

This is a closed book exam: the only resources allowed are blank paper, pens, and your head, but you may use a handwritten A4 page with information that you consider useful for solving the exam exercises. 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 for an application that concerns wildlife relocation plans among a set of nature reserves, according to the following requirements. For each *nature reserve*, we are interested in its reserve code (identifier), its name, its area, and the relocation plans in which it is involved. Each *relocation plan* concerns a species (called the target species of the plan), is established between a source reserve and a destination reserve, and has an associated planned number of animals and a risk level. Notice that a species may be the target species of any number of relocation plans (possibly none), and that each nature reserve may not be the source of more than one relocation plan having the same target species. A relocation plan may undergo *revisions* (at most one per month might be approved) in order to record a change in the planned number of animals and possibly to change the species that is the target of the relocation. For each revision of a relocation plan, we are interested in both of these pieces of information, namely, the change in the planned number of animals (which must be positive) and the possible new target species, and also in the date (i.e., day, month, and year) in which the revision is approved. For each *species*, identified by a code, we are interested in its name and average weight. *Protected species* are particular kinds of species that may have an associated recommended relocation quota, and for which we are interested in the reserves that are suited for them (at least one). Notice that a reserve may be suited for any number of protected species (possibly none).

Problem 2 [40%] Carry out the logical design of the database, producing the complete relational schema with constraints, taking into account the following requirements: (i) whenever a relocation plan is accessed, we always want to know the source and destination reserves; (ii) whenever a revision of a relocation plan is accessed, we always want to know the possible new target species established by that revision; (iii) whenever a species is accessed, we always want to know whether it is a protected species or not and, if it is, its possible recommended relocation quota.

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. [8%] the restructured relational schema (again with constraints).

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

Problem 3 [20%] Consider a database D containing the following relations:

- (i) $\text{Spacecraft}(\underline{\text{scCode}}, \text{agency}, \text{launchYear})$, which stores relevant information about spacecrafts;
- (ii) $\text{CelestialBody}(\underline{\text{bCode}}, \text{type}, \text{distance})$, which stores relevant information about celestial bodies;
- (iii) $\text{Visit}(\underline{\text{scCode}}, \underline{\text{bCode}}, \underline{\text{date}}, \text{duration})$, which stores visits carried out by spacecraft to celestial bodies.

The attribute type has 'planet' among its possible values. Write the following queries over D :

1. A query in **relational algebra** that computes the code and launch year of each spacecraft, together with the code of the celestial body and the date of the visit, for all visits carried out by spacecraft of agency 'ESA' to planets.
2. A query in **SQL** that for each spacecraft that has visited at least three distinct celestial bodies, computes the spacecraft code, the number of distinct celestial bodies it has visited, and the average duration of its visits.
3. A query in **SQL** that computes the code and launch year of all spacecraft that have visited *every planet* stored in the database at least once. What should the query return if there is no celestial body of type 'planet'?

Problem 4 [10%] Give the definition of an *integrity constraint* in general and of a *cardinality constraint* in particular. Then consider the conceptual schema S shown below and state whether there exists an instance of S in which the set of instances of F is non-empty. If the answer is positive, exhibit such an instance; otherwise, provide an appropriate justification. Recall that an instance of a conceptual schema is an extensional level in which all the properties and all the integrity constraints of the conceptual schema are satisfied.

