Department of Computer Science

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PARIS LODRON UNIVERSITÄT SALZBURG

Datenbanken I — Exam
Sommersemester 2023 — 19.09.2023

Name: _____ **Student ID:** _____

Hints

- Check whether you received all pages of the exam (11 pages).
- Write your name or your student ID on each sheet of the exam and hand in all pages.
- All answers are expected to be written on the exam sheets.
- Clearly highlight and enumerate additional pages that are used for longer answers. Match your text with the according exercise.
- Only use pencils that are permanent and non-red colored.
- Use the notation and techniques discussed in the lecture.
- Exercises with more than one solution are not graded.
- You are allowed to use one A4 sheet with your personal notes (both sides, hand written or printed).
- Exam duration: 90 minutes

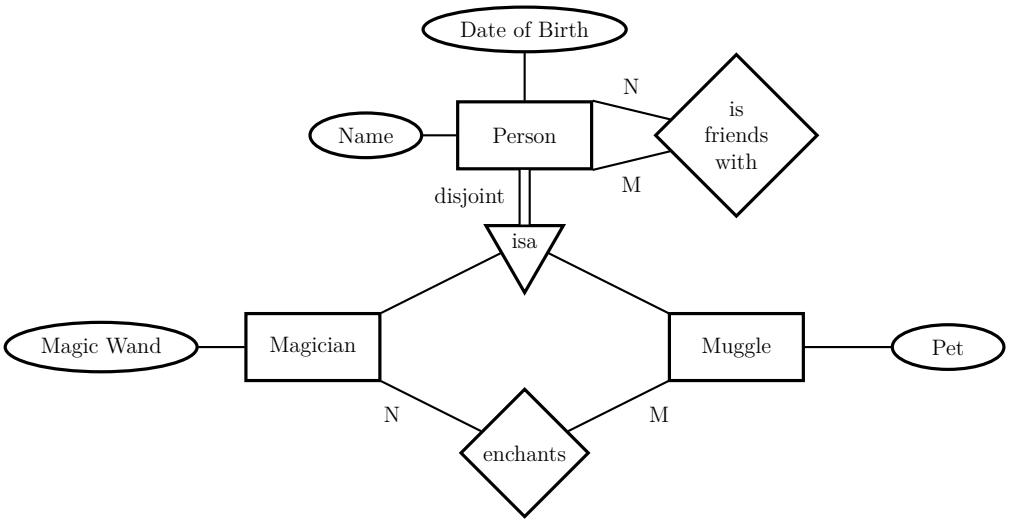
Signature _____

Grading — Filled by the examiner

Exercise	1	2	3	4	5	6	7	8	9	Sum
Total points	1	1	1	1	1	1	1	1	1	9
Points reached										

Exercise 1 — 1 Point

Mark the following statements as true (**T**) or false (**F**) with respect to the given ER-diagram.



1. A person can be a magician and a muggle. ☐
2. A muggle must be enchanted by at least one magician. ☐
3. A magician can be friends with a muggle. ☐
4. A muggle may have a magic wand. ☐
5. Every person can have a pet. ☐

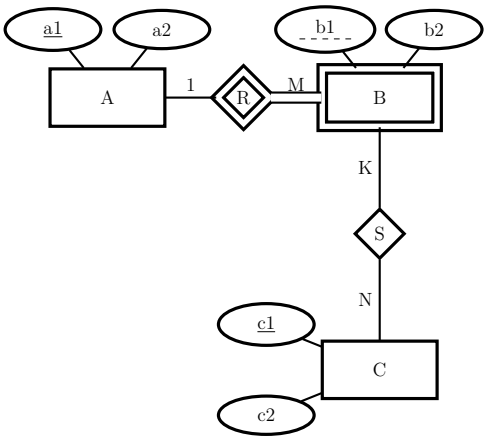
Exercise 2 — 1 Point

Draw an **ER-diagram** which satisfies the following requirements:

1. Each property has a unique plot number.
2. A property can have furniture associated with it. Each piece of furniture has to belong to a property.
3. The furniture id combined with the property's plot number is unique.
4. A person has a unique social security number (SSN) and a name.
5. A property can be owned by more than one person. A person can own several properties.
6. A property can be a house or an appartment.

Exercise 3 — 1 Point

Translate the following ER-diagram into a **relational schema** and state all **foreign key constraints** using projection and subset operations.



Relational Schema (0.5 Punkte)

Foreign Key Constraints (0.5 Punkte)

Schema for the following exercises

Relational schema

Character(<u>name</u>, species, hometown)

Game(<u>title</u>, release_year, developer, platform)

AppearsIn(<u>character_name</u>, <u>game_title</u>, <u>role</u>)

Genre(<u>game_title</u>, <u>type</u>)

Foreign key constraints

$\pi_{\text{character\_name}}(\text{AppearsIn}) \subseteq \pi_{\text{name}}(\text{Character})$

$\pi_{\text{game\_title}}(\text{AppearsIn}) \subseteq \pi_{\text{title}}(\text{Game})$

$\pi_{\text{game\_title}}(\text{Genre}) \subseteq \pi_{\text{title}}(\text{Game})$

Instance for the following exercises

(C)haracter

name	species	hometown
Bowser	koopa	Koopa Kingdom
Donkey Kong	ape	Kongo Bongo Island
Link	human	Hyrule
Funky Kong	ape	Kongo Bongo Island
Mario	human	Mushroom Kingdom
Princess Zelda	human	Hyrule
Samus	hybrid	Earth Colony K-2L
Wario	human	Mushroom Kingdom

(Ge)nre

game_title	type
Donkey Kong	platform
Metroid Dread	action
Metroid Dread	platform
Super Mario Odyssey	adventure
Super Mario Odyssey	platform
Super Smash Bros	fighting
TLoZ: Ocarina of Time	adventure
TLoZ: Ocarina of Time	action

(Ga)me

title	release_year	developer	platform	sales
Donkey Kong	1981	Nintendo	Arcade	152,000
Metroid Dread	2021	Mercury Steam	Switch	2,900,000
Super Mario Odyssey	2017	Nintendo	Switch	25,760,000
Super Smash Bros	1999	HAL	N64	5,550,000
TLoZ: Ocarina of Time	1998	Nintendo	N64	7,400,000

(A)ppearsIn

character_name	game_title	role
Bowser	Super Smash Bros	other
Bowser	Super Mario Odyssey	antagonist
Donkey Kong	Donkey Kong	antagonist
Donkey Kong	Super Smash Bros	other
Link	Super Smash Bros	other
Link	TLoZ: Ocarina of Time	protagonist
Mario	Super Smash Bros	other
Mario	Super Mario Odyssey	protagonist
Princess Zelda	TLoZ: Ocarina of Time	other
Samus	Super Smash Bros	other
Samus	Metroid Dread	protagonist

Exercise 4 — 1 Point

Given the following query in **relational algebra**:

$$\pi_{\text{game\_title}}(\sigma_{\text{hometown='Koopa Kingdom'}}(\text{Character}) \bowtie_{\text{character\_name=name}} (\text{AppearsIn}))$$

1. Describe the result of the query in natural language (in 1-2 sentences). (**0.2P**)

2. Provide the output of the result with respect to the example instance. (**0.4P**)

3. Provide a query in extended relational algebra that computes the following:
All characters which do not appear in any of the games. (**0.4P**)

Exercise 5 — 1 Point

Formulate the following queries using **SQL**. The data of the instance on page 5 is exemplary, hence, always provide solutions that are generally valid.

1. All protagonists (characters with role "protagonist") without duplicates that do not appear in games developed by Nintendo. (**0.4P**)

2. The year of each character, in which the character appeared the last time in a game. Characters not occurring in any game can be ignored. (**0.6P**)

Exercise 6 — 1 Point

Formulate the following query using **SQL**. The data of the instance on page 5 is exemplary, hence, always provide solutions that are generally valid.

For each character, the total number of sold games in which the character occurs. Characters not appearing in any game should be considered as well. Also, only characters where the total number of sold games does not exceed 10,000,000 should be in the result. (**1P**)

Exercise 7 — 1 Point

Consider relation $R[A, B, C, D, E, F, G]$ with the following functional dependencies:

$$\begin{aligned} F = \{&BC \to E, \\ &DE \to G, \\ &FG \to A, \\ &A \to E, \\ &G \to D, \\ &F \to C\} \end{aligned}$$

Find and list all candidate keys of R. **Explain your answer.**

Exercise 8 — 1 Point

Use the Armstrong axioms to show the soundness of the union rule:

$$X \to Y, X \to Z \vDash X \to YZ$$

Hint: The Armstrong axioms are given by:

- Reflexivity: $Y \subseteq X \vDash X \to Y$
- Augmentation: $X \to Y \vDash XZ \to YZ$
- Transitivity: $X \to Y, Y \to Z \vDash X \to Z$

Exercise 9 — 1 Point

Consider relation $R[A, B, C, D, E, F]$ (already in first normal form – 1NF) with the following functional dependencies:

$$\begin{aligned} F = \{ & E \to C, \\ & BC \to E, \\ & ACDE \to B, \\ & E \to CD, \\ & A \to F \} \end{aligned}$$

Is relation R in 2NF? Explain your answer.

Which functional dependencies violate either 3NF or BCNF?

	Violates 3NF	Violates BCNF
$E \to C$	☐	☐
$BC \to E$	☐	☐
$ACDE \to B$	☐	☐
$E \to CD$	☐	☐
$A \to F$	☐	☐