# Midterm Review

## CS 377: Database Systems

# Piazza Poll Results

A total of **45** vote(s) in **91** hours

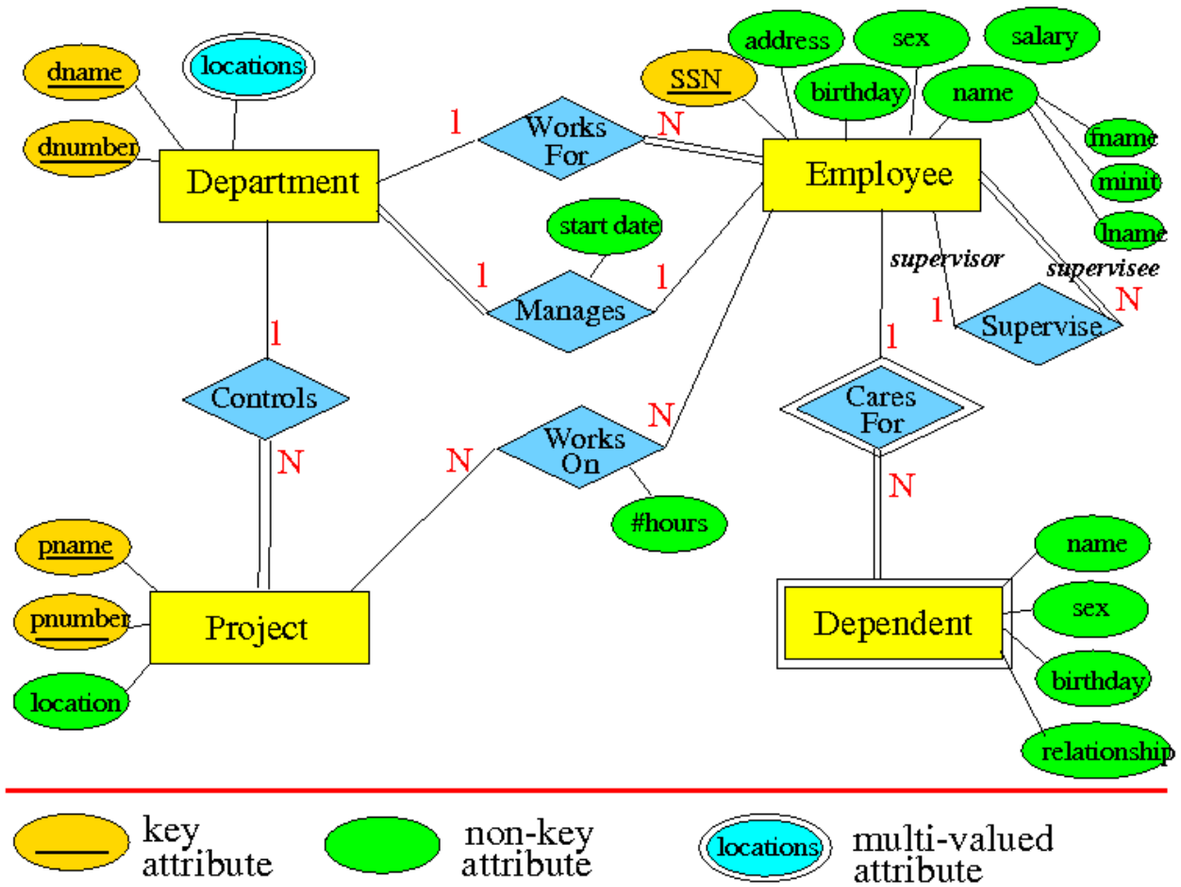
| | | |
|---|---|---|
| 4 (9% of users) | Database Concepts | Show Voters |
| 5 (11% of users) | ER Model | Show Voters |
| 6 (13% of users) | Relational Model | Show Voters |
| 23 (51% of users) | Relational Algebra | Show Voters |
| 22 (49% of users) | Relational Calculus | Show Voters |
| 6 (13% of users) | SQL Data Definition | Show Voters |
| 9 (20% of users) | SQL Modification (Add, Update, Delete) | Show Voters |
| 5 (11% of users) | SQL Basic Query (SELECT-FROM-WHERE) | Show Voters |
| 23 (51% of users) | SQL Aggregation (Group by - Having) | Show Voters |
| 30 (67% of users) | SQL Nested Queries | Show Voters |
| 41 (91% of users) | SQL Advanced Queries (QFT) | Show Voters |

# Database Concepts

- Data model categories: high-level or conceptual data models, low-level or physical data models, and representational or implementation data models
- Physical data and logical data independence
  - How metadata fits into the picture
- Three schema architecture

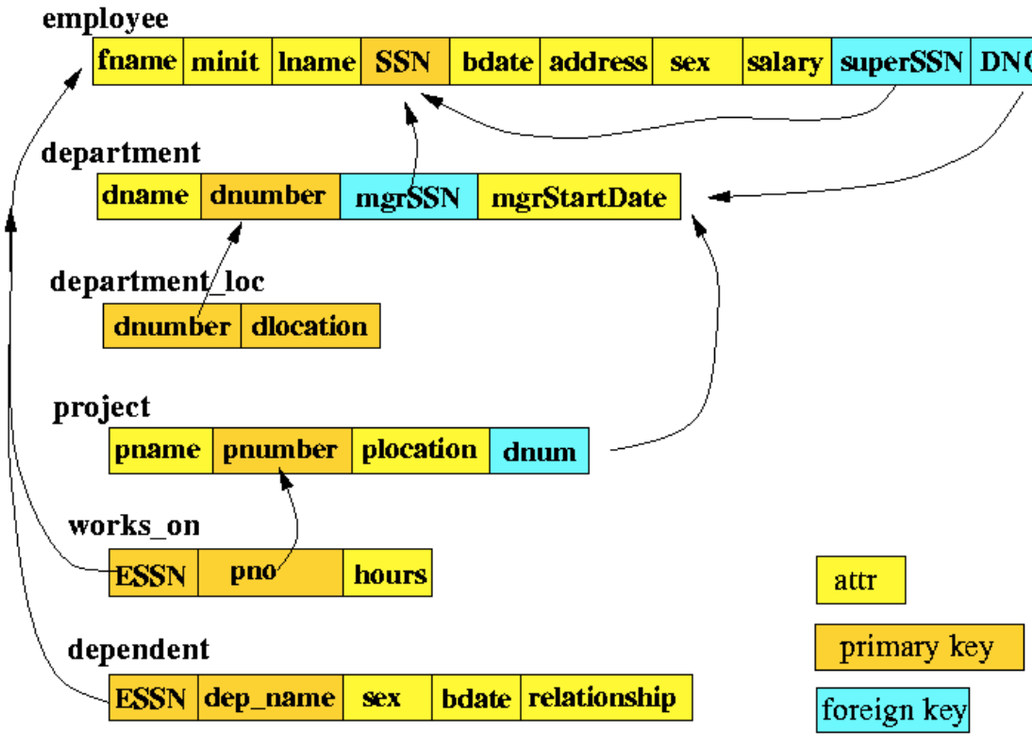
# Entity Relationship (ER) Model

- Entity
  - Attributes
  - Weak Entity
- Relationship
  - Degree
  - Cardinality ratio constraint
  - Participation constraint



# Relation Model

- Relation, attributes
- Schema vs instance
- Relational model constraints
  - Domain constraint
  - Key constraint
  - Referential integrity constraint



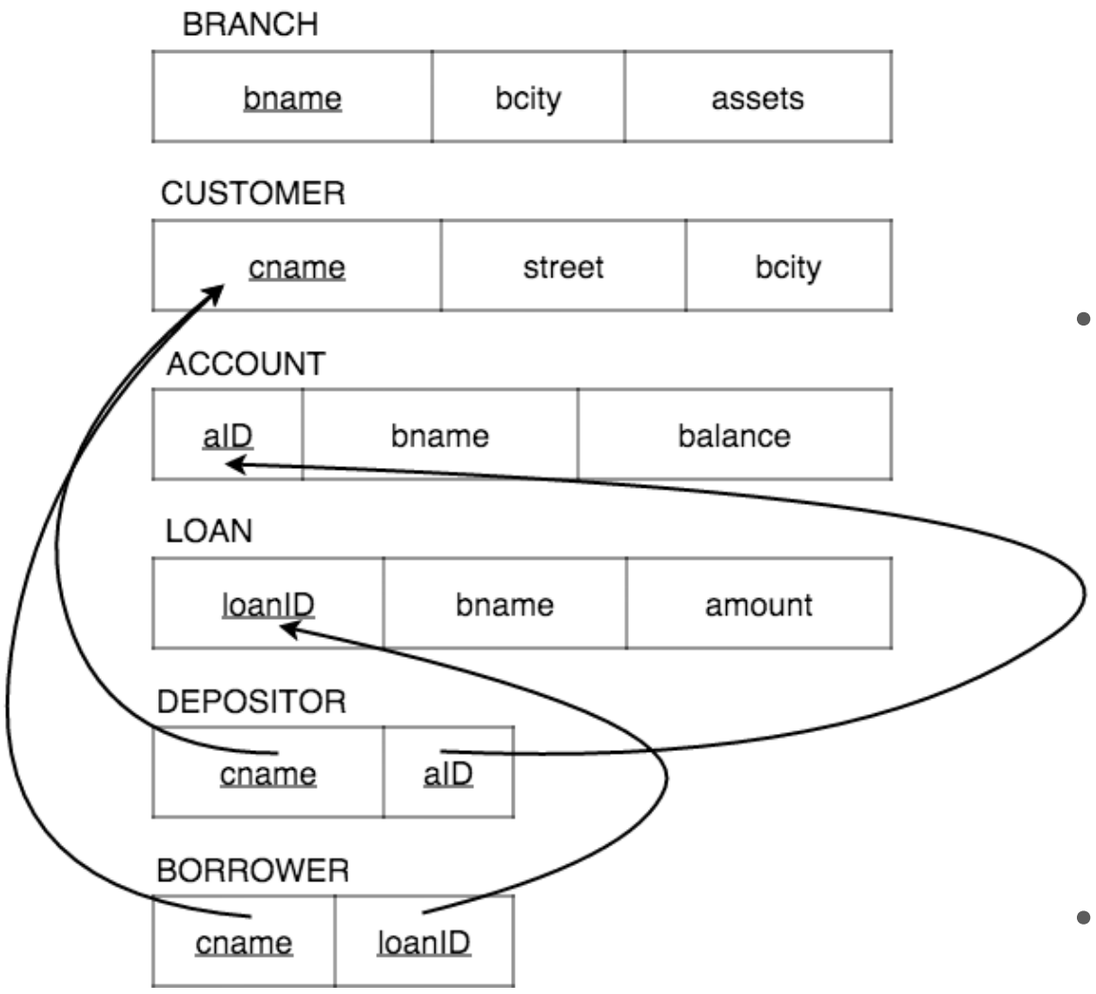
# ER to Relational Model

| ER Model | Relational model |
|---|---|
| Entity type | Entity relation |
| 1:1 or 1:N relationship | Expand (or create R relation) |
| M:N relationship | Create R relation with two foreign keys |
| n-ary relationship type | Create R relation with n foreign keys |
| Simple attribute | Attribute |
| Composite attribute | Set of simple component attributes |
| Multivalued attribute | Relation and foreign key |
| Key attribute | Primary (or secondary) key |

# Relational Algebra

| Operation | Notation | Purpose |
|---|---|---|
| SELECT | $\sigma_{<\text{selection condition}>}(R)$ | Selects all tuples that satisfy the selection condition from a relation R |
| PROJECT | $\pi_{<\text{atttribute list}>}(R)$ | New relation with subset of attributes of R and removes duplicate tuples |
| THETA_JOIN | $R_1 \bowtie_{<\text{join condition}>} R_2$ | All combinations of tuples from $R_1$ and $R_2$ that satisfy the join condition |
| EQUIJOIN | $R_1 \bowtie_{<\text{join condition}>} R_2$ | Theta join with only equality join comparisons |
| NATURAL JOIN | $R_1 *_{<\text{join condition}>} R_2$ | Equijoin except join attributes of $R_2$ are not included in the resulting relation |
| UNION | $R_1 \cup R_2$ | Relation that includes all tuples in $R_1$ or $R_2$ |
| INTERSECTION | $R_1 \cap R_2$ | Relation that includes all tuples in both $R_1$ and $R_2$ |
| DIFFERENCE | $R_1 - R_2$ | Relation that includes all tuples in $R_1$ that are not in $R_2$ |
| CARTESIAN PRODUCT | $R_1 \times R_2$ | Relation with attributes of $R_1$ and $R_2$ and includes tuples with all possible combinations of tuples of $R_1$ and $R_2$ |
| DIVISION | $R_1(Z) \div R_2(Y)$ | Relation that includes all tuples t[X] in $R_1(Z)$ that appear in $R_1$ in combination with every tuple from $R_2(Y)$ where $Z = X \cup Y$ |
| GROUP BY AGGREGATE | $<\text{group attrs}>\mathcal{F}_{<\text{set funcs}>}$ | Relation that includes the grouping attributes and the set function values |

# Banking Example




- Find the names of all customers who have a loan and a savings account at the bank
- Find the names of all customers who have a loan at the Decatur branch but do not have a savings account at any branch of the bank
- Find all customers who have a savings account at all branches located in the city of Atlanta

# Relational Calculus (Tuple Relational Calculus)

Query of the form: {t | CONDITION(t) }

- Conditions are formulas and are recursively defined
- Atomic formula (Relation(t), R.a *op* S.b / constant)
- Special formula quantifiers
  - Universal quantifier $(\forall t)\ (\mathrm{Condition}(t))$
  - Existential quantifier $(\exists t)\ (\mathrm{Condition}(t))$

# SQL Data Definition

- Create database
- Create table
  - Attribute datatypes and constraints
  - Key constraints (primary and foreign key)
  - Circular integrity constraints
- Alter tables
  - Add/remove attributes
  - Add/remove constraints
- Drop tables & databases

# SQL Data Modification

- Data modifications does not return a result but changes the database

  - INSERT (add new tuples)
    **INSERT INTO <relation> VALUES <attr values>;**

  - DELETE (remove tuples)
    **DELETE FROM <relation> WHERE <condition>;**

  - UPDATE (change value(s) of existing tuples)
    **UPDATE <relation>**
    **SET <list of attribute assignments>**
    **WHERE <condition>;**

# SQL Select-From-Where Query

- SQL Query:
  **SELECT <attribute list>**
  **FROM <table list>**
  **WHERE <condition on the tables>**

- RA Query:

$$\pi_{<\text{attribute list}>}\sigma_{<\text{condition}>}(R_1 \times R_2 \times \cdots \times R_n)$$

# SQL Basic Query

```
SELECT      [DISTINCT] <attribute list>
FROM         <table list>
[WHERE       <condition on the tables>]
[ORDER BY  <attribute list>   ASC | DESC]
[LIMIT          <number of tuples>]
```

**WHERE** conditions: comparison operations, arithmetic operations, logical operations, **IN**, **LIKE**, **IS NULL**, **EXISTS**, **ANY**, **ALL**

# SQL: Group By & Having

- GROUP BY: Apply aggregate functions to subgroups of tuples in a relation

- HAVING: Filters out groups that do not satisfy the group condition

- SQL Query:

```
SELECT     [DISTINCT] <attribute list>
FROM        <table list>
[WHERE      <condition on the tables>]
[GROUP BY <grouping attributes>]
[HAVING     <group condition>]
```

# SQL: Nested Queries

- A subquery (parenthensized **SELECT-FROM-WHERE** statement) inside the **WHERE** clause

- **SELECT …**
  **FROM …**
  **WHERE <some condition test> (SELECT …**
  **FROM …**
  **WHERE …)**

Nested query

Set membership (IN, NOT IN)
Set comparison (ANY, ALL)
Empty relation test (EXIST)

# SQL: Temporal Relations

- A subquery (parenthensized **SELECT-FROM-WHERE** statement) inside the **FROM** clause

- Must give it an alias

- **SELECT <attributes>**
  **FROM R1, R2, (SELECT … ) <alias>, …, RN**
  **WHERE <condition>;**

temporal relation

# SQL: Set Operations

- **UNION**: join two relations
  - Syntax: **(SELECT …) UNION (SELECT …)**
- **INTERSECT**: not in most SQL implementations
  - QFT: **WHERE x IN <set1>  AND x IN <set2>**
- **DIFFERENCE**: not in most SQL implementations
  - QFT: **WHERE x IN <set1>  AND x NOT IN <set2>**

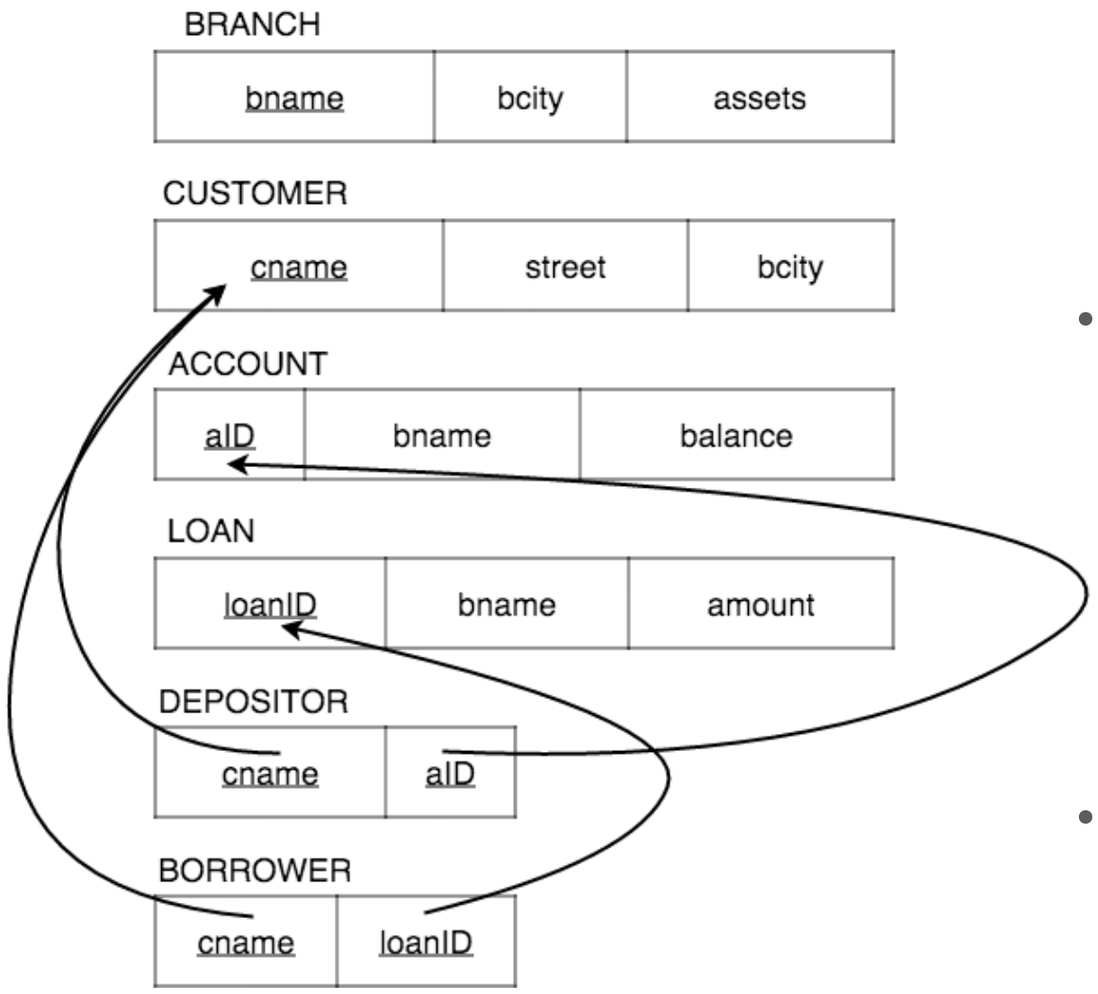
# SQL: Set Operations

- **SUPERSET**: set1 superset set2
  - QFT: **SELECT …**
    **WHERE NOT EXISTS (SELECT …**
    **WHERE x IN set2**
    **AND x NOT IN set1)**
- **DIVISION**: A division B => all tuples where a is superset of B

# SQL: Other QFTs

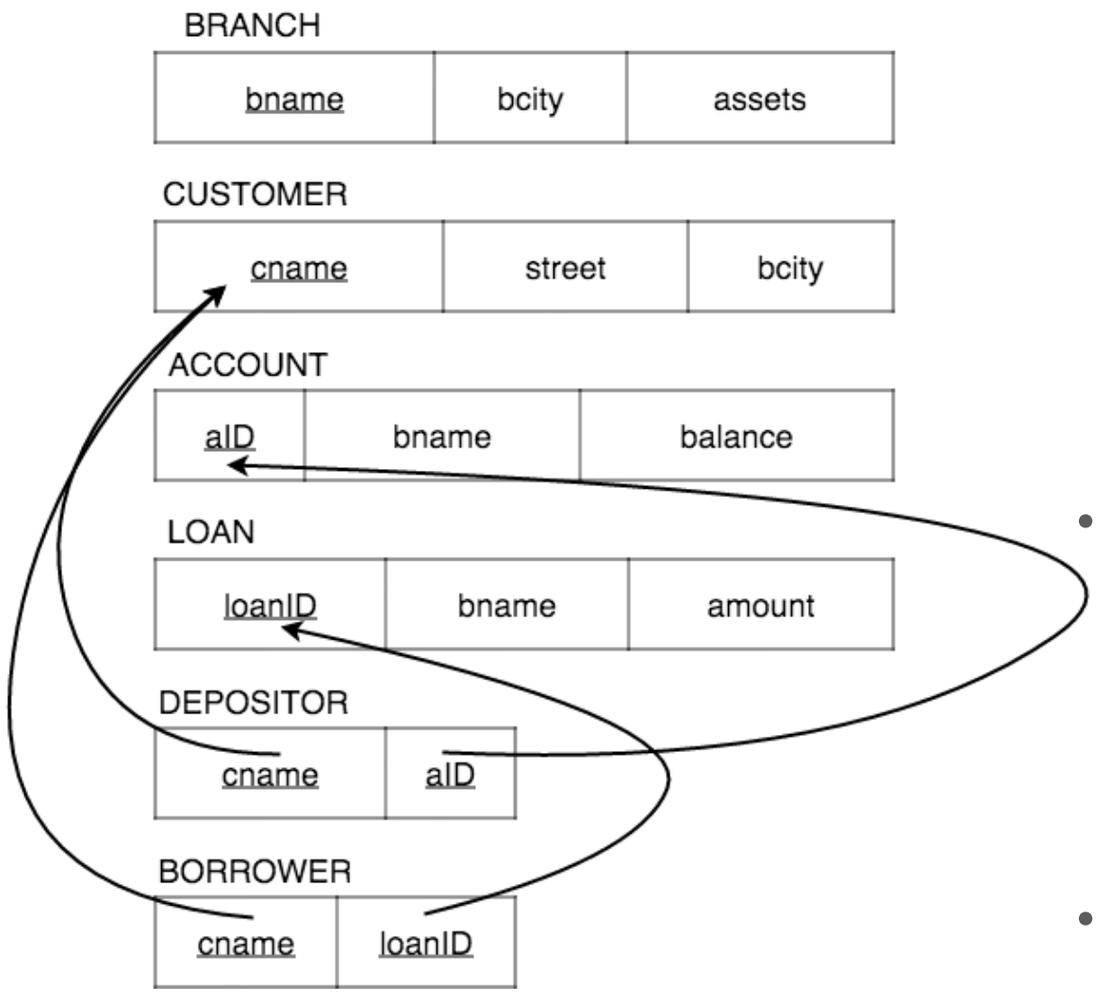
- Only: set1 subset set2
  - QFT: **SELECT …**
    **WHERE NOT EXISTS (SELECT …**
    **WHERE x IN set1**
    **AND x NOT IN set2)**
- Most number of some attribute y
  - QFT: **SELECT …**
    **GROUP BY <group>**
    **HAVING setf(y) = (SELECT MAX(setf(y)) …**
    **GROUP BY <group>)**

# Banking Example




- Find the branch names and their assets that have lent out at least 1M across all their customers
- Find the names and addresses of all customers who have a loan and a savings account at the bank
- Find the names of all branches that have assets greater than those of at least one branch located in the city of Atlanta

# Banking Example



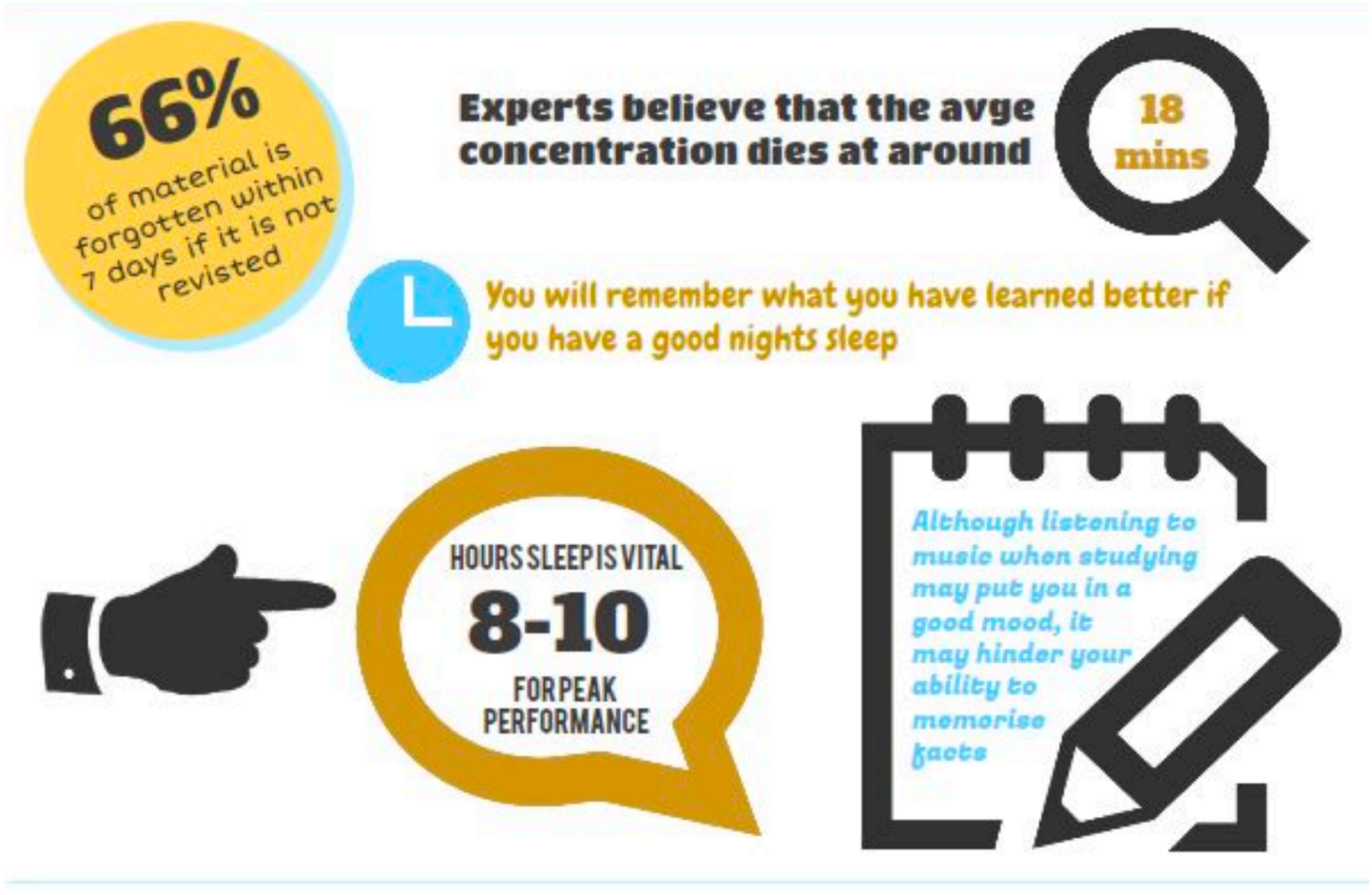

- Find the names of all customers who have a loan at the Decatur branch but do not have a savings account at any branch of the bank

- Return the customer's information who owes the bank the most amount of money

- Find all customers who have a savings account at all branches located in the city of Atlanta

# SQL Views

- View is a virtual table that does not exist in physical form
    - Allows ability to present information in different ways to different users
    - Can be used like an ordinary relation and simplifies complex queries
    - Limits data access to specific users (sensitive data can be hidden)
    - If conceptual schema changes, only the **SELECT** query needed to construct view needs to change

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