15-212
Spring 1998
Midterm Exam 1
10 Feb 1998

Full Name: _____

E-mail: _____

Section: _____

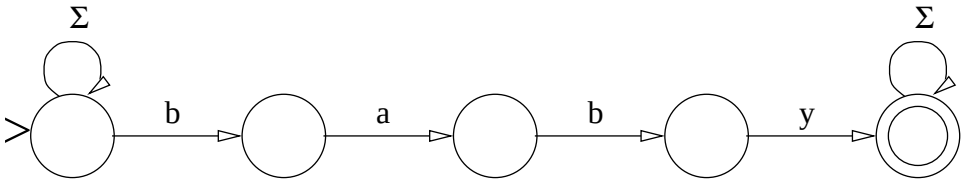
GENERAL GUIDELINES:

1. There are 8 questions in this exam, for a total of 100 points. It is closed book, closed notes.
2. Write your answers directly on the test using the space provided for each question. The amount of space provided is usually *more* than the expected length of the answer.
3. Neatness, clarity and conciseness count.

1. (*10 points*) List the following machines or languages in increasing order of power (*i.e.*, ability to represent languages that others cannot). (List equivalent ones on the same line):

   - Context-free grammars (CFG)
   - Turing machines (TM)
   - Deterministic finite state automata (DFSA)
   - Regular expressions (RE)
   - Deterministic push down automata (DPDA)
   - Non-deterministic push down automata (NPDA)
   - Non-deterministic finite state automata (NFSA)

2. (*10 points*) Briefly describe what is accepted by this FSA, and write the language accepted by it as a regular expression:



3. (*10 points*) If a DFSM F accepts a (regular) language L, then we can construct another one to accept L's complement by interchanging the accepting and non-accepting states of F. Explain why this construction fails if F were non-deterministic.

4. (*15 points*) If L is context-free, is $L' = \{w : w^R \text{ in } L\}$ also context-free? (w^R is the reverse of w.) Give an informal argument justifying your answer.

5. (*15 points*) We know that the language of balanced parenthesis strings (), (())(), ((()()), etc. is context-free but not regular. If we limit the nesting of parentheses to some constant K (i.e., at any point in a string there are at most K left parentheses pending to be closed), do we then get a regular language? Why or why not?

6. (*15 points*) How many languages are there over a finite alphabet? How many Turing machines are there? What does this imply?

7. (*15 points*) Write a CFG over $\Sigma = \{a, b\}$ for $L = \{xayb : x, y \text{ in } \Sigma^*, \text{ and } |x| = |y|\}$. ($|x|$ is the length of string x.)

8. (*10 points*) Show that $L = \{wxw^R : w \text{ and } x \text{ are strings in } \Sigma^*\}$ is regular. (w^R is the reverse of w.)