University of Nevada, Las Vegas Computer Science 456/656 Fall 2024

Assignment 2: Due Saturday September 13, 2025, 11:59:59 PM (midnight)

As usual, any student who finds a typo or error gains respect.

Name:____

You are permitted to work in groups, get help from others, read books, and use the internet. You will receive a message from the graduate assistant, Sabrina Wallace at `sabrina.wallace@unlv.edu` telling you how to turn in assignments.

1. Identify which machine accepts the language defined by each regular expression.

   (i) $a^* + b^*$

   (ii) λ

   (iii) a^*

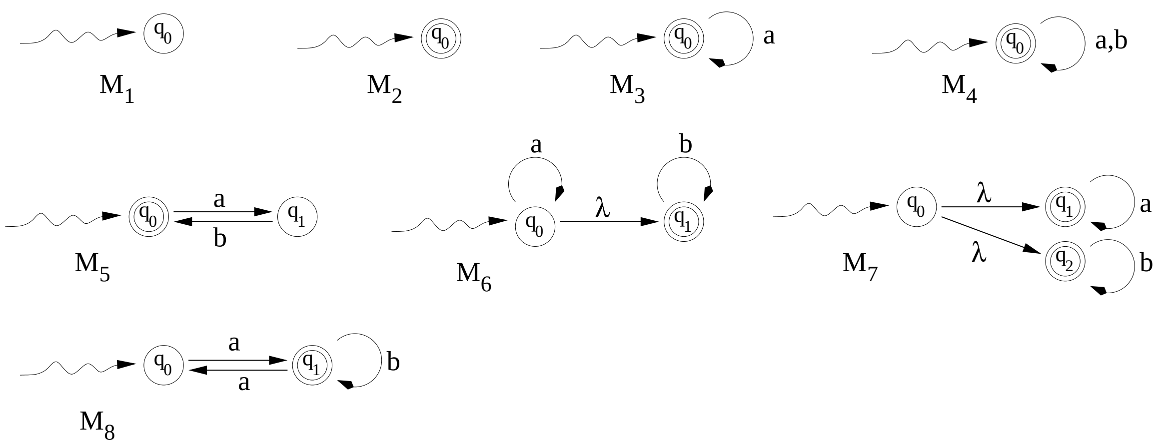
   (iv) $\emptyset$

   (v) $a(aa + b)^*$

   (vi) a^*b^*

   (vii) $(a + b)^*$

   (viii) $(ab)^*$



2. True or False.

   (i) ________ If L is any language, $L + L = L$

   (ii) ________ If L is any language, $L \cap L = L$

   (iii) ________ If L is any language, $\{\lambda\} \in L^*$.

3. Let $L_1 = \{a, ab\}$ and $L_2 = \{a, ba\}$. How many strings are there in the language L_1L_2? ________________ How many strings are there in the language L_2L_1? ________________

4. True/False. If the answer is not known to science at this time, enter “O” for Open.

   (i) ________ co-$\mathcal{P} = \mathcal{P}$.

(ii) ________ co-$\mathcal{NP} = \mathcal{NP}$.

(iii) ________ co-$\mathcal{P}$–SPACE $= \mathcal{P}$–SPACE.

(iv) ________ Block placement problems are $\mathcal{NP}$.

(v) ________ Sliding block problems are $\mathcal{P}$–SPACE.

(vi) ________ $\mathcal{P}$–SPACE $= \mathcal{NP}$

(vii) ________ Regular expression equivalence is $\mathcal{P}$.

(viii) ________ Regular expression equivalence is decidable.

(ix) ________ Context-free grammar equivalence is decidable.

(x) ________ Every regular language is context-free.

(xi) ________ The language C++ is context-free.

(xii) ________ The intersection of any two context-free languages is context-free.

(xiii) ________ The complement of any context-free language is context-free.

(xiv) ________ Every language is countable.

(xv) ________ For any real number x, there is a program that prints the decimal expansion of x. For any real number x, there is a machine that decides whether any given fraction is less than x.

(xvi) ________ There are only countably many decidable binary languages.

(xvii) ________ Given a regular grammar G with n variables, there exists an NFA with n states that accepts $L(G)$.

(xviii) ________ Given an integer n written in binary notation, it is possible to find the prime factors of n in polynomial time.

(xix) ________ Given an integer n written in binary notation, it is possible to decide whether n is prime in polynomial time.

(xx) ________ Any language generated by a grammar is decidable.

(xxi) ________ The complement of any decidable language is decidable.

(xxii) ________ The union of any two decidable languages is decidable.

(xxiii) ________ The complement of any undecidable language is undecidable.

(xxiv) ________ The union of any two undecidable languages is undecidable.

(xxv) ________ Every context-free language is accepted by some DPDA.

(xxvi) ________ Any language consisting of all decimal numerals of an arithmetic sequence (for example: $L = \{\langle 5+8n \rangle : n \geq 0\} = \{5, 13, 21, 29, 37, 45 \ldots\}$) is regular. Note: the members of L are numerals, not numbers.

(xxvii) ________ Let L_1 be a regular binary language. Let L_2 be the language of all strings obtained from members of L_1 by substituting ab for 0 and c for 1. Then L_2 must be regular. For example, if $L_1 = \{0, 10, 10011\}$ then $L_2 = \{ab, cab, cababcc\}$.

(xxviii) ________ DFA equivalence is $\mathcal{P}$–TIME.

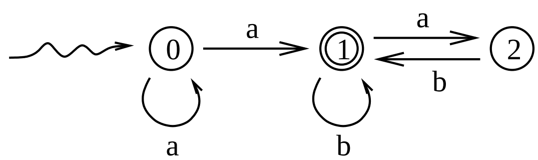
(xxix) ________ NFA equivalence is $\mathcal{P}$–TIME.

(xxx) ________ NFA equivalence is $\mathcal{NP}$–TIME.

(xxxi) ________ Regular expression equivalence is $\mathcal{NP}$–TIME.

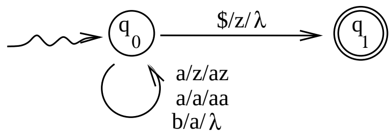
(xxxii) ________ Regular expression equivalence is $\mathcal{P}$–SPACE.

5. Any NFA with n states is equivalent to some DFA with at most 2^n states, counting the dead state. Draw a minimal DFA equivalent to the following three state NFA.

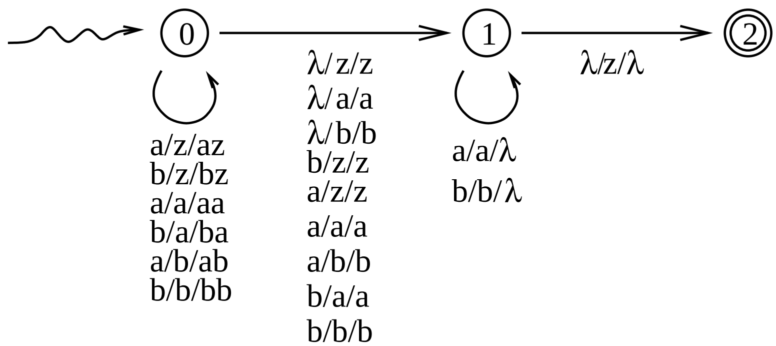


6. Match each PDA with either the desciption or the CF grammar of Problem 7 below.

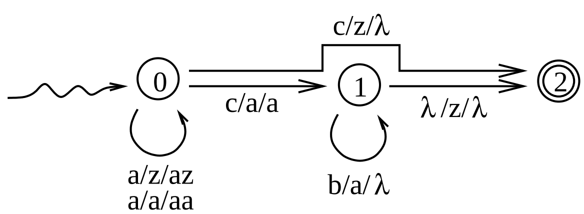
(i)



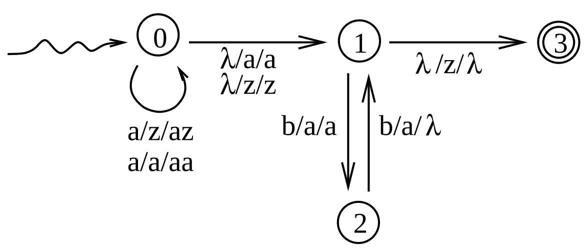
(ii)



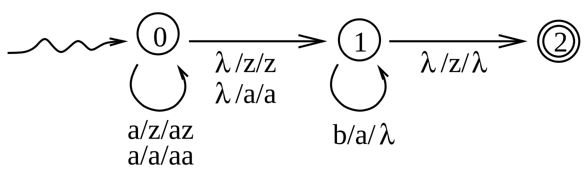
(iii)



(iv)



(v)



7. Here are the language descriptions for Problem 6.

   (a) $\{a^n b^n \ : n \geq 0\}$

   (b) $\left\{w \in \{a, b\}^* \ : \ \#_a(w) = \#_b(w)\right\}$, that is, all strings over $\{a, b\}$ with equal numbers of each symbol,

   (c) $w \in \{a, b\}^* \ : \ 2\#_a(w) = \#_b(w)$.

   (d) Generated by the CF grammar:

      1. $S \rightarrow aSbS$

      2 $S \rightarrow \lambda$

   (e) Generated by the CF grammar:

      1. $S \rightarrow aSb$

      2. $S \rightarrow c$

   (f) Palindromes over $\{a, b\}$.