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RAJARATA UNIVERSITY OF SRI LANKA
FACULTY OF APPLIED SCIENCES

B.Sc. (General) Degree in Information and Communication Technology
First Year - Semester II Examination – September/October 2020

ICT 1407 – DATABASE SYSTEMS

Time: Three (03) hours

Instructions to Candidates:

Six (06)

- This paper contains **Five (05)** questions in ~~**Seven (07)**~~ pages.
- Answer **ALL** the questions.

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1. a. Explain why it is necessary to use **databases** and why it is required to use **database technologies** using examples. (03 marks)

   b. State four (04) main advantages of using a database. (02 marks)

   c. What are the responsibilities of the Database Administrator and the Database Designer? (04 marks)

   d. Explain what you understand by the term **program data independence** of a DBMS and why it is important. (03 marks)

   e. State and discuss the three schema architecture. (03 marks)

   f. What are the two (02) types of data independence? Briefly explain how they can be achieved with three schema architecture. (03 marks)

(Total 18 marks)

2. a. What is the difference between database schema and a database state? (02 marks)

b. Discuss the entity integrity and referential integrity constraints. Why each is considered important? (03 marks)

c. Define foreign key. What is the concept of foreign key used for? (03 marks)

d. Consider the following six (06) relations for an order-processing database application in a company:

CUSTOMER(cust#, cname, city)
ORDER(order#, odate, cust#, ord_amt)
ORDER_ITEM(order#, item#, qty)
ITEM(item#, unit_price)
SHIPMENT(order#, warehouse#, ship_date)
WAREHOUSE(warehouse#, city)

Here, *ord_amt* refers to total dollar amount of an order; *odate* is the date the order was placed; and *ship_date* is the date an order (or part of an order) is shipped from the warehouse. Assume that an order can be shipped from several warehouses. Specify the foreign keys for this schema, stating any assumptions you make. What other constraints can you think of for this database? (04 marks)

e. Consider the following GRADEBOOK relational schema describing the data for a grade book of a particular instructor. (Note: The attributes A, B, C, and D of COURSES store grade cutoffs.)

CATALOG(cno, ctitle)
STUDENT(sid, fname, lname, minit)
COURSE(term, sec_no, cno, A, B, C, D)
ENROLL(sid, term, sec_no)

Specify the following queries using **SQL** on the GRADEBOOK database schema.

i. Retrieve the names of students enrolled in the Automata class during the fall 2009 term.
ii. Retrieve the sid values of students who have enrolled in CSc226 and CSc227.
iii. Retrieve the sid values of students who have enrolled in CSc226 or CSc227.
iv. Retrieve the names of students who have not enrolled in any class.

(08 marks)

(Total 20 marks)

3. a. Consider the LIBRARY relational database schema shown in the figure given below, which is used to keep track of books, borrowers, and book loans. Referential integrity constraints are shown as directed arcs in the figure. Write down relational algebraic expressions for the following queries:

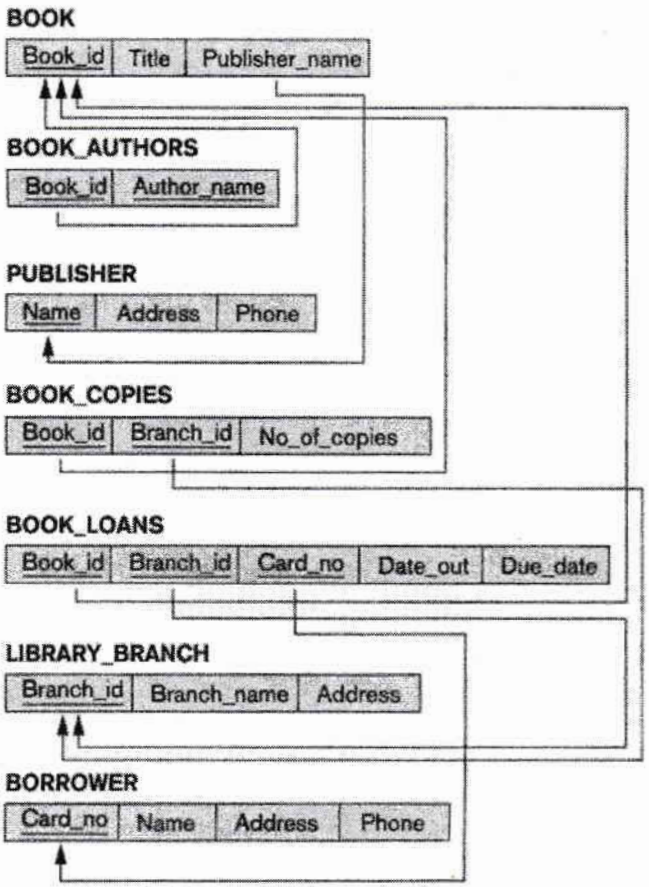
i. How many copies of the book titled 'The Lost Tribe' are owned by the library branch of which name is 'Sharpstown'?

ii. How many copies of the book titled 'The Lost Tribe' are owned by each library branch?

iii. Retrieve the names of all borrowers who do not have any books checked out.

iv. For each book that is loaned out from the Sharpstown branch and of which Due_date is today, retrieve the book title, the borrower's name, and the borrower's address.

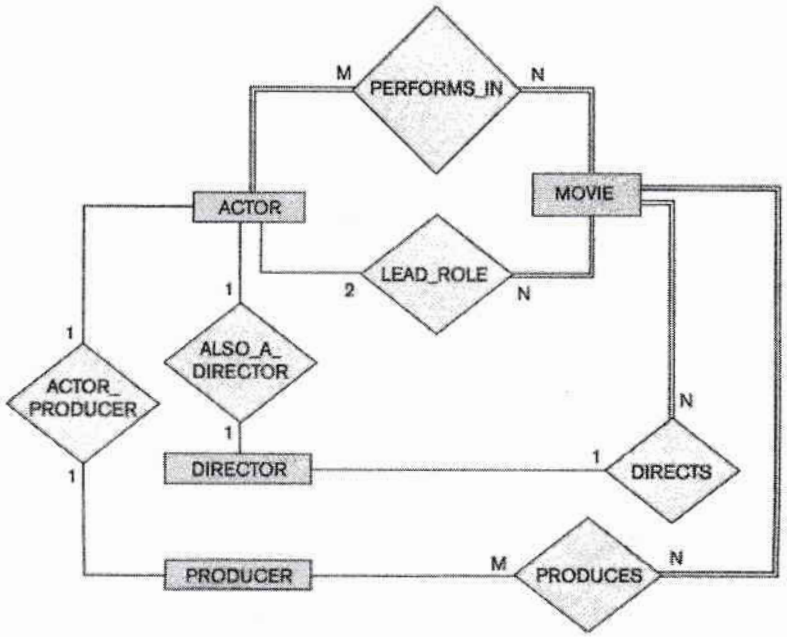
v. For each library branch, retrieve the branch name and the total number of books loaned out from that branch.



(10 marks)

b. Consider the ER schema for the MOVIES database in the figure below.

Assume that MOVIES is a populated database. ACTOR is used as a generic term and includes actresses. Given the constraints shown in the ER schema, respond to the following statements with **True**, **False**, or **Maybe**. Assign a response of Maybe to statements that, while not explicitly shown to be True, cannot be proven False based on the schema as shown. Justify each answer.



i. There are no actors in this database who have been in no movies.
ii. There are some actors who have acted in more than ten movies.
iii. Some actors have done a lead role in multiple movies.
iv. A movie can have only a maximum of two lead actors.
v. Every director has been an actor in some movie.
vi. No producer has ever been an actor.
vii. A producer cannot be an actor in some other movie.
viii. There are movies with more than a dozen actors.
ix. Some producers have been a director as well.
x. Most movies have one director and one producer. (10 marks)

(Total 20 marks)

4. a. What is a subclass? When is a subclass needed in data modeling? (02 marks)

b. Discuss the two (02) main types of constraints on specializations and generalizations. (03 marks)

c. Identify all the important concepts represented in the library database case study described below. In particular, identify the abstractions of classification (entity types and relationship types), aggregation, identification, and specialization/generalization. Specify (min, max) cardinality constraints whenever possible. List details that will affect the eventual design but that have no bearing on the conceptual design. List the semantic constraints separately.

Draw an EER diagram of the library database.

Case Study: The Georgia Tech Library (GTL) has approximately 16,000 members, 100,000 titles, and 250,000 volumes (an average of 2.5 copies per book). About 10 percent of the volumes are out on loan at any one time. The librarians ensure that the books that members want to borrow are available when the members want to borrow them. Also, the librarians must know how many copies of each book are in the library or out on loan at any given time. A catalog of books is available online that lists books by author, title, and subject area. For each title in the library, a book description is kept in the catalog that ranges from one sentence to several pages. The reference librarians want to be able to access this description when members request information about a book. Library staff includes chief librarian, departmental associate librarians, reference librarians, check-out staff, and library assistants.

Books can be checked out for 21 days. Members are allowed to have only five books out at a time. Members usually return books within three to four weeks. Most members know that they have one week of grace before a notice is sent to them, so they try to return books before the grace period ends. About 5 percent of the members have to be sent reminders to return books. Most overdue books are returned within a month of the due date. Approximately 5 percent of the overdue books are either kept or never returned. The most active members of the library are defined as those who borrow books at least ten times during the year. The top 1 percent of membership does 15 percent of the borrowing, and the top 10 percent of the membership does 40 percent of the borrowing. About 20 percent of the members are totally inactive in that they are members who never borrow.

To become a member of the library, applicants fill out a form including their SSN, campus and home mailing addresses, and phone numbers. The librarians issue a numbered, machine-readable card with the member's photo on it. This card is good for four years. A month before a card expires, a notice is sent to a member for renewal. Professors at the institute are considered automatic members. When a new faculty member joins the institute, his or her information is pulled from the employee records and a library card is mailed to his or her campus address. Professors are allowed to check out books for three-month intervals and have a two-week grace period. Renewal notices to professors are sent to their campus address.

The library does not lend some books, such as reference books, rare books, and maps. The librarians must differentiate between books that can be lent and those that cannot be lent. In addition, the librarians have a list of some books they are interested in acquiring but cannot obtain, such as rare or out-of-print books and books that were lost or destroyed but have not been replaced. The librarians must have a system that keeps track of books that cannot be lent as well as books that they are interested in acquiring. Some books may have the same title; therefore, the title cannot be used as a means of identification. Every book is identified by its International Standard Book Number (ISBN), a unique international code assigned to all books. Two books with the same title can have different ISBNs if they are in different languages or have different bindings (hardcover or softcover). Editions of the same book have different ISBNs.

The proposed database system must be designed to keep track of the members, the books, the catalog, and the borrowing activity. (20 marks)

(Total 25 marks)

5. a. Discuss insertion, deletion, and modification anomalies. Why are they considered bad? Illustrate with examples. (03 marks)

b. Consider the following relation:
CAR_SALE(Car#, Date_sold, Salesperson#, Commission%, Discount_amt)

Assume that a car may be sold by multiple salespeople, and hence {Car#, Salesperson#} is the primary key. Additional dependencies are

Date_sold → Discount_amt and
Salesperson# → Commission%

Based on the given primary key, is this relation in 1NF, 2NF, or 3NF? Why or why not? How would you successively normalize it completely? **(04 marks)**

c. Explain the terms seek time, rotational delay, and transfer time **(03 marks)**

d. Consider a disk with the following characteristics (these are not parameters of any particular disk unit): block size B = 512 bytes; inter-block gap size G = 128 bytes; number of blocks per track = 20; number of tracks per surface = 400. A disk pack consists of 15 double-sided disks.

i. What is the total capacity of a track, and what is its useful capacity (excluding inter-block gaps)?
ii. How many cylinders are there?
iii. What are the total capacity and the useful capacity of a cylinder?
iv. What are the total capacity and the useful capacity of a disk pack?
v. Suppose that the disk drive rotates the disk pack at a speed of 2400 rpm (revolutions per minute); what are the transfer rate (tr) in bytes/msec and the block transfer time (btt) in msec? What is the average rotational delay (rd) in msec? What is the bulk transfer rate? (07 marks)

(Total 17 marks)

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