United International University (UIU)

Dept. of Computer Science & Engineering (CSE)

Final Exam Fall 2024

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

Total Marks: **40** 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: [4*2]

a) $S \rightarrow XYZ$
$X \rightarrow 0X \mid 1X \mid \varepsilon$
$Y \rightarrow A \mid B$
$Z \rightarrow 0Z1 \mid Z0 \mid Z1 \mid \varepsilon$
$A \rightarrow aA \mid a$
$B \rightarrow Bb \mid bB \mid b$

With the help of **Top-Down Parse Trees**, find-out if the grammar is **Ambiguous** or not for the string: **"011b01"**

b) $S \rightarrow$ if E then S | if E then S else S | E | other
$E \rightarrow E \&\& E \mid E \| E \mid !E \mid (E) \mid id$

With the help of the **rightmost derivation**, derive the following string **"if id || id && id then if id then other else other"**

2. Design **CFGs that generate** the following languages for $\sum = \{a, b\}$: [2*4]

a) $L = \{ a^n b^m \mid n \leq m \leq 2n \text{ and } n,m \geq 1\}$

b) $L = \{ a^m b^{2n} c^{3n} d^{3m} \mid \text{where } n \geq 2, m \geq 1\}$

c) $L = \{ a^i b^j c^k \mid \text{where } i=k \text{ or } j=k \text{ and } i, j, k>0 \}$

d) L = { every even length palindrome when the string starts with a or every odd length palindrome when the string starts with b }

3. Convert the following grammars into **Chomsky Normal Form (CNF)**: [4*2]

a) $S \rightarrow S+S \mid T-S \mid S/T \mid \varepsilon$
$T \rightarrow T*TC \mid C$
$C \rightarrow 0 \mid 1 \mid 2 \mid 3$

b) $S \rightarrow SS \mid CAB \mid BA$
$A \rightarrow aAb \mid \varepsilon$
$B \rightarrow 0A1 \mid 0B1$
$C \rightarrow cA \mid Bb$

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

a) $L = \{ x^{3a} y^{2b} z^{c} w^{d} \mid (c = 3b \text{ and } a=2d) \text{ and } a \geq 1, b \geq 0 \}$
b) $L = \{ p^{3i} \# q^{2j} r^{2k} \mid (i=j \text{ or } i=k) \text{ and } i,j \geq 1 \}$

5. Draw a **Turing Machine** for the following language and show the **Tape Traversal** to validate the given input: [4*2]

$L = \{ a^{p} b^{3q} c^{r} d^{x} \mid r = 2p + q \text{ and } q = x - p \text{ and } p,q,r,x \geq 1 \}$

Input String: **aabbbccccddd**