

CONCORDIA UNIVERSITY  
Dept. of Computer Science and Software Engineering  
COMP 335 – Introduction to Theoretical Computer Science  
Fall 2024

Assignment 5

Submission through Moodle is due by Sunday, November 17th at 23:55

1. [10 Points] Show that following grammar  $G$ , where  $S$  is the starting variable, is ambiguous.

$$\begin{aligned} S &\rightarrow AB \mid aaaB, \\ A &\rightarrow a \mid Aa, \\ B &\rightarrow b. \end{aligned}$$

2. [10 Points] A context-free grammar  $G = \langle V, T, S, P \rangle$  is said to be a simple grammar or s-grammar if all its productions are of the form  $A \rightarrow ax$ , where  $A \in V, a \in T, x \in V^*$ , and any pair  $(A, a)$  occurs at most once in  $P$ .  
Find an s-grammar for  $L = \{a^n b^{2n} : n \geq 1\}$ .

3. [10 Points] Give an NPDA with 2 states that accepts  $L = \{a^n b^{n+1} : n \geq 0\}$ .

4. [20 Points] For each of the following CFLs, give a “direct” design of an NPDA. That is, it is not acceptable to first find a CFG and then convert it into an NPDA.

(a)  $L_1 = \{a^n b^{2n+1} : n \geq 0\}$

(b)  $L_2 = \{w \in \{a, b\}^* : n_a(w) \leq 3n_b(w)\}$

5. [20 Points] Show that the following CFLs are deterministic.

(a)  $L_1 = \{(ab)^n b (ba)^n : n \geq 0\} \cup \{(ab)^n b : n \geq 0\}$

(b)  $L_3 = \{w \in (a, b)^* : n_a(w) \neq n_b(w)\}$