1. Draw a neat diagram and briefly explain different components of the database management system.

Diagram:

sql
Copy code

```
+--------------------+
|   User Interfaces  |
+--------------------+
            |
+--------------------+
|   Application      |
|   Programs         |
+--------------------+
            |
+--------------------+
|   DBMS Engine      |
+--------------------+
|   - Query Processor|
|   - Transaction    |
|     Manager        |
|   - Storage Manager|
+--------------------+
            |
+--------------------+
|   Database         |
|   Storage          |
+--------------------+
```

Explanation:

- **User Interfaces**: Tools for users to interact with the DBMS, such as query tools and forms.
- **Application Programs**: Software applications that access and manipulate the database.
- **DBMS Engine**: Core component of the DBMS that handles query processing, transaction management, and storage management.
    - **Query Processor**: Interprets and executes database queries.
    - **Transaction Manager**: Manages database transactions to ensure data integrity.
    - **Storage Manager**: Manages the physical storage of data, indexing, and retrieval.

- **Database Storage**: The actual data files and structures where data is stored.

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2. List advantages of database system over file system.

1. **Data Redundancy Control**: Centralized data storage reduces duplication across files.
2. **Data Integrity**: Ensures accuracy and consistency through constraints and validation rules.
3. **Data Security**: Provides robust mechanisms to control access and protect data.
4. **Concurrency Control**: Manages simultaneous access by multiple users to maintain data consistency.
5. **Backup and Recovery**: Automated tools for data backup and recovery protect against data loss.

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3. List significant differences between a File Processing System and a DBMS.

Aspect	File Processing System	DBMS
Data Storage	Data stored in individual files	Data stored in tables
Data Integrity	Limited control over integrity	Enforced through constraints
Data Redundancy	High redundancy due to multiple files	Reduced redundancy
Concurrency	Minimal support for simultaneous access	Robust concurrency control
Data Security	Basic security features	Advanced security features
Data Retrieval	Limited querying capabilities	Advanced querying (e.g., SQL)

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4. What is Data Abstraction? Explain various levels of data abstraction in database.

Data Abstraction: The process of hiding the complexity of the database system by providing a simplified view to users.

- **Physical Level**: Describes how data is physically stored in the database (e.g., file structures, indexing).
- **Logical Level**: Describes what data is stored and the relationships among the data (e.g., tables, schemas).

- **View Level**: Provides different views of the data for different users, showing only the relevant data (e.g., user-specific reports).

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5. Explain with an example physical data independence. Also explain its importance.

Physical Data Independence: The capacity to change the physical storage of data without altering the conceptual schema.

Example: Suppose the data is initially stored in a flat file and later reorganized into an indexed file structure. Applications and queries that use the database do not need to be modified, as they interact with the data through the same conceptual schema.

Importance: Allows changes to the storage mechanism or hardware without affecting the database schema or application programs, thus minimizing disruptions and maintaining system stability.

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6. Explain DDL and DML Commands

- **DDL (Data Definition Language)**: Used to define and manage database schema.
    - **CREATE**: Creates database objects like tables and indexes.
        - Example: `CREATE TABLE Employees (EmpID INT, Name VARCHAR(100));`
    - **ALTER**: Modifies existing database objects.
        - Example: `ALTER TABLE Employees ADD COLUMN Age INT;`
    - **DROP**: Deletes database objects.
        - Example: `DROP TABLE Employees;`
- **DML (Data Manipulation Language)**: Used to query and manipulate data within tables.
    - **SELECT**: Retrieves data from one or more tables.
        - Example: `SELECT * FROM Employees;`
    - **INSERT**: Adds new rows to tables.
        - Example: `INSERT INTO Employees (EmpID, Name) VALUES (1, 'Alice');`
    - **UPDATE**: Modifies existing data.
        - Example: `UPDATE Employees SET Name = 'Bob' WHERE EmpID = 1;`
    - **DELETE**: Removes rows from tables.
        - Example: `DELETE FROM Employees WHERE EmpID = 1;`

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7. Explain referential integrity constraints and entity integrity constraints with examples.

- **Entity Integrity**: Ensures that each table has a primary key, and the key values are unique and not null.
  - **Example**: In a `Customers` table, `CustomerID` is a primary key and must be unique and not null.
- **Referential Integrity**: Ensures that foreign keys in one table correspond to primary keys in another table, maintaining consistent relationships.
  - **Example**: In an `Orders` table, `CustomerID` is a foreign key referencing `CustomerID` in the `Customers` table. This ensures that every `CustomerID` in `Orders` exists in `Customers`.

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8. What are data models? List various data models.

Data Models: Frameworks for organizing and structuring data. They define how data is connected and interacted with.

- **Relational Model**: Uses tables (relations) to represent data and relationships (e.g., SQL).
- **Hierarchical Model**: Organizes data in a tree-like structure (e.g., XML).
- **Network Model**: Uses graph structures to represent relationships (e.g., CODASYL DBMS).
- **Object-Oriented Model**: Integrates object-oriented programming principles (e.g., ObjectDB).

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9. Compare physical data independence with logical data independence.

- **Physical Data Independence**: Refers to the ability to change the physical storage of data (e.g., storage devices, file structures) without altering the conceptual schema.
  - **Example**: Changing from a flat file to an indexed file.
- **Logical Data Independence**: Refers to the ability to change the conceptual schema (e.g., adding or removing tables) without affecting the external schema or application programs.
  - **Example**: Adding a new table to the schema without altering existing applications.

Comparison: Physical data independence deals with changes in storage without affecting the logical schema, while logical data independence deals with changes in the schema without affecting application programs.

10. What are the DBMS languages? Briefly explain.

- **DDL (Data Definition Language)**: Used to define and manage database schema. Commands include:
  - **CREATE**: Create new tables, views, indexes, etc.
  - **ALTER**: Modify existing schema objects.
  - **DROP**: Delete schema objects.
- **DML (Data Manipulation Language)**: Used for querying and modifying data. Commands include:
  - **SELECT**: Retrieve data from tables.
  - **INSERT**: Add new rows to tables.
  - **UPDATE**: Modify existing data.
  - **DELETE**: Remove rows from tables.
- **DCL (Data Control Language)**: Controls access to data. Commands include:
  - **GRANT**: Provide specific privileges to users.
  - **REVOKE**: Remove specific privileges from users.
- **TCL (Transaction Control Language)**: Manages transactions within the database. Commands include:
  - **COMMIT**: Save all changes made in the transaction.
  - **ROLLBACK**: Undo changes made in the transaction.

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11. Discuss the Role of DBA.

The **Database Administrator (DBA)** is responsible for:

1. **Database Design**: Creating and maintaining database schemas, tables, indexes, and relationships.
2. **Performance Tuning**: Optimizing database performance through indexing, query optimization, and resource management.
3. **Security Management**: Implementing access controls, user authentication, and data encryption to protect data.
4. **Backup and Recovery**: Performing regular backups and ensuring data can be restored in case of failure.
5. **Monitoring**: Tracking database performance and health, addressing issues as they arise.

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12. Explain the Terms Superkey, Primary Key, Candidate Key, Foreign Key, Alternate Key

- **Superkey**: A set of one or more attributes that uniquely identifies a record in a table.
  - **Example**: In a `Student` table, `{StudentID, Email}` can be a superkey.
- **Primary Key**: A minimal superkey chosen to uniquely identify records in a table. It must be unique and not null.
  - **Example**: `StudentID` in the `Student` table.
- **Candidate Key**: A minimal superkey, meaning no subset of it can be a superkey. There can be multiple candidate keys.
  - **Example**: `StudentID` and `Email` can both be candidate keys.
- **Foreign Key**: An attribute in one table that refers to the primary key in another table, establishing a relationship between the tables.
  - **Example**: `DepartmentID` in the `Employee` table referencing `DepartmentID` in the `Department` table.
- **Alternate Key**: A candidate key that is not chosen as the primary key.
  - **Example**: If `StudentID` is the primary key, then `Email` is an alternate key.

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13. Use Relational Algebra to Express the Queries

Given relations: `PROJECT(proj#, proj_name, chief_architect)`, `EMPLOYEE(emp#, emp_name)`, `ASSIGNED(proj#, emp#)`

- **(i) Get details of employees working on project COMP33:**
  \pi_{emp#, emp_name} (\sigma_{proj# = 'COMP33'} (ASSIGNED) \bowtie EMPLOYEE)
- **(ii) Get the employee number of employees who work on all projects:**
  \pi_{emp#} (ASSIGNED) \div \pi_{proj#} (PROJECT)
- **(iii) Get details of the project on which an employee with the name 'RAM' is working:**
  \pi_{proj#, proj_name} (\sigma_{emp_name = 'RAM'} (EMPLOYEE) \bowtie ASSIGNED \bowtie PROJECT)

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14. What is Relational Algebra? Explain the Relational Algebra Operations with an Example Each

Relational Algebra: A procedural query language for relational databases that uses operations to manipulate relations.

- **Selection (σ)**: Filters rows based on a condition.
  - **Example**: σage>30(Employees)\sigma_{age > 30}(Employees)σage>30(Employees) returns employees older than 30.
- **Projection (π)**: Selects specific columns from a relation.

    - **Example**: πname,age(Employees)\pi_{name, age}(Employees)πname,age(Employees) returns names and ages of all employees.
- **Union (∪)**: Combines tuples from two relations.
    - **Example**: R1∪R2R1 \cup R2R1∪R2 combines tuples from `R1` and `R2`.
- **Difference (-)**: Returns tuples in one relation but not in another.
    - **Example**: R1−R2R1 - R2R1−R2 returns tuples in `R1` not in `R2`.
- **Cartesian Product (×)**: Combines tuples from two relations.
    - **Example**: R1×R2R1 × R2R1×R2 pairs every tuple in `R1` with every tuple in `R2`.
- **Join (⋈)**: Combines related tuples from two relations based on a common attribute.
    - **Example**: Employees⋈deptid=deptidDepartmentsEmployees ⋈_{dept_id = dept_id} DepartmentsEmployees⋈deptid=deptidDepartments returns combined tuples from `Employees` and `Departments` based on `dept_id`.

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15. Describe the Structure of DBMS

The structure of a DBMS typically includes:

1. **Database Engine**: Core software responsible for data storage, query processing, and transaction management.
2. **Database Schema**: The structure or design of the database, including tables, relationships, and constraints.
3. **Query Processor**: Handles SQL queries, interprets them, and translates them into operations on the data.
4. **Transaction Manager**: Ensures transactions are processed reliably and maintains data integrity.
5. **Storage Manager**: Manages the physical storage of data, including file management and indexing.
6. **User Interfaces**: Tools and interfaces for users to interact with the database (e.g., SQL command line, graphical tools).

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16. Differentiate Relation Schema and Relational Instance

- **Relation Schema**: Defines the structure of a relation (table) including its name, attributes, and data types.
    - **Example**: `Employee(emp#, emp_name, dept_id)`
- **Relational Instance**: The actual data in the database at a specific point in time.
    - **Example**: `{(101, 'Alice', 10), (102, 'Bob', 20)}`

Arity: Number of attributes in a relation. For `Employee(emp#, emp_name, dept_id)`, the arity is 3.

Degree: Same as arity; it indicates the number of attributes in a relation.

Domain Constraints: Rules that restrict the set of allowable values for an attribute.

- **Example**: `emp#` must be a positive integer.

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17. Explain DCL and TCL Commands

- **DCL (Data Control Language)**: Manages access control and permissions.
  - **GRANT**: Provides users with specific privileges.
  - **REVOKE**: Removes specific privileges from users.
- **TCL (Transaction Control Language)**: Manages transactions to ensure data integrity.
  - **COMMIT**: Saves all changes made in the current transaction.
  - **ROLLBACK**: Reverts changes made during the transaction.

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18. What Are Different SQL Data Types and Literals?

- **Data Types**:
  - **CHAR/VARCHAR**: Character strings.
  - **INT**: Integer numbers.
  - **FLOAT/DOUBLE**: Floating-point numbers.
  - **DATE**: Date values.
  - **BOOLEAN**: True or false values.
- **Literals**: Fixed values used directly in SQL queries.
  - **String Literals**: `'example'`
  - **Numeric Literals**: `123`, `45.67`
  - **Date Literals**: `'2024-09-10'`
  - **Boolean Literals**: `TRUE`, `FALSE`

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19. Explain Different Types of Integrity Constraints

- **Entity Integrity**: Ensures that each table has a primary key, and that the primary key values are unique and not null.
  - **Example**: A `Student` table where `StudentID` must be unique and not null.
- **Referential Integrity**: Ensures that foreign keys correctly reference primary keys in other tables.
  - **Example**: An `Order` table where `CustomerID` must exist in the `Customer` table.

- **Domain Integrity**: Ensures that all values in a column are of the correct type and within the allowable range.
    - **Example**: An `Age` column in the `Employee` table must be a positive integer.
- **User-Defined Integrity**: Custom rules specific to the application's needs.
    - **Example**: A `Salary` must be greater than a certain amount.

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20. List Various Database Architectures

- **Single-Tier Architecture**: Database and applications are on a single machine.
- **Two-Tier Architecture**: Database server and client applications are on separate machines (e.g., client-server model).
- **Three-Tier Architecture**: Involves a presentation layer, application layer, and database server (e.g., web applications).
- **N-Tier Architecture**: An extension of three-tier, involving additional layers like middle-tier services.

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21. List Various Applications of a Database Management System

1. **Banking**: Managing account transactions, customer records.
2. **E-commerce**: Storing product details, order information.
3. **Education**: Managing student records, course details.
4. **Healthcare**: Managing patient records, treatment information.
5. **Telecommunications**: Handling call records, customer information.

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22. What is a Schema Diagram? Draw a Schema Diagram for a Bank

Schema Diagram: A visual representation of the database structure, including tables and relationships.

Diagram:

lua
Copy code

```
+-------------------+      +-------------------+
|   Customer        |      |   Branch          |
+-------------------+      +-------------------+
| CustomerID (PK)   |      | BranchID (PK)     |
| Name              |      | BranchName        |
| Address           |      | Address           |
+-------------------+      +-------------------+
         |                          |
         |                          |
         |                          |
+-------------------+      +-------------------+
| Saving Account    |      | Loan Account      |
+-------------------+      +-------------------+
| AccountID (PK)    |      | LoanID (PK)       |
| Balance           |      | Amount            |
| CustomerID (FK)   |      | BranchID (FK)     |
| BranchID (FK)     |      +-------------------+
+-------------------+
         |
         |
         |
+-------------------+
| Depositor         |
+-------------------+
| CustomerID (FK)   |
| AccountID (FK)    |
+-------------------+

+-------------------+
| Borrower          |
+-------------------+
| CustomerID (FK)   |
| LoanID (FK)       |
+-------------------+
```

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23. Define Database Management System. What Do You Mean by Data Redundancy and Data Inconsistency?

- **Database Management System (DBMS)**: Software that provides an interface for managing and manipulating data, ensuring data storage, retrieval, and security, and supporting concurrent access by multiple users.
- **Data Redundancy**: The unnecessary duplication of data in multiple locations or tables. This can lead to increased storage costs and maintenance issues.

- **Data Inconsistency**: Occurs when redundant data does not match or is not synchronized across different locations or tables, leading to errors and unreliable information.

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24. List Different Types of Users of a Database System

1. **Database Administrator (DBA)**: Manages database design, security, performance, and backup.
2. **End Users**: Individuals who interact with the database through applications (e.g., employees, customers).
3. **Application Programmers**: Develop applications that interact with the database.
4. **System Analysts**: Analyze and design database systems according to business needs.
5. **Data Analysts**: Analyze and interpret data to help in decision-making.

These answers should be clear and concise for a 5-mark exam response.