Assignment 3
Computer Science 235

Reading. Section 1.3

1) Use the construction given in Theorem 1.39 in Sipser to convert the following nondeterministic finite automaton to an equivalent deterministic finite automaton.

![NFA Diagram]

2) Give regular expressions generating the following languages.
   a) \{w \mid w \text{ begins with a 1 and ends with a 0}\}
   b) \{w \mid w \text{ contains at least three 1s}\}
   c) \{w \mid w \text{ contains the substring 0101}\}
   d) \{w \mid w \text{ has length at least 3 and its third symbol is a 0}\}
   e) \{w \mid w \text{ starts with a 0 and has odd length, or starts with a 1 and has even length}\}

3) Use the procedure described in Lemma 1.55 in Sipser to convert the following regular expressions to nondeterministic finite automata.
   a) (((00)*)(11)) \cup 01)*
   b) \emptyset*

4) For each of the following languages, give two strings that are members and two strings that are not members - a total of four strings for each part. Assume the alphabet \( \Sigma = \{a, b\} \).
   a) a(ba)*b
   b) a* \cup b*
   c) \Sigma*a\Sigma*b\Sigma*a\Sigma*
   d) (\varepsilon \cup a)b

5) Use the procedure described in Lemma 1.60 in Sipser to convert the following finite automaton to a regular expression.
6) A finite state transducer (FST) is a type of deterministic finite automaton whose output is a string and not just accept or reject. The following is a state diagram of a finite transducer $T$.

Each transition of an FST is labeled with two symbols, one designating the input symbol for that transition and the other designating the output symbol. The two symbols are written with a slash, /, separating them. In $T$, the transition from $q_1$ to $q_2$ has input symbol $a$ and output symbol $1$. When an FST computes on an input string $w$, it takes the input symbols $w_1\cdots w_n$ one by one and, starting at the start state, follows the transitions by matching the input labels with the sequence of symbols $w_1\cdots w_n = w$. Every time it goes along a transition, it outputs the corresponding output symbol. For example, on input abbb, $T$ enters the sequence of states $q_1, q_2, q_1, q_3, q_2$ and produces output 1011. Give the sequence of states entered and the output produced by $T$ for the input bbab.

7) Give the formal definition of the FST model (see previous problem for definition of FST), following the pattern in Definition 1.5 in Sipser. Assume that an FST has an input alphabet $\Sigma$ and an output alphabet $\Gamma$ but not a set of accept states. Include a formal definition of the computation of an FST, following the pattern on page 40 in Sipser. (Hint: An FST is a 5-tuple. Its transition function is of the form $\delta: Q\times\Sigma \to Q\times\Gamma$.)

8) Recall that string $x$ is a prefix of string $y$ if a string $z$ exists where $xz = y$, and that $x$ is a proper prefix of $y$ if in addition $x \neq y$. Consider the following operation on a language $A$:

$$\text{NOEXTEND}(A) = \{ w \in A \mid w \text{ is not the proper prefix of any string in } A \}$$
Show that the class of regular languages is closed under the \textit{NOEXTEND} operation.

9) For languages $A$ and $B$, let the \textit{perfect shuffle} of $A$ and $B$ be the language

$$\{w \mid w = a_1b_1\cdots a_kb_k, \text{ where } a_1\cdots a_k \in A \text{ and } b_1\cdots b_k \in B, \text{ with each } a_i, b_i \in \Sigma\}.$$ 

Show that the class of regular languages is closed under perfect shuffle.

10) This semester you will engage in a project that asks you to interact with papers written in (or adjacent to) the field of Theory of Computation.

We have chosen 5 papers for us to work with as a class this semester. Although you’ll read the abstracts for all papers, you will engage with one paper in particular (given your preferences) more closely. You’ll also talk with your peers about the information in the paper, your questions on it, etc. At the end of the semester you will submit a 1-2-page reflection on the process of reading the research paper you were assigned, what you have found challenging, what you have found interesting, and what new questions it has made you ask yourself.

This is an opportunity for you to try something really challenging in a supportive environment. This is a different type of reading, and for some of you it may be a completely new type of reading.

**Part 1 (of 3).** Read the abstracts of all the papers we are working with carefully. You can find the abstracts in the document linked [here](#).

Now, for each abstract, write a short (2-3 sentence) description of what you understand the paper will be about and what fields you believe these results are (or could be) relevant to.

Next, generate a ranking of these papers, from the one you’d most like to engage with further, to the one you’d least like to engage with further.

We’ll take these rankings into account when we assign papers to students to read (mindful to also create groups that are large enough to have meaningful discussions).

**Grading**

This project is worth 5\% of your final grade. This particular part is worth 1\% of your final grade.