Exercise Sheet 2 (WS 2019)

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 8 tasks and at most 15 points that can be achieved on the entire sheet.

Deadlines

until 06.11.	**12:00 pm**:	Solve the SQL tasks with the online-tool
until 13.11.	**12:00 pm**:	Upload your solution to TUWEL
from 22.11.	1:00 pm:	Evaluation and feedback is available in TUWEL

Consultation Hours (optional)

In the week before the deadline there are consultation hours held by tutors. If you have problems understanding the topics of the exercise sheet or questions about the exercises, you are welcome to just drop in at these consultation hours. The tutors will gladly answer your questions and help you understand the subjects.

The goal of these consultation hours is to help you with **understanding the topics and specific tasks** of the exercise sheet. The tutors will not solve your exercises or check your answers before you hand them in.

Participation is completely voluntary — dates and locations of the consultation hours can be found in TUWEL.

Debriefing (optional)

A few days after you received your feedback and grading of this exercise sheet, there is the opportunity to go through the tasks in small groups (max. 25 persons). The (relative) small group size is intended to enable an active participation. Each of these groups will be held by an assistant. The specific agenda of these meetings will depend on the interests and question of the participants (i.e., you). The main objectives are answering your open questions and resolving your remaining issues regarding the exercises. Therefore, please have a look at your feedback and evaluation to identify such problems before you attend the class. When participating, dare to ask your questions – no question has a (negative) impact on your grade.

Participation is absolutely voluntary. Registration in TUWEL is required to keep the size of the groups small. Dates and locations can be found 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.

SQL

Task 1 (eSQL) [5 points]

Solve **the first 10 SQL tasks (Task 1-10)** in our SQL e-learning tool (eSQL-tool) from the current course (first course in the list). (*Pleas note:* We usually upload more than ten tasks for practicing. You are free to solve these as well – however, only the first 10 tasks will be considered for the grading of this exercise sheet.)

You can access the online tool in TUWEL: Select **eSQL Tool** in the section "2.Übungsblatt". 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.

The mandatory SQL test will also take place on exactly the same platform. We therefore recommend practicing also using the exercises from previous coursed (for two more courses, English translations are available).

Caution!
Separate deadline for finishing the SQL tasks:
Wednesday, November 6, 2019, 12:00 pm!

Normal Forms

Task 2 (Functional Dependencies) [0.4 points]

Consider the following relational schema

`Offer (Coffee, Bean, Country, Roasting, Processing, Type)`

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

Offer					
Coffee	Bean	Country	Roasting	Processing	Type
Alice	Arabica	Brazil	plus	natural	pure
Bob	Arabica	Ecuador	plus	washed	pure
Carol	Arabica	Peru	full	washed	mixed
Carol	Arabica	Honduras	full	natural	mixed
Carol	Robusta	India	plus	washed	mixed
Dan	Arabica	Brazil	full	washed	mixed
Dan	Robusta	India	full	natural	mixed
Eve	Arabica	Indonesia	full	washed	pure
Faythe	Arabica	Ethiopia	plus	natural	mixed
Faythe	Arabica	Guatemala	plus	washed	mixed
Grace	Arabica	Ethiopia	normal	washed	pure
Rupert	Robusta	India	full	washed	pure

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) `Country` $\rightarrow$ `Bean`

(b) `Bean` $\rightarrow$ `Country`.

(c) `Coffee, Bean` $\rightarrow$ `Country`.

(d) `Country` $\rightarrow$ `Bean, Processing`.

(e) `Bean, Country, Roasting` $\rightarrow$ `Coffee, Processing`.

Task 3 (Equivalence of Functional Dependencies) [0.6 points]

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

$$F_1 = \{HI \rightarrow GJ, G \rightarrow KL, IL \rightarrow JK, GK \rightarrow I\}$$
$$F_2 = \{HI \rightarrow GL, G \rightarrow KLI, IL \rightarrow JK, GKH \rightarrow H\}$$

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 functional dependencies from task a). Please show using the Armstrong axioms that $F_1 \models \{HI \rightarrow GL\}$ holds (show your reasoning).

Task 4 (Minimal Cover) [2 points]

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

(a) $\mathcal{F}_1 = \{KLN \rightarrow HI, I \rightarrow KL, H \rightarrow HKI, ILM \rightarrow LM, KH \rightarrow LM, MN \rightarrow IL\}$

(b) $\mathcal{F}_2 = \{JL \rightarrow HM, L \rightarrow I, HMI \rightarrow KN, JL \rightarrow KN, H \rightarrow L, HLM \rightarrow K, HM \rightarrow J, J \rightarrow N\}$

Task 5 (Identifying Keys and Superkeys) [2 points]

For the following relational schemata with their functional dependencies, find *all keys* and *all superkeys*. (*Please note:* For task a), please write down all superkeys. For task b) you **don't need to list all superkeys**; it is sufficient, if the reader can clearly infer the total set of superkeys.)

(a) $\mathcal{R} = FGHIJ$
$F = \{FG \rightarrow GI, FJ \rightarrow I, F \rightarrow G, FI \rightarrow J, H \rightarrow J, I \rightarrow F\}$

(b) $\mathcal{R} = EFGHIJK$
$F = \{GI \rightarrow EF, E \rightarrow K, FJ \rightarrow GE, FE \rightarrow I, IK \rightarrow KJH\}$

Task 6 (Normal Forms) [1 point]

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) $\mathcal{R} = ABCD$,
$\mathcal{F} = \{AB \rightarrow C, C \rightarrow A, B \rightarrow DBA, AC \rightarrow BD\}$

(b) $\mathcal{R} = ABCDEF$
$F = \{ACD \rightarrow BC, BDF \rightarrow CE, EF \rightarrow ABD, AEB \rightarrow CD, ABC \rightarrow BF,$
$AD \rightarrow AC, ACF \rightarrow CF\}$
The keys are given as EF, BDF, ABE, and DA.

Task 7 (Synthesis Algorithm) [2 points]

Consider the following relational schema and its functional dependencies:

$$\mathcal{R} = ABCDEFGH$$
$$\mathcal{F} = \{BCE \to AG, AB \to FH, BG \to C, A \to CH, AF \to B, D \to EF\}$$

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 8 (Decomposition Algorithm) [2 points]

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

$$\mathcal{R} = ABCDEF$$
$$\mathcal{F} = \{F \to C, D \to C, BDE \to AC, ABD \to DEF, BD \to E, EF \to AEB, AD \to CEF\}$$

Keys: DEF, BD, AD

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!