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. (No sharing of material.)
   - **E-books** may be used **subject to the restrictions** noted in class. (Briefly, do only those things with an e-book that are just as easily done with a physical book.)
   - **Computers of any kind** (including tablets, phones, and similar devices) are **not permitted** except when used exclusively as e-book readers.
   - **Network access** of any kind (cell, voice, text, data, ...) is **not permitted**.
   - Write and draw neatly and carefully. Ambiguous or cryptic answers receive no credit.
   - Use class and textbook **conventions** for notation, algorithmic options, etc.
   - Questions that ask for **explanations, proofs, etc.** allocate a sizable fraction of points to those. (Answers missing those will score very poorly.)
   - Budget your **time**, noting that *number of points = number of minutes*.

Write your name in the space provided above.
Do not write anything else on this page.

WAIT UNTIL INSTRUCTED TO CONTINUE TO REMAINING QUESTIONS.

(Do not view any other pages.)

Do not write on this page.
(It is for use in grading only.)

Q	Full	Score
1	1	
2	9	
3	15	
4	15	
5	10	
total	50	

2. (9 pts.) Consider the following context-free grammar G_1 and a binary alphabet $\Sigma_1 = \{\mathtt{0}, \mathtt{1}\}$.

$$\begin{array}{lcl} X & \rightarrow & 0 \mid 0\ X\ Y \\ Y & \rightarrow & 1\ 1 \mid 1\ 1\ Y X \end{array}$$

Provide a string $w \in L(G_1)$ with $|w| \geq 3$ along with its leftmost derivation, or prove that no such w exists. Reminder: Use class conventions for grammars, derivations, etc.

3. (15 pts.) With the grammar G_1 (duplicated below for convenience) and alphabet $\Sigma_1 = \{0, 1\}$ from Question 2, provide a binary string $x \notin L(G_1)$ with $|x| \geq 3$ and prove that claim as precisely as possible (or prove that no such x exists).

$$\begin{array}{lcl} X & \rightarrow & 0 \mid 0\ X\ Y \\ Y & \rightarrow & 1\ 1 \mid 1\ 1\ Y X \end{array}$$

[additional space for earlier material]

4. (15 pts) Convert the grammar G_1 of Question 2 (duplicated below for convenience) into Chomsky normal form. *Show enough intermediate steps to make it very clear how the textbook's method is being applied.* Also clearly list all the rules of the final grammar.

$$\begin{aligned} X &\rightarrow 0 \mid 0\, X\, Y \\ Y &\rightarrow 1\,1 \mid 1\,1\, Y X \end{aligned}$$

[additional space for earlier material]

5. (10 pts.) Prove or disprove: The following language L_2 is regular.

$$L_2 = \left\{ w \in \{a, b\}^* \;\middle|\; |w| \notin \{3, 4\} \right\}$$