Draft Undergraduate Syllabus for B. A. / B. Sc. (Honours)
In Mathematics Under Dibrugarh University

(To be effective from the session 2019-2020)

As approved in the BoS meetings held on 30/11/2016, 10/03/2017, 08/03/2019

The Objectives of the B.Sc. Programme in Mathematics are listed in the following. After completing the programme the students will be able to-

(1) Apply Mathematics as a tool to solve problems of other disciplines viz., Science and Technology, Commerce and Management, Humanities, Soft-computing etc.
(2) Pursue higher studies in the subject to take part in the academic upliftment of the subject.
(3) Develop new techniques/methods for solving the unsolved problems of the other disciplines.
(4) Construct Mathematical models to mimic real life problems and make their predictions, estimations, and regression.

Choice Based Credit System in B. Sc. (Hons.) Mathematics

Semester	Core Course (14 Credits)	Ability Enhancement Compulsory Course (AECC) (2 Credits)	Skill Enhancement Course (SEC) (2 Credits)	Discipline Specific Elective (DSE) (6)	Generic Elective (GE)(6)
I	C1 Calculus (P)	AECC-1 Communicative English			GE-1
	C2 Algebra	AECC-2 MIL/ Communicative Hindi/ Alternative English			
II	C3 Real Analysis	AECC-3 Environmental Science			GE-2
	C4 Differential Equations (P)				
III	C5 Theory of Real functions		SEC-1		GE-3
	C6 Group Theory I				
	C7 PDE and Systems of ODE (P)				
IV	C8 Numerical Methods(P)		SEC-2		GE-4
	C9 Riemann Integration and Series of Functions				
	C10 Ring Theory and Linear Algebra I				
V	C11 Multivariate Calculus			DSE-1	
	C12 Group Theory II			DSE-2	
VI	C13 Metric Spaces and Complex Analysis			DSE- 3	
	C14 Ring Theory and Linear Algebra II			DSE- 4	

(P) ***means course with Practicals***

Discipline Specific Electives (DSE) : Options will be offered subject to availability of resource persons.

Choices for DSE-1 (choose one)

1. Analytical Geometry
2. Portfolio Optimization
3. Financial Mathematics

Choices for DSE-2 (choose one)

1. Mathematical Modelling
2. Mechanics
3. Number Theory
4. Bio-Mathematics
5. Industrial Mathematics

Choices for DSE-3 (choose one)

1. Hydro-mechanics
2. Linear Programming
3. Discrete Mathematics
4. Theory of Equations
5. Dynamical Systems

Choices for DSE-4 (choose one)

1. Mathematical Methods
2. Boolean Algebra and Automata Theory
3. Probability and Statistics
4. Differential Geometry

Skill Enhancement Course (SEC)

Choices for SEC-1 (choose one)

1. Logic and Sets
2. Computer Graphic

Choices for SEC-2 (choose one)

1. Graph Theory
2. Operating System: Linux

Generic Electives (GE) (to be offered to students of other disciplines)

Choices for GE-1 (choose one)

1. Differential Calculus
2. Object Oriented Programming in C++(P)
3. Finite Element Methods

Choices for GE-2 (choose one)

1. Differential Equations
2. Econometrics

Choices for GE-3 (choose one)

1. Real Analysis
2. Cryptography and Network Security
3. Information Security

Choices for GE-4 (choose one)

1. Algebra
2. Applications of Algebra
3. Combinatorial Mathematics

Details of courses under B.Sc. (Hons.) Mathematics

Course	*Credits	
	Theory + Practical	**Theory + Tutorial**
I. Core Course (14 Courses)		
Core Course Practical / Tutorial*	4×(4+2) = 24	10×(5+1) = 60
II. Elective Course (8 Courses)		
A.1. Discipline Specific Elective **(4 Courses)**	4×4 = 16	4×5 = 20
A.2. Discipline Specific Elective Practical/ Tutorial* **(4 Courses)**	4×2 = 8	4×1 = 4
B.1. Generic Elective/ Interdisciplinary **(4 Courses)**	4×4 = 16	4×5 = 20
B.2. Generic Elective Practical/ Tutorial* **(4 Courses)**	4×2 = 8	4×1 = 4

Optional Dissertation or project work in place of one Discipline Specific Elective Paper (6 credits) in 6thSemester

III. Ability Enhancement Courses

AECC		SEC	
Course Title	**Credit**	**Course Title**	**Credits**
Environmental Science	**2**	SEC-1	**2**
Communicative English	**2**	SEC-2	**2**
MIL/ Communicative Hindi/ Alternative English	**2**		
Total= 6 Credit		**Total= 4 Credit**	

Institute should evolve a system/ policy about ECA/ General Interest/ Hobby/ Sports/ NCC/ NSS/ related courses on its own.

*** Wherever there is a practical there will be no tutorial and vice-versa.**

Total Credit Structure (Minimum)

Core	DSE	GE	AECC	SEC	Total
14 Courses of 6 Credit	**4 Courses of 6 Credit**	**4 Courses of 6 Credit**	**3 Courses of 2 Credit each**	**1 Course of 2 parts credits each**	**26 Courses**
84	**24**	**24**	**6**	**4**	**142**

C1.1 Calculus
Total Marks: 100, Theory: 60, IA: 20, Practical: 20
Credit: 4+2=6;
(L=4, P=4, T=0)

Objectives: After going through this course the students will be able to

- Apply Calculus in real life problems
- Formulate mathematical models

Unit-1 Marks: 20, Contact hrs: 20

Hyperbolic functions, higher order derivatives, Leibniz rule and its applications to problems of 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, L'Hospitals rule, applications of maxima and minima.

Unit-2 Marks: 15, Contact hrs: 10

Reduction formulae, derivations and illustrations of reduction formulae of the type $\int sin\, nx\, dx$, $\int \cos nx\, dx$, $\int \tan nx\, dx$, $\int \sec nx\, dx$, $\int (logx)^n dx$, $\int sin^n x\, sin^m x\, dx$, volume by slicing, disks and washer methods, volumes by cylindrical shells.

Unit-3 Marks: 15, Contact hrs: 20

Parameterizing a curve, arc length, arc length of parametric curves, area of surface of revolution. 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.

Unit-4 Marks: 10, Contact hrs: 10

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,

List of Practical (using any software) **Marks : 20,** Contact hrs: 30

(i) 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.

(ii) Plotting the graphs of polynomials of degree 4 and 5, the derivative graph, the second derivative graph and comparing them.

(iii) Sketching parametric curves (E.g., Trochoid, cycloid, epicycloids, hypocycloid).

(iv) Obtaining surface of revolution of curves.
(v) Tracing of conics in Cartesian coordinates/ polar coordinates.
(vi) Sketching ellipsoid, hyperboloid of one and two sheets, elliptic cone, elliptic, paraboloid, hyperbolic paraboloid using cartesian coordinates.
(vii) Matrix operations (addition, multiplication, inverse, transpose).

Text Books:

1. G.B. Thomas and R.L. Finney, *Calculus*, 9th Ed., Pearson Education, Delhi, 2005
2. B. C. Das & B. N. Mukherjee, Differential Calculus, U. N. Dhur and Sons. Pvt. Ltd
3. S. Narayan & P. K. Mittal, Integral Calculus, S. Chand Publishing
4. S. Narayan & P. K. Narayan, A Text Book on Vector Calculus, S. Chand Publishing\

Reference Books:

1. M.J. Strauss, G.L. Bradley and K. J. Smith, *Calculus,* 3rd Ed., Dorling Kindersley (India) P. Ltd. (Pearson Education), Delhi,2007.
2. H. Anton, I. Bivens and S. Davis, *Calculus,* 7th Ed., John Wiley and Sons (Asia) P. Ltd., Singapore,2002.
3. R. Courant and F. John, *Introduction to Calculus and Analysis* (Volumes I & II), Springer-Verlag, New York, Inc.,1989.

Guideline:

Unit 1: [1] Chapters 3,9
[2] Chapters 8,10,11,16,19,20 (52nd Ed., 2012).

Unit 2: [1] Chapter 5
[3] Chapter 4

Unit 3: [1] Chapters 5 (sec.7) ;8 (sec. 4,7,8) ; 10(sec. 3); 13 (sec. 3) .
[3] Chapters 10 (sec.5)

Unit 4: [1] Chapters 13 (sec.9) ;14 (sec. 1,5)
[4] Chapter 1 (sec.1--8)
Note: concept of tracing (unit 1) /sketching (unit 3) should be imparted in practical.

C1.2 Algebra
Total Marks: 100, Theory: 80, IA: 20
Credit: 5+1=6;
(L=5, P=0, T=1)

Objectives:: After going through this course the students will be able to

- Describe various algebraic structures on sets
- Identify the algebraic structures present in different branches of Sciences

Unit-1 Marks: 10, Contact hrs: 15

Polar representation of complex numbers, n^{th} roots of unity, De Moivre's theorem for rational indices and its applications.

Unit-2 Marks: 25, Contact hrs: 30

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-3 Marks: 20, Contact hrs: 20

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-4 Marks: 25, Contact hrs: 25

Introduction to linear transformations, matrix of a linear transformation, inverse of a matrix, characterizations of invertible matrices. Subspaces of R^n, dimension of subspaces of R^n and rank of a matrix, Eigenvalues, Eigen Vectors and Characteristic Equation of a matrix.

Text Books:

1. Hall & Night, Higher Algebra, Arihant Publishers, 2013.
2. K. Hoffman, R.A. Kunze, Linerar Algebra 2nd Ed., Prentice-Hall of India Pvt. Ltd.,1971.
3. S. L. Loney, Plane Trigonometry, Arihant Publishers, 2016.
4. D. C. Lay, Linear Algebra and its Applications, 3rd Ed., Pearson Education Asia, Indian Reprint,2007.
5. R.G. Bartle and D. R. Sherbert, Introduction to Real Ananlysis. Willy Std Edition, 2014.
6. B Das & B N Mukherjee, Higher Trigonometry, U N Dhur & Sons, 2007.

Reference Books:

1. T. Andreescu and D. Andrica, *Complex Numbers from A to Z*, Birkhauser,2006.
2. E. G. Goodaire and M. M. Parmenter, *Discrete Mathematics with Graph Theory,* 3rd Ed., Pearson Education (Singapore) P. Ltd., Indian Reprint, 2005**.**

Guideline:

Unit 1: [6]

Unit 2 :[5] Chapter 1(sec. 1,2)

Unit 3,4 :[4] Chapters 1(sec. 1--9); 2(sec. 2,3,8,9); 3(sec. 1,2)

C2.1 Real Analysis

Total Marks: 100, Theory: 80, IA: 20

Credit: 5+1=6;

(L=5, P=0, T=1)

Objectives:: After going through this course the students will be able to

- Identify the properties of the number system.
- Describe various analytical properties of the real number system.

Unit-1 Marks: 30, Contact hrs: 35

Review of Algebraic and Order Properties of *R,* -neighborhood of a point in *R,* Idea of countable sets, uncountable sets and uncountability of *R.* Bounded above sets, Bounded below sets, Bounded Sets, Unbounded sets, Suprema and Infima, The Completeness Property of *R,* The Archimedean Property, Density of Rational (and Irrational) numbers in *R,* Intervals. Limit points of a set, Isolated points, Illustrations of Bolzano-Weierstrass theorem for sets.

Unit-2 Marks: 30, Contact hrs: 35

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-3 Marks: 20, Contact hrs:20

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.

Text Books:

1. R.G. Bartle and D. R. Sherbert, *Introduction to Real Analysis,* 3rd Ed., John Wiley and Sons (Asia) Pvt. Ltd., Singapore,2002.
2. A. Kumar and S. Kumarasen, A Basic Course in Real Analysis, CRC Press, 2014.
3. G. B. Thomas and R. L. Finney, Calculus, Pearson, 9th Ed, 2005.

Reference Books:

1. G. G. Bilodeau , P. R. Thie, G.E. Keough, *An Introduction to Analysis,* 2nd Ed., Jones & Bartlett,2010.
2. B. S. Thomson, A. M. Bruckner and J. B. Bruckner, *Elementary Real Analysis,* Prentice Hall, 2001.
3. S.K. Berberian, *A First Course in Real Analysis*, Springer Verlag, New York, 1994.

Guideline:

Unit 1: [1] Chapter 1 (sec. 3); 2 (sec. 1—5);
[2] Chapter 1.1, 1,2, 1.3

Unit 2 : [1] Chapters 3(sec. 1---5)
[2] Chapter 2
[3] Chapter 11(sec.1,2,3)

Unit 3 : [1] Chapters 3(sec. 7); 9(sec. 1,2,3)
[3] Chapter 11(sec.4,5,6,7)

C2.2 Differential Equations
Total Marks: 100, Theory: 60, IA: 20, Practical: 20
Credit: 4+2=6;
(L=4, P=4, T=0)

Objectives:: After going through this course the students will be able to

- Use the techniques to solve differential equations.
- Apply these techniques in various mathematical models used in real life problems.

Unit-1 Marks: 15, Contact hrs: 15

Differential equations and mathematical models. General, particular, explicit, implicit and singular solutions of a differential equation. 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-2 Marks: 10, Contact hrs: 10

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-3 Marks: 25, Contact hrs: 25

General solution of homogeneous equation of second order, principle of super position for homogeneous equation, Wronskian: its properties and applications, Linear homogeneous and non-homogeneous equations of higher order with constant coefficients, Euler′s equation, method of undetermined coefficients, method of variation of parameters.

Unit-4 Marks: 10, Contact hrs: 10

Equilibrium points, Interpretation of the phase plane, predatory-prey model and its analysis, epidemic model of influenza and its analysis, battle model and its analysis.

List of Practical (using any software) **Marks: 20, Contact hrs: 30**

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. Predatory-prey 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 $(n+1)^{th}$ term.

Text Books:

1. S.L. Ross, *Differential Equations,* 3rd Ed., John Wiley and Sons, India, 2004.
2. E. A. Coddington, An Introduction to Ordinary Differential Equation, Dover Publications, 1961.

Reference Books:

1. B. B. and G. R. Fulford, *Mathematical Modeling with Case Studies, A Differential Equation Approach using Maple and Matlab,* 2nd Ed., Taylor and Francis group, London and New York,2009.
2. C.H. Edwards and D.E. Penny, *Differential Equations and Boundary Value problems Computing and Modeling,* Pearson Education India,2005.
3. M. L. Abell, J. P. Braselton, *Differential Equations with MATHEMATICA,* 3rd Ed., Elsevier Academic Press,2004.

Guideline:

Unit 1 [1] Chapter 1,2
Unit 3 [1] Chapter 4

C3.1 Theory of Real Functions
Total Marks: 100, Theory: 80, IA: 20
Credit: 5+1=6;
(L=5, P=0, T=1)

Objectives:: After going through this course the students will be able to

- Discuss limit, continuity and differentiability of real valued functions
- Expand functions in series and different form of remainders

Unit-1 Marks: 30, Contact hrs: 30

Limits of functions (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. 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.

Unit-2 Marks: 25, Contact hrs: 30

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. Applications of mean value theorem to inequalities and approximation of polynomials, Taylor′s theorem to inequalities.

Unit-3 Marks: 25, Contact hrs: 30

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 $(1 +x)^n$.

Text Books:

1. R. Bartle and D. R. Sherbert, *Introduction to Real Analysis*, John Wiley and Sons,2003.
2. S.R. Ghorpade and B.V. Limaye, *A Course in Calculus and Real Analysis,* Springer, 2006.

Reference Books:

1. K.A. Ross, *Elementary Analysis: The Theory of Calculus*, Springer,2004.
2. A. Mattuck, *Introduction to Analysis*, Prentice Hall,1999.

Guideline

Unit 1 [1] Chapter 4; Chapter 5(sec. 1—4.3)
Unit 2, 3 [1] Chapter 6(sec.1—4)

C3.2 Group Theory I
Total Marks: 100, Theory: 80, IA: 20
Credit: 5+1=6; (L=5, P=0, T=1)

Objectives: After going through this course the students will be able to

- Describe various group structures on sets.
- Indentify the group structures present in different branches of sciences.

Unit-1 Marks: 15, Contact hrs: 20

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-2 Marks: 15, Contact hrs: 15

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

Unit-3 Marks: 20, Contact hrs: 20

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, Lagrange′s theorem and consequences including Fermat′s Little theorem.

Unit-4 Marks: 15, Contact hrs: 20

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

Unit-5 Marks: 15, Contact hrs: 15

Group homomorphisms, properties of homomorphisms, Cayley′s theorem, properties of isomorphisms, First, Second and Third isomorphism theorems.

Text Books:

1. J. B. Fraleigh, *A First Course in Abstract Algebra*, 7th Ed., Pearson,2002**.**
2. M. Artin, *Abstract Algebra*, 2nd Ed., Pearson,2011.
3. J. A. Gallian, *Contemporary Abstract Algebra,* 4th Ed., Narosa Publishing House, New Delhi,1999.

Reference Books:

1. J. J. Rotman, *An Introduction to the Theory of Groups,* 4th Ed., Springer Verlag, 1995.
2. I.N. Herstein, *Topics in Algebra*, Wiley Eastern Limited, India,1975.

Guideline

Unit 1 [1] Chapter 2; [2] Chapters 2.1,2.2 ; [3] Chapters 1,2
Unit 2 [1] Chapter 3; [3] Chapter 3
Unit 3 [3] Chapter 4,5,7
Unit 4 [1] Chapter 12; [3] Chapters 8,9
Unit 5 [3] Chapters 6,10

C3.3 PDE and Systems of ODE
Total Marks: 100, Theory: 60, IA: 20, Practical: 20
Credit: 4+2=6;
(L=4, P=4, T=0)

Objectives: After going through this course the students will be able to

- make mathematical formulations and their solutions of various physical problems;
- design mathematical models used in heat, wave.
- Describe the Laplace equation and their solutions.

Unit-1 Marks: 25, Contact hrs: 25

Partial Differential Equations – Basic concepts and Definitions, Mathematical Problems. First- Order Equations: Classification, Construction and Geometrical Interpretation. Method of Characteristics for obtaining General Solution of Quasi Linear Equations. Non-linear partial differential equations, Charpit's method & Jacobi's method Canonical Forms of First-order Linear Equations. Method of Separation of Variables for solving first order partial differential equations.

Unit-2 Marks: 12, Contact hrs: 10

Classifications of second order linear equations as hyperbolic, parabolic or elliptic. Derivations of Heat equation, Wave equation and Laplace equation and their solutions Reduction of second order Linear Equations to canonical forms.

Unit-3 Marks: 8, Contact hrs: 10

Method of separation of variables, Solving the Vibrating String Problem, Solving the Heat Conduction problem

Unit-4 Marks: 15, Contact hrs: 15

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, The method of successive approximations, the Euler method, the modified Euler method, The Runge-Kutta method upto fourth order approximation.

List of Practicals (using any software) **Marks: 20** Contact hrs. 30

(i) Solution of Cauchy problem for first order PDE.
(ii) Finding the characteristics for the first order PDE
(iii) Plot the integral surfaces of a given first order PDE with initial data.
(iv) Solution of the 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) $u(x,0) = \varphi(x), u_t(x,0) = \psi(x), x \in R, t \longrightarrow 0;$
(b) $u(x,0) = \varphi(x), u_t(x,0) = \psi(x), u(0,t) = 0, x \in (0,\infty), t > 0;$
(c) $u(x,0) = \varphi(x), u_t(x,0) = \psi(x), u_x(0,t) = 0, x \in (0,\infty), t > 0;$
(d) $u(x,0) = \varphi(x), u_t(x,0) = \psi(x), u(0,t) = 0, u(1,t) = 0, 0 < x < l, l > 0.$

(v) Solution of wave equation $\frac{\partial u}{\partial t} - k^2 \frac{\partial^2 u}{\partial x^2} = 0$ for the following associate conditions

(a) $u(x,0) = \varphi(x), u(0,t) = a, u(l,t) = b, 0 < x < l, t > 0;$
(b) $u(x,0) = \varphi(x), x \in R, T > t > 0;$
(c) $u(x,0) = \varphi(x), u(0,t) = a, \ x \in (0,\infty), t \geq 0;$

Text Books:

1. S.L. Ross, *Differential equations,* 3rd Ed., John Wiley and Sons, India,2004.
2. I. N. Sneddon, Elements of Partial Differential Equations, Dover Publications, 2006.

Reference Books:

1. T. Myint-U and L. Debnath, *Linear Partial Differential Equations for Scientists and Engineers,* 4th edition, Springer, Indian reprint,2006.
2. M. L Abell, J. P Braselton, *Differential equations with MATHEMATICA,* 3rd Ed., Elsevier Academic Press,2004.

Guideline:

Unit 1 [2] Chapter 2
Unit 2 [1] Chapter 14.1,14.3
Unit 4 [1] Chapter 7.1 –7.4; 8.3,8.4

C4.1 Numerical Methods

Total Marks: 100, Theory: 60, IA: 20, Practical: 20

Credit: 4+2=6;

(L=4, P=4, T=0)

Objectives: After going through this course the students will be able to

- Discuss various numerical methods and interpolation formulae
- Apply numerical techniques for solving differential equation.

(Use of Scientific Calculator is allowed)

Unit-1 Marks: 5, Contact hrs: 5

Algorithms, Convergence, Errors: Relative, Absolute, Round off, Truncation.

Unit-2 Marks: 10, Contact hrs:10

Transcendental and Polynomial equations: Bisection method, Newton's method, Secant method. Rate of convergence of these methods.

Unit-3 Marks: 10, Contact hrs:10

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

Unit-4 Marks: 10, Contact hrs:10

Interpolation: Lagrange and Newton's methods. Error bounds. Finite difference operators. Gregory forward and backward difference interpolation.

Unit-5 Marks: 15, Contact hrs:15

Numerical Integration: Trapezoidal rule, Simpson's $1/3^{rd}$ rule, Simpsons 3/8th rule, Boole's Rule. Midpoint rule, Composite Trapezoidal rule, Composite Simpson's rule.

Unit-6 Marks: 10, Contact hrs:10

Ordinary Differential Equations: Euler's method. Runge-Kutta methods of orders two and four.

List of Practicals (using any software) **Marks: 20** Contact hrs. 30

(i) Calculate the sum 1/1 + 1/2 + 1/3 + 1/4 + ----------+ 1/N.
(ii) To find the absolute value of aninteger.
(iii) Enter 100 integers into an array and sort them in an ascendingorder.
(iv) Bisection Method.
(v) Newton Raphson Method.

(vi) Secant Method.

(vii) RegulaiFalsi Method.

(viii) LU decomposition Method.

(ix) Gauss-Jacobi Method.

(x) SOR Method or Gauss-Siedel Method.

(xi) Lagrange Interpolation or Newton Interpolation.

(xii) Simpson′s 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.

Text Books:

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. K. Atkinson, An Introduction to Numerical Analysis (2^{nd}Edition), Wiley Publications, 1978

Reference Books:

1. B. Bradie, *A Friendly Introduction to Numerical Analysis*, Pearson Education, India, 2007.

2. C.F. Gerald and P.O. Wheatley, *Applied Numerical Analysis*, Pearson Education, India, 2008.

3. U. M. Ascher and Chen Greif, *A First Course in Numerical Methods*, 7th Ed., PHI Learning Private Limited,2013.

4. J. H. Mathews and Kurtis D. Fink, *Numerical Methods using Matlab*, 4th Ed., PHI Learning Private Limited,2012.

Guideline:

Unit 1-6 [1] Chapters 1—6.

C4.2 Riemann Integration and Series of Functions

Total Marks: 100, Theory: 80, IA: 20

Credit: 5+1=6; (L=5, P=0, T=1)

Objectives: After going through this course the students will be able to

- Riemann integration, improperintegrals
- Differentiation and integration of powerseries

Unit-1 Marks: 5, Contact hrs:10

Riemann integration; inequalities of upper and lower sums; Riemann conditions of integrability.

Unit-2 Marks: 25, Contact hrs:25

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-3 Marks: 10, Contact hrs:10

Improper integrals; Convergence of Beta and Gamma functions.

Unit-4 Marks: 25, Contact hrs:25

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-5 Marks: 15, Contact hrs: 20

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

Text Books:

1. R. Bartle and D.R. Sherbert, *Introduction to Real Analysis*, John Wiley and Sons,2003.
2. S.R. Ghorpade and B.V. Limaye, *A Course in Calculus and Real Analysis,* Springer, 2006.
3. A. Kumar & S. Kumaresan , A Basic Course in Analysis . CRC Press, 2014
4. K.A. Ross, *Elementary Analysis, The Theory of Calculus*, Undergraduate Texts in Mathematics, Springer (SIE), Indian reprint,2004.

Reference Books:

1. Charles G. Denlinger, *Elements of Real Analysis*, Jones & Bartlett (Student Edition), 2011.

Guideline

Unit 1,2,3 [3] Chapter 6
Unit 4 [3] Chapter 7
Unit 5 [1] Chapter 9.4; [4] Chapter 4

C4.3 Ring Theory and Linear Algebra I
Total Marks: 100, Theory: 80, IA: 20,
Credit: 5+1=6;
(L=5, P=0, T=1)

Objectives:: After going through this course the students will be able to

- Describe various ring structures on sets.
- Solve the system of linear equations.

Unit-1 Marks: 20, Contact hrs: 20

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-2 Marks: 15, Contact hrs:20

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

Unit-3 Marks: 15, Contact hrs:20

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

Unit-4 Marks: 30, Contact hrs:30

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.

Text Books:

1. J. B. Fraleigh, *A First Course in Abstract Algebra*, 7th Ed., Pearson,2002**.**
2. J. A. Gallian, *Contemporary Abstract Algebra*, 4th Ed., Narosa Publishing House, New Delhi,1999.
3. G. Strang, *Linear Algebra and its Applications*, Thomson,2007.
4. S. Kumaresan, *Linear Algebra- A Geometric Approach*, Prentice Hall ofIndia,1999.
5. K. Hoffman, Ray Alden Kunze, *Linear Algebra,* 2nd Ed., Prentice-Hall of India Pvt. Ltd.,1971.

Reference Books:

1. M. Artin, *Abstract Algebra*, 2nd Ed., Pearson, 2011.
2. S. H. Friedberg, A. J. Insel, L. E. Spence, *Linear Algebra,* 4th Ed., Prentice-Hall of India Pvt. Ltd., New Delhi,2004.
3. S. Lang, *Introduction to Linear Algebra,* 2nd Ed., Springer,2005.
4. D.A.R. Wallace, *Groups, Rings and Fields*, Springer Verlag London Ltd.,1998.

Guideline:

Unit 1 [2] Chapter 13--15
Unit 2 [2] Chapter 15
Unit 3,4 [4] Chapter 2, 3.3, 4

C5.1 Multivariate Calculus
Total Marks: 100, Theory: 80, IA: 20,
Credit: 5+1=6;
(L=5, P=0, T=1)
(Use of Scientific calculator is allowed)

Objectives: After going through this course the students will be able to

- Extend the concepts from one variable calculus to function of several variables
- Demonstrate the ability to think critically and solving application of real world problems involving double/ triple integrals.

Unit-1 Marks: 30, Contact hrs:30

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-2 Marks: 20, Contact hrs:20

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.

Unit-3 Marks: 15, Contact hrs:20

Change of variables in double integrals and triple integrals. Line integrals, Applications of line integrals: Mass and Work. Fundamental theorem for line integrals, conservative vector fields, independence of path.

Unit-4 Marks: 15, Contact hrs:20

Green′s theorem, surface integrals, integrals over parametrically defined surfaces. Stoke′s theorem, The Divergence theorem.

Text Books:

1. G.B. Thomas and R.L. Finney, *Calculus*, 9th Ed., Pearson Education, Delhi,2005.
2. J. Stewart, *Multivariable Calculus, Concepts and Contexts*, 2nd Ed., Brooks /Cole, Thomson Learning, USA, 2001.
3. P. M. Fitzpatrick, Advanced Calculus, American Mathematical Society,2005.

Reference Books:

1. M.J. Strauss, G.L. Bradley and K. J. Smith, *Calculus,* 3rd Ed., Dorling Kindersley (India) Pvt. Ltd. (Pearson Education), Delhi,2007.
2. E. Marsden, A.J. Tromba and A. Weinstein, *Basic Multivariable Calculus*, Springer (SIE), Indian reprint,2005.

C5.2 Group Theory II

Total Marks: 100, Theory: 80, IA: 20,

Credit: 5+1=6;

(L=5, P=0, T=1)

Objectives: After going through this course the students will be able to

- Apply results from preliminary concepts to solve contemporary problems.
- Apply in communication theory, electrical engineering, computer science and cryptography

Unit-1 Marks: 30, Contact hrs: 35

Automorphism, inner automorphism, automorphism groups, automorphism groups of finite and infinite cyclic groups, applications of factor groups to automorphism groups, Characteristic subgroups, Commutator subgroup and its properties.

Unit-2 Marks: 20, Contact hrs: 25

roperties of external direct products, the group of units modulo n as an external direct product, internal direct products, Fundamental Theorem of finite abelian groups.

Unit-3 Marks: 30, Contact hrs:30

Groups acting on themselves by conjugation, class equation and consequences, conjugacy in Sn, *p*-groups, Sylow′s theorems and consequences, Cauchy′s theorem, Simplicity of Anfor $n \geq 5$, non-simplicity tests.

Text Books:

1. D. S. Dummit and R. M. Foote, *Abstract Algebra*, 3rd Ed., Wiley and Sons (Asia) Pvt. Ltd., Singapore,2004.
2. I. N. Herstein, Topics in Algebra, Wiley & Sons, 2006
3. P. B. Bhattacharjee, S. K. Jain & S. R. Nagpaul Basic Abstract Algebra, Cambridge University Press.

Reference Books:

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 A. Gallian, *Contemporary Abstract Algebra,* 4th Ed., Narosa Publishing House, 1999.
4. J.R. Durbin, *Modern Algebra*, John Wiley & Sons, New York Inc.,2000.
5. D. A. R. Wallace, *Groups, Rings and Fields*, Springer Verlag London Ltd.,1998.

C6.1 Metric Spaces and Complex Analysis
Total Marks: 100, Theory: 80, IA: 20,
Credit: 5+1=6;
(L=5, P=0, T=1)

Objectives: After going through this course the students will be able to describe

- various properties of metrics paces
- complex number system, its differentiation and integration.

Unit-1 Marks: 20, Contact hrs:20

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, Cantor′s theorem. Subspaces, dense sets, separable spaces.

Unit-2 Marks: 15, Contact hrs:15

ontinuous mappings, sequential criterion and other characterizations of continuity. Uniform continuity. Homeomorphism, Contraction mappings, compactness Banach Fixed point Theorem. Connectedness, connected subsets of R.

Unit-3 Marks: 15, Contact hrs: 20

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

Unit-4 Marks: 12, Contact hrs:15

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 integralformula.

Unit-5 Marks: 10, Contact hrs:10

Liouville′s theorem and the fundamental theorem of algebra. Convergence of sequences and series, Taylor series and its examples.

Unit-6 Marks: 08, Contact hrs:10

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

Text Books:

1. S. Kumaresan, *Topology of Metric Spaces*, 2nd Ed., Narosa Publishing House,2011.
2. G.F. Simmons, *Introduction to Topology and Modern Analysis*, McGraw-Hill,2004.
3. J. W. Brown and R. V. Churchill, *Complex Variables and Applications,* 8th Ed., McGraw – Hill International Edition,2009.

Reference Books:

1. S. Shirali and H. L. Vasudeva, *Metric Spaces*, Springer Verlag, London, 2006.
2. J. Bak and D. J. Newman, *Complex Analysis,* 2nd Ed., Undergraduate Texts in Mathematics, Springer-Verlag New York, Inc., New York,1997.

C6.2 Ring Theory and Linear Algebra II
Total Marks: 100, Theory: 80, IA: 20,
Credit: 5+1=6;
(L=5, P=0, T=1)

Objectives: Students will be able to

- Apply theorems proof/ solution techniques to solve real worldproblems
- Find the matrix associated with a linear transformation w.r.t. given bases and can understand the relationship between operations of linear transformations and corresponding matrices.

Unit-1 Marks: 30, Contact hrs:30

Polynomial rings over commutative rings, division algorithm and consequences, principal ideal domains, factorization of polynomials, reducibility tests, irreducibility tests, Eisenstein criterion, unique factorization in Z[x]**.** Divisibility in integral domains, irreducibles, primes, unique factorization domains, Euclidean domains.

Unit-2 Marks: 25, Contact hrs:30

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

Unit-3 Marks: 25, Contact hrs:30

Inner product spaces and norms, 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, Normal and self-adjoint operators, Orthogonal projections and Spectral theorem.

Text Books:

1. J. B. Fraleigh, *A First Course in Abstract Algebra*, 7th Ed., Pearson, 2002**.**
2. J. A. Gallian, *Contemporary Abstract Algebra*, 4th Ed., Narosa Publishing House, 1999.
3. G. Strang, *Linear Algebra and its Applications*, Thomson,2007.
4. S. Kumaresan, *Linear Algebra- A Geometric Approach*, Prentice Hall of India,1999.
5. K. Hoffman, R. A. Kunze, *Linear Algebra,* 2nd Ed., Prentice-Hall of India Pvt. Ltd.,1971.
6. P. B. Bhattacharjee, S. K. Jain & S. R. Nagpaul Basic Abstract Algebra, Cambridge University Press, 1994.

Reference Books:

1. M. Artin, *Abstract Algebra*, 2nd Ed., Pearson,2011.
2. S H. Friedberg, A J. Insel, Lawrence E. Spence, *Linear Algebra,* 4th Ed., Prentice-Hall of India Pvt. Ltd., New Delhi,2004.
3. S. Lang, *Introduction to Linear Algebra,* 2nd Ed., Springer,2005.
4. S.H. Friedberg, A.L. Insel and L.E. Spence, *Linear Algebra*, Prentice Hall of India Pvt. Ltd.,2004.

DSE1.1 Analytical Geometry
Total Marks: 100, Theory: 80, IA: 20,
Credit: 5+1=6;
(L=5, P=0, T=1)

Objectives: After going through this course the students will be able to

- Sketch parabola, ellipse and hyperbola
- Solve various geometrical problems analytically.

Unit-1 Marks: 45, Contact hrs:45

Techniques for sketching parabola, ellipse and hyperbola. Reflection properties of parabola, ellipse and hyperbola. Classification of quadratic equations representing lines, parabola, ellipse and hyperbola.

Unit-2 Marks: 35, Contact hrs:45

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. H. Anton, I. Bivens and S. Davis, *Calculus*, John Wiley and Sons (Asia) Pvt. Ltd.2002.
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.

DSE1.2 Portfolio Optimization

Total Marks: 100, Theory: 80, IA: 20,

Credit: 5+1=6;

(L=5, P=0, T=1)

Objectives: After going through this course the students will be able to define portfolio optimization and apply them to real world problems

Unit-1 Marks: 30, Contact hrs:30

Financial markets. Investment objectives. Measures of return and risk. Types of risks. Risk free assets. Mutual funds. Portfolio of assets. Expected risk and return of portfolio. Diversification.

Unit-2 Marks: 25, Contact hrs:30

Mean-variance portfolio optimization- the Markowitz model and the two-fund theorem, risk-free assets and one fund theorem, efficient frontier. Portfolios with short sales. Capital market theory.

Unit-3 Marks: 25, Contact hrs:30

Capital assets pricing model- the capital market line, beta of an asset, beta of a portfolio, security market line. Index tracking optimization models. Portfolio performance evaluation measures.

Books Recommended:

1. F. K. Reilly, Keith C. Brown, *Investment Analysis and Portfolio Management*, 10th Ed., South-Western Publishers,2011.
2. H.M. Markowitz, *Mean-Variance Analysis in Portfolio Choice and Capital Markets*, Blackwell, New York,1987.
3. M.J. Best, *Portfolio Optimization*, Chapman and Hall, CRC Press,2010.
4. D.G. Luenberger, *Investment Science*, 2nd Ed., Oxford University Press,2013.

DSE1.3 Financial Mathematics

Total Marks: 100, Theory: 80, IA: 20,

Credit: 5+1=6;

(L=5, P=0, T=1)

Objectives: After going through this course the students will be able to

- Build quantitative models of financial mathematics/industries
- Apply models to obtain information of practical value in the financial mathematics

Unit-1 Marks: 40, Contact hrs:45

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, putable and callable bonds.

Unit-2 Marks: 40, Contact hrs:45

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, Jensen′s index.

Books Recommended

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

DSE2.1 Mathematical Modeling

Total Marks: 100, Theory: 60, IA: 20, Practical: 20

Credit: 4+2=6;

(L=4, P=4, T=0)

Objectives:: After going through this course the students will be able to solve differential equations and linear programming problems used in mathematical modelling

Unit-1 Marks: 25, Contact hrs: 30

Power series solution of a differential equation about an ordinary point, solution about a regular singular point, Bessel's equation and Legendre's equation, Laplace transform and inverse transform, application to initial value problem up to second order.

Unit-2 Marks: 35, Contact hrs: 30

Monte Carlo Simulation Modeling: simulating deterministic behavior (area under a curve, volume under a surface), Generating Random Numbers: middle square method, linear congruence, Queuing Models: harbor system, morning rush hour, Overview of optimization modeling, Linear Programming Model: geometric solution algebraic solution, simplex method, sensitivity analysis

List of Practical (using any software) Marks: 20 Contact hrs: 30

(i) Plotting of Legendre polynomial for n = 1 to 5 in the interval [0,1]. Verifying graphically that all the roots of Pn (x) lie in the interval [0,1].

(ii) Automatic computation of coefficients in the series solution near ordinary points.

(iii) Plotting of the Bessel's function of first kind of order 0 to3.

(iv) Automating the Frobenius Series Method.

(v) Random number generation and then use it for one of the following (a) Simulate area under a curve (b) Simulate volume under asurface.

(vi) Programming of either one of the queuing model (a) Single server queue (e.g. Harbor system) (b) Multiple server queue (e.g. Rushhour).

(vii) Programming of the Simplex method for 2/3variables.

Books Recommended

1. T. Myint-U and LokenathDebnath, *Linear Partial Differential Equation for Scientists and Engineers*, Springer, Indian reprint,2006.
2. F. R. Giordano, M. D. Weir and W. P. Fox, *A First Course in Mathematical Modeling*, Thomson Learning, London and New York,2003.

DSE2.2 Mechanics

Total Marks: 100, Theory: 80, IA: 20,

Credit: 5+1=6;

(L=5, P=0, T=1)

Objectives: After going through this course the students will be able to

- Describe Moment of a force and couple, general equation of equilibrium
- Solve Problems of translation and rotation of rigid bodies

Unit-1 Marks: 20: Contact hrs: 30

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-2 Marks: 25: Contact hrs: 30

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-3 Marks: 35: Contact hrs: 30

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, 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.

Books 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.
2. R.C. Hibbeler and A. Gupta, *Engineering Mechanics: Statics and Dynamics,* 11th Ed., Dorling Kindersley (India) Pvt. Ltd. (Pearson Education),Delhi.

DSE2.3 Number Theory

Total Marks: 100, Theory: 80, IA: 20,

Credit: 5+1=6;

(L=5, P=0, T=1)

Objectives: After going through this course the students will be able to

- obtain solutions of Diophantine equations
- define number theoretic functions

Unit-1 Marks: 20: Contact hrs: 30

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-2 Marks: 30: Contact hrs:30

Number theoretic functions, sum and number of divisors, totally multiplicative functions, definition and properties of the Dirichlet product, the Mobius Inversion formula, the greatest integer function, Euler's phi- function, Euler's theorem, reduced set of residues, some properties of Euler's phi-function.

Unit-3 Marks: 30: Contact hrs: 30

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. Public key encryption, RSA encryption and decryption, the equation $x^2 + y^2 = z^2$, Fermat′s Last theorem.

Books Recommended

1. D. M. Burton, *Elementary Number Theory,* 6th Ed., Tata McGraw- Hill, Indian reprint, 2007.
2. N. Robinns, *Beginning Number Theory,* 2nd Ed., Narosa Publishing House Pvt. Ltd., Delhi,2007.

DSE2.4 Bio-Mathematics
Total Marks: 100, Theory: 80, IA: 20,
Credit: 5+1=6;
(L=5, P=0, T=1)

Objectives: After going through this course the students will be able to discuss various models and techniques to study Bio-mathematical real life problems.

Unit-1 Marks: 15, Contact hrs:20

Mathematical Biology and the modeling process: an overview. Continuous models: Malthus model, logistic growth, Allee effect, Gompertz growth, Michaelis-Menten Kinetics, Holling type growth, Bacterial growth in a Chemostat, Harvesting a single natural population, Prey predator systems and LotkaVolterra equations,

Unit-2 Marks: 15, Contact hrs:15

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-3 Marks: 15, Contact hrs:15

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-4 Marks: 15, Contact hrs:20

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. Discrete Models: Overview of difference equations, steady state solution and linear stabilityanalysis,

Unit-5 Marks: 20, Contact hrs:20

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.
3. Y.C. Fung, *Biomechanics*, Springer-Verlag,1990.
4. F. Brauer, P.V.D. Driessche and J. Wu, *Mathematical Epidemiology*, Springer,2008.
5. M. Kot, *Elements of Mathematical Ecology*, Cambridge University Press,2001.

DSE2.5 Industrial Mathematics
Total Marks: 100, Theory: 80, IA: 20,
Credit: 5+1=6;
(L=5, P=0, T=1)

Objectives: After going through this course the students will be able to

- Use various type of numerical methods to model problems and use simulation to solve problem
- Apply different methods to solve financial problems

Unit-1 Marks: 15, Contact hrs:15

Medical Imaging and Inverse Problems. The content X-ray is based on Mathematics of and CT scan based on the knowledge of equations, complexcalculus, elementary differential numbers and matrices.

Unit-2 Marks: 25, Contact hrs:15

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. Geological anomalies in Earth's interior from measurements at its surface (Inverse problems for Natural disaster) and Tomography.

Unit-3 Marks: 10, Contact hrs:15

X-ray: Introduction, X-ray behavior and Beers Law (The fundament question of image construction) Lines in the place.

Unit-4 Marks: 10, Contact hrs:15

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

Unit-5 Marks: 10, Contact hrs:15

Back Projection: Definition, properties and examples.

Unit-6 Marks: 10, Contact hrs:15

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. T. 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. A. Kirsch, *An Introduction to the Mathematical Theory of Inverse Problems*, 2nd Ed., Springer,2011

DSE 3.1 Hydro-Mechanics
Total Marks: 100, Theory: 80, IA: 20,
Credit: 5+1=6;
(L=5, P=0, T=1)

Objective: After going through this course the students will be able to describe the basic properties of Fluid Mechanics.

Unit 1: **Marks: 15, Contact hrs:15**

Kinematics: Real and ideal fluid, velocity of a fluid at a point, Eulerian and Lagrangian method, stream lines and path lines, steady and unsteady flows, velocity potential, rotational and irrotational motions, local and particle rate of change, equation of continuity, examples, acceleration of a fluid at a point, General analysis of fluid motion

Unit 2: **Marks: 12, Contact hrs:15**

Equation of Motion: Euler's equation of motion, Bernoullis equation, steady motion under conservative forces, impulsive motion, circulation, Kelvin's circulation theorem.

Unit :3 **Marks: 8, Contact hrs:15**

General theory of irrotationalmotion : Potential flow, deductions from Green's theorem, kinetic energy of a liquid, uniqueness theorems, Kelvin's minimum energy theorem, Mean value of velocity potential.).

Unit 4: **Marks: 17, Contact hrs:15**

Fluid Pressure**:** Introduction, Fluid Pressure and related theorems, Density and specific gravity, Theorems on fluid pressure under gravity, Rate of variation of pressure, Differential equation of pressure, Condition of equilibrium, Equi-pressure surfaces and lines of force, Curves of equi-pressure and equi-density, Examples.

Unit 5: **Marks: 16, Contact hrs:15**

Resultant Pressure and Centre of Pressure: Resultant fluid pressure and related theorems, Centre of pressure, Determination of centre of pressure of parallelogram, triangle, circle under different conditions, Examples, Thrust on curved surfaces, Examples.

Unit 6: **Marks: 12, Contact hrs:15**

Equilibrium and Stability of Floating Bodies: Condition of equilibrium of floating bodies, Examples, Unstable and Neutral equilibrium, Determination of Meta centre, Examples.

Books Recommended

1. F. Chorlton, Text Books of Fluid Dynamics; CBS Publishers & Distributors, 2005.
2. M. D. Raisinghania, Fluid Dynamics; S. Chand & Company Ltd, 1995.
3. M. Ray and H.S. Sharma, A Text Book of Hydrostatics; S. Chand & Company Ltd, New Delhi, 1989.

Reference Books :1. M. Thomson, Theoretical Hydrodynamics; Macmillan & Co.

DSE3.2 Linear Programming

Total Marks: 100, Theory: 80, IA: 20,

Credit: 5+1=6;

(L=5, P=0, T=1)

Objectives: After going through this course the students will be able to

- describe various optimization techniques pertaining to linear programming.
- apply linear programming to problems arising out of real life problems.

Unit-1 Marks: 25, Contact hrs: 35

Introduction to linear programming problem, Theory of simplex method, optimality and unboundedness, the simplex algorithm, simplex method in tableau format, introduction to artificial variables, two- phase method, Big- M method and their comparison.

Unit-2 Marks: 15, Contact hrs: 15

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

Unit-3 Marks: 20, Contact hrs: 20

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

Unit-4 Marks: 20, Contact hrs: 20

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. M. S. Bazaraa, J. J. Jarvis and H. D. Sherali, *Linear Programming and Network Flows,* 2nd Ed., John Wiley and Sons, India,2004.
2. F.S. Hillier and G.J. Lieberman, *Introduction to Operations Research,* 9th Ed., Tata McGraw Hill, Singapore,2009.
3. H. A. Taha, *Operations Research, An Introduction,* 8th Ed., Prentice- Hall India, 2006.
4. G. Hadley, *Linear Programming*, Narosa Publishing House, New Delhi,2002.

DSE 3.3 Discrete Mathematics

Total Marks: 100, Theory: 80, IA: 20,

Credit: 5+1=6;

(L=5, P=0, T=1)

Objectives: After going through this course, the students should be able to

- Explain various discrete structures.
- Design graph theoretic models of real life problems.

Unit-1 Marks: 25, Contact hrs:30

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-2 Marks: 25, Contact hrs: 30

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-3 Marks: 30, Contact hrs: 30

Definitions, examples and basic properties of graph, pseudographs, cpmplete graphs, bipartite graphs, isomorphism of graphs, paths and circuits, Eulerian circuits, Hamiltonian cycles, the adjacency matrix, weighted graph, travelling salesman′s problem, shortest path, Dijkstra′s algorithm, Floyd-Warshall algorithm

Books Recommended

1. B. A. Davey and H. A. Priestley, Introduction to Lattices and Order, Cambridge University Press, Cambridge,1990.
2. E. G. Goodaire and Michael M. Parmenter, Discrete Mathematics with Graph Theory (2^{nd}Edition), Pearson Education (Singapore), Pte. Ltd., Indian Reprint2003.
3. R. Lidl and G. Pilz, Applied Abstract Algebra (2^{nd}Edition), Undergraduate Texts in Mathematics, Springer (SIE), Indian Reprint,2004.

DSE3.4 Theory of Equations
Total Marks: 100, Theory: 80, IA: 20,
Credit: 5+1=6;
(L=5, P=0, T=1)

Objectives: After going through this course the students will be able to discuss various properties of algebraic equations, symmetric properties of roots and determination of roots.

Unit-1 Marks: 20, Contact hrs: 25

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, Relation between the roots and the coefficients of equations.

Unit-2 Marks: 20, Contact hrs: 25

Symmetric functions, Applications of symmetric function of the roots, Transformation of equations. Solutions of reciprocal and binomial equations. Algebraic solutions of the cubic and biquadratic. Properties of the derived functions.

Unit-3 Marks: 20, Contact hrs: 20

Symmetric functions of the roots, Newton′s theorem on the sums of powers of roots, homogeneous products, limits of the roots of equations.

Unit-4 Marks: 20, Contact hrs: 20

Separation of the roots of equations, Strums theorem, Applications of Strum′s theorem, 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. C. MacDuffee, *Theory of Equations*, John Wiley & Sons Inc.,1954.

DSE 3.5 Dynamical Systems
Total Marks: 100, Theory: 80, IA: 20,
Credit: 5+1=6;
(L=3, P=0, T=1)

Objectives: After going through this course the students will be able to

- Discuss the qualitative properties of difference/differential equations.

Unit – 1 Marks : 16, Contact hrs:20

Introduction, A Geometrical way of Thinking, Fixed Points and Stability, Population Growth, Linear Stability Analysis, Existence and Uniqueness Theorem (Statement only), Examples.

Bifurcations, Saddle-Node Bifurcation, Transcritical Bifurcation.

Unit – 2 Marks : 16, Contact hrs:20

Introduction, Investigation of Differential Equations via its Direction Field, Linear Systems, Phase Plane, Classification of Fixed Points of Non-linear Systems by Linearization, Examples.

Unit – 3 Marks : 16, Contact hrs: 20

Limit Cycles, Gradient System, Liapunov Functions, Dulac's Criteria, Poincare-Bendixon Theorem, Lorenz System and its Properties, Chaos, Necessary Condition for Chaos, Examples.

Unit – 4 Marks : 16, Contact hrs:15

Maps and Flow, Composition of Maps, Orbits, Fixed Points, Stable and Unstable Fixed Points, Basin of Attraction and Basin Boundary, Linear Stability Analysis, Cobweb Diagram, Examples.

Unit – 5 Marks : 16, Contact hrs:15

Periodic Point, Periodic Cycles, Stability of Periodic Points and Periodic Cycles, Tent Map, Logistic Map. Properties of Logistic Map. Examples.

Books Recommended

1. S. H. Strogatz :*Nonlinear Dynamics and Chaos*, Sarat Book Dist, Kolkata, ISBN : 81-87169–85–0
2. G.C. Layek :*An Introduction to Dynamical Systems and Chaos*, Springer, ISBN : 978-81-322-2555-2
3. J. Berry :*Introduction to Non-Linear Systems*, Arnold, Great Britain, ISBN : 0-340-67700-7
4. D. Kaplan and L. Gloss : *Understanding Nonlinear Dynamics*, Springer.

DSE 4.1 Mathematical Methods
Total Marks: 100, Theory: 80, IA: 20,
Credit: 5+1=6;
(L=5, P=0, T=1)

Objectives: After going through this course the students will be able to

- Construct mathematical models or real world problems.
- Solve real world problems through the studied theories.

Unit- 1: **Marks 10,** Contact hrs: 20

Fourier Series : Fourier Series, Dirichlet conditions, Fourier series for even and odd functions Half range Fourier series.

Unit – 2 **Marks 20,** Contact hrs: 15

Laplace Transform: Definition of Laplace transform, Existence theorem for Laplace transform. Linearity property of Laplace transform, Laplace transform of some elementary functions. (algebraic functions, trigonometric functions, exponential functions, hyperbolic functions). First Shifting theorem, Second shifting theorem, Change of scale property, Laplace transform of derivatives, Laplace transform of Integrals.

Unit – 3 **Marks 10,** Contact hrs: 20

Inverse Laplace Transform: Definition of Inverse Laplace Transform, Linearity property, first and second shifting theorems, change of scale, Convolution theorem.

Unit – 4 **Marks 25,** Contact hrs: 20

Fourier Transform, and Inverse Fourier transform: Dirichlet conditions, Definition of Fourier transform, Inverse theorem for Fourier transform, Fourier Sine and Fourier cosine transforms and their inversion formula, Linearity property, change of scale property , shifting property, modulation theorem, convolution theorem.

Unit- 5 **Marks 15,** Contact hrs: 15

Applications of Fourier and Laplace transform: Solution of Boundary value problems and initial value problems in 1-D and 2-D cases. Solution of Laplace and Poisson equations in 2-D cases**.**

Books Recommended:

1. S Sreennadh, S Ranganatham, M V S S N Prasad, V Ramesh Babu, Fourier series and Integral transform,S. Chand, New Delhi, 2008.
2. M R Spigel, Theory and Problems of Laplace Transform, Schaum Outline Series. 2018.

DSE 4.2 Boolean Algebra and Automata Theory
Total Marks: 100, Theory: 80, IA: 20,
Credit: 5+1=6;
(L=5, P=0, T=1)

Objectives: After going through this course the students will be able to

- Define a lattice
- identify various lattice properties and apply them to describe switching circuits.

Unit-1 Marks: 15, Contact hrs:15

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-2 Marks: 15, Contact hrs:15

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-3 Marks: 15, Contact hrs:15

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-4 Marks: 15, Contact hrs:15

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-5 Marks: 10, Contact hrs: 15

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

Unit-6 Marks: 10, Contact hrs: 15

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. E. G. Goodaire and Michael M. Parmenter, *Discrete Mathematics with Graph Theory,* (2nd Ed.), Pearson Education (Singapore) P.Ltd., Indian Reprint 2003.
3. R. Lidl and G. 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.

DSE4.3 Probability and Statistics

Total Marks: 100, Theory: 80, IA: 20,

Credit:5+1=6;

(L=5, P=0, T=1)

Objectives: After going through this course the students will be able to

- Characterize the statistical techniques.
- Define various statistical distributions and obtain their related properties
- Describe the mathematical theory of probability

Unit-1 Marks: 30, Contact hrs:30

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

Unit-2 Marks: 30, Contact hrs:30

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, bivariate normal distribution, correlation coefficient, joint moment generating function (jmgf) and calculation of covariance (from jmgf), linear regression for twovariables.

Unit-3 Marks: 20, Contact hrs:30

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, Markov Chains, Chapman-Kolmogorov equations, classification ofstates.

Books Recommended

1. R. V. Hogg, Joseph W. McKean and Allen T. Craig, *Introduction to Mathematical Statistics*, Pearson Education, Asia,2007.
2. I. Miller and Marylees Miller, John E. Freund, *Mathematical Statistics with Applications*, 7th Ed., Pearson Education, Asia,2006.
3. S. Ross, *Introduction to Probability Models,* 9th Ed., Academic Press, Indian Reprint,2007.
4. A. M. Mood, Franklin A. Graybill and Duane C. Boes, *Introduction to the Theory of Statistics*, 3rd Ed., Tata McGraw- Hill, Reprint 2007

DSE 4.4 Differential Geometry
Total Marks: 100, Theory: 80, IA: 20,
Credit: 5+1=6;
(L=5, P=0, T=1)

Objectives: After going through this course the students will be able to

- Describe various properties of space curves, surfaces and Geodesics
- Discuss the properties of algebra and calculus of tensors.

Unit-1 Marks: 15, Contact hrs: 15

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-2 Marks: 20, Contact hrs:20

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

Unit-3 Marks: 10, Contact hrs: 15

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

Unit-4 Marks: 15, Contact hrs: 20

Geodesics: Canonical geodesic equations. Nature of geodesics on a surface of revolution. Clairaut′s theorem. Normal property of geodesics. Torsion of a geodesic. Geodesic curvature. Gauss-Bonnet theorem. Surfaces of constant curvature. Conformal mapping. Geodesic mapping. Tissot′s theorem.

Unit-5 Marks: 20, Contact hrs:20

Tensors: Summation convention and indicial notation, Coordinate transformation and Jacobian, Contra-variant and Covariant vectors, Tensors of different type, Algebra of tensors and contraction, Metric tensor and 3-index Christoffel symbols, Parallel propagation of vectors, Covariant and intrinsic derivatives, Curvature tensor and its properties, Curl, Divergence and Laplacian operators in tensor form, Physical components.

Books Recommended

1. T.J. Willmore, *An Introduction to Differential Geometry*, Dover Publications,2012.
2. B. O'Neill, *Elementary Differential Geometry*, 2nd Ed., Academic Press,2006.
3. C.E. Weatherburn, *Differential Geometry of Three Dimensions*, Cambridge University Press2003.
4. D.J. Struik, *Lectures on Classical Differential Geometry*, Dover Publications,1988.
5. S. Lang, *Fundamentals of Differential Geometry*, Springer,1999.
6. B. Spain, *Tensor Calculus: A Concise Course*, Dover Publications,2003

SEC-1.1 Logic and Sets

Total Marks: 50, Theory: 40, IA: 10,

Credit: 2;

(L=2, P=0, T=0)

Objectives: After going through this course the students will be able to describe

- Analyze the truth and falsity of a logical statement
- Differentiate between a logical statement and an ordinary statement
- Define and describe various properties ofsets.

Unit-1 Marks: 16, Contact hrs:10

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.

Unit-2 Marks: 12, Contact hrs: 10

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.

Unit-3 Marks: 12, Contact hrs: 10

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, 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.

SEC-1.2 Computer Graphics
Total Marks: 50, Theory: 40, IA: 10,
Credit: 2;
(L=2, P=0, T=0)

Objectives: The students will be able to

- Indentify the core concepts of computergraphics
- Apply graphics programming techniques to create and design computer graphics scans

Marks:40, Contact hrs: 30

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., 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.

SEC-2.1 Graph Theory
Total Marks: 50, Theory: 40, IA: 10,
Credit: 2;
(L=2, P=0, T=0)

Objectives: Students should be able to

- Describe the fundamental properties of Graph Theory
- Identify different representations of a Graph for practical applications.

Marks:40, Contact hrs: 30

Definition, examples and basic properties of graphs, pseudo graphs, complete graphs, bi- partite graphs, isomorphism of graphs, paths and circuits, Eulerian circuits, Hamiltonian cycles, the adjacency matrix, weighted graph, travelling salesman's problem, shortest path, Dijkstra's algorithm, Floyd- Warshall algorithm.

Books Recommended

1. B.A. Davey and H.A. Priestley, *Introduction to Lattices and Order*, Cambridge University Press, Cambridge,1990.
2. E. G. Goodaire and M. M. Parmenter, *Discrete Mathematics with Graph Theory,* 2nd Edition, Pearson Education (Singapore) P. Ltd., Indian Reprint 2003.
3. R. Lidl and G. Pilz, Applied Abstract Algebra, 2nd Ed., Undergraduate Texts in Mathematics, Springer (SIE), Indian reprint,2004.

SEC-2.2 Operating System: Linux
Total Marks: 50, Theory: 40, IA: 10,
Credit: 2;
(L=2, P=0, T=0)

Objectives: The students will be able to

- Test the linux process model and explain how linux schedule processes and provide inter- process communication
- Explore how linux implements files systems and manages input output devices.

Unit-1 Marks: 20, Contact hrs:15

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), 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-2 Marks: 20, Contact hrs:15

Resource Management in Linux: file and directory management, system calls for files Process Management, Signals, IPC: Pipes, FIFOs, System V IPC, Message Queues, system calls for processes, Memory Management, library and system calls for memory.

Books Recommended

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

GE-1.1 Differential Calculus
Total Marks: 100, Theory: 80, IA: 20, Credit: 5+1 =6;
(L=5, P=0, T=1)

Objectives: Students will be able to

- differentiate functions
- find tangent normal, curvature, asymptotes etc.

Unit-1 Marks: 30, Contact hrs:30

Limit and Continuity (ε and δ definition), Types of discontinuities, Differentiability of functions, Successive differentiation, Leibnitz′s theorem, Partial differentiation, Euler′s theorem on homogeneous functions.

Unit-2 Marks: 20, Contact hrs:30

Tangents and normals, Curvature, Asymptotes, Singular points, Tracing of curves. Parametric representation of curves and tracing of parametric curves, Polar coordinates and tracing of curves in polar coordinates.

Unit-3 Marks: 30, Contact hrs: 30

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(l+x), $(l+x)^m$, Maxima and Minima, Indeterminate forms.

Books Recommended

1. H. Anton, I. Birens and S. Davis, *Calculus*, John Wiley and Sons, Inc.,2002.
2. G.B. Thomas and R.L. Finney, *Calculus*, Pearson Education,2007.

GE-1.2 Object Oriented Programming in C++
Total Marks: 100, Theory: 60, IA: 20, Prac:20
Credit: 4+2 = 6;
(L=4, P=4, T=0)

Objectives: After going through this course the students will be able to

- Write C-programmes to solve Mathematical problems.
- Design algorithms to solve problems.

Unit-1 Marks:25, Contact hrs:20

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. Enumeration, Arrays and Pointer.

Unit-2 Marks:10, Contact hrs:20

Implementing oops concepts in C++ Objects, Classes, Encapsulation, Data Abstraction, Inheritance, Polymorphism, Dynamic Binding, Message Passing, Default Parameter Value, Using Reference variables withFunctions.

Unit-3 Marks: 25, Contact hrs:20

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

Practical to be performed in lab. Books Recommended Marks: 20, Contact hrs:30

1. A. R. Venugopal, Rajkumar, and T. Ravishanker, M*astering C++*, TMH,1997.
2. S. B. Lippman and J. Lajoie, *C++ Primer,* 3rd Ed., Addison Wesley,2000.
3. B. Eckel, *Thinking in C++*, 2nd Ed., President, Mindview Inc., Prentice Hall.
4. D. Parasons, *Object Oriented Programming with C++*, BPBPublication.
5. B. Stroustrup ,*The C++ Programming Language*, 3rd Ed., AddisonWelsley.

GE-1.3 Finite Element Methods
Total Marks: 100, Theory: 80, IA: 20,
Credit: 5+1 =6;
(L=5, P=0, T=1)

Objectives: Students will be able to

- Describe finite element methods
- Differential equations using finite element methods

Unit-1 Marks: 20, Contact hrs:15

Introduction to finite element methods, comparison with finite difference methods, Methods of weighted residuals, collocations, least squares and Galerkin′smethod.Variational formulation of boundary value problems equivalence of Galerkin and Ritz methods.

Unit-2 Marks: 12, Contacthrs:15

Applications to solving simple problems of ordinary differential equations.

Unit-3 Marks: 12, Contact hrs:15

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

Unit-4 Marks: 12, Contact hrs:15

Simplex elements in two and three dimensions, quadratic triangular elements, rectangular elements, serendipity elements and isoperimetric elements and their assembly, discretization with curved boundaries.

Unit-5 Marks: 12, Contact hrs:15

Interpolation functions, numerical integration, and modeling considerations**.**

Unit-6 Marks: 12,Contact hrs:15

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. T. J.R. Hughes, *The Finite Element Method: Linear Static and Dynamic Finite Element Analysis*, Dover Publication,2000.
5. G. R. Buchanan, *Finite Element Analysis*, McGraw Hill,1994.

GE-2.1 Differential Equation
Total Marks: 100, Theory: 80, IA: 20,
Credit: 5+1 = 6;
(L=5, P=0, T=1)

Objectives: students will be able to describe various methods for solving differential equations.

Unit-1 Marks: 16, Contact hrs:15
First order exact differential equations. Integrating factors, rules to find an integrating factor.

Unit-2 Marks: 20, Contact hrs:20
First order higher degree equations solvable for x, y, p. Methods for solving higher-order differential equations. Basic theory of linear differential equations, Wronskian, and its properties. Solving a differential equation by reducing its order.

Unit-3 Marks: 16, Contact hrs:20
Linear homogenous equations with constant coefficients, Linear non-homogenous equations, The method of variation of parameters, The Cauchy-Euler equation, Simultaneous differential equations, Total differential equations.

Unit-4 Marks: 16, Contact hrs: 20
Order and degree of partial differential equations, Concept of linear and non-linear partial differential equations, Formation of first order partial differential equations, Linear partial differential equation of first order, Lagrange′s method, Charpit′s method.

Unit-5 Marks: 12, Contact hrs:15
Classification of second order partial differential equations into elliptic, parabolic and hyperbolic through illustrations only.

Books Recommended

1. S. L. Ross, *Differential Equations*, 3rd Ed., John Wiley and Sons,1984.
2. I. Sneddon, *Elements of Partial Differential Equations*, McGraw-Hill, International Edition,1967.

GE-2.2 Econometrics
Total Marks: 100, Theory: 80, IA: 20,
Credit: 5+1 = 6;
(L=5, P=0, T=1)

Objectives: After going through this course the students should be able to design models and solve problems related to Economic issues.

Unit-1 Marks: 16, Contact hrs: 20

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; power of a test; tests for comparing parameters from two samples.

Unit-2 Marks: 16, Contact hrs: 20

Simple Linear Regression Model: Two Variable Case Estimation of model by method of ordinary least squares; properties of estimators; goodness of fit; tests of hypotheses; scaling and units of measurement; confidence intervals; Gauss-Markov theorem;forecasting.

Unit-3 Marks: 16, Contact hrs: 20

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-4 Marks: 16, Contact hrs:15

Violations of Classical Assumptions: Consequences, Detection and Remedies Multicollinearity; heteroscedasticity; serial correlation.

Unit-5 Marks: 16, Contact hrs:15

Specification Analysis Omission of a relevant variable; inclusion of irrelevant variable; tests of specification errors.

Books Recommended

1. J. L. Devore, *Probability and Statistics for Engineers*, Cengage Learning,2010.
2. J. E. Freund, *Mathematical Statistics*, Prentice Hall,1992.
3. R. 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. C. Dougherty, *Introduction to Econometrics*, Oxford University Press, 3rd Ed., Indian edition,2007.

GE-3.1 Real Analysis
Total Marks: 100, Theory: 80, IA: 20,
Credit: 5+1 = 6;
(L=5, P=0, T=1)

Objectives: After going through this course the students will be able to

- Analyse the properties of the number line
- Describe various analytical properties of the real number system

Unit-1 Marks: 20, Contact hrs:30

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

Unit-2 Marks: 20, Contact hrs:20

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-3 Marks: 20, Contact hrs:20

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-4 Marks: 20, Contact hrs:20

Sequences and series of functions, Pointwise and uniform convergence. Mn-test, M-test, Statements of the results about uniform convergence and integrability and differentiability of functions, Power series and radius of convergence.

Books Recommended

1. T. M. Apostol, *Calculus* (Vol. I), John Wiley and Sons (Asia) P. Ltd.,2002.
2. R.G. Bartle and D. R Sherbert, *Introduction to Real Analysis,* John Wiley and Sons (Asia) P.Ltd.,2000.
3. E. Fischer, *Intermediate Real Analysis*, Springer Verlag,1983.
4. K.A. Ross, *Elementary Analysis- The Theory of Calculus Series*- Undergraduate Texts in Mathematics, Springer Verlag,2003.

GE3.2 Cryptography and Network Security
Total Marks:100, Theory: 80, IA: 20,
Credit: 5+1 = 6;
(L=5, P=0, T=1)

Objectives: After going through this course the students will be able to

- Discuss the principles of Cryptography
- Explain various ways of attacks in complex networks.
- Explain the structure and organization of the complex network.

Unit-1 Marks: 24, Contact hrs: 30

Public Key Cryptography Principles & Applications, Algorithms: RSA, Message Authentication: One way Hash Functions: Message Digest, MD5, SHA1. Public Key Infrastructure: Digital Signatures, Digital Certificates, Certificate Authorities.

Unit-2 Marks: 24, Contact hrs: 30

Network Attacks: Buffer Overflow, IP Spoofing, TCP Session Hijacking, Sequence Guessing, Network Scanning: ICMP, TCP sweeps, Basic Port Scans; Denial of Service Attacks: SYN Flood, Teardrop attacks, land, Smurf Attacks.IP security Architecture: Overview, Authentication header, Encapsulating Security Pay Load, combining Security Associations, Key Management. Virtual Private Network Technology: Tunneling using IPSEC.

Unit-3 Marks: 32, Contact hrs: 30

Requirements, Secure Socket Layer, and Secure Electronic Transactions, Network Management Security: Overview of SNMP Architecture- SNMPV1, SNMPV3.Firewall Characteristics & Design Principles, Types of Firewalls: Packet Filtering Router, Application Level Gateway or Proxy, Content Filters, Bastion Host.

Books Recommended

1. W. Stallings, *Networks Security Essentials: Application & Standards,* Pearson Education, 2000.
2. B. A. Forouzan, *Data Communication and Networking*, Tata McGrawHill, 2007.
3. W. Stallings, *Cryptography and Network Security, Principles and Practice*, Pearson Education,2000.

GE 3.3 Information Security
Total Marks: 100, Theory: 80, IA: 20, Credit: 5+1 = 6;
(L=5, P=0, T=1)

Objectives: After going through this course the students will be able to

- Describe security issues and data integrity

Unit-1 Marks: 16, Contact hrs:15

Overview of Security: Protection versus security; aspects of security–data integrity, data availability, privacy; security problems, user authentication, Orange Book.

Unit-2 Marks: 20, Contact hrs:20

Security Threats: Program threats, worms, viruses, Trojan horse, trap door, stack and buffer over flow; system threats- intruders; communication threats- tapping and piracy.

Unit-3 Marks: 16, Contact hrs:20

Cryptography: Substitution, transposition ciphers, symmetric-key algorithms-Data Encryption Standard, advanced encryption standards, public key encryption - RSA; Diffie- Hellman key exchange, ECC cryptography, Message Authentication- MAC, hash functions.

Unit-4 Marks: 16, Contact hrs:20

Digital signatures: Symmetric key signatures, public key signatures, message digests, public key infrastructures.

Unit-5 Marks: 12, Contact hrs:15

Security Mechanisms: Intrusion detection, auditing and logging, tripwire, system-call monitoring.

Books Recommended

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

GE-4.1 Algebra
Total Marks: 100, Theory: 80, IA: 20,
Credit: 5+1 = 6;
(L=5, P=0, T=1)

Objectives:: After going through this course the students will be able to

- Describe various algebraic structures onsets
- Identify the algebraic structures present in different branches ofSciences

Unit-1 Marks: 28, Contact hrs:30

Definition and examples of groups, examples of abelian and non-abelian groups, the group Zn ofintegers 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 GLn(n,R), groups of symmetries of (i) an isosceles triangle, (ii) an equilateral triangle, (iii) a rectangle, and (iv) a square, the permutation group Sym (n), Group of quaternions.

Unit-2 Marks: 28, Contact hrs:30

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

Unit-3 Marks: 24, Contact hrs: 30

Definition and examples of rings, examples of commutative and non-commutative rings: rings from number systems, Zn the ring of integers modulo n, ring of real quaternions, rings of matrices, polynomial rings, and rings of continuous functions. Subrings and ideals, Integral domains and fields, examples of fields: Zp, Q, R, and C. Field of rationalfunctions.

Books Recommended

1. J. B. Fraleigh, *A First Course in Abstract Algebra*, 7th Ed., Pearson,2002**.**
2. M. Artin, *Abstract Algebra*, 2nd Ed., Pearson,2011.
3. J. A Gallian, *Contemporary Abstract Algebra*, 4th Ed., Narosa,1999.
4. G. E Andrews, *Number Theory*, Hindustan Publishing Corporation,1984.

GE-4.2 Applications of Algebra
Total Marks: 100, Theory: 80, IA: 20,
Credit: 5+1 = 6;
(L=5, P=0, T=1)

Objectives: After going through this course you will be able to

- Explain various algebraic structure
- Solve system of linear equations.

Unit-1 Marks: 16, Contact hrs: 15

Balanced incomplete block designs (BIBD): definitions and results, incidence matrix of a BIBD, construction of BIBD from difference sets, construction of BIBD using quadratic residues, difference set families, construction of BIBD from finite fields.

Unit-2 Marks: 16, Contact hrs:15

Coding Theory: introduction to error correcting codes, linear cods, generator and parity check matrices, minimum distance, Hamming Codes, decoding and cyclic codes.

Unit-3 Marks:16, Contact hrs:20

Symmetry groups and color patterns: review of permutation groups, groups of symmetry and action of a group on a set; colouring and colouring patterns, Polya theorem and pattern inventory, generating functions for non-isomorphicgraphs.

Unit-4 Marks: 16, Contact hrs:20

Special types of matrices: idempotent, nilpotent, involution, and projection tri diagonal matrices, circulant matrices, Vandermonde matrices, Hadamard matrices, permutation and doubly stochastic matrices, Frobenius-König theorem, Birkhoff theorem. Positive Semi-definite matrices: positive semi-definite matrices, square root of apositive semi- definite matrix, a pair of positive semi-definite matrices, and their simultaneous diagonalization. Symmetric matrices and quadratic forms: diagonalization of symmetric matrices, quadratic forms, constrained optimization, singular value decomposition, and applications to image processing and statistics.

Unit-5 Marks: 16, Contact hrs:20

Applications of linear transformations: Fibonacci numbers, incidence models, and differential equations. Least squares methods: Approximate solutions of system of linear equations, approximate inverse of an m×n matrix, solving a matrix equation using its normal equation, finding functions that approximate data. Linear algorithms: LDU factorization, the row reduction algorithm and its inverse, backward and forward substitution, approximate inverse and projection algorithms.

Books Recommended

1. I. N. Herstein and D. J. Winter, *Primer on Linear Algebra*, Macmillan Publishing Company, New York,1990.
2. S. R. Nagpaul and S. K. Jain, *Topics in Applied Abstract Algebra*, Thomson Brooks and Cole, Belmont,2005.
3. R. E. Klima, Neil Sigmon, Ernest Stitzinger, *Applications of Abstract Algebra with Maple*, CRC Press LLC, Boca Raton,2000.
4. D. C. Lay, *Linear Algebra and its Applications.* 3rd Ed., Pearson Education Asia, Indian Reprint, 2007.
5. F. Zhang, *Matrix theory*, Springer-Verlag New York, Inc., New York,1999.

GE4.3 Combinatorial Mathematics
Total Marks: 100, Theory: 80, IA: 20,
Credit: 5+1 = 6;
(L=5, P=0, T=1)

Objectives: After going through this course you will be able to

- Use combinatorial approach in solving algebraic problems
- Explain counting principles.

Unit-1 Marks: 12, Contact hrs:15

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

Unit-2 Marks:10, Contact hrs:15

Principle of Inclusion and Exclusion, Derangements, Inversion formulae

Unit-3 Marks: 12, Contact hrs:15

Generating functions: Algebra of formal power series, Generating function models, Calculating generating functions, Exponential generating functions.

Unit-4 Marks: 10, Contact hrs:15

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

Unit-5 Marks: 12,, Contact hrs:10

Integer partitions, Systems of distinct representatives.

Unit-6 Marks: 12, Contact hrs:10

Polya theory of counting: Necklace problem and Burnside′s lemma, Cyclic index of a permutation group, Polya′s theorems and their immediate applications.

Unit-7 Marks: 12, Contact hrs:10

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.