CSE 355 Test 2, Fall 2016

28 October 2016, 8:35-9:25 a.m., LSA 191

Last Name		ASU ID	
First Name(s)			

Instructions

1. Do not open the exam until you are instructed to do so.
2. There are five sheets of paper, two-sided, containing "Multiple Choice Questions", "Answers to Multiple Choice", and three "Long Answer" questions. You **must** write your name and student number on each and every sheet indicated; failure to do so may result in your test not being properly graded. *Write legibly – we must be able to read your name and number.* You must turn in **all sheets** including the multiple choice questions.
3. You have 50 minutes to complete the exam.
4. No books, notes, electronic devices, or other aids are permitted. Turn off all wireless devices and place them away from your work space.
5. Write all answers on the examination paper itself. Work on pages indicated "rough work only" is not graded.
6. BUDGET YOUR TIME WELL! SHOW ALL WORK!

Question	Mark	Out Of
MC		14
1		12
2		12
3		12
Total		50

Answers to Multiple Choice [14 marks in total]

Enter each response (one of `a, b, c, d, e`) for the questions on the "Multiple Choice" pages. Giving 0, or 2 or more, responses to a question is incorrect. Illegible or blank responses are incorrect.

1	2	3	4	5	6	7
8	9	10	11	12	13	14
TOTAL						

Name:_____ Multiple Choice 1 Student Number:_____

Multiple Choice [14 marks in total] Select the most appropriate answer for each, and enter each response (one of `a, b, c, d, e`) on the *"Answers to Multiple Choice"* page.

1. A class of languages is closed under subsets if whenever L is in the class and $L' \subseteq L$, L' is also in the class. Among the context-free, regular, and finite languages, the classes that are closed under subsets are:
   (a) none of context-free, regular, or finite.
   (b) all of context-free, regular, and finite.
   (c) only context-free
   (d) only finite.
   (e) regular and context-free, but not finite.
2. A derivation of a string w of length n in a context-free grammar
   (a) must involve exactly $2n - 1$ applications of rules for all n.
   (b) must involve exactly $2n - 1$ applications of rules, except possibly when $n \leq 5$.
   (c) must involve at least n rules, but can involve an arbitrarily large number.
   (d) must involve at least n rules and at most 2^n rules.
   (e) can involve any positive integer number of rules.
3. A derivation of a string w of length n in a context-free grammar in Chomsky normal form
   (a) must involve exactly $2n - 1$ applications of rules for all n.
   (b) must involve exactly $2n - 1$ applications of rules, except possibly when $n \leq 5$.
   (c) must involve at least n rules, but can involve an arbitrarily large number.
   (d) must involve at least n rules and at most 2^n rules.
   (e) can involve any positive integer number of rules.
4. A context-free grammar G is *ambiguous* if
   (a) G is not in Chomsky normal form.
   (b) some string $w \in L(G)$ has at least two different derivations.
   (c) some string $w \in L(G)$ has at least two different parse trees.
   (d) every string $w \in L(G)$ has at least two different parse trees.
   (e) every string $w \in L(G)$ has at least two different derivations.
5. To show that a language is context-free, one could give a PDA for it. One could also
   (a) give a context-free grammar for it.
   (b) use the pumping lemma for context-free languages.
   (c) use closure properties.
   (d) (a) or (c)
   (e) (b) or (c)
6. To show that a language is **not** context-free, one could
   (a) show that it has no context-free grammar.
   (b) use the pumping lemma for context-free languages.
   (c) use closure properties.
   (d) (a) or (c)
   (e) (b) or (c)
7. Whenever each transition of a PDA M does not pop a symbol, the language of M
   (a) must be regular but need not be finite.
   (b) must be context-free but need not be regular.
   (c) must be finite but need not be empty.
   (d) may not be context-free.

(e) must be empty.

8. Whenever each transition of a PDA M that pushes also pops, the language of M
   (a) must be regular but need not be finite.
   (b) must be context-free but need not be regular.
   (c) must be finite but need not be empty.
   (d) may not be context-free.
   (e) must be empty.
9. Whenever each transition of a PDA M pops a symbol, the language of M
   (a) must be regular but need not be finite.
   (b) must be context-free but need not be regular.
   (c) must be finite but need not be empty.
   (d) may not be context-free.
   (e) must be empty.
10. Whenever each transition of PDA M either pops or pushes, but not both, the language of M
   (a) must be regular but need not be finite.
   (b) must be context-free but need not be regular.
   (c) must be finite but need not be empty.
   (d) may not be context-free.
   (e) must be empty.
11. In a CFG in CNF with start variable S, which rule could **not** arise?
   (a) $S \to BC$.
   (b) $B \to Bc$.
   (c) $B \to a$.
   (d) $S \to \varepsilon$.
   (e) $A \to BC$.
12. In converting a regular grammar to Chomsky normal form, which step is **not** required?
   (a) Break up long right hand sides.
   (b) Make the start variable be not recursive.
   (c) Eliminate unit rules.
   (d) Ensure right hand sides are single terminals *or* just variables.
   (e) Eliminate ε rules except possibly for $S \to \varepsilon$.
13. Context-free languages are closed under
   (a) union, star, and complementation but not intersection or concatenation.
   (b) union, star, and concatenation but not intersection or complementation.
   (c) union, star, intersection, and concatenation but not complementation.
   (d) union, star, intersection, concatenation, and complementation.
   (e) union and concatenation but not star, intersection, or complementation.
14. Suppose that $M = (Q, \Sigma, \Gamma, \delta, q_0, F)$ is a PDA. Which of the following must be **false**?
   (a) Q is empty.
   (b) Σ is empty.
   (c) Γ is empty.
   (d) F is empty.
   (e) $\Sigma \not\subseteq \Gamma$.

Question 1. [12 marks] The *square* of a language L is $\texttt{Sq}(L) = \{ww : w \in L\}$; the *double* of a language is $\texttt{Do}(L) = \{wx : w, x \in L\}$.

(a) [4 marks] If L is regular, must $\texttt{Do}(L)$ be context-free? Justify your answer carefully.

(b) [8 marks] If L is regular, must $\texttt{Sq}(L)$ be context-free? Justify your answer carefully.

ROUGH WORK ONLY, WILL NOT BE GRADED

Question 2. [12 marks] Let $L_1 = \{w \in \{0,1,2\}^\star : w \text{ contains more 0s than 1s}\}$. Let $L_2 = \{w \in \{0,1,2\}^\star : w \text{ has the same number of 1s and 2s}\}$.

(a) [3 marks] Give a transition diagram for a PDA to recognize L_1.

(b) [3 marks] Give a CFG to generate L_2.

(c) [6 marks] State whether or not $L_1 \cap L_2$ is context-free. Justify your answer carefully.

ROUGH WORK ONLY, WILL NOT BE GRADED

Question 3. [12 marks] Consider the context-free grammar G with variables $\{S, A, B\}$, terminals $\{0, 1\}$, and rules

1. $S \to A \mid B$
2. $A \to aAa \mid Aa \mid B \mid \varepsilon$
3. $B \to aBb \mid Bb \mid B \mid \varepsilon$

(a) [6 marks] Using grammar G *and using the methods from class*, form an equivalent grammar G' in which (1) the start variable does appear on the RHS of a rule, (2) there are no unit rules, and (3) the only ε-rule has the start variable on the LHS.

(b) [6 marks] Using the method described in class, show a transition diagram for a PDA that recognizes the language generated by G. Explain your steps.

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