

THEORY OF COMPUTATION
(CSEN 5234)

Time Allotted : 2½ hrs

Full Marks : 60

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 4 (four) from Group B to E, taking one from each group.

Candidates are required to give answer in their own words as far as practicable.

Group - A

1. Answer any twelve: **12 × 1 = 12**

Choose the correct alternative for the following

- (i) If a nondeterministic finite automaton has N states then the corresponding equivalent deterministic finite automaton cannot have more than
 - (a) N states
 - (b) (N+1) states
 - (c) 2^N states
 - (d) 2^{2^N} states
- (ii) For a DFA having N states if it accepts a string of length x such that $x \geq N$ then the language accepted by the DFA is
 - (a) Empty
 - (b) Finite
 - (c) Infinite
 - (d) Not possible to determine
- (iii) Choose the correct statement
 - (a) Moore and Mealy machine outputs does not depend on input
 - (b) Moore and Mealy machine outputs depend on input
 - (c) Moore and Mealy machine outputs depend on current state
 - (d) Moore and Mealy machine outputs depend on both the input and the current state
- (iv) Which of the following is a regular language?
 - (a) $L_1 = \{ a^n b^n \mid n \geq 0 \}$
 - (b) $L_2 = \{ a^n \mid n \text{ is a prime number} \}$
 - (c) $L_3 = \{ a^n b^m \mid n, m \geq 0 \text{ and } n+m \geq 3 \}$
 - (d) $L_4 = \{ a^n b^m \mid n, m \geq 0 \text{ and } n \geq 2^m \}$
- (v) Which of the following grammars generates a regular language?
 - (a) Right-linear grammar
 - (b) Context-free grammar
 - (c) Context-sensitive grammar
 - (d) Unrestricted grammar
- (vi) Consider the languages:
 - $L_1 = \{ ww^R \mid w \in \{0,1\}^* \}$
 - $L_2 = \{ w\#w^R \mid w \in \{0,1\}^* \}$, where # is a special symbol
 - $L_3 = \{ ww \mid w \in \{0,1\}^* \}$

Which one of the following is false?

 - (a) L_1 is deterministic CFL
 - (b) L_2 is deterministic CFL
 - (c) L_3 is CFL
 - (d) Both (b) & (c)

(vii) The language generated by the grammar $S \rightarrow aSb \mid \epsilon$ is
 (a) $\{a^n b^n \mid n \geq 0\}$ (b) $\{a^n b^m \mid n, m \geq 0\}$
 (c) $\{a^n b^n c^n \mid n \geq 0\}$ (d) $\{a^n b^n \mid n > 0\}$

(viii) For a Turing Machine M, where $\langle M \rangle$ denotes the encoding, consider the following two languages:
 $L_1 = \{ \langle M \rangle \mid M \text{ takes more than 2021 steps on all inputs}\}$
 $L_2 = \{ \langle M \rangle \mid M \text{ takes more than 2021 steps on some input}\}$
 Which of the following is true?
 (a) Both L_1 & L_2 are decidable (b) L_1 is decidable but L_2 is undecidable
 (c) Both L_1 & L_2 are undecidable (d) L_1 is undecidable but L_2 is decidable

(ix) Recursive language is closed under which of the following operations such that Recursively Enumerable language is not closed under that operation?
 (a) Union (b) Intersection
 (c) Concatenation (d) Complementation

(x) Which language is undecidable?
 (a) The language of palindromes (b) The language of prime numbers
 (c) The Post Correspondence Problem (d) The language of balanced parentheses

Fill in the blanks with the correct word

(xi) The state transition function of an NFA- ϵ , $N1 = (Q, q_0, \Sigma, F, \delta)$ is given by $\delta: \dots$.

(xii) The complement of a regular language is a \dots language.

(xiii) A pushdown automaton \dots be designed to accept the language $L = \{a^n b^n c^{2n} \mid n \geq 0\}$

(xiv) A Turing Machine is said to be \dots if it always halts on every input.

(xv) A Turing Machine that can simulate any other Turing Machine is called a \dots Turing Machine.

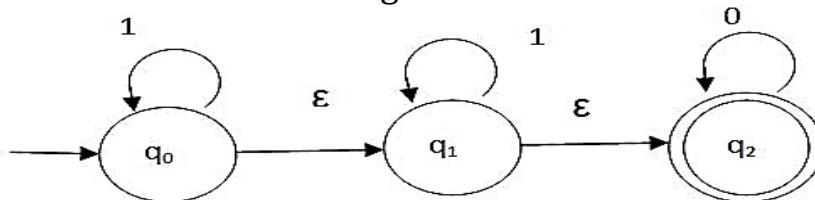
Group - B

2. (a) Convert this Mealy Machine to Moore Machine:

Present State	Next State			
	Input 0		Input 1	
	State	Output	State	Output
$\rightarrow q_1$	q3	1	q2	1
q2	q1	0	q4	1
q3	q2	0	q1	0
q4	q4	0	q3	1

(C01) (Apply/IOCQ)

(b) Remove ϵ -transitions from the given NFA



[(C01)(Apply/IOCQ)]

6 + 6 = 12

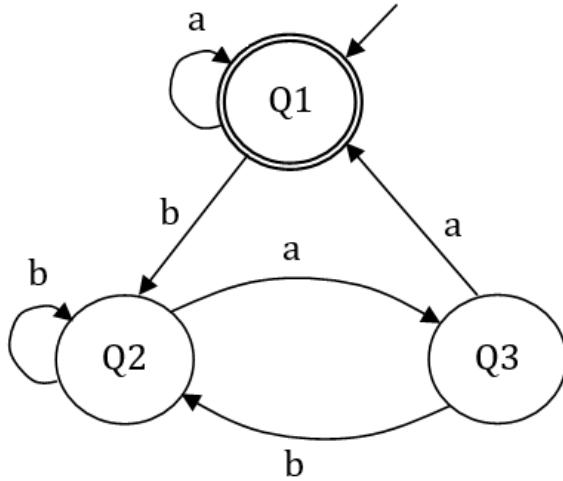
3. (a) Define the following:
 (i) DFA
 (ii) NFA
 (iii) State transition diagrams. [(CO1)(Remember/LOCQ)]

(b) Design a DFA defined over the alphabet set {0,1} which accepts all binary strings beginning with 1 and are divisible by 5. [(CO2)(Apply/HOCQ)]

$$(2 + 2 + 2) + 6 = 12$$

Group - C

4. (a) Apply Arden's theorem to find the regular expression of the following DFA:



(b) What do you mean by Chomsky classification of Grammar? [(CO3)(Remember/LOCQ)]

$$6 + 6 = 12$$

5. (a) Show that $L = \{a^p \mid p \text{ is prime}\}$ is not regular. [(CO2)(Apply/LOCQ)]
 (b) Show that The family of regular languages is closed under union, intersection, concatenation. [(CO6)(Understand/LOCQ)]

$$3 + (3 + 3 + 3) = 12$$

Group - D

6. (a) Construct PDA for the language $L = \{a^n b a^{2n} \mid n \geq 1\}$. This means the PDA should have twice as many as a's after b than before b, and there should be one and only one b. [(CO4)(Apply/LOCQ)]
 (b) Convert the following CFG to Chomsky Normal Form:

$$\begin{aligned} S &\rightarrow ASa \mid aB \\ A &\rightarrow B \mid S \\ B &\rightarrow b \mid \epsilon. \end{aligned}$$

[(CO5)(Apply/HOCQ)]

$$8 + 4 = 12$$

7. (a) State pumping lemma for Context-free Languages. [(CO3)(Remember/LOCQ)]
 (b) Prove that the family of context-free languages is closed under union and concatenation. [(CO3)(Remember/LOCQ)]

(c) Let G be the grammar $S \rightarrow 0B|1A$, $A \rightarrow 0|0S|1AA$, $B \rightarrow 1|1S|0BB$. For string 00110101, find (i) leftmost derivation (ii) rightmost derivation.

[(CO3)(Understand/LOCQ)]

$$2 + (3 + 3) + (2 + 2) = 12$$

Group - E

8. (a) Define P class and NP class. *[(CO6)(Remember/LOCQ)]*
 (b) What do you mean by $P = NP$ and $P \neq NP$? *[(CO6)(Remember/LOCQ)]*
 (c) What do you mean by polynomial-time reduction? *[(CO6)(Remember/LOCQ)]*
 (d) What is recursively enumerable language? Which type of language is recursively enumerable? *[(CO6)(Remember/LOCQ)]*

$$(2 + 2) + (2 + 2) + 2 + (1 + 1) = 12$$

9. (a) Define deterministic and nondeterministic Turing Machines. *[(CO6)(Remember/LOCQ)]*
 (b) Design a TM which can multiply two positive integers. *[(CO6)(Analyse/HOCQ)]*

$$(2 + 2) + 8 = 12$$

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	51.04	30.21	18.75