

Midterm Exam 1
CS 341: Foundations of Computer Science II — **Spring 2010, 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 Academic Honor Code.

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						

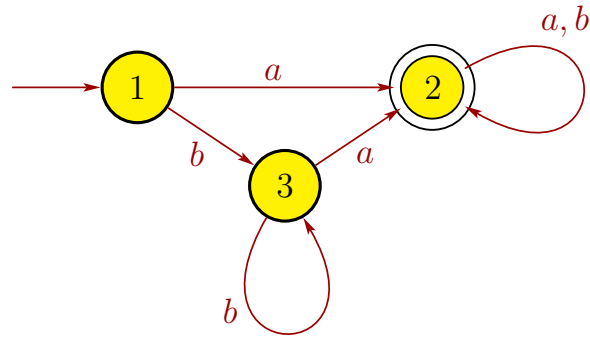
1. [20 points] For each of the following, circle TRUE if the statement is correct. Otherwise, circle FALSE

- (a) TRUE FALSE — If $A \subseteq B$ and B is a regular language, then A must be regular.
- (b) TRUE FALSE — If $A \subseteq B$ and A is a regular language, then B must be regular.
- (c) TRUE FALSE — If A is regular, then A must be finite.
- (d) TRUE FALSE — Every context-free language is also regular.
- (e) TRUE FALSE — The class of regular languages is closed under intersection.
- (f) TRUE FALSE — A regular expression for $A = \{0^n1^n \mid n \geq 0\}$ is 0^*1^* .
- (g) TRUE FALSE — If A has an NFA, then A is nonregular.
- (h) TRUE FALSE — If A has a DFA, then A must have a context-free grammar.
- (i) TRUE FALSE — If a language A has a PDA, then A must have a context-free grammar in Chomsky normal form.
- (j) TRUE FALSE — The transition function of an NFA is $\delta : Q \times \Sigma_\epsilon \rightarrow Q$.

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 DFA below.

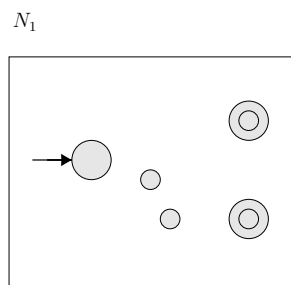
Answer: _____



(b) For the alphabet $\Sigma = \{a, b\}$, give a regular expression for the language of strings having an odd number of b 's.

Answer: _____

- (c) Suppose that language A_1 is recognized by NFA N_1 below. Note that the transitions are not drawn in N_1 . Draw a picture of an NFA for A_1^* .

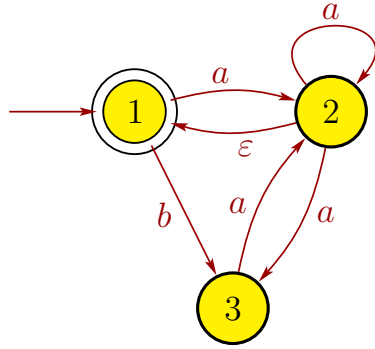


- (d) Consider the following CFG $G = (V, \Sigma, R, S)$, with $V = \{S, X, Y\}$, $\Sigma = \{a, b\}$, start variable S , and rules R as follows:

$$\begin{aligned} S &\rightarrow ba \mid Yb \mid \varepsilon \\ X &\rightarrow YS \mid \varepsilon \\ Y &\rightarrow a \mid X \end{aligned}$$

Note that G is not in Chomsky normal form. List all of the rules in G that violate Chomsky normal form. Explain your answer.

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



(a) List the strings in C in lexicographic order. If C has more than 5 strings, list only the first 5 strings in C , followed by 3 dots.

(b) Give a DFA for C .

Scratch-work area

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

$$L = \{ b^i c^j a^k \mid i, j, k \geq 0 \text{ and } i + j = k \}.$$

(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 there exists strings x, y, z such that $s = xyz$ and (i) $xy^iz \in L$ for each $i \geq 0$, (ii) $|y| \geq 1$, and (iii) $|xy| \leq p$.

Let $A = \{b^i c^j a^k \mid i, j, k \geq 0 \text{ and } i + j = k\}$. 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