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 a set of private universities. For each private university, we are interested in the code (identifier), the city in which it is located, the courses offered, administrative data, and academic data, where the academic data are the name and the budget assigned to the university by the ministry, while the administrative data are the social capital and the year of foundation. For each course offered by a private university (e.g., "mechanical engineering" of university U), we are interested in the university that offers it, the code (unique within the university that offers it), the number of lessons of which it is composed, the type (historical, economic, scientific, etc.). In addition, if the course is a course with a responsible lecturer (note that the responsible lecturer can change in the various editions of the course), we are interested also in the salary bonus set for the responsibility of a course edition. Some courses are "on-line" courses and for such courses we are also interested in the level of difficulty (expressed as an integer) and the person who has the role of coordinator of that course. For each course, we are also interested in the various editions of the course (e.g., the 2015 edition of the "mechanical engineering" course of university U). For each edition, we are interested in the course to which it refers, the year in which it was held, the starting day, the grade that measures the evaluation by the students (but this grade is not always available), and the pair of people that the university has decided to assign to the edition of the course as supervisor and evaluator. The following rules apply: *(i)* two editions of the same course are never held in the same year; *(ii)* a (supervisor, evaluator) pair is assigned to at most one edition of the same course. For each edition of a course with a responsible lecturer, we are also interested in knowing who that lecturer is. For each person, we are interested in the tax code (identifier), the date of birth, and the city of residence. Finally, for each city, we are interested in the region, the name (unique within the region), the number of inhabitants, and the private universities that carry out activities in that city.

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 have to be avoided; *(ii)* the administrative data of a university is always accessed separately from the academic data.

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%] The relation `Flight(code,departure,arrival,airline)` specifies for each flight, the flight code, the code of the city of departure, the code of the city of arrival, and the airline, while the relation `City(code,nation)` stores the code and the nation of each city.

Express in SQL the following queries over the above two relations:

1. Compute the pairs (n_1, n_2) of nations such that there is at least one flight of the airline "`Green Wings`" that departs from a city of n_1 and arrives in a city of n_2.
2. Compute the pairs (c, d) of cities with a "uniform binary connection", where a uniform binary connection for (c, d) is a sequence of two flights f_1 and f_2 of the *same* airline such that f_1 departs from c, f_2 arrives at d, and the arrival city of f_1 coincides with the departure city of f_2.
3. Compute the cities c from which depart *only* flights arriving in cities of the same nation as c.
4. For each airline, compute the number of nations touched by at least one flight of that airline, where a nation is touched by a flight f if f departs from or arrives at a city in that nation.

Problem 4 [10%] Let R be a binary relationship with roles A and B, and let $(0, 1)$ be the cardinality associated to A. Say if it is true that B is an identifier of R, motivating in detail your answer.