Gruppe **A**

Please fill in your name and registration number (Matrikelnr.) **immediately**.

EXAM ON		07.12.2018
◯ DATENMODELLIERUNG (**184.685**)	◯ DATENBANKSYSTEME (**184.686**)	**GROUP A**
Matrikelnr.	Last Name	First Name

Duration: 60 minutes. Provide the solutions at the designated pages; solutions on additional sheets of paper are not graded. **Good Luck!**

Exercise 1: (7)

a) For the relational schemas (R, F_1) and (R, F_2), where $R = ABCDEFG$, find *all keys*.

FDs	Keys
$F_1 = \{D \to CE, E \to AB, CG \to D, EF \to C\}$	.....
$F_2 = \{F \to CD, D \to B, BG \to D, CD \to AEF\}$	.....

b) Consider the relational schemas (R, F_1), (R, F_2), and (R, F_3), where $R = ABCDEFG$. Determine their corresponding normal forms, and mark the right answers.
Attention: for each correct solution: 1 point, for each wrong solution: -1 point, unanswered questions give 0 points. In total you get at least 0 points.

Dependencies	Keys
$F_1 = \{C \to CF, DF \to ABE, ABD \to BFG, AE \to C, AD \to FG\}$	`AD` , `CD` , `DF`

neither 3NF nor BCNF ◯ 3NF & not BCNF ◯
BCNF & not 3NF ◯ 3NF & BCNF ◯

$F_2 = \{A \to CDG, ADG \to CD, DFG \to ABE, G \to ACF\}$ `A`, `G`

neither 3NF nor BCNF ◯ 3NF & not BCNF ◯
BCNF & not 3NF ◯ 3NF & BCNF ◯

$F_3 = \{AEF \to BE, CD \to AEG, A \to BDG\}$ `ACF`, `CDF`

neither 3NF nor BCNF ◯ 3NF & not BCNF ◯
BCNF & not 3NF ◯ 3NF & BCNF ◯

Exercise 2: (8)

Consider the relational schemas $R(\underline{ABC})$, $S(\underline{BC})$ and $T(\underline{CDE})$.

Assume there exists an instance of R containing 4 tuples, an instance of S containing 3 tuples, and an instance of T containing 4 tuples. Thus

$$R(\underline{ABC})\colon 4 \qquad S(\underline{BC})\colon 3 \qquad T(\underline{CDE})\colon 4$$

Consider the expressions in Relational Algebra given below. For these expressions, provide the minimal and maximal possible size (= number of tuples) of their results over instances for R, S, and T of the given sizes. In addition, provide concrete instances over which the expressions actually realize these bounds, i.e. return results of minimal/maximal size. (Make sure that the provided instances contain exactly the given number of tuples.)

a) **Expression:** $\pi_B(R \ltimes S) \cap \rho_{B \leftarrow C}(\pi_C(S))$

min. size of the result: .....

R		
A	**B**	**C**

S	
B	**C**

max. size of the result: .....

R		
A	**B**	**C**

S	
B	**C**

b) **Expression:** $\pi_C(\sigma_{A=0}(R) \times \rho_{F \leftarrow C}(T)) \cup \rho_{C \leftarrow E}(\pi_E(\sigma_{C=1 \wedge D=1}(T)))$

min. size of the result: .....

R		
A	**B**	**C**

T		
C	**D**	**E**

max. size of the result: .....

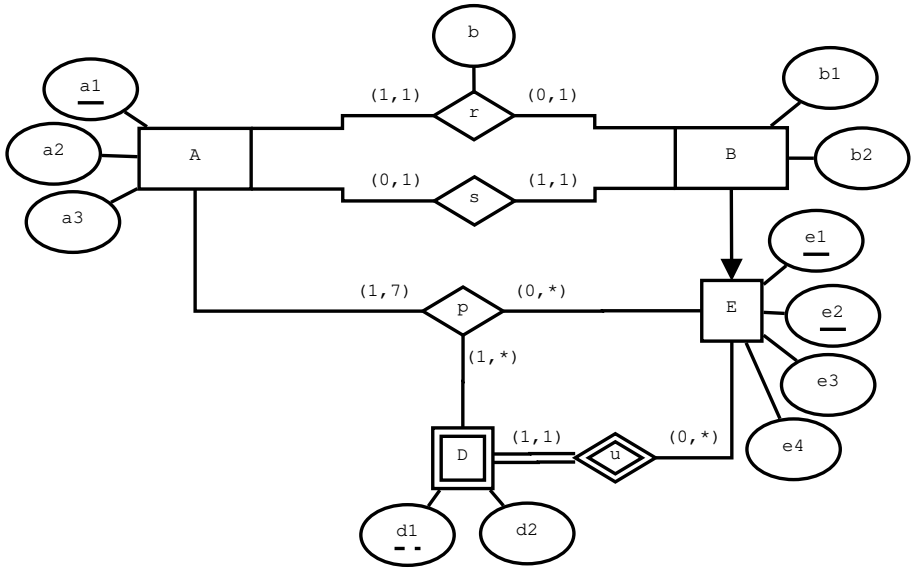
R		
A	**B**	**C**

T		
C	**D**	**E**

Exercise 3: (6)

Construct a relational schema according to the EER-diagram given below. For each relation, clearly mark the primary key by underlining the corresponding attributes. Mark foreign keys (FK) either by prefixing the name of the relation referenced by the FK (i.e., by `Relation.Attribute`) or by using the notation `NameOfAttribute:Relation.Attribute` (where `NameOfAttribute` is the name of the attribute in the current schema and `Relation.Attribute` describes the value that is referenced by the FK).

Create as few relations as possible without introducing any redundancies. Note that the database does not allow `NULL`-values.



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Exercise 4: (9)

Consider the following relational schema on libraries, their books and customers. (Primary keys are underlined, foreign keys are written in *italics*):

`Library`(LIBID, LibName)
`Book`(BID, Author, Published)
`Person`(PID, Student, Name)
`lent`(*LIBID: Library.LIBID*, *BID: Book.BID*, *PID: Person.PID*, from, until)

Whenever some person lents a book, a corresponding entry in the relation `lent` is created. These entries in `lent` are never deleted, thus they remain even once the book is returned.

(In the following, you may use suitable (unique) abbreviations for the names of both, relations and attributes.)

a) Consider the following query in the **domain calculus ("Domänenkalkül")**. Briefly (**1 short sentence!**) describe the values returned by this query. (2 points)

$$\{[pn] \mid \exists pid, ps\big([pid, ps, pn] \in \texttt{Person} \ \wedge \forall libid, libn([libid, libn] \in \texttt{Library} \ \rightarrow \exists bid, a, f, u, p([bibid, bid, pid, f, u] \in \texttt{lent} \ \wedge [bid, a, p] \in \texttt{Book}))\big)\}$$

b) We are looking for the names of all persons who, on the one hand, have already lent some books from the library "TUBib" (LibName), but, on the other hand, have never lent a book by the author "Kemper". Formulate this query in **Relational Algebra**. (3 points)

c) Consider the two queries given below in the tuple- and domain calculus, respectively. The two queries are **not** equivalent. Proof this by completing the counter example on the next page. *It is not necessary to fill all rows in the tables provided.* State the results of the two queries on your counter example. (4 points)

$$\mathbf{Q_1} = \{[b.Author, b.Published] \mid \ b \in \texttt{Book} \ \wedge \forall g \in \texttt{lent}(b.BID = g.BID \ \wedge \exists p \in \texttt{Person}(p.PID = g.PID \ \wedge p.Student = \texttt{true}))\}$$

$$\mathbf{Q_2} = \{[ba, bp] \mid \ \exists bid[bid, ba, bp] \in \texttt{Book} \ \wedge \exists pid, ps, pn([pid, ps, pn] \in \texttt{Person} \ \wedge ps = \texttt{true} \ \wedge \exists libid, f, u([libid, bid, pid, f, u] \in \texttt{geliehen})\}$$

Hint: The columns `lent.from`, `lent.until` *and* `Person.Name` *can be ignored for the counter examples.*

Book		
BID	**Author**	**Published**
1	A	1970
2	B	2000

Person		
PID	**Student**	**Name**
		—
		—
		—
		—

lent				
LIBID	**BID**	**PID**	**from**	**until**
			—	—
			—	—
			—	—
			—	—

Result Q_1:

Result Q_2:

Exercise 5: (7)

Consider the relational schema $ABCDEFGH$ and the set F_d of functional dependencies. Determine a canonical cover F_k of F_d. Beside the final result, also state the intermediate results as requested below.

$$F_d = \{AF \to GD, A \to AH, F \to BC, ABG \to H, C \to CD, AG \to B, CDH \to G\}$$

(a) Provide an equivalent set of FDs without extraneous attributes on their left hand sides (i.e., the result of reducing the LHS):

$F_l = \{$ $\}$

(b) Provide a redundant free set of FDs equivalent to F_l (that still contains no extraneous attributes on the LHS, i.e. the result of reducing the right hand sides):

$F_r = \{$ $\}$

(c) State a canonical cover of F_d:

$F_k = \{$ $\}$

Exercise 6: (8)

The instructions for this exercise are provided on the next page.

Overall: 45 points

You may separate this page form the exam and keep this page.

Thus, please do not provide any solutions on this page! Solutions written on this sheet will not be graded!

Instructions for Exercise 6:

A friend of yours plans to realize his childhood dream of running his own auction house before Christmas, in order to benefit from the abundance of unwanted Christmas gifts. He therefore asks you to help him by quickly designing a database for managing his auctions.

Create an EER-diagram based on the information described below. Use the (min,max) notation. The model shall work without using `NULL`*-values and redundancies shall be avoided.*

For each auction, the date (DATE), a description (DESC), and a theme (THEME) are recorded, whereat no two auctions with the same description can take place at the same day. Items have an initial price (SPRICE), an article number (ARTKLNO), and a catalog number (CATNO), with the article number and the catalog number each being unique.

For each item a number of bids may be entered. Bids for the same item can be distinguished by a number (NR), bids for different items may share the same number. In addition, for each bid the amount (AMOUNT) and the time (TIME) of the bid are recorded.

Each bid is made by exactly one bidder. Bidders are uniquely identified by their bidder-number (BNR) and their date of birth (DOB).

In addition, a bidder may state to an arbitrary number of items a value (VALUE) for which she or he would be willing to purchase the item outside/without an auction.

To each auction, between one and ten auctioneers are assigned. Auctioneers have a unique name (NAME), and in addition a field of expertise (EXP).

It shall be recorded which auctioneer offered which item at which auction, together with the exact time the auctioning of this particular item started. Note that at each auction, at least five items must be offered, and that each item can be offered at most once.

Good Luck!