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)

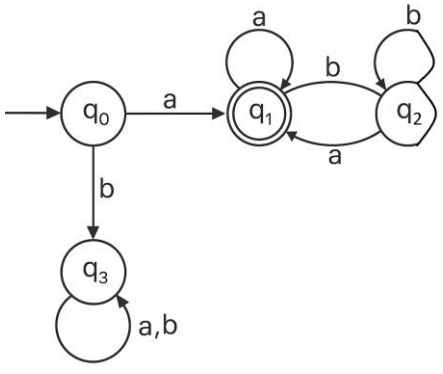
(ii) A sequence detector can be implemented using which of the following?
(a) NFA (b) DFA (c) Mealy Machine (d) All of the above.

(iii) Which of the following best describes a Deterministic Finite Automaton (DFA)?
(a) A machine where output depends on states.
(b) A machine where ε-transitions are allowed.
(c) A machine where multiple transitions are possible for a single input.
(d) A machine where for each state and input, there is exactly one transition.

(iv) Which of the following is a regular language?
(a) $L_1 = \{ a^n b^n \mid n>=0 \}$ (b) $L_2 = \{ a^n \mid n \text{ is a prime number}\}$
(c) $L_3 = \{ a^n b^m \mid n,m>=0 \text{ and } m+n>=3 \}$ (d) $L_4 = \{ a^n b^m \mid n,m>=0 \text{ and } n>=2*m\}$

(v) The language $L_1 = \{a^n b^n : n \geq 0\}$ is
(a) Unrestricted but not context sensitive (b) Context-sensitive but not context-free
(c) Context-free but not regular (d) Regular but not context-free

(vi) Which of the following is not a regular expression for the following FSA



(a) aa*(bb*a)* (b) a(a + bb*a)* (c) a(a + b)*a + a (d) a(a + aa + bb*a)*

(vii) 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

(viii) The language generated by the grammar S → aSb | ε is:
(a) {a^nb^n | n ≥ 0} (b) {a^nb^m | n, m ≥ 0}
(c) {a^nb^nc^n | n ≥ 0} (d) {a^nb^n | n > 0}

(ix) For a Turing Machine M, where <M> denotes the encoding, consider the following two languages:
L_1 = { <M> | M takes more than 2021 steps on all inputs}
L_2 = { <M> | M 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

(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) A finite state machine (FSM) with outputs that depend on the current state and the input symbol is known as a _____.

(xii) According to Arden's theorem, a regular expression R = Q + RP has a unique solution given by _____.

(xiii) A pushdown automaton _____ be designed to accept the language L = { $a^n b^n c^{2n}$ | n>=0}

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

(xv) Let L1 = { 0^i | i ≥ 0 }, L2 = {1^i | i ≥ 0 }. Then L1L2 = _____.

Group - B

2. (a) A non-deterministic finite state acceptor (NFA) M2 has the state table shown below. S is the start state, and C is the only goal state. Convert M2 to an equivalent deterministic finite state acceptor (DFA) M3, and clearly indicate the start and goal states.

	0	1
→S	P	Q
P	P, A	B, C
Q	Q, A	B, C
A	A, C	----
B	---	C
*C	C	C

[(CO1)(Apply/IOCQ)]

(b) Construct a DFA over the alphabet {0, 1} that accepts those strings that contain the pattern 101 somewhere. *[(CO2)(Create/HOCQ)]*

(c) What do you mean by 1-equivalent states? *[(CO1)(Remember/LOCQ)]*

5 + 5 + 2 = 12

3. (a) Do you agree that the main limitation of FSMs is their finite memory? Justify your response. *[(CO1)(Analyse/IOCQ)]*

(b) Design a DFA that accepts strings over the alphabet {0, 1} that end with "110". *[(CO2)(Apply/IOCQ)]*

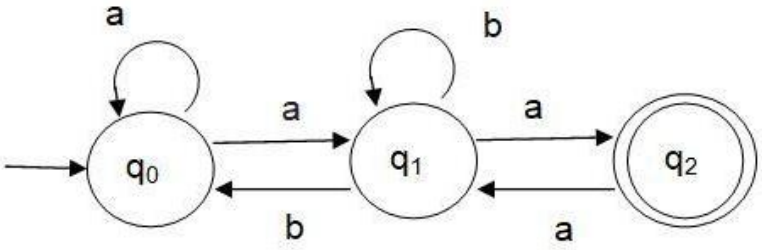
(c) Define a finite state machine (FSM) and explain its components. *[(CO1)(Remember/LOCQ)]*

4 + 4 + 4 = 12

Group - C

4. (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.



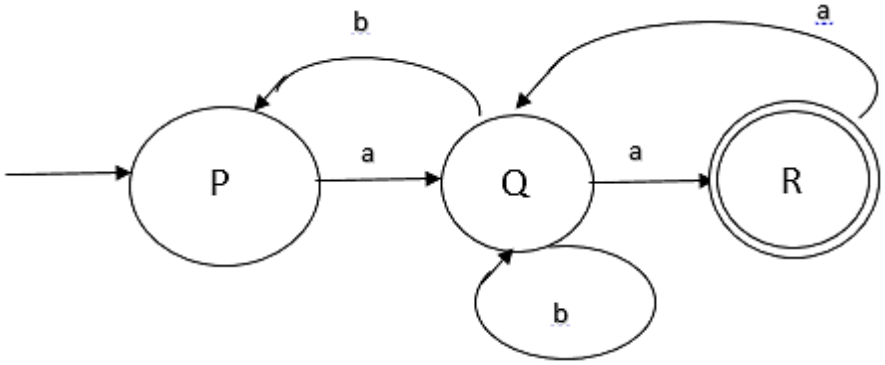
Prove that the strings recognized are (a + a(b + aa)*b)* a(b + aa)* a. *[(CO2)(Apply/IOCQ)]*

(c) What do you mean by right linear grammar? Give an example. *[(CO6)(Understand/LOCQ)]*

3 + 6 + 3= 12

5. (a) Determine with proper justification if the language L = { $a^n b^{3n}$, n>=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

Group - D

6. (a) Remove left recursion from the following grammars:-

G1	G2	G3
S → AB	S → Aa | B	S → Aa | Bb | c
A → Aa | B	A → Bb | Sc | ε	A → Bd | ε
B → c	B → d	B → Ae | ε

[(CO3)(Apply/IOCQ)]

(b) Determine with proper justification if the following grammar is ambiguous or not:- S → a | bSS | SSb | SbS | Sa. *[(CO4)(Analyse/IOCQ)]*

(3 + 3 + 3) + 3 = 12

7. (a) Design a pushdown automaton for the language L = {a^nb^n | n ≥ 0}. *[(CO6)(Create/HOCQ)]*

(b) Given the following context-free grammar (CFG):
S → aAB | bBA
A → aA | ε
B → bB | ε
Show that the given CFG is ambiguous by constructing two different parse trees for the same string. Use the string aabb as an example. *[(CO3)(Analyse/IOCQ)]*

6 + 6 = 12

Group - E

8. (a) Design a Turing Machine M_3 which accepts all odd-length palindromes defined over the alphabet set {a,b}. *[(CO6)(Create/HOCQ)]*

(b) Design a Turing Machine M_4 that accepts the language
$L_{45} = \{w\#w \mid w \in \{a,b\}^*\}$ *[(CO6)(Create/IOCQ)]*

6 + 6 = 12

9. (a) Define the diagonalization method. *[(CO2)(Understand/LOCQ)]*

(b) How does it relate to the concept of undecidability? *[(CO2)(Analyse/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	13.5	68.75	17.7