

FLA (Fall 2026) – Assignment 3

Name: _____ Dept: _____

Grade: _____ ID: _____

Due: Oct. 20, 2026

Problem 1

Give context-free grammars that generate the following languages, and give a brief description of the functionality of each variable in your grammars (in natural language) if necessary.

- (a) $\{ a^m b^{m+n} c^n \mid m, n \geq 0 \}$.
- (b) $\{ 1^m + 1^n = 1^{m+n} \mid m, n \geq 1 \}$.
- (c) $\{ a^k b^\ell a^m b^n \mid k, \ell, m, n \geq 0 \wedge (k = m \vee \ell = n) \}$.
- (d) $\{ w \in \{0, 1\}^* \mid w \neq w^R \}$, where w^R denotes the reverse of w .

LLM Usage (select one):

☐ None ☐ Assistance only ☐ Mostly/entirely generated

If used, briefly describe how: _____

Solution.

Problem 2

Consider the following context-free grammar G :

$$S \rightarrow aSb \mid aSbb \mid c$$

- (a) Show that G is ambiguous by giving a string that has two different parse trees according to G .
- (b) Construct an unambiguous context-free grammar that generates the same language as G . Briefly explain why your grammar is unambiguous.

LLM Usage (select one):

☐ None ☐ Assistance only ☐ Mostly/entirely generated

If used, briefly describe how: _____

Solution.

Problem 3

Consider the following context-free grammar G :

$$S \rightarrow aSb \mid AB \mid c$$

$$A \rightarrow aA \mid a$$

$$B \rightarrow bB \mid Sb \mid b$$

- (a) For the string $aaabcb$, give one possible parse tree and rightmost derivation according to G .
- (b) Provide a nondeterministic PDA P that accepts the language $L(G)$ by empty stack.

LLM Usage (select one):

☐ None ☐ Assistance only ☐ Mostly/entirely generated

If used, briefly describe how: _____

Solution.

Problem 4

Consider the following context-free grammar G :

$$S \rightarrow aABc \mid BD \mid C \mid DE$$

$$A \rightarrow aA \mid \epsilon$$

$$B \rightarrow bB \mid A$$

$$C \rightarrow cC \mid c$$

$$D \rightarrow dD \mid d$$

$$E \rightarrow eE$$

- (a) Eliminate all ϵ -productions.
- (b) Eliminate all unit productions from the resulting grammar of (a).
- (c) Eliminate all useless symbols from the resulting grammar of (b).
- (d) Convert the resulting grammar of (c) into Chomsky Normal Form (CNF).

LLM Usage (select one):

☐ None ☐ Assistance only ☐ Mostly/entirely generated

If used, briefly describe how: _____

Solution.

Problem 5

Construct PDAs that accept the following languages by **final states**. **Explain how your PDAs work.**

- (a) $\{ a^m x \# x^R d^m \mid m \geq 1, x \in \{0, 1\}^+ \}$, where x^R denotes the reverse of x .
- (b) $\{ w \in \{a, b\}^* \mid |w|_a = 2|w|_b \}$, where $|w|_x$ denotes the number of occurrences of symbol x in string w .

LLM Usage (select one):

☐ None ☐ Assistance only ☐ Mostly/entirely generated

If used, briefly describe how: _____

Solution.