Savitribai Phule Pune University

(Formerly University of Pune)

Four Year Graduate Degree Programme in Mathematics

(Faculty of Science & Technology)

New

Syllabi for

T. Y. B. A. / B. Sc. - Mathematics

(For Colleges Affiliated to Savitribai Phule Pune University, Pune)

(As per National Education Policy- 2020)

To be implemented from the Academic Year 2026-2027

Syllabus for T. Y. B.Sc. Mathematics as Per NEP-2020

Semester - V

MTS-301-MJ : Metric Spaces

Course type:Theory **No. of Credits: 02**

Course Outcomes: Students will able to

1. Remember: Recall definitions and examples of metric spaces, convergence, continuity, and compactness.
2. Understand: Explain concepts of open and closed sets, limit points, Cauchy sequences, and topological properties.
3. Apply: Apply definitions of continuity and compactness to determine properties of functions and sets.
4. Analyze: Analyze convergence of sequences, completeness of metric spaces, and uniform continuity of functions.
5. Evaluate: Evaluate properties of compact spaces, including continuous functions and equivalent definitions.
6. Create: Apply metric space concepts to solve problems in analysis, topology, and other areas of mathematics.

Course Contents

Unit 1 : Basic Notions **(06 Hours)**

1.1 Definition and examples of metric spaces

1.2 Open balls and open sets

1.3 Closed ball and closed sets

Unit 2 : Convergence **(06 Hours)**

2.1 Convergent sequences

2.2 Limit points and cluster points

2.3 Cauchy sequences and completeness

2.4 Bounded sets

2.5 Dense sets

2.6 Boundary of a set

Unit 3 : Continuity **(08 Hours)**

3.1 Continuous functions

3.2 Equivalent definitions of continuity

3.3 Topological properties

3.4 Uniform continuity

3.5 Open and closed maps

Unit 4 : Compactness **(06 Hours)**

4.1 Compact spaces and their properties

4.2 Continuous Function on Compact Spaces

Unit 5 : Connectedness **(04 Hours)**

5.1 Connected Spaces

5.2 Path Connected Spaces

Text Book:

1. Topology of Metric Spaces, S. Kumaresan, Narosa Publishing House ,2011.
   Unit 1: Chapter 1−Sections 1.1
   Sections 1.2
   Unit 2: Chapter 2 −Sections 2.1
   Sections 2.2
   Sections 2.3
   Sections 2.4
   Sections 2.5
   Sections 2.7
   Unit 3: Chapter 3 −Sections 3.1
   Sections 3.2
   Sections 3.3
   Sections 3.4
   Sections 3.5
   Unit 4: Chapter 4−Sections 4.1
   Sections 4.2

Reference Books:

1. Metric Spaces, Q.H. Ansari: Narosa Publishing House, New Delhi
2. Metric Spaces, E. T. Copson, University Press, Cambridge, 2nd edition
3. Metric Spaces, Satish Shirali, H. Vasudeva, Springer.
4. Real Analysis by Charles Pugh Chapman,2nd edition

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MTS-302-MJ : Real Analysis– I

Course type:Theory **No. of Credits: 02**

Course Outcomes: Students will able to

1. Remember: Recall and recognize key concepts in set theory, sequences, and series of real numbers.
2. Understand: Explain the definitions and properties of convergent and divergent sequences, and apply them to determine convergence.
3. Apply: Use operations on convergent sequences to solve problems and analyze limit superior and limit inferior.
4. Analyze: Investigate convergence and divergence of series, and apply tests for absolute convergence.
5. Evaluate: Determine conditional convergence and absolute convergence of series, and justify conclusions.
6. Create: Apply knowledge of sequences and series to analyze and solve problems in real analysis.

Course Contents

Unit 1 : Set Theory and Functions **(04 Hours)**

1.1 Cantor Sets

1.2 Relations and Functions

1.3 Countable and Uncountable Sets

Unit 2 : Sequences of Real Numbers **(06 Hours)**

2.1 Definition of a sequence and subsequence

2.2 Limit of a sequence

2.3 Convergent sequences

2.4 Divergent sequences

2.5 Bounded sequences

2.6 Monotone sequences

Unit 3 : Operations on Convergent Sequences **(08 Hours)**

3.1 Operations on convergent sequences

3.2 Operations on divergent sequences

3.3 Limit superior and limit inferior

3.4 Cauchy sequences

Unit 4 : Series of Real Numbers **(06 Hours)**

4.1 Convergence and divergence of series

4.2 Series with non-negative terms

4.3 Alternating series

4.4 Conditional convergence and absolute convergence

Unit 5 : Tests for Series convergence **(06 Hours)**

5.1 Tests for absolute convergence

5.2 Series whose terms form a non−increasing sequence

5.3 The class l^2

Recommended Books:

1. Methods of Real Analysis, Second Edition, Richard R. Goldberg, John Wiley & Sons
   Unit 1: Chapter 1, Sections 1.1−1.6
   Unit 2: Chapter 2, Sections 2.1−2.6
   Unit 3: Chapter 2, Sections 2.7−2.10
   Unit 4: Chapter 3, Sections 3.1−3.4
   Unit 5: Chapter 5, Section 3.6−3.7,3.10

Reference Books:

1. Real Analysis, N. L. Carothers, Cambridge University Press
2. Introduction to Real Analysis, Third Edition, Robert G. Bartle and Donald R. Sherbert, John Wiley & Sons
3. Real Analysis and Foundations, Second Edition, Steven G. Krantz, Chapman & Hall/CRC

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MTS-303 MJP : Practical on Metric Spaces and Real Analysis-I

Course type:Practical **No. of Credits: 02(P)**

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MTS-304 MJ : Group Theory

Course type:Theory **No. of Credits: 02**

Course Outcomes: Students will able to

1. Define and identify algebraic structures such as groups and classify them (abelian,cyclic, permutation groups).
2. Analyze subgroup structures and apply subgroup criteria to solve problems.
3. Apply Lagrange's theorem to determine orders of elements and subgroups.
4. Examine permutation groups, cycles, and alternating groups and perform computations.
5. Explain and apply group homomorphisms, kernels, and factor groups in problem−solving.
6. Construct and analyze quotient groups and understand their algebraic significance.

Course Contents

Unit I : Groups – Definitions and Properties **(08 Lectures)**

1.1 Binary operations: Definition, closure property.

1.2 Algebraic structures and isomorphic binary structures.

1.3 Definition of a group.

1.4 Basic properties: identity, inverse, uniqueness

1.5 Examples of groups (finite and infinite).

Unit II : Subgroups **(06 Lectures)**

2.1 Definition of subgroup

2.2 Subgroup criteria

2.3 Cyclic groups: Definition and properties

2.4 Generators of cyclic groups

2.5 Order of an element

Unit III : Permutation Groups **(12 Lectures)**

3.1 Permutation groups and symmetric group S_n (n$\leq$3)

3.2 Orbits and their properties.

3.3 Cycles and cycle notation.

3.4 Even and odd permutations, alternating group A_n

3.5 Cosets and Lagrange's Theorem

3.6 Direct products of groups

Unit IV : Homomorphisms and Factor Groups **(12 Lectures)**

4.1 Group homomorphisms: Definition and examples

4.2 Kernel and image of a homomorphism

4.3 Properties of homomorphisms

4.4 Factor (quotient) groups

4.5 Computation of factor groups

4.6 Introduction to simple groups

Recommended Books:

1. John B. Fraleigh, A First Course in Abstract Algebra, Seventh Edition, Pearson. Sections: 2,3,4,5,6,8,9,10, 11(only Direct Product), 13,14,15. (Fundamental Theorem of Group Homomorphism (First Isomorphism Theorem) statement only), exclude inner automorphisms.)

Reference Books:

1. Topics in Algebra − I. N. Herstein
2. Abstract Algebra − David S. Dummit and Richard M. Foote
3. Contemporary Abstract Algebra − Joseph A. Gallian
4. An Introduction to the Theory of Groups − Joseph J. Rotman

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MTS-305MJ : Ordinary Differential Equations

Course type:Theory **No. of Credits: 02**

Course Outcomes: Students will able to

1. Solve linear differential equations with constant coefficients by applying characteristic equation methods for distinct, repeated, and complex roots.
2. Analyze and solve non-homogeneous linear differential equations using the method of undetermined coefficients, reduction of order, and variation of parameters.
3. Apply the inverse differential operator technique to evaluate particular integrals for algebraic, exponential, and trigonometric functions with logical justification.
4. Formulate and solve systems of first-order linear differential equations with constant coefficients arising in mathematical and physical models.
5. Examine the power series solutions of differential equations, including classification of ordinary and singular points, and construct series solutions about an ordinary point.
6. Understand the genesis of ordinary differential equations.

Course Contents

Unit 1 : Linear Differential Equations with constant coefficients (08 Hours)

1.1 Constant coefficient homogeneous equations

1.2 Characteristic equations: distinct real roots, repeated roots, complex roots

Unit 2 : Non−Homogeneous Linear Equations (06 Hours)

2.1 Method of undetermined coefficients

2.2 Method of reduction of order

2.3 Method of variation of parameters.

Unit 3 : Inverse differential operator (08 Hours)

3.1 The operator $\frac{1}{(f(D))}$ and its evaluation for the functions x^m, e^{ax}, $e^{ax}.V$, XV.

3.2 The operator $\frac{1}{(D^2+a^2)}$ acting on $sinax$ and $cosax$ with proofs.

Unit 4 : System of Equations (04 Hours)

4.1 Introduction to system of differential equations

4.2 Solution of homogeneous first order systems with constant coefficient

Unit 4 : Power Series Solutions (04 Hours)

5.1 Review the properties of power series

5.2 Classifications of ordinary and Singular points

5.3 Series solution near an ordinary point

Recommended Books:

1. Elementary Differential Equations seventh edition by Earl D. Rainville and Philip E Bedient.

   Chapater − 6, 33 to 37. Chapater − 7, 41. Chapater − 8, 44 to 45, Chapater − 9, 47 to 50. Chapater − 13, 76 to 81. Chapater − 17, 105 to 107.

Reference Books:

1. William F Trench, Elementary Differential Equations with Boundary Value Problems, E book (Free download)
2. M. D. Raisinghania, Ordinary and Partial Differential Equations, S. Chand and Company LTD 2009.
3. George F. Simmons and Stevan G. Krantz, Differential Equations, Tata McGraw-Hill.
4. W. R. Derrick and S. I. Grossman, A First Course in Differential Equations with Applications. CBS Publishers and Distributors, Delhi 110032, Third Edition.
5. Daniel Murray, Introductory Course in Differential Equations, Orient Longman.

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MTS-306 MJP : Practical on Group Theory and Ordinary Differential Equations

Course type:Practical **No. of Credits: 02(P)**

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MTS-310-ME : A) Graph Theory

Course type:Theory **No. of Credits: 02**

Course Outcomes: Students will able to

1. Remember: Recall basic definitions and concepts of graphs, including types of graphs, graph representations, and graph terminology.
2. Understand: Explain connectivity, trees, Eulerian and Hamiltonian graphs, and apply concepts like Prim's and Kruskal's algorithms.
3. Apply: Apply graph algorithms (Dijkstra's, Prim's, Kruskal's) to solve problems like minimum spanning tree and shortest path.
4. Analyze: Analyze graph properties (connectivity, planarity, chromatic number) and apply Hall's Theorem to solve matching problems.
5. Evaluate: Evaluate graph coloring, matching, and planarity, and apply concepts to real-world problems like Chinese postman and travelling salesman.
6. Create: Create graph models for real-world applications (chemistry, social networks, data science) and analyze their properties.

Course Contents

Unit 1 : Introduction to Graphs **(10 Hours)**

1.1 Basic definitions: vertices, edges, and degree.

1.2 Graphs as models: Königsberg seven bridge problem, job assignments, three utilities graphs, traffic networks

1.3 Types of graphs: directed, undirected, simple, multigraphs, complete graphs, bipartite Graphs, regular graphs, Petersen graph

1.4 More Definitions: Subgraphs, proper and spanning subgraphs, walk, paths and cycles, graph isomorphism, complement of a graph, edge deletion, vertex deletion, edge contraction, union and intersection of graphs, Matrix representation of graphs:Adjacency matrix, Incidence matrix

Unit 2 : Connectivity and Trees **(08 Hours)**

2.1 Connectivity: Connected graph, components, cut-vertex, bridges, matrix characterization of connectivity, 2-connected graphs

2.2 Trees: Definition, examples, properties, characterizations, binary trees

2.3 Spanning trees: Definition, Cayley's formula, minimum spanning tree in a weighted graph, Prim's algorithm, Kruskal's algorithm, Dijkstra's algorithm

Unit 3 : Eulerian and Hamiltonian Graphs **(08 Hours)**

3.1 Eulerian graphs: Walk, trail, Eulerian trail, Eulerian graph, Euler's Theorem, Examples of Eulerian graphs, characterization in terms of even degree, Cycle decomposition

3.2 Hamiltonian graphs: Hamiltonian graph, definition and examples, sufficient Conditions

3.3 Applications: Chinese postman problem, travelling salesman problem

Unit 4 : Introduction to Matching and Colouring (04 Hours)

4.1 Matching: Matchings, maximum matchings, augmenting path, Hall's Theorem (statement) and its applications

4.2 Graph coloring: Vertex colouring, chromatic number, chromatic number of some special graph, definition of planar graph, four color theorem (statement)

Unit 5 : Some applications of graphs: [For Practical purpose only]

5.1 Applications in Chemistry- Graph energy, Reaction Network

5.2 Applications in Social Networks- Introduction to social network analysis, Role in real-world systems

5.3 Applications in Data Science- Neural Networks, Page ranking

Reference Books:

1. A First Look at Graph Theory, John Clark & Derek Holton, Allied Publishers Ltd. 1991.
2. Graph Theory with Applications to Engineering & Computer Science, Narsingh Deo, Prentice−Hall of India, 1974.
3. Introduction to Graph Theory (2nd Edition), Douglas West, Pearson Education (India), 2015.
4. Introduction to Graph Theory, Robin Wilson, Prentice Hall / Addison-Wesley, 1996.
5. Introduction to Chemical Graph Theory, Stephan Wagner & Hua Wang, CRC Press 2018.
6. Social Network Analysis, Tanmoy Chakraborty, Wiley India Pvt. Ltd. 2021.
7. Neural Networks and Deep Learning: A Textbook, Charu Aggarwal, Springer International Publishing AG, 2018.
8. Nine Algorithms That Changed the Future: The Ingenious Ideas That Drive Today's Computers, John MacCormick, Princeton University Press, 2012.

Other Resources:

- NPTEL Course on basic graph theory conducted by IISER, Pune: https://nptel.ac.in/courses/111106102
- NPTEL Course on graph theory conducted by IIT Madras, https://nptel.ac.in/courses/111106050
- Online Free Software: http://graphtheorysoftware.com

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MTS-310 ME : B) Linear Programming Problem and Game Theory

Course type:Theory **No. of Credits: 02**

Course Outcomes: Students will able to

1. Remember: Recall concepts of linear programming, transportation, assignment, and game theory, including methods like Simplex, Big-M, and Hungarian.
2. Understand: Explain formulations and assumptions of linear programming, transportation, and assignment problems, and characteristics of game theory.
3. Apply: Apply methods like Simplex, Big-M, North West Corner Rule, VAM, MODI, and Hungarian to solve linear programming, transportation, and assignment problems.
4. Analyze: Analyze duality in linear programming, degeneracy in transportation, and optimal strategies in game theory.
5. Evaluate: Evaluate solutions to linear programming, transportation, assignment problems, and determine optimal strategies and value of games.
6. Create: Formulate and solve real−world problems using linear programming, transportation, assignment, and game theory concepts, and apply methods like graphical and dominance methods.

Course Contents

Unit 1 : Linear Programming Problems **(10 Hours)**

1.1 Basic concepts of linear programming problem

1.2 Assumptions and limitations of linear programming problem.

1.3 Slack, Surplus variable and standard form of Simplex method.

1.4 Artificial variable and Big−M method.

1.5 Types of solutions of linear programming problems.

1.6 Duality in linear programming problem

Unit 2 : Transportation Problems **(08 Hours)**

2.1 Mathematical model of transportation problem.

2.2 Linear programming formulation of transportation problem.

2.3 Initial basic solution of transportation problem.

(a)North West Corner Rule.

(b)Lowest Cost Entry Method.

(c) Vogel's Approximation Method (VAM)

2.4 Optimal solution by Modified Distribution Method (MODI Method).

2.5 Degeneracy in transportation problem

Unit 3 : Assignment Problems **(06 Hours)**

3.1 Mathematical model of assignment problem.

3.2 Linear programming formulation of assignment problem.

3.3 Hungarian method for solving assignment problem.

Unit 4 : Game Theory **(06 Hours)**

4.1 Characteristics of Game Theory.

4.2 Saddle point, optimal strategies and value of the game.

4.3 Rectangular games without saddle point and Game as a L.P.P. formulation

(a) Algebraic Method.

(b) Graphical Method for $2 \times n$ and $m \times 2$ games.

(c) Dominanace Method for $m \times n$ game.

Text Book:
Operations Research, S.D. Sharma, Kedar Nath Ram Nath and Co, meerut, Eighteenth Edition, 2017.
Reference Book:

1. Hamdy A. Taha, Operations Research, (Eighth Edition, Prentice Hall of India), 2008.
2. Operations Research: Theory and Applications, J. K. Sharma, Macmillan India Ltd., Fifth Edition, 2013.
3. P. K. Gupta and D. S. Hira, Operations Research, (Fifth Edition, S. Chand), 2014.

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MTS-311 MEP : A) Practical on Graph Theory
or
MTS-311 MEP : B) Practical Linear Programming Problem and Game Theory

Course type:Practical **No. of Credits: 02**

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MTS-321-VSC Mathematical Statistics

Course type:Practical **No. of Credits: 02**

Course Outcomes: Students will able to

1. To understand the concept of probability theory, random variables, and probability distributions (discrete and continuous).
2. To Apply mathematical techniques to derive probability distributions of random variables and study their properties.
3. To analyze different sampling distributions and explain their role in statistical inference.
4. To Formulate and evaluate point and interval estimation methods.
5. To Develop and apply hypothesis testing procedures using classical based approaches.
6. To create methodologies to understand various statistical methods.

Course Contents

Unit 1 : Introduction to Probability & Random Variables (12 Hours)

1.1 Sample space, events, probability of an event, addition and multiplication theorem of probability, conditional probability. Numerical problems

1.2 Concept of a random variable, discrete probability distribution, continuous Probability distribution, joint probability distribution.

1.3 Independent random variables, Mean of a random variables, Variance and Covariance, Mean and variance of linear combinations of random variables

Unit 2 : Some Standard Discrete & Continuous Probability Distributions (16 Hours)

2.1 Bernoulli, Binomial, Poisson distribution, Negative binomial distribution, Geometric distribution,

2.2 Continuous Uniform distribution, Normal distribution, Central Limit Theorem, Gamma distribution, Exponential distribution, Chi − squared distribution, Student's t− distribution, F distribution, Chi square distribution.

Unit 3 : Testing of Hypothesis (20 Hours)

3.1 basics of testing of hypothesis, Parameter, Parameter Space, Statistic, Null & Alternative hypotheses, level of significance, errors in testing of hypothesis, Type I & Type II errors, meaning of test, types of test , Test Statistic, Critical region , P−value, decision by critical region and P− value criteria.

3.2 Statistical Tests: Large sample & Small sample tests.

Unit 4: Correlation & Regression Models (12 Hours)

4.1 concepts of correlation, scattered diagram, Karl Pearson's Coefficient of Correlation, properties & interpretation of Correlation coefficient.

4.2 Simple Linear Regression Model, Least square principle, fitting of linear regression model, estimation of parameters.

4.3 Multiple Linear Regression Model, estimation of parameters by least square Method of estimation.

Reference Books:

1. Ross, Sheldon M. Introduction to probability and statistics for engineers and scientists. Academic press, 2020.
2. Gupta, S.C. and Kapoor, V. K. (2020). Fundamentals of Mathematical Statistics, Tenth edition Sultan Chand and Sons Publishers, New Delhi
3. Hogg, Robert V., Elliot A. Tanis, and Dale L. Zimmerman. Probability and statistical inference. Vol. 993. New York: Macmillan, 1977.

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MTS-331-FP : Field Project

Course type:Practical **No. of Credits: 02**

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MTS-341-MN : A) Integral Transform

Course type:Theory **No. of Credits: 02**

Course Outcomes: Students will able to

1. Remember: Recall definitions and properties of Laplace transforms, Fourier series, and Fourier transforms, including standard formulas and theorems.
2. Understand: Explain concepts of piecewise continuous functions, exponential order, and Dirichlet conditions, and apply them to Laplace and Fourier transforms.
3. Apply: Apply Laplace transforms to solve linear differential equations, and use Fourier series to represent periodic functions.
4. Analyze: Analyze properties of Laplace and Fourier transforms, including shifting theorems and convergence of Fourier series.
5. Evaluate: Evaluate Laplace transforms of derivatives, inverse Laplace transforms, and Fourier transforms of standard functions.
6. Create: Apply Laplace and Fourier transforms to solve real-world problems, including initial value problems and periodic function representations.

Course Contents

Unit 1 : Basic Introduction **(04 Hours)**

1.1 Review of improper integrals

1.2 piecewise continuous functions

1.3 functions of exponential order

1.4 motivation and basic idea of integral transforms.

Unit 2 : Laplace Transform **(06 Hours)**

2.1 Definition of Laplace transform, linearity property, Laplace transform of standard functions

2.2 First and second shifting theorems, inverse Laplace transform using standard tables.

Unit 3 : Applications of Laplace Transform **(06 Hours)**

3.1 Laplace transform of derivatives

3.2 Solution of first-order and second-order linear differential equations

3.3 Initial value problems, unit step (Heaviside) function.

Unit 4 : Fourier Series and Fourier Transform **(08 Hours)**

4.1 Periodic functions, Fourier series

4.2 Dirichlet conditions (statement), Fourier sine and cosine series

4.3 Half-range expansions, Fourier transform and inverse Fourier transform, basic properties.

Unit 5:Applications of Fourier Series and Fourier Transform **(06 Hours)**

5.1 Fourier series of simple periodic functions

5.2 sine and cosine series problems

5.3 Fourier transform of standard functions, illustrative examples and interpretation.

Recommended Book:

1. INTEGRAL TRANSFORMS AND THEIR APPLICATIONS, 3rd Edition, Lokenath Debnath, Dambaru Bhatta

   Unit 1: Chapter 1: Sec- 1.1, 1.4, Chapter 3: Sec- 3.3

   Unit 2: Chapter 3: Sec- 3.2, 3.4, 3.7

   Unit 3: Chapter 3: Sec- 3.6, Chapter 4: Sec- 4.2,

   Unit 4: Chapter 1: Sec- 1.2, Chapter 2: Sec- 2.2 to 2.5, 2.13- 2.14

   Unit 5: Chapter 2: Sec- 2.10 to 2.15

Reference Book:

1. B. L. Gupta − Integral Transforms

2. M. R. Spiegel − Laplace and Fourier Transforms (Schaum's Outline)

3. E. Kreyszig − Advanced Engineering Mathematics

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MTS-341 MN : B) Operations Research

Course type:Theory **No. of Credits: 02**

Course Outcomes: Students will able to

1. Remember: Recall concepts of linear programming, transportation, and assignment problems, including methods like Simplex, Big-M, and Hungarian.
2. Understand: Explain formulations and mathematical models of linear programming, transportation, and assignment problems.
3. Apply: Apply methods like Simplex, Big−M, North West Corner Rule, VAM, MODI, and Hungarian to solve linear programming, transportation, and assignment problems.
4. Analyze: Analyze types of solutions and optimality of linear programming, transportation, and assignment problems.
5. Evaluate: Evaluate solutions to linear programming, transportation, and assignment problems using Python programming.
6. Create: Formulate and solve real-world problems using linear programming, transportation, and assignment models, and implement solutions using Python.

Course Contents

Unit 1 : Linear Programming Problem **(12 Hours)**

1.1 Basic concepts of linear programming problem

1.2 Slack, Surplus variable and standard form of Simplex method.

1.3 Artificial variable and Big−M method.

1.4 Types of solutions of linear programming problems.

1.5 Linear programming in Python Programming.

Unit 2 : Transportation Problem **(10 Hours)**

2.1 Mathematical model of transportation problem.

2.2 Linear programming formulation of transportation problem.

2.3 Initial basic solution of transportation problem.

(a)North West Corner Rule.

(b)Lowest Cost Entry Method.

(c) Vogel's Approximation Method (VAM)

2.4 Optimal solution by Modified Distribution Method (MODI Method).

2.5 Transportation Problem in Python Programming

Unit 3 : Assignment Problem **(08 Hours)**

3.1 Mathematical model of assignment problem.

3.2 Linear programming formulation of assignment problem.

3.3 Hungarian method for solving assignment problem.

3.4 Assignment Problem in Python Programming.

Reference Book:

1. Operations Research, S.D. Sharma, Kedar Nath Ram Nath and Co, meerut, Eighteenth Edition, 2017.
2. Python Programming: Introduction to Computer Science by Zelle, J. Franklin, Beedle & Associates Inc.
3. Hamdy A. Taha, Operations Research, (Eighth Edition, Prentice Hall of India), 2008.
4. Operations Research: Theory and Applications, J. K. Sharma, Macmillan India Ltd., Fifth Edition, 2013.
5. P. K. Gupta and D. S. Hira, Operations Research, (Fifth Edition, S. Chand), 2014.

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T. Y. B. Sc. (Semester−VI)

MTS 351 MJ : Complex Analysis

Course type:Theory **No. of Credits: 02**

Course Outcomes: Students will able to

1. Remember: Recall definitions and properties of complex numbers, analytic functions, and elementary functions, including Cauchy−Riemann equations and contour integrals.
2. Understand: Explain concepts of limits, continuity, differentiability, and analyticity of complex functions, and apply Cauchy's integral formula.
3. Apply: Apply techniques of contour integration, residues, and poles to evaluate complex integrals and series expansions.
4. Analyze: Analyze properties of analytic functions, including harmonic functions, and apply Liouville's Theorem and Fundamental Theorem of Algebra.
5. Evaluate: Evaluate complex integrals using Cauchy's integral formula, residues, and poles, and determine convergence of sequences and series.
6. Create: Apply complex analysis techniques to solve problems in physics, engineering, and mathematics, involving complex functions and integrals.

Course Contents

Unit 1 : Analytic functions **(08 Hours)**

Functions of a Complex Variables, Limits, Theorems on limits (Without Proof), Limits involving the point at infinity, Continuity, Derivatives, Differentiation formulas (Without Proof), Cauchy−Riemann Equations, Sufficient Conditions for differentiability (Only Statement and Examples), Polar coordinates, Analytic functions, Harmonic functions.

Unit 2 : Elementary Functions **(04 Hours)**

The Exponential functions, The Logarithmic function, Branches and derivatives of logarithms, some identities involving logarithms, Complex exponents, Trigonometric functions.

Unit 3 : Integrals **(08 Hours)**

Derivatives of functions, Definite integrals of functions, Contours, Contour integral, Examples, Upper bounds for Moduli of contour integrals, Anti-derivatives (Only Examples), Cauchy−Goursat Theorem, Simply and multiply Collected domains. Cauchy integral formula, Derivatives of analytic functions. Liouville's Theorem and Fundamental Theorem of Algebra.

Unit 4 : Series **(04 Hours)**

Convergence of sequences and series, Taylor's series (without proof), Laurent series (without proof), examples.

Unit 5 : Residues and Poles **(06 Hours)**

Isolated singular points, Residues, Cauchy residue theorem (Without Proof), residue at infinity,

types of isolated singular points, residues at poles, zeros of analytic functions, zeros and poles.

Recommended Book:
J.W. Brown and R.V. Churchill, Complex Variables and Applications, International Student Edition, 2009. (Eighth Edition).
Chapter 2: §12, §15 to §26, Chapter 3: §29 to §34, Chapter4: §37 to §44, §46 and §48 to §53.

Chapter:5 §55 to §60 and §62.Chapter 6: §68 to §76.

Reference Books:

1. S. Ponnusamy, Complex Analysis, Second Edition (Narosa).
2. S. Lang, Complex Analysis, (Springer Verlag).
3. A.R. Shastri, An Introduction to Complex Analysis, (MacMillan).
4. L.V.Ahlfors, Complex Analysis, 3rd edition, McGraw Hill, 2000.
5. H.A.Priestley, Introduction to Complex Analysis, 2nd edition (Indian), Oxford, 2006.

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MTS 352 MJ : Real Analysis-II

Course type:Theory **No. of Credits: 02**

Course Outcomes: Students will able to

1. Remember: Recall definitions and properties of Riemann integral, improper integrals, and convergence of sequences and series of functions.
2. Understand: Explain concepts of measure zero sets, pointwise and uniform convergence, and apply fundamental theorem of integral calculus.
3. Apply: Apply tests for convergence and divergence of improper integrals, and evaluate Riemann integrals using properties and fundamental theorem.
4. Analyze: Analyze uniform convergence of sequences and series of functions, and consequences of uniform convergence.
5. Evaluate: Evaluate improper integrals, and determine convergence and uniform convergence of series of functions.
6. Create: Apply Riemann integration and convergence concepts to solve problems in analysis, and investigate properties of functions defined by integrals or series.

Course Contents

Unit 1 : Riemann Integral **(10 Hours)**

1.1 Sets of measure zero,

1.2 Definition of Riemann integral

1.3 Existence of Riemann integral

1.4 properties of Riemann integral

1.5 Fundamental theorem of integral calculus

Unit 2 : Improper Integrals **(06 Hours)**

2.1 Improper integrals of first kind

2.2 Convergence, divergence, absolute and conditional convergence

2.3 Integral test for convergence of series

2.4 Improper integrals of second kind, Cauchy principal value.

Unit 3 : Sequences of functions **(08 Hours)**

3.1 Point wise convergence of sequences of functions

3.2 Uniform convergence of sequences of functions

3.3 Consequences of uniform convergence

Unit 4 : Series of functions **(06 Hours)**

4.1 Convergence and uniform convergence of series of functions

4.2 Integration and differentiation of series of functions.

Recommended Books:

R. R. Goldberg, Methods of Real Analysis, Oxford and I.B.H. Publication Co.,1970
Ch. 7: 7.1 to 7.4 and 7.8,7.9,7.10 ; Ch. 9, Art 9.1 to 9.5

Reference Books:

1. First course in mathematical analysis, D somsundaram, B Chuadhari, Narosa Publishing house 2009.
2. Robert, G. Bartle, Donald Sherbert − Introduction to real analysis, Third edition, John Wiley and Sons.
3. Shantinarayan and Mittal − A course of Mathematical Analysis, Revised edition, S. Chand and Co.(2002).
4. S.C. Malik and Savita Arora − Mathematical Analysis , New Age International Publications,Third Edition,(2008).

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MTS-353 MJP : Practical on Complex Analysis and Real Analysis-II

Course type:Practical **No. of Credits: 02**

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MTS-354-MJ : Ring Theory

Course type:Major **No. of Credits: 02**

Course Outcomes: Students will able to

1. Remember: Recall definitions and properties of rings, fields, integral domains, and polynomial rings.
2. Understand: Explain concepts of divisors of zero, characteristics of a ring, and field of quotients of an integral domain.
3. Apply: Apply evaluation homeomorphisms, division algorithm, and factorization techniques in polynomial rings.
4. Analyze: Analyze properties of ideals, factor rings, and homomorphism, and apply fundamental homomorphism theorem.
5. Evaluate: Evaluate properties of unique factorization domains, principal ideal domains, and Euclidean domains.
6. Create: Apply concepts of rings and fields to solve problems in algebra, including factorization and ideal structure, and investigate properties of Gaussian integers.

Course Contents

Unit 1 : Rings and Fields **(06 Hours)**

1.1 Ring, Subring, Fields.

1.2 Divisors of zero, Integral Domain, The Characteristics of a Ring.

1.3 The Field of Quotients of an Integral Domain.

Unit 2 : Rings of Polynomials & Factorization **(07 Hours)**

2.1 Polynomials in an determinate.

2.2 The Evaluation Homomorphisms.

2.3 Factorization of a Polynomial over a Field: The Division Algorithm in F[x]

2.4 Irreducible Polynomials, Uniqueness of Factorization in F[x].

Unit 3 : Ideals and Factor Rings **(07 Hours)**

3.1 Homomorphism, Properties of Homomorphism

3.2 Ideals, Factor Ring, Fundamental Homomorphism Theorem.

3.3 Maximal Ideal, Prime Ideal, Ideal Structure in F[x].

Unit 4 : Factorization **(10 Hours)**

4.1 Unique Factorization Domain, Principal Ideal Domain, Gauss Lemma, $D[x]$ is a UFD.

4.2 Euclidean Norm, Euclidean Domain, Euclidean Algorithm (Without Proof).

4.3 Gaussian Integers, Multiplicative Norm.

Recommended Book:

1. John B. Fraleigh, A First Course in Abstract Algebra, 7th Edition, Pearson.

   Unit 1: Section 18, 19, 21.

   Unit 2: Section 22 and 23.

   Unit 3: Section 26 and 27.

   Unit 4: Section 45, 46 and 47 (except theorem 47.10).

Reference Books:

1. Josheph A. Gallian, Contemporary Abstract Algebra, 7th Edition, Narosa Publishing House.
2. David S. Dummit and Richard M. Foote, Abstract Algebra, 3rd Edition, Jonh Wiley and Sons, Inc.
3. I.N. Herstein, Abstract Algebra, 3rd Edition, Prentice Hall of India.
4. P.B. Bhattacharya, S.K. Jain and S.R. Nagpal, Basic Abstract Algebra, 2nd Edition,Cambridge University Press.

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MTS -355-MJ : Partial Differential Equations

Course type:Major **No. of Credits: 02**

Course Outcomes: Students will able to

1. Remember: Recall definitions and concepts of ordinary and partial differential equations, including surfaces, curves, and Pfaffian differential forms.
2. Understand: Explain methods of solving simultaneous differential equations, linear equations of first order, and origin of partial differential equations.
3. Apply: Apply methods of solving partial differential equations, including separation of variables, to solve Laplace and wave equations.
4. Analyze: Analyze properties of linear partial differential equations with constant coefficients, and classify second − order partial differential equations.
5. Evaluate: Evaluate solutions of reducible and irreducible linear partial differential equations, and determine integral surfaces passing through given curves.
6. Create: Apply knowledge of partial differential equations to model and solve real − world problems, including physical and engineering applications.

Course Contents

Unit 1 : Introduction to Ordinary and Partial Differential Equations (07 Hours)

1.1 Surfaces and curves in three dimensions

1.2 Simultaneous differential equations of the first order and the first degree in three variable.

1.3 Methods of solution of $\frac{dx}{P} = \frac{dy}{Q} = \frac{dz}{R}$

1.4 Pfaffian differential forms and equations.

1.5 Solution of Pfaffian differential equations in three variables

Unit 2 : Partial Differential Equations (08 Hours)

2.1 Introduction to Partial Differential Equations

2.2 Origin of first order Partial Differential Equations

2.3 Linear equations of first order equations

2.4 Integral surfaces passing through given curve

Unit 3 : Second Order Partial Differential Equations (08 Hours)

3.1 The Origin of Second Order Partial Differential Equations.

3.2 Linear Partial Differential Equations with constant coefficients.

3.3 Methods of solving Linear Partial Differential Equations

3.3.1. Solution of reducible equations

3.3.2. Solution of irreducible equations with constant coefficients

Unit 4 : Classification of Partial Differential Equations (07 Hours)

4.1 Classification of second order partial differential equations, canonical forms

4.2 Solution of Laplace equations by separation variables methods

4.4 Solution of wave equation by separation variables method.

Recommended Books:

1. Ian Sneddon, Element of Partial Differential Equations, McGraw−Hill Book Company, McGraw−Hill Book Company.

   Unit−1: Chapter−1 : 1,2,3,5

   Unit−2: Chapter−2 :1,2,4,5

   Unit−3:Chapter−3: 1,4,5

2. J.N. Sharma, Kehar Singh, Partial Differential equations for Engineers and Scientists,second Edition, Narasa Publications.

   Unit − 4: Chapter No.3: 3.3, Chapter No.4: 4.3 ,Chapter No.5: 5.5

Reference Books:

1. T. Amaranath, An Elementary Course in Partial Differential Equations, Narosa Publishing,House 2nd Edition, 2003 (Reprint, 2006).

2. K. Sankara Rao, Introduction to Partial Differential Equations, Third Edition, PHI.

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MTS-356-MJP : Practical on Ring Theory and Partial Differential Equations

Course type:Practical **No. of Credits: 02**

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MTS-360- ME : A) Numerical Methods

Course type:Major Elective **No. of Credits: 02**

Course Outcomes: Students will able to

1. Remember: Recall numerical methods for root finding, interpolation, differentiation, integration, and solving ODEs, including formulas and algorithms.

2. Understand: Explain concepts of errors, convergence, and stability in numerical methods, and apply finite difference operators.

3. Apply: Apply numerical methods like bisection, Newton−Raphson, interpolation formulas, and Runge−Kutta methods to solve problems.

4. Analyze: Analyze accuracy and efficiency of numerical methods, and choose suitable methods for specific problems.

5. Evaluate: Evaluate numerical solutions of equations, derivatives, and integrals using methods like Simpson's rules and Taylor's series.

6. Create: Develop numerical solutions to real−world problems involving ODEs, interpolation, and optimization using Python or other tools.

Course Contents

Unit 1 : Foundations of Numerical Methods **(06 Hours)**

1.1 Mathematical Preliminaries for Numerical Methods

1.2 Errors and their computations

1.3 Bisection Method

1.4 Method of False Position

1.5 Iteration Method

1.6 Newton−Raphson Method

Unit 2 : Interpolation (08 Hours)

2.1 Finite Difference Operators and their relations (Forward Difference, Backward Difference and Shift Operator)

2.2 Differences of a polynomial

2.3 Newton's Forward Interpolation

2.4 Newton's Backward Interpolation

2.5 Lagrange's Interpolation

Unit 3 : Numerical Differentiation and Integration (08 Hours)

3.1 Numerical Differentiation (First and Second Derivative)

i) Using Newton's Forward Differences

ii) Using Newton's Backward Differences

3.2 Numerical Integration

i) Trapezoidal Rule

ii) Simpson's $\frac{1}{3}^{rd}$ Rule

iii) Simpson's $\frac{3}{8}^{th}$ Rule

Unit 4 : Numerical Solution of first order ordinary differential equations (08 Hours)

4.1 Taylor's Series Method

4.2 Picard's Method

4.3 Euler's Method

4.4 Modified Euler's Method

4.5 Runge−Kutta 2^{nd} order Method

4.6 Runge−Kutta 4^{th} order Method (Without derivation)

Recommended Book:

1. Introductory Methods of Numerical Analysis (Fourth Edition), S. S. Sastry, PHI Learning Private Limited, 2009.

   1) Section: 1.2, 1.3, 2.1, 2.2, 2.3, 2.4 (without Aitken's Δ^2-process.), 2.5 (without generalized Newton's method)

   2) Section: 3.3 (without central difference), 3.5, 3.6. 3.9.1

   3) Section: 5.1, 5.2 (without 5.2.1, 5.2.2), 5.4, 4.4.1, 5.4.2, 5.4.3

   4) Section: 7.1, 7.2, 7.3, 7.4 (without 7.4.1), 7.4.2, 7.5 (without derivation for the fourth order)

Reference Books:

1. K. E. Atkinson − Numerical Analysis (John Wiley)

2. R. L. Burden & J. D. Faires − Numerical Analysis

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MTS-360-ME : B) Computational Geometry

Course type:Major Elective **No. of Credits: 02**

Course Outcomes: Students will able to

1. Remember: Recall concepts of 2D and 3D transformations, projections, and curve representations, including matrices and homogeneous coordinates.
2. Understand: Explain transformations like rotation, scaling, and translation, and apply them to points, lines, and shapes.
3. Apply: Apply transformation techniques to perform solid body transformations, projections, and generate curves like circles and ellipses.
4. Analyze: Analyze properties of transformations, projections, and curves, including affine and perspective transformations.
5. Evaluate: Evaluate representations of curves and surfaces, including Bezier and B−spline curves, and determine suitable transformations.
6. Create: Create 2D and 3D models using transformations, projections, and curve representations, and visualize them using computer graphics.

Course Contents

Unit 1 : Two dimensional transformations **(08 Hours)**

1.1 Introduction.

1.2 Representation of points.

1.3 Transformations and matrices.

1.4 Transformation of points.

1.5 Transformation of straight lines.

1.6 Midpoint transformation.

1.7 Transformation of parallel lines.

1.8 Transformation of intersecting lines.

1.9 Transformation: rotations, reflections, scaling, shearing.

1.10 Combined transformations.

1.11 Transformation of a unit square.

1.12 Solid body transformations.

1.13 Transformation and homogeneous coordinates. Translation.

1.14 Reflection through arbitrary line

1.15 Rotation about an arbitrary point.

Unit 2 : Three dimensional transformations **(06 Hours)**

2.1 Introduction.

2.2 Three dimensional−Scaling, shearing, rotation, reflection, translation.

2.3 Rotation about − an axis parallel to coordinate axes, an arbitrary axis in space.

2.4 Reflection through−

i) coordinate planes,

ii) planes parallel to coordinate planes,

iii) arbitrary planes.

Unit 3 : Projections **(06 Hours)**

3.1 Introduction

3.2 Affine and perspective transformations.

3.3 Orthographic projections.

3.4 Axonometric projections.

3.5 Oblique projections.

3.6 Single point perspective transformations.

3.7 Vanishing point

Unit 4 : Plane Curves **(06 Hours)**

4.1 Introduction.

4.2 Curve representation.

4.3 Non−parametric curves.

4.4 Parametric curves.

4.5 Parametric representation of a circle and generation of circle.

4.6 Parametric representation of an ellipse and generation of ellipse.

4.7 Parametric representation of a parabola and generation of parabolic Segment.

4.8 Parametric representation of a hyperbola and generation of hyperbolic segment

Unit 5 : Space curves **(04 Hours)**

5.1 Bezier Curves −Introduction, definition, properties (without proof),

5.2 Curve fitting (up to $n = 3$), equation of the curve in matrix form (upto $n = 3$)

5.3 B−spline curves−introduction, definition, properties (without proof).

Recommended Books:

1. D. F. Rogers, J. A. Adams, Mathematical elements for Computer graphics, Mc Graw Hill Intnl Edition.

   Chapter 2: Sec. 2.1 to 2.20,

   Chapter 3: Sec. 3.1 to 3.10. Sec. 3.12 to 3.15,

   Chapter 4: Sec. 4.1, 4.2, 4.4, 4.5,

   Chapter 5: Sec. 5.1, 5.8.

Reference Books:

1. Computer Graphics with OpenGL, Donald Hearn, M. Pauline Baker, Warren Carithers,Pearson (4th Edition)
2. Schaum Series, Computer Graphics by Zhigang Xiang and Roy A. Plastock.

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MTS-361 MEP : A) Practical on Numerical Methods
Or
MTS-361 MEP : B) Practical on Computational Geometry

Course type:Practical **No. of Credits: 02**

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MTS-371-VSC : Data Science

Course type:VSC **No. of Credits: 02(P)**

Course Outcomes: Students will able to

1. Remember: Recall concepts of data science, Python programming, linear algebra, and data visualization, including data types, libraries, and plot types.
2. Understand: Explain data science workflow, Python basics, vector and matrix operations, and principles of data visualization.
3. Apply: Apply Python programming, linear algebra techniques, and data visualization tools to analyze and represent data.
4. Analyze: Analyze data using statistical methods, handle missing values, and interpret results of hypothesis testing and visualizations.

5. Evaluate: Evaluate data science models, visualizations, and results, and communicate insights effectively.
6. Create: Create data science projects using Python, incorporating data handling, statistical analysis, and visualization to solve real-world problems.

Course Contents

Unit I : Introduction to Data Science **(04 Hours)**

- Definition and scope of Data Science
- Data Science workflow
- Types of data and data sources
- Role of Mathematics, Statistics, and Linear Algebra in Data Science
- Applications of Data Science
- Preliminaries of Excel for Data Science

Unit II : Python Programming for Data Science **(07 Hours)**

- Python environment: Anaconda, Jupyter Notebook
- Python basics:
  - –Variables and data types
  - –Lists, tuples, sets, dictionaries
  - –Conditional statements and loops
- Functions and modules
- File handling (CSV, text files)
- Introduction to scientific libraries overview

Unit III : Linear Algebra for Data Science **(07 Hours)**

- Vectors and vector operations
- Matrices and matrix operations, Matrix transpose, inverse, rank
- Systems of linear equations and matrix representation
- Eigenvalues and eigenvectors
- Eigen−Decomposition
- Diagonalization, Singular Value Decomposition
- Data representation and system of equations
- Applications of Linear Algebra in data representation

Unit IV : Data Handling and Statistical Analysis **(07 Hours)**

- Data loading and pre-processing using Pandas
- Handling missing values and outliers
- Descriptive statistics: mean, median, variance, standard deviation
- Correlation and covariance
- Basic probability distributions (normal, binomial, Poisson)
- Introduction to hypothesis testing (t−test, chi−square)

Unit V : Data Visualization **(05 Hours)**

- Principles of data visualization
- Data visualization using Python:
  - –Matplotlib
  - –Seaborn (basic usage)
- Plot types: bar, line, histogram, box plot, scatter plot
- Interpretation of visual results
- Preparing a short data analysis report

Reference Books:

1. VanderPlas J., Python Data Science Handbook, O'Reilly.
2. McKinney W., Python for Data Analysis, O'Reilly.
3. Deisenroth et al., Mathematics for Machine Learning, Cambridge.
4. David C. Lay, Linear Algebra and Its Applications, Pearson.
5. Montgomery & Runger, Applied Statistics, Wiley.
6. Joel Grus, Data Science from Scratch, O'Reilly.
7. Gilbert Strang −Linear Algebra and Its Applications

Online Resources:

- https://youtu.be/EbU0pZZvmQc?si=SgfCXXk6oDZkSY-3
- https://youtu.be/ehwt18bt3h8?si=fBo5kOWYSEMJAzpW
- https://youtu.be/bPrmA1SEN2k?si=YLXCEs6YQuGfC7_v
- https://youtu.be/NrpG0AexIEs?si=5rnWF4Kz-lXrVPwv

Practical 1

Foundations of Data Science and Spreadsheet Practice

Part A: Basic concepts

1. Write the definition of Data Science. List at least five fields where Data Science is used.
2. Identify a real-life problem and explain how Data Science can help solve it.
3. Draw and label the complete Data Science lifecycle. Explain each stage using an example dataset.
4. Explain the types of data: structured, semi-structured, and unstructured.
5. Explain why statistics is important in data analysis.
6. Give three examples where linear algebra is used in Data Science.

Part B: Excel worksheet on employees

1. Create a worksheet containing details of 25 employees with the following columns: Employee Name, Department, Basic Salary, Bonus, and Total Salary (calculated using a formula).
    - Find the total salary payout of all employees using the SUM function.
    - Calculate the average salary using AVERAGE.
    - Identify the highest salary using MAX.
    - Identify the lowest salary using MIN.
    - Sort the data in ascending order based on Total Salary.
    - Sort the data in descending order based on Total Salary.
    - Apply a filter to display only those employees whose Total Salary is above Rs. 50,000.
    - Create a column chart showing Employee Name and Total Salary.
    - Create a pie chart showing salary distribution department−wise.

Part C: Excel worksheet on students

1. 1. Perform the following tasks in Excel for a dataset of 20 students and their marks:
    - Create the dataset.
    - Apply the formulas SUM, AVERAGE, MAX, and MIN.
    - Sort the data in ascending and descending order.
    - Apply a filter to show students scoring above 75.
    - Create a bar chart and a pie chart.

Practical 2

Python Fundamentals, File Handling, NumPy, and Pandas

Part A: Python fundamentals with student data

1. Create a dataset using a list of dictionaries for student records with the following fields: Name, Marks, Age, and Grade.
    - Print all student names.
    - Find the highest marks using a loop.

- Count the number of students scoring above 75.
- Write a function to calculate average marks.
- Assign grade using conditional statements.
- Store unique grades using a set.

Part B: CSV file handling and libraries

1. Create a CSV file named sales.csv (dataset may be prepared manually or taken from Kaggle) containing the columns: Product, Quantity, and Price.
   - Read the CSV file.
   - Display all records.
   - Calculate total sales for each product.
   - Find the product with the highest revenue.
   - Save the results to a new text file.
   - Use NumPy to compute the mean price and the standard deviation of quantity.
   - Use Pandas to load the dataset and display summary statistics.

Practical 3

Vector and Matrix Computations

1. Create the vectors: V1 = (3, -1, 2) and V2 = (1, 4, -2).
2. Compute the following:
   - Vector addition
   - Dot product
   - Magnitude of vectors
   - Angle between vectors
3. Create the matrix A shown below and perform the given operations:

$$A = \begin{bmatrix} 2 & 1 & 3 \\ 1 & 0 & 2 \\ 4 & 1 & 8 \end{bmatrix}$$

4. Find the following for matrix A:
   - Transpose
   - Determinant
   - Rank
   - Inverse (if it exists)
5. Verify whether the columns of matrix A are linearly independent.
6. Write the following system in the form $AX = B$ using NumPy:

$$\begin{aligned} x + y + z &= 6 \\ 2x + 3y + z &= 14 \\ x - y + 2z &= 2 \end{aligned}$$

Practical 4

Eigenvalues, Systems, and SVD

1. **Solve using matrix method**

$$\begin{aligned} 2x + y + z &= 7 \\ x + 3y + 2z &= 13 \\ 3x + y + 4z &= 17 \end{aligned}$$

Steps:

   1. Write the system as $AX = B$.
   2. Solve using inverse or Gaussian elimination.
   3. Verify the solution.

2. **For matrix B**

$$B = \begin{bmatrix} 5 & 2 \\ 2 & 2 \end{bmatrix}$$

   1. Find eigenvalues.
   2. Find eigenvectors.
   3. Verify the eigen equation.

3. **Compute SVD of matrix C using Python/NumPy**

$$C = \begin{bmatrix} 1 & 0 \\ 0 & 2 \\ 2 & 0 \end{bmatrix}$$

   1. Identify U, $\sum$ and V^T
   2. Explain the significance of the largest singular value.

Practical 5

Data Loading, Cleaning, and Preprocessing

1. Load a CSV dataset (from Kaggle) using Pandas.
2. Display the first 5 rows, last 5 rows, and dataset information.
3. Identify missing values.
4. Handle missing data using mean substitution, median substitution, and row removal.
5. Detect duplicate rows and remove them.
6. Identify outliers and remove or cap them.
7. Compare dataset statistics before and after cleaning.
8. Calculate mean, median, mode, variance, and standard deviation.
9. Compare the mean and median for each column.
10. Compute the correlation matrix.

11. Compute the covariance matrix.
12. Identify the strongest correlated variables.
13. Create a scatter plot for correlated variables.

Practical 6

Probability Distributions and Introduction to Hypothesis Testing

1. Generate random data for the Normal, Binomial, and Poisson distributions.
2. Plot each distribution and compare their shapes.
3. Perform the following tasks using Python (NumPy / SciPy / Matplotlib) for a Normal distribution with mean (μ) = 50 and standard deviation (σ) = 10:
   - Compute the Probability Density Function (PDF) at $x = 60$.
   - Compute the mean.
   - Compute the variance.
   - Plot the Normal distribution curve.
4. Consider a Binomial experiment with number of trials $n = 10$ and probability of success $p = 0.5$. Compute the following:
   - Probability Mass Function (PMF) for exactly 6 successes.
   - Mean.
   - Variance.
   - Plot the Binomial distribution graph.
5. Assume the average number of customer arrivals per hour is 4. Compute the following for a Poisson distribution:
   - Probability Mass Function (PMF) for exactly 3 arrivals.
   - Mean.
   - Variance.
   - Plot the Poisson distribution graph.

Practical 7

Hypothesis Testing

Question 1: One−Sample t−test

A juice company claims that the average volume of juice in its bottles is 500 ml. A quality analyst collects a sample of 16 bottles and finds the sample mean volume to be 492 ml with a sample standard deviation of 12 ml. Test whether the company's claim is true at the 5% significance level. Null Hypothesis: $H_0 : \mu = 500$ Alternative Hypothesis: $H_a : \mu \neq 500$

Question 2: Independent t−test

A researcher wants to compare the marks of students from Class A and Class B. A sample of 10 students from each class is taken.
Class A: mean = 72, standard deviation = 8
Class B: mean = 78, standard deviation = 6
Test whether there is a significant difference between the average marks of the two classes.
Null Hypothesis: $H_0 : \mu_1 = \mu_2$
Alternative Hypothesis: $H_1 : \mu_1 \neq \mu_2$

Question 3: Paired t−test

A teacher wants to know whether a special training program improves student performance. Scores of 10 students are recorded before and after training. Use a paired t−test to determine whether the program has a significant effect.

Student	1	2	3	4	5	6	7	8	9	10
Before	45	48	50	42	47	46	49	44	43	45
After	50	52	54	46	49	50	53	47	46	48

Question 4: Chi−Square test

A survey is conducted to study whether gender is associated with preferred mode of learning. Use a chi−square test to determine whether learning preference depends on gender.

Gender	**Online**	**Offline**
Male	35	15
Female	20	30

Null Hypothesis: There is no association between gender and learning mode. Alternative Hypothesis: There is an association between gender and learning mode.

Practical 8

Data Visualization

Q1

1. Load a dataset using Python.
2. Using Matplotlib, create a line plot, bar chart, and histogram.
3. Add title, axis labels, and legend.
4. Save the plots as image files.

Q2

1. Load a dataset using Python.

2. Generate a scatter plot, box plot, and distribution plot.
3. Identify outliers, correlation trends, and distribution shape.
4. Compare two numerical variables visually.
5. Write observations for each plot.

Practical 9

Case Study–Business Data Decision System

Dataset variables:

- Advertising cost
- Sales
- Profit

Tasks

1. Represent data as a matrix.
2. Check linear dependence between variables.
3. Solve a system of equations modelling profit prediction.
4. Compute the determinant to check invertibility.
5. Compute eigenvalues and eigenvectors.
6. Interpret eigenvectors as principal business patterns.
7. Use diagonalization to simplify matrix computations.
8. Determine the rank and explain data redundancy.

Practical 10

Case Study–Employee Salary Analysis

Dataset:

- Age
- Department
- Experience
- Education level
- Salary

Tasks

1. Selection of a real-world employee salary dataset.
2. Clean and preprocess the data.

3. Perform descriptive statistical analysis and visualize salary distribution.
4. Interpret insights such as salary differences across departments and experience levels.
5. Prepare a short report.

Practical 11

Case Study−Retail Sales Analysis

Dataset:

- Product category
- Unit price
- Quantity sold
- Total sales
- Region

Tasks

1. Selection of a real-world retail sales dataset.
2. Clean missing values, remove duplicates, and format variables properly.
3. Perform statistical analysis and visualize sales trends by category and region.
4. Interpret business insights such as best−selling products and high−revenue regions.
5. Write a short report based on the analysis.

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MTS-381-OJT: On Job Training

Course type:OJT **No. of Credits: 04(P)**

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