Exercise 13.1

Consider the pushdown system below, with stack alphabet $\Gamma = \{a, b\}$ where $\begin{array}{c} \text{push} \ a \rightarrow 2 \\
\text{push} \ b \rightarrow 1 \end{array}$ indicates the presence of transitions $1a \rightarrow 2aa$ and $1b \rightarrow 2ab$, and $\begin{array}{c} \text{pop} \ a \\
\text{pop} \ b \rightarrow 5 \end{array}$, indicates the presence of transition $4a \rightarrow 5$.

Let $L = 7b^* = \{7, 7b, 7bb, 7bbb, \ldots\}$. Construct the $P$-automaton accepting pre$(L)$.

Exercise 13.2

Consider the following recursive program, where ? denotes a nondeterministic Boolean value:

```plaintext
procedure main;
0: if ? then
   call a;
else
   call b;
1: return;

procedure a;
0: if ? then
   call b;
1: call b;
else
   call a;
end if;
2: return;

procedure b;
```
(a) Model the program with a pushdown system.

(b) Compute all configurations that can reach the program label m1.

Exercise 13.3
Consider the following recursive program with a global variable g and a local variable l:

```plaintext
boolean g;

procedure main(boolean l);
  m0: if l then
      call a;
      end if;
  m1: assert(g == l);
  m2: return;

procedure a();
  a0: g := not g;
  a1: if not g then
      call a;
      end if;
  a2: call a;
  a3: return;
```

(a) Model the program with a pushdown system, where the values of g and l are not initialized.

(b) Compute all configurations that can reach the program label m2.

(c) ★ Compute all configurations that are reachable from the program label m0.