St. Francis Xavier University
Department of Computer Science

CSCI 356/541: Theory of Computing
Assignment 2
Due October 21, 2026 at 12:30pm

Assignment Regulations.

- This assignment must be completed individually.
- Please include your full name and email address on your submission.
- You may either handwrite or typeset your submission. If your submission is handwritten, please ensure that the handwriting is neat and legible.

[10 marks] 1. Consider the following language over the alphabet $\Sigma = \{\mathtt{0}, \mathtt{1}\}$:

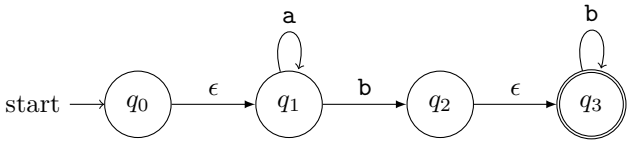
$$L = \{w \mid w \text{ both starts and ends with } \mathtt{0}\}.$$

(a) Construct a nondeterministic finite automaton recognizing the language L.

(b) Convert your nondeterministic finite automaton from part (a) to a deterministic finite automaton using the subset construction. Show all your work.

(c) Convert either your NFA from part (a) or your DFA from part (b) to an equivalent regular expression using the state elimination algorithm. Show all your work.

[5 marks] 2. Consider the following nondeterministic finite automaton $\mathcal{M}$ with epsilon transitions:



Convert this finite automaton $\mathcal{M}$ to an equivalent (non)deterministic finite automaton $\mathcal{M}'$ without epsilon transitions. Show all your work.

[5 marks] 3. Convert your finite automaton $\mathcal{M}'$ from the previous question to an equivalent regular expression. Show all your work.

[5 marks] 4. Let $\Sigma = \{\mathtt{a}, \mathtt{b}, \mathtt{c}, \mathtt{d}\}$. Using the pumping lemma for regular languages, prove that the following language is not regular:

$$L = \{\mathtt{a}^i\mathtt{b}^k\mathtt{c}^m\mathtt{d}^r \mid i \geq m \geq 0, k \geq 0, r \geq 0\}.$$

[7 marks] 5. **Only CSCI 541 students:**

Let $\Sigma = \{\mathtt{0}, \mathtt{1}\}$. *Without* using the pumping lemma, prove that the following language is not regular:

$$L = \{w \mid w \neq xx \text{ for any } x \in \Sigma^*\}.$$

[8 marks] 6. **Only CSCI 541 students:**

As we well know, 0^*1^* is a regular language. However, one of your friends who goes to Dalhousie is unconvinced, and gave you the following "proof" that 0^*1^* is not regular.

> Assume by way of contradiction that 0^*1^* is regular, and let p denote the pumping constant given by the pumping lemma. We choose the word $w = 0^p1^p$. Clearly, w is in the language and w has length at least p, but everybody knows w can't be pumped. Therefore, the language isn't regular.

What is the error in this "proof"? Give as much detail as necessary.

[10 marks] 7. **Only CSCI 541 students:**

Choose one of the following topics:

- Investigate alternatives to the pumping lemma for regular languages, such as the Myhill–Nerode theorem. When are we unable to use the pumping lemma to prove a language is nonregular? What advantages do these other methods of proof have over the pumping lemma?
- Investigate the notion of regular grammars. How do we define a regular grammar? What are some examples of regular grammars? Where are such grammars used, how do we parse such grammars, and how do these grammars compare to context-free and other types of grammars?

Find and cite at least three non-internet sources to support your answer.