

For the approval of AC

(01)

(Revised Syllabus w.e.f. 2018-19)

B.A./B.Sc.(Mathematics) Syllabus
(Choice Based Credit System)

H.N.B. Garhwal University, Srinagar (Garhwal) U. K.

Semester	Core Course (04)	Skill Enhancement Course (SEC) (02)	Discipline Specific Elective (DSE) (02)
1	Differential Calculus Credit-06 (Theory-05+Tutorial-01)		
2	Differential Equations Credit-06 (Theory-05+Tutorial-01)		
3	Real Analysis Credit-06 (Theory-05+Tutorial-01)	SEC Credit-04	
4	Algebra Credit-06 (Theory-05+Tutorial-01)	SEC Credit-04	
5		SEC Credit-04	DSE1A Credit-06 (Theory-05+Tutorial-01)
6		SEC Credit-04	DSE1B Credit-06 (Theory-05+Tutorial-01)

Discipline Specific Electives (DSE)

DSE 1A (Choose anyone):

1. Matrices
2. Mechanics
3. Linear Algebra

DSE 1B (Choose any one):

1. Numerical Methods
2. Complex Analysis
3. Linear Programming

Skill Enhancement Course (SEC): (Choose any two):

1. Integral Calculus
2. Vector Calculus
3. Theory of Equations
4. Analytical Geometry

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Core 1.1: Differential Calculus

Limit and Continuity (ϵ and δ definition), Types of discontinuities, Differentiability of functions, Successive differentiation, Leibnitz's theorem, Rolle's theorem, Mean Value theorems, Taylor's theorem with Lagrange's and Cauchy's forms of remainder.

Taylor's series, Maclaurin's series of $\sin x$, $\cos x$, e^x , $\log(1+x)$, $(1+x)^m$, Partial differentiation, Euler's theorem on homogeneous functions. Indeterminate forms.

Maxima and Minima of functions of two variables, Tangents and normal, 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.

Books Recommended

1. H. Anton, I. Bivens and S. Davis, *Calculus*, John Wiley and Sons, Inc., 2011.
2. G.B. Thomas and R.L. Finney, *Calculus*, Pearson Education, 2007.

Core 2.1: Differential Equations

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.

Linear homogenous equations with constant coefficients, Linear non-homogenous equations, The method of variation of parameters, The Cauchy-Euler equation, Simultaneous differentialequations, Total differential equations.

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.

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.

Core 3.1: Real Analysis

Finite and infinite sets, Examples of countable and uncountable sets, Real line, Bounded sets, Suprema and infima, Completeness property of \mathbb{R} , Archimedean property of \mathbb{R} , intervals, Concept of limit points and statement of Bolzano-Weierstrass theorem.

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

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.

Riemann integral : Definition and examples, Properties of Riemann integrals, Necessary and sufficient conditions for integrability, Fundamental theorem.

Books Recommended

1. T. M. Apostol, *Calculus* (Vol. I), John Wiley and Sons (Asia) P. Ltd., 2002.

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2. R.G. Bartle and D. R Sherbert, *Introduction to Real Analysis*, John Wiley and Sons (Asia) P. Ltd., 2000.
3. K.A. Ross, *Elementary Analysis- The Theory of Calculus Series-* Undergraduate Texts in Mathematics, Springer Verlag, 2003.

Core 4.1: Algebra

Definition and examples of groups, Examples of abelian and non-abelian groups, the group Z_n of integers under addition and multiplication modulo n , Cyclic groups, Complex roots of unity, Circle group, The general linear group $GL_n(n, R)$, Groups of symmetries of (i) an isosceles triangle, (ii) an equilateral triangle, (iii) a rectangle, and (iv) a square, Permutation groups, Even and odd permutations, Group of quaternions.

Homomorphism and isomorphism of groups, Subgroups, Necessary and sufficient condition, Examples of subgroups including the center of a group, Order of an element, Cosets, Index of subgroup, Lagrange's theorem, Normal subgroups: Definition and examples and characterizations, Quotient groups.

Definition and examples of rings, Examples of commutative and non-commutative rings: rings from number systems, Z_n the ring of integers modulo n , Ring of real quaternions, Rings of matrices, Subrings and ideals, Integral domains and fields, Examples of fields: Z_p , Q , R , and C .

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.

DSE 1A.1: Matrices

Types of matrices: Symmetric matrix, Hermitian matrix, Orthogonal, Involutory matrix Translation, Dilation, Rotation, Reflection in a point, Line and plane, Matrix form of basic geometric transformations.

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

Matrices in diagonal form, Reduction to diagonal form upto matrices of order 3, Computation of matrix inverses using elementary row operations.

Books Recommended

1. A.I. Kostrikin, *Introduction to Algebra*, Springer Verlag, 1984.
2. S. H. Friedberg, A. L. Insel and L. E. Spence, *Linear Algebra*, Prentice Hall of India Pvt. Ltd., New Delhi, 2004.
3. Richard Bronson, *Theory and Problems of Matrix Operations*, Tata McGraw Hill, 1989.

DSE 1A.2: Mechanics

Conditions of equilibrium of a particle and of coplanar forces acting on a rigid body, Laws of friction, Problems of equilibrium under forces including friction, Centre of gravity, Work and potential energy.

Velocity and acceleration of a particle along a curve: radial and transverse components (plane curve), Tangential and normal components (space curve), Simple harmonic motion, Simple Pendulum.

Books Recommended

1. A.S. Ramsay, *Statics*, CBS Publishers and Distributors (Indian Reprint), 1998.
2. A.P. Roberts, *Statics and Dynamics with Background in Mathematics*, Cambridge University Press, 2003.

DSE 1A.3: Linear Algebra

Vector spaces, Subspaces, Algebra of subspaces, Quotient spaces, Linear combination of vectors, Linear span, Linear independence, Basis and dimension, Dimension of subspaces.

Linear transformations, Null space, Range, Rank and nullity of a linear transformation, Matrix representation of a linear transformation, Algebra of linear transformations, Dual space, Dual basis, Double dual, Characteristic Polynomial, Eigen values and eigen vectors. Isomorphisms, Isomorphism theorems, Invertibility and isomorphisms, Change of coordinate matrix.

Books Recommended

1. Stephen H. Friedberg, Arnold J. Insel, Lawrence E. Spence, *Linear Algebra*, 4th Ed., Prentice- Hall of India Pvt. Ltd., New Delhi, 2004.
2. David C. Lay, *Linear Algebra and its Applications*, 3rd Ed., Pearson Education Asia, Indian Reprint, 2007.
3. S. Lang, *Introduction to Linear Algebra*, 2nd Ed., Springer, 2005.

DSE 1B.1: Numerical Methods

Algorithms, Convergence, Bisection method, False position method, Fixed point iteration method, Newton's method, Secant method, LU decomposition, Gauss-Jacobi, Gauss-Siedel and SOR iterative methods.

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

Recommended Books

1. B. 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*, 5th Ed., New age International Publisher, India, 2007.

DSE 1B.2: Complex Analysis

Limits, Limits involving the point at infinity, Continuity, Properties of complex numbers, Regions in the complex plane, Functions of complex variable, Derivatives, Differentiation formulas, Cauchy-Riemann equations, Sufficient conditions for differentiability.

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 integral, Cauchy-Goursat theorem, Cauchy integral formula.

Liouville's theorem, Examples based on Taylor's and Laurent's series.

Books Recommended

1. James Ward Brown and Ruel V. Churchill, *Complex Variables and Applications*, 8th Ed., McGraw-Hill International Edition, 2009.

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2. Joseph Bak and Donald J. Newman, *Complex analysis*, 2nd Ed., Undergraduate Texts in Mathematics, Springer-Verlag New York, Inc., New York, 1997.

DSE 1B.3: Linear Programming

Linear Programming Problems, Graphical approach for solving some L.P.P., Convex sets, Supporting and separating hyperplanes, Theory of simplex method, Optimality and unboundedness, The simplex algorithm, Simplex method in tableau format, Introduction to artificial variables, Two-phase method, Big-M method and their comparison. Duality, Formulation of the dual problem, Primal-dual relationships, Economic interpretation of the dual.

Recommended Books

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*, 8th Ed., Tata McGraw Hill, Singapore, 2004.
3. Hamdy A. Taha, *Operations Research, An Introduction*, 8th Ed., Prentice-Hall India, 2006.

SEC 1: Integral Calculus

Integration of rational and irrational functions, Properties of definite integrals. Reduction formulae for integrals of rational and Trigonometric functions, Gamma and Beta functions. Areas and lengths of curves in the plane, Volumes and surfaces of solids of revolution. Double and triple integrals.

Books Recommended

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

SEC 2: Vector Calculus

Multiple products, Reciprocal vectors. Differentiation and partial differentiation of a vector function. Derivatives of sum, dot product and cross product of two vectors. Gradient, Divergence and curl, Applications of Green's theorem, Gauss's divergence and Stoke's theorem (without proof)

Books Recommended

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

SEC 3: Theory of Equations

General properties of polynomials, Graphical representation of a polynomials, General properties of equations, Descartes's rule of signs, Positive and negative roots, Relation between the roots and the coefficients of equations. Symmetric functions, Applications symmetric function of the roots, Transformation of equations. Solutions of reciprocal and binomial equations, Algebraic solutions of the cubic and biquadratic equations, Properties of the derived function.

Books Recommended

1. W.S. Burnside and A.W. Panton, *The Theory of Equations*, Dublin University Press, 1954.

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2. C. C. MacDuffee, *Theory of Equations*, John Wiley & Sons Inc., 1954.

SEC 4: Analytical Geometry


Techniques for sketching parabola, ellipse and hyperbola.
Definition and equation of sphere, Intersection of a sphere and a line, Intersection of two spheres, Tangent plane, Plane of contact, Angle of intersection of two spheres.
Definition and equation of a cone, Guiding curve, Intersection of a line with cone, Tangent line and tangent plane, Reciprocal cone, Right circular cone, The cylinder, Right circular cylinder, Enveloping cylinder, Central conicoids .


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



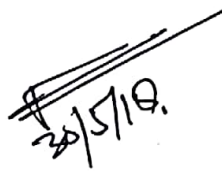
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 Professor R.C. Dimri
 Head
 Department of Mathematics
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(Revised Syllabus w.e.f. 2018-19)
H.N.B.Garhwal University Srinagar(Garhwal)
M.A/M.Sc. Mathematics Course Structure

Semester-I**Core Course**

Paper- I –	Discrete Structures	SOS/Math/ C001
Paper -II –	Abstract Algebra- I	SOS/Math/C002
Paper- III –	Mechanics	SOS/Math/C003
Paper- IV –	Complex Analysis	SOS/Math/C004
Paper -V –	Operations Research -I	SOS/Math/C005
Paper -VI-	Viva-Voce	SOS/Math/C006

Semester-II**Core Course**

Paper- VII	Abstract Algebra- II	SOS/Math/C007
Paper- VIII	Fluid Dynamics	SOS/Math/C008
Paper- IX	Operations Research- II	SOS/Math/C009
Paper- X	Real Analysis	SOS/Math/C0010
Paper- XI	Metric Spaces	SOS/Math/C0011
Paper -XII	Viva- Voce	SOS/Math/C0012

Semester-III**Core Course**

Paper- XIII	Topology	SOS/Math/C0013
Paper -XIV	Differential Equations	SOS/Math/C0014

Elective Course (Choose any three):

Paper -XV	Differential Geometry	SOS/Math/E001
Paper- XVI	Mathematical Statistics	SOS/Math/E002
Paper- XVII	Calculus of Variations	SOS/Math/E003
Paper- XVIII	Computer Fundamentals and Data Structures	SOS/Math/E004
Paper- XIX	Algebraic Coding Theory	SOS/Math/E005

Self- Study Course

Paper -XX(**Choose any one**):

- | | |
|--|--------------------|
| (a) Mathematical Methods | SOS/Math/ E006 (a) |
| (b) Tensor Analysis & Special Theory of Relativity | SOS/Math/E006(b) |
| (c) Financial Mathematics | SOS/Math/E006(c) |

Core Course

Paper- XXI	Viva-Voce	SOS/Math/C0015
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Semester-IV**Core Course**

Paper- XXII	Measure and Integration	SOS/Math/C0016
Paper -XXIII	Functional Analysis	SOS/Math/C0017

Elective Course (Choose any three):

Paper- XXIV	Linear Integral Equations	SOS/Math/E007
Paper- XXV	Fluid Mechanics	SOS/Math/E008
Paper- XXVI	Fuzzy Set Theory	SOS/Math/E009

Paper- XXVII Mathematical Modeling

SOS/Math/E0010

Paper- XXVIII Number Theory

SOS/Math/E0011

Core Course

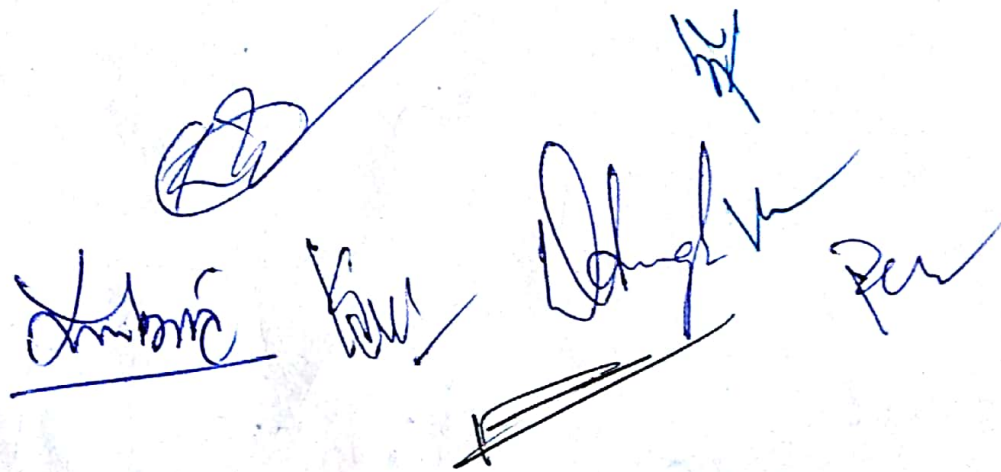
Paper- XXIX Viva-Voce

SOS/Math/C0018

Note:

- 1- In Semester- I all papers are compulsory.
- 2- In Semester- II all papers are compulsory.
- 3- In Semester III, papers - XIII, XIV & XXI are compulsory and choose any three papers out of the Elective Papers-XV, XVI, XVII, XVIII & XIX.
- 4- In Semester-IV, papers -XXII, XXIII, & XXIX are compulsory and choose any three out of the Elective Papers- XXIV, XXV, XXVI, XXVII & XXVIII.
- 5- Each paper carries 100 marks, which includes two sessional tests (each of 20 marks) and main examination of 60 marks.

Viva-Voce : In this paper evaluation will be based on the students performance in viva voce, comprehensive test and presentation /seminars on any current topic in Mathematics .

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SEMESTER- I

PAPER-I DISCRETE STRUCTURES

SOS/Math/C001

- I. Recurrence relations, Linear homogeneous recurrence relations, Non-homogeneous recurrence relations, Solutions of recurrence relations.
- II. Partially ordered sets, Different type of lattices, Sub-lattices, Direct product, Ideal Lattice, Modular and distributive lattices.
- III. Boolean algebra, Ideals in Boolean algebra, Boolean rings, Boolean functions, Karnaugh maps, Application of Boolean algebra to switching theory.
- IV. Graphs, Direct graphs, Undirected graphs, Relations and graphs, Path and circuits, Eulerian and Hamiltonian graphs, Planner graphs, Connected graphs.

TEXT/REFERENCE BOOKS

- 1. Element of Discrete Mathematics: C. I. Liu, Mcgraw Higher Edu. ,2012.
- 2. Discrete Mathematical Structures : H. G. S. Rao, Galgotia Pub. Pvt. Ltd.
- 3. Lattice and Boolean Algebra: V. K. Khanna, Vikash Pub. House.
- 4. Discrete Mathematics: R. Johnsonbaugh , Pearson Edu. Ltd., 2014.

SEMESTER- I

PAPER-II

ABSTRACT ALGEBRA- I


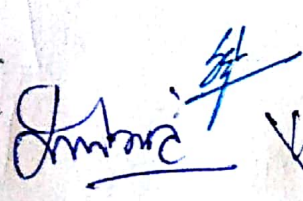

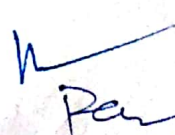
SOS/ Math/C002

- I. Simple groups, Conjugacy, Normalization, Centre of a group, Class equation of a group and its consequences, Theorems for finite groups, Cauchy's theorem, Sylow's theorem.
- II. Homomorphism, Endomorphism, Automorphism, Inner automorphism, Kernel of a homomorphism, Fundamental theorem on homomorphism of group, Group of automorphisms , Results on group homomorphism.
- III. Maximal subgroups, Composition series, Jordan-Holder theorem, Solvable groups, Commutator subgroups, Direct products
- IV. Ideals, Algebra of ideals, Principal ideal ring, Units and associates, Polynomials ring, Division and Euclidean algorithm for polynomials, Unique factorization theorem

TEXT/REFERENCE BOOKS

- 1. Contemporary Abstract Algebra: Joseph A. Gallian, Narosa Pub. House P. Ltd.
- 2. A First course in Abstract Algebra: John. B. Fraleigh, Pearson Edu. Inc. , 2003.
- 3. Abstract Algebra : V.K. Khanna and S.K. Bhambri, Vikash Pub. House P. Ltd.
- 4. Topics in Algebra: I. N. Herstein, John Wiley & Sons, New York.

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SEMESTER- I

PAPER –III

MECHANICS

SOS/ Math/C003

- I. Conservation of linear and angular momentum under finite and impulsive forces, Conservation of energy.
- II. Generalized coordinates, Lagrange’s equations of motion, Small oscillations.
- II. Hamiltonian’s canonical equations, Hamilton’s principle and principle of least action.
- III. Euler’s equations of motion, Kinetic energy, Eulerian angles, Instantaneous axis of rotation.

TEXT/REFERENCE BOOKS

- 1. Dynamics- Part II :A.S. Ramsey, Cambridge University Press, 1944.
- 2. Classical Mechanics: H. Goldstein, Pearson Education.
- 3. A Text Book on Dynamics :Ray and Sharma, S. Chand Ltd., 2005.
- 4. Dynamics of Rigid Body: S.L. Loney, Cambridge University Press.

SEMESTER-I

PAPER-IV

COMPLEX ANALYSIS

SOS/ Math/C004

- I. Power series of analytic functions,Convergence of power series,Radius of convergence,Taylor’s and Laurent’s series, Residue and poles, Singularities, Classification of singularities.
- II. Residues,Residue at infinity,Cauchy residue theorem, Applications of residue theorem in evaluation of improper real integrals.
- III. Conformal mapping: properties, Mobius transformation, Elementary examples.
- IV. Maximum modulus theorem,Mittag-Leffler theorem, Rouche’s theorem, Concept of entire functions with simple example, Analytic continuation.

TEXT/REFERENCE BOOKS

- 1. Complex Analysis:J.W. Brown and R.V.Churchill, McGraw-Hill Ed.Private Ltd.2015.
- 2. Complex Analysis:Dennis G. Zill, Jones & Bartlet Learning,2016.
- 3. Complex Analysis: H. S. Kasana, PHI Learning.
- 4. Foundation of Complex Analysis: S. Ponnusamy, Alpha Int. Sci.

SEMESTER-I

PAPER –V

OPERATIONS RESEARCH –I

SOS/ Math/C005

- I. An introduction to operations research, Methodology of O.R., Features of O.R. problems, Different models in O.R., Opportunities and shortcomings of O.R. approach.
- II. Dual simplex method, Revised simplex method,Sensitivity analysis.
- III. Assignment and Transportation problems.
- IV. Theory of games, Integer linear programming.

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TEXT/REFERENCE BOOKS

1. Operations Research: Kanti Swarup, P.K. Gupta & Man Mohan, S. Chand, 1978.
2. Operations Research: Theory and Applications: J.K. Sharma, Trinity Press, 2016.
3. Operations Research: H.A. Taha, Prentice Hall of India, 2011.
4. Operations Research: R. Bronson, Schaum's Outline Series. McGraw Hill, 1982.

SEMESTER-I**PAPER-VI****VIVA-VOCE****SOS/ Math/C006****SEMESTER-II****PAPER-VII****ABSTRACT ALGEBRA-II****SOS/ Math/C007**


- I. Embedding of rings, Ring of residue classes, Fundamental theorem on homomorphism of ring, Prime ideals, Maximal ideal.
- II. Euclidean ring, Properties of Euclidean ring, Module, sub-module, Module homomorphism, Linear sum and direct sum of sub-module
- III. Extension fields, Simple field extension, Algebraic field extension, Minimal polynomial, Roots of polynomials, Multiple roots, Splitting field.
- IV. Automorphism of field, Fixed field, Normal extension, Galois group: Examples and characterizations, Construction with straight edge and compass.

TEXT/REFERENCE BOOKS

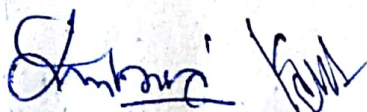
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2. A First course in Abstract Algebra : John. B. Fraleigh, Pearson Edu. Inc. , 2003.
3. Abstract Algebra : V.K. Khanna and S.K. Bhambri, Vikash Pub. House P. Ltd.
4. Topics in Algebra : I. N. Herstein, John Wiley & Sons, New York.

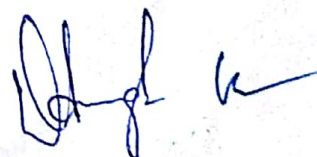
SEMESTER-II**PAPER-VIII****FLUID DYNAMICS****SOS/ Math/C008**

- I. Kinematics of fluids, Lagrangian and Eulerian methods, Local and individual time rates of change, Equation of continuity, Boundary surface.
- II. Equation of motion of inviscid fluids, Euler's equation of motion, Bernoulli's equation, Lagrange's equation, Conservative field of force, Cauchy's Integral, Helm- Holtz's equation.
- III. Impulsive motion of a fluid, Energy equation of inviscid fluid, General theory of irrotational motion, Connectivity, Flow and circulation, Kelvin's circulation theorem, Stokes's theorem, Permanence of irrotational motions, Green's theorem, Kinetic energy of finite and infinite liquid, Kelvin's minimum energy theorem, Mean value of the velocity potential over a spherical surface.
- IV. Motion in two dimensions, Stream function, Complex potential, Source, Sink, Doublet, Complex potential and images with respect to straight line and circle, Milne- Circle theorem, Blasius theorem.


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TEXT/REFERENCE BOOKS

1. Foundation to Fluid Mechanics: S.W. Yuan, Prentice Hall Pvt. Ltd., 1960.
2. Text book of Fluid Dynamics: F. Chorlton, CBS Pub. & Dist. , 2004.
3. Theoretical Hydro-Dynamics: Bansilal, Skylark Pub., 1999.
4. A text book of Fluid – Dynamics: M. Ray & Sharma, S. Chand & Co. Ltd. 2005.

SEMESTER-II

PAPER-IX

OPERATIONS RESEARCH-II

SOS/ Math/C009

- I. Inventory control, Functional role of inventory control, Classification of EOQ models with shortages and without shortages.
- II. Queuing theory, Characteristics of Queuing system, Probability distribution in queuing system, Single served queuing model, M|M|1 queuing models, Multiple server queuing models.
- III. Markov chain, Application of Markov analysis, State and transition probabilities, Steady state conditions, Sequencing problems, Processing n jobs through two and three machines.
- IV. Dynamic programming, Dynamic programming under certainty, Non-linear programming methods, Quadratic programming, Kuhn- Tucker conditions.

TEXT/REFERENCE BOOKS

1. Operations Research: Kanti Swarup, P.K. Gupta & Man Mohan, S. Chand, 1978.
2. Operations Research: Theory and Applications: J.K. Sharma, Trinity Press, 2016.
3. Operations Research: H.A. Taha, Prentice Hall, 2011.
4. Operations Research: R. Bronson, McGraw Hill, 1982.

SEMESTER-II

PAPER-X

REAL ANALYSIS

SOS/ Math/C0010

- I. The Riemann- Stieltjes Integral: Definition and existence of Riemann-Stieltjes integral, Properties of integrals, Integration and differentiation, Fundamental theorem of calculus, Integration of vector-valued functions.
- II. Sequences and series of functions, Pointwise and uniform convergence, Cauchy criterion for uniform convergence, Uniform convergence and continuity, Uniform convergence and Riemann-Stieltjes integral, Uniform convergence and differentiation, Weierstrass approximation theorem.
- III. Power series, Algebra of power series, Uniqueness theorem for power series, Abel's theorem, Taylor's theorem.
- IV. Functions of several variables, Concept of functions of two variables, Continuity, Partial derivatives, Differentiability, Change of variables, The inverse function theorem, The implicit function theorem, Chain rule.

TEXT/REFERENCE BOOKS

1. Mathematical Analysis: S.C. Malik and Savita Arora, New Age Int. 1992.
2. Mathematical Analysis: T.M. Apostol, Pearson Edu. , Taiwan Ltd., 1974.
3. Real analysis: H.L. Royden, Pearson, 2017.
4. Real Analysis: Terence Tao, Springer.

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SEMESTER-II**PAPER-XI****METRIC SPACES****SOS/ Math/C0011**

- I. Metric on a set, Pseudo-metrics, Equivalent metrics, Limit point, Closed sets, Adherent point, Dense subsets, Interior of a set and its properties, Subspaces, Product spaces.
- II. Convergent sequences, Cauchy sequences, Algebra of convergent sequences, Subsequences, Continuity at a point, Continuity over a space, Algebra of real valued continuous functions in a metric space, Homeomorphism, Isometries, Uniform continuity.
- III. Complete metric spaces, Completeness and continuous mappings, Cantor's intersection theorem, Contraction mapping theorem, Connectedness in metric spaces, Properties of connectedness.
- IV. Compact spaces, Compact subsets of the real line, Compactness and continuous mappings, Sequential compactness, Countable compactness, B-W property, B-W property and boundedness, B-W property and compactness, Compactness and uniform continuity, Lebesgue covering Lemma.

TEXT/REFERENCE BOOKS

1. Introduction to Topology and Modern Analysis: G.F. Simmons, Tata McGraw-Hill.
2. Metric Spaces: E.T. Copson, Cambridge University Press, 1968.
3. Topology :Robert H.Kasriel, Dover Pub. , 2009.
4. Topology of Metric Spaces: S.Kumaresan, Alpha Science Int. , 2011.

SEMESTER-II**PAPER-XII****VIVA-VOCE****SOS/ Math/C0012****SEMESTER-III****PAPER-XIII****TOPOLOGY****SOS/ Math/C0013**

- I. Definition and examples of topological spaces, Closed sets, Closure, Dense subsets, Neighborhoods, Interior, Exterior and accumulation points, Bases and sub bases, subspaces, Product spaces and relative topology.
- II. Continuous function, Homeomorphism, Connected and disconnected sets, Components, Locally connected spaces.
- III. Countability axioms, First and second countable spaces, Lindelof's theorem, Separable spaces, Second countable and separability, Separable axioms: $T_0, T_1, T_2, T_3, T_3\frac{1}{2}, T_4$ and their characterizations.
- IV. Compactness, Continuity and compact sets, Basic properties of compactness, Compactness and finite intersection property, Sequentially and countably compact sets, Local compactness, Tychonoff's theorem.

TEXT/REFERENCE BOOKS

1. Topology: A First Course: James R. Munkres, Prentice Hall, Incorporated, 2000.
2. General Topology: J.L. Kelly, Springer, 1975.
3. Topology and Modern Analysis: G.F. Simmons, Tata McGraw-Hill.
4. General Topology: Seymour Lipchitz, Schaum Outline Series.

SEMESTER-III

PAPER -XIV DIFFERENTIAL EQUATIONS SOS/ Math/C0014

- I. Ordinary differential equations: Qualitative properties of solution, Oscillation, Wronskian, Sturm separation and comparison theorem, Picard iteration methods, Uniqueness and existence theorem.
- II. Ordinary points, Regular and singular points, Frobenius series solution for Legendre's and Bessel's differential equations with generating functions.
- III. Classification of PDE of 2nd order and canonical forms, Concept of separation of variable solution.
- IV. Solution of heat diffusion, Laplace and wave equations, Non-linear partial differential equation of second order.

TEXT/REFERENCE BOOKS

- 1. Differential equation with Applications and Historical notes: G.F. Simmons, CRC Press, Taylor & Francis Group.
- 2. A Course in ODE : B. Rai, D.P. Chaudhary & H.I.Freedman, Alpha Sci. Int. Ltd.
- 3. Advanced Differential Equations: M.D. Raisinghanian, S. Chand Pvt. Ltd., 2008.

SEMESTER- III

PAPER- XV DIFFERENTIAL GEOMETRY SOS/ Math/ E001

- I. Curves in space; Arc length, Order of contact, Tangent, Normal, Binormal, Osculating, Plane, Serret-Frenet formulae, Curvature and torsion. Osculating circle and osculating sphere, Helix, Bertrand curves.
- II. Behaviour of a curve in the neighbourhood of a point. Concept of a surface, Envelope and developable surface, Parametric curves, Family of the surfaces, Edge of regression, Ruled surfaces, Central points.
- III. Fundamental forms and curvature of surfaces: First fundamental form. Second fundamental form of the surfaces of revolution, Weingarten's equation, Direction coefficients, Family of curves.
- IV. Local non-intrinsic properties of a surface Normal curvature, Principal directions, Principal curvatures, Minimal surface, Lines of curvature. Rodrigues and Monge's theorem, Euler's theorem, Joachimisthal's theorem. Dupin's indicatrix, Third fundamental form.

TEXT/REFERENCE BOOKS

- 1. Differential Geometry: T.J. Willmore, Dover Pub. Inc., New York.
- 2. Differential Geometry of Three Dimensions: C.E. Weathrburn, Cambridge Univ. Press.
- 3. Elements of Differential Geometry: R.S. Millman & G.D. Parket, Prentice Hall.
- 4. Introduction to Differential Geometry: A. Goetz, Addison Wesley Pub. Co., 1970.

SEMESTER – III**PAPER-XVI MATHEMATICAL STATISTICS SOS/ Math/E002**

- I. Elements of probability, Sample space, Discrete probability, Baye's theorem, Random variables and distribution functions, Mathematical expectations and moments.
- II. Some standard discrete and continuous univariate distributions: Binomial, Poisson, Normal, Gamma and Beta distributions.
- III. Correlation, Rank correlation, Regression line, Multiple and partial correlation of three variables only, Data reduction techniques, Canonical correlation.
- IV. Concepts of sampling, Stratified sampling and systematic sampling, Test of hypothesis: t,z ,chi square test.

TEXT/REFERENCE BOOKS

1. Fundamental of Mathematical Statistics : S.C. Gupta and V.K. Kapoor, S. Chand.
2. Advanced Theory of Statistics :M.G. Kandall.
3. A first Course on Mathematical Statistics: C.E.Weatherburn, Cambridge Univ. Press, 1968.

SEMESTER-III**PAPER-XVII CALCULUS OF VARIATIONS SOS/ Math/E003**

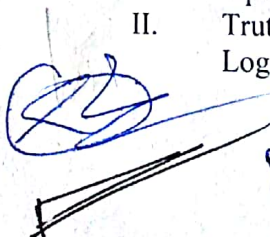
- I. Variation of functional, Continuity and differentiability of functional, Necessary condition for an extremum, Euler's equation, Variational problems in parametric form, Functional depending on higher order derivatives and variational problems with subsidiary condition.
- II. The isoperimetric problem, Invariance of Euler's equation under coordinate transformation, General variational of functional, Variable end point problems, Transversality condition transversal theorem, Weierstrass-Endmann corner condition.
- III. Sufficient condition for extremum: second variation, Legendre's and Jacobi's necessary condition, Canonical transformation, Noether's theorem, The principle of least action, Conservation law, Hamilton Jacobi's equations.
- IV. Transformation of ODE and PDE into functionals and their solutions by Ritz, Galerkin, Collocation and Kantrovitch methods.

TEXT/REFERENCE BOOKS

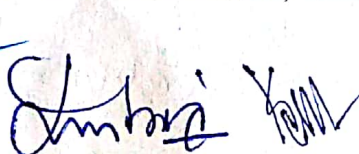
1. Calculus of Variation: Gelfrand and Fomin, Dover Pub. Inc., New York.
2. Calculus of Variation: Elsgolt, University Press of the Pacific, 2003.
3. Calculus of Variation: A.S. Gupta, PHI Learning Pvt. Ltd., 2015.

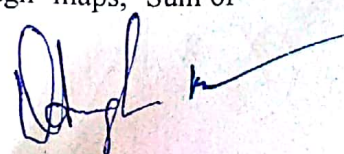
SEMESTER- III**PAPER-XVIII COMPUTER FUNDAMENTALS AND DATA STRUCTURES SOS/ Math/E004**

- I. History and classification of computers, Fundamentals of computer system: Data types, Number system, Complements; Floating point representation, Normalized floating point representation, Fixed point represented arithmetic computations.
- II. Truth tables, Boolean algebra, De-Morgan's theorem, Logical gates, Logic diagram, Logical expressions/functions, Karnaugh maps, Sum of



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- product and product of sum, Combinational circuits and integrated circuits.
- III. Introduction to data structures, Arrays, Stack and queues, Linked lists, Singly and doubly linked lists, Binary trees, Operations on binary trees and applications.
- IV. Sorting, Searching, Algorithms and graphs.

TEXT/REFERENCE BOOKS

- 1. Fundamental of Computers :V. Raja Raman, PHI Learning Pvt. Ltd.
- 2. Introduction to Computers :P. Norto, Glencoe/ McGraw-Hill, 1998.
- 3. Data Structures with C: S.Lipschutz, Tata McGraw-Hill Pvt. Ltd.

SEMESTER -III

PAPER- XIX ALGEBRAIC CODING THEORY SOS/Math/E005

- I. The communication channel, The coding problem, Types of codes, Error-detecting and error-correcting codes, Linear codes, Hamming metric, Description of linear block codes by matrices.
- II. Dual codes, Standard array, Step-by-step decoding, Modular representation, Error-correction, Capabilities of linear codes, Bounds of minimum distance for block codes, Plotkin bound, Hamming sphere packing bound, Bounds for burst-error detecting and correcting codes.
- III. Important linear block codes, Hamming codes, Golaycodes, Perfect codes, Quasi-perfect codes, Reed-Muller codes, Codes derived from Hadamard matrices, Product codes, Concatenated codes.
- IV. A double error correcting decimal code and an introduction to BCH codes, BCH bounds, Cyclic codes, Matrix representation of cyclic codes, Error detection and cyclic codes, MDS codes.

TEXT/REFERENCE BOOKS

- 1. Fundamental of Error- Correcting Codes: V. Pless and W.C. Huffman, Cambridge Univ. Press.
- 2. A First Course in Coding Theory: Ramond Hill, Oxford Univ. Press.
- 3. Error Correcting Coding Theory: M.Y. Rhee, McGraw-Hill, 1989.
- 4. Algebraic Coding Theory: E.R.Berlckamp, World Sci. Pub. Pvt. Ltd.

SEMESTER -III

PAPER -XX SELF-STUDY: (Choose any one):

Paper -XX (a) MATHEMATICAL METHODS SOS/Math/E006 (a)

- I Hermite polynomiasl.
- II Chebyshev polynomials.
- III Laguerre polynomials.
- IV Integral transforms.

TEXT/REFERENCE BOOKS

- 1. The Special Functions and their Applications: Y. L. Luke, Acad. Press, New York.

2. Special Functions: G.E. Andrews, R. Askey, R. Roy, Cambridge Univ. Press.
3. Integral Transform & Their Applications: L. Debnath & D. Bhatta, CRC Press.

PAPER- XX (b) TENSOR ANALYSIS AND SPECIAL THEORY OF RELATIVITY
SOS/Math/E006 (b)

- I. Invariance – Transformations of coordinates and its properties, Transformation by invariance, Transformations by covariance and contra variance, Tensor and their laws of transformations, Algebras of tensors- Quotient Tensors, Symmetric and skew symmetric tensors, Relative tensors.
- II. Metric Tensor, The fundamental and associated tensors, Christoffel's symbols, Transformations of Christoffel's symbols, Covariant differentiation of tensors, Formulas for covariant differentiation, Ricci theorem, Riemann-Christoffel tensor and their properties.
- III. Einstein tensor, Riemannian and Euclidean Spaces (Existence Theorem), The e- systems and the generalized Kronecker deltas, Application of the e- systems.
- IV. Special theory of relativity, Galilean transformation, Maxwell's equations, The ether theory, The principle of relativity, Relativistic kinematics, Lorentz transformation equations, Events and simultaneity, Example of Einstein strain, Time dilation, Longitudinal Contraction, Invariant Interval, Proper time and proper distance, World line, Example of twin paradox, Addition of velocities, Relativistic Doppler's effect.

TEXT/REFERENCE BOOKS

1. Tensor Analysis: I.S. Sokolnikoff, John Wiley and Sons, New York, 1964.
2. Classical Dynamics: D. Greenwood, Prentice Hall of India, New Delhi, 1985.
3. Tensor Calculus, Toronto, 1949 :J.L. Synge and A. Schild.
4. An Introduction to Theory of Relativity, New York, 1942: P.G. Bergman.

PAPER- XX (c) FINANCIAL MATHEMATICS **SOS/Math/E006 (c)**

- I. Single period model, Definitions of finance- pricing, Forward- one- step binary model, Ternary model- Characterization of no arbitrage, Risk-neutral probability measure
- II. Bi normal trees and discrete parameter martingales, Multi-period binary model, American options, Discrete parameter martingales and Markov processes, Martingale theorems, Binomial representation theorem overturn to continuous models
- III. Brownian motion, Definition of the process, Levy's construction of brownian motion, The reflection principle and scaling, Martingales, Continuous time.
- IV. Stochastic calculus, Non-differentiability of stock prices, Stochastic integration, Ito's formula, Integration by parts and stochastic, Fubini theorem, Girsanov theorem, Brownian martingale representation theorem, Geometric brownian motion, The Feynman- Kac representation.

TEXT/REFERENCE BOOKS

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Peer 3004/18

Sharma

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1. A Course in Financial Calculus: Alison Etheridge, Cambridge Univ. Press, 2002.
2. Financial Calculus: An Introduction to Derivatives Pricing : Martin Baxter and Andrew Rennie, Cambridge Univ. Press, 1996.
3. Introduction to Stochastic Calculus Applied to Finance: Damien Lamberton and Bernard Lapeyre, Chapman and Hall, 1996.
4. Martingale Methods in Financial Madeling: MarekMusielaaand MarekRuthowshi, Springer Verlag, New York, 1988.

PAPER-XXI

VIVA-VOCE

SOS/Math/C0015

SEMESTER -IV

PAPER-XXII

MEASURE AND INTEGRATION

SOS/Math/C0016

- I. Lebesgue outer measure, Measure of open and closed sets, Borel sets, Measurable sets, Measure of cantor's ternary set, Non-measurable sets.
- II. Measurable functions, Algebra of measurable functions, Step functions, Characteristic function, Simple functions, Convergence in measure, Egoroff's theorem, Reisz-Fisher theorem.
- III. Lebesgue Integral and their properties, General Lebesgue integrals, Lebesgue integrals for unbounded functions, Convergence theorems, Fatou Lemma.
- IV. Functions of bounded variations, Absolutely continuity, Variation function, Jordan-decomposition theorem, Indefinite integral and its characterizations, Differentiation of an integral, Lebesgue differentiation theorem.

TEXT/REFERENCE BOOKS

1. Real Analysis: H.L. Royden, Pearson, 2017.
2. Measure and Integration: S.K. Berberian, The Macmillan Company, 1965.
3. Lebesgue Measure and Integration: P.K. Jain and V.P. Gupta, Wiley, 1986.
4. Measure Theory and Integration: G. De. Barra, Horwood, 2003.

SEMESTER-IV

PAPER- XXIII

FUNCTIONAL ANALYSIS

SOS/Math/C0017

- I. Normed linear spaces, Banach spaces, Subspaces, Quotient Spaces, Equivalent, Norms.
- II. Bounded linear Transformation/operators, Hahn- Banach theorem, Open mapping theorem, Closed graph theorem, Uniform boundedness principle.
- III. Inner product spaces, Hilbert spaces, Orthogonality of vectors, Orthogonal complements and projection theorem, Riesz representation theorem, Orthonormal Sets.
- IV. Operators on Hilbert Spaces, Self-adjoint, Normal and unitary operators, Orthogonal projection operators.

TEXT/REFERENCE BOOKS

1. Functional Analysis: P.K. Jain, O.P. Ahuja and Khalil Ahmad, Wiley, 1996.
2. Topology and Modern Analysis: G.F. Simmons, Tata McGraw-Hill.
3. Introductory functional Analysis with Applications: E. Kreyszig, Wiley, 1989.
4. Functional Analysis: B.V. Limaye, New Age Int. Pvt. Ltd.

SEMESTER IV**Paper-XXIV LINEAR INTEGRAL EQUATIONS SOS/Math/E007**

- I. Classification of integral equations, Relation between differential and integral Equations, Fredholm integral equations, Fredholm equations of second kind with separable kernels, Eigen values and eigen functions
- II. Volterra integral equations, Resolvent kernel of Volterra equation, Convolution type kernel, Integral equations with symmetric kernel.
- III. Method of successive approximation for Fredholm and Volterra equations of the second kind.
- IV. Classical Fredholm theory, Singular integral equations, Hilbert type integral equations, Integral equation with Green's function type kernels.

TEXT/REFERENCE BOOKS

1. Integral Equations and Boundary Value Problem : M.D. Raisinghania, S. Chand.
2. Linear Integral Equations: W. V. Lovit, Dover Pub. Int. New York.
3. Linear Integral Equations: R.P. Kanwal, Birkhauser Boston, 1996.
4. Integral Equations: L. G. Chambers, International Textbook Co., 1976.

SEMESTER- IV**PAPER-XXV FLUID MECHANICS SOS/ Math/E008**

- I. Motion of the cylindrical and elliptic cylinders.
- II. Motion of Sphere, Motion of a sphere in an infinite mass of the liquid at rest at infinity, Liquid streaming past a fixed sphere, Equation of motion of a sphere, Pressure distribution.
- III. General theory of stresses and rate of strains, Newton's law of viscosity, State of stress, Principal stresses and principal directions, Transformations of two and three stresses components and rate of strain components, Relation between stresses and rate of strain components, Translation, Rotation and rate of deformation.
- IV. Navier-Stokes equation of motion; Energy equation for viscous fluid, Energy dissipation due to viscosity.

TEXT/REFERENCE BOOKS

1. Foundation to Fluid Mechanics: W. Yuan, Prentice Hall Pvt. Ltd., 1960.
2. Text book of Fluid Dynamics: F. Chorlton, CBS Pub. & Dist., 2004.

3. An Introduction to Fluid Mechanics: G.K. Batchlor, Cambridge Univ. Press.
4. Fluid Dynamics: M.D. Raisinghanian, S. Chand.

SEMESTER-IV

PAPER- XXVI

FUZZY SET THEORY

SOS/Math/E009

- I. Fuzzy sets, Basic definitions, Alpha-cut sets, Convex fuzzy sets, Basic operation on fuzzy sets, Types of fuzzy sets, Cartesian products, Algebraic products, Bounded sum and differences, t-norms and t-corners.
- II. The extension principle, The Zadeh's extension principle, Images and inverse image of fuzzy sets, Fuzzy numbers, Element of fuzzy arithmetic.
- III. Fuzzy relation and fuzzy graphs. Fuzzy relation on fuzzy sets, composition of fuzzy relation, min-max composition and properties, equivalence relations, fuzzy compatibility relation, Fuzzy relation equations.
- IV. Fuzzy logic, An overview of classical logic, Multivalued logic, Fuzzy propositions, Fuzzy qualifiers, Linguistic variables and hedge.

TEXT/REFERENCE BOOKS

1. Fuzzy sets and Fuzzy logic: G.L. Klir and Yuan, World Sci. Pub. Co. Pvt. Ltd.
2. Fuzzy set theory and its Applications: H.J. Zimmermann, Springer, 1991.
3. Fuzzy set theory, Fuzzy logic and their Applications: A.K. Bhargava, S. Chand.
4. First Course on Fuzzy Theory and Applications :Kwang H. Lee, Springer, 2004.

SEMESTER-IV

PAPER- XXVII

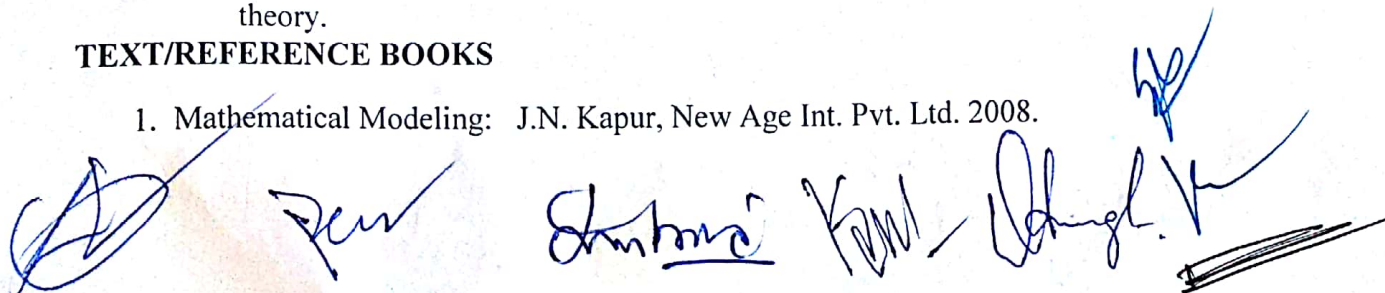
MATHEMATICAL MODELING

SOS/Math/E010

- I. Mathematical Modeling through ordinary differential equations of first order, Linear growth and decay models, Non-linear growth and decay models, Compartment models- dynamics problem, Geometrical problems.
- II. Mathematical Modeling through systems of ordinary differential equations of first order, Population dynamics, Epidemics-compartment models, Economics, Medicine, Arm- race, Battles and international trade- dynamics.
- III. Mathematical modeling through ordinary differential equations of second order, Planetary motions, Circular motion, Motion of satellites, Mathematical modeling through linear differential equations of second order, Miscellaneous mathematical models.
- IV. Mathematical modeling through difference equations, Simple models, Basic theory of linear difference equations with constant coefficients, Economics and finance- population- dynamics and genetics- probability theory.

TEXT/REFERENCE BOOKS

1. Mathematical Modeling: J.N. Kapur, New Age Int. Pvt. Ltd. 2008.



2. Mathematical Models in Biology and Medicine: J. N. Kapur, New Delhi, Affiliated East-West Press, 1985.
3. Mathematical Modeling: Dick Clements, Cambridge Univ. Press, 2012.
4. The Nature of Mathematical Modeling: Neil Gershenfeld, Cambridge Univ. Press.

SEMESTER-IV

PAPER- XXVIII NUMBER THEORY SOS/MATH/E011

- I. The division algorithm, The gcd, The Euclidean algorithm, Diophantine equation $ax + by = c$, The fundamental theorem of arithmetic, The sieve of Eratosthenes, Goldbachconjecture.
- II. The theory of congruences, Binary and decimal representation of integers, Linear congruences and Chinese remainder theorem, Fermat's theorem, Wilson's theorem.
- III. Number theoretic function, Tau and sigma function, the Mobius inversion formula, The greatest integer function, Euler's phi function, Properties of phi function, Euler theorem.
- IV. The order of an integer modulo n, Primitive roots for primes, Composite numbers having primitive roots, The theory of indices, Continued fraction, Approximation of irrationals by rationals.

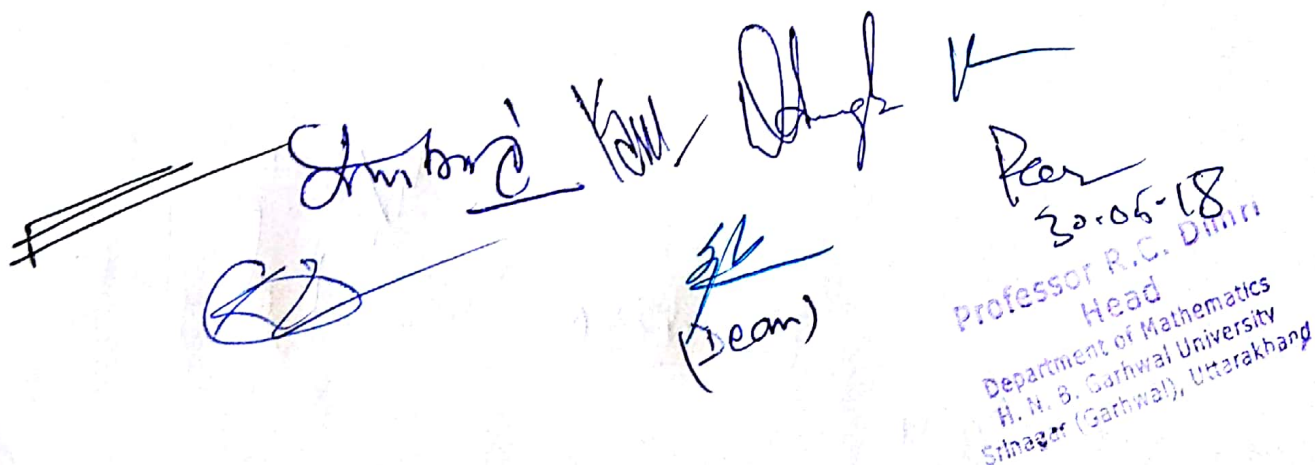
TEXT/REFERENCE BOOKS

1. Elementary Number Theory: David M. Burton, McGraw-Hill.
2. Theory of Numbers: George Andrews, Courier Corporation, 1994.
3. Elementary Number Theory with Applications: Thomas Koshy, Harcourt Acad. Press.
4. Fundamental of Number Theory: William J. Lereque, Dover Pub. Inc. New York.

PAPER-XXI

VIVA-VOCE

SOS/MATH/C0018



 The page contains several handwritten signatures in blue ink. One signature is clearly legible as 'Srinivasa Kumar' with a checkmark. Another signature is 'Rajesh' with a checkmark. A third signature is 'Ravi' with a checkmark. Below these, there is a signature 'R.C. Dhillon' with a checkmark. To the right of these signatures is a blue ink stamp that reads: 'R.C. Dhillon', '20.05.18', 'Professor R.C. Dhillon', 'Head', 'Department of Mathematics', 'H. N. B. Garhwal University', 'Srinagar (Garhwal), Uttarakhand'.

(Revised Syllabus w.e.f. 2018-19)
H.N.B. Garhwal University Srinagar (Garhwal), Uttarakhand

Pre-Ph.D. Mathematics Course Structure

Core Course

Paper I	Research Methodology	SOS/MAT/PHD/C001 (4 Credits)
Paper II	Computer Fundamentals and Programming in MATLAB	SOS/MAT/PHD/C002 (3 Credits)

Elective Course

Paper III	Applied Functional Analysis	SOS/MAT/PHD/E001 (4 Credits)
Paper IV	Partial Differential Equations	SOS/MAT/PHD/E002 (4 Credits)
Paper V	Mathematical Analysis	SOS/MAT/PHD/E003 (4 Credits)
Paper VI	Fluid Dynamics with Computational Techniques	SOS/MAT/PHD/E004 (4 Credits)
Paper VII	Differential Geometry	SOS/MAT/PHD/E005 (4 Credits)
Paper VIII	Algebraic Topology	SOS/MAT/PHD/E006 (4 Credits)

Note :

1. Papers I and II are compulsory.
2. Choose any two papers out of elective papers (III-VIII).
3. Each papers carries 100 marks which includes two sessional tests (each of 20 marks)

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Pre- Ph. D. COURSE**PAPER-I RESEARCH METHODOLOGY****(SOS/MAT/PHD/C001)**

- I. Perception of research, meaning of research, objective of research, different approaches to research, empirical and theoretical research, qualities of a research work, inductive and deductive logics.
- II. The scientific method, examples of scientific methods, different phases in scientific method, the use of computers in obtaining proofs of mathematical results, valid and invalid generalization.
- III. Problem posing, the soul of research methodology, chains of open ended problems, the art of solving problems, Polya's scheme for solving problems, model building in mathematics.
- IV. Basic idea of probability distribution, Elementary sampling theory (a brief introduction), test of significance T, F, Z and Chi-square distribution (a brief introduction).

TEXT BOOKS

1. Research Methodology for Scientists and Engineers : J.N. Kapur, Mathematical Sciences Trust Society.
2. Fundamentals of Research Methodology and Statsics : Y.K. Singh, New Age International.
3. Thesis and Assignment Writing : Anderson and Jonathon. Wiley Eastern Bombay.
4. How to write Assignments, Research papers, Dissertation and Thesis : V.H. Bedkar, Karak publication New Delhi.

PAPER- II COMPUTER FUNDAMENTALS AND PROGRAMMING IN MATLAB
(SOS/MAT/PHD/C002)

- I. History and classification of computers, fundamental of computer system : Data types, number system, complements, floating point representation, normalized floating point representation, fixed point representation, arithmetic computations.
- II. Truth tables, Boolean algebra, De-Morgan's theorem, Logical gates, logic diagram, logical expressions/ functions, Karnaugh maps, sum of product and product of sum, combinational circuits and integrated circuits.
- III. Introduction to programming in MATLAB : Scalar, vectors and matrices, graphics, program structures, decision structures, functions and loops.
- IV. Application of MATLAB : Numerical solution of algebraic and transcendental equations, system of linear equations and initial value problems.

TEXT BOOKS

1. Fundamental of computers : V. Raja Raman, PHI New Delhi.
2. Introduction to computers : P. Norten, Mc-Graw-Hill.

3. MATLAB programming for Engineers : Kenneth J. Chapman, Cengage Learning.
4. An Introduction to programming and numerical methods in MATLAB : S.R. Otto and J.P. Denier, Springer.
5. Numerical methods with MATLAB for Engineers and Scientists : S. Chapra, McGraw-Hill.

Elective (Choose any two of the following papers III-VII)

PAPER-III APPLIED FUNCTIONAL ANALYSIS (SOS/MAT/PHD/E001)

- I. Banach fixed point theorem and its applications.
- II. Approximation in normed spaces, Approximation in Hilbert spaces.
- III. Spectral theory of linear operators in normed spaces.
- IV. Spectral theory of bounded self-adjoint operators.

TEXT BOOKS

1. Introductory Functional Analysis with Applications : Kreyszig, John Wiley & Sons.
2. Functional Analysis : W. Rudin, McGraw-Hill.
3. Introduction to Hilbert spaces : S. Berberian, Oxford Univ. Press.
4. Introduction to Approximation Theory : E. W. Cheney, McGraw-Hill.

PAPER-IV PARTIAL DIFFERENTIAL EQUATIONS WITH APPLICATIONS

(SOS/MAT/PHD/E002)

- I. First order partial differential equations.
- II. Principles for higher-order equations.
- III. The wave equations.
- IV. The heat equations.

TEXT BOOKS

1. Partial Differential Equations : Methods and Applications : R.C. Mcowen, Pearson Education.
2. Partial Differential Equations : L. Bers, F. John and M. Schechter, John Wiley and Sons.
3. Introduction to Partial Differential Equations : G. Folland, Princeton Univ. Press.
4. Partial Differential Equations : F. John, Springer-Verlag, New York.

PAPER-V MATHEMATICAL ANALYSIS (SOS/MAT/PHD/E003)

- I. Power series : Properties of functions expressible as powerseries, Abel's theorem,
- II. Fourier series : Fourier coefficient, periodic functions, piecewise monotonic functions, Fourier series for even and odd functions, half range series.
- III. Function of several variables: Explicit and implicit functions, function of two variables, repeated limits, continuity, partial derivatives, differentiability, Young's theorem, Schwarz theorem.
- IV. Differentials of higher order, functions of functions, chain rule, change of variables, Taylor's theorem, functions of several variables, implicit function theorem.

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TEXT BOOKS

1. Mathematical Analysis :Apostol, Narosa Publishing House.
2. Foundations of Modern Analysis : J. Dieudonne's Academic Press.
3. Principles of Mathematical Analysis : W. Rudin, McGraw-Hill.
4. A first Course in Real Analysis : S.K. Berberian, Springer-Verlag, New York.

PAPER-VI FLUID DYNAMICS WITH COMPUTATIONAL TECHNIQUES**(SOS/MAT/PHD/E004)**

- I. Laminar flow of viscous incompressible fluids.
- II. Boundary layer theory.
- III. Dimensional analysis.
- IV. Fundamentals of finite element technique.

TEXT BOOKS

1. Foundation of Fluid Mechanics : S.W. Yuan, Prentice Hall Pvt. Ltd., 1960.
2. Text Book of Fluid Dynamics : F. Chorlton, CBS Pub. & Dist., 2004.
3. Fluid Dynamics : Hughes and Brighton, McGraw Higher Ed, 2007.
4. Finite Element Method : J.N. Reddy, McGraw-Hill, 2007.

PAPER-VII DIFFERENTIAL GEOMETRY**(SOS/MAT/PHD/E005)**

- I. Riemannian geometry.
- II. Kaehlerian, Hermitian and Tachibana spaces.
- III. Manifolds and submanifolds.
- IV. Hypersurfaces

TEXT BOOKS

1. Differential Geometry :K. Yano& M. Kon, World Sci. Pub. Pvt. Ltd.
2. Differential Geometry :Weatherburn, Cambridge Univ. Press, 1930.
3. Differential Manifold :R.S. Mishra, Indian national Sci. Acad., 1978.

PAPER-VIII ALGEBRAIC TOPOLOGY**(SOS/MAT/PHD/E006)**

- I. The fundamental group, homotopy, contractive spaces and homotopy type, the fundamental group of circle.
- II. Finite simplicial complexes, polyhedral and triangulations, simplicial approximation.
- III. Orientation of simplicial complexes, simplicial chain complex and homology, properties of integral homology groups.
- IV. Induced homomorphism, degree of a map and its applications, invariance of homology groups, homotopy invariance, Lefschetz fixed point theorem.

TEXT BOOKS

1. Algebraic Topology :StyaDeo, Hindustan Book Agency, India, 2006.
2. Algebraic Topology : William Fulton, Springer, Verlag.
3. A Basic Course in Algebraic Topology : W.S. Massely, Springer, 2007.
4. Elements of Algebraic Topology : James Munkres, CRC Press.

30.08.18
Dean School of Sciences
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Dehradun, Uttarakhand

Professor R.C. Dimri
Head
Department of Mathematics
H. N. B. Garhwal University
Dehradun, Uttarakhand