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. (20 pts.) Let $\nu(w)$ denote the number of ones in a binary string w and let $|w|$ denote its length. Let $\mathbb{N}_0$ denote the set of nonnegative integers. Consider the language:

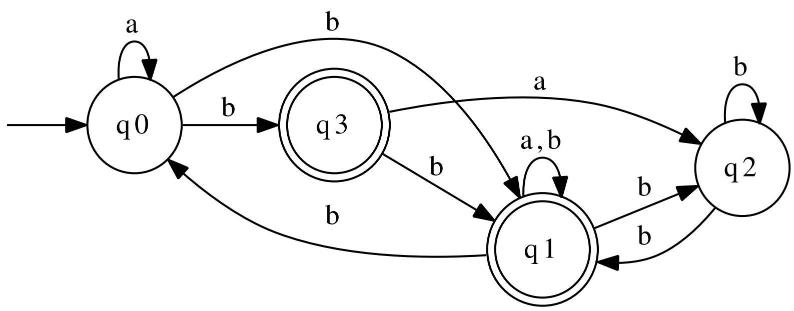
$$L_1 = \{w \in \{0,1\}^* \mid \exists k \in \mathbb{N}_0 : |w| = 3k \wedge \nu(w) = 2k\}$$

   (a) Provide a brief, intuitive, and precise description of L_1 in plain English. (Do not simply translate the formal notation into English.) Provide three illustrative examples of strings in L_1; repeat for three strings not in L_1.

   (b) Is L_1 context free? Provide a brief intuitive explanation for your answer.

(c) If your answer to Question 2b is yes then provide a CFG (or PDA) and prove that it generates (or recognizes) exactly L_1. Otherwise, use the pumping lemma to prove L_1 is not context free.

3. (20 pts.) Generate a regular expression that is equivalent to the following finite-state automaton. *Show enough intermediate results and include brief explanations* to make it clear that the method described in the textbook is being followed.



[additional space for answering the earlier question]

4. (19 pts.) Either (1) provide an *unambiguous* context-free grammar for the language recognized by the automaton of Question 3, and prove your claims (that the grammar generates the required language and that it is unambiguous) or (2) prove that no such grammar exists.

[additional space for answering the earlier question]