

This is a closed book exam: the only resources allowed are blank paper, pens, and your head, but you may use a handwritten A4 page with information that you consider useful for solving the exam exercises. Explain your reasoning. Write clearly, in the sense of logic, language, and legibility. The clarity of your explanations affects your grade. Good luck!

Write your name and student number on *all* solution sheets and here.

Name:

At the end of the exam, hand in *all* sheets that you received, including this one.

Student number:

Problem 1 [30%] Design the Entity-Relationship schema for an application that manages the shipment of merchandise items for an e-commerce business.

Of each *item* registered in the system, we are interested in its code (identifier), its value, and the requested shipments that involve it. Each *requested shipment* is submitted by a person on a certain date, concerns a set of items (at least one), has an associated estimated cost, and refers to a shipping company that has been assigned to carry it out. Two requested shipments submitted on the same date cannot refer to the same shipping company. A *completed shipment*, which is a requested shipment that has been carried out, concerns a non-empty subset of the requested items. Of each completed shipment, we are interested in the actual cost and the quality rating (if available). Note that an item may be involved in several (possibly none) requested shipments, but in at most one completed shipment. Of each *person* registered in the system, we are interested in their social security number (identifier), gender, and nationality. Of each *shipping company*, which should be assigned to at least one shipment, we are interested in its VAT number (identifier), its revenue, and the quality inspections (no more than one per year) to which it has been subjected. Of each *quality inspection*, we are interested in the year in which it was carried out, the person responsible (if known), and the outcome.

Problem 2 [40%] Carry out the logical design of the database, producing the complete relational schema with constraints, taking into account the following requirement: whenever a quality inspection of a shipping company is accessed, we are always interested in knowing the person responsible (if any), together with their nationality.

In your design you should follow the methodology adopted in the course, and you should produce:

1. [7%] the restructured Entity-Relationship schema (possibly with external constraints),
2. [25%] the direct translation into the relational model (possibly with external constraints), and
3. [8%] the restructured relational schema (again with constraints).

You should motivate explicitly how the above indications affect your design.

Problem 3 [20%] Consider a database D containing the following relations:

- (i) $\text{Person}(\text{taxCode}, \text{dateOfBirth})$, which stores the tax code (primary key) and the date of birth of persons;
- (ii) $\text{Birth}(\text{taxCode}, \text{municipality})$ and $\text{WorkedIn}(\text{taxCode}, \text{municipality})$, which store, for each person, respectively the municipality of birth (if known) and the municipalities in which they have worked (a person may have never worked).

It is known that the only foreign keys that are satisfied in the database are the one from $\text{Birth}[\text{taxCode}]$ to $\text{Person}[\text{taxCode}]$ and the one from $\text{WorkedIn}[\text{taxCode}]$ to $\text{Person}[\text{taxCode}]$.

Write the following queries over D :

1. Write a query in **SQL** that computes *all* persons, with their tax code, date of birth, and, if known, also their municipality of birth.
2. Write a query in **relational algebra** that computes the tax code of all persons who have worked *only* in their municipality of birth.
3. Write a query in **SQL** that computes, for *each* person, their tax code and the number of municipalities in which they have worked.

Problem 4 [10%] Consider the relational database shown below and answer the following questions:

1. Which key constraints are satisfied by relation R ? In other words, what are the keys of R ?
2. Which superkey constraints are satisfied by relation R ? In other words, what are the superkeys of R ?
3. Which foreign key constraints are satisfied by the database?

R	A	B	C	D	S	E
	5	7	1	5		5
	5	5	2	5		8
	null	6	3	7		9
	5	5	4	6		