



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.

1. Answer the questions based on the given CFG: 4+2
$$S \rightarrow aaBB \mid aCB$$
$$B \rightarrow b \mid \epsilon$$
$$C \rightarrow AB$$
$$A \rightarrow a \mid \epsilon$$
 - 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)
$$S \rightarrow ABC \mid BaB$$
$$A \rightarrow aA \mid BaC \mid aaa$$
$$C \rightarrow bBb \mid a \mid D$$
$$D \rightarrow \epsilon$$

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

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