	King Saud University	College of Computer and Information Sciences Department of Computer Science
	Theory of computation CSC 339	**MT2 Exam - Spring 2018**
	Date: 5/04/2018	Duration: 1.5 hours

Guidelines
•No electronic devices are allowed in this exam.
•Use a pencil in choice questions.

Student ID:	Name:
Section:	Instructor:

1	2	3	4	5	Total

Question 1: (True/False) .... **24 points**

For each statement, choose whether it is True or False.

(a) $L1 = \{0^p1^q | p, q \in N\}$ cannot be recognized by a push-down automata.

Ⓐ True **Ⓑ False**

(b) Let $\Sigma = \{a, b\}$, $L = \{xy | x, y \in \Sigma^*$ and $|x| = |y|\}$ and $R = ((a + b).(a + b))^*$. The language $L = L(R)$.

Ⓐ True Ⓑ False

(c) Let $\Sigma = \{a, b\}$ and $L = \{a^n w a^n | n \geq 1$ and $w \in \Sigma^*\}$. L is not a context-free language.

Ⓐ True **Ⓑ False**

(d) Some regular expressions cannot be converted to push-down automata.

Ⓐ True **Ⓑ False**

(e) The pumping lemma cannot be used to prove that a language is regular.

Ⓐ True Ⓑ False

(f) Some context-free languages are regular languages.

Ⓐ True Ⓑ False

(g) Ambiguous grammar is a grammar that produces just one parse tree for every string in the language.

Ⓐ True **Ⓑ False**

(h) Some context-free languages cannot be recognized by Turing machines.

Ⓐ True **Ⓑ False**

(i) If L is a language recognized by a non-deterministic Turing machine, L cannot be recognized by a deterministic turing machine.

Ⓐ True **Ⓑ False**

(j) A Turing machine with multiple track tapes has multiple heads.

Ⓐ True **Ⓑ False**

(k) Multidimensional Turing machine can be replaced by a deterministic Turing machine.

(A) **True** (B) False

(l) In Turing machines, the accept state is always different from the reject state. (A) **True** (B) False

Question 2: (Short answers) .... **12 points**

(a) Which string is generated by the following grammar:

$$S \rightarrow xSy \mid SS \mid \epsilon$$

(A) xxyxxy

(B) **xyxxyxyy**

(C) Both (A) and (B)

(D) None

(b) The context-free grammar that accepts $L = \{w|w \in \Sigma^+$ and w starts and ends with the same symbol$\}$ and $\Sigma = \{a, b\}$ is:

(A) $S \rightarrow aSa \mid bSb \mid a \mid b$

(B) $\boldsymbol{S \rightarrow aAa \mid bAb}$
$\boldsymbol{A \rightarrow aA \mid bA \mid \epsilon}$

(C) $S \rightarrow aSa \mid A \mid a \mid b$
$A \rightarrow bAb \mid a \mid b \mid \epsilon$

(D) None

(c) Let L be a context-free language. Any production rule of the grammar describing L has the following form:

$$A \rightarrow BC$$
$$A \rightarrow a$$

where A, B, and C are non-terminal symbols (B and C cannot be the start symbol) and a is a terminal symbol.

The language $L^R = \{w^R|w \in L\}$ is:

(A) not a regular language and not a context-free language

(B) **a context-free language**

(C) a context-free language for some languages L

(D) None

Question 3: (Push-down automata) .... **22 points**

Consider the following formal definition of a push-down automata (PDA): $P = (Q, \Sigma, \Gamma, \delta, q_0, \$, F)$, where $Q = \{q_0, q_1, q_2\}$, $\Sigma = \{a, b\}$, $\Gamma = \{A\}$, $F = \{q_2\}$ and δ is given as follows.

$$\delta(q_0, a, \lambda) = (q_0, A)$$

$$\delta(q_0, \lambda, \lambda) = (q_1, \lambda)$$

$$\delta(q_1, b, A) = (q_1, \lambda)$$

$$\delta(q_1, \lambda, A) = (q_2, A)$$

$$\delta(q, x, y) = \phi \text{ in all other cases } (x \in \Sigma \text{ and } y \in \Gamma).$$

(a) Draw the corresponding push-down automata (assume the stack contains already \$).

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(b) Is the string `aabb` accepted by P:

(A) Yes **(B) No**

(c) The language recognized by this PDA is:

(A) $L = \{a^n b^n | n \geq 0\}$

(B) $L = \{a^m b^n | m > n \geq 0\}$

(C) $L = \{a^m b^n | n \geq m > 0\}$

(D) None

Question 4: (Context-free grammars) .... **22 points**

Given the following context-free grammar G, where $\Sigma = \{a, b, c\}$:

$$\begin{aligned}
S &\rightarrow AX \mid YC \\
A &\rightarrow aA \mid \epsilon \\
B &\rightarrow bB \mid \epsilon \\
C &\rightarrow cC \mid \epsilon \\
X &\rightarrow bXc \mid bB \mid cC \\
Y &\rightarrow aYb \mid aA \mid bB
\end{aligned}$$

(a) The grammar G can derive:

(A) aaba

Ⓑ aabbcc

Ⓒ aaAbXc

Ⓓ None

(b) The language described by the grammar is:

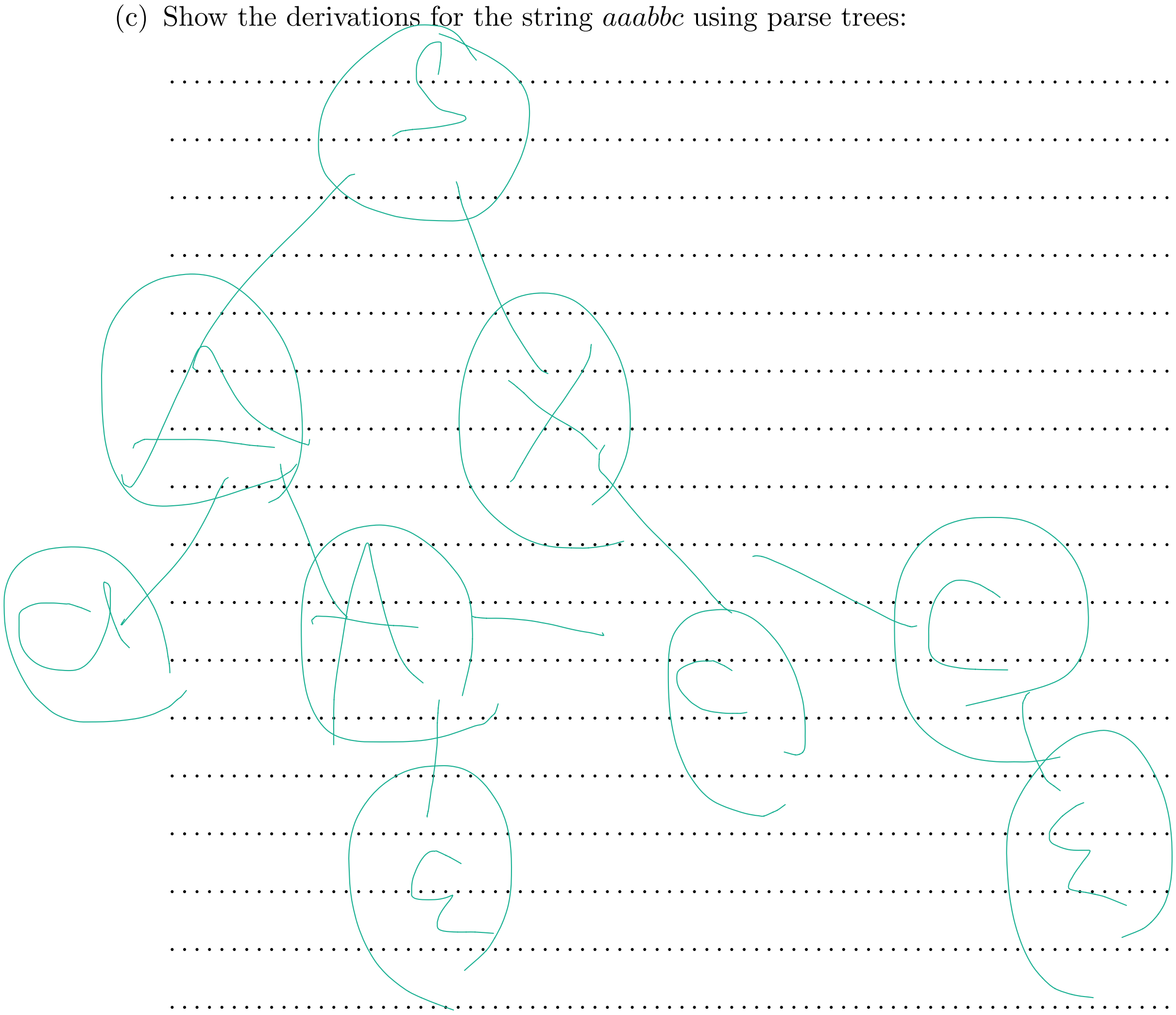
Ⓐ $L = \{a^n b^n c^n | n \geq 1\}$

Ⓑ $L = \{a^i b^j c^k | i \neq j$ or $j \neq k\}$

Ⓒ $L = \{a^i b^j c^k | i < j$ or $j < k\}$

Ⓓ None

(c) Show the derivations for the string *aaabbc* using parse trees:



(d) The grammar is:

Ⓐ ambiguous because S has two possible derivations

Ⓑ ambiguous because two parse trees can be obtained

Ⓒ not ambiguous because we can always transform an ambiguous grammar to a non-ambiguous grammar

Ⓓ None

Question 5: (Turing machine) .... **20 points**

Consider the following formal definition of a Turing machine: $M = (Q, \Sigma, \Gamma, \delta, q_0, q_{acc}, q_{rej})$ where $Q = \{q_0, q_1, q_2, q_{acc}, q_{rej}\}$, $\Sigma = \{0, 1\}$, $\Gamma = \{0, 1, \sqcup\}$, and δ is given as follows.

$$\delta(q_0, 0) = (q_1, 1, R)$$

$$\delta(q_1, 1) = (q_2, 0, L)$$

$$\delta(q_1, \sqcup) = (q_{acc}, \sqcup, R)$$

$$\delta(q_2, 1) = (q_0, 0, R)$$

(a) Draw the corresponding Turing machine.

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(b) Is the string `0111` accepted by M:

(A) Yes (B) No

(c) Is the string `0110` accepted by M:

(A) Yes **(B) No**

(d) The language accepted by M :

(A) cannot be described by a regular expression.

(B) can be described by the regular expression 01^*.

(C) can be described by the regular expression $(0110)^+$.

(D) None

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