**Exercise 4.15/4.19.**

Describe the language generated by the CFG with productions

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

Motivate your answer.

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

*From lecture 9:*

**Exercise 4.45.** ♠

Use induction to prove that the CFG below is unambiguous.

**b.** The CFG with productions $S \to (S)S \ \mid \ \Lambda$

**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 $L(G) = AEqB = \{x \in \{a,b\}^* \ \mid \ n_a(x) = n_b(x)\}$. That is, argue why $L(G) \subseteq AEqB$ and why $AEqB \subseteq L(G)$. You do not have to give formal proofs.

**b.** Show that $G$ is ambiguous, by giving a string $x \in L(G)$ and two different derivation trees for $x$ in $G$.

**c.** ♣ Give an unambiguous context-free grammar for $AEqB$.

**Exercise 4.7.**

Describe the language generated by the CFG with productions

$$S \to ST \mid \Lambda \qquad T \to aS \mid bT \mid b$$

Motivate your answer.