Name: 

This quiz is open book, open notes, but there can be no sharing of any material.

1. (1 pt) Write your name in the space provided above.

2. (2 pts) If \{(1, 2, 3), (1, 3, 2)\} is a valid instance of a relation \(S(A, B, C)\), list all functional dependencies that cannot possibly hold true. Explain your answer briefly.

3. (2 pts) Consider a relation with schema \(R(A, B, C, D)\) and functional dependencies \(AB \rightarrow D, C \rightarrow A,\) and \(D \rightarrow C\). List all keys of \(R\).

4. (2 pts) Compute \(\{BC\}^+\) for the schema in Question 3.

5. (2 pts) Consider the relation \(R\) in Question 3. Write a relational algebra query for the \(B\) and \(C\) values of tuples with \(A = 5\).
6. (3 pts) For each functional dependency in Question 3, indicate whether it is a BCNF violation, justifying your answers briefly.

7. (5 pts) Transform (if necessary) the schema in Question 3 into 4NF. Show your intermediate steps and briefly explain why your final schema is in 4NF.

8. (3 pts) Suppose we have decomposed the relation in Question 3 based on your answer to Question 7. For the new schema, write a query equivalent to the query in Question 5.
9. (2 pts) For the schema in Question 3, list one nontrivial multivalued dependency that is not a functional dependency.

10. (2 pts) Given a SQL database containing a table $R(A, B, C, D)$ with all attributes of type integer, write a SQL statement that adds a constraint called $ABisKey$ stating that $(AB)$ is a secondary key of $R$.

11. (4 pts) Suppose the database suggested by Question 10 has another table, $S(A, E)$, with both attributes of integer type. Write a SQL3 trigger that results in the following database behavior. Whenever a tuple $(a, b, c, d)$ is inserted into $R$ and $a$ is a value that does not occur as the first attribute of any tuple in $S$, a tuple $(a, \bot)$ is inserted in $S$ (where $\bot$ denotes null).

12. (2 pts) Write down all the constraints guaranteed (maintained) by the trigger in your answer to Question 11.