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 application for managing the poetry competitions that have been organized by an association. The association consists of different sites, which are responsible for organizing the competitions. Of each *competition*, we are interested in the site that organized it, the code (unique within the site that organized it), and the category. There are exactly two types of competitions, open ones and thematic ones. Of each *open competition*, we are interested in the year in which it is held (in each year a maximum of one open competition is allowed), while of each *thematic competition*, we are interested in the theme covered. Of each competition, we are interested in knowing the various poems that have been submitted and among them which is the unique winner. Of each *poem*, we are interested in the person who authored it, the title (unique to the person who authored it), the text, and the date and city where it was written. Note that a poem may be submitted to multiple competitions, but at most to one open competition. Of each *site*, we are interested in the code (identifier), the name, the person who is its president, and the city where it is located. Of each *person*, we are interested in the tax code (identifier), the date of birth, and the occupation, if any. Of each *poem author*, we are also interested in the education level. Of each *city*, we are interested in the region in which it is located, the name (unique within the region in which it is located), and the number of inhabitants.

**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)* Null values in the database should be avoided. *(ii)* When accessing the data on a poem, we always want to know its author.

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. [10%] the restructured relational schema (again with constraints).

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

**Problem 3** [18%] Consider a database that includes the relations `Company` and `City`.
The relation `Company(name,type,city,numEmp)` stores for each company the name, the type, the city where it is registered, and the number of employees. The relation `City(name,region)` stores for each city the region in which it is located.

1. Express *in SQL* the query that returns for each company type and for each region, the total number of employees of companies of that type registered in that region.
2. Express *in SQL* the query that returns the company type (or types) that have the highest total number of employees.
3. Express *in relational algebra* the query that computes the company that has (or the companies that have) the smallest number of employees, showing the name of the company, the region where it is registered, and the number of employees.

**Problem 4** [10%] Consider the following Entity-Relationship schema $S$, and show the corresponding restructured Entity-Relationship schema $S_r$ that correctly captures its semantics (i.e., such that the instances of $S$ and those of $S_r$ can be put into a one-to-one correspondence).