Last name (please print)	
First name (please print)	
Student Number	

WESTERN UNIVERSITY
DEPARTMENT OF COMPUTER SCIENCE

CS3331 - Foundations of Computer Science – Fall 2015 – Midterm Exam
Instructor: Dr. Lucian Ilie
Tuesday, Nov. 3, 2015, 3:30 - 5:30pm, B&G165

This exam consists of 5 questions (11 pages, including this page), worth a total of 100 marks. **No other materials are allowed, such as cheat-sheets (or any other sheets), books, or electronic devices.** All answers are to be written in this booklet. Scrap work (not marked!) may be done on the back of each page or on pages 7–11. The exam is 120 minutes long and comprises 30% of your final mark.

(1) 20pt	
(2) 20pt	
(3) 20pt	
(4) 20pt	
(5) 20pt	
Grade	

1. (20pt)
   (a) Construct a NDFSM M_1 equivalent with the regular expression $((\mathtt{a}^* \cup \mathtt{b}^*)\mathtt{a})^*$.
   (b) Construct a DFSM M_2 equivalent with M_1.
   (c) Minimize M_2.

2. (20pt) Give a decision procedure for each of the following problems; argue that your procedure is correct:

   (a) Given two regular languages R_1 and R_2, is it true that there are finitely many strings that belong to both languages?

   (b) Given a regular language R and a context-free language C, both over the alphabet $\{\mathtt{a}, \mathtt{b}\}$, is it true that C contains exactly 2 strings that
   - consist only of `a`'s and
   - are not in R?

3. (20pt) Indicate whether each of the following statements is true or false; explain your answer:

   (a) Given an infinite regular language R, any expression α such that $L(\alpha) = R$ must contain at least one occurrence of the Kleene '$*$' operator.

   (b) Every infinite regular language is the complement of a finite regular language.

   (c) Every context-free grammar that generates the language $\{w(\mathtt{aa})^* w^R \mid w \in \{\mathtt{a}, \mathtt{b}\}^*\}$ is ambiguous.

4. (20pt) For each of the languages below, prove whether it is regular or context-free:
   (a) $L_1 = \{\mathtt{a}^n\mathtt{b}^m \mid n, m \geq 0, n \neq m\}$.
   (b) $L_2 = \{\mathtt{a}^p\mathtt{a}^q\mathtt{a}^p \mid p, q \geq 0, p \text{ is prime}\}$.

5. (20pt) Given the grammar G for balanced parentheses:

$$\begin{array}{lcl} S & \rightarrow & SS \\ S & \rightarrow & (S) \\ S & \rightarrow & () \end{array}$$

   (a) Is G in Chomsky normal form? Prove your answer.

   (b) Is G ambiguous? Prove your answer.

   (c) Is it true that any grammar in Chomsky normal form is unambiguous? Prove your answer.

(scrap work)

(scrap work)

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