UPES

End Semester Examination, December 2025

Course: CSEG3054 **Semester:** 5

Program: BSC **Time:** 03 hrs.

Course Code: Theory of Computing **Max. Marks:** 100

Instructions: Answer all questions. Where alternatives are provided, attempt any one. For design-based questions, include appropriate diagrams wherever required.

SECTION A

(5Qx4M=20Marks)

S. No.		Marks	CO
Q 1	Explain the decidable properties of regular languages.	**4**	**CO3**
Q 2	What is an ambiguous grammar? Explain with a suitable example.	**4**	**CO1**
Q 3	Write a short note on Multi-Tape Turing Machines and comment on their computational power compared to Single-Tape Turing Machines.	**4**	**CO4**
Q 4	Using the Master Theorem, find the time complexity of $T(n) = 3T\left(\frac{n}{3}\right) + n$ and verify your result by using the standard expansion (unrolling) method.	**4**	**CO5**
Q 5	Mention the different phases of compiler design and discuss which phase is most influenced by automata theory. Illustrate your explanation with a proper example.	**4**	**CO2**
	SECTION B **(4Qx10M= 40 Marks)**		
Q 6	A. Explain the Pumping Lemma for Regular Languages. (4 marks) B. Using the Pumping Lemma, prove whether the language $L = \{a^n b^n \mid n \geq 0\}$ is regular or not. (6 marks)	**10**	**CO2**
Q 7	Explain the Chomsky hierarchy of formal languages with a proper diagram and discuss the relative computational power of each type of grammar.	**10**	**CO1**
Q 8	A. Explain the Church-Turing Thesis. (4 marks) B. Design a Turing Machine that computes the 2's complement of a binary number. (6 marks) **Or** A. Explain the claim that whatever an algorithm can do, a Turing Machine can also do. (4 marks) B. Design a Turing Machine that adds two (10 in binary) to a number represented binary. (6 marks)	**10**	**CO3**
Q 9	A. Explain P, NP, NP-Hard, and NP-Complete problems. (6 marks) B. Illustrate their relationships with a suitable diagram. (4 marks)	**10**	**CO5**
	SECTION-C **(2Qx20M=40 Marks)**		

Q 10	A. Explain the relative computational power of Finite Automata (FA), Pushdown Automata (PDA), and Turing Machines (TM). (5 marks) B. Verify your explanation by determining which of the following languages can be recognized by FA, PDA, and TM: (15 marks) i. $L_1 = \{strings\ starting\ with\ 101\}$ ii. $L_2 = \{WcW^R \mid W \epsilon \{a,b\}^*\}$ iii. $L_3 = \{WW \mid W \epsilon \{a,b\}^*\}$	**20**	**CO4**
Q 11	A. Define Pushdown Automaton (PDA)**.** (3 marks) B. Design a PDA that accepts the language: (7 marks) $L = \{a^n b^m c^m d^n \mid m,n \geq 1\}$ C. Explain the relationship between Interactive Proofs (IP) and PSpace. Discuss under what conditions IP = PSpace. (10 marks) **Or** A. Compare the computational power of a DPDA and an NPDA. Illustrate your comparison with a suitable example. (8 marks) B. Discuss three distinct fields (excluding cryptography and quantum computing) in which current research is actively progressing within the Theory of Computing (ToC). (6 marks) C. Explain how modern research in cryptography uses ToC to address quantum attacks. (6 marks)	**20**	**CO2**