Midterm Exam I
CIS 341: Foundations of Computer Science II — **Spring 2006, 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 6 pages in total, numbered 1 to 6. Make sure your exam has all the pages.
- 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. DFA stands for deterministic finite automaton; NFA stands for nondeterministic finite automaton.
    3. 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 is a regular language, then A is finite.

(b) TRUE FALSE — If R is any regular expression, then $L(R \cup \varepsilon) = L(R)$.

(c) TRUE FALSE — If R is any regular expression, then $L(R \circ \emptyset) = L(R)$.

(d) TRUE FALSE — A regular expression for the language $\{ b^n a^n \mid n \geq 0 \}$ is $\varepsilon \cup ba \cup bbaa \cup bbbaaa \cup \cdots$.

(e) TRUE FALSE — If language A has a regular expression, then $\overline{A}$ is recognized by some NFA.

(f) TRUE FALSE — If A is a nonregular language and B is a finite language, then $A \cup B$ must be nonregular.

(g) TRUE FALSE — If A is a nonregular language, then there exists a regular language B with $B \subseteq A$.

(h) TRUE FALSE — A DFA $M = (Q, \Sigma, \delta, q_0, F)$ may have $F = Q$.

(i) TRUE FALSE — A DFA $M = (Q, \Sigma, \delta, q_0, F)$ may have $F = \emptyset$.

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

2. **[20 points]** Give definitions or meanings of the following terms and phrases. Each answer should be at most two sentences. Be sure to define any notation that you use.

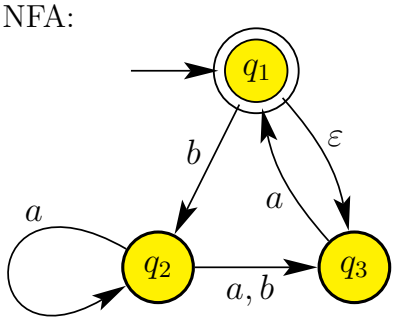
   (a) For a machine M, what is $L(M)$?

   (b) What does Kleene's Theorem say?

   (c) Define the following statement: "The class of regular languages is closed under concatenation."

   (d) Explain the difference between a DFA and an NFA.

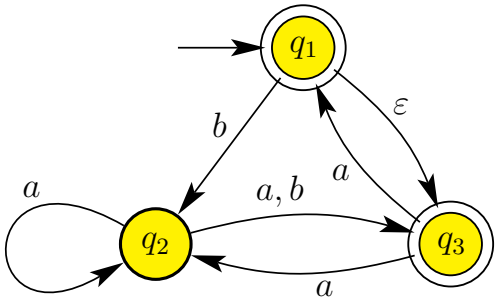
3. **[20 points]** Let A be the language over the alphabet $\Sigma = \{a, b\}$ defined by the following NFA:



Draw here a DFA that recognizes A.

Scratch-work area

4. **[20 points]** Let B be the language recognized by the following NFA:



Give a regular expression for B.

Answer:

Scratch-work area

5. **[20 points]** Recall the pumping lemma:

   Theorem: If A is a regular language, then $\exists$ number p (pumping length) where, if $s \in A$ with $|s| \geq p$, then $\exists$ strings x, y, z such that $s = xyz$ and

   (i) $xy^iz \in A$ for each $i \geq 0$,

   (ii) $|y| > 0$, and

   (iii) $|xy| \leq p$.

   Prove that $C = \{ b^{2n}a^{2n}b^{3n} \mid n \geq 0 \}$ is a nonregular language.