(Syllabus under NEP, w.e.f. 2023-24)
B.A./B.Sc.(Mathematics)
H. N.B. Garhwal University, Srinagar (Garhwal) Uttarakhand

Students enrolled in the **B.Sc.** Programme under NEP-2020 offered by the Department under the School of Sciences will have the opportunity to learn and master the following components in addition to attain important essential skills and abilities :

PO-No.	Outcomes
PO-1	Capable of delivering basic disciplinary knowledge gained during the programme.
PO-2	Capable of describing advanced knowledge gained during the programme.
PO-3	Capable of analyzing the results critically and applying acquired knowledge to solve the problems.
PO-4	Capable to identify,formulate, investigate and analyze the scientific problems and innovating to design and create products and solutions to real life problems.
PO-5	Ability to develop a research aptitude and apply knowledge to find the solution of burning research problems in the concerned and associated fields at global level.
PO-6	Ability to gain knowledge with the holistic and multidisciplinary approach across the fields.
PO-7	Learn specific sets of disciplinary or multidisciplinary skills and advanced techniques and apply them for betterment of mankind.
PO-8	Ability to learn and work in a group and capable of leading a team.

Programme Specific Outcomes (PSOs):

On completion of Integrated B.Sc.-M.Sc. (Mathematics) Programme a student**:**

Number	Programme Specific Outcomes
PSO-1	Will have a strong foundation in both pure and applied mathematics.
PSO-2	Will be able to apply mathematical skills for solving problems and for preparing various competitive exams.
PSO-3	Will be able to communicate mathematical knowledge effectively, in writingas well as orally.
PSO-4	Will identify applications of mathematics in other disciplines, leading to enhancement of career prospects in different fields and research areas.
PSO-5	Will have basic knowledge of programming and computational techniques as required for employment.
PSO-6	Should have the knowledge of the fundamental axioms in mathematics and capability of developing ideas based on them and inculcate mathematical reasoning.
PSO-7	Will be able to locate and analyse the different mathematical texts with appropriate theoretical framework.
PSO-8	Should be able to develop analytical skills, critical thinking, creativity, communication and presentation skills through assignments, seminar and project work.

Semester	Core Subject-1	Additional/ Interdisciplinary/ Multidisciplinary course	Skill/ Vocational Course-I
I	Differential Calculus (Theory-Credits-06)	Basic Calculus	Integral Calculus*(Either in I or III Semester)
II	Differential Equations (Theory-Credits-06)	Basic Differential Equations	Vector calculus*Either in II or IV Semester)
III	Real Analysis (Credits-06- Theory-05+Tutorial-01)	Elementary Real Analysis	
IV	Abstract Algebra (Credit-06 , Theory-05+Tutorial-01)	Algebra	
V	Linear Algebra (Theory-06 Credits)	Vocational Course(VOC-Either in V or VI Semester)	Choose any one of the following: (a)-Elementary Cryptography, (b)-Combinatorics and Graph Theory.
VI	Complex Analysis(Theory-06 Credits)		

Fourth Year (with Research)

Semester	Major Subject Core	Research Methodology	Elective Papers
VII	Major Paper–I: Numerical Analysis (04-Credits) Major Paper–II: Integral Transforms (04-Credits)	Paper I: Research Methodology (04-Credit) Paper II: Research Writing and Ethics (02-Credit)	Paper-I: Metric Spaces Paper-II: Financial Mathematics Paper III: Mathematical Statistics Paper IV: Fluid Dynamics Paper V: Number Theory
VIII	Paper-I: Discrete Mathematics Paper-II: Operations Research-1		Paper-I: Metric Spaces Paper-II: Financial Mathematics Paper III: Mathematical Statistics Paper IV: Fluid Dynamics Paper V: Number Theory

Fourth Year (Honours)

Semester	Major Subject: Core	Major Elective	Minor Core	Minor Elective
VII	Major Paper–I: Numerical Analysis (04-Credits) Major Paper–II: Integral Transforms (04-Credit)	Mathematical Statistics (04 Credits)	Metric Spaces (03 Credits)	Special Functions (03 Credits)
VIII	Paper-I: Discrete Mathematics Paper-II: Operations Research-1	Fluid Dynamics (04 Credits)	Number theory (03 Credits)	Financial Mathematics (03 Credits)

Semester-I

CS-1: Differential Calculus

(Theory- 06-Credits)

Unit-I: Limit and Continuity (ε and δ definition), Types of Discontinuities, Differentiability of functions, Rolle's theorem, Lagrange's Mean Value theorem, Cauchy Mean Value Theorem.

Unit-II: Successive differentiation, Leibnitz's theorem, Taylor's theorem with Lagrange's and Cauchy's forms of remainder, Taylor's series, Maclaurin's series of sin x, cos x, e^x, log(l+x), $(1+x)^m$

Unit-III: Indeterminate forms, Partial Differentiation, Euler's Theorem for Homogeneous functions,Maxima&nd minina of function of one and two varibles

Unit-IV: Tangents and normal, Curvature. Asymptotes, Singular Points.

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.

Additional Course-Part 1
Basic Calculus (04- Credits)

Unite-I: Limit, Continuity and Differentiability

Unite-II: Rolle's Theorem, Lagrange's Mean Value theorems, Cauchy Mean Value Theorem. Expansion of functions, Taylor's and Maclaurin's Series of Functions.

Unit-III: Indeterminate Forms. Partial Differentiation, Euler's Theorem for Homogeneous Function,

Unit-IV: Curvature**,** Tangents and Normal.

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.
3. Tom M. Apostol, Calculus Vol. I, John Wiley & Sons, Inc. 2007.

Course Outcome (Differential Calculus)

CO1 Determine the points of continuity and discontinuity using the definition of limit.
CO2 Understand the consequences of the Mean value theorem for continuous functions.
CO3 Use the Euler's theorem for homogenous function.
CO4 Trace the curves in Cartesian and polar form using the concepts of maxima and minima, asymptotes, tangent and normal, singular points of functions of single and two variables.

Skill Course-I
Integral Calculus (02-Credits)

Unit-I: Integration of rational and irrational functions, Properties of definite integrals. Reduction formulae for integrals of rational and trigonometric functions,

Unit-II: 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.

Course Outcome (Integral Calculus)

CO1 About different techniques of integration of rational, irrational and trigonometric functions.
CO2 How to use gamma and beta functions to evaluate the integrals.
CO3 How to compute double and triple integrals.
CO4 Compute the areas and lengths of the curves in the plane and volume and surfaces of solids of revolution.

Semester-II
Core Subject 1: Differential Equations
(Theory-06 Credits)

Unit-I: Classification of differential equations: their origin and applications, initial value problems, boundary value problems, existence of solution. Separable equation and reducible to this form.

Unit-II: Exact differential equation, integrating factors, special integrating factor and transformations. linear differential equation and Bernoulli equations, first order higher degree equations solvable for x, y, p.

Unit-III: Higher-order differential equations with constant coefficients, basic theory of linear differential equations, The Cauchy-Euler equation, Simultaneous differential equations. Wronskian and its properties Second order linear differential equations with variable coefficients, Inspection Method, Reducible to normal form, Change of Independent Variable, Variation of Parameters. Total differential equations.

Unit-IV: 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.

Course Outcome (Differential Equations)

CO1 Formulate and solve differential equations arising from changes in physical world.
CO2 Solve the first order exact differential equation by different methods.
CO3 Solve the linear homogeneous equations with constant coefficients, linear non-homogenous equations.
CO4 Formulate the first order partial differential equation. Using Lagrange and Charpit's method for finding the solution of partial differential equation.

Additional course-Part-2
Basic Differential Equations (04 credits)

Unit-I: Classifications of Differential equations, their origin and and applications, initial value problems.
Unit-II: Exact differential equations of first order, Integrating factors,special integrating factor and transformations,Linear differential equations and Bernoulli equation.
Unit-III: First order higher degree equations solvable for x,y,p. Higher order differential equations with constant coefficients.
Unit-IV: Order and degree of partial differential equations,Concept of linear and non-linear p.d.e. ,formulation of first order partial differential equations.

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.

Skill Course-II
Vector Calculus (02 Credits)

Unit-I: Scalar and vector products of three and four vectors, Reciprocal systems of vectors, Applications of vectors to three dimensional geometry. Differentiation of vectors, partial differentiation of vectors, Velocity and acceleration, Integration of vectors.
Unit-II: Differential operators, Gradient of a scalar point function, Directional Derivative,divergence and curl of vectors. Line integrals, Surface integrals, Applications of Gauss's , Green's and Stokes theorems.

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.

Course Outcome (Vector Calculus)

CO1 Find multiple products of three and more vectors.
CO2 Find differentiation and partial differentiation of vector functions.
CO3 Understand the notions of gradient, divergence and curl**.**
CO4 Verify Green's theorem, Gauss's and Stoke's theorem.

Semester-III
Major Paper-III (CS-1)
Real Analysis (Theory- 06 credits)

Unit I: Finite and infinite sets, Examples of countable and uncountable sets, Real line, Bounded sets, Supremum and infimum, Completeness property of R, Archimedean property of R, intervals, Concept of limit points, closed sets , statement of Bolzano-Weierstrass theorem.
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.
Unit III: Infinite series. Cauchy convergence criterion for series, Positive term series, Geometric series, Comparison test, p-test, Root test, Ratio test, Alternating series, Leibnitz's test, Cauchy Condensation test, absolute and conditional convergence.
Unit IV: Riemann integral : Definition and examples, Properties of Riemann integrals, Necessary and sufficient conditions for integrability, Fundamental theorem of Calculus.

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. K.A. Ross, Elementary Analysis- The Theory of Calculus Series- Undergraduate Text in Mathematics, Springer Verlag, 2003.

Course Outcome (Real Analysis)

CO1 Define and recognize the basic properties of field of real numbers.
CO2 Understand the concept of limit point and Bolzano-Weierstrass theorem.
CO3 Define and recognize the series and sequence of real numbers and their convergence.
CO4 Understand the concept of Riemann integral and its properties.

Additional Course
Part-3
Elementary Real Analysis (Theory- 04 credits)

Unit I: Supremum and infimum of a set, Completeness property of R, Archimedean property of R, Concept of limit points and statement of Bolzano-Weierstrass theorem.
Unit II: Real Sequence, Bounded sequence, Cauchy convergence criterion for sequences, Cauchy's theorem on limits, monotone sequences and their convergence , monotone convergence theorem.
Unit III: Infinite series. Cauchy convergence criterion for series,Geometric series, Comparison test, p-test, Root test, Ratio test, Alternating series, Leibnitz's test, absolute and conditional convergence.
Unit IV: Riemann integral: Definition and examples, Properties of Riemann integrals, Necessary and sufficient conditions for integrability.

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. K.A. Ross, Elementary Analysis- The Theory of Calculus Series- Undergraduate Texts in Mathematics, Springer Verlag, 2003.

Course Outcome (Elementary Real Analysis)

CO1 Understand the concept of limit point and Bolzano-Weierstrass theorem.
CO2 Define and recognize the series and sequence of real numbers and their convergence.
CO3 Understand the concept of Riemann integral and its properties.
CO4 Understand the concept of Riemann integral and its properties.

Skill Course-I
Integral calculus (02-Credits)
(If not opted in Semester I)

Major Paper-IV (CS-1)
Abstract Algebra
(Theory- 06 Credits)

Unit I: Definition and examples of groups, Abelian groups, the groups of integers under addition and multiplication modulo n, Subgroups, Necessary and sufficient condition, Examples of subgroups including the center of a group, Groups of complex roots of unity.
Unit II: The general linear group GLn (n,R), Groups of symmetries of (i) an isosceles triangle, (ii) an equilateral triangle,(iii) a rectangle, and (iv) a square, Permutation groups, Even and odd permutations, Group of quaternions.
Unit III: Homomorphism and isomorphism of groups, Order of an element, Cyclic groups and its properties, Cosets, Index of subgroup, Lagrange's theorem., Cayley's theorem.
Unit IV: Normal subgroups: Definition and examples.Definition and examples of rings, Examples of commutative and non-commutative rings, the ring of integers modulo n, Ring of
of matrices, Subrings and ideals, Integral domains and fields with examples.

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.

Course Outcome (Abstract Algebra)

CO1 Understand the basic properties of groups, identify abelian and non-abelian groups.
CO2 Discuss the Lagrange's theorem and its consequences.
CO3 Characterize the cyclic groups, normal subgroups, simple groups.
CO4 Extend group structures to ring, integral domain and field.

Additional Course
Algebra
(Theory- 04 Credits)

Unit I: Definition and examples of groups, Abelian groups, the groups of integers under addition and multiplication modulo n, Subgroups, Necessary and sufficient condition, Examples of subgroups including the center of a group, Groups of complex roots of unity.
Unit II: The general linear group GLn (n,R), Groups of symmetries of (i) an isosceles triangle, (ii) an equilateral triangle,(iii) a rectangle, and (iv) a square, Permutation groups, Even and odd permutations, Group of quaternions.
Unit III: Homomorphism and isomorphism of groups, Order of an element, Cyclic groups and its properties, Cosets, Index of subgroup, Lagrange's theorem.
Unit IV: Normal subgroups: Definition and examples.Definition and examples of rings, Examples of commutative and non-commutative rings, the ring of integers modulo n, Ring of
of matrices, Subrings and ideals.

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.

Course Outcome (Algebra)

CO1 Understand the basic properties of groups, identify abelian and non-abelian groups.
CO2 Discuss the Lagrange's theorem and its consequences.
CO3 Characterize the cyclic groups, normal subgroups, simple groups.
CO4 Extend group structures to ring, integral domain and field.

Skill Course-II
Vector Calculus (02-Credits)
(If not opted in Semester II)

Semester-V
Major Paper-V (CS-1)
Linear Algebra (Theory- 06 credits)

Unit I: Vector spaces, Subspaces, Algebra of subspaces, Quotient spaces, Linear combination of Vectors, Linear span, Linear independence/dependence, Basis and dimension, Dimension of subspaces.

Unit II: Linear transformations, Null space, Range, Rank and nullity of a linear transformation, rank-nullity theorem, Isomorphism, Isomorphism theorems, Inevitability and isomorphism's.

Unit III: Matrix representation of a linear transformation, Algebra of linear transformations, Dual space, Dual basis, Double dual, Annihilator.

Unit IV: Eigen value and eigen-vectors of Linear Transformation, Characteristics polynomial, algebraic and geometric multiplicities of eigen-value, Applications of eigen-value and eigen-vectors in finding the power of Matrix A, exp(A), sin(A), cos (A), and p(A), similar Matrices, diagonalization of 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.

Course Outcomes (Linear Algebra)

CO1 The concepts of vector spaces, quotient spaces, basis and dimension.
CO2 How to find rank and nullity of a linear transformation, matrix representation of a linear transformation.
CO3 How to find characteristic equation of a matrix and eigen values and eigen vectors.
CO4 About dual basis, isomorphism theorem and invertibility.

Vocational Course(VOC)-Semester V/VI
Choose any one of the following((a) or (b))

(a)-Elementary Cryptography (04 credits)

Unit I: The Shift Cipher, The Substitution Cipher, The Affine Cipher, The Vigenere Cipher, The Hill Cipher, The Permutation Cipher, Stream & Block ciphers.

Unit II: Shannon's Theory of Perfect Secrecy, Vernam One Time Pad, Random Numbers, Mode of operations in block cipher, the Data Encryption Standard (DES), Feistel Ciphers, the Advanced Encryption Standard(AES), Prime Number Generation, Fermat Test, Miller Rabin Test.

Unit III: Public Key Cryptography, RSA Cryptosystem, Factoring problem, Rabin Cryptosystem, Quadratic Residue Problem, Diffie-Hellman (DH) Key Exchange Protocol, Discrete Logarithm Problem (DLP), ElGamal Cryptosystem, Elliptic Curve, Elliptic Curve Cryptosystem (ECC)

Unit IV: Hash and Compression Functions, Security of Hash Functions, Iterated Hash Functions, SHA-1, MD-5, Message Authentication Codes.

Books recommended:

1. J Buchmann, Introduction to Cryptography, Springer (India) 2004
2. D R Stinson, Cryptography: Theory and Practice. CRC Press, 2000.
3. B Forouzan, Cryptography and Network security, Tata McGraw Hill, 2011
4. Wenbo Mao, Modern Cryptography: Theory and Practice. Pearsion Education, 2004

Course Outcomes

CO1 Students will understand a solid understanding of both classical and modern cryptographic techniques, including their theoretical foundations and practical applications techniques.

CO2 They will be able to analyze and implement various cryptographic algorithms, understand the mathematical foundations of cryptography, and evaluate the security of different cryptographic methods.

CO3 This knowledge will be crucial for students pursuing careers in cybersecurity, computer science, and related fields.

(b)-Combinatorics and Graph Theory(04 credits)

Unit-I: Pigeonhole principle : Simple form, Strong form, Permutations and Combinations of multisets.
Unit-II: The inclusion-exclusion principle,Combinations with repetitions, Derangements, Permutation with forbidden positions.
Unit-III:Introduction to graph theory,Basic properties, Eulerian and Hamilton graphs,Bipartite multigraphs.
Unit-IV: Trees,Spanning trees,Diagraphs and networks,Directed cycle.
Books recommended:

1. Introductory Combinatorics - Fifth Edition,by Richard A. Brualdi ,2019,Pearson India Education Services Pvt. Ltd.
2. Graph Theory by Narsingh Deo, PHI
3. A Text Book of Graph Theory by R. Balakrishnan, K.Rangnathan, Springer.
4. Foundations of Combinatorics with Applications by Edwaed A. Bender , S.Gill Williamson, Dover Books on Mathematics.

Course Outcomes

CO1 Understand the concepts of pigeonhole principles.
CO2 About the inclusion-exclusion principles.
CO3 The concepts of graph theory,diagraphs and networks.

Semester-VI

DSE-Paper (CS-1)

Complex Analysis

(Theory- 06 Credits)

Unit I: Properties of complex numbers, Regions in the complex plane, Functions of complex variable, Limits, Continuity, differentiability of complex functions, Exponential function, Logarithmic function, Trigonometric function.

Unit II: Differentiability and Analyticity, Cauchy-Riemann Equations, Sufficient conditions for analyticity, Harmonic Functions, Harmonic conjugate function, Applications, Examples of analytic functions.

Unit III: Contours, Contour integrals and its examples, Upper bounds for moduli of contour integral, Cauchy- Goursat theorem, Cauchy integral formula. Cauchy inequality, Liouville's theorem, Morera's theorem.

Unit IV: Sequences and Series, Taylor Series, Laurent Series, Singularities, Classification of singularities, Residues and Residue theorem.

Books Recommended

1. James Ward Brown and Ruel V. Churchill, Complex Variables and Applications, 8th Ed., McGraw-Hill International Edition, 2009.
2. JosephBak and Donald J. Newman, Complex analysis, 2nd Ed., Undergraduate Texts in Mathematics, Springer-Verlag New York, Inc., New York, 1997.
3. Dennis G. Zill and Patrick D. Shanahan , A First Course in with Applications Complex Analysis, Jones and Bartlett Publishers.

Course Outcomes (Complex Analysis)

CO1 Understand the concept of complex numbers**,** complex functions and their properties.

CO2 Discuss properties to analytic functions and Cauchy-Riemann equations.

CO3 Prove Cauchy-Goursat theorem, Cauchy integral formula and Liouville's theorem.

CO4 Give examples based on Taylor's and Laurent's series.

Vocational Course(VOC)-Semester V/VI

Choose any one of the following((a) or (b))

(a)-Elementary Cryptography (04 credits)/(b)- Combinatorics and Graph Theory

Semester-VII (with Research/Honours)

Major Paper –I: Numerical Analysis (04-Credit)

Unit I: Solutions of algebraic and transcendental equations using Bisection method, False position method, Secant method, Fixed point iteration method, Newton's Rapson method.

Unit II: Solutions of Linear system of equation, Gauss elimination method, LU decomposition, Gauss-Jacobi, Gauss-Siedel and SOR iterative methods.

Unit III: Calculus of Finite differences, Lagrange and Newton interpolation: linear and higher order, finite difference operators.

Unit IV: 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.

Course Outcomes (Numerical Analysis)

CO1 Find the roots of algebraic and transcendental equations using Bisection method, Regula-Falsi method, Newton-Raphson method .
CO2 Compute the numerical differentiation of the functions using Newton's method.
CO3 Using Simpson's rule, Euler's method, Trapezoidal rule to find the integral of the functions.
CO4 Discuss interpolation and extrapolation.

Major Paper –II: Integral Transforms (04-Credit)

Unit I: The concept of transform, Integral transforms and kernel, Linearity property of transforms, Laplace transform, properties of Laplace Transform.
Unit II: Inverse Laplace transform, Convolution theorem, Applications of Laplace transform to solve ordinary differential equations.
Unit III: Fourier series, Half range expansions, Fourier integral, Fourier Sine , Fourier Cosine integrals and their properties.
Unit IV: Fourier transform, Applications of Fourier transform to boundary value problems.

TEXT/REFERENCE BOOKS

1. Integral Transforms and Their Applications by Lokenath Debnath & bDambaru Bhatta, Chapman & Hall/CRC, Taylor and Francis Group , London, New York, 2007.
2. Integral Transforms in Applied Mathematics by John W. Miles, Cambridge University Press,2010.
3. Ian N. Sneddon, Fourier Transforms , Dover Publications,2010 .
4. Advanced Engineering Mathematics by H.K.Dass, S.Chand , New Delhi,2015.

Course Outcomes (Integral transforms)

CO1 Understanding of basics of integral transforms and its applications encountered in sciences and technologies. Application of Fourier series
CO2 Understand the applications of Laplace transformation and Fourier transformations and their difference.
CO3 How to solve some special ODE containing special functions with the help of Laplace Transformation.
CO4 How to solve the PDE by Fourier transformation.

Research Methodology (4-credits)

Unit I: Meaning of research, Empirical and Theoretical research, Inductive and Deductive logics
Unit II: Research hypothesis, Scientific Methods, Research Design, Types of Data & Collection,
Unit III: Sampling, Sampling Distribution, Testing of hypothesis,
Unit IV: Correlation and Regression, Time Series Analysis.

TEXT BOOKSTEXT/REFERENCE BOOKS

1. Research Methodology for Scientists and Engineers: J.N.Kapur
2. Fundamentals of Research Methodology and Statistics: Y.K.Singh, New Age International.

Course Outcomes (Research Methodology)

CO1 Understanding the basics of research and methodology
C02 Understanding the scientific method in research
CO3 Discuss the meaning of sampling and hypothesis testing

CO4 Understanding the concept of correlation and time series analysis

Research Writing and Research Ethics (02-credits)

Unit I: Scientific Writing, Semantics, syntax and styles, Approaching a writing project,
Unit II: Research and Publication Ethics: Theory: - Philosophy and ethics, Scientific conduct, Publication ethics.

TEXT BOOKS/REFERENCE BOOKS

1. Ethics in Research Practice and Innovation, Antonio Sandu, Ana Frunza and Elena Unguru, IGI Global.
2. Write Mathematics Right by L. Radhakrishna, Narosa Publishng House, 2013

Course Outcomes (Research Writing and Research Ethics)

CO1 Knowing about the scientific writing.

CO2 Understanding the basics of research writings and ethics.

CO3 Understanding the meaning of publication ethics.

CO4 Understanding the scientific conduct.

Mathematical Statistics (04 credits)

Unit I: Elements of probability, Sample space, Discrete probability, Baye's theorem, Random variables and distribution functions, Mathematical expectations and moments.

Unit II: Some standard discrete and continuous univariate distributions: Binomial, Poisson, Normal.

Unit III: Correlation, Rank correlation, Regression line, Multiple and partial correlation of three variables only, Data reduction techniques, Canonical correlation.

Unit 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.

Course Outcome (Mathematical Statistics)

CO1 Define and recognize the basic properties of probability and the Baye's theorem.

CO2 Study binomial, Poisson, normal, gamma and beta distributions.

CO3 Know about notions of the correlation and regression.

CO4 Understand the concepts of sampling and t, z, and chi- square tests.

Metric Spaces (03 Credits)

Unit 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.
Unit 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, Uniform continuity.
Unit III: Complete metric spaces, Completeness and continuous mappings, Cantor's intersection theorem, Contraction mapping theorem, Connectedness in metric spaces, Properties of connectedness.

Unit 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**.**

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.

Course Outcome(Metric Spaces)

CO1: Understand the definition of metric spaces and ideas of limit point and interior point.
CO2: Study the concept of continuity and homeomorphism in metric spaces.
CO3: Know the notion of complete metric spaces and their properties.
CO4: Know the notion of compact metric spaces and its properties.

Special Functions (03 Credits)

Unit I: Legendre Polynomial and its properties.
Unit II: Bessel Polynomial, and its properties.
Unit III: Hermite polynomials, and its properties.
Unit IV: Chebyshev polynomials, and its properties.

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.

Course Outcome (Special Functions)

CO1 Understanding of orthogonal polynomials which are solutions of some Strum-Liouville Problem (Singular as well as non-singular).

CO2 Understanding the concepts of expansions in terms of orthogonal polynomials.

CO3 Know the properties of Hermite polynomials.

CO4 Know the properties of Chebyshev polynomials.

Financial Mathematics (03 Credits)

Unit I: Single period model, Definitions of finance- pricing, Forward- one- step binary model, Ternary model- Characterization of no arbitrage, Risk-neutral probability measure
Unit 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
Unit III: Brownian motion, Definition of the process, Levy's construction of brownian motion, The reflection principle and scaling, Martingales, Continuous time.
Unit 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

1. A Course in Financial Calculus: Alison Etheridge, Cambridge Univ. Press, 2002.
2. Financial Calculus: An Introduction to Derivatives Pricing : Martin Boxter 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: MarekMusielaandMarekRuthowshi, SpringerVerlag, New York, 1988.

Course Outcome (Financial Mathematics)

CO1 Know the meaning of single period model.
CO2 How to use the Markov process.
CO3 Know the concept of Brownian motion.
CO4 Study the concepts of Stochastic calculus and its application.

Number Theory (03 Credits)

Unit I: The division algorithm, The gcd, The Euclidean algorithm, Diophantine equation $ax + by = c$, The fundamental theorem of arithmetic, The sieve of Eratosthenes, Goldbachconjucture.
Unit II: The theory of congruences,Binary and decimal representation of integers,Linearcongruences and Chinese remainder theorem, Fermat's theorem, Wilson's theorem.
Unit 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.
Unit 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.

Course Outcome (Number Theory)

CO1: Prove how certain number theoretical theorems can be applied to solve simple Diophantine equations.
CO2: Explain theory of congruence with examples.
CO3: Explain Euler's phi functions and its properties.
CO4: Know about primitive roots of primes and continued fractions.

Fluid Dynamics (3 Credits)

Unit I: Kinematics of fluids, Lagrangian and Eulerian methods, Local and individual time rates of change, Equation of continuity, Boundary surface.
Unit 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.
Unit 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
Unit 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, Blausius theorem.

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.

Course Outcome (Fluid Dynamics)

CO 1: Obtain equations of continuity in different coordinate systems.
CO 2: Study equations of motion of inviscid fluids and their applications.
CO 3: Discuss and understand impulsive motion of fluid and irrotational motion.
CO 4: Understand the concept of motion in two dimensions with complex potentials.

Semester-VIII (with Research/Honours)

Major Paper –I: Discrete Mathematics (04-Credit)

Unit I: Recurrence relations, Linear homogeneous recurrence relations, Non-homogeneous recurrence relations, Solutions of recurrence relations.
Unit II: Partially ordered sets, Different type of lattices, Sub-lattices, Direct product, Ideal Lattice, Modular and distributive lattices.
Unit III: Boolean algebra, Ideals in Boolean algebra, Boolean rings, Boolean functions, Karnaugh maps, Application of Boolean algebra to switching theory.
Unit 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.

Course Outcome (Discrete Mathematics)

CO1 Understand recurrence relations and its properties and solving the methods of recurrence relations.
CO2 Understand concept of partial ordered sets and lattices.
CO3 Find examples based on Boolean algebra.
CO4 Describe different types of graphs, Eulerian and Hamiltonian.

Semester-VIII (with Research/Honours)

Major Paper –II: Operations Research (04-Credit)

Unit 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.
Unit II: Dual simplex method, Revised simplex method, Sensitivity analysis.
Unit III: Assignment and Transportation problems.
Unit IV: Theory of games, Integer linear programming.

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.

Course Outcome (Operations Research)

CO 1: Explain the meaning of Operations Research and its applications.

CO 2: Analyze dual simplex method and revised simplex method.

CO 3: Understand the applications of assignment and transportation problems.

CO 4: Analyze the problems solved by concept of game theory.