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 relating to maintenance operations on movable power supplies. For each *power supply*, the code (identifier), the model, the company that built it, and the year of construction are of interest. *Gas power supplies* are a special kind of power supplies, the cost of which is also of interest. For each *company*, the fiscal code (identifier), the city where it is based, and the number of employees are of interest (this last information may not be available). For each *city*, the name (unique within the region), the region, and the number of inhabitants are of interest. Power supplies are subject to maintenance: for each *maintenance operation* we are interested in the power supply to which it is applied, the date, the labour cost, and the city where the operation took place. A power supply cannot be subject to more than one maintenance operation per day. For a *maintenance operation that concerns a gas power supply*, we are interested also in the company responsible for the maintenance operation. A maintenance operation may require the replacement of parts. For each *part*, the code (identifier), the unit cost, and the manufacturing company are of interest. If the part is an *engine part*, it is also important to know the reliability index (positive integer). Finally, for each part to be replaced in a maintenance operation, it is of interest to know the quantity that has been replaced (for example, 3 valves may be replaced in a maintenance operation of a power supply), and in the case of an engine part, the discount applied on the unit price.

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 data about a maintenance operation, we are always interested in knowing the city where it took place and whether it is a maintenance operation concerning a gas power supply, and in this case also the company responsible for it; *(ii)* when accessing data about a power supply, we are always interested in knowing the company that built it.

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%] Consider a database that includes the relations `Graduated`, and `School`.
The relation `Graduated(`<u>`studId`</u>`,grade,schoolCode)` stores for each graduated student, the student id, the grade obtained at the graduation, and the school where they obtained it.
The relation `School(`<u>`schoolCode`</u>`,city)` stores for each school, the city.

1. We call "exit indicator" of a school the average of the grades obtained by the graduates in that school, and "average exit indicator" the average of the exit indicators of all the schools. Then we call "school quality indicator" of a city the percentage of schools that are located in that city and that have the exit indicator higher than the average exit indicator. Write a *SQL query* that returns for each city its school quality indicator.

2. We call a city a "top city" if all its schools have at least one graduate with a grade of 100. Write a *query in relational algebra* that returns the top cities.

Problem 4 [10%] Consider the restructured conceptual schema shown below, and carry out the direct translation step, illustrating the relational schema complete with constraints resulting from that step.