

# Exercise Sheet 2 (WS 2022)

3.0 VU Datenmodellierung / 6.0 VU Datenbanksysteme

## About the exercises

### General information

In this part of the exercises you are asked to solve tasks in the areas of SQL, functional dependencies, and relational normal forms.

We recommend you to solve the problems **on your own** (it is a good preparation for the exam – and also for your possible future job – to carry out the tasks autonomously). Please note that if we detect duplicate submissions or any plagiarism, both the “original” and the “copy” will be awarded 0 points.

Your submission must consist of a single, typset PDF document (max. 5MB). **We do not accept PDF files with handwritten solutions.**

In total there are 7 tasks and at most 15 points that can be achieved on the entire sheet.

### Deadlines

**until 21.11. 12:00:** Upload your solution to TUWEL  
**from 2.12. 13:00:** Evaluation and feedback is available in TUWEL

### Further questions – TUWEL forum

If you have any further questions concerning the contents or organization, do not hesitate to ask them on TUWEL forum. **Under no circumstances should you post (partial) solutions on the forum!**

## Normal Forms

### Task 1 (Functional Dependencies)

[1 point]

Consider the following relational schema

Hiking (Name, Experience, Weather, Type, Difficulty, Recordtime)

with the following instance:

Hiking					
Name	Experience	Weather	Type	Difficulty	Recordtime
Alice	Beginner	Sunny	Climbing	medium	no
Alice	Beginner	Cloudy	Climbing	hard	no
Alice	Beginner	Sunny	Hiking	easy	no
Tobias	Advanced	Sunny	Hiking	easy	no
Martin	Advanced	Cloudy	Climbing	hard	yes
Martin	Advanced	Rainy	Climbing	hard	no
Julia	Expert	Rainy	Hiking	easy	no
Julia	Expert	Sunny	Hiking	easy	yes
Albert	Beginner	Rainy	Climbing	medium	no
Albert	Beginner	Rainy	Climbing	medium	no
Tobias	Advanced	Sunny	Hiking	hard	no
Magdalena	Expert	Cloudy	Climbing	easy	yes

Check for each functional dependency below whether it is satisfied by the given instance or not. For each FD, provide an answer (yes/no). If a FD is not satisfied, provide also a counter example. If a FD is satisfied, provide a tuple that, by adding it to the instance, would lead to a violation of the FD.

- (a)  $\text{Experience} \rightarrow \text{Difficulty}$
- (b)  $\text{Name} \rightarrow \text{Experience}$ .
- (c)  $\text{Experience}, \text{Weather} \rightarrow \text{Type}$ .
- (d)  $\text{Experience}, \text{Type} \rightarrow \text{Recordtime}$ .
- (e)  $\text{Name}, \text{Weather} \rightarrow \text{Recordtime}$ .
- (f)  $\text{Weather}, \text{Experience} \rightarrow \text{Type}, \text{Recordtime}$ .

### Task 2 (Equivalence of Functional Dependencies)

[2 points]

- (a) Consider the following relational schema  $QWERTYABC$  and two sets  $F_1$  and  $F_2$  of functional dependencies.

$$F_1 = \{RT \rightarrow QW, TE \rightarrow Y, T \rightarrow AC, A \rightarrow Y, E \rightarrow BA\}$$

$$F_2 = \{RT \rightarrow QW, E \rightarrow YB, T \rightarrow A, T \rightarrow C, A \rightarrow Y, E \rightarrow A\}$$

Are  $F_1$  and  $F_2$  equivalent? Please explain your answer using the closures of  $F_1$  and  $F_2$  and show your reasoning.

- (b) Consider the set  $F_1$  of FDs from a). Using the Armstrong-axioms, show that  $F_1 \models \{TE \rightarrow YBC\}$  (show all steps).

### Task 3 (Minimal Cover)

[2 points]

Provide a canonical cover of the sets  $\mathcal{F}_1, \mathcal{F}_2$  of functional dependencies over the relational schema  $\mathcal{R} = ABCDEFG$  and document your reasoning.

- (a)  $\mathcal{F}_1 = \{A \rightarrow C, AC \rightarrow DEG, AG \rightarrow BCE, B \rightarrow CF, B \rightarrow CE, CF \rightarrow GE, E \rightarrow BD, F \rightarrow DEF\}$
- (b)  $\mathcal{F}_2 = \{A \rightarrow C, ACF \rightarrow D, AFG \rightarrow DF, B \rightarrow F, BC \rightarrow GEF, DF \rightarrow G, F \rightarrow B\}$

### Task 4 (Identifying Keys and Superkeys)

[2 points]

For the following relational schemata with their functional dependencies, find *all keys* and *all superkeys*.

- (a)  $\mathcal{R} = ABCDEFG$   
 $F = \{B \rightarrow ACD, C \rightarrow AG, CG \rightarrow FE\}$
- (b)  $\mathcal{R} = ABCDEFG$   
 $F = \{AE \rightarrow GB, F \rightarrow E, E \rightarrow C, CG \rightarrow D\}$

**Task 5 (Normal Forms)**

[2 points]

For each subtask, assume a relational schema  $\mathcal{R}$  with its set  $\mathcal{F}$  of functional dependencies. Please check, whether  $\mathcal{R}$

- is in third normal form,
- in Boyce-Codd normal form,

and justify your answer.

- (a)  $\mathcal{R} = ABCDEFGH$   
 $F = \{AB \rightarrow ACD, C \rightarrow A, G \rightarrow GFH, D \rightarrow GE\}$
- (b)  $\mathcal{R} = TUVWXYZ$   
 $F = \{XY \rightarrow XTU, V \rightarrow W, U \rightarrow VZ, Z \rightarrow Y\}$

**Task 6 (Synthesis Algorithm)**

[3 points]

Consider the following relational schema and its functional dependencies:

$$\mathcal{R} = ASDFGHX$$

$$\mathcal{F} = \{AF \rightarrow D, D \rightarrow F, DX \rightarrow HA, X \rightarrow D, D \rightarrow G, X \rightarrow H, XHF \rightarrow A, AD \rightarrow S\}$$

We are looking for a lossless and dependency preserving decomposition in third normal form. Please apply the synthesis algorithm and show the results after every single step. Compute all keys of  $\mathcal{R}$  and all relations of the decomposition.

**Task 7 (Decomposition Algorithm)**

[3 points]

Consider the following relational schema with its functional dependencies and the list of all its keys:

$$\mathcal{R} = ABCDEFG$$

$$\mathcal{F} = \{FG \rightarrow ACE, AB \rightarrow BG, D \rightarrow F, B \rightarrow DF\}$$

The keys are  $AB$  and  $BG$ .

We are looking for a lossless decomposition into Boyce-Codd normal form. Please apply the decomposition algorithm and show the results after every single step. Compute all keys for all relations of the decomposition. Is the decomposition dependency preserving? If not, please provide the dependencies in  $\mathcal{F}$  that got lost.

*Hint:* Compute for every decomposition the corresponding closures of FDs!