Midterm Exam 1
CS 341: Foundations of Computer Science II — **Fall 2014, day section**
Prof. Marvin K. Nakayama

Print family (or last) name: ____________________________________

Print given (or first) name: ____________________________________

I have read and understand all of the instructions below, and I will obey the NJIT Code of Academic Codd Integrity.

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Signature and Date

- This exam has 7 pages in total, numbered 1 to 7. Make sure your exam has all the pages.
- Note the number written on the upper right-hand corner of the first page. On the sign-up sheet being passed around, sign your name next to this number.
- This exam will be 1 hour and 25 minutes in length.
- This is a closed-book, closed-note exam.
- For all problems, follow these instructions:
  1. Give only your answers in the spaces provided. I will only grade what you put in the answer space, and I will take off points for any scratch work in the answer space. Use the scratch-work area or the backs of the sheets to work out your answers before filling in the answer space.
  2. For any proofs, be sure to provide a step-by-step argument, with justifications for every step.

Problem	1	2	3	4	5	Total
Points						

1. **[20 points]** For each of the following, circle TRUE if the statement is correct. Otherwise, circle FALSE

(a) TRUE FALSE — If a language A is regular, then A^* must be regular.

(b) TRUE FALSE — If A_1 and A_2 are regular languages, then $A_1 \circ A_2$ must be context-free.

(c) TRUE FALSE — If a language A has an NFA, then A is nonregular.

(d) TRUE FALSE — The regular expressions $(a \cup b)^*$ and $(b^* a^*)^*$ generate the same language.

(e) TRUE FALSE — If a language A has a regular expression, then it also has a context-free grammar.

(f) TRUE FALSE — If a language A is recognized by a PDA, then it also is recognized by a DFA.

(g) TRUE FALSE — If a language A is recognized by a PDA, then it also is recognized by an NFA.

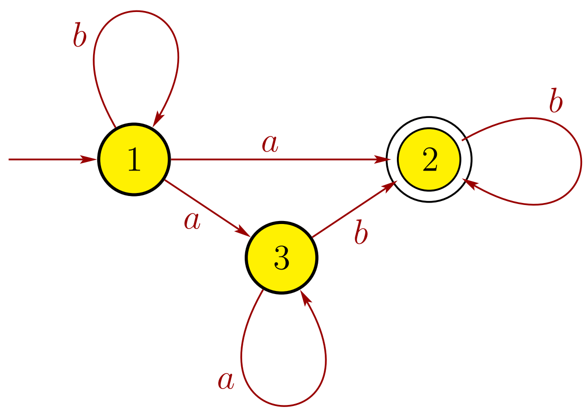
(h) TRUE FALSE — The class of context-free languages is closed under intersection.

(i) TRUE FALSE — The class of context-free languages is closed under complementation.

(j) TRUE FALSE — If A is a language generated by a context-free grammar in Chomsky normal form, then A must be regular.

2. **[20 points]** Give short answers to each of the following parts. Be sure to define any notation that you use.

(a) Give a regular expression for the language recognized by the NFA below.



(b) Suppose A is generated by a context-free grammar $G = (V, \Sigma, R, S)$. Give a context-free grammar G' for A^* in terms of G. You do not have to prove the correctness of your CFG G', but do not just give an example.

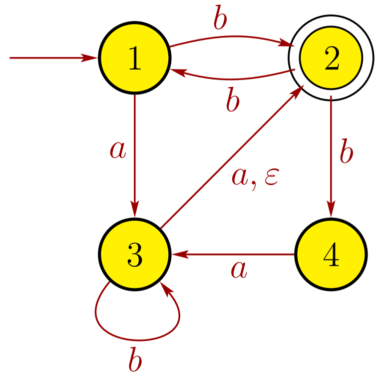
(c) Let $M_1 = (Q_1, \Sigma, \delta_1, q_1, F_1)$ be a DFA with language A_1, and $M_2 = (Q_2, \Sigma, \delta_2, q_2, F_2)$ be a DFA with language A_2. Consider the language $A = A_1 \cap A_2$. Give a DFA M_3 for A in terms of M_1 and M_2. Your DFA M_3 must be completely general. Do not prove the correctness of your DFA M_3, but do not just give an example.

(d) Suppose that we are in the process of converting a CFG G with $\Sigma = \{0, 1\}$ into Chomsky normal form. We have already applied some steps in the process, and we currently have the following CFG:

$$\begin{aligned} S_0 &\rightarrow S \\ S &\rightarrow A1SA \mid A0 \mid \varepsilon \\ A &\rightarrow 0S0 \mid \varepsilon \end{aligned}$$

In the next step, we want to remove the ε-rule $A \rightarrow \varepsilon$. Give the CFG after carrying out just this one step.

3. **[20 points]** Let N be the following NFA with $\Sigma = \{a, b\}$, and let $C = L(N)$.



Give a DFA for C.

Scratch-work area

4. **[25 points]** Consider the alphabet $\Sigma = \{a, b\}$ and the language

$$L = \{\ b^i a^j \mid i \geq j\}.$$

(a) Give a context-free grammar G for L. Be sure to specify G as a 4-tuple $G = (V, \Sigma, R, S)$.

(b) Give a PDA for L. You only need to draw the graph.

Scratch-work area

5. **[15 points]** Recall the pumping lemma for regular languages:

Theorem: If L is a regular language, then there exists a pumping length p where, if $s \in L$ with $|s| \geq p$, then s can be split into 3 pieces, $s = xyz$, with (i) $xy^iz \in L$ for each $i \geq 0$, (ii) $|y| \geq 1$, and (iii) $|xy| \leq p$.

Let $A = \{ b^i a^j \mid i \geq j \}$. Is A a regular or nonregular language? If A is regular, give a regular expression for A. If A is not regular, prove that it is a nonregular language.

Circle one: **Regular Language** **Nonregular Language**