CSE396, Spring 2021 Problem Set 3 Due Tue. 3/2, 11:59pm

Reading:

A reminder that the **First Prelim Exam** will be held on **Tue. Mar. 16** in class period. It will cover the domain of the first four problem sets. The exam will be treated with the same logistics as a homework assignment. Previous renditions of my prelim exams have used a rule of bringing one notes sheet (front-and-back allowed) but otherwise closed-book and no Internet. I will not enforce this strictly, but note that a short timed exam does not intend to allow lots of time to read notes and/or the text in order to figure out the procedure to solve a process problem—this should be at one's fingertips through practice. (My 3-hour final exams, on the other hand, do allow time for reflection and "synthesis" where different parts of the course are combined, and have been open-book except for cramped-space limitations.)

For next week, read the rest of Chapter 1—especially noting that the Myhill-Nerode theorem is "covered in exercises." The theorem has two parts, and the part that gets applied in proofs that languages are non-regular is actually the easier part, for which my required handout `https://cse.buffalo.edu/~regan/cse396/CSE396MNT.pdf` takes the place of the textbook. Treat the "Pumping Lemma" material in section 1.4 as *skim* for now—we will cover the weightier *CFL Pumping Lemma* next month—but note some parallels, especially how both employ the "pigeonhole principle" (about which, see `https://rjlipton.wordpress.com/2021/02/15/pigenhole-principle/`).

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

(1) Using *TopHat*, the "Worksheet" titled *S21 HW3 Online Part*. There are 11 questions—not 10—but still summing to 20 points total.

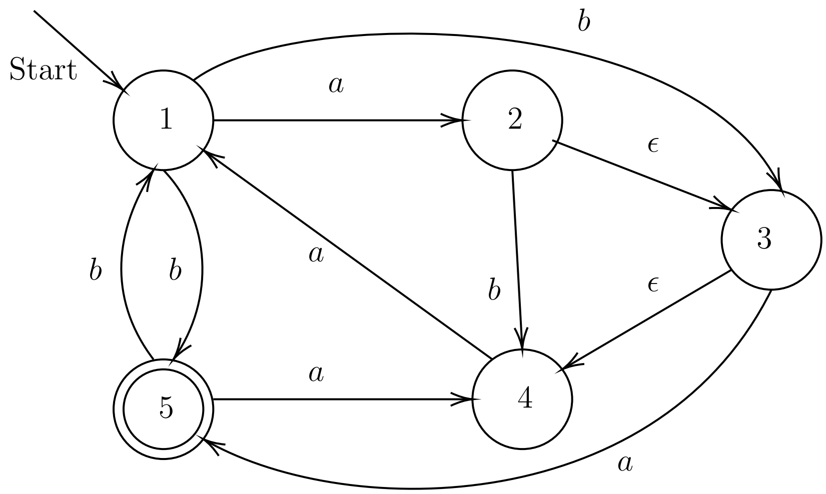
The other two problems are to be submitted as PDFs using the *CSE Autograder* system. The formats of HWs submitted so far have all been fine.

As a non-graded warmup for the written part, try converting SHIPS to WHALE going through English words by changing one letter at a time. For a cryptic hint, to get it in as few as five steps, you may need to have a little more than your wits about you.

(2) Convert the following NFA N into an equivalent DFA (24 pts.). In symbols, $N = (Q, \Sigma, \delta, s, F)$ with $Q = \{1, 2, 3, 4, 5\}$, $\Sigma = \{a, b\}$, $s = 1$, $F = \{5\}$, and

$$\delta = \{(1, a, 2), (1, b, 3), (1, b, 5), (2, \epsilon, 3), (2, b, 4), (3, \epsilon, 4), (3, a, 5), (4, a, 1), (5, a, 4), (5, b, 1)\}.$$

Show the steps of the conversion process clearly. Then, for a further 18 pts., answer the questions after the following picture of the NFA:



(a) The picture looks a little like a boat, but the main worry is that since $2^5 = 32$, the DFA could need a boatload of states. The two ϵ-arcs, however, already rule out (at least) half the possible states. Explain why and which sixteen states are never possible in a DFA that comes from a 5-state NFA with those two ϵ-arcs. (6 pts.)

(b) Does your M have a dead state? If you say yes, give a shortest string x that reaches it from start—i.e., so that N cannot process x from state 1. (3 pts.)

(c) Does your M have the "omni" state $\{1, 2, 3, 4, 5\}$? If you say yes, give a shortest string y that reaches it—i.e., so that N can process y from its start state to any of its five states. (3 pts.)

(d) Does your M have an accepting state P so that once a string u enters P, there is no way to get to a rejecting state, so that $uv \in L(M)$ for all $v \in \Sigma^*$? (3 pts.)

(e) Is there a simple way you can combine two states into one and get an equivalent machine? (3 pts., with the general understanding that your answer should include some reasoning, not just a bare "yes" or "no" here, giving 42 total on the problem)

(3) Using $\Sigma = \{0, 1\}$ this time, write a regular expression for the language of binary strings in which the number of 1's is odd. First write an expression from scratch. Then compare it with two of the expressions for $L_{s,f}$ in the two-state DFA for this language (with the start state s meaning "even" and f meaning "odd" regarding the current count of 1's). Write a few general words with your opinion of how easy it is to tell that they are equivalent. (Yes, this is "shooting the breeze," but that is an important skill for navigating this material in connection with verbal thinking, so worth 12 pts., for 74 total on the set.)