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

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 (a) the sequence of states entered and (b) 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 $\delta: Q \times \Sigma \rightarrow Q \times \Gamma$.)

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

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

10) This project will ask 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. Each paper will have around 10 students assigned to it, so you'll be able to talk with your peers about the information in the paper, your questions on it, etc. You will receive an email prior to this Assignment opening with the paper you were assigned. You will employ different techniques in order to read this paper (from skimming, to careful reading with looking up unknown words, or engaging in a peer discussion). 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.

\textbf{Part 1 (of 3).} Read the abstract of the paper you were assigned carefully (if you're reading Turing's paper, read the first section). Skim the introduction (if you're reading Turing's paper, read the first section). (If you aren't sure what "read carefully", or "skim" mean, please ask us!)

Now, in 2 sentences, write what you think this paper is about. Also write a short reflection (3-4 sentences) on what this process of reading the paper was like for you. Here are some questions to think about as you prepare to write this reflection:

- Do you feel like the abstract is informative?
- Can you identify the main argument in the introduction?
- Do you feel like you're being introduced into the field and the question this paper is trying to answer?

These are only suggestions for possible directions for your reflection; you do not have to answer any one of these questions in particular, and you *do not* have to answer all of them. We encourage you to be both reflective and creative.

\textbf{Grading}
This project is worth 3% of your final grade (this comes out of the assignment portion for your final grade). You will be graded on the final reflection you submit as part of Assignment 9.