FORMAL LANGUAGE & AUTOMATA THEORY
(CSEN 3102)

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) 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) $\{ 0^m1^n0^r \mid 0 < m, 0 < n, 0 < r \}$

(ii) The number of states in the smallest finite automata which will accept the language {x | length of x is divisible by 3} is
(a) 2 (b) 3 (c) 4 (d) 5.

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

(iv) 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)*

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

(vi) If all the productions of a grammar are right-linear (i.e., of the form A → aB or A → a where A,B are non terminal symbols and 'a' is a terminal symbol), then the grammar is
(a) Type 0 (b) Type 1 (c) Type 2 (d) Type 3.

(vii) Suppose that L_1 and L_2 are two languages (over the same alphabet) given to you such that both L_1 and L_1L_2 are regular. Then which of the following is correct?
(a) L_2 must be regular too (b) L_2 can never be regular
(c) L_2 need not be regular (d) Cannot say anything about L_2

(viii) If all the productions are Right-Linear then the grammar is
(a) Type 0 (b) Type 1 (c) Type 2 (d) Type 3.

(ix) If a Context Free Grammar is in Chomsky Normal Form then a production
(a) may contain a single non-terminal in the RHS
(b) may contain both terminal and non-terminal symbols in the RHS
(c) may be of the form $A \rightarrow \varepsilon$ where A is not the start symbol
(d) none of these.

(x) Which of the following statements is false?
(a) Finite state machines when started with any input will always finally halt.
(b) Deterministic pushdown automata when started with any input will always finally halt.
(c) Nondeterministic pushdown automata when started with any input will always finally halt.
(d) Turing Machine when started with any input will always finally halt.

Group – B

2. (a) Let L be the following language defined on the input alphabet $\sum = \{a, b\}$.
$L = \{ \omega \mid$ the string ω does *not* contain the substring 'aaa' $\}$
Thus the strings babbab and abbba are both in L, but the string baaab is not in L. Design a DFA for the language.

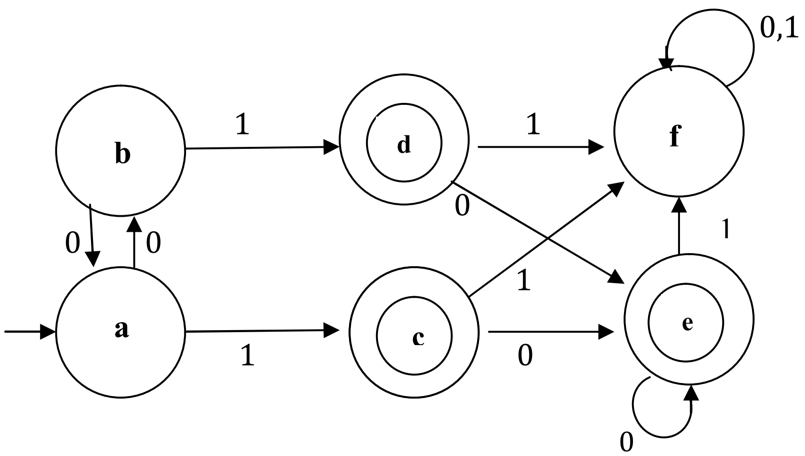
(b) Design a deterministic finite state acceptor (dfsa) M_0 that will accept only those strings on the alphabet {0,1 } that contains Odd number of 0's and Even number 1's and explain the design in brief. Show both the state table and the state transition diagram of M_0 and briefly explain how M_0 works.

(c) Let $\Sigma = \{0, 1\}$. Give DFA accepting the set of all strings, when interpreted in reverse as a binary integer, is divisible by 3.

4 + 5 + 3 = 12

3. (a) Construct NFA-ε for the following language. Then, covert it into NFA without ε and then to DFA. Show each step. $L1 = \{0^n \mid n \text{ is a multiple of 2 or 3}\}$

(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.



6 + 6 = 12

Group – C

4. (a) Give the regular expressions for the following cases on $\sum = \{a, b\}$:
   (i) $L_1 = \{w \mid w$ starts and ends with the same symbol$\}$
   (ii) $L_2 = \{vwv \mid v, w \in \{a, b\}^*, |v| = 2\}$
   (iii) $L_3 = \{w \mid$ every a in w is followed by at least one b$\}$

   (b) A non-deterministic finite state acceptor (ndfsa) M_2 has the state table shown below. The start state is S and the only final state is C. Convert M_2 to an equivalent deterministic finite state acceptor (dfsa) M_3, clearly indicating the start and final states. Briefly explain your method of conversion.

	0	**1**
S	**S, A**	**S**
A	**--**	**B**
B	**--**	**C**
C	**C**	**C**

(3 × 2) + 6 = 12

5. (a) Remove all unit-productions, all useless symbols, and all null productions from the following grammar:
   $S \rightarrow 0X|0YY$
   $X \rightarrow 00X|\lambda$
   $Y \rightarrow 1Y|11Z$
   $Z \rightarrow Y$
   What language does this grammar generate? Justify your answer.

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

(4 + 2) + 6 = 12

Group – D

6. (a) Design a PDA M over {0, 1} such that $L(M) = \{0^{2n}1^n \mid n \geq 1\}$. Explain the working strategy taking an example string of length 6.

   (b) Consider the language $L_{12} = \{ 0^m 1^n 0^n 1^m \mid m, n > 0 \}$. Provide a context-free grammar for L_{12} thereby showing that L_{12} is a context-free language.

(4 + 2) + 6 = 12

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

   (b) Using the Pumping Lemma for Context-Free Languages, show that the language $L_{14} = \{ 0^m 1^n 0^m 1^n \mid m, n > 0 \}$ is not a Type 2 (context-free) language.

   (c) Write the difference between DPDA and NPDA.

3 + 7 + 2 = 12

Group – E

8. Design a Turing machine M_5 which can accept the language
$L_{15}= \{a^nb^n : n>=1\}$.
Now show that M_5 accepts “aaabbb” but rejects “abab” and “aab”.

(8 + 4) = 12

9. (a) Design a Turing machine for the following language:
$\{0^n1^m0^n \mid m, n \geq 1\}$

(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

Department & Section	Submission link:
CSE A	https://classroom.google.com/c/MTIyMDY4NTIyMDE5/a/Mjc0ODM4NDU1NzM0/details
CSE B	https://classroom.google.com/c/MTIzNDEyMjczNDM0/a/Mjc0Mzk1NTIxNDY4/details
CSE C	https://classroom.google.com/c/MTIyNDU1MDAzNTA0/a/Mjc0NDEyODc3OTY3/details