GUJARAT TECHNOLOGICAL UNIVERSITY

COMPUTER ENGINEERING (07)
THEORY OF COMPUTATION
SUBJECT CODE:2160704
B.E. 6thSEMESTER

Type of course: Core

Prerequisite: Calculus, Data Structures and Algorithms

Rationale: Theory of computation teaches how efficiently problems can be solved on a model of computation, using an algorithm. It is also necessary to learn the ways in which computer can be made to think. Finite state machines can help in natural language processing which is an emerging area.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks						Total Marks
				Theory Marks			Practical Marks			
L	T	P	C	ESE (E)	PA (M)		ESE (V)		PA (I)	
					PA	ALA	ESE	OEP		
3	0	0	3	70	20	10	0	0	0	100

Content:

Sr. No.	Content	Total Hrs	% Weightage
1	**Review of Mathematical Theory**: Sets, Functions, Logical statements, Proofs, relations, languages, Mathematical induction, strong principle, Recursive definitions	**10**	16
2	**Regular Languages and Finite Automata:** Regular expressions, regular languages, applications, Automata with output-Moore machine, Mealy machine, Finite automata, memory requirement in a recognizer, definition, union, intersection and complement of regular languages.Non Determinism Finite Automata, Conversion from NFA to FA, $\wedge$- Non Determinism Finite Automata Conversion of NFA- $\wedge$ to NFA and equivalence of three Kleene's Theorem, Minimization of Finite automata Regular And Non Regular Languages – pumping lemma.	**12**	20
3	**Context free grammar (CFG):** Definition, Unions Concatenations And Kleen's of Context free language Regular grammar, Derivations and Languages, Relationship between derivation and derivation trees, Ambiguity Unambiguous CFG and Algebraic Expressions BacosNaur Form (BNF), Normal Form – CNF	**12**	20
4	**Pushdown Automata, CFL And NCFL:** Definition, deterministic PDA, Equivalence of CFG and PDA, Pumping lemma for CFL, Intersections and Complements of CFL, Non-CFL	**12**	20
5	**Turing Machine (TM):** TM Definition, Model Of Computation And Church Turning Thesis, computing functions with TM, Combining TM, Variations Of TM, Non Deterministic TM, Universal TM, Recursively and Enumerable Languages, Context sensitive languages and Chomsky hierarchy	**12**	20

6	**Computable Functions:** Partial, total, constant functions, Primitive Recursive Functions, Bounded Mineralization, Regular function, Recursive Functions	**2**	4

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
15	**25**	**25**	**5**	**00**	**00**

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Books:

1. An introduction to automata theory and formal languages By Adesh K. Pandey, Publisher: S.K. Kataria& Sons
2. Introduction to computer theory By Deniel I. Cohen , Joh Wiley & Sons, Inc
3. Computation: Finite and Infinite By Marvin L. Minsky Prentice-Hall
4. Compiler Design By Alfred V Aho, Addison Weslley
5. Introduction to the Theory of Computation By Michael Sipser
6. Automata Theory, Languages, and Computation By John Hopcroft, Rajeev Motowani, and Jeffrey Ullman

Course Outcome:

After learning the course the students should be able to:

1. At the end of the course the students will be able to understand the basic concepts and application of Theory of Computation.
2. Students will apply this basic knowledge of Theory of Computation in the computer field to solve computational problems and in the field of compiler also.

List of Open Source Software/learning website:

1. http://en.wikipedia.org/wiki/Theory_of_computation
2. http://meru.cecs.missouri.edu/courses/cecs341/tc.html

ACTIVE LEARNING ASSIGNMENTS: Preparation of power-point slides, which include videos, animations, pictures, graphics for better understanding theory and practical work – The faculty will allocate chapters/ parts of chapters to groups of students so that the entire syllabus to be covered. The power-point slides should be put up on the web-site of the College/ Institute, along with the names of the students of the group, the name of the faculty, Department and College on the first slide. The best three works should submit to GTU.

Laxmi Institute of Technology, Sarigam

Approved by AICTE, New Delhi; Affiliated to Gujarat Technological University, Ahmedabad

ASSIGNMENT - 1

Department:	**Computer Science and Engineering**		
Name of Subject In charge:	**Farhin Mansur**		
Subject Name:	**Theory of Computation**	**Subject Code:**	**2160704**
Academic Year:	**2018-19**	**Semester:**	**6**
		Date:	**9-1-2019**

UNIT -1 Review of Mathematical Theory

Sr. No.	Name of Question	Remark
01	Define sets, relations and functions with example.	
02	What is proof? Which types are methods used to establish proof.	
03	Prove that $\sqrt{2}$ (Square root of 2) is irrational number.	
04	Derive steps to achieve mathematical induction. And also explain mathematical induction with examples.	
05	Define strong principle of mathematical induction.	
06	What is language? Explain recursive definitions of languages with example.	

Subject In charge

Laxmi Institute of Technology, Sarigam

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ASSIGNMENT - 2

Department:	**Computer Science and Engineering**		
Name of Subject In charge:	**Farhin Mansur**		
Subject Name:	**Theory of Computation**	**Subject Code:**	**2160704**
Academic Year:	**2018-19**	**Semester:**	**6**
		Date:	**23-1-2019**

UNIT -2 Regular languages and Finite Automata

Sr. No.	Name of Question	Remark
01	Define regular languages and regular expression with examples.	
02	Define finite automata. List out applications of finite automata.	
03	Define deterministic finite automata with different examples.	
04	Explain dead end state.	
05	Explain union, intersection and difference operations on finite automata with example.	
06	Explain minimization of DFA with examples.	
07	Define non deterministic finite automata.	
08	Explain conversion from NFA to DFA with examples.	
09	Explain conversion from NFA-null to DFA with examples.	

Subject In charge

Laxmi Institute of Technology, Sarigam

Approved by AICTE, New Delhi; Affiliated to Gujarat Technological University, Ahmedabad

Question Bank

Department:	**Computer Science and Engineering**		
Name of Subject In charge:	**Farhin Mansur**		
Subject Name:	**Theory of Computation**	**Subject Code:**	**2160704**
Academic Year:	**2018-19**	**Semester:**	**6**

1. Define sets, relations and functions with example.
2. What is proof? Which types are methods used to establish proof.
3. Prove that $\sqrt{2}$ (Square root of 2) is irrational number.
4. Derive steps to achieve mathematical induction. And also explain mathematical induction with examples.
5. Define strong principle of mathematical induction.
6. What is language? Explain recursive definitions of languages with example.
7. Define regular languages and regular expression with examples.
8. Define finite automata. List out applications of finite automata.
9. Define deterministic finite automata with different examples.
10. Explain dead end state.
11. Explain union, intersection and difference operations on finite automata with example.
12. Explain minimization of DFA with examples.
13. Define non deterministic finite automata.
14. Explain conversion from NFA to DFA with examples.
15. Explain conversion from NFA-null to DFA with examples.
16. Define Context Sensitive Grammar. Design a CSG for the following language L = $\{a^n b^n c^n \mid n > 0\}$.
17. Prove that the following language is ambiguous and convert into unambiguous S → S + S | S * S | a
18. Prove that the following CFG is Ambiguous. S -> S + S | S * S | a | b

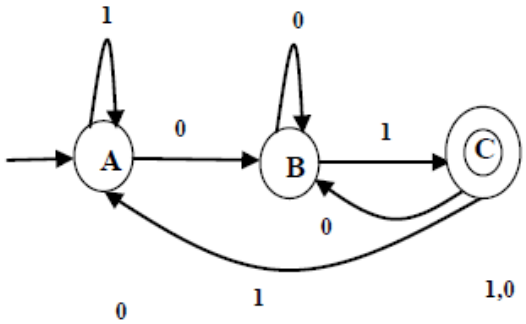
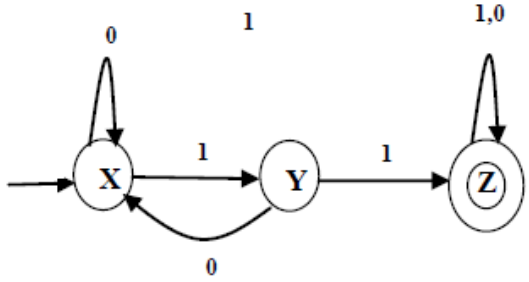
    Write the unambiguous CFG based on precedence rules for the above grammar. Derive the parse tree for expression (a + a)*b from the unambiguous grammar.
19. Define Context Free Grammar. Design a CFG for the following language. L = { x ε (0,1)* | $n_0(x) = n_1(x)$}

20. Convert the CFG, G ({S,A,B},{a,b},P , S) to CNF , where P is as follows S --> aAbB A --> Ab | b B --> Ba | a
21. Consider following grammar: A1B-->S 0A | Λ-->A 0B | 1B | Λ-->B Give leftmost and rightmost derivations of the string 00101. Also draw the parse tree corresponding to this string.
22. Define CFG. When is a CFG called an 'ambiguous CFG'?
23. Consider following grammar: ASB | Λ-->S aAS | a-->A SbS | A | bb-->B i. Eliminate useless symbols, if any. ii. Eliminate Λ productions.
24. Given the Context Free Grammar G, find a CFG G' in Chomsky Normal Form generating L(G) – { }
    1. S → aY | Ybb | Y X → Λ | a Y → aXY | bb | XXa
    2. S → AA A → B | BB B → abB | b | bb
25. Show that the CFG with productions a | Sa | bSS | SSb | SbS→S is ambiguous.
26. Explain Chomsky Hierarchy.
27. Given the context-free grammar G, find a CFG G' in Chomsky Normal Form. AaA | CA | BaB→G : S→ aaBa | CDA | aa | DCA → bB | bAB | bb | aS B→ Ca | bC | D◊C bD | ε D→ ε represents null.
28. Define Context Free Grammar. Find context-free grammar for the language: L = $\{a^i b^j \mid i < 2j\}$
29. Explain Union Rule and Concatenation Rule for Context-Free Grammar.
30. Let G be the grammar aB | bA→S a | aS | bAA→A b | bS | aBB→B For string aaabbabbba, find Left most derivation and Right most derivation.
31. Define Context-Sensitive Grammar. Write a CSG for $\{a^n b^n c^n \mid n \geq 1\}$.
32. Define Context-Sensitive Grammar. What is the language of following context-sensitive grammar? aTb | ab→S aaTb | ac.→aT
33. What is CNF? Convert the following CFG into CNF. S → ASA | aB, A → B | S, B → b | ε
34. For the following CFG, Find Chomsky normal form S->AACD A->aAb|ʌ C-> aC|a D->aDa|bDb|ʌ
35. For the following CFG, Find Chomsky normal form S->AaA|CA|BbB A->aaBa|CDA|aa|DC B->bB|bAB|bb|aS C->Ca|bC|D D->bD|ʌ
36. Define Context Free Grammar. Design a CFG for the following language L = $\{a^n b^n \mid n > 0\}$.

37. Prove that the following language is ambiguous and convert into unambiguous E → E + E | E * E | id
38. Convert the following language in Chomsky normal form. S→ASB | SAB A→ BC B→ bB | c C → e
39. Define Context Free Grammar. Design a CFG for the language L = { $a^i b^j c^k$ | i ≠ j + k }
40. Give CFG equivalent to regular expression (011 + 1)* (01)*
41. Define Context Free Grammar(CFG). Design CFG for Generating Following Language: (1) For Balanced Parenthesis (2) Set of even length strings in {a, b, c, d}* with two middle symbol equal.
42. Design an ambiguous grammar for if-then-else statement that also generates if-then statement. Re-write an equivalent unambiguous grammar. Prove that Grammar is Unambiguous by tracing "ic1tic2taea".
43. Given the Context Free Grammar G, find a CFG G' in Chomsky Normal Form generating L(G) – { } S → SS | A | B A → SS | AS | a B → /\
44. Generate the Context-Free Grammars that give the following languages. (i) {w | w contains at least three 1s} (ii) {w | w starts and ends with the same symbol}
45. For given CFG G, find Chomsky normal form: G has productions: S -> AaA|CA|BaB A-> aaBa|CDA|aa|DC B->bB|bAB|bb|aS C-> Ca|bC|D D->bD|Λ
46. Given the CFG G, find a CFG G' in Chomsky Normal form generating L(G) – { Λ} S→ A | B | C A aAa | B B bB | bb C aCaa | D D baD | abD | aa
47. Define CFG and Design a CFG for the following language. L = { x ∈ {0,1}* | n0(x) ≠ n1(x) }
48. Differentiate Regular Grammars and Context Sensitive Grammars.
49. find an equivalent unambiguous grammar for following: S→ A|B A→ aAb|ab B →abB|Λ
50. Find context free grammar generating following language {$a^i b^j c^k$ | i = j or i = k}
51. Design a CFG for the following language. L = { $0^i 1^j 0^k$ / j > i + k }
52. For the following CFG's, describe the language it accepts. 1. S→ SS | XaXaX | ^ X → bX | ^ 2. S→ aM | bS M → aF | bS F→ aF | bF | ^ 3. S → aS | bS | a | b | ^
53. Draw the PDA for the following language L = {$a^i b^j c^k$ | i = j+k}
54. Design a PDA, M to accept L = { $a^n b^{2n}$ | n ≥ 1 }
55. For the language L = { xcx^r {a,b}* } design a PDA(Push Down∈| x Automata).
56. Write Short note on Universal Turing Machine.

57. Define a Turing Machine. Design a Turing machine for deleting nth symbol from a string w from the alphabet $\sum = \{0,1\}$.
58. Give definition of Turing Machine. What do you mean by an instantaneous description of a Turing Machine?
59. Design a Turing machine for the language over {0,1} containing strings with equal number of 0's and 1's.
60. Write a Turing Machine to copy strings.
61. Draw a Turing Machine(TM) to accept Even and odd Palindromes over {a,b}.
62. Write Short note on Church-Turing Thesis.
63. Prove that following add(x,y) = x+y is primitive recursive function.
64. Draw a transition diagram for a Turing machine accepting the following language. $\{ a^n b^n c^n \mid n \geq 0 \}$
65. Define functions by Primitive Recursion. Show that the function f(x, y) = x + y is primitive recursive.
66. Describe recursive languages and recursively enumerable languages.

	Laxmi Institute of Technology, Sarigam Approved by AICTE, New Delhi; Affiliated to Gujarat Technological University, Ahmedabad **Academic Year 2018-19**	
Centre Code: **086**	Examination : Mid Semester Exam-1	
Branch: CSE	Semester: 6	Sub Code: 2160704
Sub: Theory of Computation	Date: 31-1-2019 Time:9 am to 10 am	Marks: 20
Note: Attempt any four.		

Q. 1	i. Design regular expression for the language with Σ={0,1} such that third character from right end of the string is always 0.	**1**
	ii. List out any two applications of DFA.	**1**
	iii. Define dead end state.	**1**
	iv. Draw DFA for the language which does not contain substring 00 over Σ={0,1}.	**2**
Q. 2	i. Prove that $1+3+5+\ldots+(2n-1) = n^2$ for $n \geq 1$ using principle of mathematical induction.	**3**
	ii. Find Reflexive, Symmetric and Transitive closure of the relation R={ (a,a), (b,b), (a,b), (b,a) }	**2**
Q. 3	Let M1 and M2 be the finite automata in figure below for the language L1 and L2 respectively M_1 =  M_2 =  Draw finite automata recognizing the following languages • L1 ∩ L2 • L1 – L2	**5**
Q. 4	i. Prove that $\sqrt{2}$ is irrational by method of contradiction.	**3**
	ii. Prove that ((P => Q) ∧ (Q => R)) => (P => R) is a Tautology.	**2**
Q. 5	i. Give the recursive definition of Palindrome over any alphabet Σ.	**3**
	ii. Check whether the function f : $\mathbf{R}^+ \rightarrow \mathbf{R}^+$, $f(x)= x^2$ is one to one or onto or bijection.	**2**

Seat No.: _____ **Enrolment No._____**

GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER–VI- EXAMINATION – SUMMER 2016

Subject Code:160704 **Date:17/05/2016**

Subject Name:Theory Of Computation

Time: 10:30 AM to 01:00 PM **Total Marks: 70**

Instructions:

1. **Attempt all questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**

Q.1 **(a)** Define relation. Define reflexive and transitive relation. A binary relation R on NxN is defined as (a,b)R(c,d) if $a \leq c$ or $b \leq d$. Prove that R is reflexive but not transitive. **07**

(b) Define language. **07**

Draw Deterministic Finite Automata for the following languages

i) $L_1 = \{ x \varepsilon (0,1)^* \mid x \text{ contains } 110111\}$

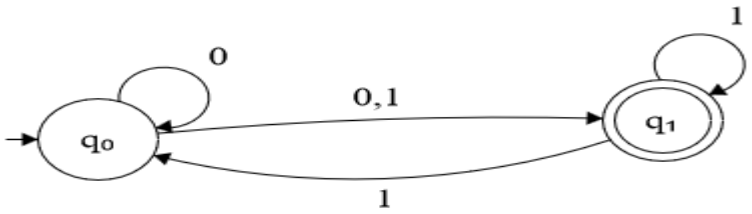
ii) $L_2 = \{ x \varepsilon (0,1)^* \mid x \text{ contains odd number of zero and even number of } 1\}$

iii) $L_3 = \{ x \varepsilon (0,1)^* \mid x \text{ do not contains } 110 \}$

Q.2 **(a)** Define mathematical induction. **02**

Prove that if $0 < a < 1$ then $(1-a)^n \geq 1 - na$. **05**

(b) Define NFA and NFA-Λ. Convert the following NFA to DFA **07**



OR

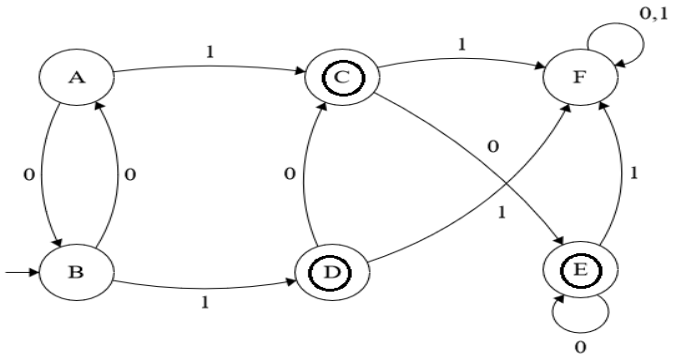
(b) Using proof by contradiction, prove $\sqrt{3}$ is Not a rational number. **07**

Q.3 **(a)** Define Context Sensitive Grammar. Design a CSG for the following language $L = \{a^n b^n c^n \mid n > 0\}$. **07**

(b) Prove that the following language is ambiguous and convert into unambiguous $S \rightarrow S + S \mid S * S \mid a$ **07**

OR

Q.3 **(a)** Minimize the following FSM **07**



(b) Define Context Free Grammar. Design a CFG for the following language. **07**
$L = \{ x \varepsilon (0,1)^* \mid n_0(x) = n_1(x)\}$

Q.4 **(a)** Define PDA. Draw a PDA for the complement of the following language **07**
$L = \{ww^R \mid w \varepsilon (0,1)^*\}$

(b) Write regular expression for the following languages **07**
i) $L_1 = \{x \varepsilon (0,1)^* \mid x$ do not ends with 11$\}$
ii) $L_2 = \{x \varepsilon (0,1)^* \mid x$ contains both 101 and 110$\}$

OR

Q.4 **(a)** Prove that any Regular Language can be accepted by FA. **07**

(b) Draw the PDA for the following language **07**
$L = \{a^i b^j c^k \mid i = j+k\}$

Q.5 **(a)** Define pumping lemma for regular language. Prove that the language **07**
$L = \{a^i \mid i$ is NOT prime$\}$ is irregular.

(b) Write Short note on Universal Turing Machine. **07**

OR

Q.5 **(a)** Define a Turing Machine. Design a Turing machine for deleting nth symbol from a string w from the alphabet $\sum = \{0,1\}$. **07**

(b) Prove that following add(x,y) = x+y is primitive recursive function. **07**

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Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

BE – SEMESTER – VI (NEW).EXAMINATION – WINTER 2016

Subject Code: 2160704 Date: 25/10/2016

Subject Name: Theory of Computation

Time: 10:30 AM to 01:00 PM Total Marks: 70

Instructions:

1. **Attempt all questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**

Q.1 **(a)** Use the principle of mathematical induction to prove that **07**

$1 + 3 + 5 + \ldots + r = n^2$ for all $n>0$ where r is an odd integer & n is the number of terms in the sum. (Note : r= 2n-1)

(b) Convert the CFG, G ({S,A,B},{a,b},P , S) to CNF , where P is as follows **07**

S --> aAbB A --> Ab | b B --> Ba | a

Q.2 **(a)** Draw a Turing Machine(TM) to accept Palindromes over {a,b}. (Even as well as Odd Palindromes) **07**

(b) Convert the NFA given in Table below to its corresponding DFA and draw the DFA . **07**

Current State	Input symbol	
	0	1
→Q_0	Q_1	Q_0, Q_2
Q_1	Q_2	Q_0
Q_2 *	Q0	---

OR

(b) Prove that the following CFG is Ambiguous. **07**

S -> S + S | S * S | a | b

Write the unambiguous CFG based on precedence rules for the above grammar. Derive the parse tree for expression (a + a)*b from the unambiguous grammar.

Q.3 **(a)** Let A = {1, 2, 3, 4, 5, 6} and R be a relation on A such that aRb iff a is a multiple of b. Write R. Check if the relation is i) Reflexive ii) Symmetric iii) Asymmetric iv) Transitive **07**

(b) There are 2 languages over $\sum$ = {a , b} **07**

L1 = all strings with a double "a"
L2 = all strings with an even number of "a"

Find a regular expression and an FA that define L1∩ L2

OR

Q.3 **(a)** If L ={ $0^i 1^i \mid i \geq 0$} Prove that L is regular. **07**

(b) Prove that if L1 and L2 are regular languages then L1∩ L2 is also a regular language. **07**

Q.4 **(a)** Given a CFG , G =({S,A,B},{0,1},P,S) with P as follows **07**
S --> 0B| 1A A --> 0S|1AA|0 B --> 1S| 0BB | 1
Design a PDA M corresponding to CFG, G. Show that the string 0001101110 belongs to CFL , L(G)

(b) Design a PDA, M to accept L = { $a^n b^{2n}$ | $n \geq 1$ } **07**

OR

Q.4 **(a)** Design a FA for the regular expression (0 + 1)(01)*(011)* **07**

(b) Write a regular expression for language L over {0,1} such that every string in L **07**
i) Begins with 00 and ends with 11.
ii) Contains alternate 0 and 1.

Q.5 **(a)** Draw a transition diagram for a Turing machine accepting the following language. { $a^n b^n c^n$ | $n \geq 0$ } **07**

(b) Explain Universal Turing machine with the help of an example **07**

OR

Q.5 **(a)** Define functions by Primitive Recursion. Show that the function f(x, y) = x + y is primitive recursive. **07**

(b) Prove Kleene's Theorem (Part I): Any Regular Language can be accepted by a Finite Automaton (FA). **07**

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Seat No.: _____ **Enrolment No._____**

GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER–VI (NEW) - EXAMINATION – SUMMER 2017

Subject Code: 2160704 **Date: 03/05/2017**

Subject Name: Theory of Computation

Time: 10:30 AM to 01:00 PM **Total Marks: 70**

Instructions:

1. **Attempt all questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**
4. **In the questions the symbol Λ denotes the null string, i.e., the string of length zero.**

			MARKS
Q.1		**Answer the following questions:**	
	1	Define onto and one-to-one functions.	**02**
	2	Give recursive definition of a tree.	**03**
	3	Define reflexivity, symmetry, and transitivity properties of relations.	**03**
	4	Consider the relation R = {(1,2), (1,1), (2,1), (2,2), (3,2), (3,3)} defined over {1, 2, 3}. Is it reflexive? Symmetric? Transitive? Justify each of your answers.	**03**
	5	Draw truth table for following logic formula: P → (¬P V ¬Q). Is it a tautology? A contradiction? Or neither? Justify your answer.	**03**
Q.2	**(a)**	Define DFA and NFA and NFA- Λ	**03**
	(b)	Give recursive definitions of the extended transition functions, $\hat{\delta}$ (i.e., for strings) for DFA and NFA.	**04**
	(c)	Minimize the DFA shown in Fig. 1.	**07**
		OR	
	(c)	Consider the NFA-Λ depicted in following table:	**07**

	Λ	a	b	c
→p	Φ	{p}	{q}	{r}
q	{p}	{q}	{r}	Φ
* r	{q}	{r}	Φ	{p}

(i) Compute the Λ-closure of each state.

(ii) Convert the NFA-Λ to a DFA.

Q.3	**(a)**	Explain 'finite state machines with outputs'. Discriminate between Mealy and Moore machines.	**03**
	(b)	Convert the Moore machine shown in Fig. 2 into an equivalent Mealy machine.	**04**
	(c)	Use Pumping Lemma to show that L = {x Є {0,1}* | x is a palindrome} is not a regular language.	**07**
		OR	
Q.3	**(a)**	Give recursive definition of regular expressions. State the hierarchy of the operators used in regular expressions.	**03**
	(b)	Using constructive approach determine NFA- Λ for the regular expression (0 + 1)*1(0 + 1).	**04**
	(c)	Fig. 3 shows two DFAs M1 and M2, to accept languages L_1 and L_2, respectively. Determine DFAs to recognize L_1 U L_2.	**07**

Q.4	**(a)**	Give formal definition of PDA. Give mathematical description of 'acceptance of a string by a PDA by empty stack'.	**03**
	(b)	Give the recursive definition of the iterated derivation (i.e., derivation in zero or more steps), denoted as $=>^*$. Give mathematical description of the language of a CFG.	**04**
	(c)	Consider following grammar: S → A1B A → 0A | Λ B → 0B | 1B | Λ Give leftmost and rightmost derivations of the string 00101. Also draw the parse tree corresponding to this string.	**07**
		OR	
Q.4	**(a)**	Define CFG. When is a CFG called an 'ambiguous CFG'?	**03**
	(b)	Consider following grammar: S → ASB | Λ A → aAS | a B → SbS | A | bb i. Eliminate useless symbols, if any. ii. Eliminate Λ productions.	**04**
	(c)	Convert the following grammar to a PDA: I → a | b | Ia | Ib | I0 | I1 E → I | E * E | E + E | (E)	**07**
Q.5	**(a)**	Give definition of Turing Machine. What do you mean by an instantaneous description of a Turing Machine?	**03**
	(b)	Describe recursive languages and recursively enumerable languages.	**04**
	(c)	Design a Turing machine to accept the language $\{0^n1^n \mid n \geq 1\}$.	**07**
		OR	
Q.5	**(a)**	Briefly describe following terms: (1) halting problem (2) undecidable problem	**03**
	(b)	Using pumping lemma for CFL's, show that the language $L = \{a^m b^m c^n \mid m \leq n \leq 2m\}$ is not context free.	**04**
	(c)	Design a Turing machine for the language over {0,1} containing strings with equal number of 0's and 1's.	**07**

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Figures

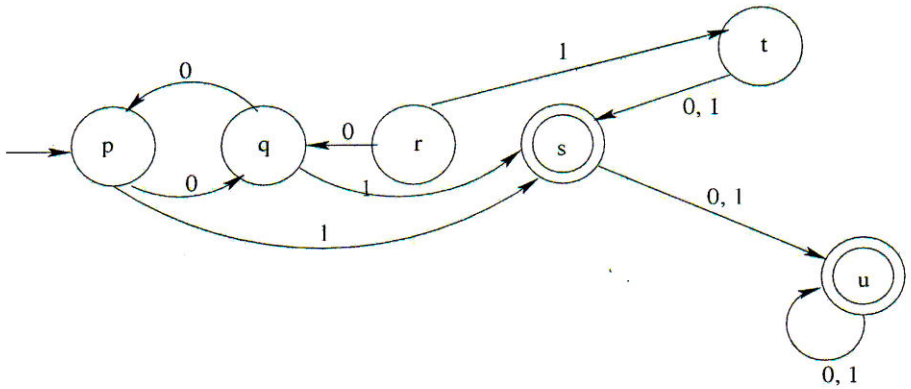

Fig. 1 for Q 2 (c)

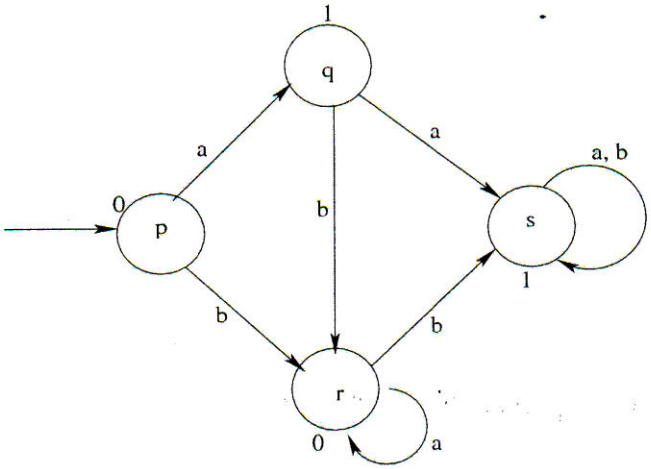

Fig. 2 for Q 3 (b)

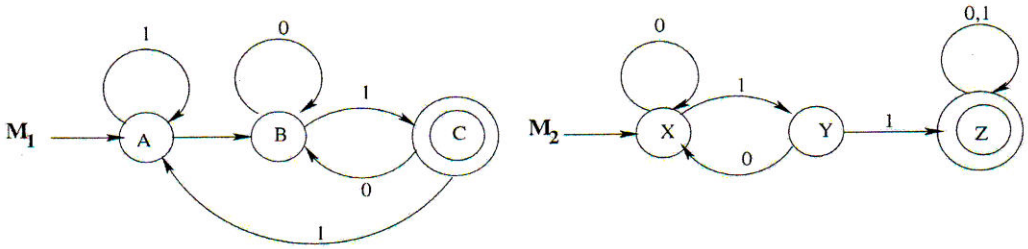

Fig. 3 for Q 3 (c) (OR)

3

Note: In Fig.3 for Q:3 (c) consider transition from A -> B having symbol 0.