

CS375 Homework Assignment 7 (40 points)

Due date: April 5, 2025

1. (5 points)

The language generated by the following grammar is
(2 points)

• $S \rightarrow abcD \mid abD$ $D \rightarrow dD \mid \Lambda$

This grammar is LL(). (1 point)

Use **left-factoring** we can find an equivalent LL(k) grammar for the above grammar where k is the smallest choice for such an integer. In the following, fill out the blank in the middle portion to make the resulting grammar such an LL(k) grammar.

$S \rightarrow abT$

$D \rightarrow dD \mid \Lambda$

(1 point)

What is the value of k? k = (1 point)

2. (6 points)

The language generated by the following grammar is
(2 points)

$S \rightarrow SaaaS \mid b$

This grammar is **left recursive**, hence, it is not LL(k) for any k.

Fill out the blank below to make the resulting grammar equivalent to the above grammar but **with no left recursion**.

$S \rightarrow bT$

(2 points)

Is the resulting grammar LL(k)? ☐ Yes ☐ No (1 point)

If your answer is YES, then what is the value of k? k = (1 point)

3. (5 points; 1 point each blank)

The following given grammar is a **left recursive** grammar

$S \rightarrow Sabcd \mid abc \mid ab$

The language generated by this grammar is $L = \{ abc(abcd)^m, ab(abcd)^n \mid m, n \in N \}$.

This left recursive grammar can be transformed to a right recursive grammar as follows:

$S \rightarrow$ \mid

$T \rightarrow$

This right recursive grammar is an LL() grammar.

4. (7 points; 1 point each blank)

The following grammar is an **indirect left recursive** grammar

$S \rightarrow Babc \mid aa \quad B \rightarrow Sabc \mid b$

The language generated by this grammar is

(2 points)

This indirect left recursive grammar can be transformed to a right recursive grammar as follows:

$S \rightarrow$ \mid (2 points)

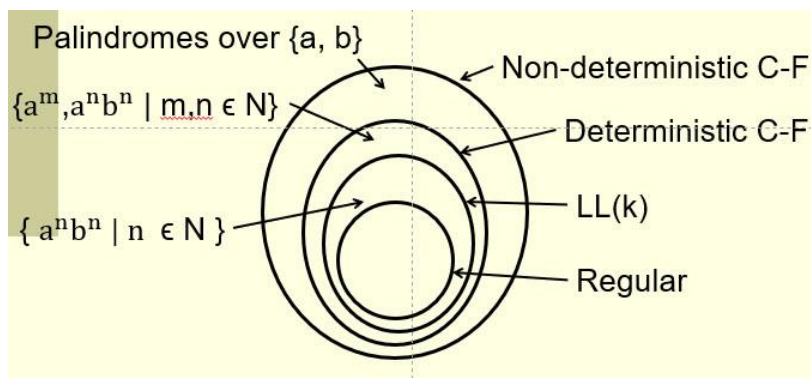
$T \rightarrow$ (2 points)

This right recursive grammar is an LL() grammar. (1 point)

5. (7 points)

In slide 41 of the notes "Context-free Languages and Pushdown Automata IV", it is shown that the set of LL(k) languages is a proper subset of the set of deterministic C-F languages (or see the following figure). In particular, it points out that the language $\{a^m, a^n b^n \mid m, n \in N\}$ is a deterministic C-F language, but not LL(k) for

any k .



To show the language is not $LL(k)$ for any k , note that a grammar for this language is

$S \rightarrow A | B$ $A \rightarrow$ $B \rightarrow$

or

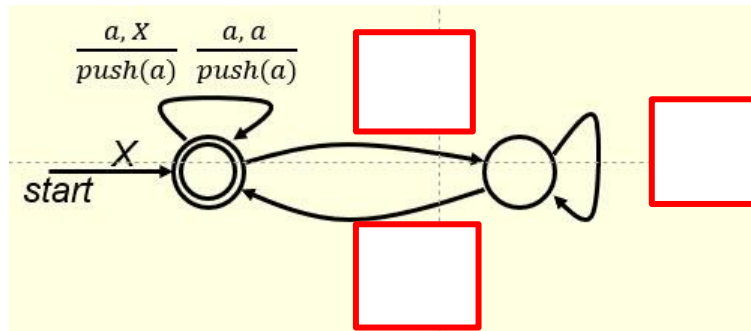
$S \rightarrow A | B$ $A \rightarrow$ $B \rightarrow$

(4 points)

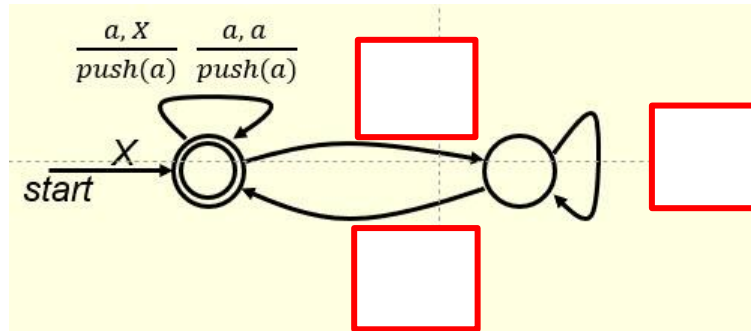
(you only need to answer one case here, either one). The language contains Λ as an element. Now consider the case $k = 1$ and consider the input string ab . When the first symbol is scanned, we get an 'a'. This information alone is not enough for us to make a proper choice. So we don't even know what to do with the first step in the parsing process.

For $k = 2$, if we consider the input string $aabb$, we face the same problem. For any $k > 2$, the input string $a^k b^k$ would cause exactly the same problem. So this grammar is not $LL(k)$ for any k .

On the other hand, by putting proper instructions into the blanks of the following figure, we get a deterministic final-state PDA that accepts the language $\{a^m, a^n b^n \mid m, n \in N\}$.



or



(3 points)

(again, you only need to answer one case here, either one). Hence, this language is indeed deterministic C-F, but not LL(k) for any k.

6. (4 points)

Fill out the following blanks for the instructions of a Turing machine that **accepts** the language $\{b^n a \mid n \in \mathbb{N}\}$. Use smallest possible non-negative integers to represent the states of the TM.

(0	,	b	,	b	,	R	,	<input type="text"/>)
(<input type="text"/>	,	a	,	a	,	R	,	<input type="text"/>)
(<input type="text"/>	,	Λ	,	Λ	,	S	,	halt)

7. (6 points)

Fill out the following blanks for the instructions of a Turing machine that **accepts** the language $\{b^n aa \mid n \in \mathbb{N}\}$. Use smallest possible non-negative integers to represent the states of the TM.

(0 , b, b, R,)
(, a, a, R,)
(, a, a, R,)
(, Λ , Λ , S, halt)

- Solutions must be typed (word processed) and submitted both as a pdf file and a word file to Canvas before 23:59 on 04/05/2025.
- Don't forget to name your files as
[CS375_2025s_HW7_LastName.docx](#) / [CS375_2025s_HW7_LastName.pdf](#)