DEPARTMENT OF MATHEMATICS
RABINDRANATH TAGORE UNIVERSITY, HOJAI
CURRICULUM FOR SEMESTER V & VI (As per NEP 2020)
COURSE DETAILS

CLASS	CURSE	SUBJECT PAPERS	PAPER CREDITS
SEMESTER-V	MAJOR	MAJ-MTH-5.1:Numerical methods(including practical) MAJ-MTH-5.2:Partial Differential equations(including practical) MAJ-MTH-5.3:Statics and Dynamics MAJ-MTH-5.4 Riemann integral and metric space	4x4=16
	MINOR-V	(Choose any one) MIN-MTH-5.1:Number theory & Vedic mathematics(compulsory for single minor students) MIN-MTH-5.2: Linear Programming	4
	SEC	x	x
	GE	x	x
	AECC	x	x
	VAD	x	x
	VOC/Minor project	x	x
			Total credit:20

CLASS	COURSE	SUBJECT PAPERS	CREDITS
SEMESTER-VI	MAJOR	MAJ-MTH-6.1: Complex Analysis(incl.pract) MAJ-MTH-6.2:Number theory and Vedic mathematics MAJ-MTH-6.3:Linear Algebra MAJ-MTH-6.4: Hydro mechanics	4x4=16
	MINOR-VI	(Choose any one) MIN-MTH-6.1: Programming in C MIN-MTH-6.2:Discrete mathematics	4
	SEC	x	x
	GE	x	x
	AECC	x	x
	VAD	x	x

	VOC		
			Total :20

SEMESTER-V

MAJ-MTH-5.1: Numerical Methods (including practical)
Total marks: 100: (Theory: 45, Internal Assessment: 30, Practical: 25)

Course objective: The main objective of the course is to

- Give the idea of various computational techniques to find approximate values for possible roots of algebraic and non-algebraic equations
- To give the idea of finding approximate solutions to a system of linear equations and quadratic equations.

Course outcome: After going through the course students will be able to

CO-1 Learn the technique of finding the roots of nonlinear functions of single variable and solution of system of linear equations by different methods.

CO-2 Learn the technique of iterative process and non-iterative process to solve system of linear equations

CO-3 Learn interpolation technique to compute the value for tabulated function at points not in the table

CO-4 Learn the technique of finding appropriate value of an integral numerically

CO-5 Solving some differential equations that can't be solved analytically

UNIT 1: 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. [1] Chapter 1 (Sections 1.1-1.2), Chapter 2 (Sections 2.1-2.5), and Chapter 3 (Sections 3.5, 3.8). **Marks-15**

UNIT 2: Lagrange and Newton interpolation: linear and higher order, finite difference operators. [1] Chapter 5 (Sections 5.1, 5.3) [2] Chapter 4 (Section 4.3). **Marks-15**

UNIT 3: Numerical differentiation: forward difference, backward difference and central difference. Integration: trapezoidal rule, Simpson's rule, Euler's method. [1]: Chapter 6 (Sections 6.2, 6.4), Chapter 7 (Section 7.2) **Marks-15**

Note: Emphasis is to be laid on the algorithms of the above numerical methods.

Practical / Lab work to be performed on a computer: Use of computer aided software (CAS), for example Matlab / Mathematica / Maple / Maxima etc., for developing the following Numerical programs: (i) Calculate the sum 1/1 + 1/2 + 1/3 + 1/4 + ----------+ 1/ N. (ii) To find the absolute value of an integer. (iii) Enter 100 integers into an array and sort them in an ascending order. (iv) Any two of the following (a) Bisection Method (b) Newton Raphson Method (c) Secant Method (d) Regulai Falsi Method (v) LU decomposition Method (vi) Gauss-Jacobi Method (vii) SOR Method or Gauss-Siedel Method (viii) Lagrange Interpolation or Newton Interpolation (ix) Simpson's rule. Note: For any of the CAS Matlab / Mathematica / Maple / Maxima etc., Data types-simple data types, floating

data types, character data types, arithmetic operators and operator precedence, variables and constant declarations, expressions, input/output, relational operators, logical operators 19 and logical expressions, control statements and loop statements, Arrays should be introduced to the students.

Text 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, New age International Publisher, India, 5th edition, 2007.

Reference Book:

1. C. F. Gerald and P. O. Wheatley, Applied Numerical Analysis, Pearson Education, India,7th edition, 2008

MAJ-MTH-5.2: Partial Differential Equations (Including practical) Total marks: 100: (Theory: 45, Internal Assessment: 30, Practical: 25)

Learning Objectives: The main objective of the course is to

- give idea of partial differential equations their classifications
- forming a partial differential equations,
- solving partial differential equations
- to understand the various physical concepts of partial differential equations**.**

Course outcomes: After going through the course students will be able to

CO-1 learn to form partial differential equations,
CO-2 distinguish various types of partial differential equations, linear, nonlinear, quasilinear PDE,
CO-3 various methods of solving partial differential equations,
CO-4 to classify and solve the higher order pde,
CO-5 Learn about Cauchy problem, heat equation, wave equation etc.

Unit 1: Introduction, Classification, Construction of first order partial differential equations (PDE). Cauchy's problem for first order equations, linear equations of the first order, Integral surfaces passing through a given curve, nonlinear partial differential equations of the first order, Cauchy's method of characteristics, Compatible system of first order equations, Charpit's method. Solutions satisfying given conditions, Jacobi's method. [1] Chapter 2 (Sections 2.1 to 2.3) [2] Chapter 2 (Section 3, 4, 5, 7, 8, 10, 12, 13) **Marks 13**

Unit 2: Canonical form of first order PDE, Method of separation of variables for first order PDE. [1] Chapter 2 (Sections 2.6 and 2.7) **Marks 10**

Unit 3: The vibrating string, Vibrating membrane, Gravitational potential, Conservation laws. [1] Chapter 3 (Sections 3.1 to 3.3, 3.5, and 3.6) **Marks 10**

Unit 4: Reduction to canonical forms, Equations with constant coefficients, General solution. [1] Chapter 4 (Sections 4.1 to 4.5) [2] Chapter 3 (Sections 4, 5) **Marks 12**

Practical /Lab work to be performed in a Computer Lab: ***Modeling of the following similar problems using Mathematica /MATLAB/ Maple/ Maxima/ Scilab etc.***

1. Solution of Cauchy problem for first order PDE.
2. Plotting the characteristics for the first order PDE.
3. Plot the integral surfaces of a given first order PDE with initial data.
4. Solution of wave equation 2 2 2 2 2 x u c t u ∂ ∂ = ∂ ∂ for any two of the following associated conditions: (a) u(x,0) = φ(x); u(x,0) =ψ (x), x ∈ R;t > 0 (b) u(x,0) = (x); u (x,0) = (x); u(0,t) = 0, x > 0;t > 0 φ t ψ (c) u(x,0) = (x); u (x,0) = (x); u (0,t) = 0, x > 0;t > 0 φ t ψ x (d) u(x,0) = (x); u (x,0) = (x); u(0,t) = 0,u(l,t) = 0; x > 0;t > 0 φ t ψ
5. Solving systems of ordinary differential equations.
6. Solution of one-Dimensional heat equation !! = ! !!! , for a homogeneous rod of length !. That is - solve the IBVP: 26 !! = ! !!!, 0 < ! < !, ! > 0 ! 0,! = 0, ! !,! = 0, ! ≥ 0 ! 0,! = ! ! , 0 ≤ ! ≤ !

Text Book:

1. Tyn Myint-U and Lokenath Debnath, Linear Partial Differential Equation for Scientists and Engineers, Springer, Indian reprint, 2006.
2. Sneddon, I. N. (2006). Elements of Partial Differential Equations, Dover Publications. Indian Reprint.

Reference Book:

1. Stavroulakis, Ioannis P & Tersian, Stepan A. (2004). Partial Differential Equations: An Introduction with Mathematica and MAPLE (2nd ed.). World Scientific

MAJ-MTH-5.3: Statics and Dynamics
Total Marks: 100: (Theory: 60, Internal assessment: 40)

Learning Objectives: The main objective of the course is to

- understand the various concepts of physical quantities like force, moment and their related motions,
- motions of bodies, velocities,
- motion of objects in various mediums
- Their applications in our daily physical activities.

Course outcomes: After going through the course students will be able to learn

CO-1 the concepts of force, moments, couples, their equilibrium conditions,
CO-2 understand theory behind friction and centre of gravity,
CO-3 Idea of principle of conservation of energy, linear momentum, works energy equation.
CO-4 Learn the translational and rotational motion of rigid bodies etc.

UNIT 1: Composition and resolution of forces, Parallelogram of forces, Triangle of forces, Converse of triangle of forces, Lami's Theorem, Parallel forces, Moment of a force about a point and

an axis. Couple, Resultant of a system of forces. Equilibrium of coplanar forces. Friction, C.G of an arc, plane area, surface of revolution, solid of revolution, Catenary. [1] Chapter 1-9 related sections only **Marks-30**

UNIT 2: Velocities and acceleration along radial and transverse directions and along tangential and normal directions, motion in a straight line under variable acceleration, simple harmonic motion and elastic string. Newton's law of motion. Work, Energy and momentum, Conservative forces Potential energy, Impulsive forces, Motion in resisting medium. [1] Vol-II Chapter I Sections 1.1, 1.2,1.3, Chapter –2 Sections 2.1,2.2, Chapter 3 Sections 3.1.3.2, Chapter 4 Sections 4.1, Chapter 5 Sections 5.1,5.3, Chapter 6 Sections 6.1,6.3. [2] Chapter 3 (Sections: 3.1, 3.2, 3.3,3.4).

Marks-30

. **Text Book**:

1. S. L. Loney, The Elements of Statics and Dynamics (Vol I & II) Publisher Arihant, 4th Edition 2014.
2. F. Chorlton, Textbook of Dynamics, CBS, Publications 2nd Edition, 1985

Reference books:

1. A.S. Ramsay, Statics, Cambridge University Press, publication year:2009
2. A.S. Ramsay, Dynamics, Cambridge University Press, publication year: 2009
3. M. R. Spiegel, Theoretical Mechanics, Schaum Series 2010.

MAJ-MTH-5.4: Riemann Integration and Metric spaces
Total Marks: 100: (External 60, Internal assessments 40)

Course objective: The main objective of the course is to –

- To develop the idea of analysis, integrability of a function defined by Riemann, various properties related to it.
- Idea of improper integrals and properties
- To develop the usual idea of distance into an abstract form on any set of objects, studying its inherent characteristics and the resulting consequences.

Course outcome: After going through the course students will learn to

CO-1 The idea of abstract thinking , analyzing a concept

CO-2 Have an idea about integrability of a function, their related properties.

CO-3 Learn about improper integrals, their related properties.

CO-4 They will learn to analyze how a theory advances from a particular frame to general frame.

CO-5 Learn some important properties of metric spaces like connectedness, compactness etc

UNIT 1: Riemann integration: upper and lower sums; Darboux integrability, properties of integral, Fundamental theorem of calculus, mean value theorems for integrals, Riemann sum and

Riemann integrability, Riemann integrability of monotone and continuous functions on intervals, sum of infinite series as Riemann integrals, logarithm and exponential functions through Riemann integrals, improper integrals, Gamma functions. [1] Chapter 6 **Marks-20**

UNIT 2: Metric spaces: definition and examples, sequences in metric spaces, Cauchy sequences, complete metric spaces. Open and closed balls, neighborhood, open set, interior of a set. Limit point of a set, closed set, diameter of a set, Cantor's theorem. Subspaces, dense sets, separable spaces. [2] Chapter 1 Sections 1.1-4, Chapter 2 Sections 2.1, 2.2 **Marks-20**

UNIT 3: Continuous mappings, sequential criterion and other characterizations of continuity. Uniform continuity. Homeomorphism, Contraction mappings, Banach contraction mapping principle. Connectedness, connected subsets of R, connectedness and continuous mappings. [2] Chapter 3, Sections 3.1, 3.4, 3.5, 3.7 (up to 3.7.7), Chapter 4 Sections 4.1. **Marks-20**

Text Books:

1. Ajit Kumar and S. Kumaresan, A Basic Course in Real Analysis, CRC Press, Indian Edn. 2014.
2. Satish Shirali & Harikishan L. Vasudeva, Metric Spaces, Springer Verlag London (2006) (First Indian Reprint 2009)

Reference Books:

1. R.G. Bartle D.R. Sherbert, Introduction to Real Analysis, 3rd Ed., John Wiley and Sons (Asia) Pvt. Ltd., Singapore, 2002.
2. Charles G. Denlinger, Elements of Real Analysis, Jones & Bartlett (Student Edition), 2011.
3. S. Kumaresan, Topology of Metric Spaces, 2nd Ed., Narosa Publishing House, 2011.
4. G.F. Simmons, Introduction to Topology and Modern Analysis, McGraw-Hill, 2004

MINOR-V (Choose any one)

MIN-MTH-5.1: Number Theory & Vedic mathematics

(Compulsory for single minor student)

Total Marks: 100 (Theory: 60, Internal assessment: 40)

Course objectives: The main objective of the course is to

- give the idea of various number system, focusing on integers, various properties and representation of integers,
- To understand the number theoretic analysis.
- To give some basic ideas of Vedic mathematics

Course outcomes: After completion of the course students will be able to

CO-1 Distinguish integers from other number systems,

CO-2 learns various properties of integers,

CO-3 concepts of congruence, linear congruence,

CO-4 explores the Chinese Remainder Theorem to solve simultaneous linear congruence,

CO-5 idea of Fermat's and Wilson's theorem,

CO-6 Applying mathematical ideas and concepts within the context of number theory.

CO-7 Able to learn Vedic mathematics and their importance

Unit 1: Well ordering principle of integers, Archimedean property, first and second principle of finite induction, division algorithm of integers, GCD, Euclidean algorithm, Linear Diophantine equation, prime counting function, statement of prime number theorem, Goldbach conjecture, linear congruence, complete set of residues, Chinese Remainder theorem, Fermat's Little theorem, Wilson's theorem. [1] Chapter 1, Chapter 2 (Section 2.5), [2] Chapter 2 (Section 2.2, 2.3) [1] Chapter 4 (Sections 4.2, 4.4) Chapter 5: Section 5.2 **Marks-25**

Unit 2: Number theoretic functions, sum and number of divisors, totally multiplicative functions, definition and properties of the Dirichlet product, the Mobius Inversion formula, the greatest integer function, Euler's phi function, Euler's theorem, reduced set of residues, some properties of Euler's phi-function. [1] Chapter 6 (Sections 6.1 to 6.2, 7.2, 7.3, and 7.4)

Marks-20

Unit 3: History of Vedic mathematics, Vedic sutras and sub sutras, addition, substraction, multiplication with Vedic rule. **Marks-15**

Text Books:

1. David M. Burton, Elementary Number Theory, 6th Ed., Tata McGraw Hill, Indian reprint, 2007.

2. G. A. Jones and J. Mary Jones, Elementary Number Theory. Undergraduate Mathematics Series (SUMS). First Indian Print. 2005
3. The essentials of VEDIC MATHEMATICS; by Rajesh Kumar Thakur
4. Vedic mathematics for all, by Dr S K Kapoor.

Reference Books:

1. Neville Robinns, Beginning Number Theory, 2nd Ed., Narosa Publishing House Pvt. Ltd., Delhi, 2007.
2. K. C. Chowdhury, A First Course in Number Theory, Asian Books Publications 2012

MIN-MTH-5.2: Linear Programming
Total Marks: 100 (Theory: 60, Internal Assessments: 40)

Course objective: The main aim of the topic is to give an idea about

- Various optimization techniques pertaining to linear programming.
- Apply linear programming techniques to problems in our real-life situations.

Course outcome: After going through the course students will be able to -

CO-1 Have ideas about various optimization techniques related to linear programming.

CO-2 Have ideas about the simplex method, Big –M method, Assignment problem, Game theory, etc.

CO-3 Use the technique of optimization in real-life situations.

Unit 1: The Linear Programming Problem: Standard, Canonical and matrix forms, Graphical solution. Hyper planes, Extreme points, Convex and polyhedral sets. Basic solutions; Basic Feasible Solutions; Reduction of any feasible solution to a basic feasible solution; Correspondence between basic feasible solutions and extreme points. [1] Chapter 1 (Section 1.1, 1.4, and 1.6) [2] Chapter 2 (Sections 2.16, 2.19, and 2.20), and Chapter 3 (Sections 3, 2, 3.4, and 3.10) **Marks 15**

Unit 2: Simplex Method: Optimal solution, Termination criteria for optimal solution of the Linear Programming Problem, Unique and alternate optimal solutions, Unboundedness; Simplex Algorithm and its Tableau Format; Artificial variables, Two-phase method, Big-M method. [1] Chapter 3 (Sections 3.3, and 3.6, 3.7, and 3.8) **Marks 15**

Unit 3: Motivation and Formulation of Dual problem; Primal-Dual relationships; Fundamental Theorem of Duality; Complimentary Slackness. [1] Chapter 4 (Sections 4.1 to 4.3) [1] Chapter 6 (Section 6.1, and 6.2, up to Example 6.4) **Marks 15**

Unit 4: Applications Transportation Problem: Definition and formulation; Methods of finding initial basic feasible solutions; North West corner rule. Least cost method; Vogel's Approximation method; Algorithm for solving Transportation Problem. Assignment Problem:

Mathematical formulation and Hungarian method of solving. Game Theory: Basic concept, Formulation and solution of two-person zero-sum games, Games with mixed strategies, Linear Programming method of solving a game. [3] Chapter 5 (Sections 5.1, 5.3, and 5.4) [2] Chapter 11 (Sections 11.12 and 11.13) **Marks 15**

Text Books:

1. Bazaraa, Mokhtar S., Jarvis, John J. and Sherali, Hanif D. (2010). Linear Programming and Network Flows (4th ed.). John Wiley and Sons.
2. Hadley, G. (1997). Linear Programming. Narosa Publishing House. New Delhi.
3. Taha, Hamdy A. (2010). Operations Research: An Introduction (9th ed.). Pearson.

Reference Books:

1. Hillier, Frederick S. & Lieberman, Gerald J. (2015). Introduction to Operations Research (10th ed.). McGraw-Hill Education (India) Pvt. Ltd.
2. Thie, Paul R., & Keough, G. E. (2014). An Introduction to Linear Programming and Game Theory. (3rd ed.). Wiley India Pvt. Ltd.

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SEM-VI

MAJ-MTH-6.1: Complex Analysis (including practical)

Total marks: 100: (Theory: 45, Internal Assessment: 30, Practical 25)

Course objective*:* The main objective of the course is to

- Give the idea of complex numbers, the complex plane , complex functions.
- Tto develop deep understanding of the topic with related concepts

Course Outcome: After going through the course students will able to learn

CO-1 About complex functions and their properties, the Cauchy-Riemann equations, conditions of continuity and differentiability of complex functions.

CO-2 Understanding of Cauchy integral formula.

CO-3 Learn some elementary functions and to evaluate contour integrals.

UNIT 1: Properties of complex numbers, regions in the complex plane, functions of complex variable, mappings. Derivatives, differentiation formulas, Cauchy-Riemann equations, sufficient conditions for differentiability. Limits, Limits involving the point at infinity, continuity. [1]: Chapter 1 (Section 11), Chapter 2 (Section 12, 13) Chapter 2 (Sections 15, 16, 17, 18, 19, 20, 21, 22) **Marks-10**

UNIT 2: Analytic functions, examples of analytic functions, exponential function, Logarithmic function, trigonometric function, derivatives of functions, definite integrals of functions. [1]:

Chapter 2 (Sections 24, 25), Chapter 3 (Sections 29, 30, 34), Chapter 4 (Section 37, 38)
Marks-10

UNIT 3: Contours, Contour integrals and its examples, upper bounds for moduli of contour integrals. [1]: Chapter 4 (Section 39, 40, 41, 43) **Marks-10**

UNIT 4: Antiderivatives, proof of antiderivative theorem, Cauchy-Goursat theorem, Cauchy integral formula. An extension of Cauchy integral formula, consequences of Cauchy integral formula, Liouville's theorem and the fundamental theorem of algebra. [1]: Chapter 4 (Sections 44, 45, 46, 50), Chapter 4 (Sections 51, 52, 53) Convergence of sequences and series, Taylor series and its examples. Laurent series and its examples, absolute and uniform convergence of power series, uniqueness of series representations of power series. [1]: Chapter 5 (Sections 55, 56, 57, 58, 59, 60, 62, 63, 66) **Marks-15**

LAB WORK TO BE PERFORMED ON A COMPUTER (MODELING OF THE FOLLOWING PROBLEMS USING MATLAB/ MATHEMATICA/ MAPLE ETC.)

1. Declaring a complex number and graphical representation. e.g. Z1 =3 + 4i, Z2 = 4 – 7i
2. Program to discuss the algebra of complex numbers, e.g., Z1 =3 + 4i, Z2 = 4 – 7i, then find Z1 + Z2, Z1 - Z2, Z1 * Z2 and Z1 / Z2
3. To find conjugate, modulus and phase angle of an array of complex numbers. e.g. Z = [2+ 3i, 4-2i, 6+11i, 2-5i]
4. To compute the integral over a straight line path between the two specified end points. e. g., Sin! !" , along the contour C which is a straight line path from -1+ i to 2 - i.
5. To perform contour integration., e.g., (i) (!! − 2! + 1)!" along the Contour C given by x = y2 +1; − 2 ≤ y ≤ 2 . (ii) (!! + 2!! + 1)!" along the contour C given by !! + !! = 1 , which can be 24 (iii) parameterized by x = cos (t), y = sin (t) for 0 ≤ y ≤ 2π.
6. To plot the complex functions and analyze the graph. e.g., (i) f(z) = z, iz, z2 , z 3 , ez and (z4 -1)1/4, etc. 7. To perform the Taylor series expansion of a given function f(z) around a given point z. The number of terms that should be used in the Taylor series expansion is given for each function. Hence plot the magnitude of the function and magnitude of its Taylors series expansion, e.g., (i) f(z) = exp(z) around z = 0, n =40 and (i) f(z) = exp(z2) around z = 0, n = 160.
7. To determines how many terms should be used in the Taylor series expansion of a given function f(z) around z = 0 for a specific value of z to get a percentage error of less than 5%. e.g., for f(z) = exp(z) around z =0, execute and determine the number of necessary terms to get a percentage error of less than 5 % for the following values of z: (i) z = 30 + 30i (ii) z = 10 +103 i
8. To perform Laurents series expansion of a given function f (z) around a given point z. e.g., (i) f(z)= (sin z -1)/z4 around z = 0 (ii) f(z) = cot (z)/z4 around z = 0.

Text Book:

1. James Ward Brown and Ruel V. Churchill, Complex Variables and Applications (Eighth Edition), McGraw – Hill International Edition, 2009.

Reference Book:

1. Joseph Bak and Donald J. Newman, Complex analysis (2nd Edition), Undergraduate Texts in Mathematics, Springer-Verlag New York, Inc., New York, 1997

MAJ-MTH-6.2: Number Theory& Vedic mathematics
Total Marks: 100 (Theory: 60, Internal Assessment: 40)

Course objective:

- To give the idea of various number system, focusing on integers, various properties and representation of integers,
- To understand the number theoretic analysis.
- To give some basic ideas of Vedic mathematics

Course outcome: After completion of this course, the students will be able to

CO-1 Learn different number theoretic functions, their applications.
CO-2 Learn different fascinating theorems in the field of number theory.
CO-3 Use the concept of primitive roots and indices for solvability of congruence of higher order.
CO-4 Explain the quadratic reciprocity law using Legendre's and Jacobi's symbol.
CO-5 Explain Fibonacci numbers and related identities.
CO-6 Able to have some idea about Vedic mathematics ,various algebraic operations used in Vedic period and their importance

UNIT 1: Division algorithm of integers, GCD, Euclidean algorithm, Linear Diophantine equation, statement of prime number theorem, linear congruence, Chinese Remainder theorem, Fermat's Little theorem, Wilson's theorem, Number theoretic functions, sum and number of divisors, totally multiplicative functions, the greatest integer function, Euler's phi function, Euler's theorem, some properties of Euler's phi-function. **Marks-15**

UNIT 2: Primitive roots: order of an integer mod m, primitive roots for primes, composite numbers having primitive roots, theory of indices. **Marks-10**

UNIT 3: Quadratic residues: Euler's criterion, Legendre's symbol and its properties, Quadratic Reciprocity Law, Fibonacci numbers and its related identities. **Marks-15**

UNIT 5: Origin of Vedic mathematics, Vedic sutras, sub sutras, addition, subtraction, multiplication and division of numbers by Vedic method Finding square and square root of rational numbers, Duplex method for finding square root. **Marks-20**

Text Books:

1) David M. Burton,Elementary Number Theory (Unit 1, 2, 3), McGraw Hill Education, 2017
2) G.E. Andrews,Number Theory (Unit 4), Dover Publications, 2012
3) Richard A Molin,Algebraic number theory,Chapman and Hall/CRC, 2011
4) The seeentials of VEDIC MATHEMATICS, by Rajesh kumar Thakur

5) Vedic mathematics for all, by Dr S K Kapoor

Reference Books:

1) I. Niven, H. S. Zuckerman and H. L. Montgomery,Introduction to Theory of Numbers, Wiley, 2008.

MAJ-MTH-6.3: Linear Algebra
Total Marks: 100 (Theory: 60, Internal Assessment: 40)

Course Objective: The main objective of learning the topic is to-

- Introduce students with fundamental theory of linear spaces
- To emphasizes the application of techniques using the adjoint of linear operator and minimal solutions to system of linear equations.

Course Outcome: After going through the course students will be able to –

CO-1 learn about linear space and their general properties, linear dependence and independence of vectors, bases, dimension of vector space etc.

CO-2 learn the basic concepts of linear transformations, matrix representation, change of coordinate matrix etc.

CO-3 Compute characteristic polynomials, Eigen values and Eigen vectors, properties related.

CO-4 Have an idea of inner product, orthogonality on vector spaces, orthogonal and orthonormal basis etc.

Unit 1: Vector spaces and subspaces, null space and column space of a matrix, linear transformations, kernel and range, linearly independent sets, bases, coordinate systems, dimension of a vector space, rank, and change of basis. [1]: Chapter 4 (Sections 4.1 – 4.7),

Marks-20

Unit 2: Eigenvectors and eigenvalues of a matrix, the characteristic equation, diagonalization, eigenvectors of a linear transformation, complex eigenvalues, [1]: Chapter 4 (Sections 5.1 – 5.5) Invariant subspaces and Cayley-Hamilton theorem. [2]: Chapter 5 (Section 5.4)

Marks-20

Unit 3: Inner product, length, and orthogonality, orthogonal sets, orthogonal projections, the Gram– Schmidt process, inner product spaces; Diagonalization of symmetric matrices, the Spectral Theorem. [1]: Chapter 6 (Sections 6.1 – 6.4, 6.7); Chapter 7 (Section 7.1).

Marks-20

Text Books:

1) David C. Lay, Linear Algebra and its Applications (3rd Edition), Pearson Education Asia, Indian Reprint, 2007.

2) Stephen H. Friedberg, Arnold J. Insel, Lawrence E. Spence, Linear Algebra (4th Edition), Prentice-Hall of India Pvt. Ltd., New Delhi, 2004.

Reference Books:

1) S. Kumaresan, Linear Algebra- A Geometric Approach, Prentice Hall of India,1999.
2) Gilbert Strang, Linear Algebra and its Applications, Thomson, 2007.
3) Kenneth Hoffman, Ray Alden Kunze, Linear Algebra, 2nd Ed., Prentice-Hall of India Pvt. Ltd., 1971.
4) G. Schay, Introduction to Linear Algebra, Narosa, 1997.

MAJ-MTH-6.4: Hydromechanics
Total Marks: 100: (Theory: 60, internal assessment: 40)

Course objective: The main aim of the objective of the topic is to -

- Give idea about mechanics behind the fluid and properties related whether they are in static or in motion.

Course outcomes: After going through the topic the students will be able to –

CO-1 Learn the basic ideas behind hydro- mechanics and related principles.

CO-2 Use the idea of hydrostatics and hydromechanics in the practical field**.**

Unit 1: Hydrostatics Pressure equation, condition of equilibrium, lines of force, homogeneous and heterogeneous fluids, elastic fluids, surface of equal pressure, fluid at rest under action of gravity, rotating fluids. Fluid pressure on plane surfaces, centre of pressure, resultant pressure on curved surfaces. Gas law, mixture of gases, internal energy, adiabatic expansion. [1] Voll-I Chapter 1-4(related sections only). **Marks-40**

Unit 2: Hydrodynamics Real and ideal fluid, velocity of a fluid at a point, Eulerian and Lagrangian method, stream lines and path lines, steady and unsteady flows, velocity potential, rotational and irrotational motions, material local, convective derivatives, local and particle rate of change, equation of continuity in Cartesian and polar form, , acceleration of a fluid particle in Cartesian and polar form ,boundary surface and examples. [1] Vol-II Chapter 1 **Marks-20**

Text Book:

1) Besant, W. H., Ramsey, A. S., A Treatise on Hydromechanics. (Part I & part II), G.Bell And Sons Limited. CBS Publication 1988(Indian print).

Reference Books:

1) H. Lamb, Hydrodynamics, University Press

2) F. Chorlton, Fluid dynamics, CBS Publisher First Edition 1985

MINOR–VI (Choose any one)

MIN-MTH-6.1: Programming in C (including practical)
Total Marks: 100 (Theory 45, Internal Assessment 30, Practical 25)

Course objective: The main objective of learning the course is to –

- Introduce the students with basic ideas of computer language, high level programming language like C, C^+ etc. And for programming with this language.

Learning outcome: After going through the topic students-

CO-1 Will have an idea about computer programming language like C,C^+ etc.

CO-2 They will be able to apply these ideas in various practical problems through computer.

Unit 1: Variables, constants, reserved words, variable declaration, initialization, basic data types, operators and expression (arithmetic, relational, logical, assignment, conditional, increment and decrement), hierarchy of operations for arithmetic operators, size of and comma operator, mixed mode operation and automatic (implicit) conversion, cast (explicit) conversion, library functions, structure of a C program, input/output functions and statements.

Marks:20

Unit 2: Control Statements: if-else statement (including nested if-else statement), switch statement. Loop control Structures (for and nested for, while and do-while). Break, continue, go to statements, and exit function. **Marks-15**

Unit 3: Arrays and subscripted variables: One- and Two-dimensional array declaration, accessing values in an array, initializing values in an array, sorting of numbers in an array, addition and multiplication of matrices with the help of array. Functions: function declaration, actual and formal arguments, function prototype, calling a function by value, recursive function.

Marks-10

Programmes for practical:

To find roots of a quadratic equation, value of a piecewise defined function (single variable), factorial of a given positive integer, Fibonacci numbers, square root of a number, cube root of a number, sum of different algebraic and trigonometric series, a given number to be prime or not, sum of the digits of any given positive integer, solution of an equation using N-R algorithm, reversing digits of an integer. Sorting of numbers in an array, to find addition, subtraction and multiplication of matrices. To find sin(x), cos(x) with the help of functions. [1] Chapters"3,"4,"5,"6,"7"and"9

Text Book:

1) T. Jeyapoovan, A First Course in Programming with C T. Jeyapoovan, Vikash Publishing House Pvt.Ltd.

Reference books:

1) E. Balaguruswamy, Programming with C, Schaum Series.
2) Y. Kanetkar, Let us C, B.P. Publication.

MIN-MTH- 6.2 Discrete Mathematics
Total Marks: 100 (Theory: 60, Internal Assessment: 40)

Course Objective: The main objective of learning the topic is to –

- Give idea of sets; perform operations and algebra on sets.
- To give logical idea of thinking through reasoning, analyzing etc.

Course outcome: After going through the course students will be able-

CO-1 To have idea of sets and set operations, algebra on sets.

CO-2 They will have idea how to think logically through reasoning, analyzing.

CO-3 Learn the field of application of discrete mathematics in practical field in modern digital technology.

Unit-1: Definition, examples and basic properties of ordered sets, maps between ordered sets, duality principle, and lattices as ordered sets, lattices as algebraic structures, sub lattices, products and homomorphisms. **Marks: 20**

Unit-2: Definition, examples and properties of modular and distributive lattices, Boolean algebras, Boolean polynomials, minimal forms of Boolean polynomials, Quinn McCluskey method, Karnaugh diagrams, switching circuits and applications of switching circuits.

Marks: 20

Unit-3: Definitions, examples and basic properties of graph, pseudographs, complete graphs, bipartite graphs, isomorphism of graphs, paths and circuits, Eulerian circuits, Hamiltonian cycles, the adjacency matrix, weighted graph, travelling salesman's problem, shortest path, Dijkstra's algorithm, Floyd-Warshall algorithm.

Marks: 20

Text Books:

1) B. A. Davey and H. A. Priestley, Introduction to Lattices and Order, Cambridge University Press, Cambridge, 1990.
2) Edgar G. Goodaire and Michael M. Parmenter, Discrete Mathematics with Graph Theory (2nd Edition), Pearson Education (Singapore), Pte. Ltd., Indian Reprint 2003.

3) Rudolf Lidl and Gunter Pilz, Applied Abstract Algebra (2nd Edition), Undergraduate Texts in Mathematics, Springer (SIE), Indian Reprint, 2004.

DEPARTMENT OF MATHEMATICS
RABINDRANATH TAGORE UNIVERSITY, HOJAI
CURRICULUM FOR FOURTH YEAR (Seventh and Eighth semester): As per NEP2020.

VII & VIII Semester

Semester	Course	Papers	Credits
VII	MAJOR	MAJ-MTH-7.1:Research Methodology MAJ-MTH -7.2:Programming in C MAJ-MTH -7.3: Rigid dynamics ***** MAJ-MTH -7.4: Mathematical Methods	4x4=16
	MINOR-VII	(Choose one) MIN-MTH-7.1:Differential equations MIN-MTH-7.2:Mechanics	4
	Dissertation	In lieu of * MAJ-MTH -7.4, For students Honours with research	4
			Total:20
VIII	MAJOR	MAJ-MTH-8.1:Real analysis and Lebesgue measure MAJ-MTH-8.2: Complex Analysis ***** MAJ-MTH-8.3:Topology ***** MAJ-MTH-8.4: Differential equations	4x4=16
	MINOR-VIII	(Choose one) MIN-MTH-8.1:Numerical Analysis MIN-MTH-8.2: Linear Algebra	4
	Dissertation	In lieu of MAJ-MTH-8.3 & 8.4, For Honours students with research	4+4=8
			Total:20

MAJ-MTH-7.1: Research Methodology
Total Marks: 100 (Theory: 60, Internal: 40)

Course objectives:
The aim of the course is to give a brief idea about research objectives, observations, formulas used, and its findings, analyzing and testing of results and prepare report**.**

Course Outcome: *After completion of this course, the students will be able to:*

CO-1 *The different steps involving in research;*
CO-2 *Identify and formulate research problems;*
CO-3 *Write a good research proposal;*
CO-4 *Collect, analyse and interpret data;*
CO-5 *Apply appropriate tools, techniques and methods;*
CO-6 *Write a research report.*

Unit 1: Introduction to Research Methodology **12 Marks**

Motivation and objective of research, Types of research: Descriptive vs. Analytical, Applied vs. Fundamental, Quantitative vs. Qualitative, and Conceptual vs. Empirical, Research methods vs. Methodology, Research process, Criteria of good research.

Unit 2: Formulating the Research Problem **12 Marks**

Defining and formulating a research problem, Selection of the problem, Necessity of defining the problem, Literature review and its importance in defining a problem, Primary and secondary sources , Web as a source , Searching the web , Critical literature review, Identifying gap areas from literature review, Development of working hypothesis.

Unit 3: Research design **12 Marks**

Research design and method, Basic Principles of research design, Need of research design, Features of good design, Important concepts relating to research design, Developing a research plan - Exploration, Description, Diagnosis and Experimentation.

Unit 4: Data collection and analysis **12 Marks**

Collection of primary data, Observation and Interview method, Data collection through Questionnaires and schedule and their differences, Sampling designs, Steps in Sampling Design, Criteria of Selecting a Sampling Procedure, Characteristics of a Good Sample Design, Different Types of Sample Designs, Hypothesis, Testing.

Unit 5: Report writing and Presentation **12 Marks**

Significance of Report Writing, Different Steps in Writing Report, Layout of the Research Report, Types of Reports, Mechanics of Writing a Research Report , Precautions for Writing Research Reports, Oral and Poster Presentation, Use of visual aids, Importance of effective communication in presentation.

Text Books:

1. C.R. Kothari, Research Methodology- Methods and Techniques, New Age International, 2nd Edition. New Delhi (2013).
2. Ranjit Kumar, Research Methodology: A Step-by-Step Guide for Beginners, 3rd Edition, SAGE Publication (2010).

Reference Books:

1. Y.K.Singh and R.B.Bajpai, Research Methodology-Techniques and Trends, APH. Publishing, 2nd Edn., New Delhi (2007).
2. B.L. Garg, R. Karadia, F. Agarwal, and U.K. Agarwal, An introduction to Research Methodology, RBSA Publishers (2002).

MAJ-MTH-7.2: Programming in C (including practical)
Total Marks: 100 (Theory -45, Practical- 25, Internal Assessment -30)

Course Objectives: The main objective of the course is to introduce C programming in the idiom and context of mathematics and imparts a starting orientation using available mathematical libraries, and their applications.

Course Outcomes:

CO-1 After completion of this paper, students will be able to:
CO-2 Understand and apply the programming concepts of C which is important to mathematical investigation and problem solving.
CO-3 Learn about structured data types in C and learn about applications in factorization of an integer and understanding Cartesian geometry and Pythagorean triples.
CO-4 Use of containers and templates in various applications in algebra.
CO-5 Use mathematical libraries for computational objectives.
CO-6 Represent the outputs of programs visually in terms of well-formatted text and plots.

Unit 1: Variables, constants, reserved words, variable declaration, initialization, basic data types, operators and expression (arithmetic, relational, logical, assignment, conditional, increment and decrement), hierarchy of operations for arithmetic operators, size of and comma operator, mixed mode operation and automatic (implicit) conversion, cast (explicit) conversion, library functions, structure of a C program, input/output functions and statements. **15 Marks**

Unit 2: Control Statements: if-else statement (including nested if-else statement), switch statement. Loop control Structures (for and nested for, while, and do-while). Break, continue, go to statements, and exit function. **15 Marks**

Unit 3: Arrays and subscripted variables: One and Two-dimensional array declaration, accessing values in an array, initializing values in an array, sorting of numbers in an array, addition and multiplication of matrices with the help of an array. Functions: function declaration, actual and

formal arguments, function prototype, calling a function by value, recursive function.

15 Marks

Programs for practical: **25 Marks**

To find roots of a quadratic equation, value of a piecewise-defined function (single variable), factorial of a given positive integer, Fibonacci numbers, square root of a number, cube root of a number, sum of different algebraic and trigonometric series, a given number to be prime or not, sum of the digits of any given positive integer, solution of an equation using N-R algorithm, reversing digits of an integer. Sorting of numbers in an array, to find addition, subtraction, and multiplication of matrices. To find sin(x), cos(x) with the help of functions. [1] Chapters 3, 4, 5, 6, 7 and 9.

Text Book:

1. T. Jeyapoovan, A First Course in Programming with C T. Jeyapoovan, Vikash Publishing House
Pvt.Ltd.

Reference books:

1. E. Balaguruswamy, Programming with C, Schaum Series.
2. Y. Kanetkar, *Let us C*, B.P. Publication.

MAJ-MTH-7.3: Rigid Dynamics
Total Marks 100 (Theory: 60, Internal Assessment: 40)

Course objective: The main objective of the topic is to –

- Idea of rigid bodies and principles behind them.
- Motion of rigid body related laws.

Course outcome: After going through the topic students will be able to –

CO-1 Have an idea about rigid body and principles behind them

CO-2 Have the idea about various effect of force during steady position and motion of rigid body and related laws.

CO-3 They will be able to apply the principles behind the rigid body to their day to day practical life.

Unit 1: Moments and products of inertia, parallel axes theorem, theorem of six constants, the momental ellipsoid, equimomental systems, principle axes. **Marks-15**

Unit 2: D'Alembert's principle, the general equation of motion of a rigid body, motion of the centre of inertia and motion relative to the centre of inertia. **Marks-15**

Unit 3: Motion about a fixed axis, the compound pendulum, centre of percussion. Motion of a body in two dimension under finite and impulsive forces. **Marks-15**

Unit 4: Conservation of momentum and energy, generalized coordinates, Lagrange's equations, initial motions. [1] Chapter -11-18 (related sections only) **Marks-15**

Text Book: 1. S.L. Loney, An elementary treatise on the Dynamics of a particle and of Rigid bodies, Cambridge University Press Kindle Edition August 2018.

Reference Book: 1. A.S. Ramsey, Dynamics Part I, Cambridge University Press; 1 edition, 1952

* MAJ-MTH-7.4: Mathematical Methods
Total Marks: 100 (Theory: 60, Internal Assessment: 40)

Course objective:

- To give some ideas about integral equations, their various types and their applications
- To give idea of integral transform and their applications
- To give idea about Laplace equation their applications

Course outcome:

CO-1 After going through the course students will be able to have some ideas about integral equations their applications in various problems.

CO-2 More over after going through the course students will have idea about integral transform of equations, Laplace equations their properties and applications in various mathematical problems.

Unit 1: **Integral Equations**:
Fredholm Integral Equations: Definition of Integral Equation, Reduction of ordinary differential equations into integral equations. Fredholm integral equations with separable kernels, Eigen values and Eigen functions, Method of successive approximation, Iterative scheme for Fredholm Integral equations of second kind Volterra Integral Equations: Volterra Integral Equations of second kind, Resolvent kernal of Volterra equation and its results, Application of iterative scheme to Volterra equation of the second kind, Convolution type kernels. **Marks-15**

Unit 2: **Integral Transforms**:
Fourier Transform: Fourier Integral Transform. Properties of Fourier Transform, Fourier sine andcosine transforms, Application of Fourier transform to ordinary and partial differential equations of initial and boundary value problems. Evaluation of definite integrals.
Marks-15

Unit 3: Laplace Transform: Basic properties of Laplace Transform, Convolution theorem and properties of Convolution, Inverse Laplace Transform. Application of Laplace Transform to solution of ordinary and partial differential equations of initial and boundary value problems, Evaluation of definite integrals. The inversion theorem, Evaluation of inverse transforms by residue method. **Marks-15**

Unit 4: Calculus of variations: Calculus of variation with one independent variable, Basic ideas of Calculus of variations, Euler's equation with fixed boundary of the functional containing only

the first order derivative of the only dependent variable with respect to one independent variable, Variational problems with functional having higher order derivatives of the only dependent variable, general case of Euler's equation, applications Calculus of Variation with several independent variables: Variational problems with functional dependent on functions of several independent variables having first order derivatives. Variational problems in parametric form, Variational problems with subsidiary condition: Isoperimetric problems, Applications.

Marks-15

Text Books:

1. R. P. Kanwal, Linear Integral Equations, Theory and Techniques, Academic Press, New York, 1971
2. M. R. Spiegel, Schaum's Outline Series: Theory and Problems of Laplace Transforms, McGraw-
Hill Book Company, 1965
3. A. S. Gupta, Calculus of variation with Applications : Prentice Hall of India, 1999

Reference Books:

1. S. G. Mikhlin, Linear Integral Equations (Translated from Russia), Hindustan Book Agency, 1960
2. F. B. Hilderbrand, Methods of Applied Mathematics, Dover Publications, 1992
3. R. Courant and D. Hilbert, Methods of Mathematical Physics- Vol- I, Wiley Interscience, New York 1953.

NOTE: Dissertation in lieu of MAT-MAJ-7.4

MINOR (Choose one)
MIN-MTH-7.1: Differential Equations
Total Marks: 100(Theory: 60, Internal Assessment: 40)

Course Objectives:

The main objective of this course is to introduce the students to the exciting world of differential equations and their solutions methods also about their applications.

Course Outcomes: The course will enable the students to:

CO-1 Learn basics of differential equations, formation of differential equation and methods for solving.

CO-2 They will learn how to apply the idea of differential equations in practical problems.

Unit 1: First Order Ordinary Differential Equations:

Degree and order of differential equations, formation of differential equation, solution of differential equation. First order exact differential equations, Integrating factors, Rules to find an integrating factor. Linear equations and Bernoulli equations, Orthogonal trajectories and oblique trajectories; Basic theory of higher order linear differential equations, Wronskian, and its properties; Solving differential equation by reducing its order. [2] Chapter 2 (Sections 2.3, and 2.4), Chapter 3 (Section 3.1), and Chapter 4 (Section 4.1). **Marks-30**

Unit 2: Second Order Linear Differential Equations
Linear homogenous equations with constant coefficients, linear non-homogenous equations, the method of variation of parameters, The Cauchy-Euler equation; Simultaneous differential equations. **Marks-30**

Text Books:
1. Kreyszig, Erwin (2011). *Advanced Engineering Mathematics* (10th ed.). John Wiley &Sons, Inc. Wiley India Edition 2015.
2. Ross, Shepley L. (1984). *Differential Equations* (3rd ed.). John Wiley & Sons, Inc.

MIN-MTH-7.2: Mechanics
Total Marks: 100: (Theory: 60, Internal Assessment: 40)

Course Objectives: The course aims at understanding the various concepts of physical quantities and the related effects on different bodies using mathematical techniques. It emphasizes knowledge building for applying mathematics in physical world.

Course Outcomes: The course will enable the students to:

CO-1	Know about the concepts in statics such as moments, couples, and equilibrium in both two and three dimensions.
CO-2	Understand the theory behind friction and center of gravity.
CO-3	Know about conservation of mechanical energy and work-energy equations.
CO-4	Learn about translational and rotational motion of rigid bodies.

UNIT 1: Composition and resolution of forces, Parallelogram of forces, Triangle of forces, Converse of triangle of forces, Lami's Theorem, Parallel forces, Moment of a force about a point and an axis. Couple, Resultant of a system of forces. Equilibrium of coplanar forces. Friction, C.G of an arc, plane area, surface of revolution, solid of revolution. **Marks-30.**

UNIT 2: Velocities and acceleration along radial and transverse directions and along tangential and normal directions, motion in a straight line under variable acceleration, simple harmonic motion and elastic string. Newton's law of motion. Work, Energy and momentum, Conservative forces-Potential energy, Impulsive forces, Motion of a Projectile, Motion in resisting medium. **Marks-30.**

Text Book:
1. S. L. Loney, The elements of Statics and Dynamics (Vol I & II) Publisher Arihant, 4th Edition 2014.
2. F. Charlton, Textbook of Dynamics, CBS, Publications 2nd Edition, 1985
Reference books:
1. A.S. Ramsay, Statics, Cambridge University Press, publication year: 2009
2. A.S. Ramsay, Dynamics, Cambridge University Press, publication year: 2009
3. M. R. Spiegel, Theoretical Mechanics, Schaum Series 2010.

SEM-VIII

MAJ-MTH-8.1: Real Analysis and Lebesgue Measure
Total Marks: 100 (Theory: 60, Internal Assessment: 40)

Course objective:

- *The main objective of the course is -to give a brief idea about real functions, sequence of real functions, their convergence and divergence criteria*
- *Introduce with Lebesgue measure, measurable functions, lebesgue integral, etc.*

Course outcome: After completing this course, the student will understand

CO-1 How Lebesgue measure on R is defined, how measures may be used to construct. integrals,

CO-2 The basic convergence theorems for the Lebesgue integral, the relation between Series and the Hilbert space of square-integrable functions.

CO-3 Have familiarity with common examples and counterexamples, knowledge of the content of the major theorems, understanding of the ideas in their proofs, and ability to make direct application of those results to related problems.

CO-4 Get the knowledge in sequences of functions and their uniform convergence and get the idea about how to find out the region of convergence of power series.

CO-5 Develop the core skills of the subject and research skills in these areas.

Unit 1: Uniform convergence of a sequence of functions at an interval, Cauchy's criterion, Test for uniform convergence, properties of uniformly convergent sequences and series of functions, results related to uniform convergence with continuity, integration, and differentiation, Weirstrass's approximation theorem, Power series, radius of convergence, Abel's and Tauber's theorem, Fundamental properties. **Marks-15**

Unit 2: Vector-valued function, continuity, differentiation, Functions of bounded variation, their continuity, and monotonicity, Definition, existence of R-S integral, Properties of R-S integral, integration and differentiation, Fundamental theorem of calculus, Integration of vector-valued functions. **Marks-15**

Unit 3: Lebesgue outer measure, Measurable sets, and properties, Borel sets and their measurability, Characterization of measurable sets, Non-measurable sets, Measurable functions and their properties, Operations of measurable functions, Sets of measure zero, Sequence of measurable functions, Convergence in measure. **Marks-15**

Unit 4: Lebesgue integral, Lebesgue integral of a bounded function, Comparison of Riemann integral and Lebesgue integral, Integral of a non-negative measurable function, General Lebesgue integral, Convergence of Lebesgue integral, Bounded convergence theorem, Monotone convergence theorem, Lebesgue convergence theorem. **Marks-15**

Text Books:

1. S.C. Malik and SavitaArora, Mathematical Analysis, New Age International Private Limited, 2017
2. H.L. Royden, Real Analysis, Prentice Hall of India, 2011
3. P.K. Jain and V.P. Gupta, Lebesgue Measure and Integration, Anshan Ltd., 2012

Reference Books:

1. W. Rudin, Principles of Mathematical Analysis, McGraw-Hill Education, 1976
2. R.R. Goldberg, Methods of Real Analysis, Oxford and IBH Publishing, 2012.

MAJ-MTH-8.2: Complex Analysis (including practical)
Total marks: 100: (Theory: 45, Practical 25, Internal Assessment: 30)

Course Objectives:
This course aims to introduce the basic ideas of analysis for complex functions with visualization through relevant practicals. Emphasis has been given on Cauchy's theorems, series expansions and calculation of residues.

Course Outcomes:

CO-1 Completion of the course will enable the students to:

CO-2 Learn the significance of the differentiability of complex functions leading to the understanding of

CO-3 Cauchy−Riemann equations.

CO-4 Learn some elementary functions and evaluate the contour integrals.

CO-5 Understand the role of the Cauchy−Goursat theorem and the Cauchy integral formula.

CO-6 Expand some simple functions as their Taylor and Laurent series, classify the nature of singularities, find residues, and apply the Cauchy Residue theorem to evaluate integrals.

UNIT 1: Properties of complex numbers, regions in the complex plane, functions of complex variables, and mappings. Derivatives, differentiation formulas, Cauchy-Riemann equations, sufficient conditions for differentiability. Limits, Limits involving the point at infinity, continuity. [1]: Chapter 1 (Section 11), Chapter 2 (Section 12, 13) Chapter 2 (Sections 15, 16, 17, 18, 19, 20, 21, 22) **Marks-10**

UNIT 2: Analytic functions, examples of analytic functions, exponential function, Logarithmic function, trigonometric function, derivatives of functions, and definite integrals of functions.[1]: Chapter 2 (Sections 24, 25), Chapter 3 (Sections 29, 30, 34),Chapter 4 (Section 37, 38) **Marks-10**

UNIT 3: Contours, Contour integrals and its examples, upper bounds for moduli of contour integrals. [1]: Chapter 4 (Section 39, 40, 41, 43) **Marks-10**

UNIT 4: Antiderivatives, proof of ant derivative theorem, Cauchy-Goursat theorem, Cauchy integral formula. Liouville's theorem and the fundamental theorem of algebra.[1]: Chapter 4 (Sections 44, 45, 46, 50), Chapter 4 (Sections 51, 52, 53). Convergence of sequences and series, Taylor series and its examples. Laurent series and its examples, absolute and uniform convergence of power series**.** [1]: Chapter 5 (Sections 55, 56, 57, 58, 59, 60, 62, 63, 66) **Marks-15**

LAB WORK TO BE PERFORMED ON A COMPUTER:
(MODELING OF THE FOLLOWING PROBLEMS USING MATLAB/ MATHEMATICA/ MAPLE ETC.)

1. Declaring a complex number and graphical representation. e.g. Z1 =3 + 4i, Z2 = 4 – 7i

2. Program to discuss the algebra of complex numbers, e.g., Z1 =3 + 4i, Z2 = 4 – 7i, then find Z1 + Z2, Z1 - Z2, Z1 * Z2 and Z1 / Z2.
3. To find the conjugate, modulus, and phase angle of an array of complex numbers. e.g. Z = [2+ 3i, 4-2i, 6+11i, 2-5i]
4. To compute the integral over a straight-line path between the two specified endpoints. e.g., Sin, along the contour C which is a straight-line path from -1+ i to 2 - i.
5. To perform contour integration., e.g.,
   (i) $(z! - 2z + 1)$ along the Contour C given by x = y2 +1; $-2 \leq y \leq 2$.
   (ii) $(z! + 2z! + 1)$ along the contour C given by $x! + y! = 1$, which can be
   (iii) parameterized by x = cos (t), y = sin (t) for $0 \leq y \leq 2\pi$.
6. To plot the complex functions and analyze the graph. e.g.,
   (i) f(z) = z, iz, z2, z3, ez and (z4-1)1/4, etc.
7. To perform the Taylor series expansion of a given function f(z) around a given point z.
8. The number of terms that should be used in the Taylor series expansion is given for each
9. function. Hence plot the magnitude of the function and magnitude of its Taylor series
10. expansion, e.g.,
    (i) f(z) = exp(z) around z = 0, n =40 and
11. f(z) = exp(z2) around z = 0, n = 160.
12. To determines how many terms should be used in the Taylor series expansion of a given function f(z) around z = 0 for a specific value of z to get a percentage error of less than 5%. e.g., for f(z) = exp(z) around z =0, execute and determine the number of necessary terms to get a percentage error of less than 5 % for the following values of z:
    (i) z = 30 + 30i (ii) z = 10 +103 i
13. To perform Laurents series expansion of a given function f(z) around a given point z. e.g.,
    (i) f(z)= (sin z -1)/z4 around z = 0 (ii) f(z) = cot (z)/z4 around z = 0.

Text Book:

1. James Ward Brown and Ruel V. Churchill, Complex Variables and Applications (Eighth Edition), McGraw–Hill International Edition, 2009.

Reference Book:

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

* MAJ-MTH-8.3: Topology
Total Marks: 100 (Theory: 60 Internal Assessments: 40)

Course objective:
The main objective of the course is to introduce with topological space, their geometrical interpretations, and their applications in different fields.

Course outcome: After going through the course students will have got ideas -

- **CO-1** to identify topological spaces and will be familiar with different types of subsets like open sets, closed sets, neighborhoods, interior, boundary, derived sets, etc. together with the ideas of bases, sub-bases, relative topology, continuous functions, and homeomorphisms.
- **CO-2** They can be able to classify different spaces like first countable, second countable, and separable spaces and give the characterization of these spaces using some important results like Urysohn's lemma, and Tietze extension theorem.
- **CO-3** To use the idea of compactness and connectedness and give their different characterizations.
- **CO-4** To explain the product topology and its relationship with compactness, connectedness,
- **CO-5** countability, etc. They can also provide examples of metrizable spaces and can explain the
- **CO-6** relationship between embedding and metrization.

Unit 1: Definition and examples of topological spaces, closed sets, closure, Dense subsets, Neighbourhood, Interior, Exterior and Boundary, Accumulation Points and Derived sets, Bases and sub bases. Sub base and Relative Topology, Continuous Functions and Homeomorphism. **10 Marks**

Unit 2: Countable and uncountable sets, First and second Countable spaces, Lindelof's theorem, Separable spaces, Second Countability and Separability. **10 Marks**

Unit 3: Separation Axioms T0, T1, T2, T31/2 , T4 ; their characterizations and basic properties, Urysohn's Lemma, Tietze Extension Theorem. **10 Marks**

Unit 4: Compactness, continuous functions and compact sets. Basic properties of compactness, Compactness and finite intersection property, sequentially and countably compact sets, Local Compactness and one point compactification. Stone-Cech Compactification, Compactness in metric spaces, Equivalence of compactness, Countable compactness and sequential compactness in metric spaces. **10 Marks**

Unit 5: Connected spaces, connectedness on the real line, components, totally disconnected spaces, Locally connected spaces. **10 Marks**

Unit 6:Tychonoff product topology in terms of standard subbase and its characterizations, Project Maps,Separation Axioms and Product Spaces, Connectedness and Product spaces, Compactness and Product Spaces (Tychonoff's) Theorem, Countability and Product Spaces, Embedding and Metrization, Urysohn Metrization theorem. **10 Marks**

Text Books:

1. J. R. Munkres, Topology: A first course, Prentice Hall of India, 1974
2. G. F. Simmons, Introduction to Topology and Modern Analysis, McGraw Hill, 2017

Reference Books:

1. K.D. Joshi, Introduction to General Topology, New Age International Private Limited, 2017
2. J. Dugundji, Topology, Allyn and Bacon, 1966 (Reprinted in India By PHI)
3. J. Hocking and G. Young, Topology, Addison Wiley Reading, 1961
4. L. A. Steen and J. A. Seebach, Counter Examples in Topology, Dover Publications, 1995.

* MAJ-MTH-8.4: Differential Equation
Total Marks: 100 (Theory: 60, Internal Assessment: 40)

Course objective:

- To introduce with various forms of differential equations.
- Introduce with partial differential equations.
- Introduce with various methods of solving differential equations.
- Introduce with applications of differential equation in various fields.

Course outcome: After completion of the course students will learn –

CO-1 The various forms of differential equations and to find solutions of them.

CO-2 To Explain and able to apply whether a differential equation has a unique solution or not

CO-3 In dealing with solution in series, great prominence has been found to the method of Frobenius

CO-4 To handle partial differential equations with different methods mainly Charpit's and the Jacobi's method

CO-5 The subject Partial Differential equations have wide range of applications in engineering and technological sciences. Using Partial Differential equations, students can solve wave equations, heat equations, Laplace equations etc.

CO-6 Laplace equation that can be solved by Partial Differential Equation is used in real life situations such as electrostatics, gravitation, steady state flow of inviscid fluids, steady state heat conduction etc.

CO-7 Using Partial Differential Equations students can formulate other mathematical applications such as semiconductor modeling, mathematical models in biology, astrophysics, etc.

CO-8 The students can apply Partial Differential Equations in medical sciences such as Kidney dialysis, blood circulation systems, etc.

Unit 1: Well-posed problems, Existence, uniqueness, and continuity of solution of ODEs of the first order, Picard's method, Existence and uniqueness of the solution of simultaneous differential equations of the first order, Sturm separation and comparison theorems, Homogeneous linear systems, Non-homogeneous Linear systems. Variation of Parameters. **10 Marks**

Unit 2. Linear homogeneous differential equation-Ordinary and singular points, Series solution, Method of Frobenius. Solutions of Bessel's and Legendre's equations. **10 Marks**

Unit 3: Two-point boundary value problems, Green's function, Construction of Green's function, Sturm Liouville systems, Eigen values and eigen functions, Stability of autonomous system of differential equations, Critical point of an autonomous system and their classification

as stable, Asymptotically stable, Strictly stable and unstable, Stability of linear systems with constant coefficients, Linear plane autonomous systems, Perturbed systems, Method of Lyapunov for nonlinear systems. **15 Marks**

Unit 4: First order PDE: Characteristics of a linear first order PDE. Cauchy's problem; Solution of nonlinear first order P.D.E. by Cauchy's method of characteristics. **15 Marks**

Unit 5: Second order linear PDE-Classification, General solution of higher order PDE with constant Coefficients. Method of Characteristics. Classification of quasi-linear equations. **10 Marks**

Text Books:

1. S.L. Ross, Differential Equations, Second Edition, John Wiley & Sons, India, 2007.
1. I. N. Sneddon, Elements of Partial Differential Equations, Mcgraw Hill 2006
2. W. E. Williams, Partial Differential Equations, Oxford University Press, 1980
3. F. H. Miller, Partial Differential Equations, J. Wiley & Sons; London, Chapman & Hall, 1941.
4. K.S. Rao, Introduction to partial differential equations, Prentice Hall, New Delhi, 1997.
5. A. Sommerfeld, Partial differential equations in physics, Academic Press, New York, 1967.
6. I. Stakgold, Green's functions and boundary value problems, Wiley, New York, 1979.

Reference Books:

1. Lawrence C. Evans, Partial DifferentialEquations, Second Edition, American Mathematical Society, 2014.
2. Erich Zauderer, Partial Differential Equations of Applied Mathematics, A Wiley- Interscience Publication, John Wiley and Sons, 1983.
3. H.F. Weinberger, A first course in partial differential equations, Blaisdell, 1965.
4. C.R. Chester, Techniques in partial differential equations, McGraw Hill, New York, 1971.
5. R. Courant and D. Hilbert :Methods of Mathematical Physics: Partial differential equations, Vol – II, Wiley-VCH, 1989

NOTE: Dissertation in lieu of MAT-MAJ-8.3 &8.4

MINOR (Choose one)
MIN-MTH-8.1: Numerical Methods
Total marks: 100: (Theory: 60, Internal Assessment: 40)

Course Objectives: To comprehend various computational techniques to find approximate value for possible root(s) of non-algebraic equations and to find the approximate solutions of system of linear equations and ordinary differential equations.

Course Learning Outcomes: The course will enable the students to:

- **CO-1** Learn some numerical methods to find the zeroes of nonlinear functions of a single variable and solution of a system of linear equations, up to a certain given level of precision.
- **CO-2** Know about methods to solve system of linear equations, such as false position method, fixed point iteration method, Newton's method, Secant method.
- **CO-3** Interpolation techniques to compute the values for a tabulated function at points not in the table.

CO-4 Applications of numerical differentiation and integration to convert differential equations into difference equations for numerical solutions.

Unit:1 Normalized floating point representation of real numbers and operations using it, normalization and its consequence, errors in arithmetic operations, absolute and relative error, truncation and round off errors, approximation and significant figures. **Marks-15**

Unit:2 Calculus of finite difference: Different interpolation formulae with remainder terms, finite difference operators and the operation on function of single variable, interpolation with equal and unequal intervals, Newton's formulae, Lagrange's formula,Gauss,Bessel and Starling's formula. **Marks-15**

Unit:3 Numerical differentiation and integration : Numerical differentiation with the help of different interpolation formulae, General Quadrature formula, Trapezoid rule,Simpson's one third and three eight rule,Weddels rule. **Marks-15**

Unit: 4 Solutions of polynomial and transcendental equations: Bisection method, secant method, regular falsi method, fixed point iteration method, Newton's method. **Marks-15**

Text Books:
1. Numerical methods, By S.Balachandra Rao and C.K Santha,Univ.Press
2. B. Bradie, *A Friendly Introduction to Numerical Analysis*, Pearson Education, India, 2007.

Reference Book:
1. Numerical methods for Mathematics, Science and Engineering, By J.H.Mathews.
2. Finite differences and Numerical Analysis, By H.C.Saxena, S.Chand co.

MIN-MTH-8.2: Linear Algebra
Total Marks: 100: (Theory 60 Internal Assessment: 40)

Course Objectives: The objective of this course is to introduce the fundamental theory of vector spaces, also emphasizes the application of techniques using the adjoint of a linear operator and their properties to least squares approximation and minimal solutions to systems of linear equations.

Course Outcomes: The course will enable the students to:

CO-1 Learn about the concept of linear independence of vectors over a field, and the dimension of a vector space.

CO-2 Basic concepts of linear transformations, dimension theorem, matrix representation of a linear

CO-3 transformation and the change of coordinate matrix.

CO-4 Compute the characteristic polynomial, eigenvalues, eigenvectors, and eigenspaces, as well as the geometric and algebraic multiplicities of an eigenvalue and apply the basic diagonalization result.

CO-5 Compute inner products and determine orthogonality on vector spaces, including Gram−Schmidt orthogonalization to obtain an orthonormal basis.

CO-6 Find the adjoint, normal, unitary, and orthogonal operators.

Unit 1: Vector spaces and subspaces, null space and column space of a matrix, linear transformations, kernel and range, linearly independent sets, bases, coordinate systems, dimension of a vector space, rank, change of basis.[1]: Chapter 4 (Sections 4.1 – 4.7)

Marks-20

Unit 2: Eigenvectors and eigenvalues of a matrix, the characteristic equation, diagonalization, eigenvectors of a linear transformation, complex eigenvalues,[1]: Chapter 4 (Sections 5.1 – 5.5) Invariant subspaces and Cayley-Hamilton theorem.[2]: Chapter 5 (Section 5.4). **Marks-20**

Unit 3: Inner product, length, and orthogonality, orthogonal sets, orthogonal projections, the Gram–Schmidt process, inner product spaces; Diagonalization of symmetric matrices,the Spectral Theorem.[1]: Chapter 6 (Sections 6.1 – 6.4, 6.7); Chapter 7 (Section 7.1) **Marks-20**

Text Books:

1. David C. Lay, Linear Algebra and its Applications (3rd Edition), Pearson Education Asia, Indian
Reprint, 2007.
2. Stephen H. Friedberg, Arnold J. Insel, Lawrence E. Spence, *Linear Algebra* (4th Edition), Prentice-Hall
of India Pvt. Ltd., New Delhi, 2004.

Reference Books:

1. S. Kumaresan, Linear Algebra- A Geometric Approach, Prentice Hall of India,1999.
2. Gilbert Strang, Linear Algebra and its Applications, Thomson, 2007.
3. Kenneth Hoffman, Ray Alden Kunze, Linear Algebra, 2nd Ed., Prentice-Hall of India Pvt. Ltd., 1971.
4. G. Schay, Introduction to Linear Algebra, Narosa, 1997.