unit-III

Algebra of linear transformations, isomorphisms, isomorphism theorems, invertibility and isomorphisms, change of coordinate matrix

Unit-IV

Eigen spaces of a linear operator, diagonalizability, invariant subspaces and Cayley-Hamilton theorem, the minimal polynomial for a linear operator

Unit-V

Inner product spaces and norms, Cauchy-Schwartz inequality, Gram-Schmidt orthogonalisation process, orthogonal complements, Bessel's inequality, the adjoint of a linear operator, least squares approximation, minimal solutions to systems of linear equations

Books Recommended

1. Gilbert Strang, *Linear Algebra and its Applications*, Thomson, 2007
2. S. Kumaresan, *Linear Algebra- A Geometric Approach*, Prentice Hall of India, 1999
3. Kenneth Hoffman, Ray Alden Kunze, *Linear Algebra*, 2nd Ed., Prentice-Hall of India Pvt. Ltd., 1971.

Discipline Specific Electives

MATHEMATICS -DSE-501 (I)

Number Theory

(Theory: 75 Lectures; 15 Tutorials; Credit: 5+1)

Full marks: 100 (ESE: 70; CCA: 30)

Pass marks: 40 (ESE: 28; CCA: 12)

(Each Unit carries equal weightage)

Unit-I

Linear Diophantine equation, prime counting function, statement of prime number theorem, Goldbach conjecture, linear congruences, complete set of residues, Chinese Remainder theorem, Fermat's Little theorem, Wilson's theorem.

Unit-II

Number theoretic functions, sum and number of divisors, totally multiplicative functions, definition and properties of the Dirichlet product, the Mobius Inversion formula

Unit-III

The greatest integer function, Euler's phi-function, Euler's theorem, reduced set of residues, some properties of Euler's phi-function.

Unit-IV

Order of an integer modulo n , primitive roots for primes, composite numbers having primitive roots, Euler's criterion, the Legendre symbol and its properties, quadratic reciprocity, quadratic congruences with composite moduli

Unit-V

Mersenne primes, perfect numbers, amicable numbers, Fermat's number, the equation $x^2 + y^2 = z^2$, Fermat's Last theorem(statement and history only)

Books Recommended

1. David M. Burton, *Elementary Number Theory*, 6th Ed., Tata McGraw-Hill, Indian reprint, 2007.
2. K.C. Choudhury, *A First Course in Theory of Numbers*, Asian Books

MATHEMATICS -DSE-501 (II)

Probability and Statistics

(Theory: 75 Lectures; 15 Tutorials; Credit: 5+1)

Full marks: 100 (ESE: 70; CCA: 30)

Pass marks: 40 (ESE: 28; CCA: 12)

(Each Unit carries equal weightage)

Unit-I

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

Unit-II

Discrete distributions: uniform, binomial, Poisson, geometric, negative binomial, continuous distributions: uniform, normal, exponential

Unit-III

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

Unit-IV

Bivariate normal distribution, correlation coefficient, joint moment generating function (jmgf) and calculation of covariance (from jmgf), linear regression for two variables

Unit-V

Chebyshev's inequality, statement and interpretation of (weak) law of large numbers and strong law of large numbers, Central Limit theorem for independent and identically distributed random variables with finite variance

Books Recommended

1. Sheldon Ross, *Introduction to Probability Models*, 9th Ed., Academic Press, Indian Reprint, 2007.
2. S.C. Gupta and V.K. Kapoor, *Fundamentals of Mathematical Statistics*, Sultan Chand and Sons

MATHEMATICS -DSE-501 (III)

Mechanics

(Theory: 75 Lectures; 15 Tutorials; Credit: 5+1)

Full marks: 100 (ESE: 70; CCA: 30)

Pass marks: 40 (ESE: 28; CCA: 12)

(Each Unit carries equal weightage)

Unit-I

Coplanar forces and their resultant, equilibrium of three coplanar forces, simple problems involving contact with smooth planes, friction, laws of friction, angle of friction, cone of friction, simple examples.

Unit-II

Radial and transverse components of velocity and acceleration of a particle moving along a plane curve, angular velocity and acceleration, tangential and normal components of acceleration, simple harmonic motion.

Unit-III

Motion under inverse square law, motion under other laws of forces: laws of attraction being $\frac{\mu}{x}$, $\frac{\mu}{x^3}$, $\frac{\mu}{x^{5/3}}$, and $\mu(x + \frac{a^4}{x^3})$, Kepler's laws of planetary motion, motion in resisting medium under gravity.

Unit-IV

Work, power, energy, impulse of a force, principle of conservation of linear momentum, impact, direct impact of two spheres, laws of K.E. due to direct impact of two smooth spheres, direct impact of a solid on a fixed smooth surface.

Unit-IV

Moments and product of inertia, theorems of parallel and perpendicular axes, M.I. about any line in terms of M.I. about any three mutually perpendicular lines, principal axes, D'Alembert's principle

Books Recommended

1. M. Ray, Dynamics
2. B.C. Das and B.N. Mukherjee, Statics, U.N. Dhur publishers

MATHEMATICS -DSE-502 (I)

Analytical Geometry

(Theory: 75 Lectures; 15 Tutorials; Credit: 5+1)

Full marks: 100 (ESE: 70; CCA: 30)

Pass marks: 40 (ESE: 28; CCA: 12)

(Each Unit carries equal weightage)

Unit-I

Change of origin, invariants in orthogonal transformation, pair of straight lines, bisector of angles between pair of straight lines

Unit-II

Orthogonal circles, radical axis, radical centre of three circles, circles through intersection of two circles, circles through intersection of a circle and a straight line, condition of tangency of a straight line to a circle, parabola, ellipse and hyperbola, pair of tangents from an external point to a circle, parabola and ellipse

Unit-III

Definition, equation of polar of a point with respect to a circle, parabola, ellipse and hyperbola, determination of the pole of a straight line with respect to a circle, parabola, ellipse and hyperbola, polar equation of a conic in the form $\frac{l}{r} = 1 + e\cos\theta$, equation of chord and tangent, related problems

Unit-IV

Shortest distance and equation of shortest distance line, general equation of a sphere, sphere through origin and having intercepts on the axes, section of a sphere by a plane, great circle, sphere through a given circle, the curve of intersection of two spheres, tangent plane to a sphere at a given point on it, condition of tangency of a given plane to be a tangent plane to a sphere

Unit-V

Cone with vertex at a given point and a given curve as base, equation of a right circular cone with vertex is at a point other than origin, cylinder, equation of a cylinder, equation of a right circular cylinder, related examples

Books Recommended

1. S.L. Loney, *The Elements of Coordinate Geometry*, McMillan and Company, London.
4. B. Das, *Co-ordinate Geometry*
5. Shanti Narayan, *Co-ordinate Geometry*, S. Chand and Sons

MATHEMATICS -DSE-502 (Option-II)

Industrial Mathematics

(Theory: 75 Lectures; 15 Tutorials; Credit: 5+1)

Full marks: 100 (ESE: 70; CCA: 30)

Pass marks: 40 (ESE: 28; CCA: 12)

(Each Unit carries equal weightage)

Unit-I

Medical imaging and inverse problems, the content is based on Mathematics of X-ray and CT scan based on the knowledge of calculus, elementary differential equations, complex numbers and matrices.

Unit-II

Introduction to Inverse problems: Why should we teach Inverse Problems? Illustration of Inverse problems through problems taught in Pre-Calculus, Calculus, Matrices and differential equations.

Unit-III

Geological anomalies in Earth's interior from measurements at its surface (Inverse problems for Natural disaster) and Tomography, X-ray: Introduction, X-ray behavior and Beers Law (The fundamental question of image construction) Lines in the plane.

Unit-IV

Radon Transform: Definition and Examples, Linearity, Phantom (Shepp - Logan Phantom - Mathematical phantoms). Back Projection: Definition, properties and examples

Unit-V

CT Scan: Revision of properties of Fourier and inverse Fourier transforms and applications of their properties in image reconstruction. Algorithms of CT scan machine. Algebraic reconstruction techniques abbreviated as ART with application to CT scan.

Books Recommended

1. Timothy G. Feeman, *The Mathematics of Medical Imaging, A Beginners Guide*, Springer Under graduate Text in Mathematics and Technology, Springer, 2010.
2. C.W. Groetsch, *Inverse Problems, Activities for Undergraduates*, The Mathematical Association of America, 1999.
3. Andreas Kirsch, *An Introduction to the Mathematical Theory of Inverse Problems*, 2nd Ed., Springer, 2011.

MATHEMATICS -DSE-502 (Option-III)
Boolean Algebra & Automata Theory

(Theory: 75 Lectures; 15 Tutorials; Credit: 5+1)

Full marks: 100 (ESE: 70; CCA: 30)

Pass marks: 40 (ESE: 28; CCA: 12)

(Each Unit carries equal weightage)

Unit-I

Definition, examples and basic properties of ordered sets, maps between ordered sets, duality principle, lattices as ordered sets, lattices as algebraic structures, sublattices, products and homomorphisms

Unit-II

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.

Unit-III

Introduction: Alphabets, strings, and languages. Finite Automata and Regular Languages: deterministic and non-deterministic finite automata, regular expressions, regular languages and their relationship with finite automata, pumping lemma and closure properties of regular languages.

Unit-IV

Context Free Grammars and Pushdown Automata: Context free grammars (CFG), parse trees, ambiguities in grammars and languages, pushdown automaton (PDA) and the language accepted by PDA, deterministic PDA, Non- deterministic PDA, properties of context free languages; normal forms, pumping lemma, closure properties, decision properties. Turing Machines: Turing machine as a model of computation, programming with a Turing machine, variants of Turing machine and their equivalence.

Unit-V

Undecidability: Recursively enumerable and recursive languages, undecidable problems about Turing machines: halting problem, Post Correspondence Problem, and undecidability problems About CFGs.

Books Recommended

1. B A. Davey and H. A. Priestley, *Introduction to Lattices and Order*, Cambridge University Press, Cambridge, 1990.
2. Edgar G. Goodaire and Michael M. Parmenter, *Discrete Mathematics with Graph Theory*, (2nd Ed.), Pearson Education (Singapore) P.Ltd., Indian Reprint 2003.
3. Rudolf Lidl and Günter Pilz, *Applied Abstract Algebra*, 2nd Ed., Undergraduate Texts in Mathematics, Springer (SIE), Indian reprint, 2004.
4. J. E. Hopcroft, R. Motwani and J. D. Ullman, *Introduction to Automata Theory, Languages, and Computation*, 2nd Ed., Addison-Wesley, 2001.
5. H.R. Lewis, C.H. Papadimitriou, C. Papadimitriou, *Elements of the Theory of Computation*, 2nd Ed., Prentice-Hall, NJ, 1997.
6. J.A. Anderson, *Automata Theory with Modern Applications*, Cambridge University Press, 2006.

MATHEMATICS -DSE-601 (I)

Linear Programming

(Theory: 75 Lectures; 15 Tutorials; Credit: 5+1)

Full marks: 100 (ESE: 70; CCA: 30)

Pass marks: 40 (ESE: 28; CCA: 12)

(Each Unit carries equal weightage)

Unit-I

Introduction to linear programming problem, convex sets and properties, theory of simplex method, optimality and unboundedness, the simplex algorithm, simplex method in tableau format

Unit-II

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

Unit-III

Transportation problem and its mathematical formulation, northwest-corner method least cost method and Vogel approximation method for determination of starting basic solution, algorithm for solving transportation problem

Unit-IV

Assignment problem and its mathematical formulation, Hungarian method for solving assignment problem

Unit-V

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

Books Recommended

1. Hamdy A. Taha, *Operations Research, An Introduction*, 8th Ed., Prentice-Hall India, 2006.
2. R.K. Gupta, *Operations Research*, Krishna Prakashan Media, Merut

MATHEMATICS -DSE-601 (II)

Biomathematics

(Theory: 75 Lectures; 15 Tutorials; Credit: 5+1)

Full marks: 100 (ESE: 70; CCA: 30)

Pass marks: 40 (ESE: 28; CCA: 12)

(Each Unit carries equal weightage)

Unit-I

Mathematical Biology and the modeling process: an overview. Continuous models: Malthus model, logistic growth, Allee effect, Gompertz growth, Michaelis-Menten Kinetics, Holling type growth

Unit-II

Bacterial growth in a Chemostat, Harvesting a single natural population, Prey predator systems and Lotka-Volterra equations, Populations in competitions, Epidemic Models (SI, SIR, SIRS, SIC), Activator-Inhibitor system, Insect Outbreak Model: Spruce Budworm, Numerical solution of the models and its graphical representation.

Unit-III

Qualitative analysis of continuous models: Steady state solutions, stability and linearization, multiple species communities and Routh-Hurwitz Criteria, Phase plane methods and qualitative solutions, bifurcations and limit cycles with examples in the context of biological scenario.

Unit-IV

Spatial Models: One species model with diffusion, Two species model with diffusion, Conditions for diffusive instability, Spreading colonies of microorganisms, Blood flow in circulatory system, Travelling wave solutions, Spread of genes in a population.

Unit-V

Discrete Models: Overview of difference equations, steady state solution and linear stability analysis, Introduction to Discrete Models, Linear Models, Growth models, Decay models, Drug Delivery Problem, Discrete Prey-Predator models, Density dependent growth models with harvesting, Host-Parasitoid systems (Nicholson-Bailey model), Numerical solution of the models and its graphical representation. Case Studies: Optimal Exploitation models, Models in Genetics, Stage Structure Models, Age Structure Models.

Books Recommended

1. L.E. Keshet, *Mathematical Models in Biology*, SIAM, 1988.
2. J. D. Murray, *Mathematical Biology*, Springer, 1993.

MATHEMATICS -DSE-601 (II)
Object Oriented Programming in C++
(Theory: 60 Lectures; Credit: 4)
Full marks: 70 (ESE: 50; CCA: 20)
Pass marks: 28 (ESE: 20; CCA: 8)
(Each Unit carries equal weightage)

Unit-I

OOP Paradigm: Comparison of Programming paradigms, Characteristics of Object-Oriented Programming Languages, Object-based programming languages C++: Brief History of C++, Structure of a C++ program, Difference between C and C++ - cin, cout, new, delete operators, ANSI/ISO Standard C++, Comments, Working with Variables and const Qualifiers.

Unit-II

Enumeration, Arrays and Pointer. Implementing oops concepts in C++ Objects, Classes, Encapsulation, Data Abstraction, Inheritance, Polymorphism, Dynamic Binding, Message Passing, Default Parameter Value, Using Reference variables with Functions.

Unit-III

Abstract data types, Class Component, Object & Class, Constructors Default and Copy Constructor, Assignment operator deep and shallow coping, Access modifiers – private, public and protected.

Unit-IV

Implementing Class Functions within Class declaration or outside the Class declaration. instantiation of objects, Scope resolution operator, working with friend functions, using static class members

Unit-V

Understanding Compile Time Polymorphism function overloading Rules of Operator Overloading (Unary and Binary) as member function/friend function, Implementation of operator overloading of Arithmetic Operators, Overloading Output/Input, Prefix/ Postfix Increment and decrement Operators, Overloading comparison operators, Assignment, subscript and function call Operator, concepts of namespaces.

Books Recommended

1. A. R. Venugopal, Rajkumar, and T. Ravishanker, *Mastering C++*, TMH, 1997
2. E. Balagurusamy, *Object oriented Programming with C++*, McGraw-Hill Publishers

MATHEMATICS -GE-101(II)-LAB
Object Oriented Programming in C++
(Practical: Credits: 2)

Full marks: 30
Pass marks: 20

Practical to be performed in lab

MATHEMATICS -DSE-602 (I)

Hydrodynamics

(Theory: 75 Lectures; 15 Tutorials; Credit: 5+1)

Full marks: 100 (ESE: 70; CCA: 30)

Pass marks: 40 (ESE: 28; CCA: 12)

(Each Unit carries equal weightage)

Unit-I

Types of fluids(real and ideal fluids), description of fluid motion(Eulerian and Lagrangian methods), stream lines, path lines, velocity potential, irrotational motion

Unit-II

Equation of continuity-Lagrangian and Eulerian forms and their equivalence, Cartesian, polar, and curvilinear forms of equation of continuity.

Unit-III

Stream functions- Definition and simple problems only, Rate of motion – Local and individual rates and their relation, acceleration of a fluid particle (vector form and its equivalence in cartesian and polar forms), Related problems.

Unit -IV

Equation of motion – Equation of motion of an inviscid fluid (Eulerian and Lamb's hydrodynamics forms) , The basic dynamical principles (the principle of linear momentum, angular momentum and energy definition only)

Unit-V

Pressure at a point in moving fluid of known velocity, Bernoulli's theorem and related problems

Books Recommended

1. M.D. Raisinghania, Hydrodynamics, S. Chand and Sons
2. Shanti Swarup, Hydrodynamics, Krishna Prakashan Media

MATHEMATICS -DSE-602 (II)

Mathematical Modeling

(Theory: 60 Lectures; Credit: 4)

Full marks: 70 (ESE: 50; CCA: 20)

Pass marks: 28 (ESE: 20; CCA: 8)

(Each Unit carries equal weightage)

Unit-I

Power series solution of a differential equation about an ordinary point, solution about a regular singular point

Unit-II

Bessel's equation and Legendre's equation.

Unit-III

Laplace transform and inverse transform application to initial value problem up to second order.

Unit-IV

Monte Carlo Simulation Modeling: simulating deterministic behavior (area under a curve, volume under a surface), Generating Random Numbers: middle square method, linear congruence

Unit-V

Queuing Models: harbor system, morning rush hour, Overview of optimization modeling, Linear Programming Model: geometric solution algebraic solution, simplex method, sensitivity analysis

Books Recommended

1. TynMyint-U and Lokenath Debnath, *Linear Partial Differential Equation for Scientists and Engineers*, Springer, Indian reprint, 2006.
2. Frank R. Giordano, Maurice D. Weir and William P. Fox, *A First Course in Mathematical Modeling*, Thomson Learning, London and New York, 2003.

MATHEMATICS -DSE-602(II)-LAB

Mathematical Modeling

(Practical: Credits: 2)

Full marks: 30

Pass marks: 20

List of Practicals (using any software)

1. Plotting of Legendre polynomial for $n = 1$ to 5 in the interval $[0,1]$. Verifying graphically that all the roots of $P_n(x)$ lie in the interval $[0,1]$.
2. Automatic computation of coefficients in the series solution near ordinary points.
3. Plotting of the Bessel's function of first kind of order 0 to 3 .
4. Automating the Frobenius Series Method.
5. Random number generation and then use it for one of the following (a) Simulate area under a curve (b) Simulate volume under a surface.
6. Programming of either one of the queuing model (a) Single server queue (e.g. Harbor system) (b) Multiple server queue (e.g. Rush hour).
7. Programming of the Simplex method for $2/3$ variables.

MATHEMATICS -DSE-602 (III)

Theory of Equations

(Theory: 75 Lectures; 15 Tutorials; Credit: 5+1)

Full marks: 100 (ESE: 70; CCA: 30)

Pass marks: 40 (ESE: 28; CCA: 12)

(Each Unit carries equal weightage)

Unit-I

General properties of polynomials, Graphical representation of a polynomial, maximum and minimum values of a polynomials, General properties of equations, Descarte's rule of signs positive and negative rule

Unit-II

Relation between the roots and the coefficients of equations.Symmetric functions, Applications of symmetric function of the roots, Transformation of equations.Solutions of reciprocal and binomial equations.

Unit-III

Algebraic solutions of the cubic and biquadratic.Properties of the derived functions, Symmetric functions of the roots, Newton's theorem on the sums of powers of roots

Unit-IV

homogeneous products, limits of the roots of equations. Separation of the roots of equations, Strums theorem, Applications of Strum's theorem

Unit-V

Conditions for reality of the roots of an equation and biquadratic, Solution of numerical equations

Books Recommended

1. W.S. Burnside and A.W. Panton, *The Theory of Equations*, Dublin University Press, 1954.
2. C. 2. MacDuffee, *Theory of Equations*, John Wiley & Sons Inc., 1954.

MATHEMATICS -DSE-602 (IV)

Project Work

Full marks: 100 (External: 70; Sessional 30)

Pass marks: 40 (External: 28; Sessional 12)

A student has to prepare a project report in any of the branches of mathematics under the supervision of a teacher, which will be evaluated by an external expert. Also the student has to present his/her work in front of the external expert and has to appear for Viva-voce conducted by the external expert.

Skill Enhancement Courses

MATHEMATICS -SEC-301 (I)

Logic & Sets

(Theory: 60 Lectures; Credits: 4)

Full marks: 100 (ESE: 70; CCA:30)

Pass marks: 40 (ESE: 28; CCA:12)

(Each Unit carries equal weightage)

Unit-I

Introduction, propositions, truth table, negation, conjunction and disjunction. Implications, biconditional propositions, converse, contra positive and inverse propositions and precedence of logical operators.

Unit-II

Propositional equivalence: Logical equivalences. Predicates and quantifiers: Introduction, Quantifiers, Binding variables and Negations.

Unit-III

Sets, subsets, Set operations and the laws of set theory and Venn diagrams. Examples of finite and infinite sets, Finite sets and counting principle. Empty set, properties of empty set. Standard set operations.

Unit-IV

Classes of sets. Power set of a set. Difference and Symmetric difference of two sets. Set identities, Generalized union and intersections.

Unit-V

Relation: Product set, Composition of relations, Types of relations, Partitions, Equivalence Relations with example of congruence modulo relation, Partial ordering relations, nary relations.

Books Recommended

1. R.P. Grimaldi, *Discrete Mathematics and Combinatorial Mathematics*, Pearson Education, 1998.
2. P.R. Halmos, *Naive Set Theory*, Springer, 1974.
3. E. Kamke, *Theory of Sets*, Dover Publishers, 1950.

MATHEMATICS -SEC-301 (II)
Computer Graphics
(Theory: 60 Lectures; Credits: 4)
Full marks: 100 (ESE: 70; CCA:30)
Pass marks: 40 (ESE: 28; CCA:12)

(Each Unit carries equal weightage)

Unit-I

Introduction to computer and its components, bits, bytes, computer memory, RAM, ROM, I/O devices, on line and off line data entry, magnetic tape, disks etc., Software and Hardware concepts, computer generations, types of computer systems, field , record, files.

Unit-II

Development of computer Graphics: Raster Scan and Random Scan graphics storages

Unit-III

Displays processors and character generators, colour display techniques, interactive input/output devices

Unit-IV

Points, lines and curves: Scan conversion, line-drawing algorithms, circle and ellipse generation, conic-section generation, polygon filling antialiasing

Unit-V

Two dimensional viewing: Coordinate systems, linear transformations, line and polygon clipping algorithm

Books Recommended

1. D. Hearn and M.P. Baker, *Computer Graphics*, 2nd Ed., Prentice–Hall of India, 2004.
2. J.D. Foley, A van Dam, S.K. Feiner and J.F. Hughes, *Computer Graphics: Principals and Practices*, 2nd Ed., Addison-Wesley, MA, 1990.
3. D.F. Rogers, *Procedural Elements in Computer Graphics*, 2nd Ed., McGraw Hill Book Company, 2001.
4. D.F. Rogers and A.J. Admas, *Mathematical Elements in Computer Graphics*, 2nd Ed., McGraw Hill Book Company, 1990

MATHEMATICS -SEC-301 (III)
Programming in C
(Theory: 60 Lectures; Credits: 4)
Full marks: 100 (ESE: 70; CCA:30)
Pass marks: 40 (ESE: 28; CCA:12)

(Each Unit carries equal weightage)

Unit-I

Introduction to C language, C characters, C constants and variables, Arithmetic expression and statements. Input/Output, statements, Assignment statements, printf and scanf statements, declaration statements.

Unit-II

Simple computer program, Logical expression and statements, logical and relational operators

Unit-III

Decision control structures, loops, if statements if-else statements, for statements, while statements, Do-while loop, Switch statements, break statements, continue statements, command operator, go to statements.

Unit-IV

Functions-defining a function, function prototypes, passing arguments to a function.

Unit-V

Return statements Arrays, defining an arrays , multi dimensional arrays.

Books Recommended:

1. Y. Kanitkar, Let us C, PHI
2. B.W Kernighan and D.M.Ritchie, The C Programming Language, PHI

MATHEMATICS -SEC-401 (I)
Graph Theory
(Theory: 60 Lectures; Credits: 4)
Full marks: 100 (ESE: 70; CCA:30)
Pass marks: 40 (ESE: 28; CCA:12)

(Each Unit carries equal weightage)

Unit-I

Definition, examples and basic properties of graphs, pseudo graphs, complete graphs, bi-partite graphs, operations on graph (union, intersection, product, composition)

Unit-II

Cut point, bridges and blocks, trees and their characterization

Unit-III

Isomorphism of graphs, paths and circuits, Eulerian circuits, Hamiltonian cycles, the adjacency matrix, weighted graph

Unit-IV

Planarity: plane and planer graphs, outerplanar graphs, characterization of planar graphs

Unit-V

Travelling salesman's problem, shortest path, Dijkstra's algorithm, Floyd-Warshall algorithm.

Recommended Books

1. Harary, Graph Theory, Addison-Wiley
2. Narsingh Deo, Graph Theory

MATHEMATICS -SEC-401 (Option-II)

Operating System: Linux

(Theory: 60 Lectures; Credits: 4)

Full marks: 100 (ESE: 70; CCA:30)

Pass marks: 40 (ESE: 28; CCA:12)

(Each Unit carries equal weightage)

Unit-I

Introduction to computer and its components, bits, bytes, computer memory, RAM, ROM, I/O devices, on line and off line data entry, magnetic tape, disks etc., Software and Hardware concepts, computer generations, types of computer systems, field , record, files.

Unit-II

Linux – The Operating System: Linux history, Linux features, Linux distributions, Linux’s relationship to Unix, Overview of Linux architecture, Installation, Start up scripts, system processes (an overview)

Unit-III

Linux Security, The Ext2 and Ext3 File systems: General Characteristics of, The Ext3 File system, file permissions. User Management: Types of users, the powers of Root, managing users (adding and deleting): using the command line and GUI tools.

Unit-IV

Resource Management in Linux: file and directory management, system calls for files
Process Management

Unit-V

Signals, IPC: Pipes, FIFOs, System V IPC, Message Queues, system calls for processes, Memory Management, library and system calls for memory.

Books Recommended

1. Arnold Robbins, *Linux Programming by Examples The Fundamentals*, 2nd Ed., Pearson Education, 2008.
2. Cox K, *Red Hat Linux Administrator’s Guide*, PHI, 2009.
3. R. Stevens, *UNIX Network Programming*, 3rd Ed., PHI, 2008.
4. Sumitabha Das, *Unix Concepts and Applications*, 4th Ed., TMH, 2009.
5. Ellen Siever, Stephen Figgins, Robert Love, Arnold Robbins, *Linux in a Nutshell*, 6th Ed., O’Reilly Media, 2009.
6. Neil Matthew, Richard Stones, Alan Cox, *Beginning Linux Programming*, 3rd Ed., 2004.

MATHEMATICS -SEC-401 (Option-III)

Special Functions

(Theory: 60 Lectures; Credits: 4)

Full marks: 100 (ESE: 70; CCA:30)

Pass marks: 40 (ESE: 28; CCA:12)

(Each Unit carries equal weightage)

Unit-I

Legendre's equation, Legendre's Polynomials, generating function, Laplace's definite integral for $P_n(x)$

Unit-II

Orthogonal properties and recurrence formulae for $P_n(x)$, Rodrigues formula, Bessel's equation of order 0,1, and n, Bessel's functions for $J_n(x)$, Recurrence formula for $J_n(x)$

Unit-III

The Laplace transform, the inverse Laplace transform.

Unit-IV

Application of Laplace transform to differential equations.

Unit-V

Fourier series and Fourier integrals, Fourier transform(infinite), Relation between Laplace and Fourier transforms problems related to Fourier integral.

Books Recommended:

1. J.N.Sharma & R. K.Gupta, Special Functions, Krishna Prakashan Media
2. M.D. Raisinghania, Laplace and Fourier Transform, S. Chand and Sons

Generic Electives

MATHEMATICS -GE-101(I)

Differential Calculus

(Theory: 75 Lectures; 15 Tutorials; Credit: 5+1)

Full marks: 100 (ESE: 70; CCA: 30)

Pass marks: 40 (ESE: 28; CCA: 12)

(Each Unit carries equal weightage)

Unit-I

Limit of a function, algebra of limits, related results and problems

Unit-II

Continuity (ϵ and δ definition), related theorems and problems, types of discontinuities, differentiability of functions

Unit-III

Successive differentiation, Leibnitz's theorem, Partial differentiation, Euler's theorem on homogeneous functions

Unit-IV

Tangents and normals, curvature, asymptotes, singular points, tracing of curves, parametric representation of curves and tracing of parametric curves

Unit-V

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

1. Das, B.C. and B.N. Mukherjee, Differential Calculus, U.N. Dhur and Sons
2. S.C. Malik and S. Arora, Principles of Mathematical Analysis, New-Age International Publishers

MATHEMATICS -GE-101(II)
Finite Element Method
(Theory: 60 Lectures; Credits: 4)
Full marks: 70 (External: 50; Sessional 20)
Pass marks: 28 (External: 20; Sessional 8)
(Each Unit carries equal weightage)

Unit-I

Introduction to finite element methods, comparison with finite difference methods, Methods of weighted residuals, collocations, least squares and Galerkin's method

Unit-II

Variational formulation of boundary value problems equivalence of Galerkin and Ritz methods. Applications to solving simple problems of ordinary differential equations

Unit-III

Linear, quadratic and higher order elements in one dimensional and assembly, solution of assembled system

Unit-IV

Simplex elements in two and three dimensions, quadratic triangular elements, rectangular elements, serendipity elements and isoperimetric elements and their assembly, discretization with curved boundaries Interpolation functions, numerical integration, and modeling considerations.

Unit-V

Solution of two dimensional partial differential equations under different Geometric conditions

Books Recommended

1. J.N. Reddy, *Introduction to the Finite Element Methods*, Tata McGraw-Hill, 2003.
2. K.J. Bathe, *Finite Element Procedures*, Prentice-Hall, 2001.
3. R.D. Cook, D.S. Malkus and M.E. Plesha, *Concepts and Applications of Finite Element Analysis*, John Wiley and Sons, 2002.
4. Thomas J.R. Hughes, *The Finite Element Method: Linear Static and Dynamic Finite Element Analysis*, Dover Publication, 2000.
5. George R. Buchanan, *Finite Element Analysis*, McGraw Hill, 1994

MATHEMATICS -GE-101(II)-LAB

Finite Element Method

(Practical: Credits: 2)

Full marks: 30

Pass marks: 20

Practical to be performed in lab

MATHEMATICS -GE-201(I)
Differential Equations
(Theory: 75 Lectures; 15 Tutorials; Credit: 5+1)
Full marks: 100 (ESE: 70; CCA: 30)
Pass marks: 40 (ESE: 28; CCA: 12)
(Each Unit carries equal weightage)

Unit-I

First order exact differential equations. Integrating factors, rules to find an integrating factor.
First order higher degree equations solvable for x, y, p

Unit-II

Methods for solving higher-order differential equations, basic theory of linear differential equations

Unit-III

Solving a differential equation by reducing its order linear homogenous equations with constant coefficients, linear non-homogenous equations, the method of variation of parameters,

Unit-IV

The Cauchy-Euler equation, simultaneous differential equations, Total differential equations

Unit-V

Order and degree of partial differential equations, concept of linear and non-linear partial differential equations, Formation of first order partial differential equations,

Books Recommended

1. Shepley L. Ross, *Differential Equations*, 3rd Ed., John Wiley and Sons, 1984.
2. M.D. Raisinghania, *Advanced Differential Equations*, S. Chand and Sons

MATHEMATICS -GE-201(II)
Econometrics
(Theory: 75 Lectures; 15 Tutorials; Credit: 5+1)

Full marks: 100 (ESE: 70; CCA: 30)
Pass marks: 40 (ESE: 28; CCA: 12)
(Each Unit carries equal weightage)

Unit-I

Statistical Concepts Normal distribution; chi-square, t and F-distributions; estimation of parameters; properties of estimators; testing of hypotheses: defining statistical hypotheses; distributions of test statistics; testing hypotheses related to population parameters; Type I and Type II errors;

Unit-II

Power of a test; tests for comparing parameters from two samples. Simple Linear Regression Model: Two Variable Case Estimation of model by method of ordinary least squares; properties of estimators; goodness of fit;

Unit-III

Tests of hypotheses; scaling and units of measurement; confidence intervals; Gauss-Markov theorem; forecasting

Unit-IV

Multiple Linear Regression Model Estimation of parameters; properties of OLS estimators; goodness of fit - R² and adjusted R² ; partial regression coefficients; testing hypotheses – individual and joint; functional forms of regression models; qualitative (dummy) independent variables.

Unit-V

Violations of Classical Assumptions: Consequences, Detection and Remedies Multicollinearity; heteroscedasticity; serial correlation. Specification Analysis Omission of a relevant variable; inclusion of irrelevant variable; tests of specification errors

Books Recommended

1. Jay L. Devore, *Probability and Statistics for Engineers*, Cengage Learning, 2010.
2. John E. Freund, *Mathematical Statistics*, Prentice Hall, 1992.
3. Richard J. Larsen and Morris L. Marx, *An Introduction to Mathematical Statistics and its Applications*, Prentice Hall, 2011.
4. D. N. Gujarati and D.C. Porter, *Essentials of Econometrics*, McGraw Hill, 4th Ed., International Edition, 2009.
5. Christopher Dougherty, *Introduction to Econometrics*, Oxford University Press, 3rd Ed., Indian edition, 2007.

MATHEMATICS -GE-301(I)
Real Analysis
(Theory: 75 Lectures; 15 Tutorials; Credit: 5+1)
Full marks: 100 (ESE: 70; CCA: 30)
Pass marks: 40 (ESE: 28; CCA: 12)
(Each Unit carries equal weightage)

Unit-I

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}

Unit-II

Intervals, open and closed subsets of \mathbb{R} , their properties, nested interval theorem, concept of cluster points and Bolzano-Weierstrass theorem

Unit-III

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).

Unit-IV

Infinite series. Cauchy convergence criterion for series, positive term series, geometric series, comparison test, convergence of p-series, Root test, Ratio test, alternating series, Leibnitz's test (Tests of Convergence without proof), Definition and examples of absolute and conditional convergence.

Unit-V

Sequential criterion of limit and continuity and the equivalence of sequential criterion with epsilon-delta definition, properties of continuous functions

Books Recommended:

1. R.G. Bartle and D. R. Sherbert, *Introduction to Real Analysis*, John Wiley and Sons (Asia) Ltd., 2000.
2. S.C. Malik and S. Arora, *Principles of Mathematical Analysis*, S. Chand and Sons

MATHEMATICS -GE-301(I)
Mathematical Finance
(Theory: 75 Lectures; 15 Tutorials; Credit: 5+1)
Full marks: 100 (ESE: 70; CCA: 30)
Pass marks: 40 (ESE: 28; CCA: 12)
(Each Unit carries equal weightage)

Unit-I

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),

Unit-II

Comparison of NPV and IRR. Bonds, bond prices and yields, Macaulay and modified duration, term structure of interest rates: spot and forward rates, explanations of term structure, running present value, floating-rate bonds, immunization, convexity, puttable and callable bonds.

Unit-III

Asset return, short selling, portfolio return, (brief introduction to expectation, variance, covariance and correlation), random returns, portfolio mean return and variance,

Unit-IV

Diversification, portfolio diagram, feasible set, Markowitz model (review of Lagrange multipliers for 1 and 2 constraints), Two fund theorem, risk free assets, One fund theorem, capital market line,

Unit-V

Sharpe index. Capital Asset Pricing Model (CAPM), betas of stocks and portfolios, security market line, use of CAPM in investment analysis and as a pricing formula, Jensen's index.

Books Recommended

1. David G. Luenberger, *Investment Science*, Oxford University Press, Delhi, 1998.
2. John C. Hull, *Options, Futures and Other Derivatives*, 6th Ed., Prentice-Hall India, Indian reprint, 2006.
3. Sheldon Ross, *An Elementary Introduction to Mathematical Finance*, 2nd Ed., Cambridge University Press, USA, 2003.

MATHEMATICS -GE-401(I)

Abstract Algebra

(Theory: 75 Lectures; 15 Tutorials; Credit: 5+1)

Full marks: 100 (ESE: 70; CCA: 30)

Pass marks: 40 (ESE: 28; CCA: 12)

(Each Unit carries equal weightage)

Unit-I

Definition and examples of groups, examples of abelian and non-abelian groups, the group Z_n of integers under addition modulo n and the group $U(n)$ of units under multiplication modulo n , Cyclic groups from number systems, complex roots of unity, circle group, the general linear group $GL(n, R)$

Unit-II

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

Unit-III

Normal subgroups: their definition examples, and characterizations, Quotient groups, group homomorphism: definition, example and related problems

Unit-IV

Definition and examples of rings, examples of commutative and non-commutative rings: rings from number systems, Z_n the ring of integers modulo n , rings of matrices, polynomial rings, and rings of continuous functions.

Unit-V

Integral domains, division ring, and fields, examples of fields: Z_p , Q , R , and C , Subrings and ideals, prime, principal and maximal ideal

Books Recommended

1. Joseph A Gallian, *Contemporary Abstract Algebra*, 4th Ed., Narosa, 1999.
2. S. Singh and K. Zameeruddin, *Modern Algebra*, PHI

MATHEMATICS -GE-401(II)
Combinatorial Mathematics
(Theory: 75 Lectures; 15 Tutorials; Credit: 5+1)
Full marks: 100 (ESE: 70; CCA: 30)
Pass marks: 40 (ESE: 28; CCA: 12)
(Each Unit carries equal weightage)

Unit-I

Basic counting principles, Permutations and Combinations (with and without repetitions), Binomial theorem, Multinomial theorem, Counting subsets, Set-partitions, Stirling numbers
Principle of Inclusion and Exclusion

Unit-II

Derangements, Inversion formulae Generating functions: Algebra of formal power series, Generating function models, Calculating generating functions

Unit-III

Exponential generating functions. Recurrence relations: Recurrence relation models, Divide and conquer relations, Solution of recurrence relations, Solutions by generating functions.

Unit-IV

Integer partitions, Systems of distinct representatives. Polya theory of counting: Necklace problem and Burnside's lemma

Unit-V

Cyclic index of a permutation group, Polya's theorems and their immediate applications. Latin squares, Hadamard matrices, Combinatorial designs: t designs, BIBDs, Symmetric designs.

Books Recommended

1. J.H. van Lint and R.M. Wilson, *A Course in Combinatorics*, 2nd Ed., Cambridge University Press, 2001.
2. V. Krishnamurthy, *Combinatorics, Theory and Application*, Affiliated East-West Press 1985.
3. P.J. Cameron, *Combinatorics, Topics, Techniques, Algorithms*, Cambridge University Press, 1995.
4. M. Jr. Hall, *Combinatorial Theory*, 2nd Ed., John Wiley & Sons, 1986.
5. S.S. Sane, *Combinatorial Techniques*, Hindustan Book Agency, 2013.
6. R.A. Brualdi, *Introductory Combinatorics*, 5th Ed., Pearson Education Inc., 2009.