Question 1

(a) Many database management systems use B^+-Trees to organise the data within the database.

   (i) What is a B^+-Tree (also how does it differ from a B-Tree)?
   (ii) Explain, with the use of a diagram, how data is stored in a B^+-Tree.
   (iii) How is the tree traversed to find an item of data?
   (iv) What happens to an already full leaf node if we try to insert a new item of data?
   (v) What benefits do B^+-Trees offer for locating data quickly (in terms of disk access, search path length, and the order of the B^+-Tree)?

[8 marks]

(b) What is the referential integrity rule? What is the entity integrity rule?

What three foreign key rules apply when a foreign key attribute is updated? Use, as an example in your answer, the relations below and an update to supplier S1 changing supplier number from S1 to S9 (assuming SNo in the SP table is a foreign key referencing the Supplier table). Also, what are the foreign key rules when deleting an attribute and what effect would be observed using each rule when S2 is deleted from the Supplier table?

Supplier			
SNo	SNAME	STATUS	CITY
S1	Smith	20	London
S2	Jones	10	Paris
S3	Blake	30	Paris
S4	Clark	20	London
S5	Adams	30	Athens

Parts				
PNo	PNAME	COLOUR	WEIGHT	CITY
P1	Nut	Red	12	London
P2	Bolt	Green	17	Paris
P3	Screw	Blue	17	Rome
P4	Screw	Red	14	London
P5	Cam	Blue	12	Paris
P6	Cog	Red	19	London

SP		
SNo	PNo	QTY
S1	P1	300
S1	P2	200
S1	P3	400
S1	P4	200
S1	P5	100
S1	P6	100
S2	P1	300
S2	P2	400
S3	P2	200
S4	P2	200
S4	P4	300
S4	P5	400

[7 marks]

Question continues on the next page.

(c) Thinking about transaction processing, draw and describe a diagram showing the five possible states a transaction can be in during the period surrounding a system failure. Describe how implementing a log file and checkpoint record can aid recovery. Which two commands are used in transaction processing, and what do they both mean? What procedure should be followed during recovery and why? (You should indicate how each transaction state is dealt with).

[10 marks]

Question 2

(a) You have been asked to model a database for an airport. The database will keep track of employees and aeroplanes. This is relevant information:

Every plane has a registration number, and is of a specific model. Each model has a model number, name, maximum passenger capacity, weight and manufacturer.

The airport has a number of employees. For each employee it needs to store the name, NI number[1], address, salary and phone number.

There are two types of employees — a technician who can be an expert on one or more plane model(s) (many technicians can be an expert in the same model) — and a traffic controller who must have an annual medical examination (only the date of the most recent examination is required to be stored).

The airport has to test planes. The date and time of each test, the technician that carries it out, and the number of hours that the technician spent testing the plane is required to be stored. Each test is allocated a unique test number by the Civil Aviation Authority (CAA).

  (i) Draw a complete ER diagram for the above problem. Include the cardinality of all relationships. The cardinality of some relationships cannot be deduced from the above passage. Assume sensible values.

  (ii) Indicate the primary key of each entity (by underlining it).

 (iii) Select one relationship from your diagram that would use the conversion rule relation to relationship relation with two foreign keys, and show how it would be represented by a table in the database. You should indicate any primary key and foreign key constraints.

 (iv) The CAA requires that testing is carried out by a technician who is an expert on that plane model. How could that be expressed in the database? If you feel you cannot express it, explain why.

[15 marks]

(b) Name the two types of locks that are available and discuss when locks can be granted or refused. What is a deadlock situation, and when does it occur? Describe in detail two methods which can detect and overcome deadlock situations?

[5 marks]

(c) How can a dynamic website be constructed using a database management system and a scripting language? Name the technologies used at each stage of the pipeline.

[5 marks]

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[1]In the UK a NI (National Insurance) number is a unique identifying number allocated to each person of employable age

Question 3

(a) Give the definitions for functional dependence and full functional dependence. Describe both with the use of an example.

[5 marks]

(b) (i) What is the definition of second normal form? Given a first normal form relation R(A,B,C,D) with a composite primary key of (A,B), give a situation where R is not in second normal form. What do you have to do to place relation R in second normal form?

   (ii) What is the definition of third normal form? Given a second normal form relation R(A,B,C) with a primary key of A, give a situation where R is not in third normal form. What do you have to do to place relation R in third normal form?

[4 marks]

(c) Consider the following relation:

    R(A,B,C,D,E,F,G,H,I,J)

with the following functional dependencies:

    A,B,C→D,G
    A,B→E,F
    B→H
    C→I,J
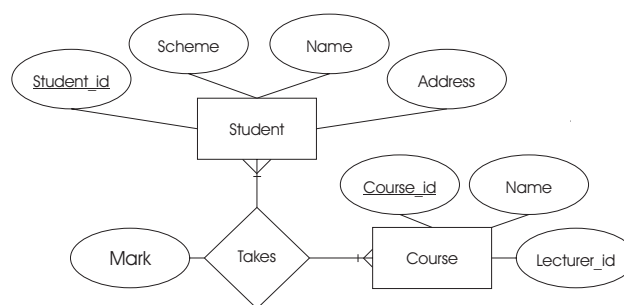   E→F
    I→J

  (i) Draw the functional dependency diagram.
  (ii) Identify the primary key and indicate how you have chosen it.
 (iii) Create a second normal form version of the database (hint: make sure you get the new relations in the correct order, also list the functional dependencies).
 (iv) Create a third normal form version of the database.

[10 marks]

(d) Given the following ER diagram:

What specific conversion rules would be followed to convert this into relations in a database? Give the resulting tables. What other rules apply when converting ER diagrams to relational tables?

[6 marks]