Chapter 1: Introduction to Database Systems

Objective: Databases and database system have become an essential component of everyday life in modern society. In course of a day, most of us encounter several activities that involve some interaction with database such as bank, supermarket etc.

To understand the fundamentals of database technology, however we must start from the basics of traditional database applications. We will start with what is database and other definitions. Then we will study characteristics of database systems and categorize the types of personnel whose jobs involve using and interacting with database systems.

1. Define the following terms
   a) Database  b) DBMS  c) Program & Data independence  d) end user  e) DBA  f) Data model  g) Database schema  h) DDL
   i) External schema  j) conceptual schema  k) DML  l) VDL

2. Explain: i) Logical data independence  ii) Physical data independence

3. Describe the role of DBA in DBMS

4. Define Schema and instance.

5. What are the elements of a database?

6. Why do we need DBMS?

7. Explain each of the following with advantage and disadvantage of its own?
   i) Hierarchical data base model. ii) Network database model. iii) Object Oriented database model.

8. Discuss some types of database utilities and their functions. 06

9. Discuss the different classifications of DBMS. 06

10. What is a database schema? What is the difference between external and internal schema?

11. What are the characteristics of a data in a database? 06

12. With a neat diagram, explain Three-Schema-Architecture. 06*

13. Discuss the main characteristics of the database approach. 08

14. What are the responsibilities of the DBA and the database designers? 08

15. What is the difference between logical data independence and physical data independence? Which is easier to accomplish? Why?

Define the following terms
   a) Entity  
   b) Attribute  
   c) Relationship instance  
   d) Multi valued Attribute.

16. How is traditional file processing different from database approach? 08*

17. Explain the types of software components which constitute a DBMS and the types of computer system software with which DMBS interacts.

18. Discuss the main characteristics of the database approach. 08

19. What are the responsibilities of the DBA and the database designers? 08

20. Discuss some types of database utilities and their functions. 08

21. What do you mean by Database Management System? Explain the various advantages of using a Database management System?

22. With a neat figure explain the database system. 10

23. Who are the different types of database end users? Discuss the main activities of each of them.

24. What is a database? Why do we need a database? Describe the organization of database?

25. Explain the advantages of database approach over file processing.

26. Who are the different types of database end users? Discuss the main activities of each of them.

27. Explain the different types of user-friendly interfaces provided by DBMS and the types of users who typically use each.

28. List out eight advantages of data base approach over file processing system and explain any four advantages in brief.

29. Describe the three-schema architecture. Why do we need the mappings between different schema levels? How do different schema definition languages support this architecture?

30. Describe the functions which are required to be performed by the database administrator.

31. What are the disadvantages of database system? Explain them briefly. 05*

32. Write the general architecture of typical DBMS. What are the effects of data independence in DBMS?

33. What are the different levels of abstraction of a DBMS? Briefly explain each of them. 06*

34. What does defining, manipulating and sharing of a database mean? 06

Chapter 2: Entity-Relationship Model

Objective: In this chapter we follow the traditional approach of concentrating on the data base structures and constraints during database design. Modeling concepts of the Entity-Relationship model, which is a popular high level conceptual data model is discussed next. Diagrammatic notation associated with the ER model known as ER diagrams are discussed. The architecture which is mostly used in all database designs is learnt here. Also the ER diagram which is the most effective way of conveying how the database works is looked into.

1. Define the following terms
   a) entity b) attribute c) key attribute d) attribute value e) stored attribute f) derived attribute g) multi valued attribute h) composite attribute i) Weak Entity j) mapping constraints k) Cardinality Ratio l) Degree of relationm) Participation constraint n) Candidate key o)Foreign key p)Super key

2. Explain the difference between an attribute and value set. 04

3. What is the difference between the terms Relations and Relation Scheme. 04

4. With example explain strong and weak entities. 04*

5. Explain any 4 types of attributes in ER model with an example 04*

6. Explain different type of attributes in ER model with an example. 06*

7. Draw an ER diagram for a database that keeps track of company and employee phones. Assume that an employee may work in up to 2 departments but may also not be assigned to any department. Employee may or may not have personal phone but a department must have one and have up to three phone numbers including employees’ personal phone number. Use (min, max) constraints to draw ER diagram 06*

8. What is an entity type, and an entity set? Explain the difference between a relationship instance and a relationship type. 08

9. Discuss the role of high-level data model in the database design process 08

10. Discuss the main categories of data models. 08

11. Discuss the main categories of data models. 08

12. Explain the concept of E-R model with an example. 08

13. Discuss the conventions for displaying an ER schema as an ER diagram. 10

14. Draw an E-R Diagram for the hospital management system. Assume your own entities (Minimum of 5 entities), attributes and relations. Explain in detail. 10

15. Draw an E-R diagram for banking System. Assume your own entities (Minimum of 5 entities), attributes and relations, Mention cardinality ratio. 10*

16. With a neat diagram, explain the main phases of database design process. 10*

17. Consider the ER diagram given below. Assume that a subject may or may not use a textbook, but that a text by definition is a book that is used in some subject. A subject may not use more than 5 books.
Instructors teach from 2 to 4 subjects.
i) Supply the attributes for the entity types and mark the key attributes.
ii) Specify the cardinality ratio and participation constraints in the diagram.
If we add the relationship ADOPTS between INSTRUCTOR and TEXT, what structural
constraints would you on it? Why?
10*

INSTRUCTOR TEACHES SUBJECT
USES
TEXT

18. Discuss the correspondences between the ER model constructs and the relational
model constructs. Show how each ER model construct can be mapped to the relational
model and discuss any alternative mapping.
12
19. Draw the ER-diagram for an ER-schema of your own choice. 12
20. Choose a database application of your choice. Design a schema and show a sample
database for that application. Think of several users for your database and design a
view for each.
12
21. A bank has many branches, the bank has many customers. A customer can open
many different kinds of accounts with the bank. Any customer of the bank can take a
loan from the bank. All branches can give loans. Bank have also installed automatic
teller machines, from which a customer can withdraw from his/her bank. Draw the ER
diagram for the bank. Create 3 NF tables of your design. Make suitable assumptions, if
any.
10*
22. Write an ER diagram for a typical bus reservation system. 06*
23. What is a cardinality ratio? What are different types of cardinality ratio in a binary
relationship? Give one example for each type. 06*
24. Define the following terms and give one example each:
i) Primary Key ii) Weak entity iii) Multivalued attribute
06*
25. What is a participation role? When is it necessary to use role names in the description
of relationship types? 08*
26. Discuss the naming convention used for ER schema diagram. 07*
27. What is the FUNCTION operation? What is it used for? 05*
28. Discuss the conventions for displaying an ER schema as an ER diagram. 05
29. What is the difference between the key and the super key? 04
30. Define foreign key. Explain the use of a foreign key with an example. 06

Chapter 3: Relational Model and Relational Algebra

Objective: The relational model was first introduced by Ted Codd of IBM research in 1970. It
attracted immediate attention due to its simplicity and mathematical foundation. The model uses the
concept of a mathematical relation-which looks somewhat like a table of values as its basic building
block, and has its theoretical basis in set theory and first order predicate logic. In this chapter we
discuss the basic characteristics of the model and its constraints. Update operations of relational
model are discussed and how violations of integrity constraints are handled.

1. Explain the following operations in Relational Algebra and give one example for each
i) Rename ii) Cartesian product iii) Natural join iv) Division
08
2. What is role of participation? When is it necessary to use role names in description or
relation types?
08
3. Discuss the entity integrity and referential integrity constraints. Why is each considered
important?
08
4. Discuss the various update operations on relations and the types of integrity constraints
that must be checked for each update operation.
08
5. Explain the select and project operations as used in relational algebra. 08
6. Why is relational data model popular than hierarchical and network models. 08
7. Discuss the different relational algebra operations. 08*
8. Explain Basic Unary and set operation in Relational Algebra operations. 08*
9. List the operations of the relational algebra and the purpose of each. 10

10. Explain the aggregate functions used in relational algebra. 10
11. List the operations of the relational algebra and the purpose of each. 10
12. Explain the different relational model constraints & possible violation during update operation.

13. Discuss the various update operations on relations and the types of integrity constraints that must be checked for each update operation.

14. Consider the following relations for a database that keeps track of business trips of sales persons in a sales office:
   Salesperson (Salespersonid, Name, Start-year, Dept-no)
   Trip (Salespersonid, from, to, Departure-date, Return-date, trip-id)
   Expense (trip-id, AccountNo, Amount)
   Specify the foreign keys for the above schema. Then specify the following queries in relational algebra.
   1. Give the details (all attributes of trip relation) for trip that exceeded 10,000/- in expenses.
   2. Print the ‘Salespersonid’ and ‘Name’ of the salespersons who took trips to ‘delhi’.
   3. Print the total trip expenses incurred by the salesman with Salespersonid = ‘504’.

15. With an example explain clearly JOIN and UNION operations in relational algebra. Bring out the difference between natural JOIN and OUTER JOIN.

16. Explain the four constraints as applied to relational database. 12
17. Consider the following schema for a company database
   Employee (Name, SSN, Address, Sex, Salary, Dno)
   Department (Dname, Dnumber, MGRSSN, MGRSTART Date)
   Dept-Locations (Dnumber, Dlocations)
   Project (Pname, Pnumber, Plocations, Dnum)
   Works-On (ESSN, PNo, Hours)
   Dependent (ESSN, Dependent-name, Sex, Bdate, Relationship)
   Give the queries in SQL
   1. Retrieve the names and address of employees who work for “Research” Department.
   2. List all the project names on which employee “Smith” is working.
   3. Retrieve all employees who either work in department 4 and make over 25000 per year or work in department 5 and make over 30,000.
   4. Retrieve the SSN of all employees who either work in department 5 or directly supervise an employee who works in department number
   5. Retrieve names of each employee who have only daughter dependent.

18. Assume there are three relations i) STUDENT whose attributes are Stud No and Stud Name, ii) ASSIGNED_TO whose attributes are Stud No and Project No and iii) PROJECT whose attributes are Project No and Project area. Represent the following queries in relational algebra.
   i) Obtain Stud No and Stud Name of Obtain Stud No and Stud Name of all those students who are working on all those students who are working on database projects.
   ii) Obtain Stud No and Stud Name of all those students who are working on both the projects having project numbers P-75 and P-81.
   iii) Obtain Stud No and Stud Name of all those students who do not work on the project number P-68.
   iv) Obtain Stud No and Stud Name of all students other than the students with Stud No 54 who work on at least one project.
In relational algebra, discuss some types of queries for which renaming are necessary in order to specify the query unambiguously.

Define different set operations in relation algebra. Give one example for each.

Consider the following schema and write the relational algebra expressions for the queries given below:

SAILORS(Sid, Sname, rating, age)
BOATS(bid, bname, color)
RESERVES(sid, bid, day)

(i) Find names of sailors who reserved green boat
(ii) Find the colors of boats reserved by ‘Ramesh’
(iii) Find names of sailors who have reserved a red or a green boat.
(iv) Find the “sids” of sailors with age over 20 who have not registered a red boat.

List aggregate functions commonly used in relational algebra. Give example for any three of them.

Chapter 4: SQL – The Relational Database Standard
Objective: SQL language may be considered one of the major reasons for the success of relational databases in the commercial world. We start with overview and basic data types in SQL. Then we discuss how basic constraints such as key and referential integrity are specified. The standard language SQL in its different formats to create, manipulate databases are learnt here.

1. Explain the following clauses:
   i) Form
   ii) Having
   iii) Order by
   iv) Group by

2. Give the syntax for creating a view in SQL.

3. List the types of privileges available in SQL.

4. What are the different reasons for having variable length records?

5. What are the different reasons for having variable length records?

6. Explain the commands available for modifying the database in SQL.

7. Explain the aggregate functions used with SQL.

8. Explain Having and Group By clauses.

9. Explain the SQL statements used with when clause.

10. How are the OUTER JOIN operations different from JOIN operations? How is the OUTER UNION operation different from UNION?

11. Why is accessing a disk block expensive? Discuss the time components involved in accessing a disk block.

12. Discuss the various types of JOIN operations.

13. What is UNION compatibility? Why do the UNION, INTERSECTION and DIFFERENCE operations require that the relations on whom they are applied be union compatible?

14. Why is accessing a disk block expensive? Discuss the time components involved in accessing a disk block.

15. List and explain the commands available for retrieving and updating the database in SQL.

16. Explain joins and views in SQL with Examples.

17. Explain with an example aggregate functions and grouping used with SQL.

18. Explain with an example in SQL
   i) Unspecified where-clause and use of asterisk.
   ii) Exist and not exists
   iii) Explicit sets and NULLS
   iv) Renaming attributes and joined tables.
19. Describe the Six clauses in the syntax of an SQL query and explain how an SQL query is executed conceptually.

20. Explain with an example in SQL
   i) HAVING clause
   ii) Nested queries
   iii) Aggregate functions and grouping
   iv) Substring comparisons and arithmetic operators and ordering

21. Write SQL commands to perform the following.
   i) To create a table STUDENT with fields Register number, St-name, Address, course section, total marks.
   ii) To insert values to that table interactively
   iii) To create a view with fields register name and st-name.
   iv) To change the total marks to 35 if the marks lies in between 25 and 34.
   v) To delete tuples from the relation if the total marks is less than 35

22. Consider the following relational schema:
   Emp (eid: integer, ename: string, age: integer, sal: real)
   Dept (did: integer, dname:string, mgrid: integer)
   Project (pid: integer, Pname: string)

   Write SQL statement to
   1. Create the ‘Works’ relation including appropriate versions of all primary and foreign key integrity constraints.
   2. Give every employee of did = ‘6’ and 10% raise in salary.
   4. Delete the ‘Research’ department and explain what happens when this statement is executed.

23. Consider the following relational database schema
   Student ( Student-id,Sname,major,GPA)
   Faculty (Faculty-id,fname,dept,designation,salary)
   Course (Course-id,Cname,Faculty-id)
   Enrol (Course-id,Student-id,grade)

   Write the following queries in SQL:
   1 List the names of all students enrolled for the course “IS6T1”.
   2 List the names of all students enrolled for the course “IS6T1 and have received “A” grade.
   3 and have received “A” grade.
   4 List all the departments having an average salary of above 5 Rs. 10,000.
   6 Give a 20% raise to salary of all faculty.
   7 List the names of all faculty members beginning with “P” and ending with letter “A”.

24. Consider the following schema for a company database
   Employee (Name, SSN, Address, Sex, Salary, Dno)
   Department (Dname, Dnumber, MGRSSN, MGRSTART Date)
   Dept-Locations (Dnumber, Dlocations)
   Project (Pname, Pnumber, Plocations, Dnum)
   Works-On (ESSN, PNo, Hours)
   Dependent (ESSN, Dependent-name, Sex, Bdate, Relationship)

   Give the queries in SQL:
   1. Retrieve the names and address of employees who work for “Research” Department.
   2. List all the project names on which employee “Smith” is working.
   3. Retrieve all employees in Dept. 5 whose salary is between 30,000 and 40,000.
4. Retrieve the name of each employee who works on all the projects controlled by department number 5.

5. Retrieve the names of employees who have no dependents.

15

25. What do you mean by integrity w.r.t database? Explain entity integrity and referential integrity.

08*

26. Bring out the different clauses of SELECT-FROM-WHERE statement. Give example for 3 types.

08*

27. What is the significance of views in SQL? Give SQL statement to update data. 06*

28. Use the schema and answer the queries in SQL.

SAILORS(Sid, Sname, rating, age)

BOATS(bid, bname, color)

RESERVES(sid, bid, day)

(i) Find names of sailors who reserved green boat

10*

(ii) Find the colors of boats reserved by “Ramesh”

(iii) Find names of sailors who have reserved a red or a green boat.

(iv) Find the names of the sailors who have reserved a red boat

(v) Find the names of sailors who have reserved all boats called ‘Interlake’

29. How do the relations in SQL differ from the relations defined formally? Discuss the differences in terminology. Why does SQL allow duplicate tuples in a table or in a query result?

08*

Chapter 5: Database Design

Objective: We define the concept of functional dependency. We discuss more general definitions of normal forms that can be directly applied to any given design. We discuss measures of appropriateness for a whole set of relational schemas that together form a relational database schema. The fundamentals of good and bad database designs are dealt formally here.

1. What is a functional dependency? 04

2. Why is a relation that is in 3NF generally considered good? 04

3. Prove augmentation rule and transitive rule of inference for functional dependencies 04

4. What is the necessity of normalization? 04*

5. What is normalization? What is normal from? 05

6. What are the different normal forms? 05

7. What are keys? What is primary, Foreign key? 05

8. What is the difference between intelligent and non-intelligent key? 05

9. What are the different types of relations between the entities in a table? 05

10. What is meant by canonical cover? 05

11. What is meant by prime and non prime attribute? 05

12. Why are normal forms alone are insufficient as conditions for a good schema design? 06

13. What do you mean by

_ Insertion Anomaly
_ Deletion Anomaly

06

14. What is the dependency preservation property for decomposition? Why is it important?

06

15. What is the loss less join property of decomposition? Why is it important? 06*

16. Write an algorithm to compute functional dependencies of an attribute set? 06

17. What is functional dependency? Explain with an example 06*

18. What is meant by the completeness and soundness of Armstrong’s interface rules? 08

19. What is meant by the closure of a set of functional dependencies? 08

20. What do you mean by equivalent minimal set of functional dependencies? Does every set of dependencies have a minimal equivalent set?

08

21. Define Boyce-Codd normal form. How does BCNF differ from 3NF? 08

22. Discuss the advantages and disadvantages of representing hierarchical structured
23. Explain each of the following with example
   i) One to One
   ii) One to Many
   iii) Many to One
   iv) Many to Many

24. Explain each of the following with example
   i) Fourth Normal Form
   ii) Boyce-Codd Normal Form

25. Consider the universal relation R = {A, B, C, D, E, F, G, H, I, J} and the set of functional dependencies
   F={ (A,B) -> {C}, A -> {D,E}, {B} -> {F}, {F} -> {G,H}, {D} -> {IJ} }.
   What is the key for R? Decompose R into 2NF, then 3NF relations.

26. Explain each of the following with example
   i) First Normal Form
   ii) Second Normal Form
   iii) Third Normal Form

27. Write loss-less Boyce Codd Normal Form decomposition algorithm

28. Discuss briefly informal design guidelines for relational schemas.

29. Define BCNF. How does it differ from 3NF? What is it considered a stronger form of 3NF? Explain with neat diagram.

30. What are the design goals good database design? Is it always possible to achieve these goals? If some of these goals are not achievable, what alternate goals should you aim for and why?

31. Prove that any relation scheme with 2 attributes is in BCNF.

32. What is the need for normalization? Explain first, second and third normal forms with example

33. What is a minimal set of functional dependencies? Give the algorithm to find a minimal cover for a given set of dependencies.

34. Define First, Second and Third normal forms when a primary key is considered. How do give the general definitions of 2NF and 3NF, when all the keys of a relation, are considered.

   Compute the closure X+ of X under F.

36. Write an algorithm to check if a decomposition dependency preserving

37. Let F be a set of functional dependencies on a relation scheme R. Define the following.
   i) F+ the closure of F
   ii) X+ the closure of X under F.

38. Explain briefly the Domain-Key Normal form with an example.

39. Explain the concepts of multi valued dependency and fourth normal form with suitable examples.

40. Explain the concepts of join dependency and lossless decomposition w.r.t 5NF

41. Write and explain the algorithms for non additive join property or lossless join.

42. What are the anomalies if the proper design of a database is not carried out? Illustrate with examples for each type.
Given different inference rules of functional dependencies.

Give the algorithm to check dependency preservation and lossless join.

Define the following terms:
4NF, BCNF, inclusion dependency, DKNF, template dependency, 5NF.

Consider the universal relation R = { A, B, C, D, E, F, G, H, I, J } and the set of functional dependencies
F = { (A, B) -> {C}, (A) -> {D, E}, (B) -> {F}, (F) -> {G, H}, (D) -> {I, J} }
What is the key for R? Decompose R into 2NF, then 3NF relations.

Discuss the problem of spurious tuples and how we may prevent it.

Why should NULL’s in a relation be avoided?

Describe the concept of transitive dependency and explain how this is used to define 3NF.

Given below are two sets of FDs for a relation R(A, B, C, D, E). Are they equivalent?
i) A -> B, AB -> C, D -> AC, D -> E
ii) A -> B, C, D -> AE

Chapter 6: Database Security
Objective: In this chapter we discuss the concepts underlying access control and security in DBMS. After introducing data security issues we consider two distinct approaches called discretionary and mandatory to specify and manage access controls. A basic overview of the security issues and access control mechanisms are dealt.

1. What does granting a privilege mean?
2. What does revoking a privilege mean?
3. List and explain the commonly accepted threats to database security.
4. Write a note on statistical access control
5. Discuss the types of privileges at the account level and at the relational level.
6. Discuss what is meant by each of the following terms.
i) Database authorization ii) access control
   iii) Privileged system account iv) audit trial.
7. Explain the discretionary and mandatory access control security measures
8. Compare discretionary access control with mandatory access control.
9. List the types of privileges available in SQL.

Chapter 7: Transaction Management
Objective: We start with fundamental properties of database transactions and how the DBMS ensures these properties. Then we discuss an abstract way of describing an interleaved execution of several transactions called a schedule. We discuss various problems that can arise due to interleaved execution. We introduce lock based concurrency control the most widely used approach. The recovery manager of DBMS is responsible for ensuring two important properties of transactions. Atomicity and durability. We discuss ARIES recovery algorithm, which is conceptually simple, works well with a wide range of concurrency control mechanisms, and is being used in an increasing number of database systems. Each database operation is an activity called transaction. Here we talk about how transactions are defined; issues concerned with transactions, concurrent operations, their recovery in case of failures are dealt here.

1. What is difference between conflict equivalence and view equivalence?
2. Explain transaction states using state transition diagram.
3. Explain locking techniques for concurrency control.
4. Write a note on Timestamp Ordering.
5. Discuss the actions taken by the read_item and write_item operations on a database.
6. Why are many nulls in a relation considered bad?
7. Explain Serial and Non-serial schedules with examples.
8. What do you mean by concurrent execution of database transactions in a multi-user system? Discuss why concurrence control is needed, and give informal examples.
9. What is a transaction? Explain with an example.
10. Discuss the different types of transaction failures. What is meant by catastrophic failure?
11. List and explain the desirable properties of transactions.
12. What is meant by transaction rollback? Why is it necessary to check for cascading rollback? Which recovery techniques do not require rollback?
13. Describe the shadow paging recovery technique. Under what circumstances does it not require a log?
14. What is meant by catastrophic failure and how recovery is handled?
15. Explain recovery based on immediate update techniques.
17. Which are the various reasons for a transaction to fail?
18. Explain multi version and optimistic concurrency control techniques.
19. Discuss the problems of deadlock and starvation in transaction processing and the different approaches to deal with these problems.
20. Explain the database recovery techniques based on deferred update.
21. Explain how strict 2-phase locking is implemented. Show them with an example.
22. What are three properties of a transaction specified in SQL for locking? Define each of them.
23. Illustrate with an example how concurrency is controlled using a B+ tree.
24. Highlight different activities involved in system crash recovery.

25. Write short notes on:
   a. ER to relational mapping
   b. Embedded SQL
   c. ACID properties
   d. Write ahead lock
20*
26. Describe the four levels of isolation in SQL.
27. What is serialisability? How can serialisability be ensured? Do you need to restrict concurrent execution of transaction to ensure serialisability? Justify your answer. Give an example of transactions and how you can force serialisability in those transactions.
28. What are the steps one must take with its database management system, in order to ensure disaster recovery? Define the process of recovery in case of disaster.
29. What is two phase locking? Describe with help of an example. Will two phase locking result in serialisable schedule? Will two phase locking result in deadlock? Justify your answer with the help of an example.
30. What is shadow paging scheme? Where is it used?
31. What is multi version technique of concurrency control? Describe with the help of an example. Will this scheme result in rollback and/or deadlock? Justify your answer.
32. What is time stamping? Explain a mechanism of concurrency control that uses time stamping with the help of an example.
33. What is intention mode locking? Describe the various intention mode locks with the help of an example.
34. What are the rules followed when shared/exclusive locking scheme is used?
Describe the three phases of the ARIES recovery method.

Describe the write-ahead logging protocol.

Note: '*' indicates questions appeared in previous exam papers.