VIDYASAGAR UNIVERSITY

Midnapore, West Bengal

PROPOSED CURRICULUM & SYLLABUS (DRAFT) OF

BACHELOR OF SCIENCE (HONOURS) MAJOR IN MATHEMATICS

4-YEAR UNDERGRADUATE PROGRAMME

(w.e.f. Academic Year 2023-2024)

Based on

Curriculum & Credit Framework for Undergraduate Programmes (CCFUP), 2023 & NEP, 2020

VIDYASAGAR UNIVERSITY
BACHELOR OF SCIENCE (HONOURS) MAJOR IN MATHEMATICS
(under CCFUP, 2023)

Level	YR.	SEM	Course Type	Course Code	Course Title	Credit	L-T-P	Marks		
								CA	ESE	TOTAL
B.Sc. (Hons.)	3rd		**SEMESTER-V**							
		V	Major-8	MATHMJ08	T: Riemann Integration and Series of Functions;	4	3-1-0	15	60	75
			Major-9	MATHMJ09	T: Multivariate Calculus;	4	3-1-0	15	60	75
			Major-10	MATHMJ10	T: Ring Theory & Linear Algebra;	4	3-1-0	15	60	75
			Major Elective-01	MATHDSE1	1.A: Linear Programming Problem 1.B: Bio-Mathematics 1.C: Industrial Mathematics	4	3-1-0	15	60	75
			Minor-5 (Disc.-I)	MATMIN05	T: Numerical Methods (To be taken from other Discipline)	4	3-1-0	15	60	75
					Semester-V Total	20				375
			SEMESTER-VI							
		VI	Major-11	MATHMJ11	T: Partial Differential Equations & Applications	4	3-1-0	15	60	75
			Major-12	MATHMJ12	T: Group Theory II	4	3-1-0	15	60	75
			Major-13	MATHMJ13	P: Metric Spaces and Complex Analysis	4	3-1-0	15	60	75
			Major Elective-02	MATHDSE2	2.A: Probability & Statistics 2.B: Logic and Graph Theory 2.C: Portfolio Optimization	4	3-1-0	15	60	75
			Minor-6 (Disc.-II)	MATMIN06	T: Numerical Methods (To be taken from other Discipline)	4	3-1-0	15	60	75
					Semester-VI Total	20				375
					YEAR-3	40				750
					Eligible to be awarded Bachelor of Science in Mathematics *on Exit*	126	Marks (Year: I+II+III)			2325

MJ = Major, MI = Minor Course, DSE = Discipline Specific Elective Course, CA= Continuous Assessment, ESE= End Semester Examination, T = Theory, P= Practical, L-T-P = Lecture-Tutorial-Practical

SEMESTER-V

MAJOR (MJ)

Major – 8
Riemann Integration and Series of Functions

[THEORY; TOTAL CREDITS: 04; 60L]

Course contents:

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.

Unit 2

Improper integrals. Convergence of Beta and Gamma functions.

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.

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.

Unit 5

Power series, radius of convergence, Cauchy Hadamard theorem. Differentiation and integration of power series; Abel's theorem; Weierstrass approximation theorem.

Reference Books

1. K.A. Ross, Elementary Analysis, The Theory of Calculus, Undergraduate
2. Texts in Mathematics, Springer (SIE), Indian reprint, 2004.
3. R.G. Bartle D.R. Sherbert, Introduction to Real Analysis, 3rd Ed., John Wiley and Sons (Asia) Pvt. Ltd., Singapore, 2002.
4. Charles G. Denlinger, Elements of Real Analysis, Jones & Bartlett (Student
5. Edition), 2011.
6. S. Goldberg, Calculus and mathematical analysis.
7. Santi Narayan, Integral calculus.
8. T. Apostol, Calculus I, II.

Course Outcomes (COs)

After successful completion of this course, students will be able to:

CO1: Develop a clear understanding of Riemann integration, explore different definitions, and apply the conditions of integrability to monotone, continuous, and piecewise functions.

CO2: Gain the ability to evaluate improper integrals and apply the properties of special functions such as Beta and Gamma in problem-solving contexts.

CO3: Understand and compare pointwise and uniform convergence of sequences and series of functions, and use key theorems to study the behavior of their limits with respect to continuity, differentiability, and integrability.

CO4: Learn to construct Fourier series expansions of functions and make use of fundamental results including Bessel's inequality, Parseval's identity, and Dirichlet's condition to analyze functions.

CO5: Apply the theory of power series to determine their convergence, perform term-by-term differentiation and integration, and utilize results like Abel's theorem and the Weierstrass approximation theorem for approximation of functions.

Major – 9
Multivariate Calculus
[THEORY; TOTAL CREDITS: 04; 60L]

Course contents:

Unit 1
Functions of several variables, limit and continuity of functions of two or more variables Partial differentiation, total differentiability and differentiability, sufficient condition for differentiability. Chain rule for one and two independent parameters, directional derivatives, the gradient, maximal and normal property of the gradient, tangent planes, Extrema of functions of two variables, method of Lagrange multipliers, constrained optimization problems

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.

Unit 3
Definition of vector field, divergence and curl.
Line integrals, applications of line integrals: mass and work. Fundamental theorem for line integrals, conservative vector fields, independence of path.

Unit 4
Green's theorem, surface integrals, integrals over parametrically defined surfaces. Stoke's theorem, The Divergence theorem.

Reference Books

1. G.B. Thomas and R.L. Finney, Calculus, 9th Ed., Pearson Education, Delhi, 2005.
2. M.J. Strauss, G.L. Bradley and K. J. Smith, Calculus, 3rd Ed., Dorling Kindersley (India) Pvt. Ltd. (Pearson Education), Delhi, 2007.
3. E. Marsden, A.J. Tromba and A. Weinstein, Basic Multivariable Calculus, Springer (SIE), Indian reprint, 2005.
4. James Stewart, Multivariable Calculus, Concepts and Contexts, 2nd Ed., Brooks /Cole, Thomson Learning, USA, 2001
5. T. Apostol, Mathematical Analysis, Narosa Publishing House
6. Courant and John, Introduction to Calculus and Analysis, Vol II, Springer
7. W. Rudin, Principles of Mathematical Analysis, Tata McGraw-Hill
8. Marsden, J., and Tromba, Vector Calculus, McGraw Hill.
9. Maity, K.C. and Ghosh, R.K. Vector Analysis, New Central Book Agency (P) Ltd. Kolkata

(India).
10. Terence Tao, Analysis II, Hindustan Book Agency, 2006
11. M.R. Speigel, Schaum's outline of Vector Analysis.

Course Outcomes (COs)

After successful completion of this course, students will be able to:

CO1: Understand the concepts of functions of several variables, continuity, differentiability, and apply methods such as the chain rule, directional derivatives, and Lagrange multipliers to solve optimization problems.

CO2: Evaluate double and triple integrals in Cartesian, polar, cylindrical, and spherical coordinates, and apply them to compute volumes and solve problems involving change of variables.

CO3: Explain the concepts of vector fields, compute divergence and curl, and apply line integrals in practical contexts such as mass and work.

CO4: Apply Green's theorem to plane regions and solve problems involving surface integrals of vector fields.

CO5: Utilize Stoke's theorem and the Divergence theorem to connect line, surface, and volume integrals, and apply these results in solving physical and geometrical problems.

Major – 10
Ring Theory and Linear Algebra-I
[THEORY; TOTAL CREDITS: 04; 60L]

Course contents:

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.

Unit 2

Ring homomorphisms, properties of ring homomorphisms. Isomorphism theorems I, II and III, field of quotients.

Unit 3

Vector spaces, subspaces, algebra of subspaces, quotient spaces, linear combination of vectors, linear span, linear independence, basis and dimension, dimension of subspaces.

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.

Reference Books

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

Course Outcomes (COs)

After successful completion of this course, students will be able to:

CO1: Understand the fundamental concepts of rings, subrings, integral domains, and fields, and analyze their basic properties including ideals, prime ideals, and maximal ideals.

CO2: Apply the concepts of ring homomorphisms, utilize the Isomorphism Theorems, and construct the field of quotients.

CO3: Demonstrate knowledge of vector spaces, subspaces, quotient spaces, and determine bases, dimensions, and linear independence of vectors.

CO4: Examine linear transformations, compute their null space, range, rank, and nullity, and represent them using matrices.

CO5: Apply algebraic properties of linear transformations, explore isomorphisms, and perform coordinate changes through invertible linear maps.

MAJOR ELECTIVE (DSE)

Major Elective-1

Elective 1. A: Linear Programming

[THEORY; TOTAL CREDITS: 04; 60L]

Course Content:

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.

Unit 2

Duality, formulation of the dual problem, primal- dual relationships, economic interpretation of the dual.

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.

Unit 3

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.

Reference Books

1. Mokhtar S. Bazaraa, John J. Jarvis and Hanif D. Sherali, Linear Programming and Network Flows, 2nd Ed., John Wiley and Sons, India, 2004.
2. F.S. Hillier and G.J. Lieberman, Introduction to Operations Research, 9th Ed., Tata McGraw Hill, Singapore, 2009.
3. Hamdy A. Taha, Operations Research, An Introduction, 8th Ed., Prentice- Hall India, 2006
4. G. Hadley, Linear Programming, Narosa Publishing House, New Delhi, 2002.

Course Outcomes (COs)

After successful completion of this course, students will be able to:

CO1: Understand the fundamentals of linear programming problems and solve them using the simplex method, graphical method, and artificial variable techniques.
CO2: Apply duality theory to formulate and interpret primal–dual problems with economic significance.
CO3: Formulate and solve transportation and assignment problems using standard algorithms such as Vogel's approximation and Hungarian method.
CO4: Analyze and solve two-person zero-sum games using graphical, simplex, and mixed strategy approaches.
CO5: Develop optimization-based problem-solving skills for decision-making in real-world applications.

OR

Elective 1. B: Bio Mathematics

[THEORY; TOTAL CREDITS: 04; 60L]

Course Content:

Unit 1

Mathematical biology and the modeling process: an overview. Continuous models: Malthus model, logistic growth, Allee effect, Gompertz growth, Michaelis-Menten Kinetics, Holling type growth, bacterial growth in a chemostat, harvesting a single natural population, Prey predator systems and Lotka Volterra equations, populations in competitions, epidemic models (SI, SIR, SIRS, SIC)

Unit 2

Activator-inhibitor system, insect outbreak model: Spruce Budworm. Numerical solution of the models and its graphical representation. Qualitative analysis of continuous models: Steady state solutions, stability and linearization, multiple species communities and Routh-Hurwitz Criteria. Phase plane methods and qualitative solutions, bifurcations and limit cycles with examples in the context of biological scenario.

Spatial models: One species model with diffusion. Two species model with diffusion, conditions for diffusive instability, spreading colonies of microorganisms, Blood flow in circulatory system, travelling wave solutions, spread of genes in a population.

Unit 3

Discrete models: Overview of difference equations, steady state solution and linear stability analysis. Introduction to discrete models, linear models, growth models, decay models, drug delivery problem, discrete prey-predator models, density dependent growth models with harvesting, host-parasitoid systems (Nicholson-Bailey model), numerical solution of the models and its graphical representation. case studies. Optimal exploitation models, models in genetics, stage structure models, age structure models.

Reference Books

1. L.E. Keshet, Mathematical Models in Biology, SIAM, 1988.
2. J. D. Murray, Mathematical Biology, Springer, 1993.
3. Y.C. Fung, Biomechanics, Springer-Verlag, 1990.
4. F. Brauer, P.V.D. Driessche and J. Wu, Mathematical Epidemiology, Springer, 2008.
5. M. Kot, Elements of Mathematical Ecology, Cambridge University Press, 2001.

Graphical demonstration as Teaching aid using any software

1. Growth model (exponential case only).
2. Decay model (exponential case only).
3. Lake pollution model (with constant/seasonal flow and pollution concentration).

4. Case of single cold pill and a course of cold pills.
5. Limited growth of population (with and without harvesting).
6. Predatory-prey model (basic volterra model, with density dependence, effect of DDT, two prey one predator).
7. Epidemic model of infuenza (basic epidemic model, contagious for life,disease with carriers).
8. Battle model (basic battle model, jungle warfare, long range weapons).

Course Outcomes (COs)

After successful completion of this course, students will be able to:

CO1: Understand the process of mathematical modeling in biology and apply continuous models such as population growth, prey–predator, competition, and epidemic models.
CO2: Analyze biological systems using stability analysis, phase plane methods, bifurcations, and diffusion-based spatial models.
CO3: Apply discrete models including growth, decay, prey–predator, and host–parasitoid systems to study biological dynamics.
CO4: Implement numerical and computational methods to solve biological models and visualize their qualitative behavior.
CO5: Develop and simulate case studies such as epidemic spread, drug delivery, ecological interactions, and resource exploitation using mathematical and computational tools.

OR

Elective 1. C: Industrial Mathematics

[THEORY; TOTAL CREDITS: 04; 60L]

Course Content:

Unit 1

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

Unit 2

Introduction to Inverse problems: Why should we teach Inverse Problems? Illustration of Inverse problems through problems taught in Pre-Calculus, Calculus, Matrices and differential equations. Geological anomalies in Earth's interior from measurements at its surface (Inverse problems for Natural disaster) and Tomography.

Unit 3

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

Unit 4

Radon Transform: Definition and Examples, Linearity, Phantom (Shepp - Logan Phantom - Mathematical phantoms).

Unit 5

Back Projection: Definition, properties and examples.

Unit 6

CT Scan: Revision of properties of Fourier and inverse Fourier transforms and applications of their properties in image reconstruction. Algorithms of CT scan machine. Algebraic reconstruction techniques abbreviated as ART with application to CT scan.

Reference Books

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

Course Outcomes (COs)

After successful completion of this course, students will be able to:

CO1: Understand the mathematical foundations of medical imaging, including X-rays, CT scans, and inverse problems.
CO2: Apply concepts from calculus, matrices, and differential equations to model and analyze inverse problems in science and industry.
CO3: Explain and utilize the principles of X-ray imaging, Beer's law, Radon transform, and back projection for image reconstruction.
CO4: Analyze mathematical phantoms and reconstruction techniques including Fourier transforms and algebraic reconstruction methods.
CO5: Develop problem-solving skills for real-world applications of inverse problems in medical imaging, tomography, and natural disaster modeling.

MINOR (MI)

Minor-5

Numerical Methods

[THEORY, CREDITS: 04; FM-75]

Course contents:

Unit 1

Algorithms. Convergence. Errors: relative, absolute. Round off. Truncation.

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.

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

Unit 4

Interpolation: Lagrange and Newton’s methods. Error bounds. Finite difference operators. Gregory forward and backward difference interpolation.

Numerical differentiation: Methods based on interpolations, methods based on finite differences.

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. Approximation:
Least square polynomial approximation.

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.

Suggested Readings:

1. Brian Bradie, A Friendly Introduction to Numerical Analysis, Pearson Education, India, 2007.
2. M.K. Jain, S.R.K. Iyengar and R.K. Jain, Numerical Methods for Scientific and Engineering

3. Computation, 6th Ed., New age International Publisher, India, 2007.
4. C.F. Gerald and P.O. Wheatley, Applied Numerical Analysis, Pearson Education, India, 2008.
5. Uri M. Ascher and Chen Greif, A First Course in Numerical Methods, 7th Ed., PHI Learning Private Limited, 2013.
6. John H. Mathews and Kurtis D. Fink, Numerical Methods using Matlab, 4th Ed., PHI Learning Private Limited, 2012.
7. Scarborough, James B., Numerical Mathematical Analysis, Oxford and IBH Publishing Co.
8. Atkinson, K. E., An Introduction to Numerical Analysis, John Wiley and Sons, 1978.
9. Yashavant Kanetkar, Let Us C , BPB Publications.
10. M.Pal, Numerical Analysis for Scientists and Engineers: Theory and C Programs, Narosa. 2007.

Course Outcomes (COs)

After successful completion of this course, students will be able to:

CO1: Understand sources of error in numerical computation and analyze convergence of numerical algorithms.

CO2: Apply iterative and direct methods to solve nonlinear equations and systems of linear equations with error and convergence analysis.

CO3: Implement interpolation, numerical differentiation, and numerical integration techniques for function approximation and evaluation.

CO4: Analyze and apply methods for solving algebraic eigenvalue problems and least-squares polynomial approximations.

CO5: Solve ordinary differential equations using numerical techniques such as Euler's method, Runge-Kutta methods, and successive approximations.

SEMESTER-VI

MAJOR (MJ)

Major-11
Partial Differential Equations & Applications
[Credits 04; Full Marks: 75]

Course contents:

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.

Unit 2

Derivation of heat equation, wave equation and Laplace equation. Classification of second order linear equations as hyperbolic, parabolic or elliptic. Reduction of second order linear equations to canonical forms.

Unit 3

The Cauchy problem, Cauchy-Kowalewskaya theorem, Cauchy problem of an infinite string. Initial 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

Unit 4

Central force. Constrained motion, varying mass, tangent and normal components of acceleration, modelling ballistics and planetary motion, Kepler's second law.

Unit 5

Graphical Demonstration(Teaching aid)

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.
1. Solution of wave equation in different initial and boundary conditions.

Reference Books

1. Tyn Myint-U and Lokenath Debnath, Linear Partial Differential Equations for Scientists and Engineers, 4th edition, Springer, Indian reprint, 2006.
2. S.L. Ross, Differential equations, 3rd Ed., John Wiley and Sons, India, 2004.
3. Martha L Abell, James P Braselton, Differential equations with MATHEMATICA, 3rd Ed., Elsevier Academic Press, 2004.
4. Sneddon, I. N., Elements of Partial Differential Equations, McGraw Hill.
5. Miller, F. H., Partial Differential Equations, John Wiley and Sons.
6. Loney, S. L., An Elementary Treatise on the Dynamics of particle and of Rigid Bodies, Loney Press.

Course Outcomes (COs)

After successful completion of this course, students will be able to:

CO1: Understand the basic concepts of partial differential equations, classify first-order PDEs, and apply methods such as characteristics and separation of variables to obtain solutions.

CO2: Derive fundamental second-order PDEs like the heat, wave, and Laplace equations, classify them as hyperbolic, parabolic, or elliptic, and reduce them to canonical forms.

CO3: Formulate and solve Cauchy problems and boundary value problems for wave and heat equations, including cases with non-homogeneous conditions, using the method of separation of variables.

CO4: Apply PDE techniques to model problems in mechanics such as central force motion, constrained motion, varying mass systems, and planetary motion governed by Kepler's laws.

CO5: Use graphical demonstrations to visualize solutions of PDEs, characteristics, integral surfaces, and solutions of wave equations under various conditions.

Major-12
Group Theory II
[THEORY, Credits 04; Full Marks: 75]

Course contents:

Unit 1

Automorphism, inner automorphism, automorphism groups, automorphism groups of finite and infinite cyclic groups, applications of factor groups to automorphism groups, Characteristic subgroups, Commutator subgroup and its properties.

Unit 2

Properties of external direct products, the group of units modulo n as an external direct product, internal direct products, Fundamental theorem of finite abelian groups.

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.

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 $n \geq 5$, non-simplicity tests.

Reference Books

1. John B. Fraleigh, A First Course in Abstract Algebra, 7th Ed., Pearson, 2002.
2. M. Artin, Abstract Algebra, 2nd Ed., Pearson, 2011.
3. Joseph A. Gallian, Contemporary Abstract Algebra, 4th Ed., Narosa Publishing House, 1999.
4. David S. Dummit and Richard M. Foote, Abstract Algebra, 3rd Ed., John Wiley and Sons (Asia) Pvt. Ltd., Singapore, 2004.
5. J.R. Durbin, Modern Algebra, John Wiley & Sons, New York Inc., 2000.
6. D. A. R. Wallace, Groups, Rings and Fields, Springer Verlag London Ltd., 1998
7. D.S. Malik, John M. Mordeson and M.K. Sen, Fundamentals of abstract algebra.
8. I.N. Herstein, Topics in Algebra, Wiley Eastern Limited, India, 1975.

Course Outcomes (COs)

After successful completion of this course, students will be able to:

CO1: Understand automorphisms, inner automorphisms, and automorphism groups, and apply properties of factor groups and commutator subgroups in group theory.
CO2: Analyze external and internal direct products of groups, and apply the Fundamental Theorem of Finite Abelian Groups to classify abelian groups.
CO3: Apply the concept of group actions to study stabilizers, kernels, and permutation representations, and use generalized Cayley's theorem and the index theorem in applications.
CO4: Examine groups acting on themselves by conjugation, apply the class equation, and study conjugacy classes in symmetric groups.
CO5: Apply Sylow's theorems, Cauchy's theorem, and results on simplicity and non-simplicity to classify finite groups, including properties of alternating groups.

Major-13
Metric Spaces and Complex Analysis
[THEORY; TOTAL CREDITS: 04; 60L]

Course Content:

Unit 1

Metric spaces: sequences in metric spaces, Cauchy sequences. Complete metric spaces, Cantor's theorem.

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.

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.

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.

Unit 5

Liouville's theorem and the fundamental theorem of algebra. Convergence of sequences and series, Taylor series and its examples.

Unit 6

Laurent series and its examples, absolute and uniform convergence of power series.

Reference Books

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

Course Outcomes (COs)

After successful completion of this course, students will be able to:

CO1: Understand the concepts of metric spaces, convergence, Cauchy sequences, completeness, and apply Cantor's theorem in analysis.

CO2: Analyze continuity and uniform continuity, connectedness, compactness, and apply important results such as the Heine–Borel property, Banach fixed point theorem, and their applications.

CO3: Explain the fundamental ideas of complex analysis including limits, continuity, differentiability, and apply Cauchy–Riemann equations to identify analytic functions.

CO4: Apply integral theorems of complex analysis such as Cauchy–Goursat theorem and Cauchy's integral formula to evaluate contour integrals and study properties of analytic functions.

CO5: Use Liouville's theorem, the Fundamental Theorem of Algebra, and power series expansions (Taylor and Laurent series) to study convergence properties and represent complex functions.

MAJOR ELECTIVE (DSE)

Major Elective-2

Elective 2. A: Probability and Statistics

[THEORY; TOTAL CREDITS: 04; 60L]

Course contents:

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.

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.

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.

Unit 4

Random Samples, Sampling Diatributions, Estimation of parameters, Testing of hypothesis.

Reference Books

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

Course Outcomes (COs)

After successful completion of this course, students will be able to:

CO1: Understand the fundamental concepts of probability, random variables, probability distributions, and their properties.

CO2: Apply discrete and continuous probability models to compute expectations, moments, and solve practical problems.

CO3: Analyze joint distributions, conditional expectations, correlations, and regression for bivariate data.

CO4: Interpret and apply laws of large numbers, central limit theorem, and concepts of Markov chains in stochastic modeling.

CO5: Perform statistical inference through sampling distributions, estimation of parameters, and hypothesis testing.

OR

Elective 2. B: Logic and Graph Theory

[THEORY; TOTAL CREDITS: 04; 60L]

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.

Unit 2

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.

Unit 3

Definition, examples and basic properties of graphs, pseudo graphs, complete graphs, bipartite graphs isomorphism of graphs.

Unit 4

Eulerian circuits, Eulerian graph, semi-Eulerian graph, theorems, Hamiltonian cycles,theorems Representation of a graph by matrix, the adjacency matrix, incidence matrix, weighted graph,

Unit 5

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

Reference Books

1. R.P. Grimaldi, Discrete Mathematics and Combinatorial Mathematics, Pearson Education, 1998.
2. P.R. Halmos, Naive Set Theory, Springer, 1974.
3. E. Kamke, Theory of Sets, Dover Publishers, 1950.
4. B.A. Davey and H.A. Priestley, Introduction to Lattices and Order, Cambridge University Press, Cambridge, 1990.
5. Edgar G. Goodaire and Michael M. Parmenter, Discrete Mathematics with Graph Theory, 2^{nd} Edition, Pearson Education (Singapore) P. Ltd., Indian Reprint 2003.
6. Rudolf Lidl and Gunter Pilz, Applied Abstract Algebra, 2nd Ed., Undergraduate Texts in Mathematics, Springer (SIE), Indian reprint, 2004.
7. N. Deo, Graph Theory with Applications to Engineering & Computer Science, Prentice Hall

India Learning Private Limited; New edition (1 January 1979).
8. D. B. West, Introduction to Graph Theory, Pearson. 2000.

Course Outcomes (COs)

After successful completion of this course, students will be able to:

CO1: Understand the fundamentals of propositional and predicate logic, logical equivalences, and quantifiers.

CO2: Apply set theory and relations, including equivalence relations and partial orderings, to solve mathematical problems.

CO3: Analyze properties of different types of graphs and identify isomorphism between graphs.

CO4: Examine Eulerian and Hamiltonian graphs, and represent graphs using matrices and weighted structures.

CO5: Apply graph algorithms such as shortest path, travelling salesman, spanning tree, Dijkstra's and Warshall's algorithms to solve real-world problems.

OR

Elective 2. C: Portfolio Optimization

[THEORY; TOTAL CREDITS: 04; 60L]

Course contents:

Unit 1
Financial markets. Investment objectives. Measures of return and risk. Types of risks. Risk free assets. Mutual funds. Portfolio of assets. Expected risk and return of portfolio. Diversification.

Unit 2
Mean-variance portfolio optimization- the Markowitz model and the two-fund theorem, risk-free assets and one fund theorem, efficient frontier. Portfolios with short sales. Capital market theory.

Unit 3
Capital assets pricing model- the capital market line, beta of an asset, beta of a portfolio, security market line. Index tracking optimization models. Portfolio performance evaluation measures.

Reference Books

1. F. K. Reilly, Keith C. Brown, Investment Analysis and Portfolio Management, 10th Ed., South-Western Publishers, 2011.
2. H.M. Markowitz, Mean-Variance Analysis in Portfolio Choice and Capital Markets, Blackwell, New York, 1987.
3. M.J. Best, Portfolio Optimization, Chapman and Hall, CRC Press, 2010.
4. D.G. Luenberger, Investment Science, 2nd Ed., Oxford University Press, 2013.

Course Outcomes (COs)

After successful completion of this course, students will be able to:

CO1: Understand the structure of financial markets, investment objectives, measures of risk and return, and the role of diversification in portfolio management.

CO2: Apply mean-variance portfolio optimization techniques including the Markowitz model, two-fund theorem, and efficient frontier analysis.

CO3: Analyze the impact of risk-free assets, short sales, and capital market theory on portfolio construction.

CO4: Evaluate asset pricing using the Capital Asset Pricing Model (CAPM), including beta, capital market line, and security market line.

CO5: Assess portfolio performance through index tracking models and performance evaluation measures.

MINOR (MI)

Minor-6

Numerical Methods

[THEORY, CREDITS: 04; FM-75]

Course contents:

Unit 1

Algorithms. Convergence. Errors: relative, absolute. Round off. Truncation.

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.

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

Unit 4

Interpolation: Lagrange and Newton's methods. Error bounds. Finite difference operators. Gregory forward and backward difference interpolation.

Numerical differentiation: Methods based on interpolations, methods based on finite differences.

Unit 5

Numerical Integration: Newton Cotes formula, Trapezoidal rule, Simpson's $1/3^{rd}$ rule, Simpsons $3/8^{th}$ rule, Weddle's rule, Boole's Rule. Midpoint rule, Composite trapezoidal rule, composite Simpson's $1/3^{rd}$ rule, Gauss quadrature formula.

The algebraic eigenvalue problem: Power method. Approximation: Least square polynomial approximation.

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.

Reference Books

1. Brian Bradie, A Friendly Introduction to Numerical Analysis, Pearson Education, India, 2007.
2. M.K. Jain, S.R.K. Iyengar and R.K. Jain, Numerical Methods for Scientific and Engineering
3. Computation, 6th Ed., New age International Publisher, India, 2007.
4. C.F. Gerald and P.O. Wheatley, Applied Numerical Analysis,

Pearson Education, India, 2008.
5. Uri M. Ascher and Chen Greif, A First Course in Numerical Methods, 7th Ed., PHI Learning Private Limited, 2013.
6. John H. Mathews and Kurtis D. Fink, Numerical Methods using Matlab, 4th Ed., PHI Learning Private Limited, 2012.
7. Atkinson, K. E., An Introduction to Numerical Analysis, John Wiley and Sons, 1978.
8. Yashavant Kanetkar, Let Us C , BPB Publications.
9. M.Pal, Numerical Analysis for Scientists and Engineers: Theory and C Programs, Narosa. 2007.

Course Outcomes (COs)

After successful completion of this course, students will be able to:

CO1: Understand sources of error in numerical computation and analyze convergence of numerical algorithms.

CO2: Apply iterative and direct methods to solve nonlinear equations and systems of linear equations with error and convergence analysis.

CO3: Implement interpolation, numerical differentiation, and numerical integration techniques for function approximation and evaluation.

CO4: Analyze and apply methods for solving algebraic eigenvalue problems and least-squares polynomial approximations.

CO5: Solve ordinary differential equations using numerical techniques such as Euler's method, Runge-Kutta methods, and successive approximations.