2910209 Database systems

Examination paper: Zone B

Time allowed: three hours

This paper consists of **5** questions. Each questions carries **25** marks. Answer only **4** of them. You may choose **any 4** questions. Full marks will be awarded for **complete** answers to **4** questions.

The mark carried by each part is printed within square brackets. **Gauge the time to be spent on each part by the number of marks awarded.**

No calculators may be used.

Question 1

a) In order to explain what a chasm trap is in ER modelling:

i. Define the concept of chasm trap. [2]

ii. Provide an example of diagram containing a chasm trap. Justify your example. Show, through a new diagram, how to resolve the chasm trap, and justify your solution. [4]

b) Define the concept of strong entity type. Provide an example to illustrate this concept. [3]

c) What is a recursive relationship in ER modelling? Provide an example of recursive relationship. [3]

d) Define each of the following types of attributes in ER modelling, providing an example for each type. Do not use more than two statements per type.

i. composite attribute [2]

ii. single-valued attribute [2]

iii. multi-valued attribute [2]

iv. derived attribute. [2]

e) Define each of the following terms in the context of the relational data model (use no more than one sentence per term):

i. Tuple [1]

ii. Relation [1]

iii. Extension [1]

iv. Cardinality [1]

v. Attribute [1]

Question 2

Consider the following schema of a database that stores data about employees working in various departments:

Department (did: integer, budget: integer, managerid: integer)
Employee (cid: integer, cname: string, age: integer, salary: integer)
Works (eid: integer, did: integer, pct_time: real)

Each department has one manager (managerid) which is also an employee.
An employee can work in more than one department, and the pct_time field of Works table gives the fraction of time (represented as a real number between 0 and 1) an employee works in a given department. Using SQL, you are required to:

a) Define the table Employee including primary and foreign keys constraints as well as a table constraint on Employee that will ensure that every employee is more than 18 ears old and earns at least £20,000. [4]

b) Define the table Department including primary and foreign keys constraints as well as a table constraint on Department that will ensure that all managers have a salary being no less than £40,000. [4]

c) Define the table Works including the primary and foreign keys constraints. Define an assertion that ensures that the percentage of time, that every employee works in the Sales department, is at least 50% of the working time of the employee. [7]

d) Mention an option that can be included in the definition of the foreign key eid on the table Works such that any delete command on Employee table is effective. Illustrate your answer using an example of such a command. [2]

e) Write the commands for increasing the salaries of all employees by 5% excepting managers whose salaries have to be increased by £5,000. [4]

f) Write a command that deletes the details of employees whose sum of the percentages of time they work in all departments is 0%. [4]

Question 3

Consider the following relations that keep track of flights information:

Flights(flno: integer, from_city: string, to_city: string, distance: integer, departs: time, arrives: time, price: integer)
Aircraft(aid: integer, aname: string, cruising_range: integer)
Certified(cid: integer, aid: integer)
Employees(eid: integer, ename: string, salary: integer)

Note that Employees relation describes pilots and other kinds of employees as well; every pilot is certified for some aircraft (otherwise, he or she would not qualify as a pilot), and only pilots are certified to fly.

Write each of the following queries in SQL:

a) Print all the prices of direct flights from London to New York. [2]

b) Print the total amount paid to employees as salaries. [2]

c) Print the number of pilots certified for some Boeing aircraft. [2]

d) Print the details of the pilots certified for some Airbus aircraft. [3]

e) Print the names of the pilots who can operate planes with a range greater than 3000 miles. [3]

f) Print the aid's of all aircraft that can be used on non-stop flights from Rome to New York. [3]

g) Print the names and cid's of employees who make the highest salary. [3]

h) Print the details of employees who make the second highest salary. [3]

i) Print the name and salary of every non pilot whose salary is more than the average salary for pilots. [4]

Question 4

Consider the relation R with the following attributes:

(Driver, Date, Destination, VIN, Model, Make)

The relation represents information about vehicles, which are assigned to drivers and destinations on different dates. VIN stands for Vehicle Identification Number, Model represents a vehicle's model (e.g. Beetle), Make represents a vehicle's make (e.g. Volkswagen), Driver stores a driver's name, and Date stores a date.

Assume that *(Driver, Date, Destination)* is the primary key, and consider the following semantic assumptions:

(1) Each vehicle has a unique VIN, a non-unique make and a non-unique model.
(2) Each model has a unique make.
(3) On a given date, each driver uses one vehicle for each destination he/she is assigned.
(4) On each date, a driver may use different vehicles for different destinations.
(5) On different dates, a driver may use different vehicles even if the destination is identical.

In each of the expressions in (a) (b) and (c) below, substitute the question mark with an attribute or a set of attributes, such that the resulting expression represents a non-trivial functional dependency that is satisfied by the relation R.
If more than one answer is right for a given expression, choose the *smallest* possible set if the question mark is on the left-hand side of the arrow, and the *largest* possible set if the question mark is on the right-hand side of the arrow.

a) ? › (Model, Make) [3]

b) ? → VIN [3]

c) Model → ? [3]

d) Is the following functional dependency left-irreducible? Explain your answer. [2]
(Driver, Date, Destination) → (VIN, Model, Make)

e) Provide at least one explanation why R is not in BCNF. Explain your answer. [2]

f) Using the functional dependencies in (a) and (b) above, apply Heath's theorem twice to derive an equivalent set of relations, all in BCNF. Each time you apply Heath's theorem, state explicitly which functional dependency you apply it to. For each new relation you obtain at each stage of the process, state if it is in BCNF; if it is not, provide a reason. State explicitly all the relations in the final set you obtain, and provide a candidate key for each. [12]

Question 5

a) Define the concept of transaction. Illustrate your definition with an example. [4]

b) Explain the ACID properties of transactions including a brief example for each property (use no more than five sentences per property). [12]

c) Give an example, of two transactions, that illustrates the "lost update problem". Show how this problem may be avoided in the case of this example. [5]

d) Provide a brief description the concept of a DBMS log, and its role in database recovery. Give at least two examples for different types of information which are normally kept on the log, and state the order in which items are kept on it (use no more than six sentences for your answer). [4]