CO-PO attainment
in
Outcome Based Education

Department of Mathematics,

Government General Degree College, Kalna-I

Program Outcome (PO)

- ❖PO1: Disciplinary knowledge
- ❖PO2: Communication Skills
- ❖PO3: Critical thinking
- ❖PO4 : Problem solving
- ❖PO5: Self-directed learning
- ❖PO6: Research-related skills
- ❖PO7: Analytical reasoning
- ❖PO8: Information/digital literacy
- ❖PO9: Lifelong learning

Program Specific Outcome (PSO): UG Mathematics

PSO1:

Foundation of Mathematical Concepts:

To use mathematical methodologies to crack problems using suitable mathematical analysis and suitable techniques.

PSO2:

Foundation of Mathematical System:

The ability to interpret the fundamental concept and methodologies of mathematical systems like group theory, mechanics, metric space and other real and abstract mathematical structures and spaces. Students can understand the functionality of analytical part and analysis of fundamental mathematical structures.

PSO3:

Foundation of Mathematical Development:

The ability to grasp the mathematical development lifecycle and methodologies of mathematical systems. Familiarity and practical proficiency with broad area of real life applications and provide new ideas and innovations towards research.

Course Content

Course code : BMH1CC01
Course name : Calculus, Geometry & Differential Equations (Marks :75)
Total Lecture Hours :60

Unit -1: Hyperbolic functions, higher order derivatives, Leibnitz rule and its applications to problems of type $e^{ax+b}\sin x$, $e^{ax+b}\cos x$, $(ax+b)^n \sin x$, $(ax+b)^n \cos x$, concavity and inflection points, envelopes, asymptotes, curve tracing in Cartesian coordinates, tracing in polar coordinates of standard curves, L'Hospital's rule, applications in business, economics and life sciences. **12L**

Unit-2 : Reduction formulae, derivations and illustrations of reduction formulae for the integration of sin nx, cosnx, tan nx, sec nx, $(\log x)^n$, $\sin^n x \sin^m x$, parametric equations, parametrizing a curve, arc length, arc length of parametric curves, area of surface of revolution.

Techniques of sketching conics. **12L**

Unit -3: Reflection properties of conics, translation and rotation of axes and second degree equations, classification of conics using the discriminant, polar equations of conics.

Spheres.Cylindrical surfaces. Central conicoids, paraboloids, plane sections of conicoids, Generating lines, classification of quadrics, Illustrations of graphing standard quadric surfaces like cone, ellipsoid. **12L**

Unit – 4: Differential equations and mathematical models. General, particular, explicit, implicit and singular solutions of a differential equation. Exact differential equations and integrating factors, separable equations and equations reducible to this form, linear equation and Bernoulli equations, special integrating factors and transformations. **12L**

Graphical Demonstration (Teaching Aid) 12L

1. *Plotting of graphs of function e^{ax+b}, $\log(ax+b)$, $1/(ax+b)$, $\sin(ax+b)$, $\cos(ax+b)$, $|ax+b|$ and to illustrate the effect of a and b on the graph*
2. *Plotting the graphs of polynomial of degree 4 and 5, the derivative graph, the second derivative graph and comparing them.*
3. *Sketching parametric curves (Eg. Trochoid, cycloid, epicycloids, hypocycloid).*

Course Outcome (CO) Paper: CC01

Sl. No.	Course Outcome (CO)	Knowledge Level (Bloom's Level)	POs	PSOs
1	**Recall** the definitions and properties of hyperbolic functions and their derivatives.	**L1: Remember**	**1, 3, 4, 6,7, 9**	**1,2,3**
2	**Understand** the concepts of higher-order derivatives, Leibnitz rule, concavity, and inflection points.	**L2 : Understand**	**1, 2, 3, 4, 7.6**	**1,2,3**
3	**Apply** reduction formulae and integration techniques to find arc length and area of surface of revolution.	**L3: Apply**	**1,3, 4, 5, 7**	**1,2,3**
4	**Analyze** the properties and characteristics of conics and quadrics..	**L4: Analyze**	**1, 3, 4, 5, 7**	**1,2,3**
5	**Evaluate** the classifications and characteristics of different types of conics and quadrics.	**L5: Evaluate**	**1,3, 4,5, 7,9**	**1,2,3**
6	**Create** connections between different solution techniques and their applications in real-world problems.	**L6: Create**	**1, 3, 4, 5,7, 9**	**1,2,3**

Programme Articulation Matrix (CO-PO Matrix)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3
CO1	3	1	2	-	-	-	2	-	3	-	-	1
CO2	2	2	2	3	1	-	2	-	3	-	-	1
CO3	3	2	3	2	2	-	1	-	3	2	1	2
CO4	2	3	2	3	3	3	1	-	2	1	2	2
CO5	3	2	3	3	2	3	1	-	2	3	2	2
CO6	3	2	2	1	2	1	2	1	2	2	3	2
AVG	2.67	2.0	2.3	2.4	2.0	2.33	1.5	1.0	2.5	2.0	2.0	1.67

Course Content

Course code : BMH1CC02
Course name : Calculus, Geometry & Differential Equations (Marks : 75)
Total Lecture Hours : 60

Unit -1 : Polar representation of complex numbers, n-th roots of unity, De Moivre's theorem for rational indices and its applications. **5L**

Theory of equations: Relation between roots and coefficients, Transformation of equation, Descartes rule of signs, Cubic and biquadratic equations. Reciprocal equation, separation of the roots of equations, Strum,s theorem. **8L**

Inequality: The inequality involving AM≥GM≥HM, Cauchy-Schwartz inequality. **4L**

Unit -2 : Equivalence relations and partitions, Functions, Composition of functions, Invertible functions, One to one correspondence and cardinality of a set. Well-ordering property of positive integers, Division algorithm, Divisibility and Euclidean algorithm. Congruence relation between integers. Principles of Mathematical Induction, statement of Fundamental Theorem of Arithmetic. **15L**

Unit -3: Systems of linear equations, row reduction and echelon forms, vector equations, the matrix equation Ax=b, solution sets of linear systems, applications of linear systems, linear independence. **10L**

Unit 4: Introduction to linear transformations, matrix of a linear transformation, inverse of a matrix, characterizations of invertible matrices. Vector Spaces of R^n, Subspaces of R^n, dimension of subspaces of R^n, rank of a matrix, Eigen values, Eigen Vectors and Characteristic Equation of a matrix. Cayley-Hamilton theorem and its use in finding the inverse of a matrix. **18L**

Course Outcome (CO) Paper: CC02

Sl. No.	Course Outcome (CO)	Knowledge Level (Bloom's Level)	POs	PSOs
1	**Understand** De Moivre's theorem for rational indices and its applications.	**L2 : Understand**	**1, 3, 4, 6,7, 9**	**1,2,3**
2	**Apply** Descartes' rule of signs to determine the possible number of positive and negative roots in a polynomial equation.	**L3: Apply**	**1, 2, 3, 4, 7.6**	**1,2,3**
3	**Apply** the division algorithm and Euclidean algorithm to find the greatest common divisor of integers.	**L3: Apply**	**1,3, 4, 5, 7**	**1,2,3**
4	**Analyze** compositions of functions and their properties.	**L4: Analyze**	**1, 3, 4, 5, 7**	**1,2,3**
5	**Understand** the concept of linear independence of vectors.	**L2 : Understand**	**1,3, 4,5, 7,9**	**1,2,3**
6	**Evaluate** the significance of the Cayley-Hamilton theorem in finding the inverse of a matrix..	**L5: Evaluate**	**1, 3, 4, 5,7, 9**	**1,2,3**

Programme Articulation Matrix (CO-PO Matrix)												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3
CO1	3	1	2	-	-	-	2	-	2	-	1	1
CO2	2	2	1	3	1	-	2	-	2	2	1	2
CO3	3	3	3	2	2	-	1	-	1	2	1	2
CO4	2	3	1	3	3	2	1	-	1	2	1	2
CO5	3	2	3	3	2	2	1	-	1	-	2	1
CO6	2	2	2	1	2	1	2	-	2	2	2	2
AVG	2.5	2.17	2.0	2.4	2.0	1.67	1.5	-	1.5	2.0	1.33	1.67

Course Content

Course code : BMH2CC03
Course name : Real Analysis

Course: BMH2CC03

Real Analysis (Marks: 75)

Total Lecture Hours: 60

Unit-1: Review of Algebraic and Order Properties of $\mathbb{R}$, ε-neighbourhood of a point in $\mathbb{R}$. Idea of countable sets, uncountable sets and uncountability of $\mathbb{R}$. Bounded above sets, Bounded below sets, Bounded Sets, Unbounded sets. Suprema and Infima. Completeness Property of $\mathbb{R}$ and its equivalent properties. The Archimedean Property, Density of Rational (and Irrational) numbers in $\mathbb{R}$, Intervals. Limit points of a set, Isolated points, Open set, closed set, derived set, Illustrations of Bolzano-Weierstrass theorem for sets, compact sets in $\mathbb{R}$, Heine-Borel Theorem. 20L

Unit-2 : Sequences, Bounded sequence, Convergent sequence, Limit of a sequence, lim inf, lim sup. Limit Theorems. Monotone Sequences, Monotone Convergence Theorem. Sub sequences, Divergence Criteria. Monotone Subsequence Theorem (statement only), Bolzano Weierstrass Theorem for Sequences. Cauchy sequence, Cauchy's Convergence Criterion. 15L

Unit-3 : Infinite series, convergence and divergence of infinite series, Cauchy Criterion, Tests for convergence: Comparison test, Limit Comparison test, Ratio Test, Cauchy's nth root test, Integral test. Alternating series, Leibniz test. Absolute and Conditional convergence. 15L

Graphical Demonstration (Teaching Aid) 10L

Course Outcome (CO) Paper: CC-03

Sl. No.	Course Outcome (CO)	Knowledge Level (Bloom's Level)	POs	PSOs
1	**Explain** Order Properties of $\mathbb{R}$, Boundedness & Unboundedness of a subset in $\mathbb{R}$.	**L2: Understand**	**1, 3, 4, 6,7, 9**	**1,2,3**
2	**Illustrate** the Archimedean Property, Density of Rational and Irrational numbers in $\mathbb{R}$.	**L4: Analyze**	**1, 2, 3, 4, 7.6**	**1,2,3**
3	**Decide** the boundedness & convergency of a Real Sequence.	**L5: Evaluate**	**1,3, 4, 5, 7**	**1,2,3**
4	**Illustrate** the concept of Subsequence and Bolzano-Weirstrass Property of a Real Sequence.	**L4: Analyze**	**1, 3, 4, 5, 7**	**1,2,3**
5	**Define** convergency of an infinite series.	**L1: Remember**	**1,3, 4, 7**	**1,2,3**
6	**Solve** the convergency problems of infinite series with Comparison test, Ratio Test, Cauchy's nth root test	**L3: Apply**	**1, 3, 4, 5,7, 9**	**1,2,3**

Programme Articulation Matrix (CO-PO Matrix)												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3
CO1	3	1	2	-	1	-	-	-	2	-	1	1
CO2	2	3	3	1	1	-	-	-	1	2	1	2
CO3	2	2	3	2	2	-	1	-	1	2	2	3
CO4	2	1	2	3	3	-	1	-	2	2	1	2
CO5	2	1	2	3	2	-	1	-	2	-	-	-
CO6	3	2	2	1	2	1	2	1	2	2	2	2
AVG	2.33	1.67	2.33	2.0	1.83	1.0	1.25	1.0	1.67	2.0	1.4	2.0

Course Content

Course code : BMH4CC04
Course name : Differential Equations and Vector Calculus

Course: BMH2CC04
Differential Equation and Vector Calculus (Marks: 75)

Total Lecture Hours: 60

Unit-1: Lipschitz condition and Picard's Theorem (Statement only). General solution of homogeneous equation of second order, principle of super position for homogeneous equation, Wronskian: its properties and applications, Linear homogeneous and non-homogeneous equations of higher order with constant coefficients, Euler's equation, method of undetermined coefficients, method of variation of parameters. **20L**

Unit -2: Systems of linear differential equations, types of linear systems, differential operators, an operator method for linear systems with constant coefficients, Basic Theory of linear systems in normal form, homogeneous linear systems with constant coefficients: Two Equations in two unknown functions. **20L**

Unit-3: Equilibrium points, Interpretation of the phase plane Power series solution of a differential equation about an ordinary point, solution about a regular singular point. **6L**

Unit- 4 : Triple product, introduction to vector functions, operations with vector-valued functions, limits and continuity of vector functions, differentiation and integration of vector functions. **10L**

Graphical Demonstration (Teaching Aid): **4L**

1. Plotting of family of curves which are solutions of second order differential equation.
2. Plotting of family of curves which are solutions of third order differential equation.

Course Outcome (CO) Paper: CC-04

Sl. No.	Course Outcome (CO)	Knowledge Level (Bloom's Level)	POs	PSOs
1	**Compute** exact solutions of solvable first order differential equations and linear differential equations of higher order using various methods.	**L3: Apply**	**1, 2, 3, 4, 5, 7, 9**	**1,2,3**
2	**Explain** the concept of a general solution of a linear differential equation of an arbitrary order, and also to obtain them using prescribed methods	**L2: Understand**	**1, 2, 3, 4, 5, 7, 9**	**1,2,3**
3	**Formulate** mathematical models in the form of ordinary differential equations to suggest possible solutions of the day to day problems arising in physical, chemical and biological disciplines.	**L6: Create**	**1, 2, 3, 4, 5, 6, 7, 8, 9**	**1,2,3**
4	**Outline** the phase plane analysis**.**	**L4: Analyze**	**1, 2, 3, 4, 5, 7, 9**	**1,2,3**
5	**Define** scalar and vector products of vectors.	**L1: Remember**	**1, 2, 3, 4, 7, 9**	**1,2,3**
6	**Evaluate** the vector triple product and product of four vectors and use it to find the equation of straight lines, planes in vector form.	**L5: Evaluate**	**1, 2, 3, 4, 5, 7, 9**	**1,2,3**

Programme Articulation Matrix (CO-PO Matrix)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3
CO1	1	1	1	2	1	1	1	-	1	2	1	2
CO2	2	2	2	-	-	-	-	-	2	-	-	1
CO3	3	2	3	2	2	1	1	1	2	3	2	3
CO4	2	3	2	3	3	3	1	-	2	2	2	2
CO5	3	2	3	2	2	3	1	-	2	-	-	-
CO6	3	2	2	1	2	1	2	-	2	2	2	2
AVG	2.33	2.0	2.17	2.0	2.0	1.8	1.20	1.0	1.83	2.25	1.75	2.0

Course Content

Course code : BMH3CC05
Course name :Theory of Real Functions & Introduction to Metric Spaces
(Marks : 75)

Total Lecture Hours: 60

Unit -1:Limits of functions (ε - δ approach), sequential criterion for limits, divergence criteria. Limit theorems, one sided limits. Infinite limits and limits at infinity. Continuous functions, sequential criterion for continuity and discontinuity. Algebra of continuous functions. Continuous functions on an interval, intermediate value theorem, location of roots theorem, preservation of intervals theorem. Uniform continuity, non-uniform continuity criteria, theorems on uniform continuity. **25L**

Unit -2 :Differentiability of a function at a point and in an interval, Caratheodory's theorem, algebra of differentiable functions. Relative extrema, interior extremum, Rolle's theorem. Mean value theorem, intermediate value property of derivatives, Darboux's theorem. Applications of mean value theorem to inequalities and approximation of polynomials, Application of differential calculus : Curvature **15L**

Unit-3:Cauchy's mean value theorem. Taylor's theorem with Lagrange's form of remainder, Taylor's theorem with Cauchy's form of remainder, application of Taylor's theorem to convex functions, relative extrema. Taylor's series and Maclaurin's series expansions of exponential and trigonometric functions, $\ln(1 + x)$, $1/ax+b$ and $(1 +x)^n$. Application of Taylor's theorem to inequalities. **10L**

Unit-4 :Metric spaces: Definition and examples. Open and closed balls, neighbourhood, open set, interior of a set. Limit point of a set, closed set, diameter of a set, subspaces, dense sets, separable spaces. **10L**

Course Outcome (CO) Paper: CC-05

Sl. No.	Course Outcome (CO)	Knowledge Level (Bloom's Level)	POs	PSOs
1	**Define** the ε - δ approach for limits.	**L1: Remember**	**1, 3, 4, 6,7, 9**	**1,2,3**
2	**Analyze** applications of the Mean Value Theorem to inequalities and approximation of polynomials.	**L4: Analyze**	**1, 2, 3, 4, 7.6**	**1,2,3**
3	**Evaluate** Taylor's series and Maclaurin's series expansions for various functions.	**L5: Evaluate**	**1,2, 3, 4, 5, 7**	**1,2,3**
4	**Understand** the definition and examples of metric spaces.	**L2: Understand**	**1,2, 3, 4, 5, 7**	**1,2,3**
5	**Apply** the Mean Value Theorem to inequalities, approximation of polynomials, and the curvature of functions.	**L3: Apply**	**1,3, 4, 5, 7**	**1,2,3**
6	**Develop** applications of Taylor's theorem to inequalities.	**L6: Create**	**1, 3, 4, 5,7, 9**	**1,2,3**

Programme Articulation Matrix (CO-PO Matrix)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3
CO1	3	2	1	1	1	-	-	-	2	-	1	-
CO2	2	1	2	2	1	-	1	-	2	2	3	2
CO3	3	2	1	1	1	1	1	-	3	2	2	2
CO4	2	3	2	1	-	-	1	-	2	-	1	-
CO5	2	1	1	2	1	-	1	-	3	2	2	2
CO6	3	2	2	1	2	1	2	2	2	2	3	3
AVG	2.5	1.83	1.5	1.33	1.2	1.0	1.2	2.0	2.5	2.0	2.0	2.25

Course Content

Course code : BMH3CC06
Course name : Group Theory-I
Marks : 75

Total Lecture Hours: 60

Unit-1 :Symmetries of a square, Dihedral groups, definition and examples of groups including permutation groups and quaternion groups (through matrices), elementary properties of groups. **10L**

Unit-2: Subgroups and examples of subgroups, centralizer, normalizer, center of a group, product of two subgroups. **5L**

Unit-3 :Properties of cyclic groups, classification of subgroups of cyclic groups, Cycle notation for permutations, properties of permutations, even and odd permutations, alternating group, properties of cosets, Lagrange's theorem and consequences including Fermat's Little theorem. **20L**

Unit-4: External direct product of a finite number of groups, normal subgroups, factor groups, Cauchy's theorem for finite abelian groups. **10L**

Unit-5: Group homomorphisms, properties of homomorphisms, Cayley's theorem, properties of isomorphisms, First, Second and Third isomorphism theorems. **15L**

Course Outcome (CO) Paper: CC-06

Sl. No.	Course Outcome (CO)	Knowledge Level (Bloom's Level)	POs	PSOs
1	**Evaluate** the conditions and consequences of Cauchy's theorem.	**L5: Evaluate**	**1, 3, 4, 5,7**	**1,2,3**
2	**Understand** the concepts of symmetries, dihedral groups, and elementary properties of groups.	**L2: Understand**	**1, 2, 3, 4, 7.6**	**1,2,3**
3	**Apply** subgroup properties to determine centralizers, normalizers, and centers of groups.	**L3: Apply**	**1,2, 3, 4, 5, 7**	**1,2,3**
4	**Analyze** the classification of subgroups of cyclic groups and properties of cosets.	**L4: Analyze**	**1,2, 3, 4, 5, 7**	**1,2,3**
5	**Recall** the definitions and examples of groups including permutation and quaternion groups.	**L1: Remember**	**1,3, 4, 5, 6, 7, 9**	**1,2,3**
6	**Create** proofs and solutions for problems involving group homomorphisms and isomorphisms, utilizing the isomorphism theorems.	**L6: Create**	**1, 3, 4, 5,7, 9**	**1,2,3**

Programme Articulation Matrix (CO-PO Matrix)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3
CO1	3	1	2	-	-	-	2	-	3	2	2	3
CO2	2	2	2	3	1	-	2	-	3	-	1	1
CO3	3	2	3	2	2	-	1	-	3	2	2	3
CO4	2	3	2	3	3	3	1	-	2	2	3	2
CO5	3	2	3	3	2	3	1	-	2	-	1	1
CO6	3	2	2	1	2	1	2	1	2	3	3	3
AVG	2.67	2.0	2.3	2.4	2.0	2.33	1.5	1.0	2.5	2.25	2.0	2.17

Course Content

Course code : BMH3CC07
Course name : Numerical Methods & Numerical Methods Lab
Total Lecture Hours 60 (Theory 40 + Practical 20)

Course: BMH3CC07

Numerical Methods & Numerical Methods Lab

(Theory: 50 & Practical: 25)

Total Lecture Hours: 60(Theory-40, Practical-20)

Unit-1: Algorithms, Convergence, Errors: Relative, Absolute. Round off, Truncation. **2L**

Unit-2 : Transcendental and Polynomial equations: Bisection method, Newton's method, Secant method, Regula-falsi method, fixed point iteration, Newton-Raphson method. Rate of convergence of these methods. **6L**

Unit -3 : System of linear algebraic equations: Gaussian Elimination and Gauss Jordan methods. Gauss Jacobi method, Gauss Seidel method and their convergence analysis, LU Decomposition. **8L**

Unit-4: Interpolation: Lagrange and Newton's methods, Error bounds, Finite difference operators. Gregory forward and backward difference interpolations.
Numerical differentiation: Methods based on interpolations, methods based on finite differences. **9L**

Unit – 5 : Numerical Integration: Newton Cotes formula, Trapezoidal rule, Simpson's 1/3rd rule, Simpsons 3/8th rule, Weddle's rule, Boole's rule. Midpoint rule, Composite Trapezoidal rule, Composite Simpson's 1/3rd rule, Gauss quadrature formula.
The algebraic eigenvalue problem: Power method. **10L**

Unit – 6: Ordinary Differential Equations: The method of successive approximations, Euler's method, the modified Euler method, Runge-Kutta methods of orders two and four. **5L**

Unit -7: Numerical Practical 20L

Lab notebook & Viva Voce : 5 marks
Numerical Problem : 15 marks (Program:10, Result:5)

List of practical (using C programming)

1. Solution of transcendental and algebraic equations by
   (a) Newton Raphson method.
   (b) Regula Falsi method.
2. Solution of system of linear equations
   (a) Gaussian elimination method
   (b) Gauss-Seidel method
3. Interpolation : Lagrange Interpolation
4. Numerical Integration
   (a) Trapezoidal Rule
   (b) Simpson's one third rule
5. Solution of ordinary differential equations : Runge Kutta method

Books Recommended :

- Brian Bradie, A Friendly Introduction to Numerical Analysis, Pearson Education, India, 2007.
- M.K. Jain, S.R.K. Iyengar and R.K. Jain, Numerical Methods for Scientific and Engineering, 2012.
- Computation, 6th Ed., New age International Publisher, India, 2007.
- C.F. Gerald and P.O. Wheatley, Applied Numerical Analysis, Pearson Education, India, 2008.
- Uri M. Ascher and Chen Greif, A First Course in Numerical Methods, 7th Ed., PHI Learning Private Limited, 2013.

Course Outcome (CO) Paper: CC-07

Sl. No.	Course Outcome (CO)	Knowledge Level (Bloom's Level)	POs	PSOs
	Theory			
1	**Analyze** the concepts of convergence and errors, including relative, absolute, round-off, and truncation errors.	**L4**: **Analyze**	**1, 2, 3, 4, 7, 9**	**1,2,3**
2	**Apply** methods such as Bisection, Newton's method, Secant method, Regula Falsi, fixed point iteration, and Newton-Raphson method to solve transcendental and polynomial equations.	**L3**: **Apply**	**1, 2, 3, 4, 5, 7, 9**	**1,2,3**
3	**Understand** error bounds and finite difference operators in interpolation.	**L2: Understand**	**1, 2, 3, 4, 5, 7, 9**	**1,2,3**
4	**Explain** methods based on interpolations and finite differences for numerical differentiation.	**L1: Remember**	**1, 2, 3, 4, 5, 7, 9**	**1,2,3**
5	**Evaluate** practical problems related to transcendental and algebraic equations, system of linear equations, interpolation, numerical integration, and ordinary differential equations.	**L5: Evaluate**	**1, 2, 3, 4, 5, 7, 9**	**1,2,3**
	Numerical Practical			
1	**Apply** C-programming to develop a stable code on different numerical schemes.	**L3**: **Apply**	**1, 2, 3, 4, 5, 7, 9**	**1,2,3**
2	**Evaluate** transcendental and algebraic equations, system of linear equations, interpolation, numerical integration, and ordinary differential equations by constructing proper C-Programming code.	**L5: Evaluate**	**1, 2, 3, 4, 5, 7, 9**	**1,2,3**

Programme Articulation Matrix (CO-PO Matrix)												
		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3
Theory	CO1	2	3	2	3	3	2	1	-	2	2	2	2
	CO2	3	2	3	2	2	-	1	-	3	2	2	3
	CO3	2	2	2	3	1	-	2	-	3	-	1	1
	CO4	3	1	2	-	-	-	2	-	3	-	1	1
	CO5	3	2	3	3	2	1	1	-	2	2	2	2
Practical	CO1	3	2	3	2	2	-	1	-	3	2	2	2
	CO2	3	2	3	3	2	2	1	1	2	2	2	2
	AVG	2.71	2.0	2.57	2.67	2.0	1.67	1.23	1.0	2.57	2.0	1.71	1.86

Course Content

Course code : BMH3SEC11
Course name : Logic and Sets (Marks : 50)
Total Lecture Hours : 40

Unit 1 : Introduction, propositions, truth table, negation, conjunction and disjunction. Implications, biconditional propositions, converse, contra positive and inverse propositions and precedence of logical operators. Propositional equivalence: Logical equivalences. Predicates and quantifiers: Introduction, Quantifiers, Binding variables and Negations. 18L

Unit 2 : Sets, subsets, Set operations and the laws of set theory and Venn diagrams. Examples of finite and infinite sets. Finite sets and counting principle. Empty set, properties of empty set. Standard set operations. Classes of sets. Power set of a set. 7L

Unit 3 : Difference and Symmetric difference of two sets. Set identities, Generalized union and intersections. Relation: Product set. Composition of relations, Types of relations, Partitions, Equivalence Relations with example of congruence modulo relation. Partial ordering relations, n- ary relations. 15L

Course Outcome (CO) Paper: SEC-11

Sl. No.	Course Outcome (CO)	Knowledge Level (Bloom's Level)	POs	PSOs
1	**Recall** definitions of propositions, truth tables, negation, conjunction, disjunction, and biconditional propositions.	**L1: Remember**	**1, 3, 4, 6,7, 9**	**1,2,3**
2	**Construct** complex propositions using logical connectives and understand their implications.	**L6: Create**	**1, 2, 3, 4, 7.6**	**1,2,3**
3	**Understand** the laws of set theory and their applications through examples and Venn diagrams.	**L2: Understand**	**1,2, 3, 4, 5, 7**	**1,2,3**
4	**Apply** set operations and counting principles to solve problems involving finite and infinite sets.	**L3: Apply**	**1,2, 3, 4, 5, 7**	**1,2,3**
5	**Analyze** properties of relations, such as n-array relations, and their implications.	**L4: Analyze**	**1,3, 4, 5, 7**	**1,2,3**
6	**Evaluate** the validity of relations and their compositions.	**L5: Evaluate**	**1, 3, 4, 5,7, 9**	**1,2,3**

Programme Articulation Matrix (CO-PO Matrix)												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3
CO1	3	1	2	-	-	-	2	-	3	-	1	1
CO2	3	2	1	1	2	1	2	1	2	3	3	3
CO3	2	3	2	1	-	-	1	-	2	-	1	1
CO4	1	1	1	2	1	1	1	-	1	2	2	1
CO5	2	3	2	2	2	2	1	-	2	2	2	2
CO6	3	2	2	3	2	2	1	2	2	2	2	2
AVG	2.33	2.0	1.67	1.8	1.75	1.5	1.33	1.5	2.0	2.25	1.83	1.67

Course Content

Course code : BMH4CC08
Course name : Riemann Integration and Series of Functions

Course: BMH4CC08

Riemann Integration and Series of Functions (Marks: 75)

Total Lecture Hours: 60

Unit -1 : Riemann integration: inequalities of upper and lower sums, Darbaux integration, Darbaux theorem, Riemann conditions of integrability, Riemann sum and definition of Riemann integral through Riemann sums, equivalence of two Definitions. Riemann integrability of monotone and continuous functions, Properties of the Riemann integral; definition and integrability of piecewise continuous and monotone functions. Intermediate Value theorem for Integrals, Fundamental theorem of Integral Calculus. **20L**

Unit-2 : Improper integrals, Convergence of Beta and Gamma functions. **7L**

Unit-3 : Pointwise and uniform convergence of sequence of functions. Theorems on continuity, derivability and integrability of the limit function of a sequence of functions. Series of functions, Theorems on the continuity and derivability of the sum function of a series of functions; Cauchy criterion for uniform convergence and Weierstrass M-Test. **15L**

Unit 4: Fourier series: Definition of Fourier coefficients and series, Riemann- Lebesgue lemma, Bessel's inequality, Parseval's identity, Dirichlet's condition. Examples of Fourier expansions and summation results for series. **10L**

Unit – 5: Power series, radius of convergence, Cauchy Hadamard Theorem. Differentiation and integration of power series; Abel's Theorem; Weierstrass Approximation Theorem. **8L**

Course Outcome (CO) Paper: CC-08

Sl. No.	Course Outcome (CO)	Knowledge Level (Bloom's Level)	POs	PSOs
1	**Define** Riemann sums and Riemann integral through Riemann sums.	**L1: Remember**	**1, 3, 4, 6,7, 9**	**1,2,3**
2	**Illustrate** Riemann integrability of monotone, continuous, piecewise continuous functions and Fundamental Theorem of Integral Calculus.	**L4: Analyze**	**1, 2, 3, 4, 7.6**	**1,2,3**
3	**Decide** Convergency of Improper integrals, Convergency of Beta and Gamma functions	**L5: Evaluate**	**1,2, 3, 4, 5, 7**	**1,2,3**
4	**Explain** Pointwise and uniform convergence of sequence and series of functions	**L2: Understand**	**1,2, 3, 4, 5, 7**	**1,2,3**
5	**Compute** sum of some infinite series through Fourier Series Expansion.	**L3: Apply**	**1,3, 4, 5, 7**	**1,2,3**
6	**Measure** radius of convergence & region of convergence of power series with Cauchy-Hadamard Theorem.	**L5: Evaluate**	**1, 3, 4, 5,7, 9**	**1,2,3**

Programme Articulation Matrix (CO-PO Matrix)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3
CO1	3	1	2	1	1	-	2	-	2	-	1	1
CO2	2	3	2	2	2	2	1	-	2	2	2	2
CO3	2	2	1	2	2	2	1	2	1	2	3	3
CO4	2	2	2	1	1	-	1	-	2	-	1	1
CO5	1	1	1	2	1	1	1	-	1	2	3	3
CO6	3	2	2	3	2	2	1	-	2	2	3	3
AVG	2.17	1.83	1.67	1.83	1.5	1.75	1.17	2.0	1.67	2.0	2.17	2.17

Course Content

Course code : BMH4CC09

Course name : Multivariate Calculus (Marks: 75) Total Lecture Hours: 60

Unit-1: Functions of several variables, limit and continuity of functions of n variables, Partial differentiation, total differentiability and differentiability, sufficient condition for differentiability. Chain rule for one and two independent parameters, directional derivatives, the gradient, Jacobian, maximal and normal property of gradient, tangent planes, Extrema of functions of n variables with necessary and sufficient conditions, method of Lagrange multipliers. **25L**

Unit-2: Double integration over rectangular region, double integration over non-rectangular region, Double integrals in polar co-ordinates, Triple integrals, Triple integral over a parallelepiped and solid regions. Volume by triple integrals, cylindrical and spherical coordinates. Change of variables in double integrals and triple integrals.

15L

Unit-3: Vector operators, Gradient of a scalar function, directional derivatives, Definition of vector field, divergence and curl. Line integrals, Fundamental theorem for line integrals, conservative vector fields, , Application of line integral to Workdone. **10L**

Unit-4: Green's theorem, surface integrals, integrals over parametrically defined surfaces. Stoke's theorem, The Divergence theorem. **10L**

Course Outcome (CO) Paper: CC-09

Sl. No.	Course Outcome (CO)	Knowledge Level (Bloom's Level)	POs	PSOs
1	**Explain** concepts of Functions of several variables, limit and continuity of functions of n variables, Partial differentiation, directional derivatives	**L2: Understand**	**1, 2, 3, 4, 5, 7, 9**	**1,2,3**
2	**Describe** extrema of functions of n variables with necessary and sufficient conditions, method of Lagrange multipliers	**L1: Remember**	**1, 2, 3, 4, 5, 7, 9**	**1,2,3**
3	**Describe** double, triple integration, Change of variables in range of integration	**L1: Remember**	**1, 2, 3, 4, 5, 7, 9**	**1,2,3**
4	**Illustrate** Vector operators, Gradient of a scalar function, directional derivatives	**L4: Analyze**	**1, 2, 3, 4, 7, 9**	**1,2,3**
5	**Summarize** vector field, divergence, curl and Line integrals	**L5: Evaluate**	**1, 2, 3, 4, 5, 7, 9**	**1,2,3**
6	**Formulate** Green's theorem, Stoke's theorem, The Divergence theorem in vector analysis	**L6: Creating**	**1, 2, 3, 4, 5, 6, 7, 9**	**1,2,3**

Programme Articulation Matrix (CO-PO Matrix)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3
CO1	2	2	2	1	1	-	1	-	2	-	1	1
CO2	3	1	2	1	1	-	2	-	2	-	1	1
CO3	3	1	2	1	1	-	2	-	2	-	1	1
CO4	2	2	2	2	2	2	1	-	2	2	3	2
CO5	3	2	2	3	1	2	1	-	2	3	3	3
CO6	3	2	1	1	2	2	2	1	2	2	3	3
AVG	2.67	1.67	1.83	1.5	1.33	2.0	1.5	1.0	2.0	2.33	2.0	1.83

Course Content

Course code : BMH4CC10
Course name : Ring Theory and Linear Algebra I

Course: BMH4CC10

Ring Theory and Linear Algebra I (Marks: 75)

Total Lecture Hours: 60

Unit 1: Definition and examples of rings, properties of rings, subrings, integral domains and fields, characteristic of a ring. Ideal, ideal generated by a subset of a ring, factor rings, operations on ideals, prime and maximal ideals. **15L**

Unit 2 : Ring homomorphisms, properties of ring homomorphisms. Isomorphism theorems I, II and III, field of quotients. **10L**

Unit 3 : Vector spaces, subspaces, algebra of subspaces, quotient spaces, linear combination of vectors, linear span, linear independence, basis and dimension, dimension of subspaces, extension, deletion and replacement theorems. **12L**

Unit 4 : Linear transformations, null space, range, rank and nullity of a linear transformation, matrix representation of a linear transformation, algebra of linear transformations, Isomorphisms, Isomorphism theorems, invertibility and isomorphisms, change of coordinate matrix. **23L**

Course Outcome (CO) Paper: CC-10

Sl. No.	Course Outcome (CO)	Knowledge Level (Bloom's Level)	POs	PSOs
1	**Describe** the fundamental concepts in ring theory such as of the ideals, quotient rings, integral domains, and fields.	**L1: Remember**	**1, 2, 3, 4, 7, 9**	**1,2,3**
2	**Explain** ring homomorphisms and isomorphism theorems	**L2: Understand**	**1, 2, 3, 4, 5, 7, 9**	**1,2,3**
3	**Identify** different kind of ideals such as prime, maximal ideals etc.	**L4: Analyze**	**1, 2, 3, 4, 5, 7, 9**	**1,2,3**
4	**Demonstrate** the concepts of vector spaces, subspaces, bases, dimension and their properties with examples.	**L3: Apply**	**1, 2, 3, 4, 5, 7, 9**	**1,2,3**
5	**Identify** matrices with linear transformations.	**L4: Analyze**	**1, 2, 3, 4, 5, 7, 9**	**1,2,3**
6	**Compute** matrix of linear transformations**.**	**L3: Apply**	**1, 2, 3, 4, 5, 7, 9**	**1,2,3**

Programme Articulation Matrix (CO-PO Matrix)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3
CO1	3	1	2	1	1	-	2	-	2	-	1	1
CO2	2	2	2	1	1	-	1	-	2	-	1	1
CO3	2	2	2	2	1	1	1	2	2	2	2	3
CO4	3	2	3	2	2	-	1	1	3	3	3	3
CO5	2	2	2	2	2	1	1	2	2	2	2	3
CO6	3	2	3	2	2	-	1	1	3	2	3	3
AVG	2.17	1.83	2.33	1.67	1.5	1.0	1.17	1.5	2.33	2.25	2.0	2.33

Course Content

Course code : BMH4SEC21
Course name : Graph Theory

Course: BMH4SEC21

Graph Theory (Marks: 50)

Total Lecture Hours: 40

Unit 1 : Definition, examples and basic properties of graphs, pseudo graphs, complete graphs, bi-partite graphs isomorphism of graphs. **10L**

Unit 2 : Eulerian circuits, Eulerian graph, semi-Eulerian graph and theorems, Hamiltonian cycles and theorems Representation of a graph by a matrix, the adjacency matrix, incidence matrix, weighted graph, **15L**

Unit 3 : Travelling salesman's problem, shortest path, Tree and their properties, spanning tree, Dijkstra's algorithm, Warshall algorithm. **15L**

Course Outcome (CO) Paper:SEC-21

Sl. No.	Course Outcome (CO)	Knowledge Level (Bloom's Level)	POs	PSOs
1	**Recall** definitions of graphs, pseudo graphs, complete graphs, bipartite graphs, and their basic properties.	**L1: Remember**	**1, 2, 3, 4, 7, 9**	**1,2,3**
2	**Understand** the concept of graph isomorphism and its significance.	**L2: Understand**	**1, 2, 3, 4, 5, 7, 9**	**1,2,3**
3	**Apply** knowledge of Eulerian and Hamiltonian paths to solve related problems.	**L3: Apply**	**1, 2, 3, 4, 5, 7, 9**	**1,2,3**
4	**Evaluate** the applicability of theorems related to Eulerian and Hamiltonian paths in specific graph scenarios.	**L5: Evaluate**	**1, 2, 3, 4, 5, 7, 9**	**1,2,3**
5	**Apply** algorithms like Dijkstra's algorithm and Warshall algorithm to find solutions to graph-related problems.	**L3: Apply**	**1, 2, 3, 4, 5, 7, 9**	**1,2,3**
6	**Understand** the concept of a spanning tree and its significance in graph theory.	**L2: Understand**	**1, 2, 3, 4, 5, 7, 9**	**1,2,3**

Course Content

Course code : BMH4SEC21
Course name : Graph Theory

Programme Articulation Matrix (CO-PO Matrix)												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3
CO1	3	1	2	1	1	-	2	-	2	-	1	1
CO2	3	2	2	1	1	-	1	-	2	-	1	1
CO3	3	2	3	2	2	-	1	-	3	2	2	3
CO4	3	2	3	2	2	1	2	1	3	2	3	3
CO5	2	2	2	1	1	-	1	-	2	2	2	3
CO6	3	2	3	2	3	-	1	-	3	-	1	1
AVG	2.67	1.83	2.5	1.5	1.67	1.0	1.33	1.0	2.5	2.0	1.67	2.0

Course Content

Course code : BMH5CC11

Course name : Partial Differential Equations and Applications (Marks : 75)

Total Lecture Hours: 60

Unit 1: Partial Differential Equations – Basic concepts and Definitions. Mathematical Problems. First- Order Equations: Classification, Construction and Geometrical Interpretation. Method of Characteristics for obtaining General Solution of Quasi Linear Equations. Canonical Forms of First-order Linear Equations. Method of Separation of Variables for solving first order partial differential equations. **22L**

Unit 2: Derivation of Heat equation, Wave equation and Laplace equation. Classification of second order linear equations as hyperbolic, parabolic, elliptic. Reduction of second order Linear Equations to canonical forms. **12L**

Unit 3: The Cauchy problem of 2^{nd} order partial differential equation, Cauchy-Kowalewskaya theorem, Cauchy problem of an infinite string, Initial and Boundary Value Problems. Semi-Infinite String with a fixed end, Semi-Infinite String with a Free end. Equations with non-homogeneous boundary conditions. Non-Homogeneous Wave Equation. Method of separation of variables: Solving the Vibrating String Problem. Solving the Heat Conduction problem. **17L**

Graphical Demonstration (Teaching Aid) 9L

1. Solution of Cauchy problem for first order PDE.
2. Finding 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 $\frac{\partial^2 u}{\partial t^2} - \frac{\partial^2 u}{\partial x^2} = 0$ for the following associated conditions:

(a) $u(x,0) = \phi(x)$, $u_t(x,0) = \psi(x)$, $x \in R$, $t > 0$.
(b) $u(x,0) = \phi(x)$, $u_t(x,0) = \psi(x)$, $u(0, t) = 0$ $x \in (0,\infty)$, $t > 0$.

5. Solution of wave equation $\frac{\partial^2 u}{\partial t^2} - c^2 \frac{\partial^2 u}{\partial x^2} = 0$ for the following associated conditions:

(a) $u(x,0) = \phi(x)$, $u(0, t) = a$, $u(l, t) = b$, $0 < x < l$, $t > 0$.
(b) $u(x,0) = \phi(x)$, $x \in R$, $0 < t < T$.

Course Outcome (CO) Paper: CC-11

Sl. No.	Course Outcome (CO)	Knowledge Level (Bloom's Level)	POs	PSOs
1	**Recall** and define basic concepts and definitions related to partial differential equations (PDEs).	**L1: Remember**	**1, 2, 3, 4, 5, 7, 9**	**1,2,3**
2	**Apply** the method of separation of variables to solve first-order PDEs.	**L3: Apply**	**1, 2, 3, 4, 5, 7, 9**	**1,2,3**
3	**Understand** the reduction of second-order linear equations to canonical forms.	**L2:Understand**	**1, 2, 3, 4, 5, 6, 7, 9**	**1,2,3**
4	**Describe** properties of heat equation, wave equation , Laplace equation.	**L1: Remember**	**1, 2, 3, 4, 7, 9**	**1,2,3**
5	**Illustrate** initial and boundary value problems for PDEs.	**L4: Analyze**	**1, 2, 3, 4, 5, 7, 9**	**1,2,3**
6	**Apply** the method of separation of variables to solve the vibrating string problem and heat conduction problem.	**L3: Apply**	**1, 2, 3, 4, 5, 6, 7, 9**	**1,2,3**

Course Content

Course code : BMH5CC11

Course name : Partial Differential Equations and Applications (Marks : 75)

Total Lecture Hours: 60

Programme Articulation Matrix (CO-PO Matrix)												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3
CO1	2	2	2	1	1	-	1	-	2	-	1	1
CO2	3	2	3	2	2	-	1	1	3	2	2	3
CO3	2	2	2	1	1	-	1	-	2	-	1	1
CO4	3	1	2	1	2	-	2	-	2	-	1	1
CO5	2	1	2	1	1	1	1	2	2	2	2	2
CO6	3	2	3	2	2	-	1	1	3	3	2	3
AVG	2.5	1.67	2.33	1.33	1.67	1.0	1.17	1.33	2.33	2.33	1.5	1.83

Course Content

Course code : BMH5CC12

Course name : Mechanics – I

Total Lecture Hours: 60

Total Lecture Hours: 60

Unit 1 : Co-planar forces. Astatic equilibrium. Friction. Equilibrium of a particle on a rough curve. Virtual work. Forces in three dimensions. General conditions of equilibrium. Centre of gravity for different bodies. Stable and unstable equilibrium, equilibrium of flexible string. **20L**

Unit 2 : Simple harmonic motion, Damped and forced vibrations, Components of velocity and acceleration, Equations of motion referred to a set of rotating axes. Motion of a projectile in a resisting medium. Motion of a particle under central force, Keplar's laws of motion, Motion under the inverse square law, Stability of nearly circular orbits, Slightly disturbed orbits, Motion of artificial satellites. Varying mass, constrained, Motion of a particle in three dimensions. Motion on a smooth sphere, cone, and on any surface of revolution. **25L**

Unit 3 : Degrees of freedom, Moments and products of inertia, Momental Ellipsoid, Principal axes, D'Alembert's Principle, Motion about a fixed axis, Compound pendulum, Motion of a system of particles, Motion of a rigid body in two dimensions under finite and impulsive forces, Conservation of momentum and energy. **15L**

Course Outcome (CO) — Paper: CC-12

Sl. No.	Course Outcome (CO)	Knowledge Level (Bloom's Level)	POs	PSOs
1	**Understand** the conditions for stable and unstable equilibrium, as well as the concept of centre of gravity for various bodies.	**L2: Understand**	**1, 2, 3, 4, 7, 9**	**1,2,3**
2	**Analyze** the equilibrium of a particle on a rough curve and the equilibrium of a flexible string.	**L4: Analyze**	**1, 2, 3, 4, 5, 7, 9**	**1,2,3**
3	**Apply** the equations of motion to solve problems involving simple harmonic motion, projectile motion, and orbital mechanics.	**L3: Apply**	**1, 2, 3, 4, 5, 7, 9**	**1,2,3**
4	**Evaluate** the stability of orbits and the motion of artificial satellites.	**L5: Evaluate**	**1, 2, 3, 5, 7, 9**	**1,2,3**
5	**Recall** the concepts of degrees of freedom, moments of inertia, and D'Alembert's Principle.	**L1: Remember**	**1, 2, 3, 4, 7, 9**	**1,2,3**
6	**Evaluate** the moments and products of inertia for different objects.	**L5: Evaluate**	**1, 2, 3, 4, 5, 7, 9**	**1,2,3**

Course Content

Course code : BMH5CC12

Course name : Mechanics – I

Total Lecture Hours: 60

Programme Articulation Matrix (CO-PO Matrix)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3
CO1	3	2	1	1	1	-	1	-	2	-	1	1
CO2	3	1	2	2	2	1	1	-	2	2	2	2
CO3	2	3	2	3	2	1	2	1	2	2	2	3
CO4	2	2	3	1	1	2	2	1	3	3	2	2
CO5	3	2	1	-	1	-	1	-	2	-	1	1
CO6	2	2	3	1	1	2	2	1	3	3	2	3
AVG	2.5	2.0	2.0	1.8	1.33	1.5	1.5	1.0	2.33	2.5	1.67	2.0

Course Content

Course code : BMH5DSE11
Course name : Linear Programming (Marks : 75)

Total Lecture Hours: 60

Unit 1 : Introduction to linear programming problem. Theory of simplex method, graphical solution, convex sets, optimality and unboundedness, the simplex algorithm, simplex method in tableau format, introduction to artificial variables, two-phase method. Big-M method and their comparison. **22L**

Unit 2 : Duality, formulation of the dual problem, primal-dual relationships, economic interpretation of the dual, Dual Simplex method. **8L**

Unit 3 : Transportation problem and its mathematical formulation, northwest-corner method, least cost method and Vogel approximation method for determination of starting basic solution, algorithm for solving transportation problem, assignment problem and its mathematical formulation, Hungarian method for solving assignment problem, Travelling salesman problem. **15L**

Unit 4 : Game theory: Formulation of two person zero sum games, solving two person zero sum games, games with mixed strategies, graphical solution procedure, linear programming solution of games. **15L**

Course Outcome (CO) — Paper: DSE-11

Sl. No.	Course Outcome (CO)	Knowledge Level (Bloom's Level)	POs	PSOs
1	**Explain** primal-dual relationships.	**L2: Understand**	**1, 2, 3, 4, 7, 9**	**1,2,3**
2	**Relate** between primal and dual problem.	**L4: Analyze**	**1, 2, 3, 4, 5, 7, 9**	**1,2,3**
3	**Apply** algorithms to solve transportation and assignment problems.	**L3: Apply**	**1, 2, 3, 4, 5, 7, 9**	**1,2,3**
4	**Formulate** of two person zero sum games	**L6: Create**	**1, 2, 3, 4, 5, 6, 7, 9**	**1,2,3**
5	**Define** linear programming problem and its components.	**L1: Remember**	**1, 2, 3, 4, 7, 9**	**1,2,3**
6	**Decide** the efficiency of different algorithms in transportation problem.	**L5: Evaluate**	**1, 2, 3, 4, 5, 7, 9**	**1,2,3**

Course Content

Course code : BMH5DSE11
Course name : Linear Programming (Marks : 75)

Programme Articulation Matrix (CO-PO Matrix)												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3
CO1	3	2	1	1	1	-	1	-	2	-	1	1
CO2	3	1	2	2	2	1	1	-	2	2	2	2
CO3	2	3	2	3	2	1	2	1	2	3	3	3
CO4	2	3	3	3	3	2	2	2	3	2	2	2
CO5	3	2	1	-	1	-	1	-	2	-	1	1
CO6	2	2	3	1	1	2	2	1	3	2	3	2
AVG	2.5	2.17	2.0	2.0	1.67	1.5	1.5	1.33	2.33	2.25	2.0	1.83

Course Content

Course code : BMH5DSE21
Course name : Probability and Statistics (Marks : 75)
Total Lecture Hours: 60

Total Lecture Hours: 60

Unit 1 : Sample space, probability axioms, real random variables (discrete and continuous), cumulative distribution function, probability mass/density functions, mathematical expectation, moments, moment generating function, characteristic function, discrete distributions: uniform, binomial, Poisson, geometric, negative binomial, continuous distributions: uniform, normal, exponential. **15L**

Unit 2 : Joint cumulative distribution function and its properties, joint probability density functions, marginal and conditional distributions, expectation of function of two random variables, conditional expectations, independent random variables, bivariate normal distribution, correlation coefficient, joint moment generating function (jmgf) and calculation of covariance (from jmgf), linear regression for two variables. **15L**

Unit 3 : Chebyshev's inequality, statement and interpretation of (weak) law of large numbers and strong law of large numbers. Central Limit theorem for independent and identically distributed random variables with finite variance, Markov Chains, Chapman-Kolmogorov equations, classification of states. **10L**

Unit 4 : Random Samples, Sampling Distributions, Estimation of parameters, Testing of hypothesis. **20L**

Course Outcome (CO) — Paper: DSE-21

Sl. No.	Course Outcome (CO)	Knowledge Level (Bloom's Level)	POs	PSOs
1	Recall the definitions and axioms of probability theory.	**L1: Remember**	**1, 2, 3, 4, 7, 9**	**1,2,3**
2	Understand the concepts of sample space, cumulative distribution functions, and probability distributions (discrete and continuous).	**L2: Understand**	**1, 2, 3, 4, 7, 9**	**1,2,3**
3	Apply joint distribution functions to calculate expectations and covariances.	**L3: Apply**	**1, 2, 3, 4, 5, 7, 9**	**1,2,3**
4	Evaluate the relationship between variables using correlation coefficients and regression analysis.	**L5: Evaluate**	**1, 2, 3, 4, 5, 7, 9**	**1,2,3**
5	Analyze the properties and behavior of Markov chains using Chapman-Kolmogorov equations.	**L4: Analyze**	**1, 2, 3, 4, 5, 7, 9**	**1,2,3**
6	Analyze the results of parameter estimation procedures and hypothesis tests.	**L4: Analyze**	**1, 2, 3, 4, 5, 7, 9**	**1,2,3**

Course Content

Course code : BMH5DSE21
Course name : Probability and Statistics (Marks : 75)
Total Lecture Hours: 60

Programme Articulation Matrix (CO-PO Matrix)												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3
CO1	3	1	-	-	1	-	1	-	3	-	1	1
CO2	3	2	1	1	1	-	1	-	2	-	1	1
CO3	2	3	2	3	2	1	2	1	2	2	2	3
CO4	2	2	3	1	1	2	2	1	3	3	2	3
CO5	3	1	2	2	2	1	1	-	2	2	2	2
CO6	3	1	2	2	2	1	1	-	2	2	2	2
AVG	2.67	1.83	2.0	1.8	1.5	1.25	1.33	1.0	2.33	2.25	1.67	2.0

Course Content

Course code : BMH6CC13

Course name : Metric Spaces and Complex Analysis (Marks : 75)

Total Lecture Hours: 60

Unit 1 : Metric spaces: Sequences in Metric Spaces, Cauchy sequences. Complete Metric Spaces, Cantor's theorem. **5L**

Unit 2 : Continuous mappings, sequential criterion and other characterizations of continuity, Uniform continuity, Connectedness, connected subsets of R.

Compactness: Sequential compactness, Heine-Borel property, Totally bounded spaces, finite intersection property, and continuous functions on compact sets.

Homeomorphism, Contraction mappings, Banach Fixed point Theorem and its application to ordinary differential equation. **25L**

Unit 3 : Limits, Limits involving the point at infinity, continuity. Properties of complex numbers, regions in the complex plane, functions of complex variable, mappings.

Derivatives, differentiation formulas, Cauchy-Riemann equations, sufficient conditions for differentiability. **7L**

Unit 4 : Analytic functions, examples of analytic functions, exponential function, Logarithmic function, trigonometric function, derivatives of functions, and definite integrals of functions. Contours, Contour integrals and its examples, upper bounds for moduli of contour integrals. Cauchy- Goursat theorem, Cauchy integral formula. **13L**

Unit 5 : Liouville's theorem and the fundamental theorem of algebra. Convergence of sequences and series, Taylor series and its examples. **6L**

Unit 6 : Laurent series and its examples, absolute and uniform convergence of power series. **4L**

Course Outcome (CO) — Paper: CC-13

Sl. No.	Course Outcome (CO)	Knowledge Level (Bloom's Level)	POs	PSOs
1	**Explain** concepts of Metric Spaces, Sequences in Metric Spaces, Complete Metric Spaces	**L2: Understand**	**1, 2, 3, 4, 5, 7, 9**	**1,2,3**
2	**Illustrate** Continuous mappings, Uniform continuity, Compactness of Metric Space	**L4: Analyze**	**1, 2, 3, 4, 5, 7, 9**	**1,2,3**
3	**Summarize** Homeomorphism, Contraction mappings, Banach Fixed point Theorem with application	**L5: Evaluate**	**1, 2, 3, 4, 5, 6, 7, 9**	**1,2,3**
4	**Describe** properties of complex numbers in Complex plane	**L1: Remember**	**1, 2, 3, 4, 7, 9**	**1,2,3**
5	**Compute** analytic functions, derivative of a function, Contour integration.	**L3: Apply**	**1, 2, 3, 4, 5, 7, 9**	**1,2,3**
6	**Explain** Liouville's theorem, The fundamental theorem of algebra, Laurent series with examples.	**L2: Understand**	**1, 2, 3, 4, 5, 6, 7, 9**	**1,2,3**

Course Content

Course code : BMH6CC13

Course name : Metric Spaces and Complex Analysis (Marks : 75)

Total Lecture Hours: 60

Programme Articulation Matrix (CO-PO Matrix)												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3
CO1	3	2	1	1	1	-	1	-	2	-	1	1
CO2	1	1	2	2	2	1	1	-	2	2	2	2
CO3	2	2	2	1	1	1	2	1	3	3	2	3
CO4	3	1	-	-	1	-	1	-	3	-	1	1
CO5	2	2	2	3	2	1	1	1	3	2	2	3
CO6	3	2	1	1	1	-	1	-	2	-	1	1
AVG	2.33	1.67	1.6	1.6	1.33	1.0	1.17	1.0	2.5	2.33	1.5	1.83

Course Content

Course code : BMH6CC14
Course name : Ring Theory and Linear Algebra II

Course : BMH6CC14

Ring Theory and Linear Algebra II (Marks : 75)

Total Lecture Hours: 60

Unit 1 : Polynomial rings over commutative rings, division algorithm and consequences, principal ideal domains, factorization of polynomials, reducibility tests, irreducibility tests, Eisenstein criterion, and unique factorization in Z [x]. Divisibility in integral domains, irreducible, primes, unique factorization domains, Euclidean domains. **20L**

Unit 2 : Dual spaces, dual basis, double dual, transpose of a linear transformation and its matrix in the dual basis, annihilators. Eigen spaces of a linear operator, diagonalizability, invariant subspaces and Cayley-Hamilton theorem, the minimal polynomial for a linear operator, canonical forms. **20L**

Unit 3 : Inner product spaces and norms, Gram-Schmidt orthogonalisation process, orthogonal complements, Bessel's inequality, the adjoint of a linear operator, Least Squares Approximation, minimal solutions to systems of linear equations, Normal and self-adjoint operators, Orthogonal projections and Spectral theorem. **20L**

Course Outcome (CO) — Paper: CC-14

Sl. No.	Course Outcome (CO)	Knowledge Level (Bloom's Level)	POs	PSOs
1	**Describe** polynomial rings, principal ideal domain, Euclidean domain and unique factorization domain, and their relationships.	**L1: Remember**	**1, 2, 3, 4, 7, 9**	**1,2,3**
2	**Judge** reducible and irreducible polynomial.	**L5: Evaluate**	**1, 2, 3, 4, 5, 7, 9**	**1,2,3**
3	**Relate** between dual basis and linear transformations.	**L4: Analyze**	**1, 2, 3, 4, 5, 7, 9**	**1,2,3**
4	**Explain** the concept of minimal polynomial.	**L2: Understand**	**1, 2, 3, 5, 7, 9**	**1,2,3**
5	**Define** an idea about inner product space and proceed to normed linear spaces.	**L1: Remember**	**1, 2, 3, 4, 7, 9**	**1,2,3**
6	**Use** Gram-Schmidt process to find orthogonal set of non-null vectors from any arbitrary set of vectors.	**L3: Apply**	**1, 2, 3, 4, 5, 7, 9**	**1,2,3**

Course Content

Course code : BMH6CC14
Course name : Ring Theory and Linear Algebra II

Programme Articulation Matrix (CO-PO Matrix)												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3
CO1	3	1	-	-	1	-	1	-	3	-	1	1
CO2	2	2	2	1	1	1	2	1	3	3	2	3
CO3	2	1	2	2	2	1	2	-	2	2	2	2
CO4	3	2	1	1	1	-	1	-	2	-	2	2
CO5	3	1	-	-	2	-	1	-	3	-	1	1
CO6	2	2	2	3	2	1	1	1	3	3	2	3
AVG	2.5	1.5	1.75	1.75	1.5	1.0	1.33	1.0	2.67	2.67	1.67	2.0

Course Content

Course code : BMH6DSE33
Course name : Group Theory II

Course : BMH6DSE33

Group Theory II (Marks : 75)

Total Lecture Hours: 60

Unit 1: Automorphism, inner automorphism, automorphism groups, automorphism groups of finite and infinitecyclic groups, applications of factor groups to automorphism groups, Characteristic subgroups, Commutatorsubgroup and its properties. 15L

Unit 2: Properties of external direct products, the group of units modulo n as an external direct product, internaldirect products, Fundamental Theorem of finite abelian groups. 10L

Unit 3: Group actions, stabilizers and kernels, permutation representation associated with a given group action.Applications of group actions. Generalized Cayley's theorem. Index theorem. 15L

Unit 4 : Groups acting on themselves by conjugation, class equation and consequences, conjugacy in Sn, p-groups,Sylow's theorems and consequences, Cauchy's theorem, Simplicity of An for n ≥ 5, non-simplicity tests.20L

Course Outcome (CO) — Paper: DSE-33

Sl. No.	Course Outcome (CO)	Knowledge Level (Bloom's Level)	POs	PSOs
1	**Define** Automorphism, Inner Automorphism, Automorphism groups, Automorphism groups of finite and infinite cyclic groups.	**L1: Remember**	**1, 3, 4, 6, 9**	**1,2,3**
2	**Illustrate** the properties of external direct products, internal direct products.	**L4: Analyze**	**1, 2, 3, 4, 6, 9**	**1,2,3**
3	**Explain** Group actions, stabilizers and kernels.	**L2: Understand**	**1,3, 4, 6,9**	**1,2,3**
4	**Solve** the existence or non-existence of normal subgroup in a group by using Generalized Cayley's Theorem.	**L3: Apply**	**1, 4, 5, 7, 9**	**1,2,3**
5	**Construct** Conjugacy Class Equations of some finite groups.	**L6: Create**	**1, 4, 7, 9**	**1,2,3**
6	**Decide** the Simple property of a Group with Sylow's Theorems.	**L5: Evaluate**	**1, 3, 4, 5, 9**	**1,2,3**

Course Content

Course code : BMH6DSE33
Course name : Group Theory II

Programme Articulation Matrix (CO-PO Matrix)												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3
CO1	3	1	-	-	1	-	1	-	3	-	1	1
CO2	2	1	2	2	2	1	2	-	2	2	2	2
CO3	3	2	1	1	1	-	1	-	2	-	1	1
CO4	2	2	2	3	2	1	1	1	3	2	2	2
CO5	1	2	3	2	3	1	2	2	2	3	2	3
CO6	2	2	2	1	1	1	2	1	3	2	2	2
AVG	2.17	1.67	2.0	1.8	1.67	1.0	1.5	1.33	2.5	2.25	1.67	1.83