CS 4114
Midterm Exam

Given: March 2, 2000, 9:30–10:45
Time: 75 minutes

Name:

Signature:

Instructions

1. Before you start answering questions, fill in your name above. Before you turn in your exam, sign above testifying that you have neither given nor received aid on this exam. **Unsigned exams will not be accepted!**

2. The exam consists of four problems worth a total of 150 points.

3. Put your answers in the space provided on the exam sheets.

4. You may consult the textbooks, your notes, or the handouts.

5. Each solution must include an explanation of how the given solution was obtained or why it is correct. An answer, correct or incorrect, without an explanation is worth no credit.

Good luck!
1. Consider the following language:

\[ L_1 = \{ w \in \{a, b\}^* \mid n_a(w) = 3 \text{ or } n_b(w) = 5 \}. \]

1. Give examples of 5 strings that are in \( L_1 \) and of 5 strings that are not in \( L_1 \).

2. Give a regular expression that represents \( L_1 \).

Space for your solution to Problem 1:
2. Consider the following language:

\[ L_2 = \{ a^i b^j c^k d^\ell \mid i + j = k + \ell \} \).

1. Give examples of 5 strings that are in \( L_2 \) and of 5 strings that are not in \( L_2 \).

2. Give a context-free grammar that generates \( L_2 \).

Space for your solution to Problem 2:
[40] 3. Context-free grammar $G_3$ is given by the following productions:

1. $S \rightarrow ba$
2. $S \rightarrow SbSa$.

1. Show the portion of $g_L(G_3)$, the leftmost graph of $G_3$, searched by a breadth-first top-down parse of the string $u = babbaa$. (See, for example, Figure 4.3.)

2. Discuss the appropriateness of $G_3$ (a) for top-down parsing and (b) for bottom-up parsing.

Space for your solution to Problem 3;
More space for your solution to Problem 3:
4. Context-free grammar $G_4$ is the following:

\[
S \rightarrow aSA \mid BA \\
A \rightarrow aA \mid a \\
B \rightarrow Bb \mid e.
\]

Convert $G_4$ into an equivalent context-free grammar in Chomsky normal form by following these steps:

1. Eliminate recursion on the start symbol;
2. Eliminate $\lambda$ rules;
3. Eliminate chain rules;
4. Eliminate useless symbols; and
5. Attain Chomsky normal form by eliminating non-binary rules.

Space for your solution to Problem 4:
More space for your solution to Problem 4: