1. Give a regular expression that describes the set accepted by this automaton:

2. Let $A, B \subseteq \{0, 1\}^*$ and $B$ be a regular language. Prove or disprove the following statements:

   (a) If $A \cup B$ is regular, then so is $A$.
   (b) If $A \cap B$ is regular, then so is $A$.

3. Let $A = \{a^n b^n c^n d^n \mid n \geq 1\}$. Prove that the set

   $$B = (a + b + c + d)^* - A$$

   is non-regular.

4. Give a DFA equivalent to the regular expression $(00 + 11)^*(01 + 10)(00 + 11)^*$. 
5. Consider the deterministic finite automaton $M = (Q, \Sigma, \delta, s, F)$ with $Q = \{1, 2, 3, 4, 5, 6\}$, $\Sigma = \{0, 1\}$, $s = 1$, $F = \{5, 6\}$, and $\delta$ specified by the following table:

$$
\begin{array}{c|cc}
 & 0 & 1 \\
\hline
\rightarrow & 1 & 4 \ 6 \\
2 & 3 & 5 \\
3 & 2 & 4 \\
4 & 1 & 3 \\
F & 5 & 6 \ 2 \\
F & 6 & 5 \ 1 \\
\end{array}
$$

Here $\rightarrow$ indicates the start state and $F$ indicates final states.

Give an equivalent minimal deterministic finite automaton.

6. Let $L = \{a^n b^n \mid n \geq 0\}$. Give a CFG for $A = \{a, b\}^* - L$.

7. Convert the following CFG for set $L$ to a Chomsky Normal Form grammar for the set $L - \{\epsilon\}$.

$$S \rightarrow aSB \mid bSa \mid \epsilon$$

8. Convert the following CFG to Greibach Normal Form.

$$S \rightarrow BA \mid CC$$

$$A \rightarrow a$$

$$B \rightarrow b$$

$$C \rightarrow SC \mid b$$

9. Show that the set $B = \{w \in \{a, b, c, d\}^* \mid \#a(w) = \#c(w) \text{ and} \#b(w) = \#d(w)\}$ is not context free.

10. For $A, B \subset \Sigma^*$, define $A/B \equiv \{x \in \Sigma^* \mid \exists y \in B, xy \in A\}$. Prove that if $L$ is a CFL and $R$ is a regular set, then $L/R$ is a CFL (i.e., given a NPDA for $L$ and a DFA for $R$, describe a NPDA for $L/R$).

11. Consider the grammar $G = \{\{S, T, B\}, \{a, +\}, \{S \rightarrow ST, S \rightarrow a, T \rightarrow BS, B \rightarrow +\}, S\}$. Use the CKY algorithm to determine whether $G$ generates the string $a + a + a$. Be sure to show the filled-out table.