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.
   - E-books may be used *subject to the restrictions* noted in class.
   - Computers are not permitted, except when used strictly as ebooks.
   - Network access of any kind (cell, voice, text, data, ...) is not permitted.
   - Write, and draw, carefully. Ambiguous or cryptic answers receive zero credit.
   - Use class and textbook conventions for notation, algorithmic options, etc.
   - There is an question marked with ⋆. It is much harder than the rest. It is required for COS 580 but optional (extra credit) for COS 480.

   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	4	
3	15	
4	10	
⋆ 5	10⋆	
total	30 + 10⋆	

2. (2 pts.) Consider the following relational instance $R_1(B, N, C, D)$ representing the building name (B), room number (N), capacity (C), and description (D) of rooms on campus.

R_1

B	N	C	D
Neville	227	30	cramped seating, blackboard
Neville	120	25	nice chairs, whiteboard, videoconferencing
Neville	225	2	office
Neville	224	3	office
East Annex	225	10	lab
East Annex	227	3	office

What is its arity? What is its cardinality?

3. (15 pts.) For each of the following expressions, indicate whether the expression is valid relational algebra. If it is then evaluate it on the above instance; else explain why it is invalid.

   (a) (3 pts.) $\pi_{B,N} R_1$

   (b) (3 pts.) $\pi_{C} R_1$

(c) (3 pts.) $\pi_B R_1 \times \pi_N R_1$

(d) (3 pts.) $\pi_{B,N} \sigma_{C>20} R_1$

(e) (3 pts.) $\sigma_{C>20} \pi_{B,N} R_1$

4. (10 pts.) Provide relational algebra queries for the following.

   (a) (5 pts.) Identifying information and descriptions of all rooms with capacity between 20 and 40.

   (b) (5 pts.) All possible 2-room combinations (unordered). That is, all possible sets of two distinct real-world rooms represented by the database.

5. $\star$ (10 pts.) Let R_1 be the relation depicted earlier. For each of the following (separately) either provide a relation S with the indicated property and justify the claim or explain why no such relation exists.

   (a) (2 pt.) $R_1 \cup S = R_1$

   (b) (2 pt.) $R_1 \cup S = S$

   (c) (3 pt.) $R_1 \times S = R_1$

   (d) (3 pt.) $R_1 \times S = S$

[additional space for answering the earlier question]