Name: _____

1. (1 pt.)
   - ○ **Read all material carefully.**
   - ○ *If in doubt whether something is allowed, ask, don't assume.*
   - ○ You may refer to your books, papers, and notes during this test.
   - ○ Write, and draw, carefully. Ambiguous or cryptic answers receive zero credit.
   - ○ Use class and textbook conventions for notation, algorithmic options, etc.
   - ○ For the duration of the exam, the only communication (live or network) should be with the instructor for clarifications, etc.
   - ○ At the end of the exam, scan your work to a PDF file named using the following template and upload it in the usual way:
     `cos451-fin-`*`lastname`*`-`*`firstname`*`-`*`pqrs`*`.pdf`
     (replacing *lastname* and *firstname* with yours and *pqrs* with an arbitrary 4-digit number).
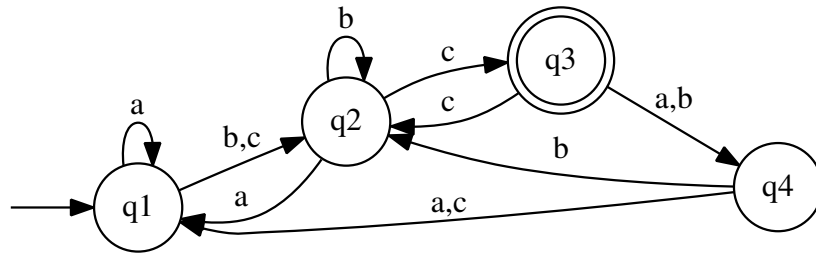
   Write your name in the space provided above.

   ┌───┐
   │ WAIT UNTIL INSTRUCTED TO CONTINUE TO REMAINING QUESTIONS.   │
   └───┘

   Do not write in the following table.

Q	Full	Score
1	1	
2	9	
3	20	
4	20	
5	10	
6	20	
7	20	
total	100	

2. (9 pts.) Consider the finite-state automaton with the following state diagram:

(a) Is it a DFA, NFA, or neither? *Justify your answer.*

(b) Provide a *formal definition* of the automaton.

3. (20 pts.) Use the textbook's method to generate a regular expression that is equivalent to the automaton of Question 2. *Show enough details* to make it obvious that the textbook's method is being followed.

[additional space for answering the earlier question]

[additional space for answering the earlier question]

4. (20 pts.) Convert the following grammar to Chomsky normal form. Upper-case letters represent variables and lower-case letters denote terminals. *Show enough intermediate results and include brief explanations* to make it clear that the method described in the textbook is being followed.

$$
\begin{aligned}
A &\ \rightarrow\ \varepsilon \mid BAB \mid ABBA \mid a \\
B &\ \rightarrow\ b \mid BB \mid BaaB
\end{aligned}
$$

[additional space for answering the earlier question]

5. (10 pts.) Prove or disprove: The language defined by the grammar G_z of Question 4 *does not* contain any strings with an odd number of bs.

6. (20 pts.) Let G_z be the grammar of Question 4. For each of the following strings, indicate whether the string belongs to $L(G_z)$. If so, provide a leftmost derivation of that string. Otherwise, prove as precisely as possible that the string does not belong to $L(G_z)$.

(a) `ababaabba`

(b) `babbaabba`

[additional space for answering the earlier question]

7. (20 pts.) Prove or disprove: The grammar G_z of Question 4 is *ambiguous*.

[additional space for answering the earlier question]