Gruppe **A**

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

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◯ 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 considered. **Good Luck!**

Exercise 1: (6)

Consider the relational schema $R = ABCDE$ and the set of functional dependencies $F = \{A \to BE, E \to D, A \to D\}$.

a) For each of the following subschemas of (R, F) state all keys, all valid, non-trivial functional dependencies, and whether the schema is in $BCNF$ or not. (4 points)

subschema	valid FDs	keys	in BCNF?
$R_1 = ABE$	.....	.....	◯ yes ◯ no
$R_2 = ACD$	.....	.....	◯ yes ◯ no
$R_3 = DE$	.....	.....	◯ yes ◯ no
$R_4 = ABED$	.....	.....	◯ yes ◯ no

b) Determine if the following subschemas of (R, F) preserve all functional dependencies. If the decomposition is not dependency preserving, state the lost (non-trivial) FDs. (2 points)

decomposition	preserves dependencies	lost FDs
(R_1, R_3)	◯ yes ◯ no	.....
(R_1, R_2)	◯ yes ◯ no	.....

Exercise 2: (2)

State all keys of the given set of FDs over the relational schema $R = ABCDEFG$.

functional dependencies	keys
$F_1 = A \to DEF, B \to CE, FG \to A, F \to G$	.....

Exercise 3: (6)

Given a relational schema $ABCDEFGH$ and the set F_d of functional dependencies. The canonical cover of F_d has to be determined.

$$F_d = \{A \to ABE, B \to CD, C \to DEFGH, D \to E, G \to H\}$$

The left-hand sides of the FDs in F_d are already minimal. Using the table below, state which FDs in F_d have to be removed in order to obtain a canonical cover of F_d.

FD	has to be removed?	justification (e.g. a list of FDs)
$A \to A$	◯ yes ◯ no	.....
$A \to B$	◯ yes ◯ no	.....
$A \to E$	◯ yes ◯ no	.....
$B \to C$	◯ yes ◯ no	.....
$B \to D$	◯ yes ◯ no	.....
$C \to D$	◯ yes ◯ no	.....
$C \to E$	◯ yes ◯ no	.....
$C \to F$	◯ yes ◯ no	.....
$C \to G$	◯ yes ◯ no	.....
$C \to H$	◯ yes ◯ no	.....
$D \to E$	◯ yes ◯ no	.....
$G \to H$	◯ yes ◯ no	.....

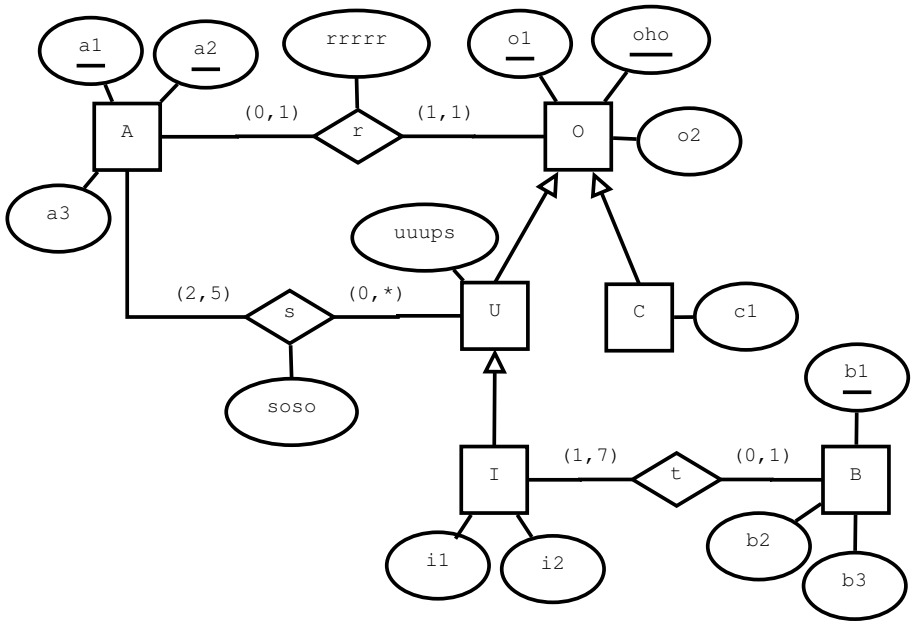
Thus the canonical cover F_c of F_d is:

$F_c = \{$ $\}$

Exercise 4: (7)

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 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 5: (8)

a) Assume the two schemas `R(ABC)` and `S(ADC)` together with two **non-equivalent** statements q_1 (relational algebra) and q_2 (domain calculus).

Provide an instance for both, `R` and `S` such that q_1 and q_2 return different results on these instances. In addition, give the result of evaluating q_1 and q_2 over the instances you provided. (2 points)

$q_1 = R \ltimes S$
$q_2 = \{[r_A, r_B, r_C] \mid [r_A, r_B, r_C] \in R \wedge \exists d, c([r_A, d, c] \in S\}$

(You do not have to use all of the rows provided in the tables – please strike out unnecessary rows – and you can also add additional rows as needed. In the tables holding the results of the expressions, please create columns as needed.)

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

S		
A	**D**	**C**

q_1

q_1

b) Given the following relational schema for a Database documenting Quality Control of a tissue factory. (Primary keys are underlined, foreign keys are written in italics):

Model(Name, layers, paper, absorptivity)
Tester(SVNR, number, SizeOfNose, ShapeOfNose)
starts_test(*SVNR: Tester.SVNR*, *Name: Model.Name*, date)
ends_test(*SVNR: Tester.SVNR*, *Name: Model.Name*, date, report)
Whenever a tester starts testing a model, an entry in the relation `starts_test` is created. Once the testing is over, a corresponding entry in `ends_test` is created. You may thus assume that the date in `ends_test` is always bigger than the date in the corresponding entry in `starts_test`.

At the start of the flu-season management requires some information from the database. Write expressions in **Relational Algebra** answering the following questions. (You may use suitable unique abbreviations for the names of relations and attributes.)

i) For each tester return all models she/he neither tested in the past nor is currently testing. The result shall be of the form (SVNR, Name). (3 points)

ii) Return all models currently being tested by testers having a nose size of at least 3 (meaning models they have started testing but have not yet finished testing). (3 points)

Exercise 6: (8)

Consider the relational schemas $R(\underline{A}C)$, $S(\underline{B}C\underline{D})$ and $T(\underline{B}E\underline{D})$.

Assume there exists an instance of R containing 3 tuples, an instance of S containing 2 tuples, and an instance of T containing 4 tuples. Thus

$R(\underline{A}C)$: 3 $\quad$ $S(\underline{B}C\underline{D})$: 2 $\quad$ $T(\underline{B}E\underline{D})$: 4

Provide the minimal and maximal size (= number of tuples) of the result of the following expressions in Relational Algebra evaluated over instances of a fixed size. In addition, provide concrete instances over which the expressions actually realize these bounds, i.e. return results of minimal/maximal size. (Take care that the provided instances contain exactly the given number of tuples.)

a) **expression:** $\sigma_{A=2}(R) \cup \pi_{AC}\big(\rho_{A \leftarrow B}(\sigma_{B=3}(S))\big)$

min. size of result: .....

R	
A	**C**

S		
B	**C**	**D**

max. size of result: .....

R	
A	**C**

S		
B	**C**	**D**

b) **expression:** $T \div \pi_{BD}(S)$

min. size of result: .....

T		
B	**E**	**D**

S		
B	**C**	**D**

max. size of result: .....

T		
B	**E**	**D**

S		
B	**C**	**D**

Exercise 7: (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 7:

To keep up with the coming- and going of politicians in this country, you are asked by a friend to design a database. 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.*

Attention!! Note that the scenario described below is heavily simplified and is not necessarily a faithful description of reality. In any case, please model the facts stated below!

For each person the first name (FNAME), last name (LNAME), and some typical property (PROPERTY) shall be stored. No two persons may have the same name (i.e., equal first- and last name).

Each party has a unique color (COLOR) and in addition a (not necessarily unique) acronym (ACR).

Each legislative period is uniquely identified by its start (START) and its end (END). Each agenda of the cabinet has a unique denotation (DENO). In addition, there is a description (DESCR) of each agenda.

It shall be recorded which person in which legislative period was responsible for which agendas. Also, for each legislative period shall be stored which agendas were located in which ministry. Each ministry has a unique name (NAME) and a budget for public relations (PRBUD). At least one agenda must be located in each ministry (in some legislative period). Furthermore, during each legislative period there exist at least three agendas.

In addition, it shall be stored how many votes each party got in the different legislative periods.

Each time a person joins a party an unique member number (NR) within the corresponding party is stored. Also, the date (DATE) of the person joining is stored together with the information which person joined the party (at each such event, exactly one person joins a party).

Good Luck, Merry Christmas, and relaxing holidays!