United International **University** (UIU)
Dept. of Computer Science and Engineering (CSE)
Final Assessment   Year: **2021**   Semester: **Spring**
Course: **CSE 2233**   Title: **Theory of Computation (Section – A/B/C)**
Marks: **40**   Time: **1 Hour 30 minutes + 15 minutes(for uploading & downloading)**

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

There are **4 (Four)** questions. Answer **all of them**. Figures in the right margin indicates full marks.

Q.1 Design context-free grammar (CFG) for the following languages over $\sum$={a,b,c}   **[3*3 = 9]**
   a) { $a^m \, b^n \, c^k$ | k = 3m+n, m >= 0, n > 0 }
   b) { w $a^m w^R$ | w $\in \{a, b\}$* and w^R is the reverse string of w, m > 2 }
   c) { a^n b^t a^(m+t) b^(m+n) | n,t>0, m>=2 }?

Q.2 a) Consider the following context-free grammar (CFG) and answer the questions that follows:
$$S \rightarrow A \mid XP$$
$$A \rightarrow 0A11 \mid Z$$
$$Z \rightarrow 0Z2 \mid 02$$
$$X \rightarrow 0X2 \mid Y$$
$$Y \rightarrow 0Y \mid 0$$
$$P \rightarrow 1P \mid 11$$

With the help of leftmost derivation decide whether the grammar is ambiguous or not for the string: ***0000221111***   **[5]**

b) Consider the following CFG,
$$S \rightarrow S1 \mid S2$$
$$S1 \rightarrow S1b \mid Ab \mid \varepsilon$$
$$A \rightarrow aAb \mid ab$$
$$S2 \rightarrow S2a \mid Ba \mid \varepsilon$$
$$B \rightarrow bBa \mid ba$$

Covert the given grammar to Chomsky Normal Form.   **[5]**

Q3. a) Design a push down automata (PDA) for the following language L

$$L = \{w \mid w \text{ contains } p^i \, q^j \, r^k \, s^m \mid i == k \text{ or } j >= m + 2, i > 0, j >= 3 \}$$

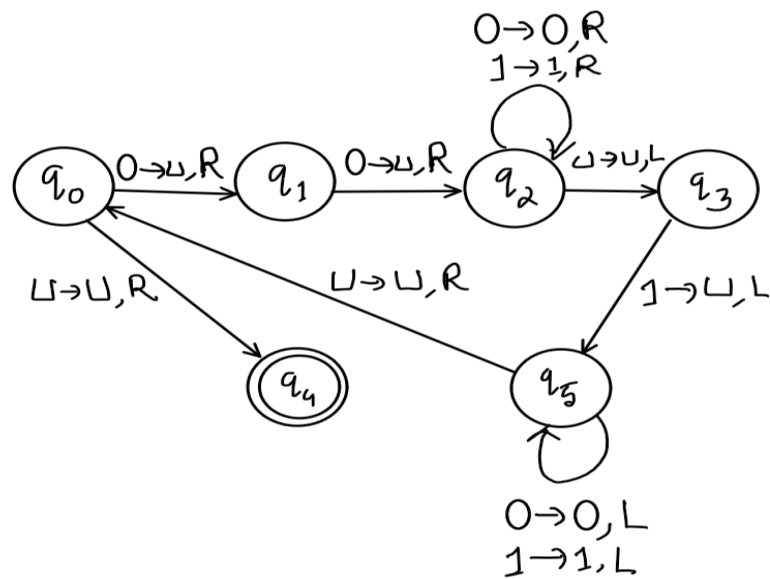Also give a formal definition of your designed PDA.   **[4+4]**

b) Design a push down automata for the language L = {w | w $\in \{a, b\}$* , w is a palindrome and |w| >= 0; here |w| = number of characters in string w}   **[5]**

Q4.

a) Is it possible to design a push down automata for the language L = {ww | w $\in$ {0,1}*}. Why or why not? Explain your answer with reasons and example.   **[3]**

b) The Turing Machine given below recognizes the language $A = \{0^{2n}1^n \mid n \geq 0\}$.

$$0 \to 0, R$$
$$1 \to 1, R$$

q_0 $0 \to \sqcup, R$ q_1 $0 \to \sqcup, R$ q_2 $\sqcup \to \sqcup, L$ q_3

$\sqcup \to \sqcup, R$ $\sqcup \to \sqcup, R$ $1 \to \sqcup, L$

q_4 q_5

$$0 \to 0, L$$
$$1 \to 1, L$$

Show the sequence of configurations(instantaneous description) that the Turning Machine enters for the input string **000011**. Also, indicate whether the input string is finally accepted or rejected .

[5]

End of Paper – Thank You