Koneru Lakshmaiah Education Foundation
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List of Pre-Ph.D. Courses A.Y 2025-26

DEPARTMENT OF MATHEMATICS

S.No	Paper 1	Subject Code **(LTPS)**
1	RESEARCH METHODOLOGY	25 RES 102 (4-0-0-0)

S. No	**Paper-2**	**Course Code (LTPS)**	**Paper-3**	**Course Code (LTPS)**
1	Topology	25MAT201 (4-0-0-0)	Fluid Dynamics	25MAT301 (4-0-0-0)
2	Numerical Methods	25MAT202 (4-0-0-0)	Fluid Mechanics	25MAT302 (4-0-0-0)
3	Time Scale Calculus	25MAT203 (4-0-0-0)	Fuzzy Algebra	25MAT303 (4-0-0-0)
4	Number Theory	25MAT204 (4-0-0-0)	Functional Analysis	25MAT304 (4-0-0-0)
5	Special Functions	25MAT205 (4-0-0-0)	Dynamical Systems on Time scale	25MAT305 (4-0-0-0)
6	Boundary Value Problems	25MAT206 (4-0-0-0)	Differential Equations	25MAT306 (4-0-0-0)
7	Distribution and Estimation Theory	25MAT207 (4-0-0-0)	Cryptography	25MAT307 (4-0-0-0)
8	Mathematical methods& Stochastic processes	25MAT208 (4-0-0-0)	Theory of Hyper Geometric Functions	25MAT308 (4-0-0-0)

9	Statistical Inference	25MAT209 (4-0-0-0)	Queueing Theory	25MAT309 (4-0-0-0)
10	Graph Theory and Applications	25MAT210 (4-0-0-0)	Sampling Theory	25MAT310 (4-0-0-0)
11	Linear Algebra with Machine Learning	25MAT211 (4-0-0-0)	Inventory Model	25MAT311 (4-0-0-0)
12	Tensor Calculus	25MAT212 (4-0-0-0)	Difference Equations	25MAT312 (4-0-0-0)
13			Computational Fluid Dynamics	25MAT313 (4-0-0-0)
14			Data Science	25MAT314 (4-0-0-0)
15			Structures on Manifolds	25MAT315 (4-0-0-0)

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25RES 102-RESEARCH METHODOLOGY

Unit I

Introduction to Research Methodology: The philosophy, objectives, scope, and significance of research across disciplines, differentiating qualitative and quantitative approaches. Includes research methods vs. methodology, nature of inquiry in various fields, qualities and ethics of a researcher, identification and formulation of research problems, literature review techniques, and formats for thesis, dissertations, and research publications, with use of referencing systems and digital resources.

Unit II

Research Design, Measurement, and Sampling: Types and features of research design, including experimental designs, measurement scales, and attitude measurement methods. Explains census vs. sample surveys, sampling steps, probability and non-probability methods, and criteria for good sample design, along with random sampling techniques.

Unit III

Data Collection and Analysis: Primary and secondary data sources, methods of data collection, and data processing steps. Covers descriptive statistics, correlation and regression, multivariate methods, fundamentals of time series and spectral analysis, error analysis, and goodness of fit, with applications of statistical software (SPSS/R/Python).

Unit IV

Hypothesis Testing and Advanced Statistical Methods: Hypothesis formulation and testing using parametric and non-parametric tests, significance testing for various measures, association of attributes, advanced probability distributions, and Bayesian inference, with applications across sciences, mathematics, social sciences, and humanities.

Unit V

Interpretation, Reporting, and Applications of Research: Interpretation techniques, precautions, report writing, thesis layout, academic writing style, patent procedures, and presentation skills. Discusses the application of research in sciences, social sciences, humanities, management, law, mathematics, and pharmacy, including modelling, simulation, decision support, and computational analysis.

Text Books:

1. Garg, B.L., Karadia, R., Agarwal, F. and Agarwal, U.K., 2002. An introduction to Research Methodology, RBSA Publishers.
2. Kothari, C.R., 1990. Research Methodology: Methods and Techniques. New Age International. 418p.

Reference Books:

1. Anthony, M., Graziano, A.M. and Raulin, M.L., 2009. Research Methods: A Process of Inquiry, Allyn and Bacon.
2. Carlos, C.M., 2000. Intellectual property rights, the WTO and developing countries: the TRIPS agreement and policy options. Zed Books, New York.
3. Coley, S.M. and Scheinberg, C. A., 1990, "Proposal Writing", Sage Publications.
4. Day, R.A., 1992.How to Write and Publish a Scientific Paper, Cambridge University Press.
5. Fink, A., 2009. Conducting Research Literature Reviews: From the Internet to Paper. Sage Publications
6. Leedy, P.D. and Ormrod, J.E., 2004 Practical Research: Planning and Design, Prentice Hall.

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25MAT201-TOPOLOGY

UNIT –I

Topological Spaces and Continuous Functions

Topological spaces, basis for a topology, the order topology, the product topology on X x Y, the sub space topology, closed sets and limit points, continuous functions, the product topology, the metric topology.

UNIT –II

Connectedness and compactness

Connected spaces, connected subspaces of the real line, compact spaces, compact subspaces of the real line, limit point compactness.

UNIT –III

Countability and separation axioms

The countability axioms, the separation axioms, normal spaces, the urysohn lemma, the urysohn metrization theorem.

UNIT –IV

The Tychnoff Theorem

The Tychnoff Theorem, Completely Regular Spaces, The Stone –Cech Compactification.

UNIT –V

Complete metric spaces and function spaces

Complete metric spaces, compactness in metric spaces, pointwise and compact convergence, ascoli's theorem.

Text Books:

1. Topology by James Dugundji; Second edition; Universal Book Stall, NewDelhi.
2. Introduction to Topology by G.F.Simmons; Reprint Version; Tata McGraw-Hill Publishing Company.

Reference Text Book:

1. Topology by James R.Munkres; Second edition, Prentice-Hall.

25MAT202-NUMERICAL METHODS

UNIT-I

Numerical Differentiation and Integration

Introduction, Numerical Differentiation, Numerical Integration, Euler-Maclaurin Formula, Adaptive Quadrature Methods, Gaussian Integration, Singular Integrals, Fourier Integrals, Numerical Double Integration

UNIT-II

Numerical Solution of Ordinary Differential Equations

Introduction, Solution by Taylor's Picard's Method, Euler's Method, Runge-Kutta Methods, Predictor-Corrector Methods, the Cubic Spline Method, Simultaneous and Higher Order Equations, Boundary Value Problems: Finite-Difference Method, The Shooting Method.

UNIT-III

Numerical Solution of Partial Differential Equations

Introduction, Finite-Difference Approximations, Laplace's Equation: Jacobi's Method, Gauss-Seidel Method, SOR Method, ADI Method, Parabolic Equations, Iterative Methods, Hyperbolic Equations.

UNIT-IV

System of Linear Algebraic Equations

Introduction, Solution of Centro-symmetric Equations, Direct Methods, LU-Decomposition Methods, Iterative Methods, III-conditioned Linear Systems.

UNIT-V

The Finite Element Method

Functionals- Base Function Methods of Approximation- The Rayleigh –Ritz Method –The Galerkin Method, Application to two dimensional problems- Finite element Method for one and two dimensional problems.

Text Books:

1. Niyogi, Pradip; Numerical Analysis and Algorithms; Tata McGraw –Hill, 2003.
2. Balagurusamy,E.; Numerical Methods; Standard Edition-1; Tata McGraw –Hill, 2006.

Reference Text Books:

1. Sastry, S.S.; Introduction Methods of Numerical Analysis; Learning Edition-5; PHI; 2012.
2. Chapra, S.C. and Canale, R.P.; Numerical Methods for Engineers; Seventh Edition; Tata McGraw Hill.

25MAT203-TIME SCALE CALCULUS

UNIT-1
Basic definitions
Jump operators, left and right dense, left and right scattered, Induction principle. Differentiation, Properties Leibnitz rule, examples and applications.

UNIT-2
Integration
Regulated function rd-continuous, Existence of pre-antiderivative and antiderivative, Mean value theorem, chain rule, Intermediate vale theorem and L'Hospitals rule.

UNIT-3
First order linear equations
Hilger's complex plane, the exponential function, examples of exponential functions, The regressive linear dynamic equations, initial value problems and variation of constants formula.

UNIT-4
Second order linear equations
Wronskians, Linear operator, Abel's theorem, Hyperbolic and Trigonometric functions, Method of factoring, reduction of order, Euler-Cauchy equations, variation of parameters formula.

UNIT 5
Self -Adjoint equations
Preliminaries and examples, The Ricati equations, Boundary value probles and Green's functions,Eigen value problems.

Text Book:
1. Martin Bohner and Allan Peterson; Dynamic equations on time scales; An introduction with Applications; BirKhauser; Boston; 2003.

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25MAT204-NUMBER THEORY

UNIT 1
Divisibility
Early Number Theory, The Division Algorithm, The Greatest Common Divisor, The Euclidean Algorithm.

UNIT II
Congruences
Basic Properties of Congruence, Binary and Decimal Representations of Integers, Linear Congruences and the Chinese Remainder Theorem.

UNIT III
Fermat's Theorem
Fermat's Little Theorem and Pseudoprimes, Wilson's Theorem.

UNIT IV
Euler's Generalization of Fermat's Theorem
Euler's Phi-Function, Euler's Theorem, Some Properties of the Phi-Function

UNIT V
Quadratic Reciprocity Law
Euler's Criterion, The Legendre Symbol and Its Properties, Quadratic Reciprocity, Quadratic Congruences with Composite Moduli.

Text Book:

David M. Burton; Elementary Number Theory; Sixth Edition; McGrawHill; 2007.

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25MAT205-SPECIAL FUNCTIONS

UNIT-I

The Gamma and Beta Functions

The Gamma function,A series for $\Gamma'(z)/\Gamma(z)$,Evaluation of $\Gamma'(1)$, the Euler product for $\Gamma'(z)$, the difference equation $\Gamma(z+1) = z\,\Gamma(z)$,evaluation of certain infinite products , Euler 's integral for $\Gamma(z)$, the Beta function, the value of $\Gamma(z)\Gamma(1-z)$, the factorial function , Legendre 's duplication formula , Gauss multiplication theorem , a summation formula due to Euler .

UNIT-II

BESSEL FUNCTIONS

Definition of Jn (x) , Bessel's differential equation , Differential recurrence relation, A pure recurrence relation, A generating function, Bessel's integral, Index half an odd integral, modified Bessel function, orthogonality property for Jn (x).

UNIT-III

LEGENDRE'S POLYNOMIALS

Definition of Pn (x) , Differential recurrence relations, the pure recurrence relation, Legendre's differential equation, the Rodrigue's formula , orthogonality property , special properties of Pn (x), more generating functions, Laplace's first Integral form , Expansion of xn

UNIT-IV

HERMITE POLYNOMIALS

Definition of Hn (x), Recurrence relations, the Rodrigue's formula ,other generating functions, integrals, the Hermite polynomials as 2F0, orthogonality, expansion of polynomial s, more generating functions.

UNIT-V

LAGUERRE POLYNOMIALS

The Laguerre polynomial definition , generating functions, , recurrence relations, the Rodrigue's formula, the differential equation , orthogonality, expansion of polynomials, special properties
,other generating functions , the simple Laguerre polynomials.

Text book:

1. Special functions; E.D. Rainville; MacMillan Company; New York; 1960.

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25MAT206-BOUNDARY VALUE PROBLEMS

UNIT-I

System of linear differential equations

System of first order equations, existence and uniqueness theorem, fundamental matrix, non-homogeneous linear systems, linear systems with constant coefficients.

UNIT-II

Existence and Uniqueness of Solutions

Introduction, preliminaries, successive approximations, Picard's theorem, continuation and dependence on initial condition, existence of solutions in the large interval.
(Scope and treatment as in chapters: 4 and 5 of Text book (1))

UNIT-III

Nonlinear boundary value problems

Kinds of boundary value problems associated with Non-linear second order differential equations, generalized Lipschitz condition, failure of existence and uniqueness of linear boundary value problems, simple nonlinear BVP, standard results concerning initial value problems.

UNIT-IV

Relation between the first and second boundary value problems

Relation between uniqueness intervals, relation between existence intervals.

UNIT-V

Contraction mapping

Introduction, Contraction mappings, boundary value problems, a more generalized Lipschitz condition.

Text Book:

1. Text book of ordinary differential equations; S. G. Deo; V. Lakshmikantham and V. Raghavendra; Second edition; Tata McGraw-Hill Publishing Company Ltd; New Delhi (2002).

Reference Text Book:

1. Non-linear two point boundary value problem; P. B. Bailey; L. P. Shampine and P. E. Waltman; Academic press; New York and London (1968).

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25MAT207-DISTRIBUTIONS & ESTIMATION THEORY

UNIT-I
DISTRIBUTIONS

Discrete And Continuous Distributions (Binomial, Poisson, Geometric, Hyper Geometric, Rectangular, Normal, Gamma Distributions and their Properties), Bi-Variate and Multivariate Normal Distributions, Exponential Family of Distributions.

UNIT-II
LIMIT THEOREMS

Modes of convergence, Weak law of large numbers, Strong law of large numbers. Limiting moment generating functions, Central limit theorem.

UNIT-III
SAMPLE MOMENTS AND THEIR DISTRIBUTIONS

Random sampling, sample characteristics and their distributions- x2, t and F distributions distribution of (S2) in sampling from a normal population. Sampling from a Bi-variate normal distribution.

UNIT-IV
THEORY OF POINT ESTIMATION

Problem of point estimation, Properties of estimates, Unbiased estimation, Lower bound for variance of estimate, Rao- Blackwell theorem, Method of moments, Maximum likelihood estimates, Bayes & Minimax estimation, Minimal sufficient statistic.

UNIT-V
CONFIDENCE INTERVAL ESTIMATION

Shortest length confidence intervals, Relation between confidence estimation and hypothesis testing, unbiased confidence intervals, Bayes confidence intervals.

Text Book:

1. An Introduction to Probability theory and Mathematical Statistics; V.K. Rohatgi, Wiley Eastern Publications first edition- 1975. [Chapters 5,6,7,8,11]

Reference Text Book:

1. Introduction to Mathematical Statistics; Robert Hogg &Allen Craig; Fourth edition; 1905.

25MAT208-MATHEMATICAL METHODS AND STOCHASTIC PROCESSES

Unit-I

Numerical Analysis

Numerical solution of simultaneous Linear equations Gauss reduction- Crout Reduction-gauss Jordan Reduction – inverse Of Matrix-Iterative methods-gauss seidel iteration, Relaxation, Inherent errors.

Numerical solution of Non-linear equations - Regular Falsi -Newton Raphson method Iterative Method of Higher order –Solutin of set of Non-Linera equations

Graffe's root squaring technique, Bairstow Iteration-scaling Method

Unit-II

Laplace transforms

The Laplace Transform, the Inverse Laplace Transform, application to differential equation and Integral and difference equations.

Unit-III

Stochastic process

Stochastic process, Markov chains.

Unit-IV

Markov processes with discrete state space-Poisson process and its extensions.

Unit-V

Markov process with continuous state space.

Text Books:

1. Introduction to Numerical analysis; F.B.hiller B; 2ndEdition; Tata Mc Graw Hill Publishing company Ltd.
2. Theory and problems of laplace transformation; Murray B.Spegel Schaum's; McGraw-Hill book company; 1989.

Reference Text Book:

1. Stochastic process; Medhi.J.Wile; Eastern Limited.

25MAT209-STATISTICAL INFERENCE

Unit-I

Theory of Estimation

Basic concepts of estimation, Point estimation, methods of estimation; method of moments, method of maximum likelihood; Unbiasedness, Minimum variance estimation, Cramer – Rao bound and its generalization, Rao Blackwell theorem, Existence of UMVUE estimators. Interval Estimation, Some results for normal population case.

Unit-II

Principle of Data Reduction

Sufficiency principle, Factorization criterion, minimal sufficiency, Completeness and bounded completeness, Likelihood principle, Equivariance principle.

Unit-III

Testing of Hypothesis

Null and alternative hypothesis, Type I and II errors error probability and power function, Method of finding tests, Neyman – Pearson lemma.

Unit-IV

Tests

Uniformly most powerful tests, likelihood ratio principle, Likelihood ratio test, Sequential probability ratio test, Some results based on normal population.

Unit-V

Analysis of Variance

One-way classification; two-way classification; simple linear regression analysis with the normal distribution.

Text Books:

1. Miller, I. and Miller, M.; Freund's Mathematical Statistics with Applications; 7th Ed.; Prentice Hall PTR; 2006.
2. Lehman, E.L.; Testing of Statistical Hypothesis; Wiley Eastern Ltd; 1959.

Reference Text Books:

3. G. Casella; R. L. Berger; Statistical Inference; Duxbury Press; 2002.
4. Lehman, E.L.; Point Estimation; John Wiley & sons; 1984.
5. Rohatgi, V.K.; Statistical Inference; Dover Publications; 2011.

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25MAT210-GRAPH THEORY AND APPLICATIONS

UNIT-I:

Graph Fundamentals and Structural Theorems

Graphs, subgraphs, isomorphism, degree sequence-Connected graphs, bridges, blocks, Menger's theorem-Eulerian and Hamiltonian graphs-Trees and spanning trees-Planarity, Kuratowski's theorem-Graph matrices: adjacency, incidence, Laplacian

UNIT-II:

Spectral and Matrix Methods in Graphs

Eigenvalues of graphs, adjacency and Laplacian spectra-Interlacing theorem, Perron-Frobenius theory-Minimax theorem, Rayleigh quotient-Spectral radius and graph connectivity-Applications to chemistry, networks, and partitions

UNIT-III:

Extremal and Probabilistic Methods

Turán's theorem, Mantel's theorem, extremal functions-Ramsey theory and bounds-Probabilistic method, Lovász Local Lemma-Graph coloring and chromatic number-Matchings, Hall's theorem-Network flow algorithms: Ford–Fulkerson, Max-Flow Min-Cut theorem

UNIT-IV:

Domination Theory

Dominating set, domination number, total domination-Independent domination, connected domination-Domination in trees, grids, and product graphs-Domatic number and applications-Algorithmic complexity and approximation of domination problems-Applications in network design, social networks, and wireless sensor networks

UNIT-V:

Applications and Advanced Models

Fuzzy graphs and applications-Graphs in optimization and decision-making-Chip-firing games, sandpile model-Probabilistic and random graphs-Graph theory in machine learning, computer vision, and electrical networks

Text Books :

1. Douglas B. West – Introduction to Graph Theory, 2nd Edition, Pearson
2. T.W. Haynes, S.T. Hedetniemi, P.J. Slater – Fundamentals of Domination in Graphs, Marcel Dekker.

References Text Books:

1. D. Cvetković, M. Doob, H. Sachs – Spectra of Graphs, Academic Press

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25MAT211-Linear Algebra for Machine Learning

UNIT I

Solution of linear systems – systems of linear equations, matrices, solving systems of linear equations. Vectors Spaces - linear independence, basis and rank, affine spaces, Norms, inner products, Lengths and distances, Angles and orthogonality, Orthonormal basis.

UNIT II

Matrix Decomposition methods - Determinant and Trace, Eigenvalues and Eigenvectors, Cholesky decomposition, Eigen-decomposition and diagonalization, singular value decomposition, matrix approximation.

UNIT III

Vector Calculus - Differentiation of univariate functions, Partial differentiation and gradients, Gradients of vector-valued functions, Gradients of matrices, Some useful identities for computing gradients, Back propagation, and automatic differentiation.

UNIT IV

Continuous Optimization - Optimization using gradient descent, Constrained optimization and Lagrange multipliers, Convex optimization.

UNIT V

Dimensionality reduction and PCA – problem setting, maximum variance perspective, projection perspective, eigen vector and low-rank approximations, PCA in high dimensions, key steps of PCA in practice, latent variable perspective, Mathematical preliminaries of SVM, primal/dual perspective for SVM, nonlinear SVM - kernels.

Text Book(s):

1. Charu C. Aggarwal, Linear Algebra and Optimization, Springer Nature Switzerland AG, 2020
2. M.P. Diesenroth, A. Aldo Faisal, Cheng Soon Ong, Mathematics for Machine Learning, Cambridge University Press, 2020.

Reference Text Book

1. K Hoffman and R Kunze, Linear Algebra, Pearson Education, 2nd Edition, 2005.

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25MAT212-TENSOR CALCULUS

UNIT-I

Tensor Algebra:

Introduction, N-Dimensional space, Transformation of coordinates, Indicial and summation conventions, Contravariant vectors, Covariant vectors, Invariants, second order tensors, Higher order tensors, Addition, subtraction, and multiplication of tensors, contraction, Quotient law, Conjugate symmetric tensors of the second order.

UNIT-II

The Line Element:

Fundamental tensor, Length of a curve, Magnitude of a vector, Associate tensors, Angle between two vectors-Orthogonally, Principal directions.

UNIT-III

Covariant Differentiation:

Christoffel symbols, Transformation law of Christoffel symbols, Covariant differentiation of vectors, Covariant differentiation of tensors, Laws of covariant differentiation, Intrinsic derivatives.

UNIT-IV

Geodesics-Parallelism:

Geodesics, Null-Geodesics, Geodesic coordinates, Parallelism, Covariant derivative.

UNIT-V

Curvature Tensor:

Riemann-Christoffel tensor, Curvature tensor, Ricci tensor-
Curvature invariant, Bianchi's identity, Riemannian Curvature, Flat space, space of constant curvature.

Text Book:

1. Bary Spain, Tensor Calculus-Radha Publishing House, Calcutta.

Reference Books:

1. Tensor Calculus, J. L. Synge and A. Schild, University of Toronto Press, Toronto.
2.Tensor Calculus, A. K. Agarwal, Krishna Prakasam mandir, Meerut.
3.Rimannian Geometry by L.P. Eisenhart, Princeton University Press, Princeton 1966.

PAPER-III
25MAT301-FLUID DYNAMICS

Unit I
Kinematics of Fluids in motion
Real fluids and Ideal fluids- Velocity of a fluid at a point, Stream lines , path lines , steady and unsteady flows- Velocity potential - The vorticity vector- Local and particle rates of changes - Equations of continuity - Worked examples - Acceleration of a fluid – Conditions at a rigid boundary.

Unit II
Equations of motion of a fluid
Pressure at a point in a fluid at rest - Pressure at a point in a moving fluid - Conditions at a boundary of two inviscid immiscible fluids- Euler's equation of motion - Discussion of the case of steady motion under conservative body forces.

Unit III
Some three-dimensional flows
Introduction- Sources, ranks and doublets - Images in a rigid infinite plane - Axis symmetric flows – Stokes stream function.

Unit IV
Some two-dimensional flows
Meaning of two-dimensional flow - Use of Cylindrical polar coordinate - The stream function - The complex potential for two dimensional, irrotational in compressible flow - Complex velocity potentials for standard two-dimensional flows - Some worked examples – Two-dimensional Image systems - The Milne Thompson circle Theorem.

Unit V
Viscous flows
Stress components in a real fluid. - Relations between Cartesian components of stress- Translational motion of fluid element - The rate of strain quadric and principle stresses - Some further properties of the rate of strain quadric - Stress analysis in fluid motion - Relation between stress and rate of strain- The coefficient of viscosity and Laminar flow - The Navier – Stokes equations of motion of a Viscous fluid.

Text books :
1. F. Chorlton, Text Book of Fluid Dynamics, CBS Publications. Delhi,1985.
2. G.K. Batchelor; An Introduction to Fluid Mechanics; Foundation Books; New Delhi; 1984.

Reference Books:
1. A.J. Chorin and A. Marsden; A Mathematical Introduction to Fluid Dynamics; Springer-Verlag; New York; 1993.
2. S.W. Yuan; Foundations of Fluid Mechanics, Prentice Hall of India Pvt Limited, New Delhi, 1976.
3. R.K. Rathy, An Introduction to Fluid Dynamics, Oxford and IBH Publishing Company, New Delhi, 1976.

25MAT302-FLUID MECHANICS

UNIT-I

Basics in Fluid Mechanics

The continuum hypothesis-Newtonian and Non-Newtonian fluids-Continuity equation-Navier- Stokes equations of motion –Energy equation, steady and unsteady flows.

UNIT-II

Navier-Stokes equations

Parallel flow through a straight channel and Couette flow-The Hagen-Poiseuille flow-The suddenly accelerated plane wall-Stokes first problem. The flow near an oscillating flat plate-Stokes second problem- Flow near a rotating disk. Parallel flow past a sphere.

UNIT-III

Boundary Layer Theory:

Derivation of Boundary Layer equations for two dimensional flow-The separation of a Boundary Layer, Skin friction-The Boundary Layer on a flat plate.

UNIT-IV

Thermal Boundary Layers in Laminar flow:

Exact solution for the problem of temperature distribution in a viscous flow: (i)couette fiow, (ii)Poiseuille flow through a channel with flat walls. Forced and natural flows-Thermal Boundary Layer in forced flow-Parallel flow past a flat plate at zero incidence. Thermal Boundary Layers in natural flow (free convection).

UNIT–V

Approximate Methods for Solving the Boundary–Layer Equations for Steady Plane Flows Integral Methods- Stratford's Separation Criterion - Comparison of the Approximate Solutions with Exact Solutions -Retarded Stagnation–Point Flow - Divergent Channel (Diffuser)-Circular Cylinder Flow- Symmetric Flow past a Joukowsky Airfoil

Text Books:

1. Boundary Layer Theory; Dr. Herman Schlicting; Mc.GrawHill Book Company; 1979.
2. Fluid Mechanics and Fluid Machines; S.K Som & G.Biswas; Revised Second Edition.

Reference Book:

1. Textbook of fluid dynamics; F.Chorlton; Van Nostrand; 1963

25MAT303-FUZZY ALGEBRA

Unit-I

Fuzzy subsets & Fuzzy sub groups

Union of two fuzzy subgroups, fuzzy subgroup generated by a fuzzy subset, fuzzy normal subgroups, fuzzy conjugate subgroups and fuzzy characteristic subgroups, fuzzy syllow subgroups.

Unit-II

Fuzzy sub rings and Fuzzy ideals

Basic concepts, properties of fuzzy ideals, union of fuzzy sub rings (fuzzy ideals), fuzzy sub ring (fuzzy ideal) generated by a fuzzy subset, fuzzy ideals and homomorphism, fuzzy cosets.

Unit-III

Fuzzy prime ideal and Maximal ideals

Fuzzy prime ideals, fuzzy maximal ideals, fuzzy semi prime ideals, characterization, Of regularity.

Unit-IV

Fuzzy primary ideals

Fuzzy primary ideals, fuzzy semi primary ideals definition and some properties, fuzzy ideals and irreducible ideals in Noetherian ring.

Unit-V

Fuzzy Sub modules and Subfields

Basic Concepts – Fuzzy Sub modules of Quotient Modules, Fuzzy Sub modules Generated by Fuzzy Subsets, Free Fuzzy Sub modules, Fuzzy Subfields and Fuzzy Field Extensions Separable and Inseparable Algebraic Extensions, Composites, Linear Disjointness, and Separability.

Text Book:

1. Fuzzy Algebra; Rajesh Kumar; University Press, University of Delhi, Delhi-110007.

Reference Book:

1. Fuzzy Commutative Algebra; John N Mordeson & D S Malik; World Scientific Publishing Co. Pte. Ltd.

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25MAT304-FUNCTIONAL ANALYSIS

Unit-I
Metric Spaces
Vector Spaces, Metric Spaces, Open and closed sets,1 Compactness and connectedness, Completeness, Continuous functions (several variables and on metric spaces), uniform continuity C(X), X, compact metric space, Uniform convergence, compactness criterion.

Unit-II
Basic Theorems on Normed Linear Spaces and Banach Spaces
Normed Linear Spaces: Properties of Normed Spaces, Finite Dimensional Normed Spaces and Subspaces. Banach spaces: Bounded Linear Transformations, Fundamental Theorems: Hahn-Banach Theorem, Open Mapping Theorem, Closed Graph Theorem and Banach – Steinhaus Theorem.

Unit-III
Hilbert Spaces
Inner Product Spaces, Orthogonal Complements and Direct Sums, Orthonormal Sets, Hilbert-Adjoint Operators, Riesz Representation Theorem, Bounded Linear Operations on Hilbert Spaces, Approximation in Hilbert Space.

Unit-IV
Fixed Point Theory
Lipschitz Mappings, Banach fixed point theorem and Its Applications, Brouwer's Fixed Point Theorem and Its Applications, Schauder's Fixed Point Theorem, Picard's iterative scheme, nonlinear contractions and related fixed-point theorems and multivalued mappings.

Unit-V
Variational Inequalities and ordered structure
Variational inequalities and related problems, Basic existence and uniqueness results, Gap functions and solutions methods. Ordered structure: orders, basic properties, Zorn's Lemma and cone topological concept.

Text Books:
1. Introduction to Functional Analysis with Applications; Erwin Kreyszig Sudarsan; University of Windsor.
2. Convex Analysis and Monotone Operators theory in Hilbert Spaces; H.H. Bauschke and P.L. Combettes; Springer; 2011.

Reference Text Book:
1. An Introduction to Variational Inequalities and Their Applications; David Kinderlehrer and Guido Stampacchia; In Applied Mathematics; SIAM.

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25MAT305-DYNAMICAL SYSTEMS ON TIME SCALES

UNIT-I

Self-Adjoint equations:

Wronskian matrix, Lagrange Identity, Abel's formula, Hermitian, Riccati equation. Sturm's separation and Comparison theorems.

UNIT-II

Linear Systems and Higher order equations:

Regressive matrices, Existence and Uniqueness theorem, matrix exponential function, Variation of constants, Liouville's Formula, Constant coefficients.

UNIT-III

Asymptotic behavior of solutions:

Growth and dichotomy conditions, Levinson's perturbation Lemma properties and applications.

UNIT-IV

Dynamic Inequalities:

Grownwall's Inequality, Bernoulli's Inequality, Holders and Minkowski's inequalities.Lyapunov inequalities.

UNIT-V

Nabla Dynamic equations on Time scales:

Introduction, Regressive functions, Nabla exponential function, Applications, Variation of constants.

Text Book:

Dynamic equations on time scales, an introduction with Applications. Martin Bohner and Allan Peterson, BirKhauser, Boston. 1st Edition (2001).

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25MAT306-DIFFERENTIAL EQUATIONS

UNIT-I

System of linear differential equations

System of first order equations, existence and uniqueness theorem, fundamental matrix, non-homogeneous linear system, linear systems with constant coefficients.

UNIT-II

Existence and Uniqueness of solutions

Introduction, preliminaries, successive approximations, Picard's theorem, continuation and dependence on initial condition, existence of solutions in the large interval.

(Scope and treatment as in Chapters : 4 and 5 of Text book (1))

UNIT- III

Oscillation theory and boundary value problems

Qualitative properties of solutions, the sturm comparison theorem, Eigen values, Eigen functions

UNIT- IV

Power series solutions and special functions

Series solutions of first order and second order linear differential equations, ordinary points, regular singular points. Gauss's hyper geometric equation, the point at infinity.

UNIT V

Non-linear equations

Autonomous systems, the phase plane and its phenomena, type of critical points, stability, critical points and stability for linear systems, stability by Liapunov's direct method, simple critical points of non-linear systems.

(Scope and treatment as in Chapters: 4 ,5(sections 25-29) and 8 (sections 40-44)of Text book (2))

Text Book:

1. Text book of ordinary differential equations by S.G.Deo, V. Lakshmikantham and V. Raghavendra, second Edition, Tata McGraw - Hill publishing Company Ltd., New Delhi, 2002.

Reference Text Book:

1. Differential equations with applications and historical Notes by George F. Simmons, Third Edition, Tata McGraw - Hill publishing Company Ltd., New Delhi, 1972.

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25MAT307-CRYPTOGRAPHY

UNIT I

Introduction to Cryptography

Classical Cryptosystems, Stream and Block ciphers, Substitution and Transposition/Permutation ciphers, Symmetric and Asymmetric Cryptosystems, Cryptanalysis, Frequency Analysis

UNIT II

Public Key Cryptography and Modern Cryptosystems

Introduction to Public-Key Cryptosystem, RSA Cryptosystem, Diffie Hellman Key Exchange Protocol, ElGAmal Cryptosystem

Data Encryption Standard (DES), Triple DES (3-DES), Advanced Encryption Standard (AES)

UNIT III

Perfect Secrecy

Perfect Secrecy, Birthday Paradox, Vernam One Time Pad (OTP), Random Numbers, Pseudo Random Numbers Generator (PRNG), Linear Feedback Shift Registers (LFSR)

UNIT IV

Cryptographic Hash functions

Hash and Compression Functions, Security of Hash Functions, SHA-1, Other Hash Functions, Message Authentication Codes.

UNIT V

Digital Signatures

Security requirements for Signature Schemes, RSA Signature, ElGAmal Signature, Digital Signature Scheme (DSA), Undeniable Signature, Blind Signature

Text Books:

1. J. Buchmann, Introduction to Cryptography, Second Edition, Springer (India) 2004.
2. W. Trappe & L. C. Washington, Introduction to Cryptography and Coding Theory, 3rd edition.

Reference Text Book:

1. Behrouz. A. Forouzan & Debdeep Mukhopadhyay, Cryptography and Network Security, 3rd edition, Mc Graw Hill.

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25MAT308-THEORY OF HYPER GEOMETRIC FUNCTIONS

UNIT-I

The Hypergeometric Function

The function F (a, b; c; z), A simple integral form, F(a,b;c;1) as a function of the parameters, Evaluation of F(a,b;c;1), The hypergeometric differential equation, F(a, b; c; z) as of its parameters, Elementary series manipulations, Simple transformations, Relation between functions of z and 1-z, A quadratic transformation, Additional properties.

UNIT-II

Generalized Hypergeometric Functions

The function pFq, The exponential and binomial functions, A differential equation, other solutions of the Differential equation, A Simple integral, The pFq with unit argument, Saalschutz's Theorem, Whippele's Theorem, Dixon's Theorem, A useful integral.

UNIT-III

The Confluent Hypergeometric Function

Basic properties of the 1F1, Kummer's first and second formula, A theorem due to Kummer. Generating functions: The generating function concept, generating functions of the form G(2xt – t2), sets generated by et Φ(xt), the generating functions A(t)exp(-xt/1-t).

UNIT-IV

Lie Algebraic Technique

Lie groups, Lie algebras and one parameter subgroups, homomorphism, linear differential operators, Preliminary observations, The Laguerre function, Ln(α)(x), the hypergeometric function 2f1 (-n, α; β; x), the modified Laguarre function Ln(α-n)(x).

UNIT-V

The Weisner Method

Introduction, The differential equation, linear differential operators, group of operators, the extended form of the group generated by B and C, Generating functions for modified Laguerre polynomials, Simple Bessel functions, Gegenbauer polynomials.

Text Books:

1. Special functions by E.D. Rainville, MacMillan Company, New York, 1960.
2. A treatise on generating functions by H.M.Srivastva and H.L.Manocha, Halsted/Wiley New York, 1984.

Reference Text Book:

1. Obtaining Generating functions by Mc.Bride, springer verlag, New York, 1971.

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21MAT309-QUEUEING THEORY

UNIT-I

Concept of queuing theory, some important Random processes, Definition and Classification of Stochastic processes. Discrete-Time Markov Chains, Continuous-Time Markov chains, Birth- Death processes.

UNIT-II

Steady state solutions M/M/1/k, M/M/m/k, M/Er/1, Er/M/1, with FCFS.

UNIT-III

Embedded Markov chain technique, non-Poisson queues

UNIT-IV

Elements of priority, tandem and parallel queues.

UNIT-V

Optimal design and control of queues. The N-Policy and the T-Policy.

Test books:

1. Queuing Systems, Volume I by Leonard Kleinrock (for Unit-I, II, & III)
2. Elements of queuing theory by Thomas L. Saaty (for Unit-IV)
3. Introduction to Queuing theory by Robert B Cooper (for Unit-V)

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25MAT310-SAMPLING THEORY

UNIT I:

Simple Random Sampling

Simple Random Sampling, Selection of a Simple Random Sample, Definitions and Notations, Properties of the Estimates, Variances of the Estimates, Estimation of the Standard Error from A Sample, Confidence Limits, Random Sampling with Replacement, Estimation of a Ratio, estimates of a Means over Sub Populations, Estimates of Totals Over Sub Populations, Comparison between domain Means, Validity of the Normal Approximation, Linear Estimators of the Population Mean.

UNIT II:

Stratified Random Sampling

Description, notation, properties of the estimates, the estimated variance and confidence limits, optimum allocation, relative precision of stratified random and simple random sampling, stratification producing large gains in precision, allocation requiring more than 100 percent, estimation of sample size with continuous data, stratified sampling for proportions, estimation of sample size with proportions

UNIT III:

Ratio Estimators:

Methods of estimation, the ratio estimate, approximate variance of the ratio estimate, estimation of a variance from a sample, confidence limits, comparison of the ratio estimate is a best linear unbiased estimator, bias of the ratio estimate ,accuracy of the formulas for the variance and estimated variance, ratio estimates in stratified random sampling, the combined ratio estimate, comparison of the combined and separate estimates, short -cut computation of the estimated variance, optimum allocation with a ratio estimate, unbiased ratio type estimates, comparison of the methods, improved estimation of the variance, comparison of two ratios, multivariate ratio estimates, product estimators

UNIT IV:

Regression Estimators:

The linear regression estimate, regression estimates with pre-assigned b, regression estimates when b is computed from the sample, sample estimate of variance. Large sample comparison with the ratio estimates and the mean per unit, bias of the linear regression estimate, the linear regression estimates under a linear regression model, regression estimates in stratified sampling, regression coefficients estimated from the sample, comparison of the two types of regression estimates

UNIT V:

Systematic Sampling:

Description, relation to the cluster sampling, variance of the estimated mean, comparison of systematic with stratified random sampling, populations in "Random"order, populations with linear trend, methods for populations with linear trends, populations with periodic variation, auto-corelated populations, natural populations, estimation of the variance from a single sample, stratified systematic sampling, systematic sampling in two dimensions, summary.

Text Book:

Sampling Techniques By W.G. Cochran, Wiley, Third Edition (Chapters: 2,5,6,7,8)

Reference Text Book:

Sampling Theory By Des Raj , Mcgraw Hill

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25MAT311-INVENTORY MODELS

UNIT-I

Deterministic inventory Models

Inventory – Types of Inventory – Inventory Decisions – Classification of Inventory Models – Concept of Average inventory – Economic Ordering Quantity (EOQ) – EOQ with shortages and without shortages - EOQ with constraints.

UNIT-II

Dynamic or Fluctuating Demand Models

Dynamic or Fluctuating Demand Models: Re-order level – Optimum Buffer stock – Inventory Control System – Deterministic Models with Price- Breaks.

UNIT-III

Probabilistic Inventory Models

Instantaneous Demand – No Set- up cost Model – Uniform Demand - No Set- up cost Model - Probabilistic order-level system with constant lead Time – Multi –period Probabilistic model with constant lead Time.

UNIT-IV

Selective Inventory Management

ABC Analysis – VED Analysis- XYZ Analysis Based on inventory value – FNSD Analysis Based on Usage rate of items.

UNIT-V

Markov Analysis

Introduction-Stochastic Process-Markov Process-Transition Probability-n-Step transition Probabilities-Markov Chain-Chapman-Kolomogrov Theorem.

Text Books:

1. S.D.Sarma,“Operations Research”
2. J.Medhi,”Stochastic Processes”, New Age International

Reference Book:

1. Prem kumar Gupta,D.S.Hira,”Operations Research” S. Chand &Company Ltd, Second edition (2003).

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25MAT312-DIFFERENCE EQUATIONS

UNIT-I

Linear difference equations:

First order equations, general results for linear difference equations, solving linear difference equations.

Unit-II

Methods of solving linear difference equations:

Solving linear difference equations with variable coefficients, nonlinear equations that can be linearized, solving difference equations using z-transforms.
(Scope and treatment as in chapter-3 of Text book (1))

Unit-III

Linear initial value problems associated with system of difference equations:

Introduction, preliminary results from algebra, linear dependence and independence, matrix linear systems, variation of constant formula, Green's matrix, systems with constant coefficients.

Unit-IV

Qualitative properties of solutions of difference systems:

Continuation and dependence on initial condition and parameters, asymptotic behavior of linear and nonlinear systems.

Unit-V

Stability of difference systems:

Concept of stability, stability of linear and nonlinear systems.

Text Books:

1. Difference equations an introduction with applications by W. G. Kelley and A. C. Peterson Second edition, Harcourt Academic Press, USA (2001).

Reference Text Book:

1. Difference equations and inequalities, theory, methods, and applications by R.P.Agarwal, Baker publications, Marcel Dekker Inc, New York (1992).

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25MAT313-COMPUTATIONAL FLUID DYNAMICS

Unit-I

Introduction to Computational Fluid Dynamics, classification of partial differential equations their physical behavior.

Unit-II

Basics of Finite Difference Methods (FDM): Finite differences, difference representation of PDE, examples, stability considerations.

Unit-III

Applications of FDM to selected model equations: Heat equation, Wave equation, Laplace equation, inviscid Burger equation, viscous Burger equation.

Unit-IV

Finite Volume approach and discretization of unsteady-state problems, Solution of systems of linear algebraic equations.

Unit-V

Simple CFD Techniques: Lax-Wendroff Technique, Mac Cormack's Techniques. Numerical Solutions of Navier-Stokes equations on collocated and on staggered grids., Simulation of fluid flow and compact discretization: Flow in a lid driven cavity, Numerical grid generation.

Textbook(s):

1. Anderson, D.A., Tannehill, J.C. and Pletcher, R.H. Computational Fluid Dynamics and Heat Transfer, (CRC Press, 2012).
2. S. V. Patankar, Numerical Heat Transfer and Fluid Flow, McGraw-Hill
3. Chung, T.J. Computational Fluid Dynamics, (Cambridge University Press, 2005).
4. Hoffman, J.D. Numerical Methods for Engineers and Scientists, CRC Press, 2001).
5. P. Niyogi, S.K. Chakrabarty, M.K. Laha: Introduction to Computational Fluid Dynamics, Pearson Education Asia, 2005.

Reference Text book(s)

1. Fletcher, C. A. J. Computational Techniques for Fluid Dynamics, Volume 1 & 2, (Springer Verlag, 1992).
2. Anderson, J. D. Computational Fluid Dynamics – The Basics with Applications (Mc- Graw Hill, 1995).
3. Ferziger, J.H. and Peric, M. Computational Methods for Fluid Dynamics (Springer, 1999).

NPTEL Online: https://onlinecourses.nptel.ac.in/noc21_me126/preview

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25MAT314-DATA SCIENCE

UNIT I

Fundamentals of Data Science: Applications, Data Science Challenges, Data Science Teams and Roles Data Science Process, CRISP-DM Methodology, SEMMA, BIG DATA LIFE CYCLE, SMAM. Ethics for Data Science: Being a data skeptic – examples of misuse of Data, Five C's, Ethical guidelines for Data Scientist, Ethics of data scraping and storage.

UNIT II

Data Models and Pipelines: Types of Data and Datasets, Data Quality and Issues: An overview, Data Models: General Framework of Formal Modeling, Association Analyses, Prediction Analyses, Data Pipelines and patterns, Data Pipeline Stages, Modern Data Infrastructure.

UNIT III

Data wrangling: Data cleaning, Data Aggregation, Sampling, Statistical descriptions of data, measuring data similarity & dissimilarity, Handling Numeric Data, Discretization, Binarization, Normalization, Data Smoothening, dealing with textual Data, Dealing with Images, audio and video data, Managing Categorical Attributes, Transforming Categorical to Numerical Values, Encoding techniques, Overview of visualization techniques for Data Exploratory analysis.

UNIT IV

Classification and Prediction: Concepts of classification and prediction, Decision trees for classification - ID3 algorithm using entropy and Gini Index, Evaluation of classification algorithms, Association Analysis.

UNIT V

Clustering: Cluster analysis concepts. Partitioning methods – k-Means algorithm, Hierarchical methods for cluster analysis Density based methods for cluster analysis – DBSCAN, Evaluation of clustering algorithms, Anomaly Detection: Concepts of Outliers, Statistical approaches, Proximity and Density based outlier detection.

Textbooks:

1. Introduction to Data Mining, by Tan, Steinbach and Vipin Kumar, Second Edition.
2. Introducing Data Science by Cielen, Meysman and Ali.

Reference Text Book:

1. Storytelling with Data, A data visualization guide for business professionals, by Cole Nussbaumer Knaflic; Wiley.

25MAT315-STRUCTURES ON MANIFOLDS

UNIT-I

Manifolds and Connection:

Concepts of manifolds, Tangent vectors, Vector fields, Lie Brackets, Affine connections, Torsion tensor of an affine connection, Curvature tensor of an affine connection.

UNIT-II

Complex and almost Complex Manifolds:

Definition and example, Nijenhuis tensor, Eigen Values of an almost complex structure, Existence theorem and inerrability condition, contravariant and covariant almost analytic vector fields.

UNIT-III

Almost Hermite Manifold:

Nijenhuis tensor, almost analytic vector fields, Curvature in almost Hermite manifold, Holomorphic Sectional Curvature, Linear connection in an almost Hermite manifold.

UNIT-IV

Kaehler Manifold:

Definition, Holomorphic Sectional Curvature, Bochner Curvature tensor, affine connection in almost Kaehler manifold.

UNIT-V

Nearly Kaehler Manifold:

Definition, Projective correspondence between two Nearly Kaehler manifolds, Curvature identities.

Text Book:

1. U. C. De and A. A. Shaikh, Complex Manifolds and Contact Manifolds, Narosa Publishing House, 2007

Reference Text Books:

1. K. Yano and M. Kon, Structures on Manifolds, World Scientific. 1984.
2. D. E. Blair, Riemannian Geometry of Contact and Symplectic Manifolds, Progress in Mathematics, Vol. 203, Birkhäuser Inc., Boston, MA, 2002.
3. R. S. Mishra, Structures on Differentiable Manifolds and their Applications, Chandrama Prakashan, Allahabad, 1984.