

MATHEMATICAL FOUNDATIONS OF COMPUTER SCIENCE

Subject Code: CS303ES

Regulations : R16 - JNTUH

Class : II Year B.Tech CSE I Semester



Department of Computer Science and Engineering
BHARAT INSTITUTE OF ENGINEERING AND TECHNOLOGY

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MATHEMATICAL FOUNDATIONS OF COMPUTER SCIENCE (CS303ES) COURSE PLANNER

I. COURSE OVERVIEW:

This course will discuss fundamental concepts and tools in discrete mathematics with emphasis on their applications to computer science. Topics include logic and Boolean circuits, sets, functions, relations, deterministic algorithms and randomized algorithms, analysis techniques based on counting methods and recurrence relations, trees and graphs.

II. PRE REQUISITE:

1. Familiarity of concepts of statements logic and truth tables
2. Familiarity of concepts of sets, functions and relations
3. Counting principles, permutations and combinations
4. Basic concepts of graphs and trees

III .COURSE OBJECTIVE:

1	To introduce the concepts of mathematical logic
2	To introduce the concepts of sets, relations, and functions.
3	To perform the operations associated with sets, functions, and relations.
4	To introduce generating functions and recurrence relations.
5	To relate practical examples to the appropriate set, function, or relation model, and interpret the associated operations and terminology in context. To use Graph Theory for solving problems

IV. COURSE OUTCOME:

S.NO	Description	Bloom's taxonomy level
1	Ability to apply mathematical logic to solve problems	Knowledge, Understand(Level1, Level2)
2	Understand sets, relations, functions and discrete structures	Apply, Create (Level 3, Level 6)
3	Able to use logical notations to define and reason about fundamental mathematical concepts such as sets relations and functions	Evaluate (Level 3)
4	Able to formulate problems and solve recurrence relations	
5	Able to model and solve real world problems using graphs and trees	Analyze (Level 4)

V. HOW PROGRAM OUTCOMES ARE ASSESSED:

Program Outcomes (PO)		Level	Proficiency assessed by
PO1	Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	Assignments, Tutorials, Mock Tests
PO2	Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	3	Assignments, Tutorials, Mock Tests
PO3	Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.	3	Assignments, Tutorials, Mock Tests
PO4	Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	-	
PO5	Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.	-	
PO6	The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.	3	Assignments, Tutorials, Mock Tests --
PO7	Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.	2	Assignments, Tutorials,
PO8	Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.	1	Assignments
PO9	Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	-	--
PO10	Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	-	--

Program Outcomes (PO)		Level	Proficiency assessed by
PO11	Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.	-	--
PO12	Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.	2	Assignments, Tutorials

1: Slight (Low)

2: Moderate (Medium)

3: Substantial (High)

- : None

VI. HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program Specific Outcomes (PSO)		Level	Proficiency assessed by
PSO1	Software Development and Research Ability: Ability to understand the structure and development methodologies of software systems. Possess professional skills and knowledge of software design process. Familiarity and practical competence with a broad range of programming language and open source platforms. Use knowledge in various domains to identify research gaps and hence to provide solution to new ideas and innovations.	3	Lectures, Assignments, Tutorials, Mock Tests
PSO2	Foundation of mathematical concepts: Ability to apply the acquired knowledge of basic skills, principles of computing, mathematical foundations, algorithmic principles, modeling and design of computer- based systems in solving real world engineering Problems.	3	Lectures, Assignments, Tutorials, Mock Tests
PSO3	Successful Career: Ability to update knowledge continuously in the tools like Rational Rose, MATLAB, Argo UML, R Language and technologies like Storage, Computing, Communication to meet the industry requirements in creating innovative career paths for immediate employment and for higher studies.	2	Lectures, Assignments
1: Slight (Low)	2: Moderate (Medium)	3: Substantial (High)	- : None

VII. SYLLABUS:

UNIT - I

Mathematical logic: Introduction, Statements and Notation, Connectives, Normal Forms, Theory of Inference for the Statement Calculus, The Predicate Calculus, Inference Theory of the Predicate Calculus.

UNIT - II

Set theory: Introduction, Basic Concepts of Set Theory, Representation of Discrete Structures, Relations and Ordering, Functions. Algebraic Structures: Introduction, Algebraic Systems, Semi groups and Monoids, Groups, Lattices as Partially Ordered Sets, Boolean algebra.

UNIT – III

Elementary Combinatorics: Basics of Counting, Combinations and Permutations, Enumeration of Combinations and Permutations, Enumerating Combinations and Permutations with Repetitions, Enumerating Permutations with Constrained Repetitions, Binomial Coefficients, The Binomial and Multinomial Theorems, The Principle of Inclusion Exclusion.

UNIT – IV

Recurrence Relations: Generating Functions of Sequences, Calculating Coefficients of generating functions, Recurrence relations, Solving recurrence relations by substitution and Generating functions, The method of Characteristic roots, Solutions of Inhomogeneous Recurrence Relations.

UNIT - V

Graphs: Basic Concepts, Isomorphisms and Subgraphs, Trees and their Properties, Spanning Trees, Directed Trees, Binary Trees, Planar Graphs, Euler's Formula, Multigraphs and Euler Circuits, Hamiltonian Graphs, Chromatic Numbers, The Four-Color Problem.

GATE SYLLABUS:

Discrete Mathematics: Propositional and first order logic. Sets, relations, functions, partial orders and lattices. Groups. Graphs: connectivity, matching, coloring. Combinatorics: counting, recurrence relations, generating functions.

IES SYLLABUS: NIL

TEXT BOOK:

1. Discrete Mathematical Structures with Applications to Computer Science, J.P. Tremblay, R. Manohar, McGraw Hill education (India) Private Limited. (UNITS - I, II)
2. Discrete Mathematics for Computer Scientists & Mathematicians, Joe L. Mott, Abraham Kandel, Theodore P. Baker, Pearson , 2nd ed. (Units - III, IV, V)

REFERENCES:

1. Discrete Mathematics and its Applications, Kenneth H. Rosen, 7th Edition, McGraw Hill education (India) Private Limited.
2. Discrete Mathematics, D.S. Malik & M.K. Sen, Revised edition Cengage Learning.
3. Elements of Discrete Mathematics, C. L. Liu and D. P. Mohapatra, 4th edition, McGraw Hill education (India) Private Limited.
4. Discrete Mathematics with Applications, Thomas Koshy, Elsevier. 5. Discrete and Combinatorial Mathematics, R. P. Grimaldi, Pearson.

NPTEL Web Course:

1. https://onlinecourses.nptel.ac.in/noc18_ma10/announcements?force=true

NPTEL Web Course:

1. <http://nptel.ac.in/courss/106106090/>

NPTEL Video Course:

1. <http://nptel.ac.in/courses/106106090/#>

UGC-NET Syllabus

Discrete structures and graph theory, statements and logic

VIII. COURSE PLAN (WEEK -WISE):

LESSON PLAN-COURSE SCHEDULE:

Session	Week No	Unit	TOPIC	Course learning outcomes	Reference
1.	1		Mathematical logic Introduction	Define mathematical logic	T1,T2,R1
2			Problems	Solve problems	T1,T2,R1
3			Statements and Notation	Define statements	T1,T2,R1
4			Connectives	Solve problems	T1,T2,R1
5	2		Normal Forms	Understand normal forms	T1,T2,R1
6			problems	Solve problems	T1,T2,R1
7			Theory of Statements Inference for the Statement Calculus,	Understand theory of statements	T1,T2,R1
8	3		The Predicate Calculus	Understand predicate	T1,T2,R1
9			Inference Theory of the Predicate Calculus	Understand theory of inference	T1,T2,R1
10			problems	Solve problems	T1,T2,R1
			<i>Topic beyond syllabus</i>		
11	4		Basic Concepts of Set Theory	Understand basic concepts of sets	T1,T2,R1
12			problems	Solve problems	T1,T2,R1
13		2	Representation of Discrete Structures,	Understand discrete structures	T1,T2,R1
14			Relations and Ordering	Solve problems	T1,T2,R1

15	5		Functions	Understand functions	T1,T2,R1
16			Introduction to Algebraic Systems,	Understand algebraic structures	
17			Semi groups and Monoids	Define semigroup and monoids	T1,T2,R1
18			Groups	Understand groups	T1,T2,R1
19			Lattices as Partially Ordered Sets,	Solve problems	T1,T2,R1
20			Boolean algebra	Define Boolean algebra	T1,T2,R1
	6	2	BRIDGE CLASS / MOCK I		
			Topic beyond syllabus		
21			Basics of Counting	Define various methods of counting	T1,T2,R1
22			Problems on counting	Solve problems	T1,T2,R1
23			Combinations and Permutations	Understand permutation and combination	T1,T2,R1
24			Enumeration of Combinations	Solve problems on combinations	T1,T2,R1
25			Permutations	Understand permutations	T1,T2,R1
26	7		problems	Solve problems on permutations	T1,T2,R1
27			Enumerating Combinations with repetitions	Solve problems on combinations	T1,T2,R1
28			Problems	Solve problems	T1,T2,R1
29			Enumerating permutations with repetitions	Understand repetitions	T1,T2,R1
30	8		problems	Solve problems	T1,T2,R1
31			Circular permutations	Define circular permutation	T1,T2,R1
32			Binomial Coefficients,	Solve problems on binomial coefficients	T1,T2,R1
33			Problems	Solve Problems	T1,T2,R1
34			The Binomial Theorem	Prove binomial theorem	T1,T2,R1
I Mid Examinations					
35	9	3	Problems	Solve problems	T1,T2,R14
36			Multinomial theorem	Prove multinomial theorem	T1,T2,R1
37			Problems	Solve problems	T1,T2,R

					1
38			Principles of inclusion and exclusion	Understand principles	T1,T2,R1
39			problems	Solve problems	T1,T2,R1
			Topic beyond syllabus		
UNIT – 4					
40	1		Generating Functions of Sequences	Define generating function	T1,T2,R1
41			Problems	Solve problems	T1,T2,R1
42			Calculating Coefficients of generating functions	Solve problems on coefficients	T1,T2,R1
43			Recurrence relations,	Define recurrence relation	T1,T2,R1
44	1		Solving recurrence relations by substitution method,	Solve problems using substitution method	T1,T2,R1
45			problems	Solve problems	T1,T2,R1
46			Solving recurrence relations by generating function	Solve problems using generating functions	T1,T2,R1
47			problems	Solve problems	T1,T2,R1
48	1		The method of Characteristic roots,	Understand method of characteristics	T1,T2,R1
49			Solutions of Inhomogeneous Recurrence Relations	Solve problems on homogeneous r r	T1,T2,R1
50			Problems	Solve problems on r r	T1,T2,R1
			Topic beyond the syllabus		
			Bridge class		
UNIT – 5					
51	13		Graphs: Basic Concepts,	Define graph and various types of graphs	T1,T2,R1
52			Isomorphism and Sub graphs	Solve problems	T1,T2,R1
53			Trees and their Properties,	Define trees	T1,T2,R1
54			Spanning Trees, Directed Trees,	Define spanning trees and directed trees	T1,T2,R1
55	14		Binary Trees	Solve problems	T1,T2,R1
56			Planar Graphs	Solve problems	T1,T2,R1
57			Euler's Formula	Solve problems	T1,T2,R1
58			Multigraphs and Euler Circuits	Solve problems	T1,T2,R1
59	15	5	Hamiltonian Graphs,	Solve problems	T1,T2,R1
60			Chromatic Numbers,	Define chromatic number	T1,T2,R1
61			The Four-Color Problem	Solve problems	T1,T2,R1
62			problems	Solve problems	T1,T2,R1

			Topic beyond syllabus	
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IX. MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES:

Course Outcome	Program Outcomes (PO)											Program Specific Outcomes (PO)		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2
CO1	1	3	1	-	-	-	-	-	-	-	-	-	1	-
CO2	2	2	-	-	-	-	-	-	-	-	-	-	1	2
CO3	2	3	1	-	2	-	-	-	-	-	-	-	2	-
CO4	2	2	-	2	-	1	-	-	-	-	-	-	-	-
CO5	1	2	-	-	-	-	-	-	-	-	-	-	1	-
AVG	1.6	1.2	0.4	0.4	0.4	0.2	-	-	-	-	-	-	1	0.4

QUESTION BANK: (JNTUH)

DESCRIPTIVE QUESTIONS:

UNIT-I

Short Answer – Questions

S.No	Question	Blooms taxonomy level	Course outcome
1	State which of the following sentences are propositions: i) A triangle contains three lines ii) $x+2$ is a positive integer	Analyze	4
2	Prove that $\{(p \rightarrow q) \rightarrow r\} \leftrightarrow \{(\sim p \vee q) \rightarrow r\}$ is a tautology.	Analyze	4
3	Define Principal disjunctive normal form & Principal conjunctive normal form	Evaluate	5
4	Write down the following prepositions in symbolic form and find its negation: “All integers are rational numbers and some rational numbers are not integers”	Understand	2
5	Give an indirect proof for each of the following statements: i) If m is an even integer, then $m+7$ is an odd integer ii) If x & y are integers such that xy is odd, then x & y are both odd	Apply	3

Long Answer Questions-

S.No	Questions	Blooms taxonomy level	CO
1	<p>a) Use De Morgan's Law to write the negation of each statement</p> <p>i. I want a car and a worth cycle</p> <p>ii. My cat stay outside or it makes a mess</p> <p>iii. I've faller and I can't get up</p> <p>iv. You study or you don't get a good grade.</p> <p>b) Are $(p \rightarrow q) \rightarrow r$ and $p \rightarrow (q \rightarrow r)$ logically equivalent? Justify your answer by using the rules of logic to simply both expression and also by using truth tables</p>	Evaluate	5
2	<p>Express the formula $P \rightarrow Q$ in terms of $\{\uparrow\}$ only</p> <p>$(A \wedge (\sim A \vee B)) \vee \sim(A \wedge B) = B$</p> <p>Which of the following formula is not a tautology</p> <p>i) $(P \rightarrow Q) \rightarrow (Q \rightarrow R)$</p> <p>ii) $(P \rightarrow Q) \wedge (Q \rightarrow P)$</p>	Apply	3
3	<p>Obtain principal conjunction normal form for the following</p> <p>i) $(\neg P \rightarrow R) \wedge (Q \leftrightarrow P)$</p> <p>ii) $((P \vee Q) \wedge (P \rightarrow R) \wedge (Q \rightarrow R)) \rightarrow R.$</p> <p>b] Prove the implication: $(P \rightarrow (Q \rightarrow R)) \Rightarrow (P \rightarrow Q) \rightarrow (P \rightarrow R)$</p>	Evaluate	5
4	<p>a) What do you mean by a variable & statement function in predicate calculus?</p> <p>b) what is a Quantifier? What are various types of quantifier?</p> <p>c) show that $\sqrt{2}$ is not a rational number, using proof by contradiction?</p>	Apply	3
5	<p>Prove using rules inference or disprove.</p> <p>(a) Duke is a Labrador retriever All Labrador like to swim. Therefore Duke likes to swim.</p> <p>(b) All even numbers that are also greater than 2 are prime 2 are prime 2 is an even number 2 is a prime Therefore some even numbers are prime UNIVERSE = numbers</p> <p>(c) if it is hot today or raining today then it is no fun to snow ski today Therefore it is hot today UNIVERSE=Days</p>	Evaluate	5

Unit 2

Short answer questions

S.No	Question	Blooms taxonomy level	CO
1	Define Poset and distributive lattice.	Analyze	4
2	Consider the following relations on the $A=\{1,2,3\}$, $f=\{(1,3),(2,3),(3,1)\}$ $g=\{(1,2),(3,1)\}$, $h=\{(1,3),(2,1),(1,2),(3,1)\}$ which of these are functions?	Create	6
3	Define Homomorphism & Isomorphism	Analyze	4
4	Let f & g be functions from R to R defined by $f(x)=ax+b$ and $g(x)=1-x+x^2$. If $(gof)(x)=9x^2-9x+3$, determine a,b	Understand	2
5	5. Consider the sets $A=\{a,b,c\}$ and $B=\{1,2,3\}$ and the relations. $R=\{(a,1),(b,1),(c,2),(c,3)\}$ and $S=\{(a,1),(a,2),(b,1),(b,2)\}$ from A to B . Determine $R, S, R \cup S, R \cap S, R^c, S^c$	Remember	1

Long Answer Questions

S.No	Question	Blooms taxonomy level	CO
1	Let $A=\{1,2,3,4,6\}$ and R be a relation on A defined by aRb if and only if 'a' is a multiple of 'b'. Represent the relation R as a matrix and draw its digraph.	Evaluate	5
2	Let $A=\{a,b,c,d\}$ R be a relation on A that has the matrix $M_r = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 1 & 1 & 1 & 0 \\ 0 & 1 & 0 & 1 \end{bmatrix}$. Construct the digraph of R and list the in-degrees and out-degrees of all vertices.	Apply	3
3	Let $A=\{1,2,3\}$ and $R=\{(1,1),(2,2),(3,3)\}$. Verify that R is an equivalence relation.	Evaluate	5
4	Let $A=\{1,2,3,4,6,8,12\}$ on A define the partial ordering relation R by aRb iff $a b$. a) Draw the Hasse diagram for R . b) Write down the relation matrix for R .	Analyze	4
5	Let $A=\{1,2,3,4,5\}$ and $R=\{(1,1),(2,2),(3,3),(1,3),(3,4),(3,5),(1,4),(4,4),(1,5),(2,3),(2,4),(2,5),(5,5)\}$. Draw the Hasse diagram for R .	Analyze	4

UNIT-3

Short Answer Questions-

S.No	Question	Blooms taxonomy level	Course outcome
1	Prove that if 30 dictionaries in a library contain a total of 61327 pages, then at least one of the dictionaries must Prove have at least 2045 pages.	Analyze	4
2	In how many ways can we distribute 10 identical marbles among 6 distinct containers?	Create	6

3	Find the number of arrangements of the letter TALLAHASSEE which have no adjacent A's	Evaluate	5
4	Find the no of positive integers solutions of the equation $x_1+x_2+x_3=17$	Understand	2
5	In how many ways can 20 similar books be placed on 5 different shelves	Analyze	4

Long Answer Questions-

S.No	Question	Blooms taxonomy level	Course outcome
1	a) Find the value of n so that $2P_{(n,2)}+50=P(2n,2)$ b) Prove that ,for all the integers $n,r \geq 0$,if $n+1 > r$,then $P(n+1,r)=\binom{n+1}{n+1-r} P(n,r)$.	Evaluate	5
2	Find the coefficient of (i) x^9y^3 in the expansion of $(x+2y)^{12}$ (ii) x^5y^2 in the expansion of $(2x-3y)^7$	Apply	3
3	State and prove The Principle of Inclusion-Exclusion.	Evaluate	5
4	Find the number of integer solutions of the equation $x_1+x_2+x_3+x_4+x_5 = 30$ under the constraints $x_1 \geq 0$ for $i=1,2,3,4,5$ and further x_2 is even and x_3 is odd.	Analyze	4
5	In how many ways can we distribute 10 identical marbles among 6 distinct containers?	Analyze	4

UNIT-4

Short answer questions

S.No	Question	Blooms taxonomy level	Course outcome
1	Find the sequences generated by the following functions : i) $(3+x)^3$ ii) $3x^3+e^{2x}$	Create	6
2	Find the generating functions for the sequences $1^2,2^2,3^2, \dots$	Create	6
3	Solve the recurrence relation $a_{n+1}=4a_n$ for $n \geq 0$, given that $a_0=3$.	Analyze	4
4	The number of virus affected files in a system is 1000 (to start with) and this increases 250% every 2 hours. Use a recurrence relation to determine the no of virus affected files in the system after one day.	Analyze	4
5	Find a_{12} if $a^2_{n+1} = 5a^2_n$, where $a_n > 0$ for $n \geq 0$, given that $a_0=2$.	Analyze	4

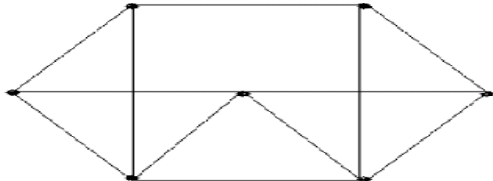
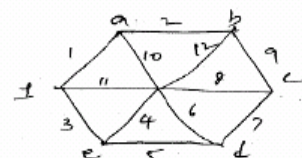
Long answer questions

S.No	Question	Blooms taxonomy level	CO
1	Find the sequence generated by the following functions: (i) $(3+x)^3$ (ii) $2x^2(1-x)^{-1}$ (iii) $(1-x)^{-1}+2x^3$ (iv)	Evaluate	5

	$(1+3x)^{-1/3}$ (v) $3x^3+e^{2x}$		
2	Find the generating functions for the following sequences. (i) 1,2,3,4,----- (ii) 1,-2,3,-4,----- (iii) 0,1,2,3,----- ----	Analyze	4
3	Determine the coefficient of (i) x^{12} in $x^3(1-2x)^{10}$ (ii) x^{10} in $(x^3-5x)/(1-x)^3$ (iii) x^5 in $(1-2x)^{-7}$	Analyze	5
4	Solve the recurrence relation $a_{n+3}-3a_{n+2}+3a_{n+1}-a_n=3+5n$ for $n \geq 0$	Analyze	4
5	Find a generating function for recurrence relation $a_{n+1}-a_n=n^2$, $n \geq 0$ and $a_0=1$. Hence solve it.	Analyze	4

UNIT-5

Short Answer Questions-

S. N	Question	Blooms taxonomy level	Course outcome
1	Define directed graph and directed edge set	Apply	3
2	Draw a diagram of the graph $G=(V,E)$ where $V=\{A,B,C,D\}$, $E=\{(A,B),(A,C),(A,D),(C,D)\}$	Apply	3
3	Define complete bipartite graph and kuratowski's second graph.	Apply	3
4	Find the chromatic number of the following graph 	Apply	3
5	a] Find minimum spanning tree for following graph. Also find dual 	Apply	3

Long Answer Questions-

SN	Question	Blooms taxonomy level	Course outcome
1	Let D be the digraph whose vertex set is $V=\{v_1, v_2, v_3, v_4, v_5\}$ and the directed edge set is $E=\{(v_1, v_4), (v_2, v_3), (v_3, v_5), (v_4, v_2), (v_4, v_4), (v_4, v_5), (v_5, v_1)\}$ write down a diagram of D and indicate the outdegrees and indegrees of all vertices.	Apply	3

2	a) Define sub graph and spanning sub graph. b) Prove that if $V = \{v_1, v_2, \dots, v_n\}$ is the vertex set of non directed graph G, then $\sum_{i=1}^n \deg(v_i) = 2 E $ [10+6]	Apply	3
3	How many vertices will the following graphs have if they contain (i) 16 edges and all vertices of degree 4? (ii) 21 edges, 3 vertices of degree 4 and other vertices of degree 3 (iii) 12 edges, 6 vertices of degree 3, and other vertices of degree <3?	Apply	3

OBJECTIVE QUESTIONS:

JNTUH:

UNIT-1

1 The binary relation $S = f(\text{empty set})$ on set $A = \{1, 2, 3\}$ is

- i. Neither reflexive nor symmetric
- ii. Symmetric and reflexive
- iii. Transitive and reflexive
- iv. Transitive and symmetric

2 Let A be a set of $n (> 0)$ elements. Let N_r be the number of binary relations on A and let N_f be the number of functions from A to A .

- i. Give the expression for N_r in terms of n .
- ii. Give the expression for N_f in terms of n .
- iii. Which is larger for all possible n , N_r or N_f ?

3 Suppose X and Y are sets and $|X|$ and $|Y|$ are their respective cardinalities. It is given that there are exactly 97 functions from X and Y . From this one can conclude that

(GATE)

- i. $|X|=1, |Y|=97$
- ii. $|X|=97, |Y|=1$
- iii. $|X|=97, |Y|=97$
- iv. none of the above

4 Identify the correct translation into logical notation of the following assertion.

Some boys in the class are taller than all the girls.

Note: taller (x, y) is true if x is taller than y .

- i. $(\exists x) (\text{boy}(x) \otimes (y) (\text{girl}(y) \dot{\cup} \text{taller}(x, y)))$
- ii. $(\exists x) (\text{boy}(x) \dot{\cup} (y) (\text{girl}(y) \dot{\cup} \text{taller}(x, y)))$
- iii. $(\exists x) (\text{boy}(x) \otimes (y) (\text{girl}(y) \otimes \text{taller}(x, y)))$
- iv. $(\exists x) (\text{boy}(x) \dot{\cup} (y) (\text{girl}(y) \dot{\cup} \text{taller}(x, y)))$

5 What is the first order predicate calculus statement equivalent to the following?

Every teacher is liked by some student

- i. $(x) [\text{teacher}(x) \otimes \exists (y) [\text{student}(y) \otimes \text{likes}(y, x)]]$
- ii. $(x) [\text{teacher}(x) \otimes \exists (y) [\text{student}(y) \dot{\cup} \text{likes}(y, x)]]$
- iii. $\exists (x) (x) [\text{teacher}(x) \otimes [\text{student}(y) \dot{\cup} \text{likes}(y, x)]]$
- iv. $(x) [\text{teacher}(x) \dot{\cup} \exists (y) [\text{student}(y) \otimes \text{likes}(y, x)]]$

UNIT-2

1 Let X, Y, Z be sets of sizes x, y and z respectively. Let $W = X * Y$ and E be the set of all subsets of W . The number of functions from Z to E is:

- i. Z^{2xy}
- ii. $Z^* 2^{xy}$
- iii. Z^{2x+y}
- iv. 2^{xyz}

2 A relation R is defined on ordered pairs of integers as follows: $(x,y) R (u,v)$ if $x < u$ and $y > v$. Then R is

- i. Neither a partial order nor an equivalence relation.
- ii. A partial order but a total order
- iii. A total order
- iv. An equivalence relation

3 Let $f : B \rightarrow C$ and $g : A \rightarrow B$ be two functions let $h = f \circ g$. Given that h is an onto function which one of the following is TRUE?

- i. f and g should both be onto functions.
- ii. f should be onto but g need not be onto
- iii. g should be onto but f need not be onto
- iv. both f and g need to be onto

4 Consider the binary relation :

$$S = \{(x,y) \mid y = x + 1 \text{ and } x, y \in \{0, 1, 2\}\}$$

- i. $\{(x,y) \mid y > x \text{ and } x, y \in \{0, 1, 2\}\}$
- ii. $\{(x,y) \mid y \geq x \text{ and } x, y \in \{0, 1, 2\}\}$
- iii. $\{(x,y) \mid y < x \text{ and } x, y \in \{0, 1, 2\}\}$
- iv. $\{(x,y) \mid y \leq x \text{ and } x, y \in \{0, 1, 2\}\}$

5 The number of binary relations on a set with n elements is:

- i. n^2
- ii. 2^n
- iii. 2^{n^2}
- iv. None of the above

UNIT-3

1 A multiset is an unordered collection of elements where elements may repeat any number of times. The size of a multiset is the number of elements in it counting repetitions.

- i. What is the number of multisets of size 4 that can be constructed from n distinct elements so that at least one element occurs exactly twice?
- ii. How many multisets can be constructed from n distinct elements?
- iii. None of the above

2. The number of binary strings of n zeroes and k ones that no two ones are adjacent is

- i. ${}^{n-1}C_k$
- ii. nC_k
- iii. ${}^nC_{k+1}$
- iv. None of the above

3. How many 4 digit even numbers have all 4 digits distinct?

- i. 2240
- ii. 2296
- iii. 2620
- iv. 4536

4. How many substrings of different lengths (non zero) can be found formed from a character string of length n?

- i. n
- ii. n^2
- iii. 2^n
- iv. None of the above

5. In a room containing 28 people, there are 18 people who speak English, 15 people who

speak Hindi and 22 people who speak Kannada. 9 persons speak both English and Hindi, 11 persons speak both Hindi and Kannada whereas 13 persons speak both Kannada and English. How many people speak all three languages?

- i. 9
- ii. 8
- iii. 7
- iv. 6

UNIT -4

- The solution to the recurrence equation $T(2^k) = 3 T(2^{k-1}) + 1$, $T(1) = 1$ is
 - 2^k
 - $(3^{k+1}-1)/2$
 -
 -
- Express $T(n)$ in terms of the harmonic number $H_n = \sum_{k=1}^n \frac{1}{k}$, where $T(n)$ satisfies the recurrence relation, $T(n) = 2T(n/2) + 1$, for $n \geq 1$ and $T(1) = 1$.-----
- Find a solution to the following recurrence equation: $T(n) = 1$.-----
- Solve the recurrence equations: $T(n) = T(n/2) + 1$.-----
- Solve the recurrence equations $T(n) = T(n-1) + n$, $T(1) = 1$.-----

UNIT -5

- Level order traversal of a rooted tree can be done by starting from the root and performing
 - preorder traversal
 - in-order traversal
 - depth first search
 - breadth first search
- How many perfect matchings are there in a complete graph of 6 vertices?
 - 15
 - 24
 - 30
 - 60
- Let S be a set of n elements $\{1,2,\dots,n\}$ and G a graph with 2^n vertices, each vertex corresponding to a distinct subset of S . Two vertices are adjacent iff the symmetric difference of the corresponding sets has exactly 2 elements.

Note: The symmetric difference of two sets R_1 and R_2 defined as $(R_1 \setminus R_2) \cup (R_2 \setminus R_1)$.

 - Every vertex in G has the same degree. What is the degree of a vertex in G ?
 - How many connected components does G have?
- Let G be a connected undirected graph. A cut in G is a set of edges whose removal results in G being broken into two or more components which are not connected with each other. The size of a cut is called its cardinality. A min-cut of G is a cut in G of minimum cardinality. Consider the following graph. (GATE)
- A graph is planar if and only if,
 - it does not contain sub graphs homomorphic to K_5 and $K_{3,3}$
 - it does not contain sub graphs isomorphic to K_5 or $K_{3,3}$
 - it does not contain sub graphs isomorphic to K_5 or $K_{3,3}$
 - it does not contain sub graphs homomorphic to K_5 or $K_{3,3}$

WEBSITES:

- www.computer.org
- www3.intersciencewiley.com
- www.vsppub.com
- www.sciencedirect.com
- www.akcejournal.org
- www.ams.org
- www.siam.org
- www.maths.ise.ac.uk

EXPERT DETAILS:

Mr. Jason. Brown Associate Professor,	Dr. K. Kumkum Dewan Department of Mathematics,	Mr. G. L. Reddy Lecturer in University of Hyderabad,	Dr. Anandbabu Professor, Department of Mathematics,
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JOURNALS:

INTERNATIONAL:

1. SIAM Journals DM
2. Journal of the American Mathematical Society
3. AKCE International Journal of Graphs and Combinations
4. Discrete Mathematics
5. Discrete Mathematics and Applications
6. Journal of Discrete Mathematical Sciences and cryptography
7. Journal of Graph Theory

NATIONAL:

1. Journal of Mathematical and Physical Sciences
2. Operations Research Society of India (OBSEARCH)
3. Journal of Discrete Mathematical Science, Cryptography
4. Nordic Journal of Computing
5. Bulletin of Calcutta Mathematical Society
6. Indian National Science Academy
7. Indian Journal of Pure and Applied Mathematics

LIST OF TOPICS FOR STUDENT SEMINARS:

- a. GRAPH THEORY
- b. RECURRENCE RELATIONS

CASE STUDIES / SMALL PROJECTS

- a. Applications of Graph theory