Group – D

6. (a) When is a Type 2 (context-free) grammar said to be ambiguous?
Consider the grammar G = (V, T, P, S), where V = { S, A, B, 0, 1, 2, 3, 4 }, T = { 0, 1 }, S is the start symbol, and the productions are as follows:
$S \rightarrow A$, $S \rightarrow B$, $S \rightarrow 0$, $S \rightarrow 1$, $A \rightarrow 01S1S$, $B \rightarrow 01S1S1S$.
Show that the grammar G is ambiguous.

(b) Design a pushdown acceptor that will recognize the following context-free language L over the input alphabet { 0, 1 }:
L = {α| the string α has an equal number of 0's and 1's}.

6 + 6 = 12

7. (a) Consider the language $L_{12} = \{ 0^m1^n0^n1^m \mid m, n > 0 \}$. Provide a context-free grammar for L_{12} thereby showing that L_{12} is a context-free language.

(b) Consider the following context-free grammar *G*:
$S \rightarrow A$
$S \rightarrow \varepsilon$
$A \rightarrow BAB$
$A \rightarrow BBB$
$B \rightarrow 00C$
$B \rightarrow 1$
$C \rightarrow 1$
Convert *G* to Chomsky Normal Form.

6 + 6 = 12

Group - E

8 Two positive integers m and n are written on a semi-infinite Turing machine tape in unary notation. The integer m is to the left of the integer n on the tape, a blank cell precedes the first 1 of m, and a single blank cell separates the two integers. At start the read/write head is positioned on the leftmost 1 of m. Give the state transition diagram of a Turing machine that will halt on the leftmost 1 of m if m = n, and will halt on the leftmost 1 of n if m ≠ n. Clearly state any assumptions made.

12

9. (a) Given two positive integers x and y, design a Turing Machine that computes (x+y).

(b) What is the 'Halting Problem' for Turing Machines? What do we mean when we say that the Halting Problem for Turing machines is unsolvable?

6 + (3 + 3) = 12

M.TECH/CSE/2ND SEM/CSEN 5201/2018

THEORY OF COMPUTATION
(CSEN 5201)

Time Allotted : 3 hrs **Full Marks : 70**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 5 (five) from Group B to E, taking at least one from each group.

Candidates are required to give answer in their own words as far as practicable.

Group – A
(Multiple Choice Type Questions)

1. Choose the correct alternative for the following: **10 × 1 = 10**

(i) Consider the language $L = \{ 0^n1^n0^m1^m \mid n > 0, m > 0 \}$ on the input alphabet { 0,1 }. Which one of the following statements is true?
(a) L can be recognized by a suitably designed deterministic finite state acceptor (dfsa).
(b) L can be recognized by a suitably designed deterministic pushdown acceptor (dpda) but not by any dfsa.
(c) L can be recognized by a suitably designed non-deterministic pushdown acceptor (ndpda) but not by any dpda.
(d) L can be recognized by a suitably designed Turing Machine but not by any ndpda.

(ii) Which of the languages will be accepted by a deterministic finite state automaton (DFSA)?
(a) $L_1=\{a^nb^n : n>1\}$ (b) $L_2=\{a^{n!} : n>10\}$
(c) $L_3=\{a^p : p$ is any prime number$\}$ (d) $L_4=\{a^nb^nc^n : 10\geq n\geq 0\}$.

(iii) L_1 and L_2 are two regular (Type 3) languages on a given input alphabet. Let the language L consist of all strings that are neither in L_1 nor in L_2. Then
(a) L is a regular language.
(b) L is a context-free language but not necessarily a regular language.
(c) L is a context-sensitive language but not necessarily a context-free language.
(d) L is a Type 0 language but not necessarily a context-sensitive language.

(iv) How many distinct arrangements of length 5 of the digits { 0, 1, 2, 3 } with repetitions allowed contain exactly two 3's?
(a) 128. (b) 135. (c) 256. (d) 270.

(v) Which one of the following languages cannot be accepted by a non-deterministic pushdown acceptor (ndpda)?

(a) $\{ 0^m1^n \mid 0 < m, 0 < n \}$ (b) $\{ 0^m1^n0^m \mid 0 < m, 0 < n \}$
(c) $\{ 0^m1^m0^m \mid 0 < m \}$ (d) $\{ 0^m1^n0^r \mid 0 < m, 0 < n, 0 < r \}$.

(vi) Let n be a positive integer that satisfies the condition ($17000 <= n <= 32000$). When n is written in octal notation with no leading zeroes, p octal digits are needed. When n is written in hexadecimal notation with no leading zeroes, q hexadecimal digits are needed. Then which one of the following statements is true?

(a) p = 7, q = 5 (b) p = 6, q = 5 (c) p = 6, q = 4 (d) p = 5, q = 4.

(vii) If a language L_6 is regular then which statement is FALSE?

(a) There exists a Pushdown automaton which acceptsL_6.
(b) There exists a Turing Machine which accepts L_6.
(c) There exists a Nondeterministic finite automaton which accepts L_6.
(d) None of the above statements are correct.

(viii) If languages of type X are closed under union and complementation operations then which of the following is correct?

(a) Type X languages must be closed under intersection.
(b) Type X languages may not be closed under intersection
(c) Type X languages will never be closed under intersection.
(d) Cannot say anything about the intersection property of Type X languages.

(ix) Let the input alphabet be { 0,1,2 }, and let the language L consist of all strings on the input alphabet that contain at least one 1 and at least one 2, no condition being imposed on the number of 0's in a string. Then the deterministic finite state acceptor (dfsa) with fewest states that recognizes L has n states where n equals

(a) 4 (b) 5 (c) 6 (d) 7.

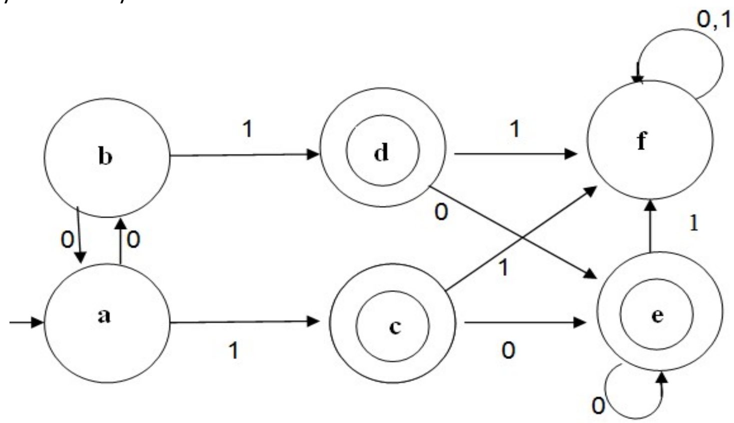
(x) Which of the following identities for regular expression is FALSE?
[Here P,Q,R are all regular expressions, ϕ denotes null set and ε denotes empty string]

(a) R+R=R (b) (PQ)*P=P(QP)* (c) $\phi^* = \varepsilon$ (d) (P+Q)*=(PQ)*..

Group - B

2. (a) Let L_{10} be the set of all palindromes over {a, b}. Construct a grammar G generating L_{10}. According to Chomsky classification, which type of grammar is this?

(b) A finite state machine M_1 has the state transition diagram shown below. The start state is **a,** and the final states are **c, d** and **e**. Minimize the number of states in the machine.



(3 + 2) + 7 = 12

3. Each of the claims given below is either TRUE or FALSE. For each claim, clearly state TRUE or FALSE, briefly giving reasons and examples in support of your choice.

(i) <u>Claim</u>: A deterministic finite state acceptor (dfsa) M must have a dead state, i.e., a non-goal state having no outgoing transitions to other states.

(ii) <u>Claim</u>: A non-deterministic finite state acceptor (ndfsa) N can have more than one start state.

(iii) <u>Claim</u>: If there is an ε-transition from a state X to another state Y in a non-deterministic finite state acceptor (ndfsa) N, then when N is converted to a reduced deterministic finite state acceptor (dfsa) M, the states X and Y will not remain separate states but will coalesce into one state.

(4 + 4 + 4) = 12

Group – C

4 (a) Construct a deterministic finite state acceptor (dfsa) M on the input alphabet { 0,1 } that accepts a string α if and only if α is contained in the regular expression (00+11)*0*.

(b) Construct a deterministic finite state acceptor (dfsa) N on the input alphabet { 0,1 } that accepts a string α if and only if α is *not* contained in the regular expression (00+11)*0*.

8 + 4 = 12

5. (a) Use the Pumping Lemma for Regular Languages to show that the language $L_{11} = \{a^{n!} : n \text{ is any integer} > 3\}$ is not regular.

(b) Prove that the family of Regular Languages is closed under intersection and concatenation operation.

6 + (3 + 3) = 12