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) In a Moore machine, the outputs are associated with:
(a) Transitions between the states (b) The input symbols
(c) The input and output symbols (d) The states themselves.

(ii) Given an alphabet {0, 1}, how many states are required in a DFA to recognize all strings with an odd number of 0's?
(a) 2 (b) 3 (c) 4 (d) 5.

(iii) Match the type of grammar according to Chomsky hierarchy

(I)	Type 0	(i)	Regular Grammar
(II)	Type 1	(ii)	Context Free Grammar
(III)	Type 2	(iii)	Context Sensitive grammar
(IV)	Type 3	(iv)	Unrestricted Grammar

(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.

(iv) If L_1 and L_2 are two regular languages, then L_1 and L_2 are closed under
(a) union (b) concatenation
(c) intersection (d) all of these.

(v) The regular expression for set of all strings of {0, 1} that contain string ending in 1 and does not contain substring 00 is given by
(a) (10 + 01)*1 (b) (01 + 11)*1
(c) (1 + 01)*+ 1 (d) None of these.

(vi) 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.

(vii) A Turing Machine can recognize which type(s) of languages?
(a) Regular languages only (b) Context-free languages only
(c) Context-sensitive languages only (d) All of the above.

(viii) Which type of automata can accept context-sensitive language?
(a) Turing machine
(b) Linear bounded automata
(c) Pushdown automata
(d) Deterministic finite automata.

(ix) Which regular expression can generate strings over {0,1}, having substring 01?
(a) $(0+1)^*01$
(b) $0^*1^*010^*1^*$
(c) $(0+1)^*01(0+1)^*$
(d) $01(0+1)^*$.

(x) Context free languages are not closed under
(a) union
(b) concatenation
(c) intersection
(d) none of these.

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 number of tuples in Turing machine definition is _________.

(xiii) In a finite state machine, the set of states where the machine can terminate and accept the input is known as the ___________ states.

(xiv) L and ~L are recursive enumerable, then L is _________.

(xv) The language which is accepted by PDA is known as _________.

Group - B

2. Provide DFA for the following language over the alphabets ∑ = {0, 1}.
(i) All strings containing three consecutive 0's.
(ii) All strings that do not end with 11.
(iii) All strings that begin with 00 and end with 11.
(iv) The string containing even number of 0's and odd number of 1's.

[(CSEN3102.6)(Apply/LOCQ)]

(3 + 3 + 3 + 3) = 12

3. (a) Design an NFA without ∈ transitions for the following ∈-NFA. Show each step.

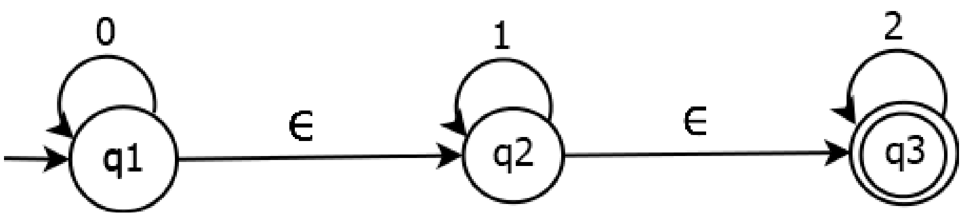

Fig. 1

[(CO2)(Analyse/IOCQ)]

(b) Construct a deterministic finite automata over Σ={0,1} such that the number of 0's is even and the number of 1's is divisible by 3. *[(CO6)(Apply/HOCQ)]*

(c) State the differences between deterministic and non-deterministic finite automata.

[(CO1)(Evaluate/LOCQ)]

4 + 5 + 3 = 12

Group - C

4. (a) Prove that the language $L=\{a^{n^2} | n>=1\}$ is not regular. Give justification of your answer. *[(CO3)(Analyse/LOCQ)]*

   (b) Construct a deterministic finite state automata over $\Sigma=\{0,1\}$ that accepts a string which is contained in the regular expression $R= 01+(0+1)^*(00+1)$. *[(CO6)(Understand/IOCQ)]*

   (c) Discuss different types of linear grammars with suitable examples. *[(CO1)(Remember/LOCQ)]*

5 + 5 + 2 = 12

5. (a) Determine the set of strings that are recognized by the given automata over the alphabets $\sum = \{0, 1\}$.

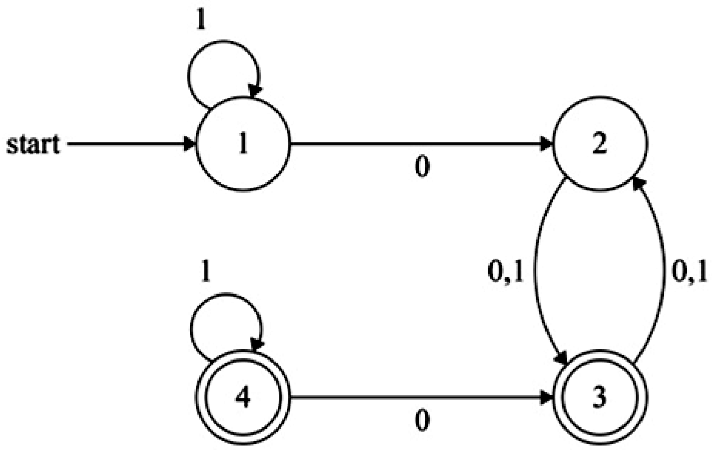

Fig. 2

[(CSEN3102.6)(Apply/IOCQ)]

   (b) List the closure properties of regular sets for each of the following operations: (i) Union (ii) Concatenation and (iii) Star (Kleene Closure)). *[(CSEN3102.2)(Remember/LOCQ)]*

6 + 6 = 12

Group - D

6. (a) Design context-free grammars for the following cases over $\Sigma=\{0,1\}$:
   (i) $L_1 = \{w \mid w$ is a string of palindromes of odd length$\}$
   (ii) $L_2 = \{w \mid w$ contains at least three 1's$\}$. *[(CO6)(Understand/IOCQ)]*

   (b) Is the following CFG ambiguous? Justify your answer.
   $S\rightarrow AB|aaB,\ A\rightarrow a|Aa,\ B\rightarrow b$ *[(CO3)(Evaluate/IOCQ)]*

   (c) Design a pushdown automata that can accept the language $L=\{a^{2n}b^n \mid n\geq=0\}$ over $\Sigma = \{a,b\}$. *[(CO6)(Apply/HOCQ)]*

(2 + 2) + 3 + 5 = 12

7. (a) Convert the following grammar to Chomsky Normal Form (CNF):
   $S\rightarrow AACD$
   $A \rightarrow aAb|\varepsilon$
   $C\rightarrow aC|a$
   $D\rightarrow aDa|bDb|\varepsilon$ *[(CSEN3102.6)(Apply/IOCQ)]*

(b) What are null productions in a Context-Free Grammar (CFG), and how can they be eliminated? *[(CSEN3102.5)(Understand/LOCQ)]*

(c) What are right-most and left-most derivations in a Context-Free Grammar (CFG)? Provide examples to demonstrate each type of derivation. *[(CSEN3102.1)(Apply/LOCQ)]*

6 + 3 + 3 = 12

Group - E

8. (a) Is the "halting problem" of Turing machine solvable or decidable? Justify. *[(CO1)(Analyse/IOCQ)]*

(b) Design a Turing machine for the language L which generates strings having equal number of 0's and 1's over $\Sigma = \{0,1\}$. *[(CO6)(Apply/IOCQ)]*

(c) Discuss different types of Turing machines. *[(CO2)(Understand/LOCQ)]*

4 + 4 + 4 = 12

9. (a) Describe Post's Correspondence Problem (PCP) and explain with appropriate example whether it is considered an undecidable problem. *[(CSEN3102.2)(Remember/IOCQ)]*

(b) Describe how a Universal Turing Machine can simulate the behaviour of any other Turing machine. *[(CSEN3102.2)(Understand/IOCQ)]*

6 + 6 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	39.58	50	10.41

Course Outcome (CO):

After the completion of the course students will be able to

CSEN3002.1. Recall the basic characteristics of various types of machines, languages and grammars.
CSEN3002.2. Compare different computational models, languages and grammars based on their properties and behaviors.
CSEN3002.3. Apply formal mathematical methods to prove properties of languages, grammars, and automata.
CSEN3002.4. Apply the knowledge of theory of computation to an engineering application (e.g., designing the compilers).
CSEN3002.5. Classify formal languages and evaluate whether a language/grammar belongs to a given type or not.
CSEN3002.6. 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.*