The answers must be the original work of the author. While discussion with others is permitted and encouraged, the final work should be done individually. You are not allowed to work in groups. You are allowed to build on the material supplied in the class. Any other source must be specified clearly.

1. *(6 points)* For each of the following regular expressions over $\{a, b\}$, give minimal length strings that are **not** in the language defined by the expression.

    a. $(aa)^*(bb)^*a^*$
    b. $a^*(ba)^* \cup b \cup ab \cup aab$
    c. $(a^* \cup b^*)(a^* \cup b^*)(a^* \cup b^*)$

2. *(27 points)* Let L over $\Sigma = \{i, u, n, a, b\}$ be the language where each string begins with in or un and the remainder of the string does not have the letters $\{i, u, n\}$.

    a. Give a recursive definition for L.
    b. Give a regular set for L.
    c. Give a regular expression for L.

3. *(27 points)* Let L over $\Sigma = \{a, b, c\}$ be the language where every b is followed by ac.

    a. Give a recursive definition for L.
    b. Give a regular set for L.
    c. Give a regular expression for L.

4. *(40 points)* Give a regular expression for the following languages.

    a. The set of strings over $\{a, b, c\}$ with length three.

    b. The set of strings over $\{a, b\}$ where every aa is followed by b.

    c. The set of strings over $\{a, b, c\}$ where the total number of b's and c's together is three.

    d. The set of strings over $\{a, b, c\}$ in which all the a's precede the b's, which in turn precede the c's. It is possible that there are no a's, or b's, or c's.

    e. The set of strings over $\{a, b, c\}$ that do not begin with the substring aaa.