CS/ECE 374 A ✧ Fall 2023

Practice Midterm 1

September 21, 2023

Name:	
NetID:	

- ***Don't panic!***
- You have 120 minutes to answer five questions. The questions are described in more detail in a separate handout.
- If you brought anything except your writing implements, your **hand-written** double-sided 8½" × 11" cheat sheet, and your university ID, please put it away for the duration of the exam. In particular, please turn off and put away *all* medically unnecessary electronic devices.
- Please clearly print your name and your NetID in the boxes above.
- Please also print your name at the top of every page of the answer booklet, except this cover page. We want to make sure that if a staple falls out, we can reassemble your answer booklet. (It doesn't happen often, but it does happen.)
- **Do not write outside the black boxes on each page**. These indicate the area of the page that our scanner can actually see. Anything you write outside the boxes will be erased before we start grading.
- If you run out of space for an answer, feel free to use the scratch pages at the back of the answer booklet, but **please clearly indicate where we should look**. Please ask for more scratch paper if you need it.
- Proofs or other justifications are required for full credit if and only if we explicitly ask for them, using the word ***prove*** or ***justify*** in bold italics.
- Please return ***all*** paper with your answer booklet: your question sheet, your cheat sheet, and all scratch paper. **Please put all loose paper *inside* your answer booklet.**

CS/ECE 374 A ✧ Fall 2023 Practice Midterm 1 Problem 1	Name:

For each of the following languages L over the alphabet $\Sigma = \{0, 1\}$, describe a DFA that accepts L **and** give a regular expression that represents L. You do not need to justify your answers.

(a) All strings in which the number of runs is divisible by 3. (Recall that a *run* is a maximal non-empty substring where all symbols are equal.)

(b) All strings that do not contain the substring `0110`.

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Let take2skip2(w) be the string function defined in the question handout, and let L be an arbitrary regular language.

(a) ***Prove*** that the language $\{w \in \Sigma^* \mid \text{take2skip2}(w) \in L\}$ is regular.

(b) ***Prove*** that the language $\{\text{take2skip2}(w) \mid w \in L\}$ is regular.

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Consider the following recursive function censor defined in the question handout.

(a) ***Prove*** that $|\mathsf{censor}(w)| \le |w|$ for all strings w.

(b) ***Prove*** that $\mathsf{censor}(\mathsf{censor}(w)) = \mathsf{censor}(w)$ for all strings w.

As usual, you can assume any result proved in class, in the lecture notes, in labs, or in homework solutions.

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Consider the language $L = \left\{ 0^a 1^b \;\middle|\; a > 2b \text{ or } 2a < b \right\}$.

(a) ***Prove*** that L is *not* a regular language.

(b) Describe a context-free grammar for L.

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For each statement below, check "Yes" if the statement is ***always*** true and check "No" otherwise, and write a ***brief*** (one short sentence) explanation of your answer. Read these statements very carefully—small details matter!

(a) For every language L, the language L^* is infinite.

Yes No

(b) If a language L is finite, the complement of L is context-free.

Yes No

(c) The language $\{0^{374n} \mid n \geq 374\}$ is regular.

Yes No

(d) The language $\left\{wxw^R \mid w, x \in \Sigma^*\right\}$ is regular.

Yes No

(e) The context-free grammar $S \rightarrow 0S1S \mid S1S0 \mid \varepsilon$ generates the set of all binary strings with the same number of 0s and 1s.

Yes No

(f) Every regular language is recognized by a DFA with at least 374 states.

Yes No

(g) If the languages L and L' are regular, their intersection $L \cap L'$ is also regular.

Yes No

(h) If a language has an infinite fooling set, then it is context-free.

Yes No

(i) Let M be a **DFA** over the alphabet Σ. Let M' be identical to M, except that accepting states in M are non-accepting in M' and vice versa. Each string in Σ^* is accepted by exactly one of M and M'.

Yes No

(j) Let M be an **NFA** over the alphabet Σ. Let M' be identical to M, except that accepting states in M are non-accepting in M' and vice versa. Each string in Σ^* is accepted by exactly one of M and M'.

Yes No

(scratch paper)

(scratch paper)