



AALBORG  
UNIVERSITY

# Database System (SW5)

## Summary

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# Exam Information

- Time: Jan. 13<sup>th</sup>, 2026, 9—11 am, 2 hours
- Books and notes are allowed
- It is NOT allowed to seek help from or consult others (human beings, artificial intelligence, etc.) during the exam.
- The exam question format is similar with Exam-2024
  - Multiple choice
  - Box filling



# Exam Information

Question	Points
1. Relational Algebra	10-15
2. SQL	15-20
3. ER Modelling	15-20
4. Relational Design Theory	10-15
5. Physical Design	10-15
6. Query Processing and Optimization	10-15
7. Transactions, Concurrency Control, and Recovery	10-15



# Suggestions to prepare the exam

- Review the slides
  - Understand the whole topic
  - Understand the terms listed in the following slides
  - Understand the in-class exercises
- Review the exercises



# 1. Relational Model

- Terms
  - Relation
  - Relation schema
  - Relation instance
  - Tuple
  - Attribute
  - Domain
  - Superkey
  - Candidate key
  - Primary key
  - Foreign key



# 1. Relational Model

- Operations
  - Select  $\sigma$
  - Project  $\Pi$
  - Cartesian product  $\times$
  - Join  $\bowtie$
  - Union  $\cup$
  - Set difference  $-$
  - Set intersection  $\cap$
  - Rename  $\rho$



# 1. Relational Model

- Requirements
  - Understand key terms
  - Understand each operation and their composition
  - Formulate relational algebra expressions
  - Interpret relational algebra expressions



## 2. SQL

- Terms
  - Create table
  - Updates to table
    - **insert**
    - **delete**
    - **drop**
    - **alter**
  - SQL query structure
    - **select** clause
    - **from** clause
    - **where** clause



## 2. SQL

- Terms (Cont.)
  - **as clause**
  - **like clause**
  - **order by clause**
  - Set operations
    - **union**
    - **intersect**
    - **except**
  - Aggregate functions
    - **avg, min, max, sum, count**
    - **group by**
    - **having**



## 2. SQL

- Terms (Cont.)
  - Null value
  - Set membership
    - In
    - not in
  - Set comparison
    - **some** clause
    - **all** clause
    - **exists** clause
    - **not exists** clause
    - **unique** clause
  - Modification
    - **delete**
    - **Insert**
    - **Update**
    - **Case**



## 2. SQL

- Terms (Cont.)
  - Join types
    - **natural join**
    - **join...using**
    - **join...on**
    - **left, right, full outer join**
  - View definition
    - **create view**
  - Transactions
    - **Begin**
    - **Commit**
    - **Rollback**
  - Constraints
    - **Check**
    - Referential integrity



## 2. SQL

- Requirements
  - Understand key terms
  - Write SQL queries
  - Interpret SQL queries

# 3. The Entity-Relationship Model

- Terms
  - Entity
  - Attribute
  - Simple attribute, Composite attribute
  - Single-valued attribute, Multi-valued attribute
  - Relationship
  - Degree
  - Cardinality ratio (Chen notation): 1:1, 1:N, N:M
  - Participation constraint: partial or total
  - Cardinality limits: [min, max]
  - Primary key
  - Weak entity, Strong entity
  - Specialization

# 3. The Entity-Relationship Model

- The 7-step mapping an ER diagram to relational tables
  - **M1:** Regular entity types
    - Create a relation
  - **M2:** Weak entity types
    - Create a relation
    - Primary key: the strong entity's primary key and part of its own attributes
  - **M3:** Binary M:N relationship types
    - Create a relation
    - Primary key: the union of the primary keys of the participating entity types
  - **M4:** Binary 1:N relationship types
    - Extend the N-side relation with foreign key

# 3. The Entity-Relationship Model

- The 7-step mapping an ER diagram to relational tables (Cont.)
  - **M5:** Binary 1:1 relationship types
    - Both two sides totally participating: extend one side relation with foreign key, or use one relation
    - Both two sides partially participating: extend one side relation with foreign key
    - One side totally participating and another side partially participating: extend totally participating side
  - **M6:** Complex relationship types
    - Recursive relationship types: create a relation
    - N:M:P / N:M:1 relation types: create a relation

# 3. The Entity-Relationship Model

- The 7-step mapping an ER diagram to relational tables (Cont.)
  - **M7:** Complex attributes
    - Multi-valued attributes: create a separate relation for each multi-valued attribute
    - Composite attributes: Include the component attributes in the relation
    - Derived attributes: Ignored during mapping to relations, can be added later by using views.

# 3. The Entity-Relationship Model

- Requirements
  - Understand key terms
  - Construct ER diagrams
    - Entity
    - Attribute
    - Relationship
    - Cardinality Constraints: Graphical notation, Chen notation, [min, max] notation
  - Map ER diagrams to relational tables



# 4. Relational Database Design

- Terms
  - Functional dependency, Holds, Trivial
  - Armstrong's axioms
    - Reflexive rule
    - Augmentation rule
    - Transitivity rule
  - Additional rules
    - Union rule
    - Decomposition rule
    - Pseudotransitivity rule
  - Closure of Attribute Sets
  - Decomposition, Lossless decompositions
  - Third normal form (3NF)
  - Boyce–Codd normal form (BCNF)



# 4. Relational Database Design

- Requirements
  - Understand key terms
  - Compute attribute closures
  - Identify superKeys and candidate keys
  - Check for normal forms (BCNF or 3NF)
  - Understand lossless decomposition



# 5. Physical Design

- Terms
  - Volatile storage, Non-volatile storage
  - Block (Page)
  - Fixed-length record, Variable-length record
  - File organization
    - Heap file organization
    - Sequential file organization
    - Multitable clustering file organization
  - B+-tree
    - Leaf node, Internal node, Root node
    - Search key, pointer
    - Insert, Delete



# 5. Physical Design

- Requirements
  - Understand key terms
  - Understand B+ tree structure
  - Insert values into a B+ Tree
  - Delete values from a B+ Tree
  - Handle node overflow
  - Handle node underflow

# 6. Query Execution and Optimization

- Terms
  - External sort-merge
  - Runs
  - Simple nested-loop join
  - Page-oriented nested loop Join
  - Block nested-loop join
  - Sort-merge join
  - Hash join
  - Size estimation
  - Histograms

# 6. Query Execution and Optimization

- Requirements
  - Understand key terms
  - External sort-merge
    - Calculate the pass number and run number in an external sort-merge operation
    - Calculate the I/O costs of an external sort-merge
  - Join techniques and their I/O costs
    - Simple nested-loop join
    - Page-oriented nested-loop join
    - Block nested-loop join
    - Sort-merge join
    - Hash join
  - Estimate selection size

# 7. Transactions, Concurrency Control, and Recovery

- Terms
  - Transaction
  - ACID properties: Atomicity, Consistency, Isolation, Durability
  - Serial schedules
  - Conflict serializable
  - Conflict/Precedence graph
  - Locking/Unlocking
  - Two-Phase locking (2PL)
  - Shared lock, Exclusive lock
  - Wait-for graph
  - Deadlock
  - Recovery
  - WAL rules
  - Log-based recovery

# 7. Transactions, Concurrency Control, and Recovery

- Requirements
  - Understand key terms
  - Draw the conflict graph
  - Determine conflict serializability
  - Understand Two-Phase Locking (2PL)
  - Draw the wait-for graph
  - Understand deadlock
  - Understand log-based recovery



# Feedbacks

- Suggestions (5 minutes)
  - Link is on Moodle

Lecture 11: Recovery ▶

Summary ▾

↗ Suggestions

Exam information ▾



# SW6 Group Formation

## 3. GROUP SIZES

The department has decided the following policy for number of students in a group:

1-3. semester: 7 students

4-5. semester: 6 students

6. semester: 4 students\*

7-8. semester 6 students

9. semester: max 6 students

10. semester: max 3 students\*

*\*On bachelor's and the thesis semester it is possible to write the project alone.*

If the number of students on a semester does not equal the group size, there will be one or more groups that are smaller. However, it is not possible to form more groups than what fits with the allocated supervisors.

Application for exemption to a higher number of students per group must be sent to the study board with a valid explanation and approval by the supervisor. Generally, the frames for group sizes, splitting of groups are decided by the Head of Studies.

- <https://www.cs.aau.dk/education/rules-and-guidelines#principles-for-group-formation>