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 the management of sports facilities (football fields, running tracks, golf fields, etc.). Each *facility* belongs to a company, is identified by a unique code within the company to which it belongs, and we are interested in the year of inauguration, and the street, street number, and city where it is located. For each *company*, we are interested in the tax code (identifier), the city in which its headquarters are located, the year it was founded, and the value. For *sport clubs*, which are special types of companies, we are also interested in the main sport for which the club is registered, and the city in which it is registered (which might coincide or not with the city where the headquarters are located). For each *city*, we are interested in the province, the name (unique within the province), and the number of inhabitants. Facilities are booked by sports clubs: for each *booking*, we are interested in the sports club that made it, the facility that was booked, the date on which the booking was made, and the date on which the facility will be used for that booking (two bookings for the same facility for the same date of use are not accepted). Each Booking might be either used or cancelled. For each *used booking*, we are interested in the cost of the use and the conditions in which the facility was left (coded with a number), while for each *cancelled booking*, we are interested in the date of cancellation and the penalty paid for the cancellation (if known). Accidents might occur during the use of a facility, and for each such *accident*, we are interested in the code (unique within a used booking), the type of accident that occurred, and the persons involved (at least one). For each *person*, we are interested in the fiscal code, the gender and the address of residence, complete with the street name, street number, and city. (Notice that the only persons we are interested in are those involved in accidents.)

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)* Avoid null values in the database. *(ii)* When accessing a facility, we are always interested in knowing the city where it is located. *(iii)* When accessing an accident, we are always interested in knowing the (used) booking during which the accident occurred.

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 `Vehicle` and `Trip`.
The relation `Vehicle(code,owner)` stores for each vehicle, the identification code and the owner, while the relation `Trip(code,city,day,month,year)` stores the trips made by the vehicles in the various cities and on the various dates. Express the following queries in SQL:

1. For each owner, return the code of the vehicles of that owner that made a trip in Bolzano in 2021.
2. For each owner, count the number of trips made by that owner's vehicles in December.
3. Return how many vehicles are owned by each person who owns at least one vehicle that since 2020 has made only trips in Merano.

Problem 4 [10%] Consider the conceptual schema S shown below and say if there is an instance I of S in which the entity B has at least one instance. If the answer is negative, explain *in detail* why such an instance I does not exist. If the answer is positive, describe *precisely* such an instance I of S (considering *all* the elements that appear in S).