

University of Nevada, Las Vegas Computer Science 456/656 Fall 2023

Answers to Assignment 3: Due Friday September 22, 2023

1. True or False, write T or F. If the answer is unknown to science at this time, write O, for Open.

- (a) **T** Every regular language is a context-free language.
- (b) **T** The problem of whether two context-free grammars are equivalent is undecidable.
- (c) **T** If a language L is accepted by an NFA with n states, then L is generated by a grammar with at most n variables. (Be prepared to search for the answer: I didn't give it in class.)
- (d) **O** $\mathcal{P} = \mathcal{NP}$.

2. For each of the grammars given below, each variable symbol is a capital Roman letter, each terminal symbol is a lower case Roman letter, and the start symbol is S .

(a) Which of these grammars generates $\{a^n b^n : n \geq 0\}$?

Ans: G_1

Grammar G_1 :

$S \rightarrow aSb$

$S \rightarrow \lambda$

(b) Which of these grammars generates

$\{a^n b^m : n, m \geq 0, n \neq m\}$?

Ans: G_2

Grammar G_2 :

$S \rightarrow aSb$

$S \rightarrow aA$

$A \rightarrow aA$

$A \rightarrow \lambda$

(c) Which two of these grammars are equivalent?

Ans: G_3 and G_4

$S \rightarrow bB$

$B \rightarrow bB$

$B \rightarrow \lambda$

(d) Which of these grammars is ambiguous?

Ans: G_4

Grammar G_3 :

$S \rightarrow aSbS$

$S \rightarrow \lambda$

Grammar G_4 :

$S \rightarrow aSb$

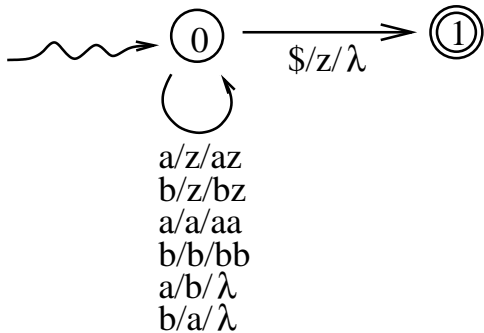
$S \rightarrow SS$

$S \rightarrow \lambda$

3. I was wrong on Monday: I wrote the three labels each transition in the wrong order. The correct order is “read/pop/push.” Commas can be used instead of slashes.

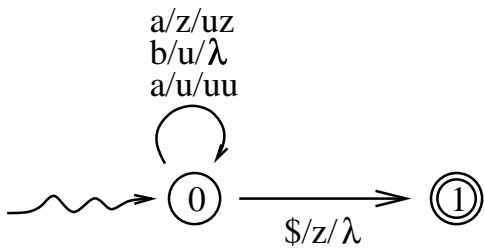
When we push two or more symbols, the topmost one is on the left of the string. For example: if the label on the transition is $a/z/az$, then z is popped, a is read, and az is pushed, but that means z is pushed first, then a is pushed on top of it. You must pop one symbol. You can read either one or zero symbols. You can push any number of symbols.

What is the language accepted by the DPDA illustrated below?



The language $\{w \in \{a, b\}^* : \#_a(w) = \#_b(w)\}$

4. Design a DPDA which accepts the Dyck language. For ease of grading, use the version where the terminal symbols are a and b , for left and right aretheses, respectively.



The symbol “u” is a stack symbol which indicates an unmatched “a” has been read but not yet matched. In prior examples I have used the terminal symbol itself also as a stack symbol since it’s easier to grasp that way. However, I made an exception for this DPDA. In fact, I could have used any symbol (other than “b”) instead of “u.”