1. Give state diagrams for NFA as required for recognizing the following languages. In all parts the alphabet is \{0, 1\}.

(a) NFA for \( \{w | w \text{ contains an even number of 0s, or contains exactly two 1s} \} \) with six states; NFA for \( 0^*1^*00^* \) with three states; NFA for \( \{0\} \) with two states (also give a formal description of this last NFA).

(b) NFA for \( A^* \) where \( A = \{01\} \cup \{001\} \). Convert this NFA to equivalent DFA.

(c) For each \( k \geq 1 \), let \( C_k = \{\Sigma^*0\Sigma^{k-1}\} \). Give an NFA with \( k + 1 \) states recognizing \( C_k \). Also give a formal description of this NFA.

2. Prove the following languages are not regular:

(a) \( \{0^n1^m0^n | m, n \geq 0\} \).

(b) \( \{0^m1^n | m \neq n\} \).

(c) \( \{w | w \in \{0, 1\}^* \text{ is not a palindrome}\} \). Palindrome is a string that reads the same forward and backward.

3. Convert the following regular expressions into NFA.

(a) \( (0 \cup 1)^*000(0 \cup 1)^* \).

(b) \( (((00)^*(11)) \cup 01)^* \).

(c) \( \phi^* \).

4. For languages \( A \) and \( B \), let the shuffle of \( A \) and \( B \) be the language:

\( \{w | w = a_1b_1 \cdots a_kb_k \text{, where } a_1 \cdots a_k \in A \text{ and } b_1 \cdots b_k \in B \text{, each } a_i, b_i \in \Sigma^* \} \).

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

5. For language \( A \), let

\( DROP-OUT(A) = \{xz | xyz \in A \text{ where } x, z \in \Sigma^*, y \in \Sigma \} \).

Show that if \( A \) is regular then \( DROP-OUT(A) \) is regular.

Continued in the next page.
6. Convert the following finite automaton into regular expressions:

Figure 1: Figure for Question 6