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.
   - The question marked with a ⋆ is ∘ required for COS 550, but
     ∘ optional (extra credit, graded more strictly than non-⋆) for COS 451.
   - *COS 550 students* (only) get *10 extra minutes*.

   Write your name in the space provided above.

WAIT UNTIL INSTRUCTED TO CONTINUE TO REMAINING QUESTIONS.

2. (19 pts.)

   - Reduce the following instance of SAT to an instance of VERTEX-COVER using the textbook's method.
   - Determine the solution to either the SAT or VERTEX-COVER instance (your choice).
   - Use the above solution to one instance to determine the solution to the other instance. Briefly explain your answer.

   $(x \vee \neg y \vee z) \wedge (\neg x \vee \neg y \vee z) \wedge (x \vee y \vee z) \wedge (\neg x \vee y \vee \neg z)$

[additional space for answering the earlier question]

$(x \vee \neg y \vee z) \wedge (\neg x \vee \neg y \vee z) \wedge (x \vee y \vee z) \wedge (\neg x \vee y \vee \neg z)$

3. (20 pts.)

   - Reduce the following instance of TQBF to an instance of GG (Generalized Geography) using the textbook's method.
   - Determine the solution to either the TQBF or GG instance (your choice).
   - Use the above solution to one instance to determine the solution to the other instance. Briefly explain your answer.

$$\exists x \forall y \exists z [(x \vee \neg y \vee z) \wedge (\neg x \vee \neg y \vee z) \wedge (x \vee y \vee z) \wedge (\neg x \vee y \vee \neg z)]$$

[additional space for answering the earlier question]

$\exists x \forall y \exists z [(x \vee \neg y \vee z) \wedge (\neg x \vee \neg y \vee z) \wedge (x \vee y \vee z) \wedge (\neg x \vee y \vee \neg z)]$

4. (20 pts.) Trace the operation of the CYK algorithm (using the tabular format from the class exercise) on the following grammar and the string `1101011` as input.

$$
\begin{aligned}
S &\rightarrow \epsilon | AB \\
A &\rightarrow 1 \\
B &\rightarrow SC \\
C &\rightarrow DE \\
D &\rightarrow 0 \\
E &\rightarrow 1
\end{aligned}
$$

[additional space for answering the earlier question]

$$
\begin{array}{lcl}
S & \rightarrow & \epsilon | AB \\
A & \rightarrow & 1 \\
B & \rightarrow & SC \\
C & \rightarrow & DE \\
D & \rightarrow & 0 \\
E & \rightarrow & 1
\end{array}
$$

5. (15 $\star$ pts.) Prove or disprove: The following language L is in PSPACE (where Σ is a finite alphabet as usual).

$$L = \{\langle M \rangle \mid M \text{ is an NFA and } \exists w \in \Sigma^* : w \notin L(M)\}$$