

**Problem 5.1.** (10 points) Consider the following CFG  $G$ .

$$\begin{aligned} S &\rightarrow A \mid B \\ A &\rightarrow 0B1 \mid 1 \mid \varepsilon \\ B &\rightarrow 1A0 \end{aligned}$$

- a. Give a derivation tree for 010110101.
- b. Convert  $G$  into an equivalent CFG in Chomsky normal form.
- c. Give a PDA that recognizes the same language as  $G$ .

**Problem 5.2.** (20 points) Which of the three five languages  $L_i$  over the alphabet  $\{0, 1, 2\}$  is context-free? For each  $L_i$ , either give a PDA that recognizes  $L_i$  or a CFG that generates  $L_i$ , or use the pumping lemma for the context-free languages to prove that  $L_i$  is not context-free.

- a.  $L_1 = \{0^i 1^j 2^k \mid j = 2 \cdot i + k\}$ .
- b.  $L_2 = \{0^i 1^j 2^k \mid i < j < k\}$ .
- c.  $L_3$  is the complement of  $L_2$ .