# University of Washington

CSE 322: Introduction to Formal Models in Computer Science
Midterm 2 Review
Midterm 2: Monday, May 20, 2002, 10:30am

Spring 2002 May 13, 2002

Here's a list of things you should know about for Midterm 2 on Monday, May 20. The test will cover primarily Section 1.4 (nonregular languages) and Chapter 2 (context-free languages), Sections 2.1 and 2.2, not including the material on Chomsky Normal Form. However, you will need to know everything we learned in Chapters 0 and 1. There will be a small portion of the test devoted to regular languages.

- The Pumping Lemma (Section 1.4): Understand the proof. Understand why it is important. Understand how to use it to prove languages are not regular.
- Closure properties of regular languages (Section 1.4): Know how to use the closure properties of regular languages to prove that a language is not regular.
- Context-free grammars (Section 2.1): Definition of a CFG. Given a language, construct a CFG that generates that language. Given a CFG, determine what language it generates.
- Pushdown automata (Section 2.2): Definition of a PDA. Given a language, construct a PDA that accepts that language. Given a PDA, determine what language it accepts.
- Equivalence of CFGs and PDAs (Section 2.2): Know roughly how the constructions work. You don't need to know the proofs in detail, but you should have a feel for how they work.
- Properties of context-free languages: closure under union, concatenation, and Kleene star.

Some tips:

- Make sure you know and understand all of the definitions of the various objects we have encountered so far.
- To get more practice, do some (or all) of the suggested exercises from the homework assignments.
- Take a look at the homework solutions that have been handed out.
- You might find it helpful to solve some problems (for example, the suggested problems) in a small group for a little while to get more practice.
- To do well on the exam, you must understand the concepts, not just mimic what we have done so far in lecture and on the homework.

(more review on the next page)

Here is a list of languages. For each one, determine whether it is regular or not and whether it context-free or not. If it is not context-free, try to convince yourself that there is no CFG or PDA for it. If it is context-free, try to construct a CFG or PDA for it. If (in addition) it is regular, try to construct a DFA, NFA, or regular expression for it. If it is not regular, prove it is not regular. Unless otherwise noted, assume we are using a fixed alphabet $\Sigma$.

- $\phi$, $\Sigma^*$
- any finite set of strings
- $\{ w : |w| \text{ is even}\}$
- $\{ w : |w| \text{ is divisible by } 71 \}$
- $L(\alpha)$, where $\alpha$ is a regular expression
- $\{ xy : x, y \in \Sigma^*, x \in L_1, y \in L_2, \text{ where } L_1 \text{ is regular and } L_2 \text{ is regular} \}$
- $\{ w : |w| \geq 53 \}$
- $\{ w : |w| \leq 74 \}$
- $\{ w : w \text{ contains } aab \text{ as a substring} \}$
- $\{ w : w \text{ has an even number of } a\text{'s and an odd number of } b\text{'s} \}$
- $\{ w : \text{when interpreted as a binary number, } w \text{ is divisible by } 7 \}$
- $\{ w^R : w \in L, \text{ where L is regular} \}$
- $\{ w^R : w \in L, \text{ where L is context-free} \}$
- $\{ w : w = w^R \}$
- $\{ w w^R : w \in \Sigma^* \}$
- $\{ w w' : w \in \{a, b\}^*$ and $w'$ is the same as $w$ but with each occurrence of $a$ replaced by $b$ and vice versa $\}$
- $\{ ww : w \in \Sigma^* \}$
- $\{ a^n b^n : n \geq 0 \}$
- $\{ a^n a^n : n \geq 0 \}$
- $\{ a^n b a^n : n \geq 0 \}$
- $\{ a^{5n} : n \geq 0 \}$
- $\{ a^k : k = n^2, n \geq 0 \}$
- $\{ a^k : k = 3^n, n \geq 0 \}$
- $\{ w : w \text{ has an equal number of } a\text{'s and } b\text{'s} \}$
- $\{ a^p : p \text{ is a prime number} \}$
- $\{ a^i b^j : i > j \}$
- $\{ a^i b^j : i \neq j \}$
- $\{ a^i b^j : i = j \}$
- $\{ a^n b^n c^n : n \geq 0 \}$
- $\{ w \in \{a, b, c\}^* : w \text{ has an equal number of } a\text{'s, } b\text{'s, and } c\text{'s} \}$