Homework #4

1. Each of the following CFGs has a production using the symbol $\Lambda$ and yet $\Lambda$ is not a word in its language. Using the algorithm in Chapter 13, show that there are other CFGs for these languages that do not use $\Lambda$-productions.

(i) $S \rightarrow aX \mid bX$
    $X \rightarrow a \mid b \mid \Lambda$

(ii) $S \rightarrow aX \mid bS \mid a \mid b$
    $X \rightarrow aX \mid a \mid \Lambda$

(iii) $S \rightarrow aS \mid bX$
      $X \rightarrow aX \mid \Lambda$

(iv) $S \rightarrow XaX \mid bX$
      $X \rightarrow XaX \mid XbX \mid \Lambda$

2. Convert each of the following CFGs to CNF

(i) $S \rightarrow SS \mid a$

(ii) $S \rightarrow aSa \mid SSa \mid a$

(iii) $S \rightarrow aXX$
     $X \rightarrow aS \mid bS \mid a$

(iv) $E \rightarrow E + E$
     $E \rightarrow E * E$
     $E \rightarrow (E)$
     $E \rightarrow 7$

     The terminals are $+ * ( ) 7$
3. Consider the following deterministic PDA

(i) What is the language accepted by this PDA?
(ii) Find a CFG that generates this language.
(iii) Is this language regular?
4. Consider the following nondeterministic PDA

Show that the language recognized by this machine is

\[ \text{TRAILINGCOUNT} = \{ s a^{\text{length}(s)} \} \]

= any string \( s \) over the alphabet \( \{ab\} \) followed by as many \( a \)'s as \( s \) has letters

5. Using the algorithm of Theorem 30, construct a PDA that accepts the same language as the following grammar.

\[
S \rightarrow XaaX \\
X \rightarrow aX | bX | \Lambda
\]