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**CORE COURSES**  
B.Sc.(Honours)-Mathematics

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**Semester-I**

**C-1.1: Calculus-I**  
**(Total Marks:100)**

**Part-I(Marks:75)**  
**(Theory:60 Marks+Mid-Sem:15 Marks)**

**Unit-I**

Hyperbolic functions, higher order derivatives, Leibniz rule and its applications to problems of the type  $e^{ax+b} \sin x$ ,  $e^{ax+b} \cos x$ ,  $(ax + b)^n \sin x$ ,  $(ax + b)^n \cos x$ , concavity and inflection points, asymptotes, curve tracing in Cartesian coordinates, tracing in polar coordinates of standard curves, LHospitals rule, applications in business, economics and life sciences.

**Unit-II**

Reduction formulae, derivations and illustrations of reduction formulae of the type  $\int \sin nx dx$ ,  $\int \cos nx dx$ ,  $\int \tan nx dx$ ,  $\int \sec nx dx$ ,  $\int (\log x)^n dx$ ,  $\int \sin^n x \cos^n x dx$ , volumes by slicing, disks and washers methods, volumes by cylindrical shells, parametric equations, parameterizing a curve, arc length, arc length of parametric curves, area of surface of revolution.

**Unit-III**

Techniques of sketching conics, reflection properties of conics, rotation of axes and second degree equations, classification into conics using the discriminant, polar equations of conics. Sphere, Cone, Cylinder, Central Conicoids.

**Unit-IV**

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.

**Part-II(Practical, Marks:25)**

**List of Practicals (Using any software)**  
**Practical/Lab work to be performed on a Computer.**

1. Plotting the graphs of the functions  $e^{ax+b}$ ,  $\log(ax + b)$ ,  $1/(ax + b)$ ,  $\sin(ax + b)$ ,  $\cos(ax + b)$ ,  $|ax + b|$  and to illustrate the effect of a and b on the graph.
2. Plotting the graphs of the 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.
7. Matrix operation (addition, multiplication, inverse, transpose).

**Books Recommended:**

1. M.J. Strauss, G.L. Bradley and K. J. Smith, Calculus, 3rd Ed., Dorling Kindersley (India) P. Ltd. (Pearson Education), Delhi, 2007. Chapters:4(4.3,4.4,4.5 & 4.7), 9(9.4), 10(10.1-10.4).
2. H. Anton, I. Bivens and S. Davis, Calculus, 7th Ed., John Wiley and Sons (Asia) P. Ltd., Singapore, 2002. Chapters: 6, (6.2-6.5),7(7.8), 8(8.2-8.3, Pages:532-538), 11(11.1), 13(13.5)
3. Analytical Geometry of Quadratic Surfaces, B.P. Acharya and D.C. Sahu, Kalyani Publishers, New Delhi, Ludhiana.

**+878Books for Reference:**

1. G.B. Thomas and R.L. Finney, Calculus, 9th Ed., Pearson Education, Delhi, 2005.
2. R. Courant and F. John, Introduction to Calculus and Analysis (Volumes I & II), Springer-Verlag, New York, Inc., 1989.
3. Text Book of Calculus, Part-II- Shantinayakan, S. Chand & Co.,
4. Text Book of Calculus, Part-III-Shantinayakan, S. Chand & Co.,
5. Shanti Narayan and P.K. Mittal-Analytical Solid Geometry, S. Chand & Company Pvt. Ltd., New Delhi.

**C-1.2: Algebra-I****Total Marks:100****Theory:80 Marks+Mid-Sem:20 Marks****5 Lectures, 1 Tutorial (per week per student)****Unit-I**

Polar representation of complex numbers,  $n$ -th roots of unity, De Moivres theorem for rational indices and its applications.

**Unit-II**

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

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.

**Unit-IV**

Introduction to linear transformations, 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, Eigen values, Eigen Vectors and Characteristic Equation of a matrix.

**Books Recommended:**

1. L.V. Ahlfors, Complex Analysis, McGraw-Hill(International Student Edn.)
2. Titu Andreescu and Dorin Andrica, Complex Numbers from  $A$  to  $Z$ , Birkhauser, 2006. Chapter:2
3. Edgar G. Goodaire and Michael M. Parmenter, Discrete Mathematics with Graph Theory, 3rd Ed., Pearson Education (Singapore) P. Ltd., Indian Reprint, 2005. Chapters:2(2.4), 3,4(4.1-4.1.6, 4.2-4.2.11, 4.4(4.1-4.4.8),4.3-4.3.9, 5(5.1-5.1.4).
4. David C. Lay, Linear Algebra and its Applications, 3rd Ed., Pearson Education Asia, Indian Reprint, 2007. Chapters:1(1.1-1.9), 2(2.1-2.3, 2.8, 2.9), 5(5.1,5.2)

## Semester-II

### C-2.1: Real Analysis (Analysis-I)

Total Marks:100

Theory:80 Marks+Mid-Sem:20 Marks

5 Lectures, 1 Tutorial (per week per student)

#### Unit-I

Review of Algebraic and Order Properties of  $\mathbb{R}$ , Neighborhood of a point in  $\mathbb{R}$ , Idea of countable sets, uncountable sets and uncountability of  $\mathbb{R}$ . Bounded above sets, Bounded below sets, Bounded Sets, Unbounded sets, Suprema and Infima.

#### Unit-II

The Completeness Property of  $\mathbb{R}$ , The Archimedean Property, Density of Rational (and Irrational) numbers in  $\mathbb{R}$ , Intervals. Limit points of a set, Isolated points, 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. Subsequences, Divergence Criteria, Monotone Subsequence Theorem (statement only), Bolzano Weierstrass Theorem for Sequences. Cauchy sequence, Cauchy's Convergence Criterion.

#### Unit-IV

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.

#### Book Recommended:

1. G. Das and S. Pattanayak, Fundamentals of Mathematics Analysis, TMH Publishing Co., Chapters: 2(2.1 to 2.4, 2.5 to 2.7), 3(3.1-3.5), 4(4.1 to 4.7, 4.10, 4.11, 4.12, 4.13).

#### Books for References:

1. R.G. Bartle and D. R. Sherbert, Introduction to Real Analysis, 3rd Ed., John Wiley and Sons (Asia) Pvt. Ltd., Singapore, 2002.
2. Gerald G. Bilodeau, Paul R. Thie, G.E. Keough, An Introduction to Analysis, 2nd Ed., Jones & Bartlett, 2010.
3. Brian S. Thomson, Andrew M. Bruckner and Judith B. Bruckner, Elementary Real Analysis, Prentice Hall, 2001.
4. S.K. Berberian, A First Course in Real Analysis, Springer Verlag, New York, 1994.
5. S.C. Mallik and S. Arora-Mathematical Analysis, New Age International Publications.
6. D. Smasundaram and B. Choudhury-A First Course in Mathematical Analysis, Narosa Publishing House.
7. S.L. Gupta and Nisha Rani-Real Analysis, Vikas Publishing House Pvt. Ltd., New Delhi.

**C-2.2: Differential Equations**  
(Total Marks:100)

**Part-I(Marks:75)**

**Theory:60 Marks+Mid-Sem:15 Marks**

**04 Lectures(per week per student)**

**Unit-I**

Differential equations and mathematical models. First order and first degree ODE (variables separable, homogeneous, exact, and linear). Equations of first order but of higher degree. Applications of first order differential equations(Growth, Decay and Chemical Reactions, Heat flow, Oxygen debt, Economics).

**Unit-II**

Second order linear equations(homogeneous and non-homogeneous) with constant coefficients, second order equations with variable coefficients, variation of parameters, method of undetermined coefficients, equations reducible to linear equations with constant coefficients, Euler's equation. Applications of second order differential equations.

**Unit-III**

Power series solutions of second order differential equations.

**Unit-IV**

Laplace transforms and its applications to solutions of differential equations.

**Part-II(Practical: Marks:25)**

**List of Practicals (Using any Software)**  
**Practical/Lab work to be performed on a Computer.**

1. Plotting of second order solution of family of differential equations.
2. Plotting of third order solution of family of differential equations.
3. Growth model (exponential case only).
4. Decay model (exponential case only).
5. Oxygen debt model.
6. Economic model.
7. Vibration problems.

**Book Recommended:**

1. J. Sinha Roy and S. Padhy, A Course of Ordinary and Partial Differential Equations, Kalyani Publishers, New Delhi. Chapters: 1, 2(2.1 to 2.7), 3, 4(4.1 to 4.7), 5, 7(7.1-7.4), 9(9.1, 9.2, 9.3, 9.4, 9.5, 9.10, 9.11, 9.13).

**Books for References:**

1. Martin Braun, Differential Equations and their Applications, Springer International.
2. M.D. Raisinghania-Advanced Differential Equations, S. Chand & Company Ltd., New Delhi.
3. G. Dennis Zill-A First Course in Differential Equations with Modelling Applications, Cengage Learning India Pvt. Ltd.
4. S.L. Ross, Differential Equations, John Wiley & Sons, India, 2004.

**Semester-III****C-3.1: Theory of Real Functions (Analysis-II)****Total Marks:100****Theory:80 Marks+Mid-Sem:20 Marks****5 Lectures, 1 Tutorial (per week per student)****Unit-I**

Limits of functions ( $\epsilon - \delta$  approach), sequential criterion for limits, divergence criteria. Limit theorems, one sided limits. Infinite limits and limits at infinity. Continuous functions, sequential criterion for continuity and discontinuity.

**Unit-II**

Algebra of continuous functions. Continuous functions on an interval, intermediate value theorem, location of roots theorem, preservation of intervals theorem. Uniform continuity, non-uniform continuity criteria, uniform continuity theorem. Differentiability of a function at a point and in an interval, Caratheodorys theorem, algebra of differentiable functions.

**Unit-III**

Relative extrema, interior extremum theorem. Rolles theorem, Mean value theorem, intermediate value property of derivatives, Darboux's theorem. Applications of mean value theorem to inequalities and approximation of polynomials, Taylors theorem to inequalities.

**Unit-IV**

Cauchys mean value theorem. Taylors theorem with Lagranges form of remainder, Taylors theorem with Cauchys form of remainder, application of Taylors theorem to convex functions, relative extrema. Taylors series and Maclaurins series expansions of exponential and trigonometric functions,  $\ln(1+x)$ ,  $1/(ax+b)$  and  $(1+x)^n$ .

**Book Recommended:**

1. G. Das and S. Pattanayak, Fundamentals of Mathematics Analysis, TMH Pub-lishing Co., Chapters:6(6.1-6.8), 7(7.1-7.7),

**Books for References:**

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. A. Mattuck, Introduction to Analysis, Prentice Hall, 1999.
4. S.R. Ghorpade and B.V. Limaye, A Course in Calculus and Real Analysis, Springer, 2006.

**C-3.2: Group Theory(Algebra-II)****Total Marks:100****Theory:80 Marks+Mid-Sem:20 Marks****5 Lectures, 1 Tutorial (per week per student)****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. Subgroups and examples of subgroups, centralizer, normalizer, center of a group, product of two subgroups.

### Unit-II

Properties of cyclic groups, classification of subgroups of cyclic groups. Cycle notation for permutations, properties of permutations, even and odd permutations, alternating group, properties of cosets, Lagranges theorem and consequences including Fermats Little theorem.

### Unit-III

External direct product of a finite number of groups, normal subgroups, factor groups, Cauchys theorem for finite abelian groups.

### Unit-IV

Group homomorphisms, properties of homomorphisms, Cayleys theorem, properties of isomorphisms, First, Second and Third isomorphism theorems.

#### Book Recommended:

1. Joseph A. Gallian, Contemporary Abstract Algebra(4th Edn.), Narosa Publishing House, New Delhi.

#### Books for References:

1. John B. Fraleigh, A First Course in Abstract Algebra, 7th Ed., Pearson, 2002.
2. M. Artin, Abstract Algebra, 2nd Ed., Pearson, 2011.
3. Joseph J. Rotman, An Introduction to the Theory of Groups, 4th Ed., Springer Verlag, 1995.
4. I.N. Herstein, Topics in Algebra, Wiley Eastern Limited, India, 1975.

### C-3.3: Partial Differential Equations and Systems of Ordinary Differential Equations (Total Marks:100)

#### Part-I(Marks:75)

Theory:60 Marks+Mid-Sem:15 Marks

04 Lectures(per week per student)

#### Unit-I

Systems of linear differential equations, types of linear systems, differential operators, an operator method for 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). Simultaneous linear first order equations in three variables, methods of solution, Pfaffian differential equations, methods of solutions of Pfaffian differential equations in three variables.

#### Unit-II

Formation of first order partial differential equations, Linear and non-linear partial differential equations of first order, special types of first-order equations, Solutions of partial differential equations of first order satisfying given conditions.

#### Unit-III

Linear partial differential equations with constant coefficients, Equations reducible to linear partial differential equations with constant coefficients, Partial differential equations with variable coefficients, Separation of variables, Non-linear equation of the second order.

## Unit-IV

Laplace equation, Solution of Laplace equation by separation of variables, One dimensional wave equation, Solution of the wave equation(method of separation of variables), Diffusion equation, Solution of one-dimensional diffusion equation, method of separation of variables.

### Part-II(Practical: Marks:25)

#### List of Practicals (Using any Software) Practical/Lab work to be performed on a Computer.

1. To find the general solution of the non-homogeneous system of the form:

$$\frac{dx}{dt} = a_1x + b_1y + f_1(t), \quad \frac{dy}{dt} = a_2x + b_2y + f_2(t)$$

with given conditions.

2. Plotting the integral surfaces of a given first order PDE with initial data.

3. Solution of wave equation  $\frac{\partial^2 u}{\partial t^2} - c^2 \frac{\partial^2 u}{\partial x^2} = 0$  for the following associated conditions:

(a)  $u(x, 0) = \phi(x), u_t(x, 0) = \psi(x), x \in \mathbb{R}, t > 0$ . (b)  $u(x, 0) = \phi(x), u_t(x, 0) = \psi(x), u_x(0, t) = 0, x \in (0, \infty), t > 0$ . (c)  $u(x, 0) = \phi(x), u_t(x, 0) = \psi(x), u(0, t) = 0, x \in (0, \infty), t > 0$ . (d)  $u(x, 0) = \phi(x), u_t(x, 0) = \psi(x), u(0, t) = 0, u(1, t) = 0, 0 < x < 1, t > 0$ .

4. Solution of wave equation  $\frac{\partial u}{\partial t} - k^2 \frac{\partial^2 u}{\partial x^2} = 0$  for the following associated conditions:

(a)  $u(x, 0) = \phi(x), u(0, t) = a, u(l, t) = b, 0 < x < l, t > 0$ .  
 (b)  $u(x, 0) = \phi(x), x \in \mathbb{R}, 0 < t < T$ .  
 (c)  $u(x, 0) = \phi(x), u(0, t) = a, x \in (0, \infty), t \geq 0$ .

#### Book Recommended:

1. J.Sinha Roy and S. Padhy, A Course on Ordinary and Partial Differential Equations, Kalyani Publishers, New Delhi, Ludhiana, 2012.  
 Chapters:11, 12, 13(13.1-13.5), 15(15.1,15.5), 16(16.1, 16.1.1), 17(17.1, 17.2, 17.3).

#### Books for References:

1. Tyn Myint-U and Lokenath Debnath, Linear Partial Differential Equations for Scientists and Engineers, 4th edition, Springer, Indian reprint, 2006.
2. S.L. Ross, Differential equations, 3rd Ed., John Wiley and Sons, India, 2004.

**Semester-IV****C-4.1: Numerical Methods  
(Total Marks:100)****Part-I(Marks:75)****Theory:60 Marks+Mid-Sem:15 Marks****04 Lectures(per week per student)****Unit-I**

Algorithms, Convergence, Errors: Relative, Absolute, Round off, Truncation. Transcendental and Polynomial equations: Bisection method, Newtons method, Secant method. Rate of convergence of these methods.

**Unit-II**

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

**Unit-III**

Interpolation: Lagrange and Newtons methods. Error bounds. Finite difference operators. Gregory forward and backward difference interpolation.

**Unit-IV**

Numerical Integration: Trapezoidal rule, Simpsons rule, Simpsons 3/8th rule, Booles Rule. Midpoint rule, Composite Trapezoidal rule, Composite Simpsons rule. Ordinary Differential Equations: Eulers method. Runge-Kutta methods of orders two and four.

**Part-II(Practical: Marks:25)**

**List of Practicals (Using any Software)  
Practical/Lab work to be performed on a Computer.**

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. Regulai Falsi Method.
8. LU decomposition Method.
9. Gauss-Jacobi Method.
10. SOR Method or Gauss-Siedel Method.
11. Lagrange Interpolation or Newton Interpolation.
12. Simpsons rule.



**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.

**Book Recommended:**

1. B.P. Acharya and R.N. Das, A Course on Numerical Analysis, Kalyani Publishers, New Delhi, Ludhiana. Chapters: 1, 2(2.1 to 2.4, 2.6, 2.8, 2.9), 3(3.1 to 3.4, 3.6 to 3.8, 3.10), 4(4.1, 4.2), 5(5.1, 5.2, 5.3), 6(6.1, 6.2, 6.3, 6.10, 6.11), 7(7.1, 7.2, 7.3, 7.4 &7.7).
2. Brian Bradie, A Friendly Introduction to Numerical Analysis, Pearson Education, India, 2007.

**Books for References:**

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. C.F. Gerald and P.O. Wheatley, Applied Numerical Analysis, Pearson Education, India, 2008.
3. Uri M. Ascher and Chen Greif, A First Course in Numerical Methods, 7th Ed., PHI Learning Private Limited, 2013.
4. John H. Mathews and Kurtis D. Fink, Numerical Methods using Matlab, 4th Ed., PHI Learning Private Limited, 2012.

**C-4.2: Riemann Integration and Series of Functions (Analysis-III)**

**Total Marks:100**

**Theory:80 Marks+Mid-Sem:20 Marks**

**5 Lectures, 1 Tutorial (per week per student)**

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

**Unit-II**

Improper integrals; Convergence of Beta and Gamma functions.

**Unit-III**

Pointwise and uniform convergence of sequence of functions. Theorems on continuity, derivability and integrability of the limit function of a sequence of functions. Series of functions; Theorems on the continuity and derivability of the sum function of a series of functions; Cauchy criterion for uniform convergence and Weierstrass M-Test.

**Unit-IV**

Limit superior and Limit inferior. Power series, radius of convergence, Cauchy Hadamard Theorem, Differentiation and integration of power series; Abels Theorem; Weierstrass Approximation Theorem.

**Book Recommended:**

1. G. Das and S. Pattanayak-Fundamentals of Mathematics Analysis, TMH Publishing Co., Chapters: 8, 9.

**Books for References:**

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. Charles G. Denlinger, Elements of Real Analysis, Jones & Bartlett (Student Edition), 2011.
4. S.C. Mallik and S. Arora-Mathematical Analysis, New Age International Ltd., New Delhi.
5. Shanti Narayan and M.D. Raisinghania-Elements of Real Analysis, S. Chand & Co. Pvt. Ltd.

**C-4.3: Ring Theory and Linear Algebra-I(Analysis-III)****Total Marks:100****Theory:80 Marks+Mid-Sem:20 Marks****5 Lectures, 1 Tutorial (per week per student)****Unit-I**

Definition and examples of rings, properties of rings, subrings, integral domains and fields, characteristic of a ring. Ideal, ideal generated by a subset of a ring, factor rings, operations on ideals, prime and maximal ideals.

**Unit-II**

Ring homomorphisms, properties of ring homomorphisms, Isomorphism theorems I, II and III, field of quotients.

**Unit-III**

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

**Unit-IV**

Linear transformations, null space, range, rank and nullity of a linear transformation, matrix representation of a linear transformation, algebra of linear transformations. Isomorphisms, Isomorphism theorems, invertibility and isomorphisms, change of coordinate matrix.

**Book Recommended:**

1. Joseph A. Gallian, Contemporary Abstract Algebra(4th Edn.), Narosa Publishing House, New Delhi. Chapters:12, 13, 14, 15.
2. Stephen H. Friedberg, Arnold J. Insel, Lawrence E. Spence, Linear Algebra, 4th Ed., Prentice-Hall of India Pvt. Ltd., New Delhi, 2004. Chapters: 1 (1.2-1.6), 2(2.1-2.5).

**Books for References:**

1. John B. Fraleigh, A First Course in Abstract Algebra, 7th Ed., Pearson, 2002.
2. M. Artin, Abstract Algebra, 2nd Ed., Pearson, 2011.
3. S. Lang, Introduction to Linear Algebra, 2nd Ed., Springer, 2005.
4. Gilbert Strang, Linear Algebra and its Applications, Cengage Learning India Pvt. Ltd.
5. S. Kumaresan, Linear Algebra- A Geometric Approach, Prentice Hall of India,1999.
6. Kenneth Hoffman, Ray Alden Kunze, Linear Algebra, 2nd Ed., Prentice-Hall of India Pvt. Ltd., 1971.
7. I.N. Herstein-Topics in Algebra, Wiley Eastern Pvt. Ltd.

## Semester-V

### C-5.1: Multivariate Calculus (Calculus-II)

Total Marks:100

Theory:80 Marks+Mid-Sem:20 Marks

5 Lectures, 1 Tutorial (per week per student)

#### Unit-I

Functions of several variables, limit and continuity of functions of two variables Partial differentiation, total differentiability and differentiability, sufficient condition for differentiability. Chain rule for one and two independent parameters, directional derivatives, the gradient, maximal and normal property of the gradient, tangent planes. Extrema of functions of two variables, method of Lagrange multipliers, constrained optimization problems, Definition of vector field, divergence and curl

#### Unit-II

Extrema of functions of two variables, method of Lagrange multipliers, constrained optimization problems, Definition of vector field, divergence and curl.

#### Unit-III

Double integration over rectangular region, double integration over non-rectangular region, Double integrals in polar co-ordinates, 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.

#### Unit-IV

Line integrals, Applications of line integrals: Mass and Work. Fundamental theorem for line integrals, conservative vector fields, independence of path. Greens theorem, surface integrals, integrals over parametrically defined surfaces. Stokes theorem, The Divergence theorem.

#### **Books Recommended:**

1. M.J. Strauss, G.L. Bradley and K. J. Smith, Calculus, 3rd Ed., Dorling Kindersley (India) Pvt. Ltd. (Pearson Education), Delhi, 2007. Chapters: 11(11.1(Pages: 541-543), 11.2-11.6, 11.7(Pages:598-605), 11.8(Pages:610-614)), 12 (12.1, -12.3, 12.4(Pages:652-660), 12.5, 12.6), 13 (13.2, 13.3, 13.4(Pages:712-716), 13.5(Pages:723-726; 729-730), 13.6 (Pages:733-737), 13.7(Pages:742-745)).

#### **Books for Reference:**

1. G.B. Thomas and R.L. Finney, Calculus, 9th Ed., Pearson Education, Delhi, 2005.
2. E. Marsden, A.J. Tromba and A. Weinstein, Basic Multivariable Calculus, Springer (SIE), Indian reprint, 2005.
3. Santosh K. Sengar-Advanced Calculus, Cengage Learning India Pvt. Ltd.

### C-5.2: Probability and Statistics

Total Marks:100

Theory:80 Marks+Mid-Sem:20 Marks

5 Lectures, 1 Tutorial (per week per student)

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

## Unit-III

Expectation of function of two random variables, conditional expectations, independent random variables, bivariate normal distribution, correlation coefficient, joint moment generating function (jmgf) and calculation of covariance (from jmgf), linear regression for two variables.

## Unit-IV

Chebyshevs 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, Markov Chains, Chapman-Kolmogorov equations, classification of states.

### Books Recommended:

1. Robert V. Hogg, Joseph W. McKean and Allen T. Craig, Introduction to Mathematical Statistics, Pearson Education, Asia, 2007. Chapters: 1(1.1, 1.3, 1.5-1.9), 2(2.1, 2.3-2.5).
2. Irwin Miller and Marylees Miller, John E. Freund, Mathematical Statistics with Applications, 7th Ed., Pearson Education, Asia, 2006. Chapters: 4, 5(5.1-5.5, 5.7), 6(6.2,6.3, 6.5-6.7), 14(14.1, 14.2)
3. Sheldon Ross, Introduction to Probability Models, 9th Ed., Academic Press, Indian Reprint, 2007. Chapters:2(2.7), 4(4.1-4.3).

### Books for References:

1. Alexander M. Mood, Franklin A. Graybill and Duane C. Boes, Introduction to the Theory of Statistics, 3rd Ed., Tata McGraw- Hill, Reprint 2007.
2. S.C. Gupta and V.K. Kapoor-Fundamentals of Mathematical Statistics, S. Chand and Company Pvt. Ltd., New Delhi.
3. S. Ross-A First Course in Probability, Pearson Education.

## Semester-VI

### C-6.1: Metric Spaces and Complex Analysis (Analysis-IV)

Total Marks:100

Theory:80 Marks+Mid-Sem:20 Marks

5 Lectures, 1 Tutorial (per week per student)

#### Unit-I

Metric spaces: definition and examples. Sequences in metric spaces, Cauchy sequences. Complete Metric Spaces. Open and closed balls, neighbourhood, open set, interior of a set, Limit point of a set, closed set, diameter of a set, Cantors theorem. Subspaces, dense sets, separable spaces. Continuous mappings, sequential criterion and other characterizations of continuity. Uniform continuity. Homeomorphism, Contraction mappings, Banach Fixed point Theorem. Connectedness, connected subsets of  $\mathbb{R}$ .

#### Unit-II

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

#### Unit-III

Analytic functions, examples of analytic functions, exponential function, Logarithmic function, trigonometric function, derivatives of functions, 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

Liouvilles theorem and the fundamental theorem of algebra. Convergence of sequences and series, Taylor series and its examples. Laurent series and its examples, absolute and uniform convergence of power series.

#### **Books Recommended:**

1. P.K. Jain and K. Ahmad, Metric Spaces, Narosa Publishing House, New Delhi. Chapters: 2(1-9), 3(1-4), 4(1-4), 6(1-2), 7(1 only).
2. James Ward Brown and Ruel V. Churchill, Complex Variables and Applications, 8th Ed., McGraw Hill International Edition, 2009. Chapters: 1(11 only), 2(12,13), 2(15-22, 24, 25), 3(29, 30, 34) 4(37-41, 43-46, 50-53), 5(55-60, 62,63,66).

#### **Books for References:**

1. Satish Shirali and Harikishan L. Vasudeva, Metric Spaces, Springer Verlag, London, 2006.
2. S. Kumaresan, Topology of Metric Spaces, 2nd Ed., Narosa Publishing House, 2011.
3. S. Ponnusamy-Foundations of Complex Analysis, Alpha Science International Ltd.
4. J.B. Conway-Functions of one complex variable, Springer.
5. N. Das- Complex Function Theory, Allied Publishers Pvt. Ltd., Mumbai.

## **C-6.2: Linear Programming**

**Total Marks:100**

**Theory:80 Marks+Mid-Sem:20 Marks**

**5 Lectures, 1 Tutorial (per week per student)**

### **Unit-I**

Introduction to linear programming problem, Theory of simplex method, optimality and unboundedness, the simplex algorithm, simplex method in tableau format, introduction to artificial variables, twophase method, BigM method and their comparison.

### **Unit-II**

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

### **Unit-III**

Transportation problem and its mathematical formulation, northwestcorner method least cost method and Vogel approximation method for determination of starting basic solution, algorithm for solving transportation problem, assignment problem and its mathematical formulation, Hungarian method for solving assignment problem.

### **Unit-IV**

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.

### **Recommended Books:**

1. Mokhtar S. Bazaraa, John J. Jarvis and Hanif D. Sherali, Linear Programming and Network Flows, 2nd Ed., John Wiley and Sons, India, 2004. Chapters:3(3.2-3.3, 3.5-3.8), 4(4.1-4.4), 6(6.1-6.3).
2. F.S. Hillier and G.J. Lieberman, Introduction to Operations Research, 9th Ed., Tata McGraw Hill, Singapore, 2009. Chapter:14
3. Hamdy A. Taha, Operations Research, An Introduction, 8th Ed., PrenticeHall India, 2006. Chapter:5(5.1, 5.3, 5.4).

### **Books for Reference:**

1. G. Hadley, Linear Programming, Narosa Publishing House, New Delhi, 2002.
2. Kanti Swarup, P.K. Gupta and Man Mohan-Operations Research, S. Chand and Co. Pvt. Ltd.
3. N.V.R. Naidu, G. Rajendra and T. Krishna Rao-Operations Research, I.K. International Publishing House Pvt. Ltd., New Delhi, Bangalore.
4. R. Veerachamy and V. Ravi Kumar-Operations Research- I.K. International Publishing House Pvt. Ltd., New Delhi, Bangalore.
5. P.K. Gupta and D.S. Hira-Operations Research, S. Chand and Company Pvt. Ltd., New Delhi.

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**Discipline Specific Electives(DES)**

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**DSE-1**  
**Programming in C++ (Compulsory)**  
**Part-I(Marks:75)**  
**(Theory:60 Marks+Mid-Sem:15 Marks)**

Introduction to structured programming: data types- simple data types, floating data types, character data types, string data types, arithmetic operators and operators precedence, variables and constant declarations, expressions, input using the extraction operator  $\ll$  and  $\text{cin}$ , output using the insertion operator  $\ll$  and  $\text{cout}$ , preprocessor directives, increment(++ ) and decrement(–) operations, creating a C++ program, input/ output, relational operators, logical operators and logical expressions, if and if-else statement, switch and break statements. for, while and do-while loops and continue statement, nested control statement, value returning functions, value versus reference parameters, local and global variables, one dimensional array, two dimensional array, pointer data and pointer variables.

**Book Recommended:**

1. D. S. Malik: C++ Programming Language, Edition-2009, Course Technology, Cengage Learning, India Edition. Chapters: 2(Pages:37-95), 3(Pages:96-129), 4(Pages:134-178), 5(Pages:181-236), 6, 7(Pages:287-304), 9 (pages: 357-390), 14(Pages:594-600).

**Books for References:**

1. E. Balaguruswami: Object oriented programming with C++, fifth edition, Tata McGraw Hill Education Pvt. Ltd.
2. R. Johnsonbaugh and M. Kalin-Applications Programming in ANSI C, Pearson Education.
3. S. B. Lippman and J. Lajoie, C++ Primer, 3rd Ed., Addison Wesley, 2000.
4. Bjarne Stroustrup , The C++ Programming Language, 3rd Ed., Addison Welsley.

**Part-II(Practical, Marks:25)**

**List of Practicals (Using any software)**  
**Practical/Lab work to be performed on a Computer.**

1. Calculate the Sum of the series  $\frac{1}{1} + \frac{1}{2} + \frac{1}{3} \dots + \frac{1}{N}$  for any positive integer  $N$ .
2. Write a user defined function to find the absolute value of an integer and use it to evaluate the function  $(-1)^n/|n|$ , for  $n = -2, -1, 0, 1, 2$ .
3. Calculate the factorial of any natural number.
4. Read floating numbers and compute two averages: the average of negative numbers and the average of positive numbers.
5. Write a program that prompts the user to input a positive integer. It should then output a message indicating whether the number is a prime number.
6. Write a program that prompts the user to input the value of  $a, b$  and  $c$  involved in the equation  $ax^2 + bx + c = 0$  and outputs the type of the roots of the equation. Also the program should outputs all the roots of the equation.
7. write a program that generates random integer between 0 and 99. Given that first two Fibonacci numbers are 0 and 1, generate all Fibonacci numbers less than or equal to generated number.

8. Write a program that does the following:
  - a. Prompts the user to input five decimal numbers.
  - b. Prints the five decimal numbers.
  - c. Converts each decimal number to the nearest integer.
  - d. Adds these five integers.
  - e. Prints the sum and average of them.
9. Write a program that uses whileloops to perform the following steps:
  - a. Prompt the user to input two integers :first Num and second Num (first Num should be less than second Num).
  - b. Output all odd and even numbers between first Num and second Num.
  - c. Output the sum of all even numbers between first Num and second Num.
  - d. Output the sum of the square of the odd numbers first Num and second Num.
  - e. Output all uppercase letters corresponding to the numbers between first Num and second Num, if any.
10. Write a program that prompts the user to input five decimal numbers. The program should then add the five decimal numbers, convert the sum to the nearest integer, and print the result.
11. Write a program that prompts the user to enter the lengths of three sides of a triangle and then outputs a message indicating whether the triangle is a right triangle or a scalene triangle.
12. Write a value returning function smaller to determine the smallest number from a set of numbers. Use this function to determine the smallest number from a set of 10 numbers.
13. Write a function that takes as a parameter an integer (as a long value) and returns the number of odd, even, and zero digits. Also write a program to test your function.
14. Enter 100 integers into an array and sort them in an ascending/ descending order and print the largest/ smallest integers.
15. Enter 10 integers into an array and then search for a particular integer in the array.
16. Multiplication/ Addition of two matrices using two dimensional arrays.
17. Using arrays, read the vectors of the following type:  $A = (12345678)$ ,  $B = (02340156)$  and compute the product and addition of these vectors.
18. Read from a text file and write to a text file.
19. Write a function, reverse Digit, that takes an integer as a parameter and returns the number with its digits reversed. For example, the value of function reverse Digit12345 is 54321 and the value of reverse Digit  $-532$  is  $-235$ .

## DSE-II

**Total Marks:100**

**Theory:80 Marks+Mid-Sem:20 Marks**

**5 Lectures, 1 Tutorial (per week per student.**

**(Any one of the following)**

### 1-Discrete Mathematics

#### Unit-I

Logic, propositional equivalence, predicates and quantifiers, nested quantifiers, methods of proof, relations and their properties, n-ary relations and their applications, Boolean functions and their representation. The basic counting, the Pigeon-hole principle, Generalized Permutations and Combinations.



## Unit-II

Recurrence relations, Counting using recurrence relations, Solving linear homogeneous recurrence relations with constant coefficients, Generating functions, Solving recurrence relations using generating functions.

## Unit-III

Partially ordered sets, Hasse diagram of partially ordered sets, maps between ordered sets, duality principle, Lattices as ordered sets, Lattices as algebraic structures, sublattices, Boolean algebra and its properties.

## Unit-IV

Graphs: Basic concepts and graph terminology, representing graphs and graph isomorphism. Distance in a graph, Cut-vertices and Cut-edges, Connectivity, Euler and Hamiltonian path.

### Book Recommended:

1. Kenneth H. Rosen, Discrete Mathematics and Applications, Tata McGraw Hill Publications, Chapters: 1(1.1 to 1.5), 4(4.1, 4.2, 4.5), 6(6.1, 6.2, 6.5, 6.6), 7(7.1, 7.2), 8,10(10.1,10.2).

### Books for References:

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 Edition), Pearson Education (Singapore) Pte. Ltd., Indian Reprint 2003.
3. Rudolf Lidl and Gnter Pilz, Applied Abstract Algebra (2nd Edition), Undergraduate Texts in Mathematics, Springer (SIE), Indian reprint, 2004.
4. D.S. Malik-Discrete Mathematics: Theory & Applications, Cengage Learning India Pvt. Ltd.
5. Kevin Ferland-Discrete Mathematical Structures, Cengage Learning India Pvt. Ltd.

## 2-Mathematical Modelling

### Unit-I

Simple situations requiring Mathematical modelling. The technique of Mathematical modelling, Mathematical modelling through differential equations, linear growth and decay models, non-linear growth and decay models, compartment models, Mathematical modelling of geometrical problems through ordinary differential equations of first order.

### Unit-II

Mathematical modelling in population dynamics, Mathematical modelling of epidemics through systems of ordinary differential equations of first order, compartment models through systems of ordinary differential equations, Mathematical modelling in economics through systems of ordinary differential equations of first order.

### Unit-III

Mathematical models in medicine, arms race, battles and international trade in terms of systems of ordinary differential equations, Mathematical modelling of planetary motions, Mathematical modelling of circular motion and motion of satellites, mathematical modelling through linear differential equations of second order.

### Unit-IV

Situation giving rise to partial differential equations models, mass balance equations: First method of getting PDE models, momentum balance equations. The second method of obtaining partial differential models, variational principles, third function, fourth method of obtaining partial differential equation models, models for traffic flow of a highway. Situation that can be modelled through graphs, mathematical models in terms of directed graphs, optimization principles and techniques, Mathematical modelling through calculus of variations.

#### Books Recommended:

1. J.N. Kapur-Mathematical Modelling, Chapters: 1(1.1 and 1.2), 2(2.1 to 2.4, 2.6), 3(3.1 to 3.5), 4(4.1 to 4.3), 6(6.1 to 6.6), 7(7.1 to 7.2), 9(9.1 and 9.2).

### 3-Number Theory

#### Unit-I

Divisibility theorem in integers, Primes and their distributions, Fundamental theorem of arithmetic, Greatest common divisor, Euclidean algorithms, Modular arithmetic, Linear Diophantine equation, prime counting function, statement of prime number theorem, Goldbach conjecture.

#### Unit-II

Introduction to congruences, Linear Congruences, Chinese Remainder theorem, Polynomial congruences, System of linear congruences, complete set of residues, Chinese remainder theorem, Fermats little theorem, Wilsons theorem.

#### Unit-III

Number theoretic functions, sum and number of divisors, totally multiplicative functions, definition and properties of the Dirichlet product, the Mbius inversion formula, the greatest integer function, Eulers phifunction, Eulers theorem, reduced set of residues, some properties of Eulers phi-function.

#### Unit-IV

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

#### Book Recommended:

1. D.M. Burton-Elementary Number Theory, McGraw Hill, Chapters: 2(2.1 to 2.4), 3(3.1 to 3.3), 4(4.1 to 4.4), 5(5.1 to 5.4), 6(6.1 to 6.3), 7(7.1 to 7.3), 8(8.1 to 8.2), 9(9.1 to 9.3).

#### Books for References:

1. K.H. Rosen-Elementary Number Theory & its Applications, Pearson Addition Wesley.
2. I. Niven and H.S. Zuckerman-An Introduction to Theory of Numbers, Wiley Eastern Pvt. Ltd.
3. Tom M. Apostol-Introduction to Analytic Number Theory, Springer International Student Edn.
4. Neville Robinns, Beginning Number Theory (2nd Edition), Narosa Publishing House Pvt. Limited, Delhi, 2007.

## 4-Boolean Algebra and Automata Theory

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

### Unit-II

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-III

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.

### Unit-IV

Turing Machines: Turing machine as a model of computation, programming with a Turing machine, variants of Turing machine and their equivalence. 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 Gnter 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.

**DSE-III****Total Marks:100****Theory:80 Marks+Mid-Sem:20 Marks****5 Lectures, 1 Tutorial (per week per student.****(Any one of the following)****1-Differential Geometry****Unit-I**

Theory of Space Curves: Space curves, Planer curves, Curvature, torsion and Serret-Frenet formulae. Osculating circles, Osculating circles and spheres. Existence of space curves. Evolutes and involutes of curves.

**Unit-II**

Osculating circles, Osculating circles and spheres. Existence of space curves. Evolutes and involutes of curves.

**Unit-III**

Developables: Developable associated with space curves and curves on surfaces, Minimal surfaces.

**Unit-IV**

Theory of Surfaces: Parametric curves on surfaces. Direction coefficients. First and second Fundamental forms. Principal and Gaussian curvatures. Lines of curvature, Eulers theorem. Rodrigues formula, Conjugate and Asymptotic lines.

**Book Recommended:**

1. C.E. Weatherburn, Differential Geometry of Three Dimensions, Cambridge University Press 2003. Chapters:1(1-4, 7,8,10), 2(13, 14, 16, 17), 3, 4(29-31, 35, 37, 38).

**Books for References**

1. T.J. Willmore, An Introduction to Differential Geometry, Dover Publications, 2012.
2. S. Lang, Fundamentals of Differential Geometry, Springer, 1999.
3. B. O'Neill, Elementary Differential Geometry, 2nd Ed., Academic Press, 2006.
4. A.N. Pressley-Elementary Differential Geometry, Springer.
5. B.P. Acharya and R.N. Das-Fundamentals of Differential Geometry, Kalyani Publishers, Ludhiana, New Delhi.

**2-Mechanics****Unit-I**

Moment of a force about a point and an axis, couple and couple moment, Moment of a couple about a line, resultant of a force system, distributed force system, free body diagram, free body involving interior sections, general equations of equilibrium, two point equivalent loading, problems arising from structures, static indeterminacy.

## Unit-II

Laws of Coulomb friction, application to simple and complex surface contact friction problems, transmission of power through belts, screw jack, wedge, first moment of an area and the centroid, other centers, Theorem of Pappus-Guldinus, second moments and the product of area of a plane area, transfer theorems, relation between second moments and products of area, polar moment of area, principal axes.

## Unit-III

Conservative force field, conservation for mechanical energy, work energy equation, kinetic energy and work kinetic energy expression based on center of mass, moment of momentum equation for a single particle and a system of particles.

## Unit-IV

Translation and rotation of rigid bodies, Chasles theorem, general relationship between time derivatives of a vector for different references, relationship between velocities of a particle for different references, acceleration of particle for different references.

### Book Recommended:

1. I.H. Shames and G. Krishna Mohan Rao, Engineering Mechanics: Statics and Dynamics, (4th Ed.), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education), Delhi, 2009. Chapters:3, 4, 5, 6(6.1-6.7), 7, 11, 12(12.5, 12.6), 13.

### Books for References:

1. R.C. Hibbeler and Ashok Gupta, Engineering Mechanics: Statics and Dynamics, 11th Ed., Dorling Kindersley (India) Pvt. Ltd. (Pearson Education), Delhi.
2. Grant R Fowles, Analytical Mechanics, Cengage Learning India Pvt. Ltd.

## 3-Mathematical Finance

### 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), 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-II

Asset return, short selling, portfolio return, (brief introduction to expectation, variance, covariance and correlation), random returns, portfolio mean return and variance, diversification, portfolio diagram, feasible set, Markowitz model (review of Lagrange multipliers for 1 and 2 constraints), Two fund theorem, risk free assets, One fund theorem, capital market line, 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, Jensens index.

### Unit-III

Forwards and futures, marking to market, value of a forward/futures contract, replicating portfolios, futures on assets with known income or dividend yield, currency futures, hedging (short, long, cross, rolling), optimal hedge ratio, hedging with stock index futures, interest rate futures, swaps.

### Unit-IV

Lognormal distribution, Lognormal model / Geometric Brownian Motion for stock prices, Binomial Tree model for stock prices, parameter estimation, comparison of the models. Options, Types of options: put / call, European / American, pay off of an option, factors affecting option prices, put call parity.

#### Books Recommended:

1. David G. Luenberger, Investment Science, Oxford University Press, Delhi, 1998. Chapters:1, 2, 3, 4, 6, 7, 8(8.5-8.8), 10(except 10.11, 10.12), 11(except 11.2 11.8).
2. John C. Hull, Options, Futures and Other Derivatives (6th Edition), Prentice-Hall India, Indian reprint, 2006. Chapters: 3, 5, 6, 7(except 7.10, 7.11), 8, 9.
3. Sheldon Ross, An Elementary Introduction to Mathematical Finance (2nd Edition), Cambridge University Press, USA, 2003. Chapter:3

#### Books for References:

1. R.C. Hibbeler and Ashok Gupta, Engineering Mechanics: Statics and Dynamics, 11th Ed., Dorling Kindersley (India) Pvt. Ltd. (Pearson Education), Delhi.
2. Grant R Fowles, Analytical Mechanics, Cengage Learning India Pvt. Ltd.

## 4-Ring Theory and Linear Algebra-II

### Unit-I

Polynomial rings over commutative rings, division algorithm and consequences, principal ideal domains, factorization of polynomials, reducibility tests, irreducibility tests, Eisenstein criterion, unique factorization in  $\mathbb{Z}[x]$ .

### Unit-II

Divisibility in integral domains, irreducibles, primes, unique factorization domains, Euclidean domains.

### Unit-III

Dual spaces, dual basis, double dual, transpose of a linear transformation and its matrix in the dual basis, annihilators, Eigenspaces of a linear operator, diagonalizability, invariant subspaces and Cayley-Hamilton theorem, the minimal polynomial for a linear operator.

### Unit-IV

Inner product spaces and norms, Gram-Schmidt orthogonalisation process, orthogonal complements, Bessels inequality, the adjoint of a linear operator, Least Squares Approximation, minimal solutions to systems of linear equations, Normal and self-adjoint operators, Orthogonal projections and Spectral theorem.

#### Books Recommended:

1. Joseph A. Gallian, Contemporary Abstract Algebra (4th Ed.), Narosa Publishing House, 1999. Chapters: 16, 17, 18.
2. Stephen H. Friedberg, Arnold J. Insel, Lawrence E. Spence, Linear Algebra (4th Edition), Prentice-Hall of India Pvt. Ltd., New Delhi, 2004. Chapters: 2(2.6 only), 5(5.1, 5.2, 5.4), 6(6.1, 6.4, 6.6), 7(7.3 only).

**Books for References:**

(For Linear Algebra)

1. S Lang, Introduction to Linear Algebra (2nd edition), Springer, 2005
2. Gilbert Strang, Linear Algebra and its Applications, Thomson, 2007
3. S. Kumaresan, Linear Algebra- A Geometric Approach, Prentice Hall of India, 1999.
4. 4. Kenneth Hoffman, Ray Alden Kunze, Linear Algebra 2nd Ed., Prentice-Hall Of India Pvt. Limited, 1971.

(For Ring Theory )

1. John B.Fraleigh, A first course in Abstract Algebra, 7th Edition, Pearson Education India, 2003.
2. Herstein, Topics in Algebra (2nd edition), John Wiley & Sons, 2006
3. M ichael Artin, Algebra (2nd edition), Pearson Prentice Hall, 2011
4. Robinson, Derek John Scott., An introduction to abstract algebra, Hindustan book agency, 2010.

**DSE-IV****Project Work(Compulsory)**

**Total Marks:100 (Project:75 Marks+Viva-Voce:25 Marks)**

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**Skill Enhancement Courses(SEC)**  
(Credit: 2 each, Total Marks:50)  
SEC-I to SEC-IV

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**SEC-I**  
**Communicative English and Writing Skill(Compulsory)**

**SEC-II**  
(Any one of the following)

**1-Computer Graphics**

Development of computer Graphics: Raster Scan and Random Scan graphics storages, displays processors and character generators, colour display techniques, interactive input/output devices. Points, lines and curves: Scan conversion, line-drawing algorithms, circle and ellipse generation, conic-section generation, polygon filling anti aliasing. Two-dimensional viewing: Coordinate systems, linear transformations, line and polygon clipping algorithms.

**Books Recommended:**

1. D. Hearn and M.P. Baker-Computer Graphics, 2nd Ed., PrenticeHall 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.

**2-Logic and Sets**

Introduction, propositions, truth table, negation, conjunction and disjunction. Implications, biconditional propositions, converse, contra positive and inverse propositions and precedence of logical operators. Propositional equivalence: Logical equivalences. Predicates and quantifiers: Introduction, Quantifiers, Binding variables and Negations. 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. Classes of sets. Power set of a set. Difference and Symmetric difference of two sets. Set identities, Generalized union and intersections. Relation: Product set, Composition of relations, Types of relations, Partitions, Equivalence Relations with example of congruence modulo relation, 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.



### 3-Combinatorial Mathematics

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, Derangements, Inversion formulae Generating functions: Algebra of formal power series, Generating function models, Calculating generating functions, Exponential generating functions. Recurrence relations: Recurrence relation models, Divide and conquer relations, Solution of recurrence relations, Solutions by generating functions. Integer partitions, Systems of distinct representatives.

#### 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.

### 4-Information Security

Overview of Security: Protection versus security; aspects of security data integrity, data availability, privacy; security problems, user authentication, Orange Book. Security Threats: Program threats, worms, viruses, Trojan horse, trap door, stack and buffer over flow; system threats- intruders; communication threats- tapping and piracy. Security Mechanisms: Intrusion detection, auditing and logging, tripwire, system-call monitoring.

#### Books Recommended:

1. C. Pfleeger and S.L. Pfleeger-Security in Computing , 3rd Ed., Prentice-Hall of India, 2007.
2. D. Gollmann-Computer Security, John Wiley and Sons, NY, 2002.
3. J. Piwprzyk, T. Hardjono and J. Seberry-Fundamentals of Computer Security, Springer- Verlag Berlin, 2003.
4. J.M. Kizza-Computer Network Security, Springer, 2007.
5. M. Merkow and J. Breithaupt-Information Security: Principles and Practices, Pearson Education, 2006.

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**Generic Electives/Interdisciplinary**  
**(04 Papers, 02 papers each from two Allied disciplines)**  
**(Credit: 06 each, Marks:100)**  
**GE-I to GE-IV**

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**GE-I: Calculus and Ordinary Differential Equations**

**Unit-I**

Curvature, Asymptotes, Tracing of Curves (Cartenary, Cycloid, Folium of Descartes, Astroid, Limacon, Cissoid & loops), Rectification, Quadrature, Volume and Surface area of solids of revolution.

**Unit-II**

Sphere, Cones and Cylinders, Conicoid.

**Unit-III**

Explicit and Implicit functions, Limit and Continuity of functions of several variables, Partial derivatives, Partial derivatives of higher orders, Homogeneous functions, Change of variables, Mean value theorem, Taylors theorem and Maclaurins theorem for functions of two variables. Maxima and Minima of functions of two and three variables, Implicit functions, Lagranges multipliers. Multiple integrals.

**Unit-IV**

Ordinary Differential Equations of 1st order and 1st degree (Variables separable, homogenous, exact and linear). Equations of 1st order but higher degree.

**Unit-V**

Second order linear equations with constant coefficients, homogeneous forms, Second order equations with variable coefficients, Variation of parameters. Laplace transforms and its applications to solutions of differential equations.

**Books Recommended:**

1. Shantinayakan-Text Book of Calculus, Part-II, S. Chand and Co., Chapter-8 (Art. 24, 25, 26)
2. Shantinayakan-Text Book of Calculus, Part-III, S. Chand and Co., Chapter-1 (Art 1,2), 3, 4(Art. 10 to 12 ommitting Simpsons Rule), 5(Art-13) and 6(Art-15).
3. B.P. Acharya and D.C. Sahu-Analytical Geometry of Quadratic Surfaces, Kalyani Publishers, New Delhi, Ludhiana.
4. Santosh K. Sengar-Advanced Calculus, Chapters: 2, 4, 5, 6, 7, 11, 12, 13.
5. J. Sinharoy and S. Padhy-A Course of Ordinary and Partial Differential Equations, Kalyani Publishers. Chapters: 2(2.1 to 2.7), 3, 4(4.1 to 4.7), 5, 9(9.1, 9.2, 9.3, 9.4, 9.5, 9.10, 9.11, 9.13).

**Books for References:**

1. Shanti Narayan and P.K. Mittal-Analytical Solid Geometry, S. Chand & Company Pvt. Ltd., New Delhi.
2. David V. Weider-Advanced Calculus, Dover Publications.
3. Martin Braun-Differential Equations and their Applications-Martin Braun, Springer International.
4. M.D. Raisinghania-Advanced Differential Equations, S. Chand & Company Ltd., New Delhi.

5. G. Dennis Zill-A First Course in Differential Equations with Modelling Applications, Cengage Learning India Pvt. Ltd.

## **GE-II: Linear Algebra and Advanced Algebra**

### **Unit-I**

Vector space, Subspace, Span of a set, Linear dependence and Independence, Dimensions and Basis. Linear transformations, Range, Kernel, Rank, Nullity, Inverse of a linear map, Rank-Nullity theorem.

### **Unit-II**

Matrices and linear maps, Rank and Nullity of a matrix, Transpose of a matrix, Types of matrices. Elementary row operations, System of linear equations, Matrix inversion using row operations, Determinant and Rank of matrices, Eigen values, Eigen vectors, Quadratic forms.

### **Unit-III**

Group Theory: Definition and examples, Subgroups, Normal subgroups, Cyclic groups, Cosets, Quotient groups, Permutation groups, Homomorphism.

### **Unit-IV**

Ring Theory: Definition and examples, Some special classes of Rings, Ideals, Quotient rings, Ring homomorphism. Isomorphism theorems.

### **Unit-V**

Zero divisors, Integral domain, Finite fields, Finite field  $Z/pZ$ , Field of quotients of an Integral domain, Polynomial ring, Division algorithm, Remainder theorem, Factorization of polynomials, irreducible and reducible polynomials, Primitive polynomials, Irreducibility tests, Eisenstein Criterion.

### **Books Recommended:**

1. V. Krishnamurthy, V. P. Mainra, J. L. Arora-An introduction to Linear Algebra, Affiliated East-West Press Pvt. Ltd., New Delhi, Chapters: 3, 4(4.1 to 4.7), 5(except 5.3), 6(6.1, 6.2, 6.5, 6.6, 6.8), 7(7.4 only).
2. I.H. Seth-Abstract Algebra, Prentice Hall of India Pvt. Ltd., New Delhi. Chapters:13, 14, 15, 16, 17,18,19,20.

### **Books for References:**

1. S. Kumaresan-Linear Algebra: A Geometric Approach, Prentice Hall of India.
2. Rao and Bhimasankaran-Linear Algebra, Hindustan Publishing House.
3. S. Singh-Linear Algebra, Vikas Publishing House Pvt. Ltd., New Delhi.
4. Gilbert Strang-Linear Algebra & its Applications, Cengage Learning India Pvt. Ltd.
5. I.N. Herstein-Topics in Algebra, Wiley Eastern Pvt. Ltd.
6. Gallian-Contemporary Abstract Algebra, Narosa publishing House.
7. Artin-Algebra, Prentice Hall of India.
8. V.K. Khanna and S.K. Bhambri-A Course in Abstract Algebra, Vikas Publishing House Pvt. Ltd., New Delhi.