Kadi Sarva Vishwavidyalaya, Gandhinagar

25CAMD203 : Discrete Mathematics and Statistical Methods

Program:B.E. Computer Engineering / Computer Science and Engineering / Information Technology (Year - 2).

Teaching Scheme: 3L - 1T - 2P (5 Credits)

Prerequisite: Basic knowledge of mathematics requires as sets, relations, functions, algebraic manipulation and equations, Logic, graphs and logical reasoning, and statistics.

Rationale: This course provides a strong foundation in discrete mathematical structures and statistical methods, which are essential for various fields like computer science, engineering, and data analysis. Topics such as lattices, algebraic structures, and graph theory develop analytical and problem-solving skills, while statistics supports data interpretation and decision-making. The course prepares students for advanced study and real-world applications in modelling, optimization, and computation.

1. Course Objectives:

The Purpose of learning this course is

- To develop a strong foundation in **set theory, relations, and lattices** for analyzing ordered structures and discrete systems.
- To understand and analyze **algebraic structures such as semigroups, groups, rings, and fields** for mathematical modelling in engineering applications.
- To study and apply **graph theory concepts** including paths, cycles, and graph properties for solving network-related problems.
- To introduce **data handling and descriptive statistics** for organizing, analyzing, and interpreting real-world data.
- To understand **sampling, correlation, and regression techniques** for data analysis, prediction, and decision-making.

2. Teaching and Evaluation Scheme:

Teaching Scheme				Examination Scheme					
L	T	P	C	Hrs./ Week	IE	EE	CIA	Practical	Total Marks
3	1	2	5	6	40	60	30	20	150

IE: Internal Exam **EE:** External Exam (End Semester)

CIA: Continuous Internal Assessment **Practical:** Practical Exam (End Semester)

3. Detailed Syllabus

Unit	Topic	No. of Lectures	% Weight	Outcomes
1	**Lattices:** Basic Concepts of Set Theory: Definitions, Inclusion, Equality of Sets, Cartesian product, The Power Set, some operations on Sets, Relation, Partial Ordering Relation, Equivalence Relation Hasse, Diagrams, Lattices as POSET, properties of lattices, bounds of lattices, bounded lattice, distributive lattice, complemented lattices. Strengthens mathematical foundations and logical reasoning skills. Supports structured problem-solving used in computational systems and decision models.	05	11	CO1
2	**Algebraic Structures:** Algebraic Structures with one Binary Operation, Semi Groups, Monoids, Groups, Sub-group, Congruence Relation, Permutation Groups, cyclic groups, Normal Subgroups, Quotient group, homomorphisms Algebraic Structures with two Binary Operation: Rings, Integral Domain and Fields (definition and properties). Enhances abstract mathematical thinking and analytical skills. Provides a foundation for cryptography, coding theory, and computational applications.	10	22	CO2

3	**Graphs:** Introduction of Graph, Directed graph, Undirected graph with examples;, Loops (sling), Parallel edges, Multi-graph Pseudo graph, Simple graph, Weighted graphs, Isolated nodes, Null graph, Isomorphic graphs, Degree of nodes, examples; Subgraphs: Definition, examples; Path: Definition, Paths of a given graph, length of path, examples; Simple path (edge simple), elementary path (node simple), examples; Cycle (circuit), elementary cycle, examples; Eulerian and Hamiltonian Walks, Planar Graphs, Graph coloring: coloring maps, coloring Vertices, Colorings Edges. Supports network design, optimization, and communication systems. Helps in transportation planning, traffic systems, and smart city infrastructure.	08	18	CO3
4	**Data Handling & Descriptive Statistics**: Types of data (categorical, numerical); data presentation (tables, histograms – conceptual); measures of central tendency (mean, median, mode); measures of dispersion (range, variance, standard deviation); interpretation of results (focus on intuition, not just formulas). Develops statistical literacy and analytical thinking Supports data-driven decision-making in professional and business environments.	08	18	CO4
5	**Sampling & Estimation**: Sampling methods (random, stratified – concept only); population vs sample; estimation (point estimation only); introduction to sampling error (conceptual understanding. Improves decision-making using accurate data sampling methods. Supports research and innovation through reliable statistical estimation.	08	18	CO5
6	**Correlation & Regression**: Correlation, Types of Correlations, Methods of Studying Correlation,Scatter Diagram,Simple Graph, Karl Pearson's Coefficient of Correlation, Rank Correlation, Regression, Types of Regression, Lines of Regression, Regression Coefficients. Helps in business forecasting and decision-making using data analysis. Supports predictive modeling and analytical problem-solving in industry.	06	13	CO5

4. List of Tutorials:

No	Details	Hours	CO
1	Problem solving on Set Theory, Relations, and Lattices	3	CO1
2	Problem solving on Algebraic Structures	4	CO2
3	Problem solving on Graph Theory	3	CO3
4	Problem solving on Data Handling and Descriptive Statistics	3	CO4
5	Problem solving on Sampling, Correlation, and Regression	3	CO5

5. List of Experiments:

Module # / Practical #	Particular	Hrs	CO
Module 1: Sets, Relations, and Lattices			**CO1**
Practical 1	Set Operations Implementation: Perform union, intersection, difference, symmetric difference, Cartesian product, and power set using Python.	2	
Practical 2	Relations and Their Properties: Given a relation, check properties: reflexive, symmetric, transitive, and equivalence relation.	2	
Practical 3	Partial Order and Hasse Diagram: Represent a partially ordered set (POSET) and generate a simple Hasse diagram using Python.	2	

Module 2: Algebraic Structures			**CO2**
Practical 4	Binary Operation Checker: Define a binary operation and verify closure, associativity (limited cases), and identity element.	2	
Practical 5	Group Property Verification: Check group properties including inverse and identity for a given set and operation.	2	
Practical 6	Subgroup and Cyclic Group: Identify subgroups and generate cyclic groups from a given group.	2	
Practical 7	Homomorphism Checker: Verify whether a given mapping between algebraic structures is a homomorphism.	2	
Module 3: Graphs			**CO3**
Practical 8	Graph Representation: Represent directed and undirected graphs using adjacency matrix and adjacency list.	2	
Practical 9	Degree of Nodes: Compute degree of each vertex in a graph and analyze graph properties (Hand-Shaking Lemma).	2	
Practical 10	Graph Properties: Detect cycles and check Eulerian/ Hamiltonian graph conditions for a given graph.	2	
Module 4: Data Handling & Descriptive Statistics			**CO4**
Practical 11	Descriptive Statistics: Compute mean, median, mode, variance, and standard deviation for a dataset.	2	
Practical 12	Data Visualization: Create frequency tables and histograms using Python and interpret results.	2	
Module 5: Sampling & Estimation			**CO5**
Practical 13	Sampling Techniques: Perform random sampling and compare sample statistics with population statistics.	2	
Module 6: Correlation & Regression			**CO5**
Practical 14	Correlation Analysis: Implement Karl Pearson's coefficient and rank correlation to study relationships between variables.	2	
Practical 15	Linear Regression: Perform simple linear regression and plot regression line for prediction.	2	

6. Course Outcomes (COs)

CO No.	Course Outcome	RBT Level
CO1	Apply fundamental concepts of set theory, relations, and lattices to analyze ordered structures and solve related problems.	Apply
CO2	Analyze algebraic structures such as groups, rings, and fields and interpret their properties in mathematical systems.	Analyze
CO3	Apply graph theory concepts to model and solve real-world problems involving networks and connectivity.	Apply
CO4	Analyze and interpret data using descriptive statistics and sampling techniques for informed decision-making.	Analyze
CO5	Apply correlation and regression techniques to study relationships between variables and perform predictive analysis for informed decision-making, industrial innovation, and sustainable economic development.	Apply

7. Mapping of COs with POs & PSOs:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	1	1	1	-	-	-	-	-	1	3	2
CO2	3	3	1	2	1	-	-	-	-	-	1	3	2
CO3	3	3	2	2	2	-	-	1	-	-	1	2	3
CO4	2	3	1	3	2	1	-	-	1	-	1	3	3
CO5	2	3	2	3	2	1	-	-	1	-	1	3	3
Avg.	2.6	2.8	1.4	2.2	1.6	0.4	0	0.2	0.4	0	1	2.8	2.6

8. Reference Reading:

8.1 Text Books

1. Kenneth H. Rosen, Discrete Mathematics and Its Applications, McGraw-Hill Education, Latest Edition.
2. J. P. Tremblay and R. Manohar, Discrete Mathematical Structures with Applications to Computer Science, McGraw-Hill Education.

8.2 Reference Books

3. C. L. Liu and D. P. Mohapatra, Elements of Discrete Mathematics, McGraw-Hill Education.
4. Narsingh Deo, Graph Theory with Applications to Engineering and Computer Science, Prentice Hall.
5. J. D. Ullman, Principles of Database and Knowledge-Based Systems, Computer Science Press.

8.3 Online References

6. NPTEL – Discrete Mathematics / Graph Theory (IIT Lectures)
7. MIT OpenCourseware – Mathematics for Computer Science.
8. Khan Academy – Statistics and Probability

9. Course Outcomes Mapping Table

CO	Course Outcome (CO)	POs/PSOs Map
CO1	Apply fundamental concepts of set theory, relations, and lattices to analyze ordered structures and solve problems.	PO1, PO2, PO3, PO4, PO5, PO11, PSO1, PSO2
CO2	Analyze algebraic structures such as groups, rings, and fields and interpret their properties.	PO1, PO2, PO3, PO4, PO5, PO11, PSO1, PSO2
CO3	Apply graph theory concepts to solve engineering-related network problems.	PO1, PO2, PO3, PO4, PO5, PO8, PO11, PSO1, PSO2
CO4	Analyze and interpret data using statistical methods and sampling techniques.	PO1, PO2, PO3, PO4, PO5, PO6, PO9, PO11, PSO1, PSO2
CO5	Apply correlation and regression techniques to study relationships between variables and perform predictive analysis for informed decision-making, industrial innovation, and sustainable economic development.	PO1, PO2, PO3, PO4, PO5, PO6, PO9, PO11, PSO1, PSO2

10. Evaluation Scheme:

- The course evaluation shall comprise Internal Examination (IE) and End Semester Examination (EE) for theory, along with Continuous Internal Assessment (CIA) and External Practical Examination.
- The Internal Examination (40 marks) will be conducted through one or more mid-semester tests covering the prescribed syllabus.
- The End Semester Examination (60 marks) will assess the overall understanding of the course with emphasis on problem-solving and analytical ability.
- The Practical Examination (20 marks) shall be conducted externally and will include implementation, performance, and viva-voce.
- Students are required to secure minimum qualifying marks in each component separately as per university rules.

11. Pedagogical Framework:

- The course adopts a **blended teaching approach** combining lectures, tutorials, and problem-solving sessions focused on mathematical concepts.
- Emphasis is placed on **conceptual clarity** through definitions, theorems, and illustrative examples from set theory, algebraic structures, and graph theory.
- Practical understanding is developed by applying concepts of **graphs, lattices, and algebraic structures** to engineering and computational problems.
- Statistical topics are taught using **real-life data interpretation**, focusing on understanding rather than rote computation.
- Continuous assessment through **assignments, tutorials, and internal evaluations** ensures progressive learning and analytical skill development.

12. Innovative Practices:

- Real-world applications of **graphs, relations, and algebraic structures** are incorporated to connect theory with engineering problems.
- Students engage in **analytical problem-solving exercises** involving lattices, group structures, and graph models.
- **Statistical analysis using real datasets** is introduced to demonstrate concepts like correlation and regression.
- Interactive tutorial sessions encourage students to **derive results, verify properties, and explore mathematical structures independently**.
- Use of **basic computational tools and visualization techniques** (where appropriate) to enhance understanding of graphs, relations, and statistical behaviour.

13. Self-Learning Component:

- Students are encouraged to engage in self-paced learning through online learning platforms (NPTEL/SWAYAM), tutorials, and technical resources to strengthen their understanding of discrete mathematics, graph theory,algebraicstructures,and statistics**(e.g. https://nptel.ac.in/courses/106106183and https://nptel.ac.in/courses/111106102)**.
- Regular practice of logical reasoning problems, theorem-based exercises, and numerical problems beyond the syllabus helps in improving analytical ability and mathematical thinking.
- Utilizing online mathematical tools and digital platforms, such as graph visualization software, truth table generators, and statistical calculators, helps students experiment and verify concepts independently (i.e. GeoGebra, Wolfram Alpha, Desmos, Symbolab etc.).
- Students can strengthen their learning by solving real-world engineering problems involving graphs, logical models, and statistical data interpretation.

Sustainable Development Goals (SDG) Integration

This course integrates principles of sustainable engineering by emphasizing efficient mechanism design, reduced material consumption, and applications in sustainable infrastructure and transportation systems aligned with SDG 4 (Quality Education), SDG 8 (Decent Work and Economic Growth), SDG 9 (Industry, Innovation and Infrastructure), and SDG 11 (Sustainable Cities and Communities).

CO	Course Outcome (CO)	Mapped SDGs	Justification
CO1	Apply fundamental concepts of set theory, relations, and lattices to analyze ordered structures and solve related problems.	SDG 4 – Quality Education SDG 9 – Industry, Innovation and Infrastructure	Strengthens mathematical reasoning and logical problem-solving skills required for computational systems and technological innovation.
CO2	Analyze algebraic structures such as groups, rings, and fields and interpret their properties in mathematical systems.	SDG 4 – Quality Education SDG 9 – Industry, Innovation and Infrastructure	Supports abstract thinking and provides the mathematical foundation for applications such as cryptography, coding theory, and computing systems.
CO3	Apply graph theory concepts to model and solve real-world problems involving networks and connectivity.	SDG 9 – Industry, Innovation and Infrastructure SDG 11 – Sustainable Cities and Communities	Helps in network optimization, communication systems, transport planning, and smart infrastructure development.
CO4	Analyze and interpret data using descriptive statistics and sampling techniques for informed decision-making.	SDG 4 – Quality Education SDG 8 – Decent Work and Economic Growth	Enhances data literacy and supports informed decisions in business, research, and professional environments.
CO5	Apply correlation and regression techniques to study relationships between variables and perform predictive analysis for informed decision-making, industrial innovation, and sustainable economic development.	SDG 8 – Decent Work and Economic Growth SDG 9 – Industry, Innovation and Infrastructure	Supports forecasting, business analytics, industrial decision-making, and predictive modeling for sustainable development.