Exercise 1 (Conceptual Database Design). Perform a conceptual database design satisfying the following constraints:

- PCs execute at least one program.
- Programs are executable on arbitrarily many PCs.
- PCs are used by one user only.
- Optionally, a PC can be administrated by an administrator.
- One administrator is responsible for at most 42 PCs.
- Not every user likes his administrator.
- A user can destroy arbitrarily many programs.

Construct an Entity-Relationship diagram with functionalities and give the (min,max)-notation. First, think about the required entity types and relations. Then fill in the functionalities.

Exercise 2 (Normal Forms). Recapitulate all concepts occurring in the database normalization process (functional dependencies, Armstrong’s axioms, transitive closure, . . . ) and give the definition of the 1st, 2nd and 3rd normal form.

Exercise 3 (Decomposing relational schemes). Consider the following schema with attributes $S, R, V, O, I, A$:

- $S \equiv$ name of a share
- $R \equiv$ interest rate of a share
- $V \equiv$ name of a vendor
• \( O \) = a vendor’s office address
• \( I \) = name of an investor
• \( A \) = amount of a share bought

We have the following functional dependencies: \( S \rightarrow R, I \rightarrow V, IS \rightarrow A \) and \( V \rightarrow O \).

a) What are the key candidates of the relation \( R = SRVIOA \)?

b) What are possible redundancies and anomalies if we decompose \( R \) into \( VOI \) and \( SRIA \)?

c) Determine a decomposition of \( R \) in 3NF without information loss preserving the functional dependencies.