Thapar Institute of Engineering and Technology, Patiala
Electrical and Instrumentation Engineering (EIED)

UCS701

Theory of Computation

END-SEMESTER EXAM (MST)

BE-Electrical and Computer, VII Semester, 2023-24

December 12, 2023	Tuesday, 2 PM
Duration: 3 Hrs	Max. Marks: **70**
Name of Faculty :	Dr. Ashish Gupta

General Instructions: Attempt any **FIVE** (out of Six) questions with proper Justification. Each question has two or more parts. Attempt all parts of a question together at one place. **Without Justification Zero marks will be awarded.** CLO-4 applies to all questions.

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1. (a) Let $1^*(10)^*1^*$ be a regular expression denoted by R. Do as directed below to design recognizers of $L(R)$. **[3 × 3, CLO-1]**

   i) Convert R into ε-NFA by using Thompson's construction.

   ii) Apply e-closure based subset-construction method to convert ε-NFA to an equivalent DFA.

   iii) Finally, write and follow the steps of Partition method to minimize the states of DFA accepting $L(R)$.

   (b) Use Pumping Lemma to prove that the following language is NOT regular: $L = \{(ab)^n a^k | n > k, k \geq 0\}$ **[5, CLO-1]**

2. (a) Explain the Chomsky classification of grammars and relationship between different types of grammars and automata with the help of suitable **examples** and a **diagram.** **[7, CLO-4]**

   (b) Write the formal definition of a Pushdown Automata (PDA). Design separate PDAs accepting by final state and by empty stack for $L = \{a^n b^n | n \geq 1\}$. **[2+5, CLO-2]**

3. (a) The following are the productions of a Context free grammar G: **[7, CLO-2]**

$S \rightarrow XY \mid YZ$

$X \rightarrow YX \mid 0$

$Y \rightarrow ZZ \mid 1$

$Z \rightarrow XY \mid 0$

Use the CYK algorithm to determine whether 10010 is a member of $L(G)$, i.e., the language generated by G.

(b) Write the steps and follow to convert the following CFG into Greibach Normal Form (GNF):

$S \rightarrow BB \mid a$

$B \rightarrow SS \mid b$ **[7, CLO-2]**

4. Consider the following language over $\Sigma = \{0, 1\}$ where w^R denotes the string reversal of w:

$$L = \{wcw^R | w \in (0+1)^*\}$$

(a) Write the logic for design of a single-track Turing machine M for L. **[4, CLO-3]**

(b) Design the Turning machine M accepting L. **[6, CLO-3]**

(c) Define Instantaneous description (ID) for Turing Machines. Give the entire sequence of moves of M using IDs to accept the string w= 110c011. **[4, CLO-3]**

5. (a) Design a Multi-tape Turing machine M to accept the following language over $\Sigma = \{a, b, c\}$:

$L = \{a^n b^n c^n | n > 0\}$ **[6, CLO-3]**

(b) Write short notes on **[4+4, CLO-3/4]**

i Variants of Turing Machine

ii Categorization/classes of recursively enumerable (RE) languages with examples.

6. (a) Convert the following CFG into Chomsky Normal Form (CNF) grammar. **[6, CLO-2]**

$$S \rightarrow AB$$
$$A \rightarrow aAA|\varepsilon$$
$$B \rightarrow aBB|\varepsilon$$

(b) Consider the following two languages: **[2+2+4, CLO-2]**

$$L_1 = \{a^n b^{2n} c^m \ | n, m \geq 0\}$$

$$L_2 = \{a^n b^n c^{2m} \ | n, m \geq 0\}$$

i) Write CFGs for L_1 and L_2.

ii) Is $L_1 \cap L_2$ a CFL? Justify your answer using Pumping lemma for CFLs.