Information and Database Management Systems I (CIS 4301)  
(Spring 2017)

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Exam 2 Part 1 Solutions

Name:  
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Pledge (Must be signed according to UF Honor Code)

On my honor, I have neither given nor received unauthorized aid in doing this assignment.

_______________________________________________
Signature

For scoring use only:

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Question 1 (Relational Algebra) [25 points]

Let \( R(A, B) \) be a relation with \( r > 0 \) tuples, and let \( S(B, C) \) be a relation with \( s > 0 \) tuples. We assume that \( A, B, \) and \( C \) have the same data type (that is, domain). We make no assumptions about keys. For each of the following Relational Algebra expressions, in terms of \( r \) and \( s \), determine the \textit{minimum} and \textit{maximum number of tuples} that can be found in the result relation of the evaluated expression (“Minimum: …”, “Maximum: …”). Answers have to be provided in mathematical notation in terms of \( r \) and \( s \). Answers that are exclusively textual will not be accepted. Comment precisely on necessary conditions or assumptions for each number determined.

1. \( R \cup \rho_{T(A,B)}(S) \) [5 points]

   [Comment: The term \( \rho_{T(A,B)}(S) \) renames \( S \) into \( T \) and the attributes \( B \) and \( C \) of \( S \) into \( A \) and \( B \) to make both operand schemas of the union operator compatible.]

   Minimum: \( \max(r, s) \) (if one relation is a subset of or equal to the other relation)
   Maximum: \( r + s \) (if the relations are disjoint)

   A term that covers both the minimum number and the maximum number of tuples and precisely yields the result is \( r + s - |R \cap S| \).

2. \((R \bowtie R) \bowtie R\) [4 points]

   Minimum: \( r \) (the expression yields \( R \))
   Maximum: \( r \) (the expression yields \( R \))

3. \( \pi_{A,C}(R \bowtie S) \) [6 points]

   Minimum: \( 0 \) (if \( \pi_B(R) \cap \pi_B(S) = \emptyset \))
   Maximum: \( r \cdot s \) (if \( \pi_B(R) = \pi_B(S) \) and \( |\pi_B(R)| = |\pi_B(S)| = 1 \))

4. \( \sigma_{A>B}(R) \cup \sigma_{A>B}(R) \) [4 points]

   Minimum: \( 0 \) (if the \( A \) value is equal to the \( B \) value in each tuple of \( R \))
   Maximum: \( r \) (if the \( A \) value is unequal to the \( B \) value in each tuple of \( R \))

5. \( \pi_B(R) - (\pi_B(R) - \pi_B(S)) \) [6 points]

   Minimum: \( 0 \) (if \( \pi_B(R) \cap \pi_B(S) = \emptyset \))
   Maximum: \( \min(r, s) \) (if \( |\pi_B(R)| = r, |\pi_B(S)| = s \), and \( \pi_B(R) \subseteq \pi_B(S) \) or \( \pi_B(R) \supseteq \pi_B(S) \))
Question 2 (Relational Algebra) [25 points]

Consider the following database schema:

- **Employee** (personName: string, street: string, city: string)
- **Work** (personName: string, companyName: string, salary: integer)
- **Company** (companyName: string, city: string)
- **IsManagedBy** (personName: string, managerName: string)

Give an expression in the relational algebra to express each of the following queries.

1. Find the names of all managers who work for Google. [3 points]
   \[ \pi_{\text{personName}} (\sigma_{\text{companyName} = 'Google'} \land \text{Work.personName} = \text{IsManagedBy.managerName} (\text{Work} \bowtie \text{IsManagedBy})) \]

2. Find the names of all employees who live in the same city as their managers. [5 points]
   \[ \pi_{\text{personName}} ((\text{Employee} \bowtie \text{IsManagedBy}) \bowtie \text{managerName} = \text{employee2.personName} \land \text{Employee.city} = \text{employee2.city} (\rho_{\text{employee2}} (\text{Employee}))) \]

3. Find the highest salary among employees who work for Google. [5 points]
   \[ \rho_{\text{Work2}} (\text{Work}) \]
   \[ \pi_{\text{Work.salary}} (\sigma_{\text{Work.companyName} = 'Google'} (\text{Work})) - \pi_{\text{Work.salary}} (\sigma_{\text{Work.companyName} = 'Google'} \land \text{Work2.companyName} = 'Google' \land \text{Work.salary} < \text{Work2.salary} (\text{Work} \bowtie \text{Work2})) \]

4. Assume a person may work for more than one company. Find the names of all employees who work for all the companies ‘Jim Green’ works for [6 points]
   \[ \pi_{\text{personName}} (\text{Work} \div (\pi_{\text{companyName}} (\sigma_{\text{personName} = 'Jim Green'} (\text{Work})))) \]

5. Find the names of all employees who earn more than every employee of Google. [6 points]
   \[ \rho_{\text{Work2}} (\text{Work}) \]
   \[ \pi_{\text{personName}} (\text{Work}) - \pi_{\text{Work.personName}} (\sigma_{\text{Work.salary} < \text{Work2.salary} \land \text{Work2.companyName} = 'Google'} (\text{Work} \bowtie \text{Work2})) \]