UNIVERSITY OF BIRMINGHAM

School of Computer Science

Data Structures, Algorithms and Databases

Class Test #2 [2022-23]

Data Structures, Algorithms and Databases

Question 1 Entity-Relationship modelling

A database is required for a driving school. The school maintains a number of vehicles, instructors that are qualified to teach driving on particular types of vehicles (cars, buses, trucks etc.), and technicians that maintain the vehicles.

Vehicles have registration numbers and belong to particular types. Their year of purchase and the current market value must be recorded.

Students enrol for driving courses for particular types of vehicles after obtaining a learner's permit. Once they are enrolled, they are assigned an instructor, who is responsible for giving them driving lessons. The instructor is qualified to teach on a particular type of vehicle and is allocated a vehicle of that type. The course involves a standard number of driving hours (called "lessons"). The lessons are scheduled depending on instructor availability with a target of 2–3 hours per week. If the assigned instructor is not available, substitute instructors may be allocated for individual lessons.

After the students complete the required number of driving hours, they will be allowed to take a driving test. If they do not pass the test, they will be given additional driving lessons for extra fees. The students also have the option of leaving the school.

The school needs to maintain employee information for all employees (name, address, phone number etc.). For instructors, it needs to keep track of their teaching schedules, and their performance in terms of how many students they have taught over a period of time and their success rate. ("Keeping track" means that it should be possible to calculate these pieces of informaion from the stored data.)

a. Develop an **Entity-Relationship model** for the application. Explain the key design decisions made in your choice of entities, relationships and any other (ownership or hierarchical) aspects. **[4 marks]**

   Annotate it with **multiplicities** and **hierarchy** annotations, if any. **[3 marks]**

b. Carry out **logical design** for the model, representing the design with relational schemas for tables. Annotate the schemas with primary keys and the possibility of null attributes. **[4 marks]**

c. Write SQL "`CREATE TABLE`" statements for 2–3 tables. Include among them at least one table for a relationship, weak entity or subclass entity. The other table(s) may be those that are linked to this table.

   Include all the necessary constraints and "`ON DELETE`" actions. **[3 marks]**

Question 2 Relational Algebra

a. Given below are two tables T_1 and T_2.

T_1 :

A	W	X	Y	B
a	1	*x*	5	*e*
b	2	*x*	7	*f*
b	3	*x*	5	*g*
a	4	*y*	5	*h*

T_2 :

D	X	W	Y
p	*x*	1	7
t	*y*	2	7
p	*y*	3	5
r	*x*	4	7

Show the table obtained by evaluating the following expression: **[3 marks]**

$$(\pi_{(A,X,Y,B)} T_1) \bowtie T_2$$

b. Given below are the schemas for a database representing staff members, courses, and a relationship of staff members lecturing courses in particular years.

```
staff(sid, title, firstname, lastname, email, office, phone)
courses(cid, level, name, credits)
lecturing(cid, sid, year)
```

We want to find the courses that were taught by the same staff member during the year 2021 as well as 2022. Write a relational algebra expression for this purpose.

(Hint: Consider calculating the cid's of such courses first.) **[3 marks]**