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) If a nondeterministic finite automaton has N states then the corresponding equivalent deterministic finite automaton cannot have more than
(a) N states (b) (N+1) states (c) 2*N states (d) 2^N states

(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 ε-transitions
(d) It accepts context-free languages.

(iii) What will be the minimum number of possible states of a DFA that accepts a language L = $\{w_1 0 w_2 | w_1, w_2 \in \{0, 1\}^*, |w_1|=2, |w_2|>=3\}$?
(a) 5 (b) 8 (c) 6 (d) 7

(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) A regular language:
(a) is also a context free language (b) is also a linear language
(c) need not to be context free (d) both (a) and (b)

(vi) Which of the following grammars generates a regular language?
(a) Right-linear grammar (b) Context-free grammar
(c) Context-sensitive grammar (d) Unrestricted grammar

(vii) Which of the following is a CFL?
(a) $L_1 = \{a^n b^m c^k \mid m, n, k>=0 \text{ and } k = m + n\}$ (b) $L_2 = \{a^n b^{2n} \mid n>=0\}$
(c) $L_3 = \{a^n b^n c^{3n} \mid n>=0\}$ (d) Both (a) & (b)

(viii) If a Context Free Language L_3 has a Type 2 grammar G which is ambiguous then there must be a terminal string α such that
(a) α has two different derivation trees
(b) α has two different rightmost derivations
(c) α has two different leftmost derivations
(d) All of the above.

(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) 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.

Fill in the blanks with the correct word

(xi) The state transition function of a ∈ – NFA, N1= (Q, q_0, Σ, F, δ), is given by δ: _____.

(xii) The complement of a regular language is a _____ language.

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

(xiv) A Turing Machine can be formally described by a 7-tuple, which includes a finite set of states, a finite set of input symbols, a _____, a transition function, a start state, an accept state, and a reject state.

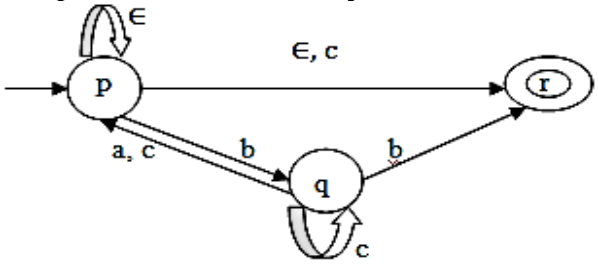
(xv) According to Arden's theorem, a regular expression R = Q + RP has a unique solution given by _____.

Group - B

2. (a) Consider the following Mealy machine. Convert this machine to its equivalent Moore machine with the clear explanations of all the steps. *[(CSEN3002.2)(Apply/IOCQ)]*

P.S.	Input = 0		Input = 1	
	N.S.	Output	N.S	Output
→q1	q3	1	q2	1
q2	q1	0	q4	1
q3	q2	0	q1	0
q4	q4	0	q3	1

(b) Define epsilon closure of a state in nondeterministic finite automata (NFA). Consider the following ∈ – NFA on ∑ = {a, b, c}, where p is the initial state, r is the final state and ∈ represents the null symbol:



Find the equivalent DFA of the given ε – NFA.

[(CSEN3002.1)(CSEN3002.2)(Remember/LOCQ)(Apply/IOCQ)]

6 + (1 + 5) = 12

3. (a) Define a finite state machine (FSM) and explain its components.

[(CSEN3002.1)(Remember/LOCQ)]

(b) Do you agree that the main limitation of FSMs is their finite memory? Justify your response. *[(CSEN3002.1)(Analyse/IOCQ)]*

(c) Design a DFA that accepts strings over the alphabet {0, 1} that ends with "110".

[(CSEN3002.6)(Apply/IOCQ)]

4 + 4 + 4 = 12

Group - C

4. (a) Consider the following 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. *[(CSEN3002.5)(Analyze/IOCQ)]*

(b) Derive a regular (Type 3) grammar for the regular expression 0*1(0 + 10*1)*

[(CSEN3002.6)(Apply/IOCQ)]

6 + 6 =12

5. (a) Let L1 be the following language defined on the input alphabet $\sum = \{0, 1\}$.

L1 = {α | the string α does not contain the substring '00'}

Thus the strings 101101 and 01110 are both in L1, but the string 1001 is not in L1.

Now, answer the following questions:

(i) Give a regular expression for L1.

(ii) Design a NFA from the regular expression that you obtained at part (i).

[(CSEN3002.6)(Apply/IOCQ)]

(b) Consider the following language L2:

$L2 = \left\{1^{n^2} \mid n \geq 0\right\}$

Prove that L2 is not a regular language by using pumping lemma.

[(CSEN3002.5)(Evaluate/HOCQ)]

(3 + 5) + 4 = 12

Group - D

6. (a) Simplify the given CFG whose productions are as follows:

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

[(CSEN3002.4) (Apply/IOCQ)]

(b) Prove that if L1 and L2 are context free then L1 ∪ L2 is also context free but L1 ∩ L2 need not to be context free. *[(CSEN3002.3)(Analyze/IOCQ)]*

6 + 6 = 12

7. (a) For each of the following given languages, mention which one is supposed to be accepted by a deterministic push down automata or non-deterministic push down automata or both or none of these.

(i) $L(G) = \{ww^R \mid w \in \{a, b\}^*\}$

(ii) $L(G) = \{a^n b^{n+2} \mid n > 0\}$

(iii) $L(G) = \{a^n b^n c^m \mid n, m > 0\}$

(iv) $L(G) = \{a^{n+m} b^{n+m} c^m \mid n, m > 0\}$

(v) $L(G) = \{a^n b^m \mid n, m > 0\}$ *[(CSEN3002.3)(Understand/LOCQ)]*

(b) A pushdown automaton (PDA) cannot accept the language $L = \{a^n b^n c^n \mid n \geq 1\}$. Justify with proper reasons. *[(CSEN3002.3)(Analyse/HOCQ)]*

(5 × 1) + 7 = 12

Group - E

8. (a) Design a Turing Machine *M* which accepts all odd length palindromes defined over the alphabet set {a, b}. *[(CSEN3002.6)(Apply/IOCQ)]*

(b) Design a Turing Machine *M* which accepts the language

$L = \{w\#w \mid w \in \{a, b\}^*\}$ *[(CSEN3002.6)(Apply/IOCQ)]*

6 + 6 = 12

9. (a) Design a Turing machine *M* that finds the 1's complement of a binary number. e.g. if the input number is 00110 then the output will be 11001. *[(CSEN3002.6)(Apply/ IOCQ)]*

(b) Explain the differences between recursively enumerable and recursive language with suitable examples. *[(CSEN3002.1)(Understand/LOCQ)]*

7 + 5 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	11.46	77.08	11.46