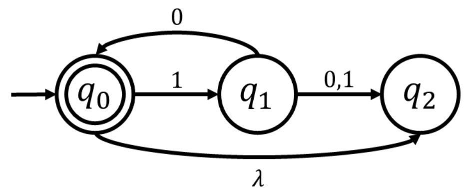
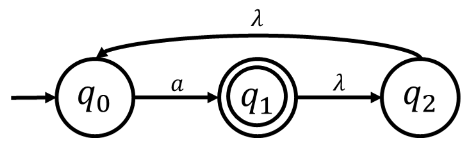
# NFAs
## In Class Examples and Extra Problems

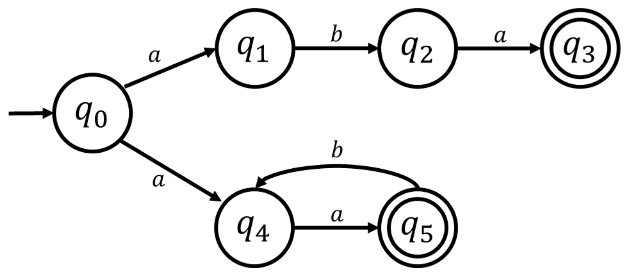
1. Given the following NFA, what language does it recognize?




2. Given the following NFA, what language does it recognize?



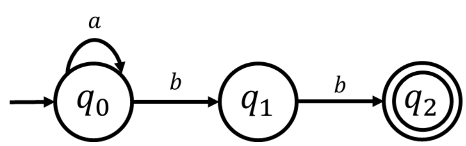

3. Given the following NFA, what language does it recognize?




4. Find an NFA with <u>five states</u> for the language $L = \{abab^n : n \geq 0\} \cup \{aba^n : n \geq 0\}$

5. Find an NFA without $\lambda$-transitions and with a single final state that accepts the language $L = \{a\} \cup \{b^n : n \geq 2\}$

6. An NFA in which there are no $\lambda$-transitions, and for all $q \in Q$ and all $a \in \Sigma$, $\delta(q, a)$, it contains at most one element, is sometimes called an **incomplete DFA**. This is reasonable because the conditions make it such that there is never any choice of moves. For $\Sigma = \{a, b\}$, convert the incomplete DFA below into a standard DFA.



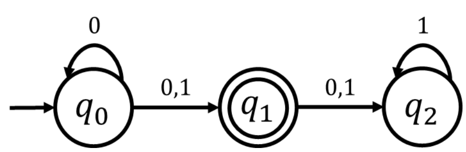

7. Construct an NFA with three states that accepts the language $L = \{ab, abc\}^*$

8. We know that an NFA is defined as a 5 tuple $M = (Q, \Sigma, \delta, q_0, F)$. Consider the following modification of our definition of an NFA, $M = (Q, \Sigma, \delta, Q_0, F)$, where $Q_0 \subseteq Q$ is a set of possible initial states. The language accepted by such automaton is defined as

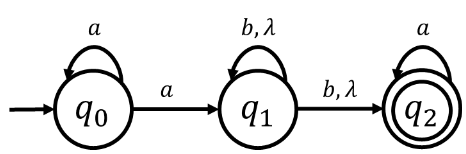
$$L(M) = \{w : \ \delta^*(q_0, w) \text{ contains } q_f, \text{ for any } q_0 \in Q_0, \ q_f \in F\}$$

Show that for every NFA with multiple initial states there exists an NFA with a single initial state that accepts the same language.

9. Convert the following NFA into its equivalent DFA.




10. Convert the following NFA into its equivalent DFA.




11. Show that if L is regular, then $L^R$ is also regular.

12. Let $L$ be any language. Define $even(w)$ as the string obtained by extracting from $w$ the letters in even-numbered positions; that is, if

$$w = a_1 a_2 a_3 a_4 ...,$$

then

$$even(w) = a_2 a_4 ...$$

Corresponding to this, we can define a language $even(L) = \{even(w) : w \in L\}$. Prove that if $L$ is regular, so is $even(L)$.