SAVEETHA University

CSA13 Theory of Computation

Time: **2 Hours** Total marks: **70**

Answer all the questions. Make your answers short and precise.

1. (2.5+2.5 marks) Let the alphabet be $\{a, b\}$. Write regular expressions for the following languages.
   (a) The set of all words where all a's are before all b's.
   (b) The set of all words that contain at most two a's.
2. (5 marks) Define what is Greibach Normal Form (GNF). Convert the following grammar to GNF.
$$\begin{aligned} S &\to T \mid aSd \\ T &\to \$ \mid bTc \end{aligned}$$
3. (12 marks) Construct an NFA for the set of all words over the alphabet $\{a, b\}$ that end with ab. For instance the word aab is in the language but not a or baa. Then determinize the automaton and draw the equivalent DFA.
4. (6+6 marks)
   (a) Write a regular expression for the language L over the alphabet $\{a, b\}$ where L is the set of all words that contains no adjacent b's. For instance $abab \in L$ but not $aabb$.
   (b) Is the language $L = \{a^m b^n \mid m \neq n, m \geq 0, n \geq 0\}$ regular? Justify?
5. (6+6 marks)
   (a) Write a context-free grammar for the language
$$\{a^i b^j c^k \mid i = j \text{ or } j = k, i \geq 0, j \geq 0, k \geq 0\}.$$
   (b) Assume L_1 and L_2 are context-free languages. Is $L_1 \cdot L_2$ context-free? Justify.
6. (12 marks) Is the language $\{a^n b^n c^n \mid n \in \mathbb{N}\}$ accepted by a deterministic Turing machine? If not, prove it. Otherwise give an informal definition of such a machine.
7. (6+6 marks)
   (a) Is the family of recursively enumerable languages closed under union? Justify.
   (b) Show that it is undecidable to check if $L(M_1) \subseteq L(M_2)$ for two given Turing machines M_1 and M_2.