CSE396, Spring 2021 Problem Set 1 Due Tue. 2/16, 11:59pm

Office Hours: (all remote)

Regan: Regular schedule TBA, this week Fri. 1–3pm again

Rui Li: Tue. and Wed. 4pm–5pm.

Reading:

Thursday's lecture will begin covering *NFAs* and *regular expressions* in tandem. The text delays the formal definition of regular expressions until section 1.3. Please first read section 1.2 plus the part of section 1.3 that defines regular expressions. Then note that the text divides the treatment of closure under regular operations between the same sections. Please then read that treatment in one piece—*skipping over* the theorem about converting an NFA into an equivalent DFA for now—it will likely start off Thursday of next week. Stop before reading the topic of "generalized NFAs (GNFAs)" in section 1.3 (p69 on)—that won't come until week 4.

Please also, as a dry-run of *CSE Autograder* (especially if you have not used it before), submit the "Survey" sheet—which is in a separate non-graded item.

Homework—part online (TopHat), part written, and all *individual work*:

(1) Using *TopHat*, the "Worksheet" titled *S21 HW1 Online Part*. There are 10 questions, each worth 2 points, for 20 total.

The other two problems are to be submitted as PDFs using the *CSE Autograder* system. Scans of handwritten sheets are fine provided they are *easily legible* and *do not have excessive file-size*. Or you may type your answers.

(2) Define a function f from the set $\mathbb{N}^+$ to the set of binary strings as follows: Write a number n in standard binary notation (with no redundant leading 0s). Then define $f(n)$ to be the string you get by removing the leading '1'. For example, 5 in binary is 101, so $f(5) = 01$.

(a) Is this function one-to-one?

(b) Is it onto the set $\{0,1\}^*$ of all binary strings? What happens with the empty string?

(c) Now suppose we want to extend the domain of f to include zero. Let's call that a new function $f' : \mathbb{N} \to \{0,1\}^*$ where $f'(0) =$ `"0"` (that is, the binary string of just one 0 char) and $f'(n) = f(n)$ for numbers $n \geq 1$. Re-answer questions (a) and (b) for f' in place of f.

(d) How about if we try defining $f'(0) = \epsilon$ instead?

Please write your answers in *essay format*, in such a way that a reader could understand your answer without necessarily having to refer to the question. That is, do not just write "(a) yes/no (b) yes/no." Note that the question has been written to ward that off anyway: question (b) has a second part that is open-ended rather than a yes-no answer, question (c) re-hashes (a) and (b), and (d) is worded in a "do you catch my drift?" manner. Questions of the last kind often provide that even if you don't catch the intent (or if you see the intended answer but think it is wrong), you can explain your understanding and still get full or near-full credit. (So this is 24 points total with further breakdown unspecified.)

(3) Design a deterministic finite automaton M with alphabet $\{a, b\}$ so that $L(M)$ equals the language of strings x over that alphabet that:

1. have at least 2 a's in them (i.e., $\#a(x) \geq 2$), and
2. have at most 1 b in them (i.e., $\#b(x) \leq 1$).

You must design M by strategy and give a well-commented arc-node diagram. An option is to use the Cartesian product construction on two smaller machines M_1 and M_2 that handle the properties 1 and 2 separately; then you can comment M_1 and M_2 while showing how M gets cranked out by the construction. (24 pts., for 68 total on the problem set)