United International University (UIU)

Dept. of Computer Science & Engineering (CSE)

Assignment (Spring 2024)

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

(Total Marks : 5)

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1. Design Context-Free Grammar (CFG) for the following languages.

L1 = {Strings with equal number of a's and b's (in any order)}

L2 = {Strings not of the form $0^i 1^j$,where, i = j ; i,j $\geqslant$ 0 }

L3 = { $a^n b^{2m}$ | $n \geq 1, m \geq n$ }

L4 = { $a^n b^m$ | $n \leq m \leq 2n$ }

2. Convert the following **Context Free Grammar**'s (CFG) into **Chomsky Normal Form** (CNF):

i.

$S \rightarrow aX \mid bY \mid b \mid ZZc$

$X \rightarrow Yaa \mid abZ \mid \varepsilon$

$Y \rightarrow bXXb \mid ab \mid cZ$

$Z \rightarrow a \mid b \mid XZ \mid \varepsilon$

ii.

$Q_0 \rightarrow 0Q_0 \mid 1Q_2$

$Q_1 \rightarrow 0Q_3 \mid 1Q_0 \mid \varepsilon$

$Q_2 \rightarrow 0Q_1 \mid 1Q_3 \mid \varepsilon$

$Q_3 \rightarrow 0Q_4 \mid 1Q_1 \mid \varepsilon$

$Q_4 \rightarrow 0Q_2 \mid 1Q_4 \mid \varepsilon$

3. Design a **Push-Down Automata** for each one of the following languages:

L1 = { $a^{n+m} b^{m+t} a^t b^n$ | n,t >0 and m>=0 } , $\sum$ = { a,b }

L2 = { $a^{2n+1} b^n$ | n > 0 } , $\sum$ = { a,b }

L3 = { $0^i 1^j$ | $i \leq j \leq 2i$ } , $\sum$ = { 0,1 }

L4 = { $a^p b^q c^{2r}$ | $p \neq q$; p,q,r ≥ 0 }