# Lovely Professional University, Punjab

| Course Code | Course Title | Lectures | Tutorials | Practicals | Credits | |
|---|---|---|---|---|---|---|
| MTH401 | DISCRETE MATHEMATICS | 3 | 0 | 0 | 3 | |
| **Course Weightage** | ATT: 5 CA: 25 MTT: 20 ETT: 50 | | | | | |

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| **Course Focus** | EMPLOYABILITY |

**Course Outcomes** :Through this course students should be able to

CO1 :: understand several methods for proving or disproving particular logical propositions.

CO2 :: describe the recursive processes that can be used for solving counting problems.

CO3 :: apply the equivalence and partial order relation properties on graph.

CO4 :: interpret various graph theoretic concepts and familiarize with their applications.

CO5 :: learn about the chromatic number of a graph and the properties of tree graphs.

CO6 :: compute the solution of linear congruences using the Euclidean algorithm.

| | **TextBooks ( T )** | | |
|---|---|---|---|
| **Sr No** | **Title** | **Author** | **Publisher Name** |
| T-1 | DISCRETE MATHEMATICS AND ITS APPLICATIONS | KENNETH H ROSEN | MCGRAW HILL EDUCATION |

| | **Reference Books ( R )** | | |
|---|---|---|---|
| **Sr No** | **Title** | **Author** | **Publisher Name** |
| R-1 | HIGHER ENGINEERING MATHEMATICS | B. V. RAMANA | MC GRAW HILL |

| **Other Reading ( OR )** | |
|---|---|
| **Sr No** | **Journals articles as Compulsary reading (specific articles, complete reference)** |
| OR-1 | https://home.iitk.ac.in/~arlal/book/mth202.pdf , |
| OR-2 | https://users.encs.concordia.ca/~doedel/courses/comp-232/slides.pdf , |

| **Relevant Websites ( RW )** | | |
|---|---|---|
| **Sr No** | **(Web address) (only if relevant to the course)** | **Salient Features** |
| RW-1 | https://www.khanacademy.org/computing/computerscience/cryptography/modarithmetic/a/equivalence-relations | It explain the concept of number theory |

| | | |
|---|---|---|
| RW-2 | http://www.cse.ust.hk/~dekai/271/notes/L10/L10.pdf | Explain Dijkstra's algorithm. |
| RW-3 | https://nptel.ac.in/courses/106106094/ | The course comprises some counting and proof techniques for computer science students. |
| RW-4 | https://nptel.ac.in/courses/106106183/ | The course is an introduction to discrete mathematics, which comprises some essentials for computer science students. |

| **Audio Visual Aids ( AV )** | | |
|---|---|---|
| **Sr No** | **(AV aids) (only if relevant to the course)** | **Salient Features** |
| AV-1 | https://www.mathsisfun.com/games/towerofhanoi.html | Explain the visuals of tower of Hanoi game. |

| **LTP week distribution: (LTP Weeks)** | |
|---|---|
| **Weeks before MTE** | 7 |
| **Weeks After MTE** | 7 |
| **Spill Over (Lecture)** | 7 |

## Detailed Plan For Lectures

| **Week Number** | **Lecture Number** | **Broad Topic(Sub Topic)** | **Chapters/Sections of Text/reference books** | **Other Readings, Relevant Websites, Audio Visual Aids, software and Virtual Labs** | **Lecture Description** | **Learning Outcomes** | **Pedagogical Tool Demonstration/ Case Study / Images / animation / ppt etc. Planned** | **Live Examples** |
|---|---|---|---|---|---|---|---|---|
| Week 1 | Lecture 1 | Logic and Proofs (Propositional logic) | T-1 | RW-3 | Zero lecture and propositional logic (conjunction, disjunction and negation of propositions, conditional and bi-conditional statements) | Students will be familiar with the course content through the zero lecture PPT and get an understanding of logical statements | Discussion | The truth table of a conditional statement: if Riya learns Discrete Mathematics then she will find a good job. |
| | Lecture 2 | Logic and Proofs (propositional equivalences) | T-1 | RW-3 | Propositional equivalences (tautology, contradiction, contingency and logical equivalences), their truth tables, De-Morgan's law | Student will be able to express the truth table of propositional equivalences | Brainstorming problems using white board | |

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|---|---|---|---|---|---|---|---|---|
| Week 1 | Lecture 3 | Logic and Proofs (quantifiers) | T-1 | | Quantifiers: universal and existential quantifiers with restricted domain, precedence of quantifiers, negating quantified expressions | Students will be able to understand the different types of quantifiers | Discussion | |
| Week 2 | Lecture 4 | Logic and Proofs (Introduction to proof, direct proof,proof by contraposition) | T-1 | | Introduction to proof, direct proof, proof by contraposition | Students will be able to learn different types of proof techniques | Brainstorming problems using white board | |
| | Lecture 5 | Logic and Proofs(vacuous and trivial proof, proof strategy, proof by contradiction) | T-1 | | Vacuous and trivial proof, proof strategy, proof by contradiction | Students will be able to learn different types of proof techniques | Brainstorming problems using white board | |
| | Lecture 6 | Logic and Proofs(proof of equivalence and counterexamples, mistakes in proof) | T-1 | | Proof of equivalence and counterexamples, mistakes in proofs | Students will be able to learn different types of proof techniques and identify the mistakes in the proofs | Brainstorming problems using white board | |
| Week 3 | Lecture 7 | Recurrence relations (recurrence relation) | T-1<br>R-1 | AV-1 | Introduction to recurrence relation, modelling with recurrence relations | Students will be able to understand the concept of recurrence relation and formation | Brainstorming problems using white board | Solution of Tower of Hanoi game can be obtained by first order linear recurrence relation [A(k +1) - 2A(k)=1, under A(0)=0]. For more details please visit https://www.mathsisfun.com/games/towerofhanoi.html |

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|---|---|---|---|---|---|---|---|---|
| Week 3 | Lecture 7 | Recurrence relations (modelling with recurrence relations) | T-1<br>R-1 | AV-1 | Introduction to recurrence relation, modelling with recurrence relations | Students will be able to understand the concept of recurrence relation and formation | Brainstorming problems with white board | Solution of Tower of Hanoi game can be obtained by first order linear recurrence relation [A(k +1) - 2A(k)=1, under A(0)=0]. For more details please visit https://www.mathsisfun.com/games/towerofhanoi.html |
| | Lecture 8 | | | | Test 1 | | | |
| | Lecture 9 | Recurrence relations (homogeneous linear recurrence relations with constant coefficients) | T-1<br>R-1 | | Homogeneous linear recurrence relations with constant coefficients | Students will be able to understand the different cases for solutions of homogeneous linear recurrence relations with constant coefficients | Lecture delivery using white board | |
| Week 4 | Lecture 10 | Recurrence relations (Method of inverse operator to solve the non-homogeneous recurrence relation with constant coefficient) | T-1<br>R-1 | | Method of inverse operator to solve the non-homogeneous recurrence relation with constant coefficients | Students will be able to find the solution of non-homogeneous recurrence relation with constant coefficients via inverse operator method | Brainstorming problems using white board | |
| | Lecture 11 | Recurrence relations (generating functions, solution of recurrence relation using generating functions) | T-1 | | Lecture 11: Introduction to generating functions, Lecture 12 : solution of recurrence relation using generating functions | Students will explore the generating functions to solve the recurrence relations | Brainstorming problems using white board | |
| | Lecture 12 | Recurrence relations (generating functions, solution of recurrence relation using generating functions) | T-1 | | Lecture 11: Introduction to generating functions, Lecture 12 : solution of recurrence relation using generating functions | Students will explore the generating functions to solve the recurrence relations | Brainstorming problems using white board | |

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|---|---|---|---|---|---|---|---|---|
| Week 5 | Lecture 13 | Counting principles and relations(principle of Inclusion-Exclusion) | T-1 | | Principle of Inclusion-Exclusion, an alternative form of Inclusion - Exclusion, computation of the number of onto functions | Students will be able to learn the principle of Inclusion-Exclusion for more than two sets | Brainstorming problems using white board | |
| | Lecture 14 | Counting principles and relations(Pigeonhole, generalized pigeonhole principle) | T-1 | | Pigeonhole principle and generalized pigeonhole principle | Students will be able to solve the problems based on pigeonhole principle and generalized pigeonhole principle | Lecture delivery using white board | |
| | Lecture 15 | Counting principles and relations(relations and their properties, combining relation) | T-1 | | Relations and their properties, combining relations | Students will be able to understand relations, their properties and types | Lecture delivery using white board | |
| Week 6 | Lecture 16 | Counting principles and relations(composition, representing relation using matrices and graph) | T-1 | | Composition of relations, representing relation using matrices and graphs | Students will be able to find the composition of relations and represent them in the form of matrices and graphs | Lecture delivery using white board | |
| | Lecture 17 | | | | Test 2 | | | |
| | Lecture 18 | Counting principles and relations(equivalence relations, partial and total ordering relations) | T-1 | | Equivalence relations, partial and total ordering relations | Students will be able to understand the relations, their properties and types | Discussion | The relation (height of a student is greater than another one) on a set of students of the class is not reflexive, symmetric, equivalence |
| Week 7 | Lecture 19 | Counting principles and relations(lattice, sub lattice, Hasse diagram and its components) | T-1 | | Hasse diagram and its components (maximal, minimal, greatest, least elements, upper, lower bounds, supremum and infimum), lattice | Student will be able to understand the graphical rendering of a partially ordered set displayed via the cover relation and also able to identify its different components | Brainstorming problems using white board | |
| | | **SPILL OVER** | | | | | | |
| Week 7 | Lecture 20 | | | | Spill Over | | | |
| | Lecture 21 | | | | Spill Over | | | |

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|---|---|---|---|---|---|---|---|---|
| | | **MID-TERM** | | | | | | |
| Week 8 | Lecture 22 | Graphs theory I(graph terminologies) | T-1 | OR-2<br>RW-4 | Undirected graph (simple, multi and pseudo-graphs), directed graph, basic terminology (loop, adjacent, isolated and<br>pendant vertex, incident edge, degree) | Students will be able to understand graph terminologies and visualise<br>special types of graphs | Discussion using white board | |
| | Lecture 23 | Graphs theory I(special types of graphs(complete, cycle, regular, wheel, cube, bipartite and complete bipartite)) | T-1 | OR-2<br>RW-4 | Special types of graphs (complete, cycle, regular, wheel, cube, bipartite and complete bipartite) | Students will analyze different types of graphs and also able to classify the number of vertices, edges, degree sequence for each type | Discussion using white board | |
| | Lecture 24 | Graphs theory I(representing graphs, adjacency and incidence matrix) | T-1 | OR-2<br>RW-4 | Sub graph, union, intersection and complement of graph, adjacency and incidence matrices of graphs | Students will be able to explore the representation of graphs | Discussion using white board | |
| Week 9 | Lecture 25 | Graphs theory I(graph-isomorphism) | T-1 | OR-1<br>OR-2<br>RW-4 | Graph isomorphism | Student will be able to describe whether two graphs are isomorphic | Discussion using white board | |
| | Lecture 26 | Graphs theory I(path and connectivity for undirected and digraphs) | | OR-2<br>RW-4 | Graph connectivity (Path, circuit, Euler path and circuit, connected graph and component, cut edge and vertices, strongly and weakly connectivity of directed graph, Path isomorphism) | Students will be able to visualise the transportation network through the graph connectivity | Discussion with white board | |
| | Lecture 27 | Graphs theory I(Dijkstra’s algorithm for shortest path problem) | T-1 | RW-2 | Shortest path by Dijkastra's algorithm | Students will be able to calculate the shortest path between two vertices of the graph | Problem solving with white board | Least fare between two city |

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|---|---|---|---|---|---|---|---|---|
| Week 10 | Lecture 28 | Graphs theory II(planner graphs) | T-1 | RW-4 | Planner graphs, Euler's formula for planner graph | Students will be able to draw the planner representation of a graph and also able know that whether the planner representation is possible | Lecture delivery | The architecture of petrol pump, fire cracker factory should be designed in such a way that there should not be any edge crossing |
| | | Graphs theory II(Euler formula) | T-1 | RW-4 | Planner graphs, Euler's formula for planner graph | Students will be able to draw the planner representation of a graph and also able know that whether the planner representation is possible | Lecture delivery | The architecture of petrol pump, fire cracker factory should be designed in such a way that there should not be any edge crossing |
| | Lecture 29 | Graphs theory II(colouring of a graph and chromatic number) | T-1 | OR-2 | Graph colouring, Chromatic number, Chromatic number of special graphs(complete, cycle, regular, wheel, cube, bipartite and complete bipartite) the four colour theorem | Students will be able to calculate the chromatic number of different types of graph | White board teaching with discussion | |
| | Lecture 30 | Graphs theory II(tree graph and its properties) | T-1 | OR-2 | Tree graph and its properties | Student will be able to determine whether the give graph is a tree | White board teaching with discussion | |
| Week 11 | Lecture 31 | Graphs theory II(rooted tree) | T-1 | | Introduction of rooted tree and its properties, m-ary and full m-ary tree | Students will be able to get the idea of rooted tree and its results | White board teaching with discussion | |
| | Lecture 32 | Graphs theory II(spanning and minimum spanning tree) | T-1 | | Spanning tree and its properties, minimum spanning tree- Prims and Kruskal algorithm | Students will be able to find the minimum spanning tree from the weighted graph | Lecture delivery with white board | |
| | Lecture 33 | Graphs theory II(decision tree, infix, prefix, and postfix notation) | T-1 | | Infix, prefix, and post-fix notation | Students will be able to calculate the value by the the pre, in and post fix expression | Lecture delivery with white board | |
| Week 12 | Lecture 34 | | | | Test 3 | | | |

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|---|---|---|---|---|---|---|---|---|
| Week 12 | Lecture 35 | Number theory and its application in cryptography (divisibility and modular arithmetic) | T-1 | OR-1<br>RW-1 | Divisibility definition, properties, the division algorithm, Modular arithmetic | Students will learn the concept of division algorithm and modular arithmetic | Lecture delivery with white board | |
| | Lecture 36 | Number theory and its application in cryptography (primes, greatest common divisors and least common multiples) | T-1 | OR-1<br>RW-1 | Primes, fundamental theorem of arithmetic, greatest common divisor, least common multiple and Euclidean algorithm | Student will be familiar with the primes , least common multiple and greatest common divisor and also able to find the the G.C.D. using Euclidean algorithm . | Lecture delivery with white board | |
| | | Number theory and its application in cryptography (Euclidean algorithm) | T-1 | OR-1<br>RW-1 | Primes, fundamental theorem of arithmetic, greatest common divisor, least common multiple and Euclidean algorithm | Student will be familiar with the primes , least common multiple and greatest common divisor and also able to find the the G.C.D. using Euclidean algorithm . | Lecture delivery with white board | |
| Week 13 | Lecture 37 | Number theory and its application in cryptography (Bezout's lemma) | T-1 | OR-1<br>RW-1 | Bezout's theorem of G.C.D. (G.C.D. of positive integers as linear combination) | Students will be able to find the Bezout's coefficients of positive integers using Euclidean algorithm | Lecture delivery with white board | |
| | Lecture 38 | Number theory and its application in cryptography (linear congruence, inverse of (a modulo m)) | T-1 | OR-1<br>RW-1 | Inverse of (a modulo m), solutions of linear congruence's and properties | Students will be able to find the inverse using Bezout's theorem and use it to solve linear congruence's | Lecture delivery with white board | |
| | Lecture 39 | Number theory and its application in cryptography (encryption and decryption by Ceasar cipher and affine transformation) | T-1 | OR-1<br>RW-1 | Encryption and decryption by Ceasar cipher and affine transformation | Students will be able encode and decode the messages by Ceasar cipher and affine transformation | Problem solving | Encrypt the messages by changing each letter to a different letter |

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|---|---|---|---|---|---|---|---|---|
| Week 14 | Lecture 40 | Number theory and its application in cryptography (Chinese remainder theorem) | T-1 | OR-1 | System of linear congruences and solutions by Chinese remainder theorem, Fermat's little theorem | Students will be able to find the solutions of system of linear concordances using Chinese remainder theorem and also understand the Fermat's little theorem | Lecture delivery with white board | |
| | | Number theory and its application in cryptography (Fermat's little theorem) | T-1 | OR-1 | System of linear congruences and solutions by Chinese remainder theorem, Fermat's little theorem | Students will be able to find the solutions of system of linear concordances using Chinese remainder theorem and also understand the Fermat's little theorem | Lecture delivery with white board | |
| | | **SPILL OVER** | | | | | | |
| Week 14 | Lecture 41 | | | | Spill Over | | | |
| | Lecture 42 | | | | Spill Over | | | |
| Week 15 | Lecture 43 | | | | Spill Over | | | |
| | Lecture 44 | | | | Spill Over | | | |
| | Lecture 45 | | | | Spill Over | | | |

## Scheme for CA:

CA Category of this Course Code is:A0203 (2 best out of 3)

| Component | Weightage (%) | Mapped CO(s) |
|---|---|---|
| Test 1 | 50 | CO1 |
| Test 2 | 50 | CO2 |
| Test 3 | 50 | CO1, CO2, CO4, CO5 |

## Details of Academic Task(s)

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| Academic Task | Objective | Detail of Academic Task | Nature of Academic Task (group/individuals) | Academic Task Mode | Marks | Allottment / submission Week |
|---|---|---|---|---|---|---|
| Test 1 | To test the understanding of logic, proofs and mistakes in proof. | Propositional logic, propositional equivalences, quantifiers, Introduction to proof, direct proof, proof by contraposition, vacuous and trivial proof, proof strategy, proof by contradiction, proof of equivalence and counterexamples, mistakes in proof. | Individual | Offline | 30 | 2 / 3 |
| Test 2 | To test the understanding of recursive processes and solution of recurrence relation. | Recurrence relation, modelling with recurrence relations, homogeneous linear recurrence relations with constant coefficients, Method of inverse operator to solve the nonhomogeneous recurrence relation with constant coefficient, generating functions, solution of recurrence relation using generating functions. | Individual | Offline | 30 | 5 / 6 |
| Test 3 | To check the understanding of concepts of graph theory and graph representation. | graph terminologies, special types of graphs (complete, cycle, regular, wheel, cube, bipartite and complete bipartite), representing graphs, adjacency and incidence matrix, graph-isomorphism, path and connectivity for undirected and digraphs, Dijkstra's algorithm for shortest path problem, planner graphs, Euler formula, colouring of a graph and chromatic number, tree graph and its properties, rooted tree, spanning and minimum spanning tree, decision tree, infix, prefix, and postfix notation. | Individual | Offline | 30 | 11 / 12 |

## MOOCs/ Certification etc. mapped with the Academic Task(s)

| Academic Task | Name Of Certification/Online Course/Test/Competition mapped | Type | Offered By Organisation |
|---|---|---|---|
| Test 1 | DISCRETE MATHEMATICS | MOOCs | NPTEL |
| Test 2 | DISCRETE MATHEMATICS | MOOCs | NPTEL |
| Test 3 | DISCRETE MATHEMATICS | MOOCs | NPTEL |

Where MOOCs/ Certification etc. are mapped with Academic Tasks:
1. Students have choice to appear for Academic Task or MOOCs etc.
2. The student may appear for both, In this case best obtained marks will be considered.

## MOOCs/ Certification etc. not-mapped with the Academic Task(s) (Available for students for better learning/ will get students ready for )

| Name Of Certification/Online Course/Test/Competition mapped | Type | Offered By Organisation |
|---|---|---|
| GATE | Test/Examination | IIT KANPUR |