Assignment 3

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In this assignment, you will practice working with SQL. Your solutions, containing PostgreSQL statements for solving the problems, should be submitted to IUCanvas in a file Assignment3.sql. It is advised that you also include comments in this file to elaborate on your solutions.

1. Let $A(x)$ be the relation schema for a set of positive integers.

   Write a SQL statement that produces a table which, for each $x \in A$, lists the tuple $(x, \sqrt{x}, x^2, 2^x, x!, \ln x)$.

   For example, if $A = \{1, 2, 3, 4, 5\}$ then your SQL statement should produce the following table:

```
   x |  square_root_x   | x_squared | two_to_the_power_x | x_factorial |    logarithm_x
---+------------------+-----------+--------------------+-------------+-------------------
   1 |                1 |         1 |                  2 |           1 |                 0
   2 |  1.4142135623731 |         4 |                  4 |           2 | 0.693147180559945
   3 | 1.73205080756888 |         9 |                  8 |           6 |  1.09861228866811
   4 |                2 |        16 |                 16 |          24 |  1.38629436111989
   5 | 2.23606797749979 |        25 |                 32 |         120 |   1.6094379124341
( 5 rows)
```

2. Let $A(x)$ and $B(x)$ be two unary relation schemas that represent sets A and B.

   Determine the truth-value of $A - B$ is empty, $(A - B) \cup (B - A)$ is not empty, and $A \cap B$ is empty.

   For example, if $A = \{1, 2, 3\}$ and $B = \{1, 3, 4, 5\}$ then because

$$\begin{aligned} A - B &= \{2\} \\ (A - B) \cup (B - A) &= \{2, 4, 5\} \\ A \cap B &= \{1, 3\} \end{aligned}$$

   your SQL statement should produce the output:

```
 empty_a_minus_b | not_empty_symmetric_difference | empty_a_intersection_b
-----------------+--------------------------------+------------------------
 f               | t                              | f
(1 row)
```

Your solution should work for arbitrary A and B.

3. Let `Pair`(x, y) be a relation of pairs (x, y). (The domain of x and y is INTEGER.) Write a SQL query that produces a relation with attributes (x_1, y_1, x_2, y_2) such that (1) (x_1, y_1) and (x_2, y_2) are different pairs in the relation `Pair`, and (2) $x_1 + y_1 = x_2 + y_2$.

4. Let $A(x)$, $B(x)$ and $C(x)$ be three unary relation schemas that represent sets A, B and C of integers.

   Give answers to the following problems. You should provide two different SQL queries. One answer wherein you can use the set operations INTERSECT and/or EXCEPT, and a second answer wherein you can not use these operators.[1] You can use user-defined functions but you can not use aggregate functions.

   (a) Determine the truth-value of $A \cap B \neq \emptyset$. For example, if $A = \{1, 2\}$ and $B = \{1, 4, 5\}$ then the result of your SQL statements should be

   ```
    answer
   --------
    t
   (1 row)
   ```

   If, however, $A = \{1, 2\}$ and $B = \{3, 4\}$ then the result of your statement should be

   ```
    answer
   --------
    f
   (1 row)
   ```

   (b) Determine the truth-value of $A \subseteq B$.

   (c) Determine the truth-value of $A \cap B = B$.

   (d) Determine the truth-value of $A \neq B$.

   (e) Determine the truth-value of $|A \cap B| \leq 2$.

   (f) Determine the truth-value of $(A \cup B) \subseteq C$.

   (g) Determine the truth-value of $|(A - B) \cup (B - C)| = 1$.

[1] You are permitted to use the UNION operator.

5. Repeat Problem 4 by using the COUNT aggregate function. For each sub-problem, you only need to provide one answer and you are allowed to use the set operations UNION, INTERSECT, and EXCEPT.

6. Use the same files student.txt, majors.txt, book.txt, and buys.txt from Assignment 2.

   Consider the following relation schemas about students and books.

   Student($Sid, Sname$)
   Major($Sid, Major$)
   Book($BookNo, Title, Price$)
   Buys($Sid, BookNo$)

   The relation Major stores students and their majors. A student can have multiple majors but we also allow that a student has no major.

   Assume the following domains for the attributes:

Attribute	Domain
Sid	INTEGER
Sname	VARCHAR(15)
Major	VARCHAR(15)
BookNo	INTEGER
Title	VARCHAR(30)
Price	INTEGER

   (a) i. Write a function

```
booksBoughtbyStudent(sid int)
    returns table(bookno int, title VARCHAR(30), price int)
```

   that takes a student sid as input and returns the book information of books bought by that student.

   ii. Test this function on the student with sid 1001 and on the student with sid 1015.

   iii. Using this function, write the following queries:

   A. Find the sids and names of students who bought exactly one book that cost less than $50.

   B. Find the pairs of different student sids (s1,s2) such that student s1 and student s2 bought the same books.

   (b) i. Write a function

```
studentsWhoBoughtBook(bookno int)
    returns table(sid int, sname VARCHAR(15))
```

that takes a bookno as input and returns the student information of students who bought that book.

ii. Test your function on the book with bookno 2001 and that with bookno 2010.

iii. Using this function and the `booksBoughtbyStudent` function from problem 6(a)i write the query "Find the booknos of books bought by a least two CS students who each bought at least one book that cost more that $30."

(c) Write the following queries in SQL by using aggregate functions and user-defined functions. You can not use the EXISTS and NOT EXISTS predicates.

i. Find the sid and major of each student who bought at least 4 books that cost more than $30.

ii. Find the pairs (s_1, s_2) of different students who spent the same amount of money on the books they bought.

iii. Find the sid and name of each student who spent more money on the books he or she bought than the average cost that was spent on books by students who major in 'CS'.

iv. Find the booknos and titles of the third most expensive books.

v. Find the bookno and title of each book that is only bought by students who major in 'CS'.

vi. Find the sid and name of each student who did not only buy books that were bought by at least two 'CS' students.

vii. Find each (s, b) pair where s is the sid of a student and where b is the bookno of a book bought by that student whose price is strictly below the average price of the books bought by that student.

viii. Find each pair (s_1, s_2) where s_1 and s_2 are the sids of different students who have a common major and who bought the same number of books.

ix. Find the triples (s_1, s_2, n) where s_1 and s_2 are the sids of two students who share a major and where n is the number of books that was bought by student s_1 but not by student s_2.

x. Find the bookno of each book that was bought buy all-but-one student who majors in 'CS'.