Final Exam

Started: Oct 25 at 1:16pm

Quiz Instructions

Question 1	12 pts

Consider the following relation that describes a directed graph where the edges are colored: **Edges (start, end, color).**

A **triangle** is a pattern of three directed edges a -> b, b -> c, c -> a. A triangle is **monochromatic** if all edges have the same color. Write a SQL query that counts the **non-monochromatic triangles** (i.e., the ones that have at least two edges with a different color).

Be careful: the triangles a -> b -> c -> a, b -> c -> a -> b and c -> a -> b -> c are the same triangle and should be counted only once!

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Question 2   **10 pts**

Consider a relational schema with one relation R(A, B) and the following query in Relational Algebra:

$$q = \pi_A(\sigma_{B=1}(R) \bowtie_{A=A'} \rho_{A \to A', B \to B'}(R))$$

Which of the following queries are equivalent to q? Choose all the correct options.

☐ $\pi_A(\sigma_{B=1}(R))$

☐ $\sigma_{B=1}(\pi_A(R) \bowtie_{A=A'} \rho_{A \to A', B \to B'}(R))$

☐ $\pi_A(\sigma_{B=1}(R \bowtie_{A=A'} \rho_{A \to A', B \to B'}(R)))$

☐ $\pi_A(R) - \pi_A(\sigma_{B \neq 1}(R))$

☐ $\pi_A(\sigma_{B=1}(R)) \cap \pi_A(R)$

Question 3   5 pts

Consider the relation R(A, B, C, D, E, F) with functional dependencies:

A, B -> C

    C -> D, E

 C, F -> B

Which of the following are **keys** in R?

☐ A, B

☐ A, B, F

☐ A, B, C

☐ A, C, F

☐ A, B, E, F

Question 4   8 pts

Explain your answer to the above question.

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Question 5   10 pts

We are given a relation R(A, B) with 100 pages, and a relation S(C, D) with 200 pages. In relation R, attribute A is the primary key and takes values 1, 2, 3 . . . . Each record in R is 40 bytes long, while each record in S is 10 bytes long. The size of a page is 1, 000 bytes.

How many pages do we need to store the output of the following SQL query?

```
SELECT *

FROM R, S

WHERE R.A = 1
```

Question 6   8 pts

Consider a B+ tree index with order d = 5, fill factor F = 1 and height h = 3. What is the total number of pages in the tree, including leaf and non-leaf pages?

Question 7   10 pts

Consider the following extendible hash index. What is the smallest number of entries you can insert so that the global directory doubles in size?

exhash-2.pdf

○ 1

○ 2

○ 3

○ 4

Question 8   5 pts

We are given two relations: R with 20,000 pages and S with 10,000 pages. We are performing a key-foreign key join between R and S, wherein S has the foreign key attribute. Suppose that R is already sorted on the join attribute.

What is the I/O cost of the Sort Merge Join algorithm that uses replacement sort to create the initial runs? Do not count the cost of writing the join result to disk. Assume that the size of the buffer is 100 pages.

Question 9

10 pts

Explain your answer to the above question.

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Question 10

15 pts

Suppose we have a schema with two relations:

- R(A,B) has 2,000,000 tuples.

- S(C,D,E) has 3,000,000 tuples.

Consider the following SQL query:

```
SELECT COUNT(*)

FROM R, S

WHERE R.B = S.C AND R.A = 10 ;
```

Assume that:

- Each page holds 1,000 tuples

- The selectivity of the predicate (R.A = 10) is 1%

- The buffer has size 100 pages.

What is the I/O cost of the best query plan? Describe your answer in detail by presenting the annotated query plan (Here you just need to describe the sequence and implementation of each operator, and where you use materialization or pipelining).

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Question 11   4 pts

If a transaction reads a data object after it has been written by an uncommitted transaction, then isolation is always violated.

○ True

○ False

Question 12   4 pts

A protocol that writes a page to disk immediately after the page is modified by a transaction guarantees durability.

○ True

○ False

Question 13   3 pts

Consider the following SQL query:

```
SELECT *
FROM R
WHERE R.A = 1 AND R.B > 10 ;
```

A **B+ tree index on (B,A)** matches the selection predicate in the above query.

○ True

○ False

Question 14

3 pts

A bitmap index can be efficiently updated.

○ True

○ False

Question 15

3 pts

A bitslice index can be used to answer range queries efficiently.

○ True

○ False

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