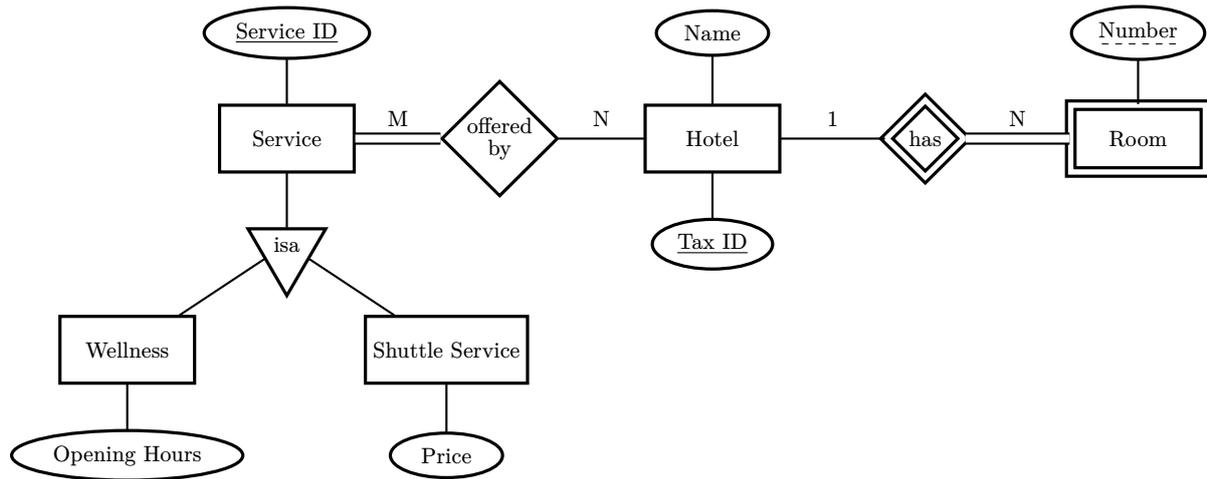


Exercise 1

1 Point

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



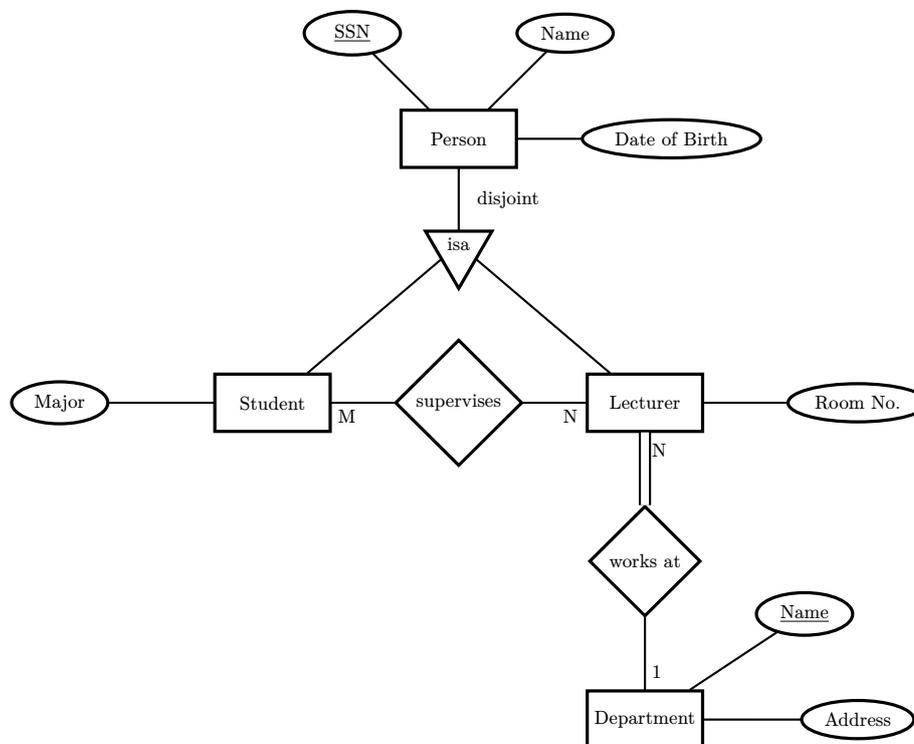
1. There can be hotels which offer no services.
2. There can be more than one hotel with the same name.
3. Every service has a price.
4. There can be services which are neither wellness nor a shuttle service
5. A service can be wellness and shuttle at once.
6. There may be rooms with the same number in different hotels.
7. There can be a room without a hotel.
8. A hotel must have at least one room.

Exercise 2

1 Point

Correct the ER diagram to satisfy the following requirements:

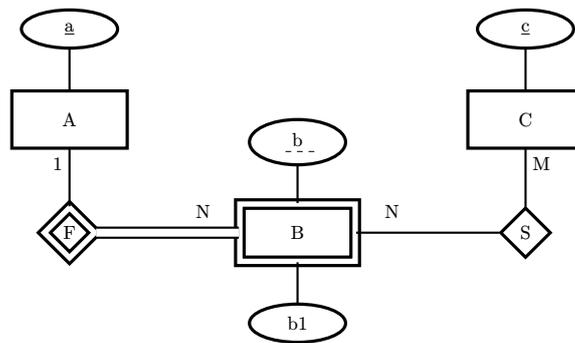
1. A person can be both a student and a lecturer.
2. A student has an address.
3. A lecturer must supervise exactly one student.
4. A lecturer must work in one or several departments.
5. A student can take exams and each exam can be taken by multiple students.



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)

This schema is used for the following exercises

Relational schema

Superhero(hero_name, firstname, lastname, birthplace)

Mission(mission_id, description, priority, time)

City(stadt_name, state, population)

MissionAssignment(mission_id, hero_name, city_name)

Foreign keys

$\pi_{\text{birthplace}}(\text{Superhero}) \subseteq \pi_{\text{city_name}}(\text{City})$

$\pi_{\text{hero_name}}(\text{MissionAssignment}) \subseteq \pi_{\text{hero_name}}(\text{Superheld})$

$\pi_{\text{mission_id}}(\text{MissionAssignment}) \subseteq \pi_{\text{mission_id}}(\text{Mission})$

$\pi_{\text{city_name}}(\text{MissionAssignment}) \subseteq \pi_{\text{city_name}}(\text{City})$

Database instance for the following exercises

| City | | | MissionAssignment | | |
|------------|---------|------------|-------------------|-----------------|------------|
| city_name | state | population | mission_id | hero_name | city_name |
| Berlin | Germany | 4M | 1 | Batman | Gotham |
| Dayton | US | 140500 | 57 | Black Widow | Dayton |
| Gotham | US | 30M | 81 | Superman | Metropolis |
| Kandor | Krypton | 8M | 196 | Captain America | Berlin |
| Manhattan | US | 2M | 272 | Hulk | Manhattan |
| Metropolis | US | 23M | 272 | Iron Man | Manhattan |
| Stalingrad | Russia | 1M | 272 | Captain America | Manhattan |
| Tokyo | Japan | 10M | 272 | Black Widow | Manhattan |
| Waverly | US | 10000 | 521 | Iron Man | Waverly |

Superhero

| hero_name | firstname | lastname | birthplace |
|-----------------|-----------|----------|------------|
| Batman | Bruce | Wayne | Gotham |
| Black Widow | Natasha | Romanoff | Stalingrad |
| Captain America | Steven | Rogers | Manhattan |
| Hulk | Bruce | Banner | Dayton |
| Iron Man | Tony | Stark | Manhattan |
| Superman | Kal | El | Kandor |
| Hawkeye | Clinton | Barton | Waverly |

Mission

| mission_id | description | priority | time |
|------------|---|----------|------------|
| 1 | Vanquish the nefarious Joker | 8 | 3.10.2008 |
| 57 | Pacify the formidable Hulk | 7 | 28.9.2010 |
| 81 | Rescue the intrepid Lois Lane | 7 | 19.7.1968 |
| 196 | Combat the insidious Hydra organization | 9 | 2.4.1944 |
| 272 | Thwart the omnipotent Thanos | 10 | 8.7.2019 |
| 521 | Liberate the captive Pepper Potts | 7 | 11.12.2022 |

The space above and below the message intentionally is left blank.

Exercise 4

1 Point

The following query is given in **relational algebra**:

$$\pi_{\text{hero_name}}(\text{Superhero} \triangleright \text{MissionAssignment})$$

- (1) Describe in natural language (in 1-2 sentences) what the query calculates.

- (2) Provide the result based on the example instance.

- (3) Provide a query in extended relational algebra that calculates the following:

The first- and lastname of all superheroes born in US.

Exercise 5

1 Point

Formulate the following queries using **SQL**. The data of the instance on page 5 are exemplary. Always provide solutions that are generally applicable.

(1) List all hero names (without duplicates) that are assigned to a mission after timestamp '1.1.2019'.

(2) List for each state (not city) that has at least two missions assigned, the number of assigned missions.

Output schema: `state | number_missions`

Exercise 6

1 Point

$R[\underline{A}, B]$ and $S[\underline{D}, \underline{E}, \underline{F}]$ are relations; underlined attributes together form a key; no attribute can have null values.

Consider the following SQL query. Decide for each of the following queries if it is equivalent (E) or not equivalent (NE) to the given SQL query. Subtle differences between the queries are highlighted. **Wrong answers result in point deductions!**

```
select distinct R.A
from R, S
where R.A = S.D
group by R.A
having count(*) >= 2
```

1.

```
select distinct R.A
from R, S as S1, S as S2
where R.A = S1.D and R.A = S2.D
and not (S1.E = S2.E and S1.F = S2.F)
```

2.

```
select distinct R.A
from R, S
where R.A = S.D
group by R.A, R.B
having count(*) >= 2
```

3. $\pi_A(R \bowtie_{A=D} S \bowtie_{D=D_1 \wedge E \neq E_1 \wedge F \neq F_1} (\rho_{[D_1, E_1, F_1]}(S)))$

4. $\pi_A(R \bowtie_{A=D} S \bowtie_{D=D_1 \wedge (E \neq E_1 \vee F \neq F_1)} (\rho_{[D_1, E_1, F_1]}(S)))$

5. $\pi_A(\sigma_{C \geq 2}(\rho_{[A, C]}(\gamma_{A; count(*)}(R \bowtie_{A=D} S))))$

Exercise 7

1 Point

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

$$F = \{E \rightarrow BCF, \\ ABDE \rightarrow F, \\ F \rightarrow ACE, \\ BDE \rightarrow F\}$$

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 decomposition rule:

$$X \rightarrow YZ \models X \rightarrow Y, X \rightarrow Z$$

Hint: The Armstrong axioms are given by:

- Reflexivity: $Y \subseteq X \models X \rightarrow Y$
- Augmentation: $X \rightarrow Y \models XZ \rightarrow YZ$
- Transitivity: $X \rightarrow Y, Y \rightarrow Z \models X \rightarrow Z$

Exercise 9

1 Point

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

$$F = \{B \rightarrow D, \\ AD \rightarrow C, \\ AC \rightarrow D, \\ CD \rightarrow B\}$$

Compute the restrictions F_1 and F_2 of F to the decomposition $R_1[BD]$ and $R_2[ABC]$. Either prove or disprove that this restriction is dependency preserving. Explain your answer.