General Instructions: Homework must be typeset in \LaTeX, and is due at the beginning of class on the due date. No late work is accepted.

For clarification about how to describe Turing Machine algorithms, see Section 3.3 in the book, or Slide Set #15.

1. (20 Points) Example 3.9 in the book defines a machine $M_1$. Use that definition and state diagram to give the sequence of configurations that $M_1$ enters when started with the following two input strings:
   a. 10#11  
   b. 10#10

2. (20 Points) Give an implementation-level description of a Turing Machine that decides the language $X = \{w \mid w$ does not contain twice as many 0s as 1s$\}$.

3. (40 Points) Let a $k$-PDA be a pushdown automaton that has $k$ stacks. Thus a 0-PDA is an NFA and a 1-PDA is a conventional PDA. You already know that 1-PDAs are more powerful (recognize a larger class of languages) than 0-PDAs. For these proofs, you may omit the Intuition section if you feel confident in your formal proof presentation.
   a) Write a proof showing that 2-PDAs are more powerful than 1-PDAs.
   b) Write a proof showing that 3-PDAs are not more powerful than 2-PDAs.
      (Hint: Simulate a Turing machine tape with two stacks.)

4. (35 Points) A queue automaton is like a push-down automaton except that the stack is replaced by a queue. A queue is a tape allowing symbols to be written only on the left-hand end and read only at the right-hand end. Each write operation (we’ll call it a push) adds a symbol to the left-hand end of the queue and each read operation (we’ll call it a pull) reads and removes a symbol at the right-hand end. As with a PDA, the input is placed on a separate read-only input tape, and the head on the input tape can move only from left to right. The input tape contains a cell with a blank symbol following the input, so that the end of the input can be detected. A queue automaton accepts its input by entering a special accept state at any time. Write a proof showing that a language can be recognized by a deterministic queue automaton iff the language is Turing-recognizable. Your solution should follow the standard, 3-part format for proof-based answers.