Exercise 4.26. In each part, draw an NFA (which might be an FA) accepting the language generated by the CFG having the given productions.

a.

$$S \to aA \mid bC \qquad A \to aS \mid bB \qquad B \to aC \mid bA \qquad C \to aB \mid bS \mid \Lambda$$

Exercise 4.27.

Find a regular grammar generating the language $L(M)$, where M is the FA shown in Figure 4.33 (on the blackboard).

Exercise 4.22.

Show that if G is a context-free grammar in which every production has one of the forms

$$A \to aB, \quad A \to a \quad \text{and } A \to \Lambda$$

(where A and B are variables and a is a terminal), then $L(G)$ is regular.

Suggestion: construct an NFA accepting $L(G)$, in which there is a state for each variable in G and one additional state F, the only accepting state.

Exercise 4.28.

Draw an NFA accepting the language generated by the grammar with productions

$$S \to abA \mid bB \mid aba \qquad A \to b \mid aB \mid bA \qquad B \to aB \mid aA$$

Exercise 4.29.

Each of the following grammars, though not regular, generates a regular language. In each case, find a regular grammar generating the language.

a. $S \to SSS \mid a \mid ab$

b. $S \to AabB \quad A \to aA \mid bA \mid \Lambda \quad B \to Bab \mid Bb \mid ab \mid b$

Exercise 4.34.

Show that the CFG with productions

$$S \to a \mid Sa \mid bSS \mid SSb \mid SbS$$

is ambiguous.

Exercise 4.36.

In each case below, decide whether the grammar is ambiguous or not, and prove your answer.

b. $S \to SS \mid bS \mid a$

c. $S \to SaS \mid b$

e. $S \to TT \qquad T \to aT \mid Ta \mid b$

f. $S \to aSa \mid bSb \mid aAb \mid bAa \qquad A \to aAa \mid bAb \mid a \mid b \mid \Lambda$

g. $S \to aT \mid bT \mid \Lambda \qquad T \to aS \mid bS$

Exercise 4.38.

In each case below, show that the grammar is ambiguous, and find an equivalent unambiguous grammar.

a. $S \to SS \mid a \mid b$

b. $S \to ABA \qquad A \to aA \mid \Lambda \qquad B \to bB \mid \Lambda$

c. $S \to aSb \mid aaSb \mid \Lambda$

d. $S \to aSb \mid abS \mid \Lambda$

Exercise.

Let G be a context-free grammar with start variable S and the following productions:

$$S \to aSbS \quad | \quad bSaS \quad | \quad \Lambda$$

a. Show that $L(G) = \mathit{AEqB} = \{x \in \{a,b\}^* \ \ | \ \ n_a(x) = n_b(x)\}$

b. Is G ambiguous? Motivate your answer.