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

Final Exam Summer 2024

CSE 2233/CSI 233: Theory of Computation/Theory of Computing
Total Marks: **50**   Duration: 2 Hours
Answer all questions. Figures are in the right-hand margin indicates 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. Consider the following Context-free grammars (CFG) and answer according to it: 5*2

a) $S \rightarrow DBC$
    $B \rightarrow 0B1 \mid 0B \mid 1B \mid \in$
    $C \rightarrow aCb \mid aC \mid Bb \mid b$
    $D \rightarrow bD \mid D \mid Ba$

    With the help of **Top-Down Parse Trees,** find-out if the grammar is **Ambiguous** or not for the string: "**a01aa0bbb**":

b) $SWITCH \rightarrow switch (EXPR) : CASE$
    $CASE \rightarrow case\ EXPR : STMT\ CASE \mid DF$
    $DF \rightarrow df : STMT$
    $STMT \rightarrow a+b \mid a++ \mid a*b \mid a/b \mid a\%b \mid a \mid b$
    $EXPR \rightarrow INT \mid CHAR$
    $INT \rightarrow 0 \mid 1 \mid 2 \mid 3 \mid 4 \mid 5 \mid 6 \mid 7 \mid 8 \mid 9$
    $CHAR \rightarrow a \mid b \mid c \mid d \mid e$

    With the help of **leftmost** derivation derive the following string:
    "**switch (5): case 1: a+b case 2: a++ df: a*b**"

2. Design **CFGs** that generate the following languages: 3*4

a) $L = \{ a^n b^{2m} c^n \mid n, m \geq 1 \}$
b) L is a language where every string is a palindrome of odd length over the alphabets {a,b}.
c) L is a language of Roman number systems where I = 1, V = 5, X = 10, L = 50. (e.g. I, IV, VII. XLIX representing numbers 1,4,7, 49 respectively)
    *You only need to consider up to the 50th number.
d) $L = \{p^n q^m r^o s^x \mid n = 2m, x = 2o, n, x \geq 0\}$

3. Convert the following grammars into Chomsky Normal Form (CNF):   4*2
a) $S \rightarrow BAC \mid B$
    $B \rightarrow 0B1 \mid 01$
    $A \rightarrow aAb \mid \in$
    $C \rightarrow Bc$

b) $S \rightarrow ABA$
    $A \rightarrow aA \mid \in$
    $B \rightarrow bBc \mid \in$

4. Draw the Push Down Automata (PDA) for the following languages: 5*2

    a) $L = \{ x^n y^{3m} z^{2m} v^n \mid n, m \geq 1 \}$
    b) $L = \{ p^i q^j r^k s^m \mid i==k \text{ or } m \geq j+2, i, j, k, m \geq 1 \}$

5. Draw a **Turing Machine** for the following language and show the **Tape Traversal** to validate the given input: 5*2

$L = \{ x^{2i} y^j z^i w^{3j} \mid i, j \geq 1 \}$
Input String: **xxxxyyzzwwwwww**