

**FORMAL LANGUAGE & AUTOMATA THEORY
(CSE3002)**

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) A Moore machine with N states is converted into a Mealy machine which has M states. Which of the following is not possible?
(a) $N = M$ (b) $N < M$ (c) $N > M$ (d) Both (a) & (b)
- (ii) If two states are 2-Equivalent, then they are
(a) 3-Equivalent as well
(b) 1-Equivalent as well
(c) Both (a) and (b) are correct
(d) Can't say anything regarding the other equivalence
- (iii) In a Moore machine, the output depends on:
(a) Input only (b) Current state only
(c) Input and current state (d) Input, current state and transition
- (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) $L_3 = \{ a^n b^m \mid n, m \geq 0 \text{ and } m+n \geq 3 \}$ (d) $L_4 = \{ a^n b^m \mid n, m \geq 0 \text{ and } n \geq 2 \cdot m \}$
- (v) The Pumping Lemma for Regular Languages can be used to prove that a given language
(a) is Type 2 (b) is Type 3
(c) is not Type 2 (d) is not Type 3
- (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 a deterministic CFL (b) L_2 is a 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) If L_4 is a Context Free Language and L_5 is a Regular Language then the intersection of L_4 and L_5 i.e. $L_4 \cap L_5$ is
- (a) Also a Regular language (b) A context-free language
(c) a Linear language (d) Neither a CFL nor a Regular language
- (ix) 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
- (x) A language is called **decidable** if:
- (a) There exists a TM that accepts all strings
(b) There exists a TM that halts for every input
(c) There exists an NFA for the language
(d) There exists a PDA for the language

Fill in the blanks with the correct word

- (xi) The number of states of a DFA which accepts at most N a's in the language defined over $\Sigma = \{a, b\}$ is _____.
- (xii) The regular expression to denote the language L defined over $\Sigma = \{a, b\}$ is given by _____.
- (xiii) In the Chomsky hierarchy, regular grammars are classified as Type _____ grammars.
- (xiv) A _____ pushdown automaton has at most one transition for each input symbol and stack symbol.
- (xv) The **Pumping Lemma** for regular languages is mainly used to prove that a language is _____.

Group - B

2. (a) A non-deterministic finite state acceptor (NFA) M_2 has the state table shown below. S is the start state, and C is the only goal state. Convert M_2 to an equivalent deterministic finite state acceptor (DFA) M_3 , and clearly indicate the start and goal states.

	0	1
$\rightarrow S$	P	Q
P	P, A	B, C
Q	Q, A	B, C
A	A, C	----
B	---	C
*C	C	C

- (b) Construct a DFA over the alphabet $\{0, 1\}$ that accepts those strings that contain the pattern 101 somewhere.
- (c) What do you mean by 1-equivalent states?

[[CO1] (Apply/IOCQ)]

[[CO2] (Create/HOCQ)]

[[CO1] (Remember/LOCQ)]

5 + 5 + 2 = 12

3. (a) Convert the given Moore machine to a Mealy machine.

State Transition Table:

Current State	Input	Next State	Output
q0	0	q1	0
q0	1	q2	1
q1	0	q0	0
q1	1	q3	1
q2	0	q3	1
q2	1	q0	0
q3	0	q2	1
q3	1	q1	0

[[CO2](Apply/IOCQ)]

(b) Define the 5-tuple for a DFA and explain each component.

[[CO3](Apply/LOCQ)]

(c) Design a DFA for the language consisting of binary strings with an even number of '1's.

[[CO3](Apply/IOCQ)]

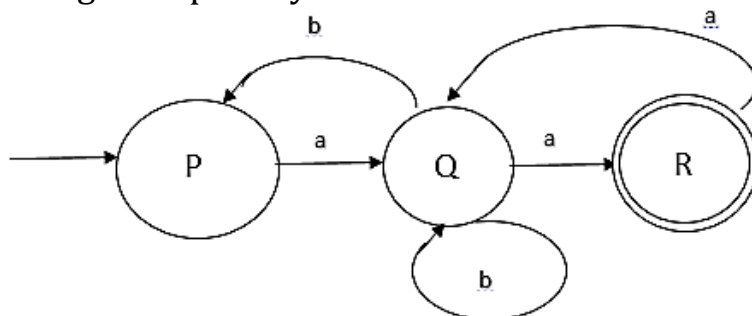
6 + 3 + 3 = 12

Group - C

4. (a) Determine with proper justification if the language $L = \{a^n b^{3n}, n \geq 0\}$ is regular or not.

[[CO3](Analyse/IOCQ)]

(b) Consider the state transition diagram of an FSM given below, defined over the alphabet set $\{a, b\}$. Using Arden's theorem, obtain the regular expression of the strings accepted by the FSM.



[[CO6](Analyse/IOCQ)]

6 + 6 = 12

5. (a) Write short notes on the following with examples:

(i) Chomsky's classification of Grammar

(ii) Left Linear Grammar

(iii) Pumping Lemma for Regular Language.

[[CO6](Understand/LOCQ)]

(b) (i) What can you say about the number of 0's & 1's accepted in the language described by the following regular expression? Show all steps of deduction.

$$((0+1)(0+1))^* + ((0+1)(0+1)(0+1))^*$$

(ii) Prove that $(0 + 11^*0) + (0 + 11^*0)(1 + 00^*1)^*(1 + 00^*1) = 1^*0(1 + 00^*1)^*$

[[CO2](Apply/IOCQ)]

(4 + 2 + 2) + (2 + 2) = 12

Group - D

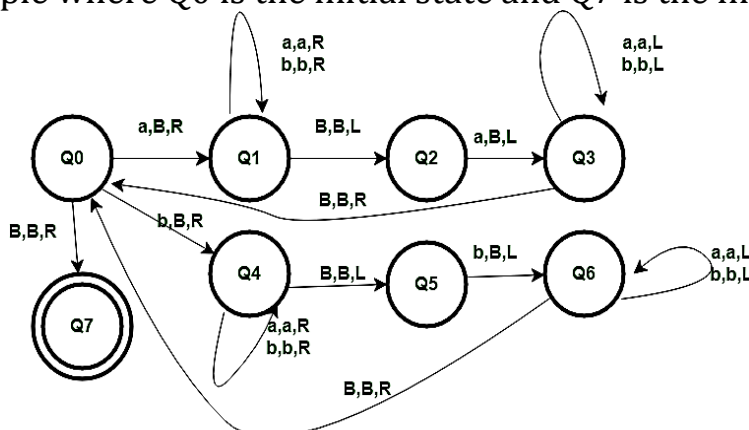
6. (a) Design a pushdown automata accepting $L = \{w \in \{a, b\}^*: \text{number of } a\text{'s in } w \text{ is exactly equal to the number of } b\text{'s in } w\}$.

[[CO4](Create/HOCQ)]

- (b) Using the Pumping Lemma for Context-Free Languages, show that $L = \{ 0^a 1^b 0^a 1^b \mid a > 0, b > 0 \}$ is not a Type 2 (context-free) language.
 [[CO3](Analyze/IOCQ)]
6 + 6 = 12
7. (a) Show all steps to obtain a parse tree for the string "0011000" using the following grammar:
 $S \rightarrow A0S \mid 0 \mid SS$
 $A \rightarrow S \mid 1A \mid 10$
 [[CO3](Apply/IOCQ)]
- (b) Write appropriate grammars for the following languages:
 (i) $a^i b^j c^k d^l \mid i, j > 0$
 (ii) $a^x b^2 y c^x \mid x \geq 0 \text{ and } y > 0$
 [[CO4](Apply/IOCQ)]
- (c) Convert the following CFG to Greibach Normal Form:
 $S \rightarrow aSb \mid a \mid b$
 [[CO3](Apply/IOCQ)]
3 + (3 + 3) + 3 = 12

Group - E

8. (a) What is the language accepted by the below-mentioned Turing machine? Where B, L, and R stand for a blank symbol, Left movement of the R/W head, and Right movement of the R/W head, respectively. Explain it with proper justification and example where Q0 is the initial state and Q7 is the final state.



[[CO5](Analyze/IOCQ)]

- (b) Among the below-mentioned problem statements, which problems are undecidable?
 (i) Turing Machine Halting problem
 (ii) Is a given CFG ambiguous or not?
 (iii) Complement of a Recursively Enumerable language
 (iv) Whether the intersection of two regular languages is infinite?
 (v) Whether two Push Down Automata accept the same language?
 (vi) Whether the given grammar is regular or not?
 [[CO2, CO3](Analyze/IOCQ)]
6 + (6 × 1) = 12
9. (a) Design a Turing Machine M_6 which accepts the language $L_{61} = \{ 0^i 1^j 0^i 1^j \mid i, j > 0 \}$
 [[CO6](Create/HOCQ)]
- (b) What do you understand about a multi-tape Turing Machine & Nondeterministic Turing Machine?
 [[CO1](Remember/LOCQ)]
8 + (2 + 2) = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	17.7	62.5	19.8