	Indian Institute of Information Technology Design and Manufacturing, Kancheepuram Chennai – 600 127, India An Autonomous Institute under MHRD, Govt of India An Institute of National Importance CS 2009 Theory of Computation	Instructor N.Sadagopan EndSem 24-Apr-2023 40 Marks 9.00-12.00 AM

Roll No: Name:

Answer must be written in the space provided. No Answer booklet / additional sheets.

1. **Light Dose - (2 marks each)**
   1. Define Recursive and Recursively Enumerable Languages

   2. Define Class P, NP from the perspective of Turing machines

   3. State pumping lemmas for Regular sets and Context free sets

   4. Write CFG for $L = \{x \mid x \in \{a, b\}^*$ x has unequal a's and b's $\}$

5. Write PDA (transition function) for $L = \{a^n b^m \mid n \leq m \leq 2n\}$.

2. **Medium Dose** (4 marks each)
1. Prove that the Halting problem is undecidable.

2. Design a deterministic turing machine to accept the language $L = \{x \mid x = www, w \in \{a, b\}^*\}$. Present only the logic. No need to describe transition function (diagram).

3. Consider a TM-variant, namely READ-ONLY-TM (can read, no write, can move left as well as right). Whether the computing power of READ-ONLY-TM is superior to DFA. Justify.

4. Consider the language $L = \{x \mid x \in \{0,1\}^*$ second symbol from the last in x is 1 $\}$. Find the regular expression using Arden's Theorem.

5. (A) For a context free language L, it turns out that L and L^c (Complement of L) are context free. Can we conclude that L is regular. Justify.
   (B) Suppose L and L^c are recursively enumerable, can we conclude that L is recursive. Justify.

3. **Strong Dose**

1. (6 marks) Consider the language $L = \{x \mid |n_0(x) - n_1(x)| \leq 1$, n_0 represents the number of 0's in $x \in \{0,1\}^*$.
   (A) Prove or disprove that L is regular

(B) Prove or disprove that L is context free

(C) Prove or disprove that L is recursive

2. (4 marks) What is the computing status (decidable vs undecidable) of the following two questions (i) Given an arbitrary C program, will it compile without errors (ii) Given an arbitrary C program, will it execute without errors. Justify your answer.

Extra Credits (4 marks) Is there a computational problem P that is solvable in polynomial-time (polynomial in the input size) under Turing Machine model (unary representation) but P is not solvable in polynomial time under RAM model (the computing model followed by C programs, decimal representation)

Space for Rough work (Do NOT use any additional sheets)