



United International University (UIU)
Dept. of Computer Science & Engineering (CSE)

Final Exam (Fall 2023)

CSE 2233/CSI 233: Theory of Computation/Theory of Computing

Total Marks: **40**

Duration: **2 Hours**

Answer all questions. Figures in the right-hand margin indicate full marks.

Any examinee found adopting unfair means will be expelled from the trimester/program as per UIU disciplinary rules.

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1. Answer the questions based on the given CFG: 4+2
- $S \rightarrow aaBB \mid aCB$
 $B \rightarrow b \mid \varepsilon$
 $C \rightarrow AB$
 $A \rightarrow a \mid \varepsilon$
- a) With the help of **Parse Tree** show that the CFG is ambiguous for the string ‘aabb’.
- b) Modify the CFG to remove the ambiguity for the said string.
2. Design CFGs that generate the following languages: 2x3
- a) $L = \{ a^n b^m c^m d^n \mid n, m \geq 1 \text{ and } \Sigma = \{a, b, c, d\} \}$
- b) $L = \{ ww^R \mid w \in \{a, b\}^+ \}$
- c) $L = \{ w \in \{a, b\}^* \mid w \text{ contains at least three 1s} \}$
3. Showing all necessary steps, convert the following CFGs into their equivalent **Chomsky Normal Form (CNF)**. 4x2
- a) $S \rightarrow ABC \mid BaB$
 $A \rightarrow aA \mid BaC \mid aaa$
 $C \rightarrow bBb \mid a \mid D$
 $D \rightarrow \varepsilon$

- b) $S \rightarrow BAC \mid B$
 $B \rightarrow 0B1 \mid 01$
 $A \rightarrow aAb \mid \varepsilon$
 $C \rightarrow Bc$

4. Draw the **Push Down Automata (PDA)** for the following languages:

5x2

a) $L = \{ x^m \# y^n z^w \mid m = n/2 \text{ or } w = m/3 \text{ and } m, n, w > 0 \}$

b) $L = \{ a^i b^j c^k \mid i + j = 2k \text{ and } i, j, k \geq 0 \}$

5. Draw a **Turing Machine** for the following language and show the **Tape Traversal** to validate the given input:

5+5

$$L = \{ a^p b^r c^q d^x \mid r = x-p \text{ and } q = p+r \text{ and } p, q, r, x \geq 1 \}$$

Input String: aabbccccddddd