Some problems in this homework have similar ones solved in the starred exercises. So please take a look at the solutions for the starred exercises from the book’s website.

For grammars, by default, assume that the variable S is the start variable unless otherwise specified.

1. (16 points)

Eliminate $\epsilon$ productions, unit productions, useless symbols and then rewrite the resulting grammar in the Chomsky Normal Form (in that order) for the following two input grammars:

a) $S \rightarrow 0E0 \mid 1FF \mid \epsilon$
   
   $E \rightarrow G$
   
   $F \rightarrow S|E$
   
   $G \rightarrow S|\epsilon$

b) $S \rightarrow 0AA \mid 1BB \mid \epsilon$

   $A \Rightarrow AC \mid 0$

   $B \Rightarrow CB \mid 11$
2. (5 points) (from Exercise 7.1.6.)
Design a CNF grammar for the set of strings of balanced parentheses. It is your choice to either start or not start from any particular non-CNF grammar.

3. (18 points) (from Exercise 7.2.1: parts (b), (e) and (f))
Using the pumping lemma for CFLs, show that the following languages are not context-free:

a) \( L = \{ a^n b^n c^i | i \leq n \text{ and } i, n \geq 0 \} \)

b) \( L = \{ a^n b^n c^i | n \leq i \leq 2n \text{ and } i, n \geq 0 \} \)

c) \( L = \{ ww^R w | w \text{ is a string of 0s and 1s} \} \)