

Gruppe A

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

EXAM AUS		26.08.2020
<input type="radio"/> DATENMODELLIERUNG 2 (184.790)		<input type="radio"/> DATENBANKSYSTEME (184.686) GROUP A
Matrikelnr.	Last Name	First Name

Duration: 90 minutes. Provide the solutions at the designated pages; solutions on additional sheets of paper are not considered. **Good Luck!**

Attention!

To all questions with a multiple choice option, the following rule applies: Just checking an option gives no points; points are only granted in combination with the required justification/example/...

Notation:

In exercises 1 – 3, the following notation (as known from the lecture slides and exercises) for transactions T_i is used:

- $r_i(O)$ and $w_i(O)$: Read, respectively write operation of transaction T_i on object O .
- b_i , c_i , a_i : begin (BEGIN OF TRANSACTION), commit (COMMIT) and abort (ABORT/ROLLBACK) of T_i .

The indices i can be omitted if it is clear which transaction an operation belongs to.

In addition, log records also have the same format as used throughout the lecture:

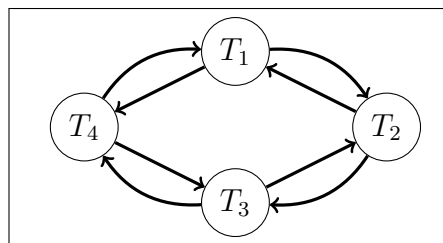
[LSN, TA, PageID, Redo, Undo, PrevLSN] for “normal” records,
[LSN, TA, BOT, PrevLSN] for BOT log-records, and
[LSN, TA, COMMIT, PrevLSN] for COMMIT records.

Compensation log records (CLRs) follow the format $\langle \text{LSN, TA, PageID, Redo, PrevLSN, UndoNextLSN} \rangle$ and $\langle \text{LSN, TA, BOT, PrevLSN} \rangle$

In these records, LSN denotes the Log-Sequence Number, TA the transaction, PageID the page that was updated, Redo and Undo the information needed for the Redo resp. Undo operations, UndoNextLSN the LSN of the next log record of the same transaction to be undone, and PrevLSN the LSN of the previous log record of the same transaction.

In case of logical logging, the changes to the previous value of the database instance are stated only using *addition* and *subtraction*, e.g. $[\cdot, \cdot, \cdot, X+=d_1, X-=d_2, \cdot]$.

a) Consider the precedence graph (“Serialisierbarkeitsgraph”) shown right. Give a schedule of the four transactions T_1 , T_2 , T_3 and T_4 that produces *exactly* this precedence graph. Amount and names of the database fields can be chosen freely. For each transaction, state its begin (b_i) and end (c_i).



b) Is each correct solution to exercise a) **conflict serializable**?
 If yes, provide a conflict equivalent, serial execution order of the transaction.
 If not, state a minimal set of transactions that had to be removed for all correct solutions to be conflict serializable. In addition, state for the remaining transactions a conflict equivalent, serial execution order.

all correct schedules are conflict serializable: ☐ yes ☐ no

(if “no”) remove transaction(s):

Conflict equivalent, serial order of the (remaining) transactions:

c) Consider the schedule of the transactions T_1 , T_2 , T_3 , and T_4 given below. Determine whether the schedule is **strict**, and provide a short (1 sentence) justification.

T_1	b	$r(B)$	$w(A)$	$w(B)$	$w(D)$	c
T_2	b	$r(A)$			$w(A)$	a
T_3	b	$r(B)$		$r(D)$		$w(B)$
T_4	b	$w(C)$			$r(B)$	$r(A)$
						$w(C)$

Schedule is strict: ☐ yes ☐ no

Justification:

Exercise 2: Logging and Recovery (11)

Consider the following schedule, which is given as the sequence of basic operations on the records A , B , C , and D of the three transactions T_1 , T_2 , and T_3 . Assume that each record X is located on page P_X , and that the initial values are $A = B = C = D = 20$.

Schritt	T_1	T_2	T_3
1	BOT		
2	$r(A, a_1)$		
3			BOT
4			$w(C, 4)$
5		BOT	
6		$r(B, b_2)$	
7		$r(D, d_2)$	
8	$w(A, a_1 - 1)$		
9			$r(B, b_3)$
10	ROLLBACK		
11			$r(A, a_3)$
12		$w(B, b_2 + d_2)$	
13			$w(C, a_3 - 1)$
14		$w(A, b_2 + d_2)$	

a) Between steps 12 and 13, a “operation consistent” checkpoint is created (no active read/write operation while checkpoint is created).

i) State the content of the pages P_B and P_C (LSN, values of B and C) in the persistent storage **immediately after creating the checkpoint**.

Assumption: Each log record receives as LSN the number of the step of the corresponding action.

P_B	LSN:	
$B =$		
P_C	LSN:	
$C =$		

ii) What is the latest step the Redo-Phase can now start at? To which step must the Undo-Phase go back?

Redo: Undo:

b) Provide all log records that are created when executing the schedule (when using the logging protocol presented in the lecture). All actions necessary for performing the ROLLBACK in step 10 are to be executed before the action in step 11. Use logical logging.

(This task is independent of a), i.e. there is no checkpoint and the LSN can be chosen freely.)

[#1, T_1 , BOT, #0], [#2, T_3 , BOT, #0]
.....
.....
.....
.....

c) Assume that after step 14 a recovery (using the ARIES algorithm) is performed due to a loss of the non-persistent memory. Assume further that immediately after the recovery has finished *successfully*, yet another crash with loss of the non-persistent memory occurs.

How many log records are created during the recovery after this second crash?

Number of log records:

Exercise 3: Locking/Concurrency Control

(10)

a) Two transactions T_1 and T_2 are given by the following basic operations:

- $T_1: b_1, r_1(D), w_1(A), r_1(B), r_1(A), w_1(C), c_1$
- $T_2: b_2, w_2(B), r_2(C), w_2(C), r_2(A), c_2$

Both transactions use the following lock-protocol: For exclusive locks a “normal” Two-Phase Locking protocol (2PL) is used. Locks are requested as late as possible and released at the earliest possible moment.

Share locks are requested directly before each read operation and released immediately after (no 2PL). The release of share locks does not influence the 2PL for exclusive locks.

State a schedule (=sequence of basic operations) of the two transactions T_1 and T_2 which *results in a deadlock*. State the schedule only until the deadlock occurs, and make sure that blocked transactions do not execute any further operations (but please state the operation that leads to the transaction being blocked).

(E.g., if T_1 would block at $r_1(D)$, then $r_1(D)$ should be stated, but not $w_1(A)$.)

b) *The unavoidable, Covid-19 inspired, task:*

In a factory workshop, components are assembled. Usually workers share the required tools. Covid-19 regulations now require tools to be disinfected before being used by another person. To reduce the number of disinfections, following rules have been formulated:

- Each component is assembled by exactly one person.
- Once the work on a component has started, it **is neither aborted nor paused**.
- Tools are only allowed to be passed on when they are no longer needed for the assembly of the component.

The first attempt of implementing this strategy lead to occasional deadlocks. Which of the locking protocols presented in the lecture could be used to solve this problem? Describe possible prerequisites for the protocol(s) to work and a possible alternative, if these prerequisites are not met.

Tasks 4–6 are all based on the database schema described on this page.

Exercise 4: Defining a database schema using SQL and dependencies

(11)

a) The following schema is given:

```
artist      (name, zodiac, mainMovement: movement.title)
movement    (title, repName: artist.name, repZodiac: artist.zodiac)
follows      (name: artist.name, zodiac: artist.zodiac, movement: movement.title)
influence     (from: movement.title, to: movement.title)
```

Each artist (**artist**) has a name and a zodiac sign, the combination of these two is unique. In addition, it is recorded which is her/his most influential art movement (**mainMovement**). Zodiac signs are implemented as Enum, with the database only allowing the values “Aries”, “Virgo”, and “Leo”. Each artistic movement has a unique name. In addition, each movement has a representative (**repName**, **repZodiac**). Each artist may follow one or more movements, recorded in the table (**follows**). The combination of artist and movement is unique. Finally, influences between different movements is stored as well (**influence**). The table records which movement (**from**) influences which other movement (**to**). The combination of two movements is unique.

Provide the necessary SQL statements to create the described schema, with all described integrity constraints. Choose appropriate types for attributes. **You may use VC in place of VARCHAR(100).**

Hint: Take care of the order of your statements.

b) Consider the following database instance:

Movement			Artist		
title	repName	repZodiac	name	zodiac	mainMovement
Post-Impressionism	Paul Cézanne	Aries	Claude Monet	Aries	Expressionism
Impressionism	Claude Monet	Aries	Edvard Munch	Leo	Impressionism
Fauvism	Henri Matisse	Virgo	Gino Severini	Aries	Futurism
Cubism	Pablo Picasso	Aries	Henri Matisse	Virgo	Cubism
Futurism	Gino Severini	Aries	Pablo Picasso	Aries	Expressionism
Expressionism	Edvard Munch	Leo	Paul Cézanne	Leo	Fauvism

Check whether this database instance satisfies the schema from a). If not, please list the tuples that violate the schema and provide a **simple** explanation (1 sentence!) of the problem.

Database instance satisfies the schema from a) ☐ yes ☐ no

Exercise 5: Recursive Queries

(12)

Create a recursive SQL query/

Based on the schema from Exercise 4 a), implement the following query:

The table **influence** defines which (arts-) movement influenced which other movements. We are looking for all movements that were – directly or indirectly – influenced by the main movement of the artist ('Klimt', 'Leo'), including the main movement of ('Klimt', 'Leo') itself. With the exception of the main movement of ('Klimt', 'Leo'), only movements that are the main movement of at least two artists shall be taken into account.

The result shall contain the title of the movements, with no title occurring more than once.

Formulate this query in SQL.

Note: Make sure your query terminates.

Exercise 6: PL/SQL Trigger

(12)

Assume the **functions and triggers** are defined as stated on **page T** (towards the end of this exam). The following tasks are based on the database instance shown on **page B** (last page of the exam).

Each of the following tasks consists of a SQL statement which is executed every time **on the original database instance** shown on page B. (This means, that the statement in task a) has no effect for the solution of task b), and so forth.) Provide the results of the **SELECT**-statements. **In case an error would occur, state what this error is.**

You are free to use arbitrary shorthand notations in your answers (as long as they can be uniquely identified).

a)

```
UPDATE movement SET repname='Mucha' WHERE title='Jugendstil';
```

```
SELECT * from movement WHERE title='Jugendstil';
```

```
SELECT name, movement from follows;
```

b)

```
BEGIN;  
UPDATE movement SET title='Romantizismus' WHERE repname='Goya';  
DELETE FROM follows WHERE movement = 'Glas';  
COMMIT;
```

```
SELECT * from movement WHERE repname='Goya';  
SELECT * from follows WHERE movement = 'Glas';
```


c)

```
UPDATE movement SET repname = 'Titian', repZodiac = 'Jungfrau';
```

```
SELECT * from movement;
```

```
SELECT count(*) from follows;
```

Overall: 70 points

Good Luck!

You may separate this page from 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!

Trigger for Task 6:

```
CREATE FUNCTION upB() RETURNS TRIGGER AS $$  
BEGIN  
    IF (OLD.repZodiac = 'Aries') THEN  
        RETURN OLD;  
    END IF;  
  
    IF (OLD.repName != NEW.repName OR  
        OLD.repZodiac != NEW.repZodiac) THEN  
        DELETE FROM follows WHERE name = OLD.repName AND stern = OLD.repZodiac;  
        RETURN NEW;  
    END IF;  
  
    RETURN NEW;  
END;  
$$ LANGUAGE plpgsql;
```

```
CREATE TRIGGER trB BEFORE UPDATE ON movement  
    FOR EACH ROW EXECUTE PROCEDURE upB();
```

```
CREATE FUNCTION delF() RETURNS TRIGGER AS $$  
BEGIN  
    IF OLD.zodiac = 'Virgo' THEN  
        RETURN NULL;  
    END IF;  
    RETURN OLD;  
END;  
$$ LANGUAGE plpgsql;
```

```
CREATE TRIGGER trF BEFORE DELETE ON follows  
    FOR EACH ROW EXECUTE PROCEDURE delF();
```


Sample instance for Task 6:

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

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Artist

name	zodiac	mainMovement
Klimt	Lion	Jugendstil
Mucha	Lion	Jugendstil
Bresson	Lion	Surrealismus
Da Vinci	Aries	Renaissance
Goya	Aries	Romantik
Botticelli	Aries	Renaissance
Chihuly	Virgo	Glas
Titian	Virgo	Renaissance

Movement

titel	repName	repZodiac
Jugendstil	Klimt	Lion
Surrealismus	Bresson	Lion
Renaissance	Da Vinci	Aries
Glas	Chihuly	Virgo
Romantik	Goya	Aries

Follows

name	zodiac	movement
Klimt	Lion	Romantik
Klimt	Lion	Jugendstil
Mucha	Lion	Jugendstil
Titian	Virgo	Romantik
Da Vinci	Aries	Jugendstil
Bresson	Lion	Glas
Chihuly	Virgo	Glas