Academic Syllabus for

UG Mathematics

(Core + GE)

Academic Session : 2018 – 21, onward.

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

Semester	Core Course (14)	Ability Enhancement Compulsory Course (AECC) (2)	Skill Enhancement Course (SEC) (2)	Discipline Specific Elective (DSE) (4)	Generic Elective (GE) (4)
1	C1: Calculus C2: Algebra	AECC1			GE1
2.	C3: Real Analysis C4: Differential Equations	AECC2			GE2
3.	C5: Theory of Real Functions C6: Group Theory I C7: PDE and Systems of ODE		SEC1		GE3
4.	C8: Numerical Methods C9: Riemann Integration and Series of Functions C10: Ring Theory		SEC2		GE4
5.	C11 Multivariate Calculus C12: Group Theory II			DSE-1 DSE-2	
6.	C13: Metric Spaces and Complex Analysis C14: Linear Algebra			DSE-3 DSE-4	

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(P) means course with practical

Discipline Specific Electives (DSE)

Choices for DSE 1 (choose one)

1. Linear Programming
2. Number Theory
3. Analytical Geometry

Choices for DSE 2 (choose one)

1. Industrial Mathematics
2. Boolean Algebra and Automata Theory
3. Probability and Statistics

Choices for DSE 3 (choose one)

1. Theory of Equations
2. Bio-Mathematics
3. Portfolio Optimization

Choices for DSE 4 (choose one)

1. Mathematical Modeling
2. Mechanics
3. Differential Geometry

Skill Enhancement Course (SEC)

Choices for SEC 1 (choose one)

1. Logic and Sets
2. Computer Graphics

Choices for SEC 2 (choose one)

1. Graph Theory
2. Operating System: Linux

Generic Electives (GE)

Choices for GE 1 (choose one)

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

Choices for GE 2 (choose one)

1. Mathematical Finance
2. Econometrics
3. Diffential Equations(except mathematics hons.)

Choices for GE 3 (choose one)

1. Cryptography and Network Security
2. Information Security
3. Real analysis(except mathematics hons.)

Choices for GE 4 (choose one)

1. Applications of Algebra
2. Combinatorial Mathematics
3. Algebra (except mathematics hons.)

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

Course *Credits

Theory + Practical Theory + Tutorial

I. Core Course

(14 Papers) 14×4 = 56 14×5 = 70

Core Course Practical / Tutorial* 14×2 = 28 14×1 = 14

(14 Papers)

II. Elective Course (8 Papers)

A.1. Discipline Specific Elective 4×4 = 16 4×5 = 20

(4 Papers)

A.2. Discipline Specific Elective

Practical/ Tutorial* 4×2 = 8 4×1 = 4

(4 Papers)

B.1. Generic Elective/

Interdisciplinary 4×4 = 16 4×5 = 20

(4 Papers)

B.2. Generic Elective

Practical/ Tutorial* 4×2 = 8 4×1 = 4

(4 Papers)

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

III. Ability Enhancement Courses

1.**Ability Enhancement Compulsory Courses (AECC)**

(2 Papers of 2 credit each) 2×2 = 4 2×2 = 4

Environmental Science English/MIL Communication

2. **Skill Enhancement Courses (SEC)**

(Minimum 2) 2×2 = 4 2×2 = 4

(2 Papers of 2 credit each)

_____ _____

Total credit 140 140

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**

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C1.1: Calculus

FULL MARKS: 80 **TIME: 3 hours**

Eight questions will be set out of which candidates are required to answer ***four*** questions. Question number **1** is compulsory consists of ***ten*** short answer type questions each of ***two*** marks covering entire syllabus uniformly.

UNIT - I

Hyperbolic functions, higher order derivatives, Leibniz rule and its applications to problems of type eax+bsinx, eax+bcosx, (ax+b)nsinx, (ax+b)ncosx, concavity and inflection points, asymptotes, curve tracing in Cartesian coordinates, tracing in polar coordinates of standard curves, L'Hospital's rule. (2 questions)

UNIT - II

Reduction formulae, derivations and illustrations of reduction formulae of the type ∫sinnx dx, ∫cosnx dx, ∫tannx dx, ∫sinnx cosmx dx, ∫sin mx cos nx dx, ∫ (log x)n dx, parametric equations,parameterizing a curve, arc length, arc length of parametric curves, volume and area of surface of revolution. (2 questions)

UNIT - III

Techniques of sketching conics, reflection properties of conics, rotation of axes and second degree equations, classification into conics using the discriminant, polar equations of conics. (1 questions)

UNIT - IV

Triple product, introduction to vector functions, operations with vector-valued functions, limits and continuity of vector functions, differentiation and integration of vector functions, tangent and normal components of acceleration. (2 questions)

Books Recommended

1. G.B. Thomas and R.L. Finney, *Calculus*, 9th Ed., Pearson Education, Delhi, 2005.
2. M.J. Strauss, G.L. Bradley and K. J. Smith, *Calculus*, 3rd Ed., Dorling Kindersley (India) P. Ltd. (Pearson Education), Delhi, 2007.
3. H. Anton, I. Bivens and S. Davis, *Calculus*, 7th Ed., John Wiley and Sons (Asia) P. Ltd., Singapore, 2002.
4. R. Courant and F. John, *Introduction to Calculus and Analysis* (Volumes I & II), SpringerVerlag, New York, Inc., 1989.

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C1.2: Algebra

FULL MARKS: 80 **TIME: 3 hours**

Eight questions will be set out of which candidates are required to answer ***four*** questions. Question number **1** is compulsory consists of ***ten*** short answer type questions each of ***two*** marks covering entire syllabus uniformly.

UNIT - I

Polar representation of complex numbers, nth roots of unity, De Moivre's theorem for rational indices and its applications, logarithmic of complex numbers. (2 questions)

UNIT - II

Equivalence relations, Functions, Composition of functions, Invertible functions, One to one correspondence and cardinality of a set, Well-ordering property of positive integers, Division algorithm, Divisibility and Euclidean algorithm, Congruence relation between integers, Principles of Mathematical Induction, statement of Fundamental Theorem of Arithmetic. (2 questions)

UNIT - III

Rank of a matrix, row and column rank of a matrix, vector space and subspace, theorem of subspaces, Rn space and its subspaces, basis and dimension of subspaces of Rn, system of linear equations Ax=B, Consistency of the system Ax=B, Set of Solutions of Ax=0, invertible matrices and Characterizations of invertible matrices, Characteristic polynomial of a matrix, Eigen values and Eigen vectors of a matrix, Linear transformations and their matrix representation, transition matrices. (3 questions)

Books Recommended

1. Titu Andreescu and Dorin Andrica, *Complex Numbers from A to Z*, Birkhauser, 2006.
2. Edgar G. Goodaire and Michael M. Parmenter, *Discrete Mathematics with Graph Theory*, 3rd Ed., Pearson Education (Singapore) P. Ltd., Indian Reprint, 2005.
3. David C. Lay, *Linear Algebra and its Applications*, 3rd Ed., Pearson Education Asia, Indian Reprint, 2007.

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C2.1: Real Analysis

FULL MARKS: 80 **TIME: 3 hours**

Eight questions will be set out of which candidates are required to answer ***four*** questions. Question number **1** is compulsory consists of ***ten*** short answer type questions each of ***two*** marks covering entire syllabus uniformly.

UNIT - I

Review of Algebraic and Order Properties of R, δ -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.

(2 questions)

UNIT - II

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. (2 questions)

UNIT - III

Infinite series, convergence and divergence of infinite series, Cauchy Criterion, Tests for convergence: Comparison test, Limit Comparison test, Ratio Test, Cauchy's nth root test, Raabe,s test, DeMorgan's and Bertrand's test, Alternating series, Leibniz test, Absolute and Conditional convergence, Kummer's test, logarithmic ratio test.

(3 questions)

Books Recommended

1. R.G. Bartle and D. R. Sherbert, *Introduction to Real Analysis*, 3rd Ed., John Wiley and Sons (Asia) Pvt. Ltd., Singapore, 2002.
2. Gerald G. Bilodeau , Paul R. Thie, G.E. Keough, *An Introduction to Analysis*, 2nd Ed., Jones & Bartlett, 2010.
3. Brian S. Thomson, Andrew. M. Bruckner and Judith B. Bruckner, *Elementary Real Analysis*, Prentice Hall, 2001.
4. S.K. Berberian, *A First Course in Real Analysis*, Springer Verlag, New York, 1994.

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C2.2: Differential Equations

FULL MARKS: 80 **TIME: 3 hours**

Eight questions will be set out of which candidates are required to answer ***four*** questions. Question number **1** is compulsory consists of ***ten*** short answer type questions each of ***two*** marks covering entire syllabus uniformly.

UNIT - I

First order exact differential equations. Integrating factors, rules to find an integrating factor. First order and higher degree equations solvable for x, y, p. Clairaut's form, singular solutions, general solution. Second order linear differential equation with constant coefficient.

(2 questions)

UNIT - II

General solution of second order linear homogeneous and non-homogeneous equations, linear homogeneous and non-homogeneous equations of higher order with constant coefficients, The Cauchy-Euler equation. Second order linear differential equations with variable coefficients.

(2 questions)

UNIT -III

Power series solution of a differential equation about an ordinary point, solution about a regular Singular point, Bessel's equation and Legendre's equation, recurrence formulae, orthogonal properties, generating function. (2 questions)

UNIT IV

Laplace transform and inverse transform, properties, application to initial value problem up to second order ODE. (1 questions)

Books Recommended

1. Ordinary and partial differential equation, M.D. Raisinghania, S.Chand and Company limited, 2006.
2. Integral transform, A.R.Vashistha, krishna Publication.
3. C.H. Edwards and D.E. Penny, *Differential Equations and Boundary Value problems Computing and Modeling,* Pearson Education India, 2005.
4. S.L. Ross, *Differential Equations,* 3rd Ed., John Wiley and Sons, India, 2004.
5. Martha L Abell, James P Braselton, *Differential Equations with MATHEMATICA,* 3rd Ed., Elsevier Academic Press, 2004

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C3.1: Theory of Real Functions

FULL MARKS: 80 **TIME: 3 hours**

Eight questions will be set out of which candidates are required to answer ***four*** questions. Question number **1** is compulsory consists of ***ten*** short answer type questions each of ***two*** marks covering entire syllabus uniformly.

UNIT - I

Limits of functions 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. Uniform continuity, non-uniform continuity criteria, uniform continuity theorem. (3 questions)

UNIT - II

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. (2 questions)

UNIT - III

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 $(1 +x)_n$. (2 questions)

Books Recommended:

1. R. Bartle and D.R. Sherbert, *Introduction to Real Analysis*, John Wiley and Sons, 2003.
2. K.A. Ross, *Elementary Analysis: The Theory of Calculus*, Springer, 2004.
3. A. Mattuck, *Introduction to Analysis*, Prentice Hall, 1999.
4. S.R. Ghorpade and B.V. Limaye, *A Course in Calculus and Real Analysis,* Springer, 2006.

C3.2 Group Theory I

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FULL MARKS: 80 **TIME: 3 hours**

Eight questions will be set out of which candidates are required to answer ***four*** questions. Question number **1** is compulsory consists of ***ten*** short answer type questions each of ***two*** marks covering entire syllabus uniformly.

UNIT - I

Symmetries of a square, Dihedral groups, definition and examples of groups, abelian groups, permutation groups, Cycle notation for permutations, even and odd permutations, quaternion group and its matrix representation, elementary properties of groups. (1 questions)

Order of a group element and order of a group, Subgroups and examples and theorems on subgroups, normal subgroups and their properties, centralizer (normalizer) of a group element, centre of a group. (2 questions)

UNIT - II

Properties of cyclic groups, classification of subgroups of cyclic groups. Cosets and their properties, Lagrange's theorem and consequences including Fermat's Little theorem. Group homomorphism, kennel of homomorphism, properties of homomorphism. (2 questions)

UNIT - III

factor groups (quotient groups), Cauchy's theorem for finite abelian groups; Group isomorphism, properties of isomorphisms, First, Second and Third isomorphism theorems, Cayley theorem. External direct product of a finite number of groups. (2 questions)

Books Recommended

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, New Delhi, 1999.
4. Joseph J. Rotman, *An Introduction to the Theory of Groups*, 4th Ed., Springer Verlag, 1995.
5. I.N. Herstein, *Topics in Algebra*, Wiley Eastern Limited, India, 1975.

C3.3: Systems of ODE and ODE

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FULL MARKS: 80 **TIME: 3 hours**

Eight questions will be set out of which candidates are required to answer ***four*** questions. Question number **1** is compulsory consists of ***ten*** short answer type questions each of ***two*** marks covering entire syllabus uniformly.

UNIT - I

Systems of linear differential equations, types of linear systems, differential operators, an operator method for linear systems with constant coefficients, Basic Theory of linear systems in normal form. (1 questions)

UNIT - II

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. Canonical Forms of First-order Linear Equations, Lagrange's equation, Method of Separation of Variables for solving first order partial differential equations (3 questions)

UNIT - III

Classification of second order linear equations as hyperbolic, parabolic and elliptic. Reduction of second order Linear Equations to canonical forms. (1 questions)

UNIT - IV

Nonlinear partial differential equation, standard forms I, II,III and IV, Charpit's method, Monge's method to solve equation of the form $Rr + Ss + Tt = V$ (2 questions)

Books Recommended:

1. Tyn Myint-U and Lokenath Debnath, *Linear Partial Differential Equations for Scientists and Engineers*, 4th edition, Springer, Indian reprint, 2006.
2. S.L. Ross, *Differential equations*, 3rd Ed., John Wiley and Sons, India, 2004.
3. Martha L Abell, James P Braselton, *Differential equations with MATHEMATICA*, 3rd Ed., Elsevier Academic Press, 2004.

C4.1: Numerical Methods

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FULL MARKS: 80 **TIME: 3 hours**

Eight questions will be set out of which candidates are required to answer ***four*** questions. Question number **1** is compulsory consists of ***ten*** short answer type questions each of ***two*** marks covering entire syllabus uniformly. **Use of Scientific Calculator is allowed.**

UNIT - I

Algorithms, Convergence, Errors: Relative, Absolute, Round off, Truncation. Transcendental and Polynomial equations: Bisection method, Newton-Raphson method, Secant method and their rate of convergence. (1 questions)

UNIT - II

System of linear algebraic equations: Gaussian Elimination and Gauss Jordan methods. Gauss Jacobi method, Gauss Seidel method. (1 question)

Interpolation: Calculus of finite difference operators, Newton's Gregory forward and backward difference interpolation. Lagrange and Newton interpolation formula for unequal intervals. (2 questions)

UNIT - III

Numerical differentiation, Numerical Integration: Trapezoidal rule, Simpson's rule, Simpsons 3/8th rule, Boole's Rule, Midpoint rule, Composite Trapezoidal rule, Composite Simpson's rule. (2 question)

Ordinary Differential Equations: Euler's method. Runge-Kutta methods of orders two and four. (1 question)

Books Recommended:

1. Brian Bradie, *A Friendly Introduction to Numerical Analysis*, Pearson Education, India, 2007.
2. 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.
3. C.F. Gerald and P.O. Wheatley, *Applied Numerical Analysis*, Pearson Education, India, 2008.
4. Uri M. Ascher and Chen Greif, *A First Course in Numerical Methods*, 7th Ed., PHI Learning Private Limited, 2013.
5. John H. Mathews and Kurtis D. Fink, *Numerical Methods using Matlab*, 4th Ed., PHI Learning Private Limited, 2012.

C4.2: Riemann Integration and Series of Functions

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FULL MARKS: 80 **TIME: 3 hours**

Eight questions will be set out of which candidates are required to answer ***four*** questions. Question number **1** is compulsory consists of ***ten*** short answer type questions each of ***two*** marks covering entire syllabus uniformly.

UNIT - I

Riemann integration; inequalities of upper and lower sums; Riemann conditions of integrability. (1 question)

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. (3 questions)

UNIT - II

Improper integrals and their convergence, μ –test, Dirichlets and abel's tests, Convergence of Beta and Gamma functions. (2 question)

UNIT - III

Limit superior and Limit inferior. Power series, radius of convergence. (1 questions)

Books Recommended:

1. K.A. Ross, *Elementary Analysis, The Theory of Calculus*, Undergraduate Texts in Mathematics, Springer (SIE), Indian reprint, 2004.
2. R.G. Bartle D.R. Sherbert, *Introduction to Real Analysis,* 3rd Ed., John Wiley and Sons (Asia) Pvt. Ltd., Singapore, 2002.
3. Charles G. Denlinger, *Elements of Real Analysis*, Jones & Bartlett (Student Edition), 2011.

C4.3: Ring Theory and Linear Algebra I

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FULL MARKS: 80 **TIME: 3 hours**

Eight questions will be set out of which candidates are required to answer ***four*** questions. Question number **1** is compulsory consists of ***ten*** short answer type questions each of ***two*** marks covering entire syllabus uniformly.

UNIT - I

Definition and examples of rings, properties of rings, subrings, integral domains and fields, characteristic of a ring, Ideals, ideal generated by a subset of a ring, factor rings, prime and maximal ideals, principal ideal domain. (3 questions)

UNIT - II

Ring homomorphisms, properties of ring homomorphisms, Isomorphism theorems, field of quotients. (2 question)

UNIT - III

Polynomial rings over commutative rings, division algorithm and consequences, 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 (2 questions)

Books Recommended

1. John B. Fraleigh, *A First Course in Abstract Algebra*, 7th Ed., Pearson, 2002.
2. M. Artin, *Abstract Algebra*, 2nd Ed., Pearson, 2011.
3. Stephen H. Friedberg, Arnold J. Insel, Lawrence E. Spence, *Linear Algebra*, 4th Ed.,
4. PrenticeHall of India Pvt. Ltd., New Delhi, 2004.
5. Joseph A. Gallian, *Contemporary Abstract Algebra*, 4th Ed., Narosa Publishing House, New Delhi, 1999.
6. S. Lang, *Introduction to Linear Algebra*, 2nd Ed., Springer, 2005.
7. Gilbert Strang, *Linear Algebra and its Applications*, Thomson, 2007.
8. S. Kumaresan, *Linear Algebra- A Geometric Approach*, Prentice Hall of India,1999.
9. Kenneth Hoffman, Ray Alden Kunze, *Linear Algebra*, 2nd Ed., Prentice-Hall of India Pvt. Ltd., 1971.
10. D.A.R. Wallace, *Groups, Rings and Fields*, Springer Verlag London Ltd., 1998.

C5.1: Multivariate Calculus

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FULL MARKS: 80 **TIME: 3 hours**

Eight questions will be set out of which candidates are required to answer ***four*** questions. Question number **1** is compulsory consists of ***ten*** short answer type questions each of ***two*** marks covering entire syllabus uniformly.

UNIT - I

Functions of several variables, limit and continuity of functions of two variables, Partial differentiation, total differentiability and differentiability, sufficient condition for differentiability. Extrema of functions of two variables, method of Lagrange multipliers,

(2 question)

UNIT - II

Double and triple integrals, change of order of integration, surface area by double integral and Volume by triple integrals. (2 questions)

UNIT - III

The gradient, divergence and curl. Line integrals, surface integral, Green's theorem,. Stoke's theorem and Gauss theorem (3 questions)

Books Recommended:

1. G.B. Thomas and R.L. Finney, *Calculus*, 9th Ed., Pearson Education, Delhi, 2005.
2. M.J. Strauss, G.L. Bradley and K. J. Smith, *Calculus*, 3rd Ed., Dorling Kindersley (India) Pvt. Ltd. (Pearson Education), Delhi, 2007.
3. E. Marsden, A.J. Tromba and A. Weinstein, *Basic Multivariable Calculus*, Springer (SIE), Indian reprint, 2005.
4. James Stewart, *Multivariable Calculus, Concepts and Contexts*, 2nd Ed., Brooks /Cole, Thomson Learning, USA, 2001.

C5.2: Group Theory II

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FULL MARKS: 80 **TIME: 3 hours**

Eight questions will be set out of which candidates are required to answer ***four*** questions. Question number **1** is compulsory consists of ***ten*** short answer type questions each of ***two*** marks covering entire syllabus uniformly.

UNIT - I

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. (3 questions)

UNIT - II

Properties of external direct products, the group of units modulo n as an external direct product, internal direct products, Fundamental Theorem of finite abelian groups. (2 questions)

UNIT - III

Class equation and consequences, conjugacy in Sn, p-groups, Sylow's 1st , 2nd and 3rd theorems. (2 questions)

Books Recommended

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. David S. Dummit and Richard M. Foote, *Abstract Algebra*, 3rd Ed., John Wiley and Sons (Asia) Pvt. Ltd., Singapore, 2004.
5. J.R. Durbin, *Modern Algebra*, John Wiley & Sons, New York Inc., 2000.
6. D. A. R. Wallace, *Groups, Rings and Fields*, Springer Verlag London Ltd., 1998.

C6.1: Metric Spaces and Complex Analysis

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FULL MARKS: 80 **TIME: 3 hours**

Eight questions will be set out of which candidates are required to answer ***four*** questions. Question number **1** is compulsory consists of ***ten*** short answer type questions each of ***two*** marks covering entire syllabus uniformly.

UNIT - I

Metric spaces: definition and examples. Sequences in metric spaces, Cauchy sequences. Complete Metric Spaces. Open and closed balls, neighbourhood, open set, interior of a set. Limit point of a set, closed set, diameter of a set, Cantor's intersection theorem. Subspaces.

(2 questions)

UNIT - II

Continuous mappings, sequential criterion and other characterizations of continuity. Uniform continuity. Homeomorphism, Contraction mappings, Banach Fixed point Theorem.

(1 questions)

UNIT - III

Geometry of complex numbers, regions in the complex plane, Limits and continuity of functions of complex variable, Derivatives, Necessary and sufficient conditions for differentiability.

(1 questions)

UNIT - IV

Analytic functions, examples of analytic functions, Cauchy-Riemann equations, exponential function, Logarithmic function, trigonometric function, derivatives of functions, bilinear transformation, cross ratio, conformal mapping. (3 questions)

Books Recommended

1. Satish Shirali and Harikishan L. Vasudeva, *Metric Spaces*, Springer Verlag, London, 2006.
2. S. Kumaresan, *Topology of Metric Spaces*, 2nd Ed., Narosa Publishing House, 2011.
3. G.F. Simmons, *Introduction to Topology and Modern Analysis*, McGraw-Hill, 2004.
4. James Ward Brown and Ruel V. Churchill, *Complex Variables and Applications,* 8th Ed., McGraw – Hill International Edition, 2009.
5. Joseph Bak and Donald J. Newman, *Complex Analysis,* 2nd Ed., Undergraduate Texts in Mathematics, Springer-Verlag New York, Inc., NewYork, 1997.

C6.2: Linear Algebra

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FULL MARKS: 80 **TIME: 3 hours**

Eight questions will be set out of which candidates are required to answer ***four*** questions. Question number **1** is compulsory consists of ***ten*** short answer type questions each of ***two*** marks covering entire syllabus uniformly.

UNIT - I

Vector spaces, subspaces, algebra of subspaces, quotient spaces, linear combination of vectors, linear span, linear independence, basis and dimension, dimension of subspaces, theorems. Linear transformations, null space, range, rank and nullity of a linear transformation, matrix representation of a linear transformation, algebra of linear transformations.

(3 questions)

UNIT - II

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. (2 questions)

UNIT - III

Inner product spaces and norms, Gram-Schmidt orthogonalisation process, orthogonal complements, Bessel's inequality, the adjoint of a linear operator, minimal solutions to systems of linear equations, Normal and self-adjoint operators (2 questions)

Books Recommended

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. Stephen H. Friedberg, Arnold J. Insel, Lawrence E. Spence, *Linear Algebra*, 4th Ed., PrenticeHall of India Pvt. Ltd., New Delhi, 2004.
5. S. Lang, *Introduction to Linear Algebra*, 2nd Ed., Springer, 2005.
6. Gilbert Strang, *Linear Algebra and its Applications*, Thomson, 2007.
7. S. Kumaresan, *Linear Algebra- A Geometric Approach*, Prentice Hall of India, 1999.
8. Kenneth Hoffman, Ray Alden Kunze, *Linear Algebra*, 2nd Ed., Prentice-Hall of India Pvt. Ltd., 1971.
9. S.H. Friedberg, A.L. Insel and L.E. Spence, *Linear Algebra*, Prentice Hall of India Pvt. Ltd., 2004.

DSE1.1: Linear Programming

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FULL MARKS: 80 **TIME: 3 hours**

Eight questions will be set out of which candidates are required to answer ***four*** questions. Question number **1** is compulsory consists of ***ten*** short answer type questions each of ***two*** marks covering entire syllabus uniformly.

UNIT - I

Introduction to linear programming problem, convex sets and their properties, Graphical method, Theory of simplex method, optimality and unboundedness, the simplex method, introduction to artificial variables, two-phase method, Big-M method. (3 questions)

UNIT - II

Duality, formulation of the dual problem, primal-dual relationships. (1 question)

Transportation problem and its mathematical formulation, northwest-corner method, lowest cost entry method and Vogel's approximation method for determination of starting basic solution, optimality test, algorithm for solving transportation problem, assignment problem and its mathematical formulation, Hungarian method for solving assignment problem.

(2 questions)

UNIT - III

Game theory: formulation of two person zero sum games, solving two person zero sum games, games with mixed strategies, graphical solution procedure. (2 questions)

Books Recommended

1. Mokhtar S. Bazaraa, John J. Jarvis and Hanif 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. Hamdy A. Taha, *Operations Research, An Introduction,* 8th Ed., Prentice-Hall India, 2006.
4. G. Hadley, *Linear Programming*, Narosa Publishing House, New Delhi, 2002.

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DSE1.2: Number Theory

FULL MARKS: 80 **TIME: 3 hours**

Eight questions will be set out of which candidates are required to answer ***four*** questions. Question number **1** is compulsory consists of ***ten*** short answer type questions each of ***two*** marks covering entire syllabus uniformly.

UNIT - I

Linear Diophantine equation, prime counting function, statement of prime number theorem, Goldbach conjecture, linear congruences, complete set of residues, Chinese Remainder theorem, Fermat's Little theorem, Wilson's theorem. (3 questions)

UNIT - II

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. (2 questions)

UNIT - III

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 . (2 questions)

Books Recommended

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

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DSE1.3: Analytical Geometry

FULL MARKS: 80 **TIME: 3 hours**

Eight questions will be set out of which candidates are required to answer ***four*** questions. Question number **1** is compulsory consists of ***ten*** short answer type questions each of ***two*** marks covering entire syllabus uniformly.

UNIT - I

Techniques for sketching parabola, ellipse and hyperbola. Reflection properties of parabola, ellipse and hyperbola. Classification of quadratic equations representing lines, parabola, ellipse and hyperbola. (4 questions)

UNIT - II

Spheres, cone, Cylindrical surfaces. Illustrations of graphing standard quadric surfaces like cone, ellipsoid. (3 questions)

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.

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DSE2.1: Industrial Mathematics

FULL MARKS: 80 **TIME: 3 hours**

Eight questions will be set out of which candidates are required to answer ***four*** questions. Question number **1** is compulsory consists of ***ten*** short answer type questions each of ***two*** marks covering entire syllabus uniformly.

UNIT - I

Medical Imaging and Inverse Problems. The content is based on Mathematics of X-ray and CT scan based on the knowledge of calculus, elementary differential equations, complex numbers and matrices. (1 questions)

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. (2 questions)

UNIT - II

X-ray: Introduction, X-ray behavior and Beers Law (The fundament question of image construction) Lines in the place. (1 question)

Radon Transform: Definition and Examples, Linearity, Phantom (Shepp - Logan Phantom - Mathematical phantoms). Back Projection: Definition, properties and examples. (1 question)

UNIT - III

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. (2 questions)

Books Recommended

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

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DSE 2.2: Boolean Algebra and Automata Theory

FULL MARKS: 80 **TIME: 3 hours**

Eight questions will be set out of which candidates are required to answer ***four*** questions. Question number **1** is compulsory consists of ***ten*** short answer type questions each of ***two*** marks covering entire syllabus uniformly.

UNIT - I

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

(3 questions)

UNIT - II

Boolean algebras,Boolean polynomials, minimal forms of Boolean polynomials Quinn-McCluskey method, Karnaugh diagrams, switching circuits and applications of switching circuits.

(2 questions)

UNIT - III

Introduction: Alphabets, strings, and languages. Finite Automata and Regular Languages: deterministic and non-deterministic finite automata, regular expressions, regular languages and their relationship with finite automata, pumping lemma and closure properties of regular languages. (1 questions)

Context Free Grammars and Pushdown Automata: Context free grammars (CFG), parse trees, ambiguities in grammars and languages, pushdown automaton (PDA) and the language accepted by PDA, deterministic PDA, Non- deterministic PDA, properties of context free languages; normal forms, pumping lemma, closure properties, decision properties. Turing Machines: Turing machine as a model of computation, programming with a Turing machine, variants of Turing machine and their equivalence. (1 questions)

Books Recommended

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

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DSE2.3: Probability and Statistics

FULL MARKS: 80 **TIME: 3 hours**

Eight questions will be set out of which candidates are required to answer ***four*** questions. Question number **1** is compulsory consists of ***ten*** short answer type questions each of ***two*** marks covering entire syllabus uniformly.

UNIT - I

Sample space, probability axioms, real random variables (discrete and continuous), cumulative distribution function, probability mass/density functions, mathematical expectation, moments, moment generating function, characteristic function, discrete distributions: uniform, binomial, Poisson, continuous distributions: uniform, normal, exponential. (3 questions)

UNIT - II

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, rank correlation coefficient, covariance, linear regression for two variables.
(2 questions)

UNIT - III

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

Books Recommended:

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

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DSE3.1: Theory of Equations

FULL MARKS: 80 **TIME: 3 hours**

Eight questions will be set out of which candidates are required to answer ***four*** questions. Question number **1** is compulsory consists of ***ten*** short answer type questions each of ***two*** marks covering entire syllabus uniformly.

UNIT - I

General properties of polynomials, Descarte's rule of signs, Relation between the roots and the coefficients of equations. (2 questions)

UNIT - II

Transformation of equations. Solutions of reciprocal and binomial equations. Algebraic solutions of the cubic and biquadratic. (2 questions)

UNIT - III

Symmetric functions, Applications of symmetric function of the roots, Newton's theorem on the sums of powers of roots, homogeneous products, limits of the roots of equations.
(1 questions)

UNIT - IV

Separation of the roots of equations, Strums theorem, Applications of Strum's theorem, Conditions for reality of the roots of an equation and biquadratic. Numerical Solution of equations.
(2 questions)

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.

DSE3.2: Bio-Mathematics

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FULL MARKS: 80 **TIME: 3 hours**

Eight questions will be set out of which candidates are required to answer ***four*** questions. Question number **1** is compulsory consists of ***ten*** short answer type questions each of ***two*** marks covering entire syllabus uniformly.

UNIT - I

Mathematical Biology and the modeling process: an overview. Continuous models: Malthus model, logistic growth, Allee effect, Gompertz growth, Michaelis-Menten Kinetics, Holling type growth, Bacterial growth in a Chemostat, Harvesting a single natural population, Prey predator systems and Lotka Volterra equations, Populations in competitions, Epidemic Models (SI, SIR, SIRS, SIC). (2 questions)

UNIT - II

Activator-Inhibitor system, Insect Outbreak Model: Spruce Budworm, Numerical solution of the models and its graphical representation. 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. (2 questions)

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. (1 questions)

UNIT - III

Discrete Models: Overview of difference equations, steady state solution and linear stability analysis, Introduction to Discrete Models, Linear Models, Growth models, Decay models, Drug Delivery Problem, Discrete Prey-Predator models, Density dependent growth models with harvesting, Host-Parasitoid systems (Nicholson-Bailey model),Numerical solution of the models 34 and its graphical representation. Case Studies: Optimal Exploitation models, Models in Genetics, Stage Structure Models, Age Structure Models. (2 questions)

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.

DSE3.3: Portfolio optimization

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FULL MARKS: 80 **TIME: 3 hours**

Eight questions will be set out of which candidates are required to answer ***four*** questions. Question number **1** is compulsory consists of ***ten*** short answer type questions each of ***two*** marks covering entire syllabus uniformly.

UNIT - I

Hydrostatics, Mass, Density, Specific gravity (relative density) Fluid-Pressure under Gravity : Solid, Fluid, Liquid, Gases, Perfect fluids, Viscous fluid, Experimental observation about fluid pressure under gravity, Liquid exerts pressure normally on a plane in contact (An Analytical treatment), Equality of pressure in all directions, Transmissibility of fluid pressure, In a fluid at rest under gravity the pressure is same at all points in the same horizontal plane, Find the pressure at a point of a liquid or establish pressure equation for a fluid at rest under gravity, Free surface and effective surface of a liquid, Common surface of two heavy homogenous liquids that don't mix is a horizontal plane.

(2 questions)

UNIT – II: Thrust on a Plane Surface and Centre of Pressure:

Whole pressure on a plane surface, Resultant thrust on a plane surface below the layers of different liquids only.Depth of C.P. of the plane area, Position of the C.P. of the area.

(2 questions)

UNIT – III: Thrust on Curved Surfaces:

Thrust on curved surfaces, vertical surfaces, Horizontal thrust.Equilibrium of fluids under given field of forces and Pressure of Elastic rotating fluids. (1 questions)

UNIT – IV

Equilibrium of floating bodies. Archimedes' Principle, Force of Buoyancy, Centre of Buoyancy and Plane floatation, Body floats freely in one or more liquids, Body floating in a liquid under constraints, Condition of equilibrium of a body immersed in a liquid and supported by a string, Weighing a body in air, Weighing a body immersed in a liquid, The positions of equilibrium of a body floating in a homogenous liquid. (2 questions)

Books Recommended:

1. B. D. Sharma and M. R. Hassan, "Hydrostatics", Kedar Nath Ram Nath, Meerut, 2018.
2. S.L.Loni, "An Introduction to Hydrostatics

DSE4.1: Mathematical Modeling

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FULL MARKS: 80 **TIME: 3 hours**

Eight questions will be set out of which candidates are required to answer ***four*** questions. Question number **1** is compulsory consists of ***ten*** short answer type questions each of ***two*** marks covering entire syllabus uniformly.

UNIT - I

Introduction to Mathematical modeling, its need, techniques and classifications. Linear growth and decay model and its uses in modeling dynamical and geometrical problems, mathematical modeling in population dynamics and Economics. (3 questions)

UNIT - II

Compartmental model, exponential decay model. Mathematical Modeling in Economics. Exponential growth of population. (2 questions)

UNIT - III

Modeling through linear programming; graphical solution, simplex method. (1 question)

UNIT - IV

Mathematical models on environmental pollution: air and water pollution. (1 question)

Books Recommended

1. **Mathematical Modeling, J.N.Kapur**
2. Frank R. Giordano, Maurice D. Weir and William P. Fox, *A First Course in Mathematical Modeling*, Thomson Learning, London and New York, 2003.
3. **Mathematical Modeling in medicine and Biology, J.N.Kapur**

DSE4.2: Mechanics

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FULL MARKS: 80 **TIME: 3 hours**

Eight questions will be set out of which candidates are required to answer ***four*** questions. Question number **1** is compulsory consists of ***ten*** short answer type questions each of ***two*** marks covering entire syllabus uniformly.

UNIT - I

Analytical conditions of equilibrium of coplanar forces, virtual work, common catenary, forces in three dimension, Poinsot's central axis, wrenches. Null lines and planes, stable and unstable equilibrium. (4 questions)

UNIT - II

Velocities and acceleration along radial and transverse directions, along tangent and normal directions, simple harmonic motion, elastic string , Hook's law. Central orbit, kepler's laws of motion. (3 questions)

Books Recommended

1. I.H. Shames and G. Krishna Mohan Rao, *Engineering Mechanics: Statics and Dynamics*, (4^{th} Ed.), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education), Delhi, 2009.
2. R.C. Hibbeler and Ashok Gupta, *Engineering Mechanics: Statics and Dynamics*, 11th Ed., Dorling Kindersley (India) Pvt. Ltd. (Pearson Education), Delhi.

DSE 4.3: Differential Geometry

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FULL MARKS: 80 **TIME: 3 hours**

Eight questions will be set out of which candidates are required to answer ***four*** questions. Question number **1** is compulsory consists of ***ten*** short answer type questions each of ***two*** marks covering entire syllabus uniformly.

UNIT - I

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.
(2 questions)

UNIT - II

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.
(3 questions)

UNIT - III

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.
(2 questions)

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 Press 2003.
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.

GE 1.1 Object Oriented Programming in C++

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FULL MARKS: 80 **TIME: 3 hours**

Eight questions will be set out of which candidates are required to answer ***four*** questions. Question number **1** is compulsory consists of ***ten*** short answer type questions each of ***two*** marks covering entire syllabus uniformly.

UNIT - I

OOP Paradigm: Comparison of Programming paradigms, Characteristics of Object-Oriented Programming Languages, Object-based programming languages C++: Brief History of C++,Structure of a C++ program, Difference between C and C++ - cin, cout, new, delete operators, ANSI/ISO Standard C++, Comments, Working with Variables and const Qualifiers. Enumeration, Arrays and Pointer. (2 questions)

UNIT - II

Implementing oops concepts in C++ Objects, Classes, Encapsulation, Data Abstraction, Inheritance, Polymorphism, Dynamic Binding, Message Passing, Default Parameter Value,Using Reference variables with Functions. (2 questions)

UNIT - III

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.

(3 questions)

Books Recommended:

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. Bruce Eckel, *Thinking in C++*, 2nd Ed., President, Mindview Inc., Prentice Hall.
4. D. Parasons, *Object Oriented Programming with C++*, BPB Publication.
5. Bjarne Stroustrup , *The C++ Programming Language*, 3rd Ed., Addison Welsley.

GE1.2: Finite Element Methods

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FULL MARKS: 80 **TIME: 3 hours**

Eight questions will be set out of which candidates are required to answer ***four*** questions. Question number **1** is compulsory consists of ***ten*** short answer type questions each of ***two*** marks covering entire syllabus uniformly.

UNIT - I

Introduction to finite element methods, comparison with finite difference methods, Methods of weighted residuals, collocations, least squares. (1 questions)

Applications to solving simple problems of ordinary differential equations. Linear, quadratic and higher order elements in one dimensional and assembly, solution of assembled system. (2 questions)

UNIT - II

Simplex elements in two and three dimensions, quadratic triangular elements, rectangular elements, serendipity elements and isoperimetric elements and their assembly, discretization with curved boundaries. (1 questions)

Interpolation functions, numerical integration. (2 questions)

UNIT - III

Solution of one dimensional heat and wave equation and solution of two dimensional Laplace equation under different Geometric conditions. (1 questions)

Books Recommended:

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

GE 1.3: CACULUS (except mathematics hons.)

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FULL MARKS: 80 **TIME: 3 hours**

Eight questions will be set out of which candidates are required to answer ***four*** questions. Question number **1** is compulsory consists of ***ten*** short answer type questions each of ***two*** marks covering entire syllabus uniformly.

UNIT - I

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. (2 questions)

UNIT - II

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. (2 questions)

UNIT- III

Reduction formulae, length of curves, volume and area of surface of revolution. (2 questions)

Vector differentiation, curl, divergence and gradient. (1 question)

Books Recommended

1. G.B. Thomas and R.L. Finney, *Calculus*, 9th Ed., Pearson Education, Delhi, 2005.
2. M.J. Strauss, G.L. Bradley and K. J. Smith, *Calculus*, 3rd Ed., Dorling Kindersley (India) P. Ltd. (Pearson Education), Delhi, 2007.
3. H. Anton, I. Bivens and S. Davis, *Calculus*, 7th Ed., John Wiley and Sons (Asia) P. Ltd., Singapore, 2002.
4. R. Courant and F. John, *Introduction to Calculus and Analysis* (Volumes I & II), SpringerVerlag, New York, Inc., 1989.

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GE2.1: Mathematical Finance

FULL MARKS: 80 **TIME: 3 hours**

Eight questions will be set out of which candidates are required to answer ***four*** questions. Question number **1** is compulsory consists of ***ten*** short answer type questions each of ***two*** marks covering entire syllabus uniformly.

UNIT - I

Basic principles: Comparison, arbitrage and risk aversion, Interest (simple and compound, discrete and continuous), time value of money, inflation, net present value, internal rate of return (calculation by bisection and Newton-Raphson methods), comparison of NPV and IRR. Bonds, bond prices and yields, Macaulay and modified duration, term structure of interest rates: spot and forward rates, explanations of term structure, running present value, floating-rate bonds, immunization, convexity, putable and callable bonds. (4 questions)

UNIT - II

Asset return, short selling, portfolio return, (brief introduction to expectation, variance, covariance and correlation), random returns, portfolio mean return and variance, diversification, portfolio diagram, feasible set, Markowitz model (review of Lagrange multipliers for 1 and 2 constraints), Two fund theorem, risk free assets, One fund theorem, capital market line, Sharpe index. Capital Asset Pricing Model (CAPM), betas of stocks and portfolios, security market line, use of CAPM in investment analysis and as a pricing formula, Jensen's index. (3 questions)

Books Recommended:

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

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GE2.2: Econometrics

FULL MARKS: 80 **TIME: 3 hours**

Eight questions will be set out of which candidates are required to answer ***four*** questions. Question number **1** is compulsory consists of ***ten*** short answer type questions each of ***two*** marks covering entire syllabus uniformly.

UNIT - I

Statistical Concepts Normal distribution; chi-square, t and F-distributions; estimation of parameters; properties of estimators; testing of hypotheses: defining statistical hypotheses; distributions of test statistics; testing hypotheses related to population parameters; Type I and Type II errors; power of a test; tests for comparing parameters from two samples.

(2 questions)

UNIT - II

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.

(3 questions)

UNIT - III

Violations of Classical Assumptions: Consequences, Detection and Remedies Multicollinearity; heteroscedasticity; serial correlation. (1 question)

Specification Analysis Omission of a relevant variable; inclusion of irrelevant variable; tests of specification errors. (1 question)

Books Recommended:

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

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GE2.3 Differential equations (except mathematics hons.)

FULL MARKS: 80 **TIME: 3 hours**

Eight questions will be set out of which candidates are required to answer ***four*** questions. Question number **1** is compulsory consists of ***ten*** short answer type questions each of ***two*** marks covering entire syllabus uniformly.

UNIT I

First order exact differential equations. Integrating factors, rules to find an integrating factor. First order higher degree equations solvable for x, y, p. 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. (2 questions)

UNIT II

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. (3 questions)

UNIT - III

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.

(2 questions)

Books Recommended:

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

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GE3.1: Cryptography and Network Security

FULL MARKS: 80 **TIME: 3 hours**

Eight questions will be set out of which candidates are required to answer ***four*** questions. Question number **1** is compulsory consists of ***ten*** short answer type questions each of ***two*** marks covering entire syllabus uniformly.

UNIT - I

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.

(2 questions)

UNIT - II

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.

(3 questions)

UNIT - III

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.

(2 questions)

Books Recommended:

1. W. Stallings, *Networks Security Essentials: Application & Standards,* Pearson Education, 2000.
2. TCP/IP Protocol Suite , Behrouz A. Forouzan, *Data Communication and Networking*, Tata McGraw Hill.
3. W. Stallings, *Cryptography and Network Security, Principles and Practice*, Pearson Education, 2000.

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GE 3.2: Information Security

FULL MARKS: 80 **TIME: 3 hours**

Eight questions will be set out of which candidates are required to answer ***four*** questions. Question number **1** is compulsory consists of ***ten*** short answer type questions each of ***two*** marks covering entire syllabus uniformly.

UNIT - I

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

(1 questions)

Security Threats: Program threats, worms, viruses, Trojan horse, trap door, stack and buffer over flow; system threats- intruders; communication threats- tapping and piracy. (2 questions)

UNIT - II

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.

(2 questions)

UNIT - III

Digital signatures: Symmetric key signatures, public key signatures, message digests, public key infrastructures. (1 questions)

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

(1 questions)

Books Recommended:

1. W. Stallings, *Cryptography and Network Security Principles and Practices*, 4th Ed., PrenticeHall 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*, SpringerVerlag 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.

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GE 3.3: Real analysis (except mathematics hons.)

FULL MARKS: 80 **TIME: 3 hours**

Eight questions will be set out of which candidates are required to answer ***four*** questions. Question number **1** is compulsory consists of ***ten*** short answer type questions each of ***two*** marks covering entire syllabus uniformly.

UNIT - I

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. (2 questions)

UNIT - II

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). (2 questions)

UNIT - III

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. (3 questions)

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.

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GE4.1 Applications of Algebra

FULL MARKS: 80 **TIME: 3 hours**

Eight questions will be set out of which candidates are required to answer ***four*** questions. Question number **1** is compulsory consists of ***ten*** short answer type questions each of ***two*** marks covering entire syllabus uniformly.

UNIT - I

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. (2 questions)

UNIT - II

Coding Theory: introduction to error correcting codes, linear cods, generator and parity check matrices, minimum distance. (1 questions)

Symmetry groups and color patterns: review of permutation groups, groups of symmetry and action of a group on a set; colouring and colouring patterns. (1 questions)

UNIT - III

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. (2 questions)

UNIT - IV

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. (1 questions)

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. Richard E. Klima, Neil Sigmon, Ernest Stitzinger, *Applications of Abstract Algebra with Maple*, CRC Press LLC, Boca Raton, 2000.
4. David C. Lay, *Linear Algebra and its Applications*. 3rd Ed., Pearson Education Asia, Indian Reprint, 2007.

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GE4.2: Combinatorial Mathematics

FULL MARKS: 80 **TIME: 3 hours**

Eight questions will be set out of which candidates are required to answer ***four*** questions. Question number **1** is compulsory consists of ***ten*** short answer type questions each of ***two*** marks covering entire syllabus uniformly.

UNIT - I

Basic counting principles, Permutations and Combinations (with and without repetitions), Binomial theorem, Multinomial theorem, Counting subsets, Set-partitions, Stirling numbers. Principle of Inclusion and Exclusion, Derangements, Inversion formulae. (1 questions)

Generating functions: Algebra of formal power series, Generating function models, Calculating generating functions, Exponential generating functions. (1 questions)

UNIT - II

Integer partitions, Systems of distinct representatives, Polya theory of counting: Necklace problem and Burnside's lemma, Cyclic index of a permutation group, Polya's theorems and their immediate applications. (2 questions)

Integer partitions, Systems of distinct representatives, Polya theory of counting: Necklace problem and Burnside's lemma, Cyclic index of a permutation group, Polya's theorems and their immediate applications. (1 questions)

UNIT - III

Latin squares, Hadamard matrices, Combinatorial designs: t designs, BIBDs, Symmetric designs. (2 questions)

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. 48
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.

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GE 4.3: Algebra (except mathematics hons.)

FULL MARKS: 80 **TIME: 3 hours**

Eight questions will be set out of which candidates are required to answer ***four*** questions. Question number **1** is compulsory consists of ***ten*** short answer type questions each of ***two*** marks covering entire syllabus uniformly.

UNIT - I

Definition and examples of groups, examples of abelian and non-abelian groups, the group Zn of integers under addition modulo n and the group U(n) of units under multiplication modulo n, complex roots of unity, introduction to cyclic group. (2 questions)

UNIT - II

Subgroups, cyclic subgroups, the concept of a subgroup generated by a subset and the commutator subgroup of group, examples of subgroups including the center of a group. Cosets, Index of subgroup, Lagrange's theorem, order of an element, Normal subgroups: their definition, examples, and characterizations, Quotient groups. (3 questions)

UNIT - III

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. (2 questions)

Books Recommended:

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, 1999.
4. George E Andrews, *Number Theory*, Hindustan Publishing Corporation, 1984.

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SEC1.1: Logic and Sets

FULL MARKS: 80 TIME: 3 hours

Eight questions will be set out of which candidates are required to answer four questions. Question number 1 is compulsory consists of ten short answer type questions each of two marks covering entire syllabus uniformly.

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. (2 questions)

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. countability of a set. (3 questions)

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,equivalence relations, Partial ordering relations, n-ary relations, lattices. (2 questions)

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.

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SEC1.2: Computer Graphics

FULL MARKS: 80 TIME: 3 hours

Eight questions will be set out of which candidates are required to answer four questions. Question number 1 is compulsory consists of ten short answer type questions each of two marks covering entire syllabus uniformly

UNIT - I

Development of computer Graphics: Raster Scan and Random Scan graphics storages, displays processors and character generators, colour display techniques, interactive input/output devices. (3 questions)

UNIT - II

Points, lines and curves: Scan conversion, line-drawing algorithms, circle and ellipse generation, conic-section generation, polygon filling anti aliasing. (2 questions) UNIT III Two-dimensional viewing: Coordinate systems, linear transformations, line and polygon clipping algorithms. (2 questions)

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.

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SEC 2.1: Graph Theory

FULL MARKS: 80 TIME: 3 hours

Eight questions will be set out of which candidates are required to answer four questions. Question number 1 is compulsory consists of ten short answer type questions each of two marks covering entire syllabus uniformly.

UNIT - I

Definition, examples and basic properties of graphs, pseudo graphs, complete graphs, bi-partite graphs, isomorphism of graphs. (2 questions)

UNIT - II

Eulerian circuits, Eulerial graph, semi-Eulerian graph, theorems, Hamiltonian cycles,theorems (2 questions)

Representation of a graph by matrix, the adjacency matrix, incidence matrix, weighted graph, (1 questions)

UNIT – III

Travelling salesman's problem, shortest path, Tree and their properties, spanning tree, Dijkstra's algorithm, Warshall algorithm. (2 questions)

Books Recommended:

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

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SEC 2.2: Operating System: Linux

FULL MARKS: 80 TIME: 3 hours

Eight questions will be set out of which candidates are required to answer four questions. Question number 1 is compulsory consists of ten short answer type questions each of two marks covering entire syllabus uniformly.

UNIT - I

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. (2 questions)

UNIT - II

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. (3 questions) UNIT III 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. (2 questions)

Books Recommended:

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

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