

**FORMAL LANGUAGE & AUTOMATA THEORY  
(CSEN 3002)**

**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) 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
- (ii) Which of the following is true about a DFA?  
(a) It can have multiple initial states  
(b) It can have multiple accepting states  
(c) It allows  $\epsilon$ -transitions  
(d) It accepts context-free languages.
- (iii) 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)  $L_3 = \{ a^n b^m \mid n, m \geq 0 \text{ and } m+n \geq 3 \}$  (d)  $L_4 = \{ a^n b^m \mid n, m \geq 0 \text{ and } n \geq 2 \cdot m \}$ .
- (iv) Which of the following is true?  
(a)  $(01)^*0 = 0(10)^*$   
(b)  $(0+1)^*01(0+1)^*+1^*0^* = (0+1)^*$   
(c)  $(0+1)^*0(0+1)^*1(0+1) = (0+1)^*01(0+1)^*$   
(d) All of the above.
- (v) Which of the following is a CFL?  
(a)  $L_1 = \{ a^n b^m c^k \mid m, n, k \geq 0 \text{ and } k = m+n \}$  (b)  $L_2 = \{ a^n b^{2n} \mid n \geq 0 \}$   
(c)  $L_3 = \{ a^n b^n c^{3n} \mid n \geq 0 \}$  (d) Both (a) & (b).
- (vi) A PDA is defined by which of the following components?  
(a) States, alphabet, stack alphabet, transitions, start state, accept state, stack  
(b) States, alphabet, transitions, start state, accept state  
(c) States, alphabet, stack alphabet, transitions, start state, accept state  
(d) States, alphabet, transitions, start state.

- (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) 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.
- (ix) Which machine model is used to define the concept of decidability?  
 (a) Finite Automaton (b) Pushdown Automaton  
 (c) Counter Machine (d) Turing Machine.
- (x) Which of the following problems is known to be undecidable?  
 (a) Checking if a CFG is ambiguous  
 (b) Checking if a Turing Machine halts on an input  
 (c) Checking if a language is regular  
 (d) Checking if a PDA accepts a given input.

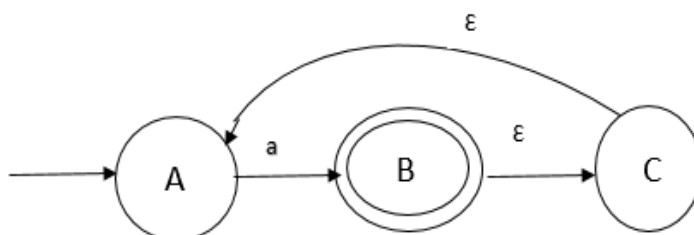
*Fill in the blanks with the correct word*

- (xi) The state transition function of an NFA- $\epsilon$ ,  $N1=(Q, q_0, \Sigma, F, \delta)$  is given by  $\delta$ : \_\_\_\_\_.
- (xii) The number of states of a minimum state DFA which accepts at most N a's in the language defined over  $\Sigma =\{a,b\}$  is \_\_\_\_\_.
- (xiii) A finite state machine (FSM) with outputs that depend on the current state and the input symbol is known as a \_\_\_\_\_.
- (xiv) The complement of a regular language is a \_\_\_\_\_ language.
- (xv) A Turing Machine that can simulate any other Turing Machine is called a \_\_\_\_\_ Turing Machine.

### Group - B

2. (a) Give 5-tuple definitions of the following:-  
 (i) DFA (ii) NFA (iii) NFA- $\epsilon$   
 You must state the meaning of each symbol used in the definitions. [[CO1](Remember/LOCQ)]
- (b) Design a minimum state 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**

3. (a)



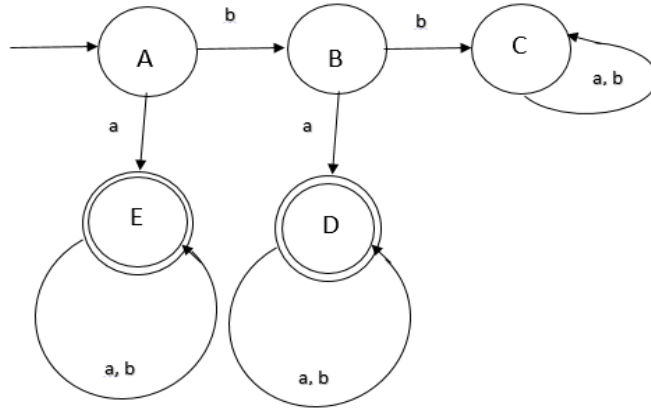
Given the above state transition diagram of an NFA-ε defined over the alphabet set {a} answer the following:-

- (i) Write the regular expression of the language accepted by the NFA-ε
- (ii) Draw a minimum state DFA defined over the same alphabet set which accepts the complement of the language accepted by the given NFA-ε.

[[CO2](Apply/IOCQ)]

- (b) Consider the following DFA defined over the alphabet set {a,b} Obtain the distinguishable & indistinguishable states and hence design the minimum state equivalent DFA.

[[CO2](Apply/IOCQ)]



**(2 + 3) + 7 = 12**

**Group - C**

4. (a) Consider this language:  
 $L = \{a^m b^n : m \geq 0 \ \& \ n \geq 0 \ \text{and} \ m=n\}$ .  
 Is this language regular? If this language is regular then prove your conjecture by constructing a regular grammar/regular expression or deterministic finite automata which accepts this language. If this language is not regular then prove this hypothesis.

[[CO2](Analyze/IOCQ)]

- (b) Let  $L_{10}$  be the set of all palindromes over {a, b}.  
 Construct a grammar G generating  $L_{10}$ .  
 According to Chomsky classification, which type of grammar is this?  
 Can we construct a nondeterministic finite automaton for this language?

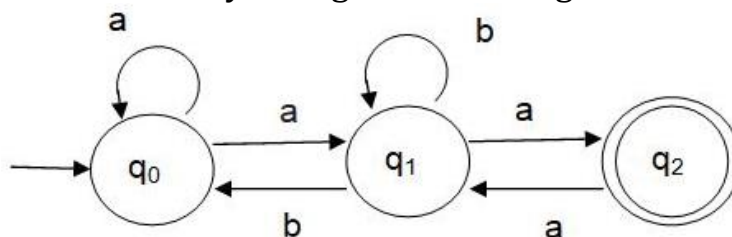
[[CO6](Understand/LOCQ)]

**5 + (3 + 2) + 2 = 12**

5. (a) Prove,  $(1 + 00^*1) + (1 + 00^*1)(0 + 10^*1)^* (0 + 10^*1) = 0^*1(0 + 10^*1)^*$

[[CO2](Apply/IOCQ)]

- (b) Consider the transition system given in the Figure.



Prove that the strings recognized are  $(a + a(b + aa)^*b)^* a(b + aa)^* a$ .

[[CO2](Apply/IOCQ)]

- (c) What do you mean by right linear grammar? Give an example.

[[CO6](Understand/LOCQ)]

**3 + 6 + 3 = 12**

## Group - D

6. (a) Design a pushdown automata accepting  $L = \{w \in \{a,b\}^* : \text{number of } a\text{'s in } w \text{ is exactly equal to the number of } b\text{'s in } w\}$ . [[CO4](Create/HOCQ)]
- (b) Using the Pumping Lemma for Context-Free Languages, show that the given language
- $$L = \{0^a 1^b 0^a 1^b \mid a > 0, b > 0\}$$
- is not a Type 2 (context-free) language. [[CO3](Analyze/IOCQ)]
- 6 + 6 = 12**
7. (a) Design a pushdown automaton which accepts the language  $L = \{a^i b^j c^{(i+2j)} \mid i, j > 0\}$  [[CO6](Create/HOCQ)]
- (b) Convert the following CFG to Greibach Normal Form:-  
 $S \rightarrow AB$   
 $A \rightarrow aA \mid bB \mid B$   
 $B \rightarrow b$  [[CO5](Apply/HOCQ)]
- (c) Remove all unit productions from the following CFG:-  
 $S \rightarrow Aa \mid B$   
 $B \rightarrow A \mid bb$   
 $A \rightarrow a \mid bc \mid B$  [[CO6](Apply/IOCQ)]
- 6 + 3 + 3 = 12**

## Group - E

8. (a) Design a Turing machine  $M_{11}$  that find the 1's complement of a binary number. e.g. if the input number is 00110 then the output will be 11001. [[CO5](Create/HOCQ)]
- (b) What is the difference between recursively enumerable and recursive language? [[CO7](Understand/LOCQ)]
- 7 + 5 = 12**
9. (a) Define the diagonalization method. [[CO2](Understand/LOCQ)]
- (b) How does it relate to the concept of undecidability? [[CO2](Analyze/IOCQ)]
- (c) What is meant by decidability in the context of Turing Machines? [[CO1](Understand/IOCQ)]
- 4 + 4 + 4 = 12**

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	26	45	29