**Name:** _____

1. (1 pt.)

   - **Read all material carefully.**
   - You may refer to your books, papers, and notes during this test.
   - No computer or network access of any kind is allowed (or needed).
   - Write, and draw, carefully. Ambiguous or cryptic answers receive zero credit.
   - Use textbook and classroom conventions for notation, algorithmic options, etc.
   - Ask for clarifications on the above if needed.

   Write your name in the space provided above.

2. (14 pts.) Consider the language L_1 of binary strings in which the absolute value of the difference between the number of zeros and number of ones is a multiple of five. Is L_1 regular? If so, depict a FSA that recognizes the language, and prove that claim. Otherwise, use the pumping lemma to prove nonregularity.

[additional space for answering the earlier question]

3. (15 pts.) Using the textbook's method, find a regular expression that is equivalent to the following FSA. Show enough intermediate steps to make it clear that you are following the textbook's method exactly.
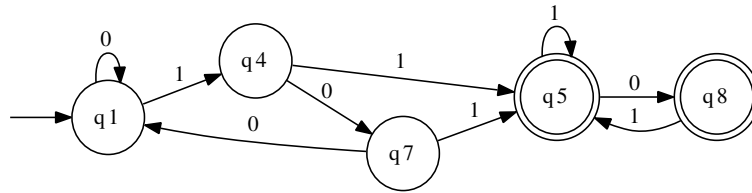
[additional space for answering the earlier question]

4. (15 pts.) Let $|R|$ denote the cardinality of the language recognized by regular expression R. For each of the following, provide the tightest possible lower and upper bounds on $|R|$ in terms of $|R_1|$ and $|R_2|$, and prove your claims.

    (a) $R = R_1 \circ R_2$

    (b) $R = R_1 \cap R_2$

    (c) $R = R_1^*$

[additional space for answering the earlier question]