Chapter 1: Pumping Lemma

Question 1: Question 1.29 Part b

Question 2: Problem 1.39

First, think of a language $L$ that requires $k$ states in a DFA, and where there is a string $w \in L$ where $|w| \geq k$. Formally give the language, and informally describe the DFA that will recognize it.

Prove that it cannot be done in $k - 1$ states. Your proof will be similar to the proof of the pumping lemma.

Question 3: Problem 1.54

Chapter 1: Closure

Question 4: Problem 1.43

Question 5

Pick one of the following two questions.

Option 1:
This is a variation on question 1.45.
Define $A/B = \{ w | wx \in A \text{ for some } x \in B \}$.

The textbook asks you to prove that if $A$ is regular, and $B$ is any language, then $A/B$ is regular.

I am going to have you do a variation of this. Show that if $A$ and $B$ are regular, so is $A/B$.

Do this as a proof by construction. You do not have to give a formal definition for the delta transition, but you do need to explain the operation of your constructed FA in enough detail that someone could write a formal definition. Make sure you explain what your states are, start state and end state.

Hint: your construction will use a DFA for $A$ and $B$.

Option 2:

Question 1.57

This question also involves a construction.
Chapter 2: CFG

Question 6: Question 2.2

Part 0
Prove that CFLs are closed under union.

Part 1
Give an example of two CFL’s whose intersection is a CFL.

Let \( A = \emptyset \). Let \( B = \Sigma^* \).
A and B are both regular, and therefore CFL.
Since they are regular, the intersection is also regular, and so a CFL.

Part a
There is a quick solution to this. As the textbook says, you can use the fact that \( a^n b^n c^n \) is not a CFL, without proving it. But you need to prove that A and B are CFL. Make sure you fully write out the proof.

Also explain why this is not a contraction with part 1.

Part b
From part a, use the actual languages A and B, together with Theorem 0.20. You might find it easy to use proof by contradiction.

To format complementation in latex, use \( \overline{A} \)

Question 7: Question 2.4 Part b, c, e, f

Question 8: Question 2.6 Part b, d

For part b, think of several cases. Here are the cases that I can think of. If you can think of others, please write them down explicitly.
Case 1: \( a^i b^j \) where \( i > j \)
Case 2: \( a^i b^j \) where \( i < j \)
Case 3: any string that starts with \( b \).
Case 4: any string of the form \( a^+ b^+ a(a, b)^* \)

For part d, I am changing the language to the following:
\( \{x_1 \# x_2 \# \ldots \# x_k | k \geq 2, \text{ each } x_i \in \{a, b\}^*, \text{ and for some } i \neq j, \text{ where } i \neq j, x_i = x_j^R \} \)
This way, you do not have to worry about the case where \( i = j \), thus making \( x_i \) a palindrome.
I just used 3 variables for my answer.