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 the conventions used in class and the textbook for all material.
   - COS 480 students should answer non-⋆ questions; ⋆ questions are for extra credit.
   - COS 580 students should answer all questions, including ⋆ questions.

   Write your name in the space provided above.

2. (14 pts.) Recall, from class exercises, the database composed of relations `Students(id, name, year)`, `Courses(id, title, ta)`, and `Enrolls(student, course, credits)`, with the semantics described there.

   Provide a SQL query for the set of all tuples (t, s, c) such that $c > 0$ is the total number of credits for which the student with ID s is enrolled and t is the ID of a person who is a TA for all classes in which s is enrolled. If no such TA exists for a student, then t should be 0 in the tuple for that student. You may use views to present your query.

   Briefly explain why your query is correct.

[additional space for answering the earlier question]

3. (15 pts.) Either (a) provide, with explanation, a relational algebra query that is equiv-
   alent to the query of Question 2 using only the operators selection, projection, cross
   product, union, difference, and renaming, along with a small (constant) number of
   constant database relations of your choice; or (b) prove that no such query exists. You
   may use the linear notation for algebra.

4. ⋆ (10 pts.) Let P, S, C, U, I, D denote the algebraic operators projection, selection, cross product, union, intersection, and difference. Combinations of the letters (e.g., PSC) denote the algebraic languages with only those operators. Prove or disprove each:

(a) PSC ≡ PSCU

(b) PSCI ⊑ PSCD