

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.

2. (9 pts.) Provide a *precise* English description of the language defined by the following context-free grammar.

$$S \rightarrow aSaa \mid bSc \mid m$$

3. (15 pts.) Provide a *high-level description* of a Turing Machine that *decides* the language of Question 2. *Explain* why your answer is correct.

4. (15 pts.) Provide an *implementation description* of the Turing Machine of Question 3.  
*Explain* why your answer is correct.

5. (10 ★ pts.) Provide a *formal description* of the Turing Machine of Question 4. *Explain* why your answer is correct.