Due at the start of class Tuesday, October 11, 2005.

Problem 1. Do Exercises 3.6 (page 111) in Kinber and Smith.

Problem 2. Consider the language of all words over the alphabet $\{a, b\}$ with twice as many a's as b's. For example aba, $babaaa$, and $ababaa$ are in the language. The empty word is also in the language.

- **a.** Give a context free grammar that generates all words in the language.
- **b.** Give a PDA that recognizes all words in the language.

Problem 3. Consider the language of all words over the alphabet $\{a, b\}$ with *more than* twice as many a's as b's. For example a, $aaba$, $babaaaa$, and $abaaaabaa$ are in the language, but aab is not.

- **a.** Give a context free grammar that generates all words in the language.
- **b.** Give a PDA that recognizes all words in the language.

Problem 4. A **queue automaton** is a device like a pushdown automaton, except the stack is replaced by a queue.

- **a.** Formally define
  - **i.** a **queue automaton**;
  - **ii.** a **configuration**;
  - **iii.** the **yields in one step** relation between configurations;
  - **iv.** the notion that an automaton **accepts** a string;
- **b.** Construct the queue automaton that accepts all strings over the alphabet $\{a, b\}$ with the same number of a's as b's.
- **c.** State a language that is accepted by a pushdown automaton, but not a queue automaton. No proof necessary.
- **c.** State a language that is accepted by a queue automaton, but not a pushdown automaton. Construct the queue automaton. No proof necessary for the latter.

Challenge problem. Is there a natural way of associating a queue automaton with a grammar?