COURSE STRUCTURE FOR M.Sc. (MATHEMATICS)														
Semester I			**M.Sc. (Mathematics)**											
Sr. No.	**Course/Lab Code**	**Course/Lab Name**	**Teaching Scheme**					**Examination Scheme**						
			L	**T**	**P**	**C**	**Hrs./Wk**	**Theory**			**Practical**		**Total**	
								MS	**ES**	**IA**	**LW**	**LE/Viva**	**Marks**	
1.	20MSM501T	Real Analysis	3	1	0	4	4	25	50	25	--	--	100	
2.	20MSM502T	Theory of ODE	3	1	0	4	4	25	50	25	--	--	100	
3.	20MSM503T	Linear Algebra	3	1	0	4	4	25	50	25	--	--	100	
4.	20MSM504T	Probability and Statistics	3	1	0	4	4	25	50	25	--	--	100	
5.	20MSM505T	Numerical Analysis	3	1	0	4	4	25	50	25	--	--	100	
6.	**20HS501P**	**HSS - Communication Skills**	**0**	**0**	**2**	**1**	**2**	**--**	**--**	**--**	**50**	**50**	**100**	
		Total	**15**	**5**	**2**	**21**	**22**						**600**	

IA - Internal Assessment, MS - Mid Semester, ES – End Semester Exam.

HSS - Communication skills are to be floated and taught by other department from SLS.

20MSM501T					Real Analysis					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs. /Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	1	0	4	4	25	50	25	--	--	100

COURSE OBJECTIVES

- To be able to understand the concept of metric space, compactness, connectedness and uniform convergence.
- To be able to develop ideas in constructing rigorous mathematical proofs.
- To be able to determine if a function on a metric space is continuous or discontinuous.
- To understand the concept of pointwise and uniform convergence.

UNIT 1 INTRODUCTION TO REAL NUMBER SYSTEM AND METRIC SPACES 09 Hrs.

Real Number system: Completeness property, Finite, Countable and Uncountable Sets, Cantor's set. Metric Spaces: Metric spaces, Some Useful inequalities: Holder's inequality, Cauchy's inequality, Minkowski's inequality. Open sets, Closed sets in a metric space, Closure of a set, Limit Point, Interior Point, Exterior Point and their theorems.

UNIT 2 SEQUENCES 11 Hrs.

Sequence, Convergence of a sequence, Cauchy Sequence, Limit point of a Sequence. Continuity, Completeness: Complete metric space, Cantor's Intersection Theorem, Dense Set, Contraction Mapping.

UNIT 3 COMPACTNESS AND CONNECTEDNESS 11 Hrs.

Compactness: Totally bounded, Characterizations of compactness, Finite intersection property, Continuous functions on compact sets. Connectedness: Characterizations of connectedness, Continuous functions on connected sets.

UNIT 4 PROPER AND IMPROPER INTEGRATION 09 Hrs.

Riemann integration, Sequences and Series of Functions: Definition of point-wise and uniform convergence, Uniform convergence and continuity, Uniform convergence and differentiation.

40 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to
CO1 – Identify rigorous arguments developing the theory of underpinning real analysis
CO2 – Understand fundamental properties of the real numbers that lead to the formal development of real analysis
CO3 – A pply the acquired knowledge in important practical problems and extend ideas to a new context.
CO4 – Analyze the concept of compactness, connectedness and uniform convergence with various aspects
CO5 – Evaluate the problems of the subsets of a metric space are open, closed, compact and/or connected.
CO6 – Develop abstract ideas in analyzing proofs of theorems

TEXT/REFERENCE BOOKS

1. W. Rudin, Principles of Mathematical Analysis, McGraw Hill, 1976.
2. R. G. Bartle, Introduction to Real Analysis, John Wiley and Sons, 2000.
3. T. M. Apostol, Mathematical Analysis, Addison-Wesley Publishing Company, 1974.
4. A. J. Kosmala, Introductory Mathematical Analysis, WCB Company , 1995.
5. W. R. Parzynski and P. W. Zipse, Introduction to Mathematical Analysis, McGraw Hill Company, 1982.
6. H. S. Gaskill and P. P. Narayanaswami, Elements of Real Analysis, Prentice Hall, 1988.

20MSM502T					Theory of Ordinary Differential Equations					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs. / Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	1	0	4	4	25	50	25	--	--	100

COURSE OBJECTIVES

- To understand the subject at greater depth than the standard undergraduate-level ODE course.
- Introduce the theory, solution, and application of ordinary differential equations.
- Analyze some critical non-linear problems in ODE.
- To encounter confidently the courses like PDE, mathematical modeling using this course of ODE.

UNIT 1 LINEAR EQUATIONS WITH CONSTANT COEFFICIENTS 11 Hrs.

The second order homogeneous equation, initial value problems for second order equations, Linear dependence and independence, A formula for Wronskian, A non-homogeneous equation of order two, The homogeneous equation of order n, Bernoulli's equations, Initial value problems for nth order equations, equations with real constants, A non-homogeneous equation of order n.

UNIT 2 LINEAR EQUATIONS WITH VARIABLE COEFFICIENT AND REGULAR SINGULAR POINT 10 Hrs.

Linear equations with variable coefficient: Initial value problems for the homogeneous equation, Solution of the homogeneous equation, The Wronskian and linear independence, Reduction of the order of the order of homogeneous equation, The non-homogeneous equation, Homogeneous equations with analytical co-efficient, The Legendre's equation.
Linear equations with Regular singular point: The Euler equation, Second order equations with regular singular points, its convergence (with proof), The Bessel equation, regular singular points at infinity.

UNIT 3 EXISTENCE AND UNIQUENESS OF SOLUTION TO FIRST ORDER EQUATIONS 09 Hrs.

Equations with variables separated, Exact equations, The method of successive approximations, The Lipschitz condition, Convergence of successive approximations, non-local existence of solutions, Approximations to, and uniqueness of, solutions, Equations with complex valued functions.

UNIT 4 BOUNDARY VALUE PROBLEMS 10 Hrs.

Green's function, Sturm-Liouville problem, eigenvalue problems. Stability of linear and nonlinear systems: Lyapunov stability, Sturm's Comparison theorem, mathematical modeling.

40 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to
CO1 – Identify the ordinary differential equations and their importance in applied sciences.
CO2 – Understand the types of ODE's and their theoretical aspects.
CO3 – Demonstrate various linear differential equations along with their theory and applications.
CO4 – Analyze the methods to solve ordinary differential equations and also the nature of their solution.
CO5 – Appraise the existence and uniqueness of solution of first order differential equations.
CO6 – Develop the solutions of boundary value problem for linear and nonlinear cases.

TEXT/REFERENCE BOOKS

1. S.G. Deo, V. Raghavendra, Rasmita Kar, V. Lakshmikantham, Textbook of Ordinary Differential Equations, 3rd ed., McGraw Hill Education Pvt. Ltd., India, 2015.
2. G.F. Simmons, Differential equations with applications and historical notes, 2nd ed., McGraw-Hill, 2017.
3. S. L. Ross, Differential Equations-3rd ed., John Wiley & Sons, 1980 .
4. L. Perko, Differential Equations and Dynamical Systems, Texts in Applied Mathematics, 2nd ed., Springer Verlag, 1998.
5. Carl M. Bender, Steven A. Orszag, Advanced mathematical methods for Scientists and Engineers, Springer, New York,1999.

20MSM503T					Linear Algebra					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs. / Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	1	0	4	4	25	50	25	--	--	100

COURSE OBJECTIVES

- To understand the need of introducing vector spaces and to be able to apply various operations therein.
- To be able to associate matrices to linear transformation, verify Rank-Nullity theorem.
- To understand the concept of inner product spaces, apply Orthogonalization and Spectral theorem.
- To be able to apply diagonalization, singular value decomposition and solve ordinary differential equations.

UNIT 1 VECTOR SPACES **09 Hrs.**

Introduction to Matrices, Determinants and systems of linear algebraic equations, Vector spaces, Subspaces, Linear Dependence and Independence, Basis and Dimension, Range and Null space, Rank-Nullity theorem, Linear span, Change of basis, Row column space, Direct sum and complement, least squares, orthogonal subspaces.

UNIT 2 LINEAR TRANSFORMATIONS **09 Hrs.**

Introduction to linear transformation, Algebra, Isomorphism, Representation by matrices, Change of basis, Diagonal Forms, Triangular Forms, Jordan Forms, Inverse of a linear transformation, Linear Functional.

UNIT 3 INNER PRODUCT AND ORTHOGONALITY **10 Hrs.**

Metric and Normed spaces, Inner Product Spaces, Orthogonality, Orthonormal Basis, Gram-Schmidt Orthogonalization process, Expansion, Orthogonal and Unitary Matrices, Orthogonal projections, Adjoints, Hermitian, self adjoint, Unitary and Normal operators, Spectral Theorem for normal operators, Rayleigh quotient, Min-Max Principle.

UNIT 4 EIGEN VALUES AND VECTORS WITH APPLICATIONS **12 Hrs.**

Modal matrix and Diagonalization, Similarity Transformation, Powers and functions of matrices, Eigen systems of real symmetric, orthogonal, Hermitian and Unitary matrices, Quadratic forms, Positive definite matrices, Computation of eigen values, Singular value decomposition (Principal Component Analysis), Norm of a matrix, Condition number, Applications to solving ordinary differential equations and image processing.

40 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to
CO1 – Recall the concept of vector spaces and find basis and dimension.
CO2 – Associate the linear transformations with matrices.
CO3 – Apply appropriate tool/method to extract the solutions of practical problems.
CO4 – Analyze the obtained solution in context with theory.
CO5 – Appraise practical problems in terms of vectors and arrays and solve them using algebraic methods.
CO6 – Create various patterns of image processing through singular value decomposition.

TEXT/REFERENCE BOOKS

1. Hoffman K. & Kunze R., Linear Algebra, Pearson Education (India), 2008.
2. Strang, G., Linear Algebra and its applications, 3rd ed .,Thomson, 1998.
3. Anton, H. & Rorres C., Elementary linear algebra, 9th ed., Wiley India, 2005.
4. David C. Lay, Steven C. Lay, Judi J. McDonald, Linear Algebra and its applications, 5th ed., Pearson, 2015.

20MSM504T					Probability And Statistics					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs. / Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	1	0	4	4	25	50	25	--	--	100

COURSE OBJECTIVES

- To be able to understand of data collection, its distribution and testing and Goodness of Fit.
- To be able to apply the central measure of various data related to real world problem.
- To be able to analyze the data using analysis of variance related to various field of science and engineering.
- To be able to evaluate problems related to probability and distribution.

UNIT 1 THEORY OF PROBABILITY **12 Hrs.**

Sample Space, Discrete probability, Independent Events, Baye's Theorem, Random Variables and Distribution Functions (Univariate and Multivariate) Expectation and Moments, Independent Random Variables, Marginal and Conditional Distributions, Characteristic Functions, Probability Inequalities, Techbyshef, Markov, Jensen, Modes of Convergence, Weak and Strong Laws of Large Numbers, Central Limit Theorems (i.i.d. case), Markov Chains with Finite and Countable State Space

UNIT 2 PROBABILITY DISTRIBUTION **08 Hrs.**

Standard Discrete and Continuous Univariate Distribution, Sampling Distributions, Standard Errors and Asymptotic Distribution. Functions of random variables, joint distributions, multivariate distributions.

UNIT 3 STATISTICAL INFERENCES **10 Hrs.**

Method of Estimation Properties of Estimators, Confidence Intervals, Type I and Type II errors, Neyman-Pearson Lemma and Applications. Tests of Hypothesis, Likelihood Ration Tests, Analysis of Discrete Data and Chisquare Test of Goodness of Fit, Large Sample Tests, Simple Non-parametric Tests for One and Two Sample Problem.

UNIT 4 GAUSS MARKOV MODEL **10 Hrs.**

Gauss Markov Models, Estimability of Parameters, Best Linear Unbiased Estimators, Tests for Linear Hypothesis and Confidence Intervals, Analysis of Variance and Covariance. Fixed, Random and Mixed Effects Models, Simple and Multiple Linear Regression, Elementary Regression Diagnostics, Logistic Regression, Multivariate Normal Distribution.

40 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to
CO1 – Identify the use of probability and distribution functions in engineering aspects.
CO2 – Understand the concept of sampling and hypothesis test.
CO3 – Apply appropriate tool/method to extract the statistical solutions of engineering problems.
CO4 – Analyze the obtained solution of data analysis in context with theory.
CO5 – Appraise mathematical/statistical problems from real to complex domain.
CO6 – Design mathematical model in context with real world problem.

TEXT/REFERENCE BOOKS

1. Jay L. Devore, Probability and Statistics for Engineering and the Sciences, Cenage Learning.
2. Ronald E. Walpole, Sharon L. Myers and Keying Ye, Probability & Statistics For Engineers & Scientists, 8th ed., Pearson Education.
3. Sheldon M. Ross, Introduction to Probability Models, 10th ed., Academic Press.
4. Sheldon M. Ross, Introduction to Probability and Statistics for Engineers and Scientists,4th ed., Academic Press.
5. S.C. Gupta & V.K. Kapoor, Fundamentals of Mathematical Statistics, 11th ed., Sultan Chand & Sons.

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20MSM505T					Numerical Analysis					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	1	0	4	4	25	50	25	--	--	100

COURSE OBJECTIVES

- To understand and acquaint the concept of various numerical methods.
- To develop numerical skills in solving problem of engineering interest.
- To enrich the concept of finite element techniques.
- To extract the roots of a polynomial equation.

UNIT 1 EIGEN VALUES EIGEN VECTORS AND INTERPOLATION **10 Hrs.**

Eigen values and eigen vectors: Numerical evaluation of largest as well as smallest (numerically) Eigen values and corresponding Eigen vectors. **Interpolation:** Introduction, Newton Gregory Forward Interpolation Formula, Newton Gregory Backward Interpolation Formula, Central difference interpolation formula, Lagrange's Interpolation Formula for unevenly spaced Formula, Error in interpolation, Newton's Divided Difference Formula, cubic spline interpolation, surface interpolation.

UNIT 2 NUMERICAL SOLUTION NON LINEAR EQUATIONS AND POLYNOMIAL **08 Hrs.**

Introduction, Solution of non - linear simultaneous equations, Descarte's Sign rule, Horner's method, Lin-Bairstow's method, Graeffe's root squaring method, Muller's method, Comparison of various methods.

UNIT 3 NUMERICAL SOLUTION OF ODEs AND PDEs **14 Hrs.**

Taylor's method, Euler's method, Runge-Kutta methods of various order, Modified Euler's method, Predictor corrector method: Adam's method, Milne's method. Solution of Boundary value problems using finite differences. Finite difference approximation of partial derivatives, Classification of 2nd order PDEs, different type of boundary conditions, solutions of Elliptic, parabolic and hyperbolic equations of one and two dimensions, Crank- Nicholson method, ADI method.

UNIT 4 FINITE ELEMENT METHOD **08 Hrs.**

Introduction, Method of Approximation, The Rayleigh-Ritz Method, The Galerkin Method, Application to One dimensional and two dimensional problems.

40 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to
CO1 – Apply a suitable numerical technique to extract approximate solution to the problem.
CO2 – Estimate the errors in various numerical methods.
CO3 – Analyze and interpret the achieved numerical solution of problems by reproducing it in graphical or tabular form.
CO4 – Compare the data generated by performing an experiment or by an empirical formula with a polynomial on which operations like division, differentiation and integration can be done smoothly.
CO5 – Evaluate a sufficiently accurate solution of various physical models of science as well as engineering
CO6 – Design/ create an appropriate numerical algorithm for various problems of science and engineering.

TEXT/REFERENCE BOOKS

1. B.S. Grewal, Numerical Methods in Engineering and Science with Programs in C & C++,Khanna Publishers,2010.
2. S.S. Sastry, Introductory Methods for Numerical Analysis,4th ed., Prentice Hall of India ,2009.
3. M.K. Jain, S.R.K. Iyenger and R.K. Jain, Numerical Methods for Scientific and Engineering Computation, 5th ed., New Age Int., 2007.
4. C F Gerald and P O Wheatley, Applied Numerical analysis, 7th ed., Pearson education, 2003.
5. R.K. Jain & S.R.K. Iyenger, Advanced Engineering Mathematics, 3rd Ed., Narosa , 2002.

Semester II			M.Sc. (Mathematics)										
Sr. No.	**Course/Lab Code**	**Course/Lab Name**	**Teaching Scheme**					**Examination Scheme**					
								Theory			**Practical**		**Total**
			L	**T**	**P**	**C**	**Hrs/ Wk**	**MS**	**ES**	**IA**	**LW**	**LE/Viva**	**Marks**
1.	20MSM506T	Theory of PDE	3	1	0	4	4	25	50	25	--	--	100
2.	20MSM507T	Complex Analysis	3	1	0	4	4	25	50	25	--	--	100
3.	20MSM508T	Modern Algebra	3	1	0	4	4	25	50	25	--	--	100
4.	20MSM509T	Topology	3	1	0	4	4	25	50	25	--	--	100
5.	20MSM510T	Calculus of Variation and Integral Equations	3	1	0	4	4	25	50	25	--	--	100
6.	20MSM511T	Object Oriented and Python Programming	3	0	0	3	3	25	50	25	--	--	100
7.	20MSM511P	Object Oriented and Python Programming Lab	0	0	2	1	2	--	--		50	50	100
		Total	**18**	**5**	**2**	**24**	**25**						**700**

IA- Internal Assessment, MS-Mid Semester; ES – End Semester Exam

20MSM506T					Theory of Partial Differential Equations					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	1	0	4	4	25	50	25	--	--	100

COURSE OBJECTIVES

- To familiarize the students with first and higher order partial differential equations and their classification.
- To provide a broad coverage of various mathematical techniques that is widely used for solving and to get analytical solutions to partial differential equations of first and second order.
- To introduce various applications of partial differential equations in many fields of science and engineering.
- To develop an understanding of numerical methods for partial differential equations.

UNIT 1 LINEAR AND SEMILINEAR PDEs 10 Hrs.

Linear and semi-linear equations, Cauchy problem, Method of characteristics. Cauchy-Kowalewsky theorem, Holmgren's Uniqueness Theorem. Classification of second order equations, Laplace equation, fundamental solutions, maximum principles and mean value formulas, Properties of harmonic functions, Green's function, Energy methods, Perron's method.

UNIT 2 NON-LINEAR PDEs 09 Hrs.

Parabolic equations in one space dimension, fundamental solution, maximum principle, existence and uniqueness theorems. Wave equation, Solutions by spherical means, Non-Homogeneous Problems, Nonlinear first order PDE's: Complete integrals, Envelopes and singular solutions. Some special methods for finding solutions: Similarity solutions, Hopf-Cole transformation.

UNIT 3 MODELLING AND APPLICATIONS 06 Hrs.

Mathematical models leading to partial differential equations. Riemann's method and applications. Vibration of a membrane. Duhamel's principle. Solutions of equations in bounded domains and uniqueness of solutions. BVPs for Laplace's and Poisson's equations.

UNIT 4 NUMERICAL METHODS FOR PDEs 15 Hrs.

Finite difference methods for the existence and computation of Laplace, heat and wave equations, Jacobi's, Gauss-Seidel and SOR methods for solving Laplace equation, Crank-Nicolsan and Lax-Wendroff methods for solving heat equation, Explicit formula of three level difference schemes for solving wave equation.

40 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to
CO1 – Understand the formation and solution of PDEs of first, second and higher order.
CO2 – Solve first-order linear and nonlinear PDEs using the method of characteristics.
CO3 – Apply various analytic methods to obtain solutions to PDEs of first and second order, which occur in science and engineering.
CO4 – Use appropriate numerical methods to study phenomena modeled as PDEs.
CO5 – Analyze the method of characteristics to understand the concepts related to shocks.
CO6 – Point out real phenomena as models of partial differential equations.

TEXT/REFERENCE BOOKS

1. Sneddon, I.N. , Elements of Partial Differential Equations, Dover, 1st ed., 2006.
2. John F., Partial Differential Equations, Springer Velag, 4th Ed., 1982.
3. G. D. Smith: Numerical Solutions of Partial Differential Equations: Finite Difference Methods, Oxford University Press, U.S.A., 3rd Ed, 1986.
4. T. Amaranath: An Elementary Course in Partial Differential Equations, Narosa Publishing House, New Delhi.
5. Y. Pinchover and J. Rubinstein, An introduction to partial differential equations, Cambridge, 2005.

20MSM507T					Complex Analysis					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs. / Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	1	0	4	4	25	50	25	--	--	100

COURSE OBJECTIVES

- To equip students with necessary knowledge and skills of complex functions.
- To enable students handle mathematical operations, analyses and problems involving complex numbers.
- To make students understand the role of singularities and their consequences.
- To enable students apply Weierstrass factorization theorem to a suitable class of complex functions.

UNIT 1 COMPLEX DIFFERENTIATION — 11 Hrs.

The extended plane and its spherical representation, elementary properties and examples of analytic functions, Power functions, analytic functions as mappings, zeroes of analytic functions, Conformal mappings, Mobius transformations, branch of logarithm.

UNIT 2 EXPANSION OF FUNCTIONS AND ANALYTIC CONTINUATION — 09 Hrs.

Taylor and Laurent series expansion of complex functions , Mittag-Leffler theorem, Weierstrass factorization theorem, Analytic continuation.

UNIT 3 COMPLEX INTEGRATION — 12 Hrs.

Rieman - Stieltjes integrals, The index of a closed curve, Cauchy Theorem and integral formula, The homotopic version of Cauchy's Theorem and simple connectivity, Counting zeroes, The open mapping theorem, Goursat's Theorem, Liouville's theorem, Morera's theorem, Maximum modulus theorem.

UNIT 4 SINGULARITIES AND THEORY OF RESIDUES — 08 Hrs.

Singularities, Classification of singularities, Residues, The argument principle, Cauchy Residue theorem, Applications of residues- evaluating real integrals (three cases), Summation of series.

40 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to
CO1 – Define various transformations identified in complex scenario.
CO2 – Understand the concept analytic functions and illustrate contour integration to complex functions.
CO3 – Apply appropriate tool/method to extract the solutions to practical problems.
CO4 – Analyze the obtained solution in context with theory.
CO5 – Appraise mathematical problems from real to complex domain.
CO6 – Formulate problems on factorization of entire functions.

TEXT/REFERENCE BOOKS

1. J. W. Brown, R. V. Churchill, Complex Variables and Applications, McGraw Hill, 2009.
2. W. Kaplan, Introduction to Analytic Functions, Addison-Wesley, 1966.
3. H. S. Kasana, Complex Variables: Theory and Applications, Prentice Hall, 2005.
4. Lar's V. Ahlfors , Complex Analysis, 3rd ed., Mc Graw Hill, 1988.
5. John H. Mathew and Russel, W.Howell, Complex analysis for Mathematics and Engineering, 3rd ed., Jones and Bartlett publishers, 1977.

20MSM508T					Modern Algebra					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs. / Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	1	0	4	4	25	50	25	--	--	100

COURSE OBJECTIVES

- To enable student to give a good mathematical maturity and to build mathematical thinking and skill.
- To learn the general algebraic structure of various sets (such as real numbers, complex numbers, matrices, and vector spaces), rather than rules and procedures for manipulating their individual elements.
- To develop the skill of constructing proofs and writing in mathematics.
- To identify the applications of modern algebra in various fields of sciences.

UNIT 1 GROUPS **12 Hrs.**

Introduction to groups, Finite groups, Subgroups, Cyclic groups, Permutation groups, Isomorphism, External direct product, Internal direct product, Cosets and Lagrange's theorem, Normal subgroups, Group homomorphism, Fundamental theorem of finite Abelian groups.

UNIT 2 RINGS **10 Hrs.**

Introduction to Rings, Properties of rings, Integral domains, Ideals and factor rings, Ring homomorphism, Polynomial rings, Factorization of polynomials, Divisibility in integral domains.

UNIT 3 FIELDS **08 Hrs.**

Vector spaces, Extension fields, Algebraic extensions, Finite fields, Geometric constructions.

UNIT 4 SPECIAL TOPICS **10 Hrs.**

Sylow theorems, Finite simple groups, Generators and relations, Symmetry groups, Cayley diagraphs of groups, Introduction to algebraic coding theory, Introduction to Galois theory, Introduction to Boolean Algebra.

40 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 – Define algebraic structures and to construct substructures.

CO2 – Assess properties implied by the definitions of groups and rings.

CO3 – Apply the theories in abstract algebra in communication theory, electrical engineering, computer science, and cryptography.

CO4 – Analyze and demonstrate examples of subgroups, normal subgroups and quotient groups, Ideals and quotient rings, isomorphism and homomorphism for groups and rings.

CO5 – Appraise the theoretical concepts studied in this subject in the more applied subjects in higher education.

CO6 – Develop new structures based on given structures and compare structures.

TEXT/REFERENCE BOOKS

1. J. A. Gallian, Contemporary Abstract Algebra, 8th ed., Cengage Learning, 2013.
2. A. R. Vasishtha, A. K. Vasishtha, Modern Algebra, Krishna Prakashan Media (P) Ltd., 2002.
3. M. Artin, Algebra, 2nd ed., Pearson, 2010.
4. D. S. Dummit, R. M. Foote, Abstract Algebra, 3rd ed., John Wiley & Sons, 2003.
5. I. N. Herstein, Topics in Algebra, 2nd ed., John Wiley and Sons, 1975 .
6. Lang, Serge, Algebra, Graduate Texts in Mathematics, Revised 3rd ed., New York: Springer-Verlag, 2011.

20MSM509T					Topology					
Teaching Scheme					**Examination Scheme**					
L	**T**	**P**	**C**	**Hrs. / Week**	**Theory**			**Practical**		**Total Marks**
					MS	**ES**	**IA**	**LW**	**LE/Viva**	
3	**1**	**0**	**4**	**4**	**25**	**50**	**25**	**--**	**--**	**100**

COURSE OBJECTIVES

- To be able to gain knowledge of topological spaces with different characteristics.
- To be able to work out the product of two spaces and the role of bounded sets in pure mathematics
- To be able to relate the compactness and different sets.
- To study separable and regularity axioms and their significance.

UNIT 1 TOPOLOGICAL SPACES 10 Hrs.

Topological Spaces, Bases, Subspace, Closed Sets, Open Sets, Interior, Closure, Limit point, Boundary of a set. T1, T2-spaces, Continuous functions, Pasting Lemma

UNIT 2 PRODUCT SPACES AND BOUNDED SETS 12 Hrs.

Product space, Projections, Weak topology, Product of T1, T2-spaces, Metric topology, Basic concepts and sequences, Continuity and uniform continuity, Bounded subsets, Totally bounded subsets.

UNIT 3 COMPACT SPACES 08 Hrs.

Compact topological spaces, Finite Intersection Properties, Hausdorff and Compactness, Compact metric spaces, Heine-Borel Theorem.

UNIT 4 REGULAR, COUNTABLE AND SEPARABLE SPACES 10 Hrs.

Regular, Normal, Completely regular spaces, Compact Hausdorff spaces, Second Countable space, separable space, second Countability and Separability in metric space.

40 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to
CO1 – Identify variety of spaces in Topological aspect.
CO2 – Understand the concept of closed and opens sets in different contexts and continuous functions in topology. .
CO3 – Explain various metric topologies and demonstrate the uniform continuity.
CO4 – Analyze the compactness of a topological space and to justify whether the space is Hausdorff or not.
CO5 – Appraise the significance of Heine-Borel theorem and the connection with different topological spaces.
CO6 – Evaluate regularity, countability and separability of various spaces.

TEXT/REFERENCE BOOKS

1. Simmons G F, Introduction to Topology and Modern Analysis, McGraw-Hill Co., Tokyo, 1963.
2. Munkres, J, Topology: A First Course, Prentice Hall of India Pvt. Ltd., New Delhi, 2000.
3. Kumaresan S., Topology of Metric Spaces, Narosa Publication, New Delhi, 2011.
4. Joshi K.D., Introduction to General Topology, New Age Publishers, New Delhi, 1983.

20MSM510T					Calculus of Variation and Integral Equations					
Teaching Scheme					**Examination Scheme**					
L	**T**	**P**	**C**	**Hrs/Week**	**Theory**			**Practical**		**Total Marks**
					MS	**ES**	**IA**	**LW**	**LE/Viva**	
3	**1**	**0**	**4**	**4**	**25**	**50**	**25**	**--**	**--**	**100**

COURSE OBJECTIVES

- To understand the Fredholm and Volterra Integral Equations.
- To classify the initial and boundary value problems and evaluate.
- To apply variation problem technique for solving differential equations and extremum problems.
- To explain the significance of Eigen-values and Eigen-vectors.

UNIT 1 CALCULUS OF VARIATION – PART 1 10 Hrs.

Variational problems with fixed boundaries - Euler's equation for functional containing first-order derivative and one independent variable. Extremals, Functional dependent on higher order derivatives. Functional dependent on more than one independent variable. Variational problems in parametric form. Invariance of Euler's equation under coordinate transformation.

UNIT 2 CALCULUS OF VARIATION – PART 2 10 Hrs.

Variational problems with moving boundaries. Functional dependent on one and two functions. One sided variations. Sufficient conditions for an extremum — Jacobi and Legendre conditions. Second variation. Variational principle of least action. Applications.

UNIT 3 INTEGRAL EQUATIONS – PART 1 10 Hrs.

Linear integral equations: Volterra integral equations, Fredholm integral equations, Some basic identities, Types of kernels: Symmetric kernel, Separable kernel, Iterated kernel, Resolvent kernel, Initial value problems reduced to Volterra integral equations, Solution of Volterra integral equation using: Resolvent kernel, Successive approximation, Neumann series method.

UNIT 4 INTEGRAL EQUATIONS – PART 2 10 Hrs.

Boundary value problems reduced to Fredholm integral equations, Solution of Fredholm integral equations using separable kernel, Resolvent kernel. Methods of successive approximation and successive substitution to solve Fredholm equations of second kind. Solution of Homogeneous Fredholm integral equation: Eigen values, Eigen vectors.

40 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to
CO1 – Understand theory of calculus of variations to solve initial and boundary value problems.
CO2 – Summarize the concept of Kernels.
CO3 – Apply the concept of Eigen-values and Eigen-vectors.
CO4 – Explain the principle of least action.
CO5 – Analyze the maxima and minima of a functional.
CO6 – Construct linear integral equations of first and second type (Volterra and Fredholm).

TEXT / REFERENCE BOOKS

1. I. M. Gelfand and S.V. Fomin, Calculus of variations, Prentice Hall. Inc., 1963.
2. William Vernon Lovitt, Linear integral equations, Dover Publication Inc. Newyork, 2005.
3. M. Rahman, Integral equations and their applications, WIT Press, Boston, 2007.
4. Lev D. Elsgole, Calculus of Variations, Dover Publication Inc. Newyork, 2007.
5. S.G. Mikhlin, Integral equations, Pergamon Press, 1965.

20MSM511T					Object Oriented And Python Programming					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs. / Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	0	3	3	25	50	25	--	--	100

COURSE OBJECTIVE

- ➢ Understanding about object oriented programming.
- ➢ To make aware the concept of classes and objects.
- ➢ Understanding the process of exposing essential data and hiding the low level data.
- ➢ Implementation of object oriented programming concepts in PYTHON.
- ➢ Understand the basics of constructors, destructors, inheritance and polymorphism.

UNIT 1 CONSTRUCTORS, DESTRUCTORS, INHERITANCE AND POLYMORPHISM 10 Hrs.

What is object oriented programming. Programming characteristics of object oriented languages, constructors and destructors, types of constructors, destructors, declaration and application of constructors, Private constructor and destructors, program on constructors and destructors, Inheritance, Virtual functions and Function overriding, Polymorphism

UNIT 2 INTRODUCTION TO PYTHON 10 Hrs.

The basic elements of Python, Branching programs, Strings and Input, Iteration Functions and Scoping, Specifications, Recursion, Global variables, Modules, Testing, Debugging, Numpy, Spicy modules.

UNIT 3 CLASSES AND OBJECTS 10 Hrs.

Introduction to classes and objects, class, encapsulation, objects, member function, static member.

UNIT 4 STRUCTURED TYPES, MUTABILITY 10 Hrs.

Tuples, Lists and Mutability, Functions as Objects, Strings, Tuples and Lists, Dictionaries
Handling exceptions, Exceptions as a control flow mechanism, Assertions, Abstract Data Types and Classes, Inheritance, encapsulation.

40 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to
CO1 – Apply the object oriented programming paradigm to write computer program.
CO2 – Demonstrate the ability to apply concepts of OOP.
CO3 – Apply data structures available in Python library.
CO4 – Analyze mathematical problems by writing simple program in OOP approach.
CO5 – Evaluate scientific/ mathematical problem by writing simple program in PYTHON.
CO6 – Create/manipulate object belonging to the class.

TEXT/REFERENCE BOOKS

1. Object-Oriented Programming with C++, E. Balagurusamy, Tata McGraw Hill.
2. Object Oriented Programming & C++, R. Rajaram, New Age International.
3. C++ The complete Reference, H. Schildt, 4th Ed, Tata McGraw Hill.
4. Object-Oriented Programming with C++ and JAVA, D. Samanta, PHI.
5. John V Guttag. “Introduction to Computation and Programming Using Python”, Prentice Hall of India.
6. Allen Downey, Jeffrey Elkner and Chris Meyers "How to think like a Computer Scientist, Learning with Python", Green Tea Press.

20MSM511P					Object Oriented and Python Programming Lab					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
0	0	2	1	2	---	---	---	50	50	100

COURSE OBJECTIVES

- ➢ Understanding about object oriented programming.
- ➢ To make aware the concept of classes and objects.
- ➢ Understanding the process of exposing essential data and hiding the low level data.
- ➢ Implementation of object oriented programming concepts in PYTHON.
- ➢ Understand the basics of constructors, destructors, inheritance and polymorphism.

LIST OF EXPERIMENTS

1. Program illustrating use of inline functions and default arguments.
2. Program implementing the concept of function overloading.
3. Program implementing the concept of class/ nesting of member function.
4. Program for processing shopping list.
5. Program implementing the concept of static member function.
6. Program illustrating the concept of arrays of objects/ objects as arguments.
7. Program illustrating the concept of swapping private data of classes.
8. Program to write a class to represent a bank account including the following members: data members
   (i) Name of the depositor
   (ii) Account number
   (iii) Types of account
   (iv) Balance amount in the account
   Member functions: to assign initial values, to deposit an account, to withdraw an amount after checking the balance, to display name and balance.Write a main program to test the program.
9. Program implementing the concept of class with constructors or destructors/ overloaded constructors/ dynamic initialization of constructors.
10. Programs carrying out the concept of operator overloading and type conversions.
11. Creation of class **MAT** of size $m \times n$ and defining all possible matrix operations for **MAT** type objects.
12. Programs carrying out the concept of single inheritance public and private.

COURSE OUTCOMES

On completion of the course, student will be able to
CO1 – Apply the object oriented programming paradigm to write computer program.
CO2 – Demonstrate the ability to apply concepts of OOP.
CO3 – Apply data structures available in Python library.
CO4 – Analyze mathematical problems by writing simple program in OOP approach.
CO5 – Evaluate scientific/ mathematical problem by writing simple program in PYTHON.
CO6 – Create/manipulate object belonging to the class.

TEXT/REFERENCE BOOKS

1. Object-Oriented Programming with C++, E. Balagurusamy, Tata McGraw Hill.
2. Object Oriented Programming & C++, R. Rajaram, New Age International.
3. C++ The complete Reference, H. Schildt, 4th Ed, Tata McGraw Hill.
4. Object-Oriented Programming with C++ and JAVA, D. Samanta, PHI.
5. John V Guttag. “Introduction to Computation and Programming Using Python”, Prentice Hall of India.
6. Allen Downey, Jeffrey Elkner and Chris Meyers "How to think like a Computer Scientist, Learning with Python", Green Tea Press.

COURSE STRUCTURE FOR M.Sc. (MATHEMATICS)														
Semester III			**M.Sc. (Mathematics)**											
Sr. No.	**Course/Lab Code**	**Course/Lab Name**	**Teaching Scheme**					**Examination Scheme**						
			L	**T**	**P**	**C**	**Hrs/Wk**	**Theory**			**Practical**		**Total**
								MS	**ES**	**IA**	**LW**	**LE/Viva**	**Marks**
1.	20RM601T	**Research Methodology**	1	0	0	1	1	25	50	25	--	--	100
2.	20MSM602T	**Functional Analysis**	3	1	0	4	4	25	50	25	--	--	100
3.	20MSM603	**Project-I**	--	--	--	8	--	--	--	--	--	--	100
4.	20MSM----	Elective-1	3	1	0	4	4	25	50	25	50	50	100
5.	20MSM----	Elective-2	3	1	0	4	4	25	50	25	--	--	100
		Total	**10**	**3**	**0/2**	**21**	**13+project-1**						**500**

IA- Internal Assessment, MS-Mid Semester; ES – End Semester Exam

The department offers two elective courses, to be chosen from the courses listed below, with the available combination, listed in a row (a student may choose any one row):

Elective-1			**Elective-2**		
20MSM604T	Fluid Mechanics	3,1,0	20MSM605T/20MSM606T	Continuum Mechanics/Classical Mechanics	3,1,0
20MSM607T	Bio-Mathematics	3,1,0	20MSM608T	Finite Element Method	3,1,0
20MSM609T	Optimization	3,1,0	20MSM610T	Modeling and Simulation	3,1,0
20MSM611T	Fractional Calculus and Special function	3,1,0	20MSM612T	Numerical Linear Algebra	3,1,0
20MSM613T	Numerical Solution of Differential Equations	3,1,0	20MSM614T	Boundary Element Method	3,1,0
20MSM615T/P	Artificial Neural Network	3,0,0/0,0,2	20MSM616T	Tensor and Special Theory of Relativity	3,1,0

20RM601T					Research Methodology					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
1	0	0	1	1	25	50	25	--	--	100

COURSE OBJECTIVES

- To expose the students to the basic elements of research.
- To teach students the basic mathematical and statistical tools available for research.
- To help develop research aptitude in students.
- To be able to select and define appropriate research problem and parameters.

UNIT 1 : PRIMARY RESEARCH **6 Hrs.**

Conducting Primary Research: Definition and characteristics of research. Different types of research, Steps in research, Identification, selection and formulation of research problems, Details about research questions, interviews, surveys, observations, and analysis research. Formulation of hypothesis, Review of Literature.

UNIT 2 : RESEARCH TOOLS **7 Hrs.**

Sampling techniques, sampling theory, types of sampling, sampling and non-sampling error, sample size, advantages and limitation of sampling, collection of data, primary data, meaning, data collection method, secondary data, meaning, relevance, limitations and cautions. Statistics in research, measures of central tendency, dispersion, skewness and kurtosis in research, hypothesis, fundamentals of hypothesis testing, standard error, point and interval estimates, important non-parametric tests, Testing of significance, mean, proportion, variance and correlation-testing for significance of difference between means, proportions, variances and correlation co-efficient, Chi-Square tests-Anova-One way and Two way, Research Report writing.

COURSE OUTCOMES

On completion of the course, student will be able to
CO1-- understand some basic concepts of research and its methodologies.
CO2 – identify appropriate research topic
CO3 – select and define appropriate research problem and parameters.
CO4 – prepare a project proposal.
CO5 – write a research report and thesis
CO6 – organize and conduct research (advanced project) in a more appropriate manner

TEXT/REFERENCE BOOKS

1. C.R. Kothari, Gaurav Garg, Research Methodology: Methods and techniques, 4th ed., New Age International Publishers, 2019.
2. E. Bright Wilson Jr. , An Introduction to Scientific Research, 3rd ed., Dover Publication, 1990.

20MSM602T					Functional Analysis					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	1	0	4	4	25	50	25	--	--	100

COURSE OBJECTIVES

- To familiarize the students with the basic concepts, principles and methods of functional analysis.
- To introduce the concepts of Banach spaces and Hilbert spaces.
- To give students a working knowledge of the basic properties of bounded linear operators.
- To illustrate the uses of the theory of functional analysis.

UNIT 1 SPACES AND OPERATORS **12Hrs**

Metric spaces, Normed and Banach spaces, Compactness and Finite Dimension, Linear operators, Bounded and Continuous Linear Operators, Inner product and Hilbert spaces, Orthogonal Complements and Direct Sums, Representation of Functionals on Hilbert Spaces, Self-Adjoint, Unitary and Normal Operators.

UNIT 2 FUNDAMENTAL THEOREMS **8 Hrs**

Hahn-Banach theorem, Uniform boundedness theorem, Open mapping theorem, Closed graph theorem.

UNIT 3 SPECTRAL THEORY **10 Hrs**

Basic concepts, Complex analysis on Banach spaces, Spectral Properties of Compact Linear Operators, Spectral Properties of Bounded Self-Adjoint Linear Operators.

UNIT 4 APPLICATIONS **10 Hrs**

Unbounded Linear Operators, Momentum Operator, Heisenberg Uncertainty Principle, Time-Independent Schrodinger Equation.

40 Hrs

COURSE OUTCOMES

On completion of the course, student will be able to
CO1 – Understand and appreciate the basic concepts of functional Analysis.
CO2 – Illustrate linear operators, self adjoint, isometric and unitary operators on Hilbert spaces.
CO3 – Understand the fundamentals of spectral theory.
CO4 – Understand how the abstract theory works in practice.
CO5 – Thoroughly explain Banach and Hilbert spaces.
CO6 – Apply fundamental theorems from the theory.

TEXT/REFERENCE BOOKS

1. Walter Rudin, Functional Analysis-McGraw-Hill, 1991.
2. Karen Saxe, Beginning functional analysis-Springer,2002.
3. Erwin Kreyszig, Introductory functional analysis with applications.
4. John B. Conway, A Course in Functional Analysis, z-lib.org.
5. D. H. Griffel , Applied Functional Analysis-Ellis Horwood, 1985.
6. Yu.I. Lyubich, N.K. Nikol'skij, I. Tweddle, Functional Analysis I_Linear Functional Analysis -Springer, 1992.

20MSM604T					Fluid Mechanics					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	1	0	4	4	25	50	25	--	--	100

COURSE OBJECTIVES

- To expose the students to the basic elements of fluid mechanics in sufficiently rigorous manner.
- To familiarise with the properties of fluids and applications of fluid mechanics.
- To understand the concept of dynamics of fluid flows and governing non-dimensional parameters.
- To understand concepts of mass, momentum and energy conservation to fluid flows.

UNIT 1 VISCOUS FLOW **10 Hrs.**

Real and Ideal Fluids: Types of fluid Flow (Real/Ideal Fluid Flow, Compressible/Incompressible flow, Newtonian/Non-Newtonian fluids, Rotational/irrotational flows, Steady/Unsteady Flow, Uniform/Non uniform Flow, One, Two or three Dimensional Flow, Laminar or Turbulent Flow), Preliminaries for the derivation of governing equation (Coordinate systems: Lagrangian description and Eulerian description). Models of the flow (Infinitesimal Fluid Element), Substantial Derivative.

UNIT 2 DERIVATION OF GOVERNING EQUATIONS **10 Hrs.**

Derivation of Continuity Equation, Derivation of Momentum Equation, Special case (Incompressible Newtonian Fluid), Physical interpretation of each term, Derivation of Energy Equation, Boundary Conditions.

UNIT 3 BOUNDARY LAYER THEORY **10 Hrs.**

Prandtl's Concept of Boundary Layer, Boundary Layer Flow along a Flat Plate, Governing Equations, Boundary Conditions, Exact Solution of the Boundary-Layer Equations for Plane Flows (Similarity Solution).

UNIT 4 EXACT/ ANALYTICAL SOLUTION OF NAVIER-STOKES EQUATION **10 Hrs.**

Reynolds number, Nondimensionalization, Importance of Reynolds number to Navier-Stokes Equation, Exact Solution of Navier-Stokes Equation (Couette-Poisseuille flow, Flow of a Viscous Fluid with Free Surface on an Inclined Plate)

40 Hrs.

COURSE OUTCOMES

CO1 – Explain the motion of fluids and identify the derivation of basic governing equations of fluid mechanics and apply.
CO2 – Demonstrate dimensional analysis and similitude.
CO3 – Apply the preliminary computational techniques for the Navier-Stokes equation.
CO4 – Survey boundary layer theory.
CO5 – Analyze hydrostatic problems.
CO6 – Evaluate the exact/analytical Solution of Navier-Stokes equation for some physical problems.

TEXT/REFERENCE BOOKS

1. John D. Anderson Jr., Computational Fluid Dynamics the Basics with Applications, McGraw-Hill Education, 2017.
2. G. K. Batchelor, An Introduction to Fluid Dynamics, 2nd ed., Cambridge University Press, 2000.
3. Frank M. White, Fluid Mechanics, 8th ed., McGraw-Hill, 2016
4. Hermann Schlichting, Boundary Layer Theory, 7th ed., McGraw-Hill Education, 2014.
5. T. J. Chung, Computational Fluid Dynamics, 2nd ed., Cambridge University Press, 2002.

20MSM605T					Continuum Mechanics					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	1	0	4	4	25	50	25	--	--	100

COURSE OBJECTIVES

- To expose the students to the basic elements of continuum mechanics in sufficiently rigorous manner.
- To understand the necessity of constitutive equations.
- To explain governing equations for physical problem by first principles
- To demonstrate knowledge of the physical meanings, principles and mathematics of continuous media represented as solids, liquids and gases.

UNIT 1 TENSOR ALGEBRA AND CALCULUS 12 Hrs.

Continuum hypothesis and concept of field, scalar, vectors and second order tensors, tensor formalism and notational conventions, algebra of tensors, tensor transformation, tensor calculus: time derivative, gradient operator, directional derivative.

UNIT 2 KINEMATICS OF A CONTINUUM 10 Hrs.

Displacement field, displacement and deformation gradients, rotation and strain tensors for infinitesimal deformation, finite deformation, polar decomposition, Lagrangian and Eulerian measures of strain.

UNIT 3 STRESS ANALYSIS 08 Hrs.

Stress and integral formulation of general principles: stress tensor, principles of linear and angular momentum, conservation of mass, energy equation.

UNIT 4 CONSTITUTIVE RELATIONSHIP 10 Hrs.

Constitutive Relationships: the elastic solid, infinitesimal theory of elasticity: linear isotropic and anisotropic materials, finite deformation theory for isotropic materials, Newtonian fluids: inviscid and linear viscosity flows.

40 Hrs.

COURSE OUTCOMES

CO1 – Demonstrate knowledge of the physical meanings, principles, and mathematics of continuous media represented as solids, liquids, and gases.
CO2 – Apply physical laws such as the conservation of mass, the conservation of momentum, and the conservation of energy in models to derive differential equations describing the behaviour of such objects, and some information about the particular material studied to be added through constitutive relations.
CO3 – Explain relationship between strain tensor and stress tensors in an elastic substance.
CO4 – Analyze strain/stress vector of an object as a continuum which assumes that the substance of the object completely fills the space it occupies.
CO5 – Evaluate simplified problems using the language and methods of continuum mechanics.
CO6 – Formulate simplified problems using the language and methods of continuum mechanics.

TEXT/REFERENCE BOOKS

1. W. M. Lai, D. Rubin, and E. Krempl, Introduction to Continuum Mechanics, 4th ed. Butterworth-Heinemenn, 2015.
2. J. N. Reddy, An Introduction to Continuum Mechanics, 2nd ed. Cambridge University Press, 2016.
3. D. S. Chandrasekharaiah and L. Debnath, Continuum Mechanics. Academic Press, 1994.
4. Gedrge R. Mase, Continuum Mechanics: Schaum's Outline of Theory and Problem of Continuum Mechanics: McGraw Hill Education, 1969.
5. R. Chatterjee, Mathematical Theory of Continuum Mechanics: Narosa Publishing House, 2019.

20MSM606T					Classical Mechanics					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs. /Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	1	0	4	4	25	50	25	--	--	100

COURSE OBJECTIVES

- To demonstrate knowledge and understanding of the following fundamental concepts in: the dynamics of system of particles, motion of rigid body.
- To be able to understand the Lagrangian and Hamiltonian formulation of mechanics.
- To represent the equations of motion for complicated mechanical systems using the Lagrangian and Hamiltonian formulation of classical mechanics.
- To develop math skills as applied to mechanics.

UNIT 1 INTRODUCTION TO MOTION **09 Hrs.**

Motion of a particle in a central field, stability of orbits and disturbed orbits, deduction of Kepler's laws. D'Alembert's principle, compound pendulum.

UNIT 2 CALCULUS OF MOTION **11 Hrs.**

Langrange's Equations, small oscillations, Elements of calculus of variations, Hamilton's principle, principle of least action, Fermat's principle, Brachistochrone's problem

UNIT 3 MOTION OF A RIGID BODY **11 Hrs.**

Angular velocity, angular momentum of a rigid body, equations of motion of a rigid body, Eulerian angles, Euler's equations, the asymmetrical top.

UNIT 4 CANONICAL EQUATIONS **09 Hrs.**

Lagrange and Poisson Brackets, contact transformation, Elements of Hamilton Jacobi theory, Adiabatic invariants, Canonical variables, Conditionally periodic motion.

40 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 – Define and understand basic mechanical concepts related to discrete and continuous mechanical systems.

CO2 – Describe and understand the vibrations of discrete and continuous mechanical systems.

CO3 – Apply the acquired knowledge in important practical problems and extend ideas to a new context.

CO4 – Analyze the planar and spatial motion of a rigid body.

CO5 – Evaluate the complicated mechanical system using classical mechanics.

CO6 – Develop the motion of a mechanical system using Lagrange-Hamilton formalism.

TEXT/REFERENCE BOOKS

1. Goldstein, Classical Mechanics, Pearson Education India, 3rd edition, 2013
2. Herbert Charles Corben, Philip Stehle, Classical Mechanics, Dover Publications, 2nd edition, 1994.
3. A.S.Ramsey, Hydrostatics: A Text-book for the Use of First Year Students at the Universities and for the Higher Divisions in Schools, Cambridge University Press, 1946.
4. David Morin, Introduction to Classical Mechanics: With Problems and Solutions, Cambridge University Press, 2008.

20MSM607T					Biomathematics					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	1	0	4	4	25	50	25	--	--	100

COURSE OBJECTIVES

- To be able to understand the advantage of biomathematics.
- To be able to formulate mathematical models of population dynamics.
- To be able to analyse the process nervous system of human body.
- To be able to formulate and solve various mathematical models of biophysical problems.

UNIT 1 INTRODUCTION TO BIOMATHEMATICS 08 Hrs.

Geometric and analytic approaches to understanding models. Fixed points and their stability. Simple population models. Linearization. Saddle node, transcritical and pitchfork bifurcations. Structural stability. Oscillators and phases. Biological examples.

UNIT 2 MATHEMATICAL MODELING OF POPULATION DYNAMICS 10 Hrs.

Models for population growth, exponential, logistic, interacting populations, Predator-Prey, Lotka-Volterra and food webs. SIR models and their generalizations, e.g. SIRS, SIS.

UNIT 3 MATHEMATICAL MODELS OF BIOLOGICAL DIFFUSION AND PHARMCOKINETICS 10 Hrs.

Chemical Interactions, law of mass action, enzymatic reactions, chemical master equations, Brownian motion, random walks, Fick's law, diffusion with advection and chemotaxis.

UNIT 4 FUNDAMENTALS OF NEUROSCIENCE 12 Hrs.

Cellular and Molecular Neuroscience, Electronic Properties of Neuron cell, Glia, General Overview of Signaling in the Nervous System, General Physiology of Glail Cells, Neuronal-Glial Interactions, Astrocytes, Oligodendrocytes, Schwann Cells and Myelination, The cell membrane, Diffusion, Single-Channel Analysis, Excitability, The Hodgkin-Huxley Model, The FitzHugh-Nagumo Equations

40 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to
CO1 – Identify the use of continuity and convergence of solution of mathematical problems.
CO2 – Understand the concept of stability of mathematical models.
CO3 – Explain mathematical models of biophysical problems.
CO4 – Analyze the obtained solution in context with theory.
CO5 – Appraise mathematical problems from real to complex domain.
CO6 – Develop to formulate mathematical models on biological and physiological problems.

TEXT/REFERENCE BOOKS

1. J. D. Murray, Mathematical Biology 1: An Introduction, Third edition, springer.
2. J. N. Kapur, Mathematical modeling, John Wiley & Sons Inc., 1988.
3. James Keener and James Sneyd, Mathematical Physiology, 2nd ed.,Springer, 2009.
4. Larry R. Squire and others, Fundamental Neuroscience, 3rd ed., Elsevier, 2008.
5. Alexei Verkhratsky and Arthur Butt, Glial Neurobiology: A textbook, John Wiley and Sons Ltd, 2007.

20MSM608T					Finite Element Method					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	1	0	4	4	25	50	25	--	--	100

COURSE OBJECTIVES

- To be able to understand the advantage of finite element method.
- To be able to obtain weak form of the mathematical models.
- To be able to analyse the process of finite element method.
- To be able to formulate and solve various mathematical equations using finite element method.

UNIT 1 INTRODUTION TO FINITE ELEMENT METHOD **08 Hrs.**

Introduction of Finite Element Method - Comparison of finite element method with other methods of analysis - Engineering applications of FEM - Discretization of the domain- Basic element shapes - Discretization process - mesh generation.

UNIT 2 STEPS IN FINITE ELEMENT METHOD **12 Hrs.**

Interpolation models, polynomial form of the interpolation functions - degree of freedom, convergence requirement - linear interpolation polynomial in terms of local and global coordinates - higher order and isoparametric elements quadratic elements - continuity and compatibility- numerical integration- Derivation of element matrices and vectors.

UNIT 3 SOLUTION PROCEDURE OF FEM **10 Hrs.**

Week form of the mathematical models - variational approach - Rayleigh-Ritz method - derivation of finite element equations using variational approach - weighted residual approach - assembly of element matrices and vectors- Numerical solution of finite element equations, Gauss elimination method - solution of propagation problem- basic equations and solution procedure.

UNIT 4 SOLUTION OF DIFFERENTIAL EQUATIONS USING FEM **10 Hrs.**

Solution of one and two dimensional problems using Finite Element Method.

40 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to
CO1 – Identify the use of continuity and convergence of solution of mathematical problems.
CO2 – Understand the concept of finite element method in aspect of real world problems.
CO3 – Apply finite element method in various physical problems of science and engineering.
CO4 – Analyze the obtained solution in context with theory.
CO5 – Appraise mathematical problems from real to complex domain.
CO6 – Develop problems on real world using finite element method.

TEXT/REFERENCE BOOKS

1. S. S. Rao, The finite element method in engineering, 4th edition, Elsevier, 2004.
2. J. N. Reddy, An Introduction to the Finite Element Method (Engineering Series), 3rd edition, McGraw Hill Education, 2005.
3. Young W. Kwon and Hyochoong Bang, The Finite Element Method Using MATLAB, 2nd edition, CRC Press; 2000.
4. Desai C.S, Introduction to The Finite Element Method - A Numerical Method for Engineering Analysis, CBS Publishers & Distributors, 2005.

20MSM609T					Optimization					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	1	0	4	4	25	50	25	--	--	100

COURSE OBJECTIVES

- To make students understand about basics non - linear programming.
- To make students understand about dynamic programming and its application is real world problems.
- To introduce basic concepts and principles of inventory management
- To make students aware about planning and scheduling issues and their solutions.

UNIT 1 NON LINEAR PROGRAMMING-CLASSICAL APPROACH **10 Hrs.**

Non-Linear Programming: Convex function and its properties, basics of NLP, Method of Lagrange multiplier, Karush-Kuhn-Tucker optimality conditions, Quadratic Programming: Basic Concepts, Wolfe's method, Beale's method.

10 Hrs.

UNIT 2 NUMERICAL OPTIMIZATION TECHNIQUES

Numerical optimization techniques: line search methods, gradient methods, Newton's method, conjugate direction methods, quasi-Newton methods, projected gradient methods, penalty methods.

UNIT 3 GEOMETRIC PROGRAMMING **10 Hrs.**

Dynamic Programming: Multistage decision processes, Recursive nature of computations, Forward and Backward recursion, Bellman's principle of optimality, Selective dynamic programming applications involving additive and multiplicative separable returns for objective as well as constraint functions, Problem of dimensionality.

UNIT 4 DYNAMIC PROGRAMMING **10 Hrs.**

Dynamic Programming: Multistage decision processes, Recursive nature of computations, Forward and Backward recursion, Bellman's principle of optimality, Selective dynamic programming applications involving additive and multiplicative separable returns for objective as well as constraint functions, Problem of dimensionality.

40Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to
CO1 – Understand material requirement planning and enterprise resource planning.
CO2 – Apply concepts of EOQ to quantity discount models.
CO3 – Apply concept of dynamic programming and its recursive nature for computation of problems.
CO4 – Develop Optimal non - linear problems with or without constraints.
CO5 – Construct economic order quantity to minimize total cost.
CO6 – Plan material requirement planning for an enterprise in the presence of known resources.

TEXT/REFERENCE BOOKS

1. Hamdy A. Taha, Operations Research-An Introduction, Prentice Hall, 9th Edition, 2010.
2. S. Chandra, Jayadeva, AparnaMehra, Numerical Optimization with Application, Narosa Publishing House, 2009.
3. V. V. Sople, Supply Chain Management: Text and Cases. Pearson Education India, 2011.
4. R. Ravindran, and D.P. Warsing Jr., Supply Chain Engineering: Models and Applications. CRC Press, 2012.
5. Gopalkrishanan P, Handbook of material management, Second edition, Prentice Hall India Learning Private Limited, 2015.

20MSM610T					Modeling And Simulation					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs. / Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	1	0	4	4	25	50	25	--	--	100

COURSE OBJECTIVES

- To be able to understand the role of mathematical modeling in daily life.
- To be able to obtain model and fitting it with experimental data or realistic data.
- To be able to classify and workout different types of modeling.
- To study the role and importance of various simulations and how it's related with real world problems.

UNIT 1 INTRODUCTION, MODEL FITTING AND EXPERIMENTAL MODELING **10 Hrs.**

Introduction: Models, reality, Properties of models, model classification and characterization, steps in building mathematical models, sources of errors, dimensional analysis, Modeling using Proportionality, Modeling using Geometric similarity; graphs of a functions as models.
Model Fitting – Fitting models to data graphically, Analytic methods of model fitting, Applying the least square criterion,
Experimental Modeling – High order polynomial models, Cubic Spline Models.

UNIT 2 DISCRETE PROBABILISTIC AND OPTIMIZATION MODELING **10 Hrs.**

Discrete Probabilistic Modeling: Probabilistic modeling with discrete system, Modeling components & System Reliability, Linear Regression.
Discrete Optimization Modeling: Linear Programming – Geometric solutions, Algebraic Solutions, Simplex Method and Sensitivity Analysis

UNIT 3 MODELING WITH DIFFERENTIAL EQUATIONS AND SYSTEMS OF DIFFERENTIAL EQUATIONS **10 Hrs.**

Modeling with Differential Equations – Population Growth, Graphical solutions of autonomous differential equations, numerical approximation methods- Euler's Method and R.K. Method.
Modeling with systems of Differential Equations – Predator Prey Model, Epidemic models, Euler's method for systems of Differential equations.

UNIT 4 SIMULATION MODELING AND CASE STUDIES **10 Hrs.**

Simulation Modeling – Discrete-Event Simulation, generating random numbers; Simulating probabilistic behaviour; Simulation of Inventory model and Queueing Models using C program. Other Types of simulation—Continuous Simulation, Monte-Carlo simulation. Advantages, disadvantages and pitfalls of simulation
Case Studies: Case Studies of various aspects of Modeling to be done.

40 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to
CO1 – Identify the use of mathematical modeling in real world problem.
CO2 – Understand the theoretical as well as experimental modeling and also able to establish the best fit results.
CO3 – Prepare various models suitable to the problem.
CO4 – Analyze the role of modeling in context with differential equations and its system.
CO5 – Appraise mathematical models pertaining to various Simulations and able to analyze advantages and disadvantages.
CO6 – Formulate in-depth analysis of various case-studies for modeling and simulations.

TEXT/REFERENCE BOOKS

1. Giordano F. R., Mawrice D W., William P. F., A first course in Mathematical Modeling, 3rd ed., Thomson Brooks/Cole, 2003.
2. Murray J.D., Mathematical Biology – I, 3rd ed., Springer International Edition, 2004.
3. J.N. Kapoor, Mathematical Models in Biology and Medicine, East West Press, New Delhi, 1985.
4. Sannon R.E, System Simulation: The Art and Science, Prentice Hall, U.S.A., 1975.
5. Averill M. & Kelton W. D., Simulation Modeling and Analysis, 3rd ed., Tata Mc-Graw Hill, 2003.

20MSM611T					Fractional Calculus And Special Functions					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	1	0	4	4	25	50	25	--	--	100

COURSE OBJECTIVES

- To explain the historical development of the fractional calculus as an extension of classical calculus.
- To define fractional derivative/integral and evaluate it for some common functions.
- To solve linear fractional differential equations using the Laplace transform method.
- To introduce various applications of fractional differential equations in many fields of science and engineering.

UNIT 1 FRACTIONAL CALCULUS **10Hrs.**

Origin and history of arbitrary order derivatives/integrals, Euler-Gamma function, Grunwald-Letnikov's differ-integral, Riemann-Liouville, Caputo's and Weyl's fractional order operators, Leibnitz rule, Composition rules, Geometrical and physical significance.

UNIT 2 SPECIAL FUNCTIONS **10 Hrs.**

Fractional derivative of functions (exponential, sine, cosine, logarithmic), Hyper-Geometric function, Mittag-Leffler functions (one and two parameter), Wright functions, Laplace transform of fractional derivatives and its applications.

UNIT 3 FRACTIONAL DIFFERENTIAL EQUATIONS **10 Hrs.**

Introduction, General form, Existence and uniqueness theorem, Solutions of homogeneous and non-homogeneous fractional differential equations, Linearly dependent and independent solutions, Reduction of fractional differential equations to ordinary differential equations, Laplace transform method.

UNIT 4 RESEARCH BASED APPLICATIONS **10 Hrs.**

Generalized Abel's integral equations, Concepts of Fractional diffusion, Fractional divergence and Fractional Curl, Modelling of physical systems with fractional differential equations.

40 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to
CO1 – Identify the scope of fractional calculus in science and engineering.
CO2 – Apply suitable methods to solve a fractional differential equations arising in various research problems.
CO3 – Demonstrate the use of fractional order derivatives to generalize the existing mathematical results.
CO4 – Develop the skills to analyze a mathematical model of fractional-order.
CO5 – Appraise distinct applications of the fractional calculus to the real world.
CO6 – Compare the ideas to use classical and fractional derivatives while modelling some physical system.

TEXT/REFERENCE BOOKS

1. K.B. Oldham and J. Spanier, The Fractional Calculus, New York, Academic press, 1974.
2. K.S. Miller and B. Ross, An Introduction to the Fractional Calculus and Fractional Differential Equations, Wiley, 1993.
3. I. Podlubny, Fractional Differential Equations, Academic Press, 1998.
4. A.A. Kilbas, H.M. Srivastava, and J.J. Trujillo, Theory and Applications of Fractional Differential Equations, Elsevier, New York, 2006.
5. S. Das, Functional Fractional Calculus, Springer-Verlag, Berlin Heidelberg, 2011.
6. K. Diethlam, The Analysis of Fractional Differential Equations, Springer-Verlag, Berlin Heidelberg, 2010.

20MSM612T					Numerical Linear Algebra					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs. / Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	1	0	4	4	25	50	25	--	--	100

COURSE OBJECTIVES

- To understand basic matrix factorization methods for solving systems of linear equations and linear least squares problems.
- To learn basic computer arithmetic and the concepts of conditioning and stability of a numerical method.
- To be able to compute eigenvalues using the basic numerical methods.
- To be able to apply iterative numerical methods to solve large-scale problems.
- To learn the implementation and usage of these numerical methods in MATLAB.

UNIT 1 BASIC CONCEPTS 08 Hrs.

Floating point arithmetic, stability of algorithms, conditioning of a problem, perturbation analysis, algorithmic complexity.

UNIT 2 DIRECT SOLUTION METHODS 10 Hrs.

Linear systems, Gaussian elimination, LU factorization, Cholesky factorization, QR, and singular value decomposition (SVD).

UNIT 3 COMPUTATION OF EIGENVALUES 11 Hrs.

Power methods for symmetric and non-symmetric problems, QR algorithm for symmetric problems, Jacobi methods and tridiagonal methods for symmetric problems, Hessenberg form, Schur form and the QR algorithm for non-symmetric problems.

UNIT 4 ITERATIVE SOLUTION METHODS FOR LINEAR ALGEBRAIC SYSTEMS 11 Hrs.

Classical linear iterations and their convergence, Line search methods and conjugate gradient methods, Krylov subspace methods, Generalized minimal residual method (GMRES), Preconditioning.

40 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to
CO1 – Discuss the implications of problem conditioning and the consequences of using floating-point arithmetic.
CO2 – Demonstrate an understanding of the way in which error in data can corrupt solution and, therefore, how much confidence you can place in the solution you obtain.
CO3 – Identify the applicability of direct and iterative methods for a particular problem and also illustrate the advantages, disadvantages and costs of these methods.
CO4 – Derive and use the numerical techniques needed for a professional solution of a given linear algebra problem.
CO5 – Construct some key matrix factorizations using elementary transformations.
CO6 – Design algorithms that exploit matrix structures such as triangularity, sparsity, banded structure, and symmetric positive definiteness.

TEXT / REFERENCE BOOKS

1. L. N. Trefethen and David Bau, Numerical Linear Algebra, SIAM, 1997.
2. D. S. Watkins, Fundamentals of Matrix Computation, Wiley, 2nd ed., 2002.
3. J.W. Demmel, Applied Numerical Linear Algebra, SIAM, 1997.
4. B. N. Datta, Numerical Linear Algebra and Applications, 2nd ed., SIAM, 2010.
5. G. H. Golub and C.F.Van Loan, Matrix Computation, 3rd ed., Hindustan book agency, 2007.

20MSM613T					Numerical Solution of Differential Equations					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs. / Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	1	0	4	4	25	50	25	--	--	100

COURSE OBJECTIVES

- Apply the concept of Splines for solving ordinary differential equations.
- Analyze the stability of the methods.
- Construct the Initial value problems for ordinary differential equations.
- Develop the solutions for parabolic, elliptic and hyperbolic equations.

UNIT 1 SPLINES AND THEIR APPLICATIONS **10 Hrs.**

Introduction, Spline Approximation, Uniqueness of Cubic Splines, Construction of Cubic Splines (First and Second Derivative form), Minimal Property of a Cubic Spline, Applications to Differential Equations.

UNIT 2 INITIAL VALUE PROBLEMS **10 Hrs**.

Initial value problem for ODEs, Zero-stability and convergence for initial value problems, Absolute stability for ODEs, Stiff ODEs, Diffusion equations and parabolic problems, Advection equations and hyperbolic systems.

UNIT 3 PARTIAL DIFFERENTIAL EQUATIONS **10 Hrs.**

Finite Difference approximations for derivatives, Methods for solving parabolic equations – Explicit, Implicit and Crank-Nicolson's methods. Comparison of three schemes. Parabolic equation in two dimensions, ADI method, Non-rectangular space domains.

UNIT 4 ELLIPTIC AND HYPERBOLIC EQUATIONS **10 Hrs.**

Elliptic equations – Solution by Gauss-Seidel and Gauss Elimination, Solution by SOR method, Solution of elliptic equation by ADI method. Hyperbolic equations – Finite difference methods, Explicit method, Implicit method, Stability analysis.

40 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to
CO1 – Understand the initial – boundary value problems.
CO2 – Classify the partial differential equations.
CO3 – Apply cubic splines method for solving ordinary differential equations.
CO4 – Analyze the solutions obtained by solving ODEs.
CO5 – Analyze the stability of the methods.
CO6 – Develop the PDEs and solve them.

TEXT / REFERENCE BOOKS

1. M.K. Jain, S.R.K. Iyenger and R.K. Jain, Numerical Methods for Scientific and Engineering Computation, 5th ed., New Age International, 2007.
2. C. F. Gerald and P. O. Wheatley, Applied Numerical analysis, 7th ed., Pearson education, 2003.
3. Erwin Kreyszig, Advanced Engineering Mathematics, 9th ed., Wiley publication, 2005.
4. R.K. Jain and S.R.K. Iyenger, Advanced Engineering Mathematics, 3rd ed., Narosa, 2002.

20MSM614T					Boundary Element Method					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs. / Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	1	0	4	4	25	50	25	--	--	100

COURSE OBJECTIVES

- ➢ To understand the basic concepts of boundary element method through theory and examples.
- ➢ To derive boundary integral formulation for two-dimensional potential problems.
- ➢ To develop a boundary integral formulation for two-dimensional Stokes equation in terms of primitive and non-primitive variables.
- ➢ To apply BEM to solve engineering problems in fluid mechanics, ocean and naval architecture, solid mechanics etc.

UNIT 1 BOUNDARY INTEGRAL EQUATION METHOD FOR POTENTIAL PROBLEMS 10 Hrs.

Introduction to BEM and preliminaries on summation notation, tensors, Dirac-delta function and properties; Green's identities, free-space Green's function, potential problems, Direct formulation of BEM for two-dimensional isotropic and anisotropic Laplace equation.

UNIT 2 DISCRETIZATION OF BOUNDARY INTEGRAL EQUATIONS USING COLLOCATION METHOD 10 Hrs.

Boundary discretization, polynomial interpolation on boundary elements, classification of singularities, evaluation of influence coefficients, Regularization approaches on singular elements.

UNIT 3 DUAL RECIPROCITY BEM AND NON-PRIMITIVE BEM FOR STOKES EQUATION 10 Hrs.

Poisson equation: transforming domain integral to boundary integral (special cases), Poisson equation: Dual reciprocity method (general case), Stokes equation: stream function and vorticity variables, biharmonic equation: boundary integral representation.

UNIT 4 BOUNDARY ELEMENT METHOD FOR STOKES EQUATION IN TERMS OF PRIMITIVE VARIABLES 10 Hrs.

Stokes equation: singularities (point source, point source dipole, potential dipole) velocity and stress operators due to these singularities, Stokes equation: Lorentz reciprocal theorem, Free space Green's function of Stokes equation, boundary integral representation, Stokes flow over a plate, Stokes flow past a sphere.

40 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to
CO1 – Understand the fundamentals of boundary element method.
CO2 – Understand the different discretization procedures of boundary integral equations into boundary element methods.
CO3 – Illustrate the ability to solve boundary value problems governed by partial differential equations with the aid of theoretical basis of the boundary element method.
CO4 – Apply boundary element method to solve engineering problems in fluid mechanics, acoustics, solid mechanics etc.
CO5 – Analyze the obtained BEM solution in context to other numerical methods to establish the reliability and accuracy of the boundary element method.
CO6 – Develop the ability to correlate a differential equation with its equivalent boundary integral form.

TEXT / REFERENCE BOOKS

1. J.T. Katsikadelis, Boundary Elements: Theory and Applications, Elsevier, 1st ed., 2002.
2. C. Pozrikidis, A Practical Guide to Boundary Element Methods with the Software Library BEMLIB, CRC Press, 2002.
3. C. Pozrikidis, Boundary integral and singularity methods for linearized viscous flow, Cambridge University Press, 1st ed., 1992.
4. C.A. Brebbia, S. Walker, Boundary Element Techniques in Engineering, Butterworth & Co. Ltd, 1st ed., 1980.

<table>
<tr><th colspan="5">20MSM615T</th><th colspan="6">Artificial Neural Network</th></tr>
<tr><th colspan="5">Teaching Scheme</th><th colspan="6">Examination Scheme</th></tr>
<tr><th rowspan="2">L</th><th rowspan="2">T</th><th rowspan="2">P</th><th rowspan="2">C</th><th rowspan="2">Hrs. /Week</th><th colspan="3">Theory</th><th colspan="2">Practical</th><th rowspan="2">Total Marks</th></tr>
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</table>

COURSE OBJECTIVES

- To be able to understand the fundamentals of neural networks so that in future the student can pursue advanced soft computing methodologies
- To apply the acquired knowledge of neural network on real world problem
- To be able to understand the mathematics behind artificial neural networks.
- To be able to develop a thorough understanding of supervised and unsupervised learning.

PREREQUISITES

1. Familiarity with linear algebra, multivariate calculus, and probability theory.
2. Knowledge of a programming language (MATLAB® recommended).

UNIT 1 INTRODUCTION TO ARTIFICIAL NEURAL NETWORKS **12 Hrs.**

Biological motivation, Terminology, Models of neuron, Topology, characteristics of artificial neural networks, types of activation functions; Single Layer Feedforward Networks, Multilayer Feedforward Networks, Artificial Intelligence and Neural Networks, McCulloch -Pitts Neuron model, Learning: Learning Algorithms, Error correction and Gradient Descent Rules, Perceptron Learning Algorithm, Perceptron: XOR Problem, Perceptron Convergence Theorem.

UNIT 2 LEARNING PROCESSES **09 Hrs.**

Supervised Learning: Perceptron learning and Non Separable sets, Least Mean Square Learning, Steepest Descent Search, Multi-layered Network Architecture, Backpropagation Learning Algorithm, Practical consideration of BP algorithm, Recurrent Neural Networks, Hopfield neural network, Associative Memory.

UNIT 3 COMPETITIVE NETWORKS **10 Hrs.**

Fixed weight competitive nets: Max Net, Hamming Net. Kohonen Self-Organizing Maps: Architecture, Algorithm and Application.

UNIT 4 RADIAL BASIS FUNCTION AND SUPPORT VECTOR MACHINE **09 Hrs.**

Support Vector Machines, Learning from Examples, Support Vector Machines, SVM application to Image Classification, Radial Basis Function, Generalized RBF Networks, Learning in RBFNs, RBF application to face recognition

40 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to
CO1– Identify Artificial Neural Network techniques in building intelligent techniques.
CO2 – Apply artificial neural network models to handle uncertainty and to solve real world problems.
CO3 – Understand the mechanism of training of neural networks.
CO4 – Develop and deploy neural network models on practical problems.
CO5 – Analyze network architecture and detect problems of missing or unconnected layers, incorrectly sized layer inputs or an incorrect number of layer inputs.
CO6 – Evaluate the performance of neural network model.

TEXT/REFERENCE BOOKS

1. Zurada, Jacek M. Introduction to artificial neural systems, West St. Paul, 1992.
2. Hagan, Martin T., Howard B. Demuth, and Mark H. Beale. Neural network design. Boston: Pws Pub., 1996.
3. Haykin, Simon. Neural networks: a comprehensive foundation. Prentice Hall PTR, 1994.
4. Hertz, John, Anders Krogh, and Richard G. Palmer. Introduction to the Theory of Neural Computation. Redwood City, CA: Addison-Wesley Pub. Co., 1991.

20MSM615P					Artificial Neural Network					
Teaching Scheme					**Examination Scheme**					
L	**T**	**P**	**C**	**Hrs. /Week**	**Theory**			**Practical**		**Total Marks**
					MS	**ES**	**IA**	**LW**	**LE/Viva**	
0	**0**	**2**	**1**	**2**	**--**	**--**	**--**	**50**	**50**	**100**

COURSE OBJECTIVES

- To be able to conceptualize the programming setup.
- To apply the knowledge of neural network on real world problem
- To be able to understand the algorithms of artificial neural networks.
- To be able to develop a thorough understanding of writing codes of neural network models.

LIST OF EXPERMENTS

1. Programming Setup
2. Understanding data sets
3. Implementation: weight initialization
4. Graph-based computation
5. Implementation, modeling the perception of Hot and Cold with a McCulloch -Pitts Neuron model
6. Implementation procedure of feed forward neutral network
7. Implementation procedure of multi-layerd neural networks
8. Implementation procedure of recurrent neural network
9. Implementation procedure of Max Net, Hamming Net
10. Implementation procedure of Kohonen Self-Organizing Map
11. SVM application to Image Classification
12. RBF application to face recognition.

20MSM616T					Tensors And Special Theory Of Relativity					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs. / Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	1	0	4	4	25	50	25	--	--	100

COURSE OBJECTIVES

- ➢ To be able to understand the significance of tensors in cartesian forms.
- ➢ To be able to discuss the transformation of co-ordinates and invariance nature of tensors.
- ➢ To be able to understand the Galilean relativity and beyond which formulates the good platform for the existence of special relativity.
- ➢ To study the transformation equations, relativistic force components and how the mass-energy equivalence can be established.

UNIT 1 CARTESIAN TENSORS **08 Hrs.**

Transformation of Co-ordinates. Einstein's Summation Convention. Relation between Direction Cosines. Tensors. Algebra of Tensors. Sum, Difference and Product of Two Tensors. Contraction. Quotient Law of Tensors. Symmetric and Antisymmetric Tensors. Invariant Tensors: Kronecker and Alternating Tensors. Association of Antisymmetric Tensor of Order Two and Vectors. Vector Algebra and Calculus using Cartesian Tensors: Scalar and Vector Products, Scalar and Vector Triple Products. Differentiation, Gradient, Divergence and Curl of Tensor Fields.

UNIT 2 GENERAL TENSORS **12 Hrs.**

Transformation of Co-ordinates, Minkowski Space, Contravariant & Covariant Vectors, Contravariant, Covariant and Mixed Tensors, Kronecker Delta and Permutation Tensors, Algebra of Tensors, Sum, Difference & Product of Two Tensors, Contraction, Quotient Law of Tensors, Symmetric and Anti-symmetric Tensors, Metric Tensor.

UNIT 3 BASICS OF SPECIAL RELATIVITY **10 Hrs.**

Speed of light and Galilean relativity, Michelson-Morley experiment, Lorentz-Fitzgerald contraction hypothesis, Relative character of space and time, Postulates of special theory of relativity, Lorentz transformation and its geometric interpretation, Group properties of Lorentz transformations, Composition of parallel velocities, Length contraction, Time dilation.

UNIT 4 TRANSFORMATION EQUATIONS AND RELATIVISTIC FORCE **10 Hrs.**

Transformation equation for components of velocity and acceleration, The four-dimensional Minkowskian space-time, Four-vectors and tensors in Minkowskian space-time, Variation of mass with velocity, equivalence of mass and energy, Transformation equations of mass, momentum and energy, energy-momentum four-vector, force in mechanics, Relativistic force and transformation equations for its components.

40 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to
CO1 – Identify the use of limitations of vector and notion of tensors in real life.
CO2 – Understand the concept of General tensors and their invariance nature which will help to study in arbitrary reference frames.
CO3 – Apply algebra of tensors in various relativistic contexts.
CO4 – Analyze the relation between Galilean relativity and Special Relativity.
CO5 – Evaluate different paradoxes in context of length contraction and time dilation.
CO6 – Formulate various transformation equations and understand the role of Minkowskian space in Relativity.

TEXT/REFERENCE BOOKS

1. R. Adler, M. Bazin, and S. Schiffer, Introduction to General Relativity, McGraw Hill Book Co, 1965.
2. C. E. Weatherburn, An Introduction to Riemannian Geometry and Tensor Calculus, Cambridge University Press, 2008.
3. R. Resnik, Introduction to Special Relativity, Wiley Eastern Pvt. Ltd., 1972.
4. W. Rindler, Essential Relativity, Van Nostrand Reinhold Company, 1969.
5. Arfken G. B., Weber H. J., Harris F. E., Mathematical Methods for Physicists, Elsevier, 2005.

<table>
<tr><th colspan="15">COURSE STRUCTURE FOR M.Sc. (MATHEMATICS)</th></tr>
<tr><th colspan="3">Semester IV</th><th colspan="12">M.Sc. (Mathematics)</th></tr>
<tr><th rowspan="3">Sr. No.</th><th rowspan="3">Course/Lab Code</th><th rowspan="3">Course/Lab Name</th><th colspan="5">Teaching Scheme</th><th colspan="7">Examination Scheme</th></tr>
<tr><th rowspan="2">L</th><th rowspan="2">T</th><th rowspan="2">P</th><th rowspan="2">C</th><th rowspan="2">Hrs/Wk</th><th colspan="3">Theory</th><th colspan="3">Practical</th><th>Total</th></tr>
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