Practice Exam - Harder Version

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2023 Final Exam Questions for [subject] . The exam duration was 2 hours; there were 17 questions, worth a total of 100 points. The questions were grouped in 5 sections.

The questions in Section A and B are all based on the following relational logical schema about a library system:

```
CREATE TABLE Book (
    ISBN VARCHAR(20) PRIMARY KEY,
    Title VARCHAR(100) NOT NULL,
    Author VARCHAR(50) NOT NULL,
    Genre VARCHAR(20) NOT NULL,
    PublicationYear INTEGER NOT NULL,
    Price INTEGER NOT NULL
);

CREATE TABLE Member (
    MemberId INTEGER PRIMARY KEY,
    Name VARCHAR(50) NOT NULL,
    Address VARCHAR(100) NOT NULL,
    PhoneNumber VARCHAR(15) NOT NULL,
    MembershipType VARCHAR(20) NOT NULL,
    JoinDate DATE NOT NULL
);

CREATE TABLE Borrowed (
    ISBN VARCHAR(20) NOT NULL,
    MemberId INTEGER NOT NULL,
    BorrowDate DATE NOT NULL,
    DueDate DATE NOT NULL,
    ReturnedDate DATE,
    PRIMARY KEY (ISBN, MemberId, BorrowDate),
    FOREIGN KEY (ISBN) REFERENCES Book(ISBN),
    FOREIGN KEY (MemberId) REFERENCES Member(MemberId)
);
```

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Section A [SQL queries, 25 points in total]

Q1. [4 points] Write a SQL query to find the titles of all books that were borrowed by members who joined the library in 2022 and have a "Premium" membership type.

Q2. [4 points] Write a SQL query to find the number of books borrowed by each member who has borrowed at least 3 books.

Q3. [5 points] Write a SQL query to find the total amount of overdue fines for all books borrowed by members who have not returned the books yet. Assume a fine of $5 per day for each day overdue.

Q4. [6 points] Write a SQL query to find the average price of books borrowed by members with a "Basic" membership type for each genre.

Q5. [6 points] Write a SQL query to find the name and phone number of members who have borrowed books by the author "Stephen King" but have not returned any books yet.

Section B [Relational concepts, 25 points in total]

Q6. [5 points] In the library schema shown on page 1, the table Borrowed has a primary key which is (ISBN, MemberId, BorrowDate). Describe in English, what restrictions this puts on the contents of the table.

Q7. [5 points] Write a relational algebra expression involving the tables in the library schema shown on page 1, whose result will answer the request “Find the titles of all books that were borrowed by members who joined the library in 2022 and have a "Premium" membership type.”

Q8. [7 points] Consider the SQL query below, that refers to the library schema shown on page 1:

```
SELECT MemberId, COUNT(*) AS TotalBooksBorrowed
FROM Borrowed
GROUP BY MemberId
HAVING COUNT(*) > 3;
```

Write SQL to create an index that will allow much faster execution for the query above, when the database has a large amount of data in the table. Also, explain how the index would allow the query to be calculated.

Q9. [8 points] Produce an ER diagram, for a conceptual model from which one could produce the relational library schema shown on page 1. Include entities, attributes, and relationships with their cardinalities.

Section C [Conceptual model, 10 points in total]

Q10. [10 points] An online marketplace for buying and selling used electronics needs to manage its users, products, and transactions. Each user has a unique ID, name, and contact details. Products have a unique ID, description, price, and category. Transactions involve a buyer, a seller, and a product. Each transaction has a date, a quantity, and a total price. There are different types of sellers: individuals and businesses. Businesses have additional attributes like name and registered address. Draw an ER diagram of a conceptual model for the information described here, and give CREATE TABLE statements for a relational design that represents the information from your conceptual design as well as possible.

The questions in Section D are all based on the following relational design, which collects data about the orders placed at an online store:

```
CREATE TABLE Orders (
    OrderID INTEGER PRIMARY KEY,
```

```
    CustomerID INTEGER NOT NULL,
    OrderDate DATE NOT NULL,
    ShippingAddress VARCHAR(100) NOT NULL,
    TotalAmount INTEGER NOT NULL
);

CREATE TABLE OrderItems (
    OrderID INTEGER NOT NULL,
    ProductID INTEGER NOT NULL,
    Quantity INTEGER NOT NULL,
    UnitPrice INTEGER NOT NULL,
    PRIMARY KEY (OrderID, ProductID),
    FOREIGN KEY (OrderID) REFERENCES Orders(OrderID)
);

CREATE TABLE Product (
    ProductID INTEGER PRIMARY KEY,
    ProductName VARCHAR(50) NOT NULL,
    Category VARCHAR(20) NOT NULL,
    Price INTEGER NOT NULL
);
```

The following functional dependencies are valid in this schema:

- CustomerID ® ShippingAddress
- OrderID, ProductID ® Quantity, UnitPrice
- ProductID ® ProductName, Category, Price

Section D [Relational design theory, 25 points in total]

Q11. [4 points] Based on the Orders, OrderItems, and Product schema and functional dependencies given on page 5, explain in English the meaning of the functional dependency OrderID, ProductID ® Quantity, UnitPrice. Also, give an example of data that would not be allowed in the table OrderItems because of this dependency.

Q12. [4 points] Based on the Orders, OrderItems, and Product schema and functional dependencies given on page 5, calculate the attribute closure (CustomerID, ProductID)+. Show the step-by-step working of the calculation. Write your answer in the box below.

Q13. [5 points] Based on the Orders, OrderItems, and Product schema and functional dependencies given on page 5, the relation OrderItems is not in BCNF. Justify this statement.

Q14. [12 points] Based on the Orders, OrderItems, and Product schema and functional dependencies given on page 5,

- give a lossless-join decomposition of OrderItems into TWO relations;
- for each of the two decomposed relations, state the functional dependencies that hold for that relation, and state a primary key for that relation, and indicate whether or not that relation is in BCNF.
- justify that your decomposition has the lossless-join property,
- indicate whether or not your decomposition has the dependency-preserving property, and justify your decision.

Section E [Database-backed applications, 15 points in total]

Q15. [5 points] In the code you used as a skeleton for asst3 (and which had previously been used in lab for week 8), there are several places where the end-user enters some value (such as a name), and this value is then used in querying the database. Describe the aspects of the application code, which aim to prevent a SQL injection attack from damaging the data.

Q16. [5 points] In the code you used as a skeleton for asst3 (and which had previously been used in lab for week 8), the data about end-users (such as their name and password for accessing the web application) is stored in the PostgreSQL database. Describe one security mechanism that is used in this code, to try to protect the confidentiality of the information about end-users. Discuss one attack that could be made to breach the security you described.

Q17. [5 points] In the code you used as a skeleton for asst3 (and which had previously been used in lab for week 8), describe the steps by which information returned from a database query is displayed to the end-user. Mention explicitly the files and functions in the code, where each step is done.