Midterm Exam II
CIS 341: Foundations of Computer Science II — **Spring 2005, 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; CFG stands for context-free grammar; PDA stands for pushdown automaton.
  3. For any proofs, be sure to provide a step-by-step argument, with justifications for every step. Unless you are specifically asked to prove a theorem from the book, you may assume that the theorems in the textbook hold; i.e., you do not have to reprove the theorems in the textbook. When using a theorem from the textbook, make sure you provide enough detail so that it is clear which result you are using; e.g., say something like, "By the theorem that shows every NFA has an equivalent DFA, it follows that ..."

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 has a CFG, then $\overline{A}$ has a PDA.

(b) TRUE FALSE — If language A_1 is recognized by an NFA and language A_2 has a PDA, then $A_1 \cup A_2$ has a CFG.

(c) TRUE FALSE — If A is a context-free language, then A has a CFG G in Chomsky normal form.

(d) TRUE FALSE — A Turing machine will halt on every input.

(e) TRUE FALSE — If A is a Turing-decidable language, then A is also Turing-recognizable.

(f) TRUE FALSE — Every nondeterministic Turing machine has an equivalent Turing machine.

(g) TRUE FALSE — The language $A = \{ a^n b^n c^n \mid n \geq 0 \}$ is context-free.

(h) TRUE FALSE — It is impossible to determine if a CFG generates ε.

(i) TRUE FALSE — The language

$$A_{\text{DFA}} = \{ \langle M, w \rangle \mid M \text{ is a DFA that accepts } w \}$$

is Turing-decidable.

(j) TRUE FALSE — There are some languages recognized by a 4-tape Turing machine that cannot be recognized by a 1-tape Turing machine.

2. **[20 points]** Give a short answer (at most two sentences) for each part below. No proofs are required, but be sure to define any notation that you use.

   (a) Give an example of a context-free language that is not a regular language.

   (b) Explain the difference between a Turing-decidable language and a Turing-recognizable language.

   (c) What is the Church-Turing Thesis?

   (d) What does it mean for a CFG G to be in Chomsky normal form?

3. **[20 points]** Give an implementation-level description of a Turing machine that decides the language $L = \{ a^n b^n c^n \mid n \geq 0 \}$.

Scratch-work area

4. **[20 points]** Consider the following statement:

   The class of context-free languages is closed under intersection.

   Is the statement TRUE or FALSE. If it is TRUE, give a proof. If it is FALSE, give a counterexample. Be sure to explain your answer in detail.

   TRUE **FALSE** (circle one)

5. [**20 points**] Consider the problem of testing whether a DFA and regular expression are equivalent. Express this problem as a language and show that it is decidable.