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 <u>any 4 (four)</u> from Group B to E, taking <u>one</u> 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**

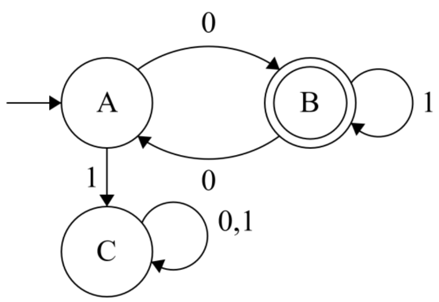
Choose the correct alternative for the following

(i) In a Mealy machine, the outputs are associated with transitions between states and are dependent on
(a) Current state only
(b) The input symbols only
(c) Both the input and output symbols
(d) Both the current state and the input symbols

(ii) A compiler must check the following syntactic error in a program :
Every opening curly bracket i.e. '{' must be associated with a closing curly bracket i.e. '}'. Which machine is sufficient (according to computation power) to decide it?
(a) Deterministic Finite Automata (b) Non Deterministic Finite Automata
(c) Pushdown Automata (d) None of the above.

(iii) Which of the languages will be accepted by a deterministic finite state automaton (DFSA):
(a) $L1=\{a^n b^n : n>5\}$ (b) $L2=\{a^{n!} : n>4\}$
(c) $L3=\{a^p : p \text{ is any prime number}\}$ (d) $L4=\{a^n b^n c^n : 10 \geq n \geq 0\}$

(iv) Which of the following will not be accepted by the following DFA?



(a) 01110011 (b) 011100 (c) 010100100 (d) 011001100

(v) Which one of the following languages cannot be accepted by a non-deterministic pushdown acceptor (ndpda)?
(a) $\{ 0^m 1^n \mid 0 < m, 0 < n \}$ (b) $\{ 0^m 1^n 0^m \mid 0 < m, 0 < n \}$
(c) $\{ 0^m 1^m 0^m \mid 0 < m \}$ (d) $\{ 0^m 1^n 0^r \mid 0 < m, 0 < n, 0 < r \}$.

(vi) Can a DFA recognize a palindrome number?
(a) Yes (b) No
(c) Yes, with input alphabet as ∑* (d) Can't be determined.

(vii) Match the type of language according to Chomsky hierarchy

(I)	Type 0	(i)	Regular Language
(II)	Type 1	(ii)	Context-Free Language
(III)	Type 2	(iii)	Context-Sensitive Language
(IV)	Type 3	(iv)	Recursively Enumerable Language

(a) I-iv, II-iii, III – ii, IV - i (b) I-iv, II-i, III – ii, IV– iii
(c) I-iv, II-iii, III – i, IV– ii (d) I-iii, II-iv, III – ii, IV – i

(viii) Which of the following identities for regular expression is FALSE?
[Here P, Q, R are all regular expressions, ϕ denotes null set and ε denotes empty string]
(a) R+R=R (b) (PQ)*P= P(QP)* (c) ϕ* = ε (d) (P+Q)*= (PQ)*

(ix) An ambiguous grammar for which there exists a string that can have more than one leftmost derivation or parse tree, cannot be
(a) regular (b) context free
(c) context sensitive (d) regular or context free.

(x) Arden's theorem is used for solving equations in the context of which type of grammars?
(a) Regular (b) Context-free (c) Context-sensitive (d) Unrestricted.

Fill in the blanks with the correct word

(xi) In a pushdown automaton (PDA), it employs a _____ data structure to determine its next move by considering its current state and the next input symbol.

(xii) The complement of Recursively Enumerable language is _________.

(xiii) PCP is _________.

(xiv) The formal definition of a context-sensitive language is based on a set of rules called ___________ rules.

(xv) If the TM halts, then the accepted/rejected language is _________.

Group - B

2. (a) A non-deterministic finite state acceptor (ndfsa) 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 (dfsa) M_3 and clearly indicating 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 an DFA over alphabet {0, 1} that accepts those strings that contain the pattern 001 somewhere. *[(CO1)(Design/HOCQ)]*

(c) What do you mean by 2- equivalent states? *[(CO1)(Remember/LOCQ)]*

5 + 5 + 2 = 12

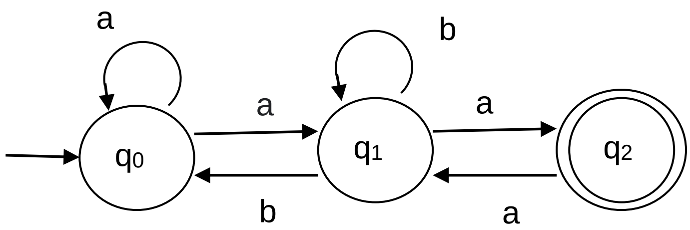
3. Provide DFA for the following language over the alphabets $\sum = \{0, 1\}$.
   (i) All strings containing three 1's.
   (ii) All strings containing even number of 0's and odd number of 1's
   (iii) All strings containing even number of 0's and 1's.
   (iv) All strings that begins with 10 and ends with 01. *[(CO6)(Apply/LOCQ)]*

(3 + 3 + 3 + 3) = 12

Group - C

4. (a) Describe the Pumping Lemma for regular languages, and then apply the Pumping Lemma to demonstrate that the language $L = \{1^n0^n \mid n \geq 0\}$ does not belong to the class of regular languages. *[(CO3)(Understand/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)(Evaluate/HOCQ)]

6 + 6 = 12

5. (a) Prove that, (1 + 00*1) + (1 + 00*1)(0 + 10*1)* (0 + 10*1) =0*1(0 + 10*1)* *[(CO2)(Apply/IOCQ)]*

(b) Describe the differences between right-linear and left-linear grammars and illustrate each type with an example. *[(CO2)(Analyze/LOCQ)]*

(c) Let L_{10} be the set of all palindromes over {a, b}.
Construct a grammar G generating L_{10}. *[(CO6)(Apply/IOCQ)]*

3 + 6 + 3 = 12

Group - D

6. (a) Simplify the given CFG.

$S \rightarrow ACD$
$A \rightarrow a \mid F$
$B \rightarrow \varepsilon$
$C \rightarrow ED \mid \varepsilon$
$D \rightarrow BC \mid b$
$E \rightarrow b$
$F \rightarrow aF$

[(CO3)(Apply/IOCQ)]

(b) Prove that if L1 and L2 are context free then L1 ∪ L2 is context free but L1 ∩ L2 need not be context free. *[(CO3)(Apply/IOCQ)]*

6 + 6 = 12

7. (a) Design a Pushdown Automata (PDA) that recognizes the language L = $\{1^n0^n \mid n \geq 0\}$. Provide a high-level description of how your PDA works. *[(CO4)(Create/HOCQ)]*

(b) Explain the process of converting a Context-Free Grammar (CFG) into an equivalent Pushdown Automata (PDA). What are the steps involved? Provide a simple example. *[(CO1)(Remember/IOCQ)]*

6 + 6 = 12

Group - E

8. (a) Design a Turing machine M_5 which can accept the language $L_{15} = \{a^nb^n: n>=1\}$. *[(CO5)(Create/HOCQ)]*

(b) Now show that M_5 accepts "aabb" but rejects "aba" and "baab". *[(CO5)(Apply/IOCQ)]*

7 + 5 = 12

9. (a) Explain the terms "decidable" and "undecidable" in the context of computational problems, with an example for each situation. *[(CO2)(Remember/IOCQ)]*

(b) Briefly explain the concept of a 'Universal Turing Machine'. Can it execute any effective procedure given suitable input? *[(CO2)(Understand/IOCQ)]*

(c) Is Turing Machine Halting Problem decidable or undecidable? Explain with reasons. *[(CO2)(Analyze/HOCQ)]*

4 + 4 + 4 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	20.83	50	29.17

Course Outcome (CO):

After the completion of the course students will be able to

CO1. Recall the basic characteristics of various types of machines, languages and grammars.

CO2. Compare different computational models, languages and grammars based on their properties and behaviors.

CO3. Apply formal mathematical methods to prove properties of languages, grammars, and automata.

CO4. Apply the knowledge of theory of computation to an engineering application (e.g., designing the compilers).

CO5. Classify formal languages and evaluate whether a language/grammar belongs to a given type or not.

CO6. Design automata for given languages/grammars. Generate languages/grammars for a given automaton and Construct grammars for languages and vice versa

**LOCQ: Lower Order Cognitive Question; IOCQ: Intermediate Order Cognitive Question; HOCQ: Higher Order Cognitive Question.*