Exercise Sheet 2 (WS 2020)

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 11.11.	**12:00 pm**:	Solve the SQL tasks with the online-tool
until 18.11.	**12:00**:	Upload your solution to TUWEL
from 30.11.	13:00:	Evaluation and feedback is available in TUWEL

SQL Exercise

Note that the **mandatory** SQL exercise takes place in parallel to this exercise sheet. The SQL exercise takes place in its own online tool and is not part of the exercise sheet.

You can access the online tool in TUWEL: Select **eSQL Tool** in the section "SQL exercise". No additional password is needed, you are authenticated via TUWEL. *Please note:* Unfortunately, the interface of the online tool is currently available only in German. However, task descriptions and the description of the database are available in English.

Caution!
Separate deadline for finishing the SQL tasks:
Wednesday, November 11, 2019, 12:00 pm!

Further questions – TUWEL forum

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

Changes due to COVID-19

Due to the ongoing situation with COVID-19 we will not offer in-person office hours for the exercise sheets. If you have technical issues, trouble understanding the tasks on this sheet, or other questions please use the TUWEL forum.

We also recommend that you get involved in the forum and actively discuss with your colleagues on the forum. From experience we believe that this helps all parties in the discussion greatly to improve their understanding of the material.

Normal Forms

Task 1 (Functional Dependencies) [1 point]

Consider the following relational schema

`Boat (Type, Length, Rooms, Sail, Name, Hull)`

with the following instance (sorted by `Type`):

Boat					
Type	**Length**	**Rooms**	**Sail**	**Name**	**Hull**
Barge	8	1	yes	Atafu	1
Canoe	2	0	no	Lihou	1
Canoe	3	0	no	Truk	1
Dinghy	6	0	yes	Maro	1
Houseboat	48	3	no	Ari	1
Katamaran	36	2	yes	Koror	2
Katamaran	42	5	yes	Ladi	2
Pinnace	18	1	yes	Atafu	1
Pinnace	19	1	yes	Masabu	1
Yacht	30	3	no	Deahu	1
Yacht	34	3	no	Maro	1
Yacht	40	5	no	Palau	2

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) `Type` $\rightarrow$ `Hull`.

(b) `Length` $\rightarrow$ `Type`

(c) `Name, Rooms` $\rightarrow$ `Sail`.

(d) `Rooms, Sail` $\rightarrow$ `Name`.

(e) `Länge, Rumpf` $\rightarrow$ `Zimmer`.

(f) `Name, Type` $\rightarrow$ `Rooms, Hull`.

Task 2 (Equivalence of Functional Dependencies) [2 points]

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

$$F_1 = \{V \rightarrow WY, UX \rightarrow UV, Y \rightarrow UXV, XV \rightarrow Y, UX \rightarrow Z\}$$
$$F_2 = \{V \rightarrow WY, UX \rightarrow UV, Y \rightarrow UX, XVW \rightarrow Y, Y \rightarrow WZ\}$$

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_2 of functional dependencies from task a). Please show using the Armstrong axioms that $F_2 \models \{UX \to VZ\}$ holds (show your reasoning).

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) $\mathcal{F}_1 = \{A \to DEG, BE \to F, CG \to ECF, E \to CA, E \to AE, FG \to AB, G \to C\}$

(b) $\mathcal{F}_2 = \{AB \to C, EFG \to CDE, CD \to F, A \to F, FGA \to C, E \to A\}$

Task 4 (Identifying Keys and Superkeys) [2 points]

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

(a) $\mathcal{R} = ABCDE$
$F = \{AB \to DE, CD \to BE, E \to A, D \to C\}$

(b) $\mathcal{R} = ABCDEFG$
$F = \{AB \to EF, CD \to G, F \to DG, E \to B\}$

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) $\mathcal{R} = VWXYZ$,
$\mathcal{F} = \{XZ \to V, Z \to WY, VX \to WX, W \to YXZ\}$

(b) $\mathcal{R} = UVWXYZ$
$F = \{UWZ \to UVY, XYZ \to W, VZ \to WXY, XY \to UZ,$
$UVW \to YW, UZ \to X\}$
The keys are given as VZ, UWZ, $UVWX$, UYZ, and XY.

Task 6 (Synthesis Algorithm) [3 points]

Consider the following relational schema and its functional dependencies:

$$\mathcal{R} = ABCDEF$$
$$\mathcal{F} = \{BC \to A, A \to D, BE \to DF, EF \to C, E \to F, A \to B, B \to D\}$$

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:

$$\mathcal{R} = ABCDEF$$
$$\mathcal{F} = \{ABC \to B, AC \to DE, E \to C, F \to B\}$$

Keys: ACF, AEF

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!