

Exercise 4.53.

c. In each case, given the context-free grammar G , find an equivalent CFG with no useless variables.

ii. G has productions

$$\begin{array}{lll} S \rightarrow AB \mid AC & A \rightarrow aAb \mid bAa \mid a & B \rightarrow bbA \mid aaB \mid AB \\ C \rightarrow abCa \mid aDb & D \rightarrow bD \mid aC & \end{array}$$

Exercise 4.50.

In each case, given the context-free grammar G , find a CFG G' in **Chomsky normal form** that generates the language $L(G) - \{\Lambda\}$.

a. G has productions

$$S \rightarrow ABA \quad A \rightarrow aA \mid \Lambda \quad B \rightarrow bB \mid \Lambda$$

b. G has productions

$$S \rightarrow aSa \mid bSb \mid \Lambda \quad A \rightarrow aBb \mid bBa \quad B \rightarrow aB \mid bB \mid \Lambda$$

Exercise 4.54.

In each case below, given the context-free grammar G , find a CFG G_1 in Chomsky normal form generating $L(G) - \{\Lambda\}$.

a. G has productions $S \rightarrow SS \mid (S) \mid \Lambda$

b. G has productions $S \rightarrow S(S) \mid \Lambda$

c. G has productions

$$\begin{array}{l} S \rightarrow AaA \mid CA \mid BaB \quad A \rightarrow aaBa \mid CDA \mid aa \mid DC \\ B \rightarrow bB \mid bAB \mid bb \mid aS \quad C \rightarrow Ca \mid bC \mid D \quad D \rightarrow bD \mid \Lambda \end{array}$$

Exercise 4.48.

Show that the nullable variables defined by Definition 4.26 are precisely those variables A for which $A \Rightarrow^* \Lambda$.

Exercise.

Let $L_1 = \{a^i b^j c^k \mid i, j, k \geq 0 \text{ en } 2i > j\}$.

- a. Give the first five elements of L_1 in the canonical order.
- b. Give a PDA M_1 such that $L(M_1) = L_1$.