This is a closed book exam: the only resources allowed are blank paper, pens, and your head. 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 information system that concerns the elections of municipality councils. Each *election* is held for a municipality on a certain date, with the condition that at most one election per year may be held in the same municipality. For each election, we are interested in the persons who are candidates, with the date where they have presented their candidacy and the political party of reference for the candidacy itself. Note that nobody can present more than one candidacy for the same election. In addition, if a candidate for an election is elected, then we are interested in the number of votes with which the candidate was elected. For each *person*, we are interested in the tax code (identifier), the date of birth, the municipality of birth, the political party (if any) to which the person is currently registered, with the start date of the registration, and the role (if any) played during the registration period (e.g., provincial secretary, regional secretary, etc.). We are also interested in the political parties to which the person has been registered in the past, with the start date and end date of the registration, and again the role (if any) played during the registration period. For each *municipality*, we are interested in the code (identifier), the number of inhabitants, and the province to which it belongs. For each *province* we are interested in the name (identifier), the size, the region to which it belongs, and the municipality that, among those that belong to the province itself, is the capital. For each *region* we are interested in the name (identifier), the type (normal, special statute, etc..), and the municipality that is the capital of that region. Note that the municipality that is the capital of a region is also the capital of a province belonging to that region. For the municipalities that are provincial capitals we are interested also in the quality of life index, and for the provincial capitals that are also regional capitals we are interested also in the year of foundation. Finally, for each *political party* we are interested in the code (identifier), the year of foundation, and the political group (left, center, etc..) to which it belongs.

Problem 2 [42%] Carry out the logical design of the database, producing the complete relational schema with constraints, taking into account the following indications: *(i)* When accessing the data of a candidacy, we always want to know the candidate, the political party of reference for the candidacy, the election in which the candidacy was presented and possibly the number of votes with which the person was elected. *(ii)* When accessing a municipality, we always want to know the province to which it belongs.

As steps in your design you should produce:

1. [7%] the restructured ER schema (possibly with external constraints),
2. [25%] the direct translation into the relational model (possibly with external constraints), and
3. [10%] the restructured relational schema (again with constraints).

Motivate explicitly how the above indications affect your design.

Problem 3 [18%] In a database, the relation `City(name,population,level)` stores the data about population and pollution level of cities, the relation `Sensor(code,day,numVehicles)` stores, for each sensor represented by the code, and for each day (of the current year), the number of vehicle passages measured by the sensor, while the relation `Location(sensorCode,cityName)` stores, for each sensor, the city in which it is located.

Express in SQL the following queries over the above relations:

1. Calculate the name, population, and pollution level of the cities in which at least one sensor is located that has detected more than 100 vehicle passages in at least one day.
2. For each city with a pollution level greater than 5, calculate how many vehicle passages in total were detected throughout the year by all sensors located in that city.
3. For each day of the current year and for each city with at least 10,000 inhabitants, calculate the average number of vehicle passages measured in that day by the sensors located in that city.

Problem 4 [10%] Consider the conceptual schema S shown below. If we change the schema S as follows, do we get a schema equivalent to S (i.e., that admits the same instances)?

1. Setting the minimum cardinality of Q in the role B to 0.
2. Setting the maximum cardinality of Q in the role B to 1.

Motivate you answer in both cases.