THEORY OF COMPUTATION
(CSEN 5234)

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) For a Mealy machine, if the input string is of length n, then, which of the following will be the length of the output string?
(a) n (b) n + 1 (c) n – 1 (d) None of these.

(ii) Given the language L = {ab, aa, baa}, which of the following strings are in L*?
1) abaabaaabaa 2) aaaabaaaa 3) baaaaabaaaab 4) baaaaabaa
(a) 1, 2 and 3 (b) 2, 3 and 4 (c) 1, 2 and 4 (d) 1, 3 and 4

(iii) The production rules, S→aA, A→aB | a, B→b represent a
(a) regular grammar (b) CFG but not regular
(c) neither CFG nor Regular (d) regular grammar but not CFG

(iv) Which of the following is the regular expression representing all strings on ∑ = {a, b}, starting with 'ab' and ending with 'bba'
(a) aba*b*bba (b) ab(ab)*bba
(c) ab(a+b)*bba (d) both (b) and (c) are correct

(v) Which one of the following languages can be accepted by a deterministic pushdown acceptor (dpda)?
(a) $\{ 0^m1^n0^m \mid 1 \leq m, 1 \leq n \}$; (b) $\{ 0^m1^m0^m \mid 1 \leq m \}$;
(c) $\{ 0^m1^n0^m1^n \mid 1 \leq m, 1 \leq n \}$; (d) $\{ 0^m1^m2^{2m} \mid 1 \leq m \}$.

(vi) If P & Q be two regular expressions over ∑, then the equation R = Q+RP will have a unique solution R = QP* if (where λ is the empty string)
(a) P contains λ (b) P does not contain λ
(c) Q does not contain λ (d) None of these.

(vii) 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.

(viii) L_1 and L_2 are two Type 3 (regular) languages. Let the language L consist of all strings that are in L_2 but not in L_1. Then
(a) L is a Type 3 language;
(b) L is a Type 2 language but not necessarily a Type 3 language;
(c) L is a Type 1 language but not necessarily a Type 2 language;
(d) L is a Type 0 language but not necessarily a Type 1 language.

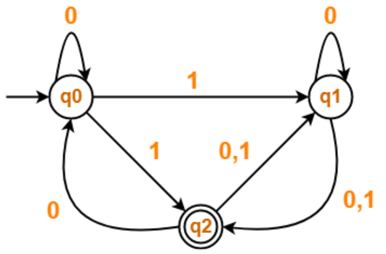
(ix) Which of the following problems is undecidable?
(a) Deciding if a given CFG is ambiguous
(b) Deciding if a given string is generated by a given CFG
(c) Deciding if a language generated by a given CFG is empty
(d) Deciding if a language generated by a given CFG is finite.

(x) A machine M has been designed that, given a positive integer n as input, accepts n if and only if n is a prime number. Then which one of the following alternatives is false?
(a) M cannot be a non-deterministic finite state acceptor (ndfsa)
(b) M cannot be a deterministic pushdown acceptor (dpda)
(c) M cannot be a non-deterministic pushdown acceptor (ndpda)
(d) M cannot be a Turing machine.

Group – B

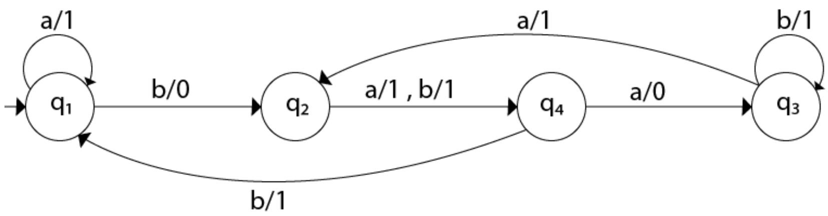
2. (a) Design a deterministic finite state acceptor (dfsa) M that accepts only those strings on the alphabet {0, 1} that do *not* begin with 01 *and* do *not* end with 10. Show both the state table and the state transition diagram of M.
Briefly explain how M accepts the string 101 but fails to accept the string 010.

(b) Convert the following Non-Deterministic Finite Automata (NFA) to Deterministic Finite Automata (DFA).



(4 + 2) + 6 = 12

3. (a) Convert the following Mealy machine into equivalent Moore machine.

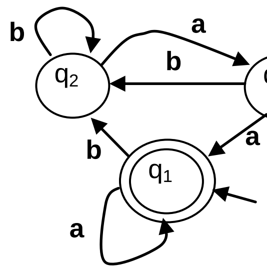


(b) Construct a deterministic finite state acceptor (dfsa) M on the input alphabet {0, 1} that accepts a string α if and only if α is *not* contained in the regular expression 0*1*01.

6 + 6 = 12

Group – C

4. (a) Find the regular expression for the following DFA.



(b) What will be the regular expression of the Finite State Automata (FSA) that will accept all the binary strings (i.e. ∑: {0, 1}) that start with even number of zeros and ending with odd number of ones?

(c) Construct a left-linear grammar for the following language:
$L = \{a^n b^m | \ n \geq 2, m \geq 3\}$

6 + 4 + 2 = 12

5. (a) Consider the following languages on the alphabet ∑ = {a, b, c}. Give regular expressions for each of them.
(i) any non-empty string on ∑
(ii) any string that does not contain ‘a’
(iii) any string that contains at least one ‘a’.

(b) Describe in words the strings accepted by the deterministic finite state acceptor (dfsa) shown below. The start (initial) state is A and the goal (final) state is D. Also express the set of accepted strings in the form of a regular expression.

	0	1
A	B	A
B	C	C
C	D	D
D	C	D

(2 × 3) + (4 + 2) = 12

Group – D

6. (a) Show that there does not exist any PDA that will accept the language,
L: a^n| n is a prime number

(b) The language L_3 is defined on the alphabet ∑ = {‘(’, ‘)’, ‘{’, ‘}’} and consists of all sequences of well-formed (*i.e.*, balanced) parentheses and braces. Thus the

sequences '(()()())', '(())()(())', '{()}', '(()({()})' are in L_3, but the sequences '())(()', '{()}' are not in L_3.
Give a Type 2 or a context-free grammar that generates the set L_3.

6 + 6 = 12

7. (a) Simplify the following CFG as much as possible
S → DAa
A → b
B → a
D → Ɛ (Ɛ represents NULL).

(b) Explain acceptance by empty stack and acceptance by final state for a PDA.

(c) Design a pushdown acceptor (pda) M to accept the following context-free language L on the input alphabet { 0,1 }:
L = { α | the string α has an equal number of 0's and 1's }.
Explain how M accepts the string 001011110100.

4 + 2 + 6 = 12

Group – E

8. (a) Design a Turing machine that will accept the language L, such that {L: $a^n bc^n$ | n > 0} over the input alphabets (i.e. ∑: {a, b, c}).

(b) There exists a Turing machine M that accepts the language L. Can we infer that L is a recursive language? Justify your answer.

8 + 4 = 12

9. (a) Design a Turing machine that generates one's complement over any binary input string (i.e. ∑ = {0, 1}).

(b) Write short note on the following topics —
(i) Turing Halting Problem.
(ii) Multi-tape Turing machine.

4 + (4 + 4) = 12

Department & Section	Submission Link
CSE	https://classroom.google.com/w/MzEyMzA1ODk2NjU4/tc/Mzc0MTMwMDYyNjE5