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Database Systems — Autumn 2025

Exercise 3 — Hand-in: 09.11.2025 (11:59 pm)

Solving the Exercises: The exercises must be solved in groups of three people. Use the notations introduced in the lecture. Please choose the same partners for exercises and project. The DMI plagiarism guidelines apply for this lecture.

Submission Information: Please upload your solutions BEFORE the deadline to ADAM using the team hand-in feature. Solutions that are handed in too late cannot be considered. The use of the exercise template, located in "Exercise Material", is mandatory.

Task 1: Functional Dependencies (4 points)

The government of canton Appenzell Innerrhoden currently organizes resident information using a single relational database table. However, this has certain limitations and redundancies that could impact data integrity and efficiency. Further does this schema not prevent inconsistencies. Your task is to analyze and improve the structure of this database to address these issues.

Resident(FirstName, LastName, FullName, AHV, Birthday, YearOfBirth, Zip, City, Country)
⟨ *'Jean', 'Neige', 'Neige, Jean', '756.0232.8238.23', '1993-04-21', 1994, 4123, 'Oberegg', 'Switzerland'* ⟩

a) Provide reasonable functional dependencies derived from the schema and explain your choices.

(1 points)

b) Denote all candidate keys of the relation *Resident* using the algorithm presented in the lecture slides.

(1 points)

c) Explain in which normal form relation *Resident* is and bring into 3NF, if it is not already. You are allowed to introduce new relations, as well as at most one artificial key per relation, you are allowed to drop attributes, if the information is preserved.

(2 points)

Task 2: Normal Forms (3 points)

Consider the following relation, which is already in 1NF:

R(A, B, C, D, E)

and the following functional dependencies

$$\begin{array}{ll} \{\text{A, B, C} & \rightarrow \text{D, E} \\ \text{B} & \rightarrow \text{D} \\ \text{C, D} & \rightarrow \text{B, E } \} \end{array}$$

a) Denote all candidate keys of the relation using the algorithm presented in the lecture slides.

(2 points)

b) In which normal form is relation R? Explain your answer

(1 points)

Task 3: Normal Forms (3 points)

Consider the following relation S, which is already in 1NF:

S(A, B, C, D)

and the following functional dependencies

$$\begin{array}{ll} \{\text{A, B} & \rightarrow \text{C, D} \\ \text{C} & \rightarrow \text{B } \} \end{array}$$

a) Denote all candidate keys of the relation using the algorithm presented in the lecture slides.

(1 points)

b) In which normal form is relation S? Explain your answer

(2 points)

Task 4: Functional Dependencies (4 points)

Consider the following relation:

T (A, B, C, D, E, U, V, W)

and the following functional dependencies

$$
\begin{array}{ll}
\{\text{A} & \rightarrow \text{B, D} \\
\text{W} & \rightarrow \text{E,} \\
\text{D} & \rightarrow \text{U,} \\
\text{A} & \rightarrow \text{C,} \\
\text{D, E} & \rightarrow \text{V, W}\}
\end{array}
$$

a) List all candidate keys of relation T.

(2 points)

b) Apply all derivation rules for functional dependencies introduced in the lecture except for Reflexivity and Augmentation to determine *all* possible functional dependencies where the attribute A fully or partially determines another attribute, i.e. is on the left side of the dependency.

(2 points)

Task 5: Decomposition (16 points)

Consider – you guessed it – the following relation, which is already in 1NF:

U (A, B, C, D, E, U, V, W)

The following functional dependencies exist in U:

$$
\begin{array}{ll}
\{\text{C, U} & \rightarrow \text{D} \\
\text{D} & \rightarrow \text{E, V, W} \\
\text{D} & \rightarrow \text{U, A} \\
\text{U} & \rightarrow \text{B} \\
\text{V} & \rightarrow \text{A}\}
\end{array}
$$

a) Determine all key candidates of U.

(2 points)

b) In which normal form is relation U? Explain your answer

(1 points)

c) Provide a lossless decomposition of U into the highest possible normal form that *preserves all dependencies*. Provide the details of the decomposistion steps. In which normal forms are the resulting relations at the end?

(10 points)

d) Provide a lossless BCNF decomposition of U. Is your decomposition the same as in c? If there are differences, explain them. Lose as few dependencies as possible.

(3 points)