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 of an application related to an association with members and organized in various interest groups, for which the following information is of interest. Every *interest group* within the association has an identifier code, a name, a thematic focus it aligns with, a non-empty set of members currently active within the interest group, and a member among its currently active ones who leads it. For every *member* of the association, their social security number (which is an identifier) and the city of birth are of interest. A member is currently active in exactly one interest group. Some of the association members are *board members*, and for each of them, the city of residence, gender, and the interest groups in which they have been active in the past are also of interest. Every time a board member has been active in an interest group (currently or in the past), the date of joining the interest group, optionally the thematic focus they were associated with at that time, and the date of departure have been recorded. Notice that the date of departure is undefined for the interest group within which a board member is currently active. Take into account that a board member can switch interest group at most once per month. Of each *thematic focus*, the name (identifier) and a description are of interest.

Problem 2 [40%] Carry out the logical design of the database, producing the complete relational schema with constraints, taking into account the following indications: *(i)* we want to avoid null values in the database; *(ii)* every time we access the information about an association member, we always want to know whether they are a board member, and if so, we want to know their gender and city of residence.

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

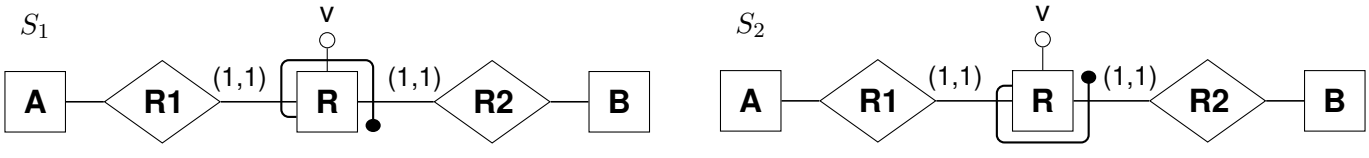
1. [7%] the restructured Entity-Relationship schema (possibly with external constraints),
2. [25%] the direct translation into the relational model (possibly with external constraints), and
3. [8%] the restructured relational schema (again with constraints).

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

Problem 3 [20%] Consider a database containing the two tables: *(i)* `Delivery(courier,item,date,district)`, which stores the information regarding courier deliveries, each with the courier, the delivered item, and the date and city district where the delivery was done, and *(ii)* `Express(courier,item,date)`, which stores the same information (without the district), but only for the express deliveries (these are a subset of all deliveries).

1. [4%] Write a *SQL* query that returns, for each courier and each district in which the courier has delivered some item, the courier, the district, and the date on which the courier has done their first delivery in that district.
2. [10%] Write a *SQL* query that computes, for each courier that has done some express delivery and for each district, the average number of items per day that that courier has delivered express to that district, returning that number together with the courier and the district.
3. [6%] Write a *relational algebra* query that computes all couriers that on at least one date have done both an express delivery and a non-express delivery.

Problem 4 [10%]



Consider the two ER schemas S_1 and S_2 above.

1. [5%] Is there a legal instance of S_1 that is *not* a legal instance of S_2?
   If yes, show such an instance; if no, argue why such an instance cannot exist.
2. [5%] Is there a legal instance of S_2 that is *not* a legal instance of S_1?
   If yes, show such an instance; if no, argue why such an instance cannot exist.