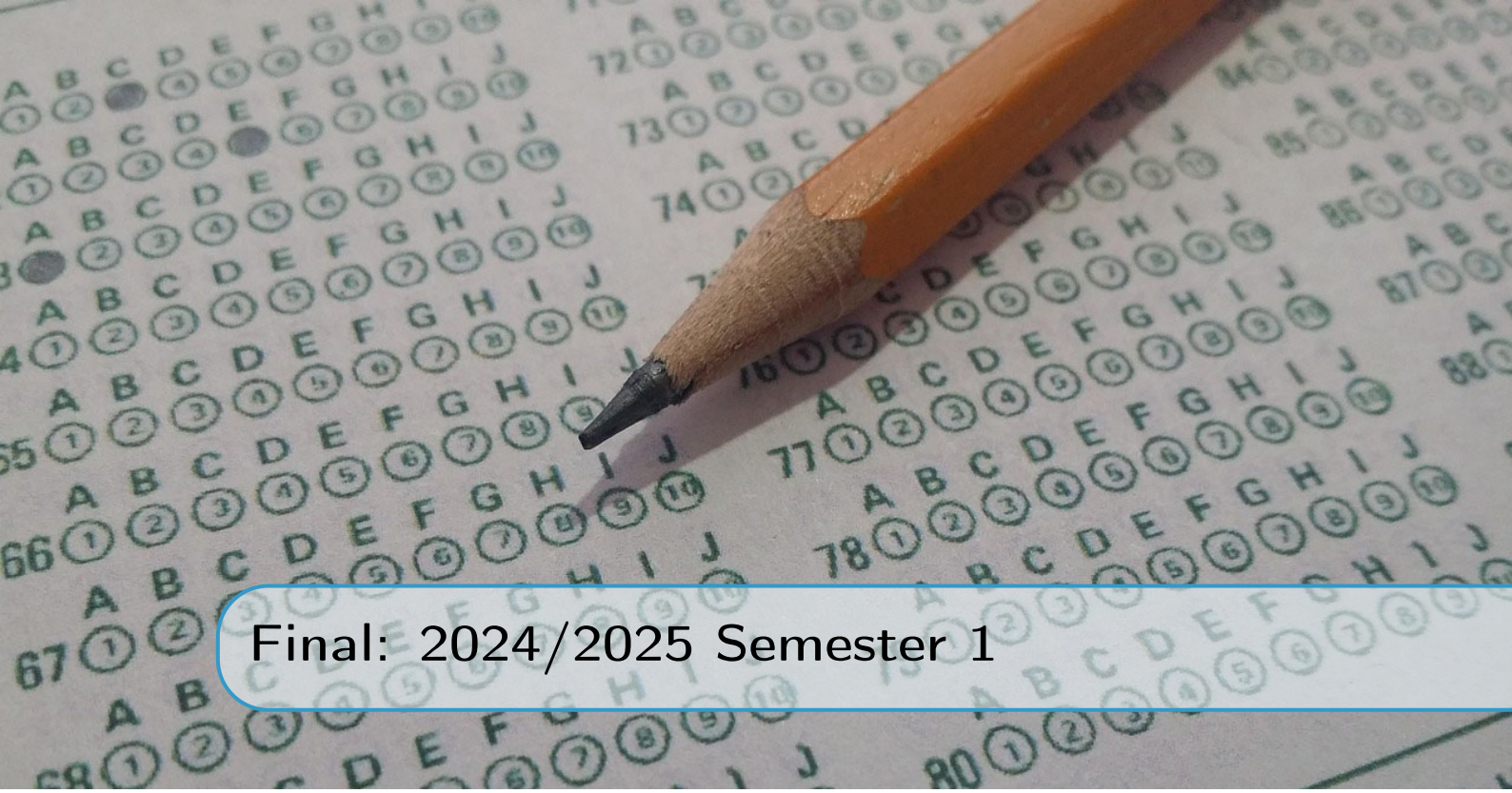
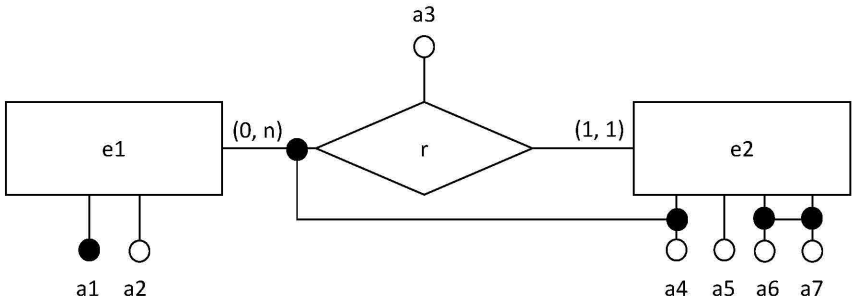


Final: 2024/2025 Semester 1

For the next 8 questions, we will be using the following entity-relationship diagram.



A functional dependency holds on the entity-relationship diagram if all the tables and their natural join in all instances of the design do not violate the functional dependency.

All options are on Examplify and may be randomized.

1. Which of the following functional dependencies hold on the following entity-relationship diagram?

   Notes: $\{a_1\} \to \{a_2\}$

2. Which of the following functional dependencies hold on the following entity-relationship diagram?

   Notes: $\{a_6, a_7\} \to \{a_3\}$; $\{a_1, a_4\} \to \{a_1, a_3, a_5\}$; $\{a_6, a_7\} \to \{a_1\}$

3. Which of the following functional dependencies hold on the following entity-relationship diagram?

   Notes: $\{a_1, a_4\} \to \{a_1, a_5\}$

4. Which of the following is a canonical cover (*i.e.,* minimal basis after union of FDs with the same LHS) of the set of functional dependencies holding on the following entity-relationship diagram?

   Notes: $\{ \{a_1, a_4\} \to \{a_6, a_7\}, \ \{a_6, a_7\} \to \{a_1, a_3, a_4, a_5\}, \ \{a_1\} \to \{a_2\} \}$

5. Which of the following is a lossless dependency-preserving decomposition in 3NF of $R = \{a_1, a_2, a_3, a_4, a_5, a_6, a_7\}$ with the set of functional dependencies holding on the following entity-relationship diagram?

> **Notes:** $R_1 = \{a_1, a_3, a_4, a_5, a_6, a_7\}$, $R_2 = \{a_1, a_2\}$

6. Which of the following is a superkey of $R = \{a_1, a_2, a_3, a_4, a_5, a_6, a_7\}$ with the set of functional dependencies holding on the following entity-relationship diagram?

> **Notes:** $\{a_1, a_2, a_3, a_4\}$, $\{a_4, a_5, a_6, a_7\}$, $\{a_1, a_2, a_6, a_7\}$

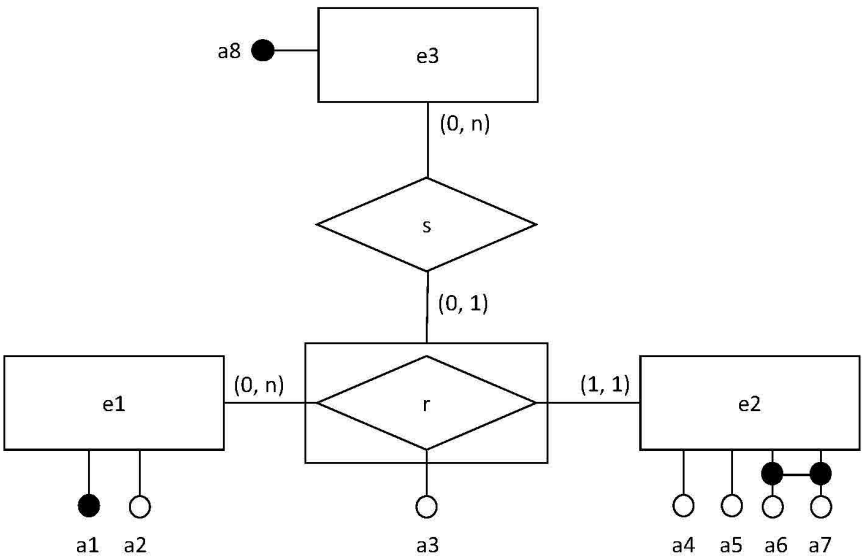
7. Which of the following is a lossless dependency-preserving decomposition in BCNF of $R = \{a_1, a_2, a_3, a_4, a_5, a_6, a_7\}$ with the set of functional dependencies holding on the following entity-relationship diagram?

> **Notes:** All of below.
> - $R_1 = \{a_1, a_4, a_5, a_6, a_7\}$, $R_2 = \{a_1, a_3, a_4\}$, $R_3 = \{a_1, a_2\}$
> - $R_1 = \{a_1, a_4, a_6, a_7\}$, $R_2 = \{a_1, a_3, a_4, a_5\}$, $R_3 = \{a_1, a_2\}$
> - $R_1 = \{a_1, a_3, a_4, a_6, a_7\}$, $R_2 = \{a_5, a_6, a_7\}$, $R_3 = \{a_1, a_2\}$

8. Which of the following sets of attributes is a candidate key of $R = \{a_1, a_2, a_3, a_4, a_5, a_6, a_7\}$ with the set of functional dependencies holding on the following entity-relationship diagram?

> **Notes:** $\{a_1, a_4\}$

For the next question, we will be using the following entity-relationship diagram.



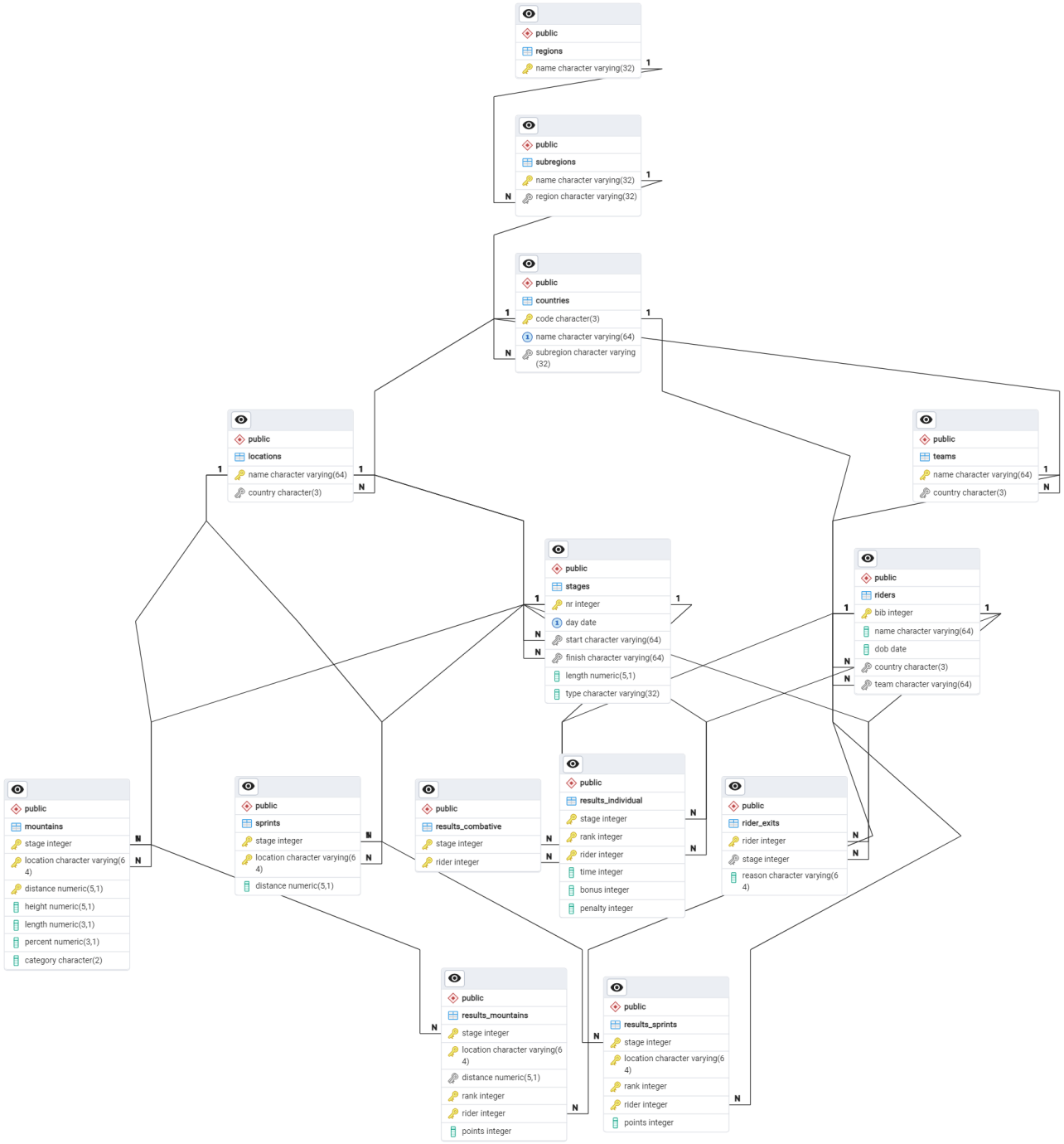
A functional dependency holds on the entity-relationship diagram if all the tables and their natural join in all instances of the design do not violate the functional dependency.

All options are on Examplify and may be randomized.

9. Which of the following functional dependencies hold on the following entity-relationship diagram?

> **Notes:** All of below.
> - $\{a_1\} \to \{a_2\}$
> - $\{a_6, a_7\} \to \{a_3, a_4\}$
> - $\{a_6, a_7\} \to \{a_1, a_5, a_8\}$
> - $\{a_6, a_7\} \to \{a_4, a_5\}$
> - $\{a_6, a_7, a_8\} \to \{a_2\}$

For the next 5 questions, we will be using the following logical diagram from Le Tour 2024.



All options are on Examplify and may be randomized.

10. **(Out of Scope)** Which of the following tuple calculus queries finds the stage numbers and locations of the stages that start and end at the same location?

    Notes: $\{T \mid \exists T_1(T_1 \in \text{stages} \wedge T_1.\text{nr} = T.\text{stage} \wedge T_1.\text{start} = T_1.\text{finish} \wedge T_1.\text{start} = T.\text{location})\}$

11. **(Out of Scope)** Which of the following tuple calculus queries finds the names of the riders who have participated in every stage?

    Notes: "All of the above".

12. Which of the following relational algebra queries finds the stage numbers and the country codes of the start and finish locations of the stages that start in one country and finish in another?

> **Notes:** $\pi_{[s.\text{snr},l_1.\text{country},l_2.\text{country}]}(\sigma_{[l_1.\text{country}\neq l_2.\text{country}\wedge s.\text{finish},l_2.\text{name}\wedge s.\text{start},l_1.\text{name}]}($
> $(\rho(\text{stages}, s) \times \rho(\text{locations}, l_1)) \times (\rho(\text{locations}, l_2))$
>))

13. Which of the following relational algebra queries finds the stage numbers of the stages that start and end at the same location?

> **Notes:** $\pi_{[s.\text{snr}]}(\sigma_{[s.\text{finish}=s.\text{start}]}(\rho(\text{stages}, s)))$

14. Which of the following relational algebra queries finds the bib of the riders who have participated in every stage?

> **Notes:** $\pi_{[ri_1.\text{rider}]}(\rho(\text{results\_individual}, ri_1))$
> $-\pi_{[ri_2.\text{rider}]}(\pi_{[ri_2.\text{rider},s.\text{snr}]}($
> $\rho(\text{results\_individual}, ri_2) \times \rho(\text{stages}, s)) - \pi_{[ri_3.\text{rider},ri_3.\text{stage}]}(\rho(\text{results\_individual}, ri_3))$
>)

For the next 16 questions, we will be using the following relation and set of functional dependencies.

- $R = \{A, B, C, D, E\}$
- $\Sigma = \{\ \{B, E\} \to \{C, D\},\ \ \{A, B, C, D\} \to \{B, E\},\ \ \{B, D\} \to \{C, D, E\},\ \ \{C\} \to \{E\},$
  $\{A, B, D, E\} \to \{C\},\ \ \{D\} \to \{C\},\ \ \{A, D\} \to \{A\}\ \}$

All options are on Examplify and may be randomized.

15. Select all the trivial functional dependencies in Σ.

> **Notes:** $\{A, D\} \to \{A\}$

16. Select all the non-trivial but not completely non-trivial functional dependencies in Σ.

> **Notes:** $\{B, D\} \to \{C, D, E\}$

17. Select all the completely non-trivial functional dependencies in Σ.

> **Notes:** $\{B, E\} \to \{C, D\}$; $\{C\} \to \{E\}$; $\{D\} \to \{C\}$

18. Select all the functional dependencies that are logically entailed by Σ.

> **Notes:** $\{B, E\} \to \{C\}$; $\{D\} \to \{E\}$

19. Select all the superkeys of R with Σ.

> **Notes:** All the superset of: $\{A, B, C\}$; $\{A, B, D\}$; $\{A, B, E\}$

20. Select all the candidate keys of R with Σ.

Notes: $\{A, B, C\}$; $\{A, B, D\}$; $\{A, B, E\}$

21. Select all the prime attributes of R with Σ.

Notes: $\{A, B, C, D, E\}$

22. Select all the projected functional dependencies on $\{A, D, E\}$ from R with Σ.

Notes: "None of the above".

23. Select all the functional dependencies that violates BCNF property of R with Σ.

Notes: $\{B, E\} \to \{D\}$; $\{B, D\} \to \{C\}$; $\{B, D\} \to \{E\}$; $\{C\} \to \{E\}$; $\{D\} \to \{C\}$

24. Select all the functional dependencies that violates 3NF property of R with Σ.

Notes: "None of the above".

25. Select the canonical cover (*i.e.,* minimal basis after performing union of all FDs with the same LHS) of R with Σ.

Notes: $\{ \{C\} \to \{E\}, \ \{B, E\} \to \{D\}, \ \{D\} \to \{C\} \}$

26. Select all the lossless-join decomposition of R with Σ.

Notes: All of below.
- $\delta = \{ \{A, D, E\}, \{A, B, C, D\} \}$
- $\delta = \{ \{A, B, D\}, \{B, C, D, E\} \}$

27. Consider a decomposition into $\delta = \{\{A, B, D\}, \{A, D, E\}\}$. This decomposition is not a lossless-join decomposition. This decomposition can be made into a lossless-join decomposition by adding more fragments into the fragment.

Notes: All of below.
- $\{B, C, D\}$
- $\{C, D, E\}$

28. Select all the lossless-join decomposition of R with Σ in BCNF.

Notes: $\{ \{A, B, D\}, \{C, E\}, \{C, D\} \}$

29. Select all the lossless-join dependency preserving decomposition of R with Σ in 3NF.

Notes: All of below.
- $\{ \{A, B, C\}, \{B, C, D\}, \{B, C, E\} \}$
- $\{ \{A, B, D\}, \{B, C, D\}, \{B, C, E\} \}$
- $\{ \{A, B, E\}, \{B, C, D\}, \{B, C, E\} \}$
- $\{ \{A, B, C, D, E\} \}$

Consider a different schema R and a set of function dependencies Σ below.

- $R = \{A, B, C, D, E\}$
- $\Sigma = \{\ \{A\} \to \{C\},\ \ \{B\} \to \{A\},\ \ \{C\} \to \{A, B\},\ \ \{D, E\} \to \{B\}\ \}$

All options are on Examplify and may be randomized.

30. A naive 3NF synthesis will give us 4 fragments. However, there are decompositions with fewer fragments that satisfy the following criteria.

    - The decomposition is a lossless-join decomposition.
    - The decomposition is a dependency preserving decomposition.
    - The number of fragments is fewer than 4.
    - All the fragments are in 3NF.
    - All the functional dependencies in Σ can be enforced from the fragments using only primary key, foreign key, unique, and not null constraints.

    Find all decompositions that satisfy the criteria above. Recap that you need to think carefully about potential subsumption to ensure that we can actually enforce the functional dependencies.

    Notes: All of below.
    - $\{\ \{A, B, C\}, \{A, D, E\}\ \}$
    - $\{\ \{A, B, C\}, \{B, D, E\}\ \}$
    - $\{\ \{A, B, C\}, \{C, D, E\}\ \}$
    - $\{\ \{A, B\}, \{A, C\}, \{A, D, E\}\ \}$