

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

Assignment 4

Submission through Moodle is due by Sunday, November 3rd at 23:55

Total points: 45

1. [20 Points] For each of the following languages, give a context-free grammar (CFG).

- (a) (5 Points) $L_a = \{a^n b^m : m, n \geq 0 \text{ and } 2n \leq m \leq 3n\}$
- (b) (5 Points) $L_b = \{a^n b^m c^k : k = 2m + n\}$
- (c) (5 Points) $L_c = \{a^n b^m c^k : n = m \text{ or } m \leq k\}$
- (d) (5 Points) $L_d = \{w \in \{a, b\}^* : w \neq xx, \text{ for any } x \in \{a, b\}^*\}$.

2. [10 Points] Consider the language $L = \{a^{n+1}b^n : n \geq 0\}$.

- (a) (5 points) Describe in English the complement \bar{L} of L .
- (b) (5 points) Give a CFG for \bar{L} .

3. [15 Points] Let G be the following CFG in which S is the start variable:

$$\begin{aligned} S &\rightarrow AB \mid aB \\ A &\rightarrow aab \mid \lambda \\ B &\rightarrow bbA \end{aligned}$$

- (a) (5 Points) Using the procedure discussed in the class, convert G into an equivalent grammar in Chomsky Normal Form (CNF).
- (b) (5 Points) Find an equivalent grammar to G in Greibach Normal Form (GNF).
- (c) (5 Points) Suppose we modify the original grammar G as follows: *remove* the λ -production $A \rightarrow \lambda$ and instead *add* the unit production $A \rightarrow A$. Let us call the resulting grammar as G' . Convert G' into CNF, and simplify, if possible. Also describe in English the language $L(G')$.