



**KOÇ
UNIVERSITY**

Database Management Systems

Advanced SQL

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Outline

- In this lecture, we will cover some more advanced issues related to SQL.
 - NULLs and three-valued logic (3VL)
 - Nested SQL queries
 - Different types of JOINS
 - Aggregate operators: COUNT, SUM, MIN, MAX, ...
 - Grouping (GROUP BY – HAVING)
 - Triggers and views

NULLs and 3VL



NULL

- **NULL**: A **reserved word** in SQL to mean "value does not exist" or "unknown" or "could be anything".
 - Not every field is allowed to be NULL
 - E.g., primary key
 - Subject to table definition and integrity constraints

sid	name	login	age	gpa
53666	Jones	jones@cs	18	3.4
53688	Shero	shero@cs	18	NULL
53650	Shero	NULL	19	3.8

CREATE TABLE EMPLOYEE

(Fname	VARCHAR(15)	NOT NULL,
Minit	CHAR,	
Lname	VARCHAR(15)	NOT NULL,
Ssn	CHAR(9)	NOT NULL,
Bdate	DATE,	
Address	VARCHAR(30),	
Sex	CHAR,	
Salary	DECIMAL(10,2),	
Super_ssn	CHAR(9),	
Dno	INT	NOT NULL,

PRIMARY KEY (Ssn),

CREATE TABLE DEPARTMENT

(Dname	VARCHAR(15)	NOT NULL,
Dnumber	INT	NOT NULL,
Mgr_ssn	CHAR(9)	NOT NULL,
Mgr_start_date	DATE,	

PRIMARY KEY (Dnumber),

UNIQUE (Dname),

FOREIGN KEY (Mgr_ssn) REFERENCES EMPLOYEE(Ssn));



Checking for NULLs

- You should **NOT** use comparison operators or arithmetic operators with NULL.
 - Avoid: $x = \text{NULL}$ or $x < \text{NULL}$ or $x \neq \text{NULL}$
 - These evaluate to "Unknown" (neither True nor False)
 - Not even $\text{NULL} = \text{NULL}$
- Instead, use: **IS NULL** and **IS NOT NULL**

Query 18. Retrieve the names of all employees who do not have supervisors.

```
Q18:  SELECT  Fname, Lname
      FROM    EMPLOYEE
      WHERE   Super_ssn IS NULL;
```



3VL

- SQL uses three-valued logic (3VL)
 - True, False, **Unknown**
- Truth tables for 3VL:

p	q	$p \text{ OR } q$	$p \text{ AND } q$	$p = q$
True	True	True	True	True
True	False	True	False	False
True	Unknown	True	Unknown	Unknown
False	True	True	False	False
False	False	False	False	True
False	Unknown	Unknown	False	Unknown
Unknown	True	True	Unknown	Unknown
Unknown	False	Unknown	False	Unknown
Unknown	Unknown	Unknown	Unknown	Unknown

p	$\text{NOT } p$
True	False
False	True
Unknown	Unknown



3VL

```
SELECT *  
FROM t  
WHERE i = NULL;
```

- A common mistake!
- **WHERE** clause always evaluates to **Unknown**, which is not equal to **True**. So, this SQL query returns nothing.
 - That's why you should use **IS NULL** instead
- (ps: In some practical SQL implementations, the above **may** behave the same as "IS NULL", but that's an engineering fix.)



Example

- Sailors (sid, sname, rating, age)
- Boats (bid, bname, color)
- Reserves (sid, bid, day)
- Find the names and ages of sailors who do not yet have a rating.



SELECT S.sname, S.age
FROM Sailors S
WHERE S.rating IS NULL

SELECT S.sname, S.age
FROM Sailors S
WHERE S.rating IS NULL

Nested SQL Queries



Nested Queries

- Nested SQL query: SQL query inside an SQL query
 - Nested queries often appear in the WHERE clause
- Useful keywords when building nested queries: **IN, NOT IN, ALL, ANY, EXISTS, NOT EXISTS, UNIQUE**

```
Q4A:  SELECT  DISTINCT Pnumber
      FROM    PROJECT
      WHERE   Pnumber IN
            ( SELECT  Pnumber
              FROM    PROJECT, DEPARTMENT, EMPLOYEE
              WHERE   Dnum=Dnumber AND
                     Mgr_ssn=Ssn AND Lname='Smith' )

      OR

      Pnumber IN
            ( SELECT  Pno
              FROM    WORKS_ON, EMPLOYEE
              WHERE   Essn=Ssn AND Lname='Smith' );
```



"IN", "NOT IN"

- **IN** and **NOT IN** are comparison operators
 - Compares a value **v** with a set (or multiset) **V**
 - **IN** returns TRUE if $v \in V$, FALSE otherwise
 - The opposite holds for **NOT IN**

SELECT	DISTINCT Essn
FROM	WORKS_ON
WHERE	Pno IN (1, 2, 3);

- You can also do "**tuple comparisons**" (use parantheses):

SELECT	DISTINCT Essn		
FROM	WORKS_ON		
WHERE	(Pno, Hours) IN (SELECT	Pno, Hours
		FROM	WORKS_ON
		WHERE	Essn='123456789');



"ALL", "ANY"

- **ALL**: value must exceed all values from nested query

```
SELECT      Lname, Fname
FROM        EMPLOYEE
WHERE       Salary > ALL ( SELECT      Salary
                           FROM        EMPLOYEE
                           WHERE       Dno=5 );
```

- **ANY**: value should exceed any value from nested query
 - "Find sailors whose rating is greater than some sailor called Charlie"

```
SELECT *
FROM Sailors S
WHERE S.rating > ANY ( SELECT S2.rating
                      FROM Sailors S2
                      WHERE S2.sname='Charlie' )
```



"EXISTS", "NOT EXISTS"

- **EXISTS**: check whether the result of the nested query is empty or not.
- **NOT EXISTS**: logically opposite of EXISTS
- **EXISTS** and **NOT EXISTS** are Boolean operators, i.e., they return TRUE or FALSE

Find the first and last names of managers who have at least one dependent.

```
SELECT Fname, Lname
FROM Employee
WHERE EXISTS (SELECT *
               FROM Dependent
               WHERE Ssn = Essn)

AND EXISTS (SELECT *
             FROM Department
             WHERE Ssn = Mgr_Ssn)
```

Referring to
Employee.Ssn



"EXISTS", "NOT EXISTS"

- **EXISTS**: check whether the result of the nested query is empty or not.
- **NOT EXISTS**: logically opposite of EXISTS
- **EXISTS** and **NOT EXISTS** are Boolean operators, i.e., they return TRUE or FALSE

Retrieve the names of employees who have no dependents.

```
SELECT      Fname, Lname
FROM        EMPLOYEE
WHERE       NOT EXISTS ( SELECT      *
                        FROM        DEPENDENT
                        WHERE       Ssn = Essn )
```



"UNIQUE"

- **UNIQUE**: check for duplicate tuples.
 - If the set contains duplicates, return FALSE
 - Otherwise, return TRUE

Find the names of sailors who reserved a boat at most once.

```
SELECT S.sname
FROM Sailors S
WHERE UNIQUE ( SELECT R.bid
                  FROM Reserves R
                  WHERE S.sid=R.sid)
```



Division in SQL

Find the first and last names of employees who work on ALL projects controlled by department number 5.

- Logically equivalent to: "Find the first and last names of employees for whom there does NOT EXIST a project controlled by dept no 5 that this employee does not work on.

```
SELECT      Fname, Lname
FROM        EMPLOYEE
WHERE       NOT EXISTS ( ( SELECT      Pnumber
                           FROM        PROJECT
                           WHERE       Dnum = 5)
                     ( SELECT      Pno
                       FROM        WORKS_ON
                       WHERE       Ssn = Essn) )
```




Division in SQL

Find the names of sailors who have reserved all boats.

```
SELECT S.sname
FROM   Sailors S
WHERE  NOT EXISTS ((SELECT B.bid
                    FROM   Boats B)
                  EXCEPT ( SELECT R.bid
                              FROM   Reserves R
                              WHERE  R.sid = S.sid))
```

Types of JOINS



INNER JOIN

- **INNER JOIN**s are the "default" kind of join

```
SELECT *  
FROM Employee, Department  
WHERE Employee.DepartmentID = Department.DepartmentID
```

```
SELECT *  
FROM Employee INNER JOIN Department  
ON Employee.DepartmentID = Department.DepartmentID
```

Employee
table

LastName	DepartmentID
Rafferty	31
Jones	33
Steinberg	33
Robinson	34
Smith	34
Jasper	36

DepartmentID	DepartmentName
31	Sales
33	Engineering
34	Clerical
35	Marketing

Department
table



NATURAL JOIN

- Result of INNER JOIN:

Employee.LastName	Employee.DepartmentID	Department.DepartmentName	Department.DepartmentID
Smith	34	Clerical	34
Jones	33	Engineering	33
Robinson	34	Clerical	34
Steinberg	33	Engineering	33
Rafferty	31	Sales	31

- You can eliminate duplicate DepartmentID column by doing a **NATURAL JOIN**. (column name **must** be same)

SELECT *
FROM Employee **NATURAL JOIN** Department

Employee.LastName	DepartmentID	Department.DepartmentName
Smith	34	Clerical
Jones	33	Engineering
Robinson	34	Clerical
Steinberg	33	Engineering
Rafferty	31	Sales



NATURAL JOIN

- If you want to do a NATURAL JOIN but column names are not the same, you can use **renaming**.
- Employee table has **Dno**, Department table has **Dnumber**
- Temporarily "rename" **Dnumber** in Department to **Dno** so that **Employee.Dno = Department.Dno** can be executed by the NATURAL JOIN

```
SELECT      Fname, Lname, Address
FROM        (EMPLOYEE NATURAL JOIN
             (DEPARTMENT AS DEPT (Dname, Dno, Mssn, Msdate)))
WHERE       Dname = 'Research';
```



OUTER JOIN

- **INNER JOIN:** Tuple is included in the result only if a matching tuple exists in the other relation.
- **LEFT OUTER JOIN:** Every tuple in the **left** table **must** appear in the result. If no matching tuple, pad with NULLs.

```
SELECT *  
FROM Employee LEFT OUTER JOIN Department  
      ON Department.DepartmentID = Employee.DepartmentID
```

Employee. LastName	Employee. DepartmentID	Department. DepartmentName	Department. DepartmentID
Jones	33	Engineering	33
Rafferty	31	Sales	31
Robinson	34	Clerical	34
Smith	34	Clerical	34
Jasper	36	NULL	NULL
Steinberg	33	Engineering	33



JOINS

- **INNER JOIN:** Tuple is included in the result only if a matching tuple exists in the other relation.
- **NATURAL JOIN:** Inner join with an implicit column equality condition (column names must be the same!).
- **LEFT OUTER JOIN:** Every tuple in the **left** table **must** appear in the result. If no matching tuple, pad with NULLs.
- **RIGHT OUTER JOIN:** Every tuple in the **right** table **must** appear in the result. If no matching tuple, pad with NULLs.
- **FULL OUTER JOIN:** Combine the result of LEFT OUTER JOIN and RIGHT OUTER JOIN.
- **CROSS JOIN:** Equivalent of Cartesian product from relational algebra.

 `SELECT *`
`FROM Employee XYZ JOIN Department`

Aggregate Operators



Aggregate Operators

- Used to summarize information from multiple tuples into a short summary.
- Commonly used for reporting purposes:
 - Total sales in year 2004
 - Average salary of employees
 - Number of employees hired/fired in 2004
 - ...

```
COUNT (*)  
COUNT ( [DISTINCT] A)  
SUM ( [DISTINCT] A)  
AVG ( [DISTINCT] A)  
MAX (A)  
MIN (A)
```



Aggregate Operators

- Total number of sailors in the club?

```
SELECT COUNT (*)  
FROM   Sailors S
```

```
COUNT (*)  
COUNT ([DISTINCT] A)  
SUM ([DISTINCT] A)  
AVG ([DISTINCT] A)  
MAX (A)  
MIN (A)
```

- Average [distinct] age of sailors in the club whose rating is 10?

```
SELECT AVG (S.age)  
FROM   Sailors S  
WHERE  S.rating=10
```

```
SELECT AVG (DISTINCT S.age)  
FROM   Sailors S  
WHERE  S.rating=10
```

- Names of sailors whose rating is equal to the max rating in the club?

How about the #
of sailors with
max rating?

```
SELECT S.sname  
FROM   Sailors S  
WHERE  S.rating = (SELECT MAX(S2.rating)  
                  FROM   Sailors S2)
```



Aggregate Operators

- Display the min, max, sum, avg salary of EMPLOYEEs.

```
SELECT          SUM (Salary) AS Total_Sal, MAX (Salary) AS  
                  Highest_Sal, MIN (Salary) AS Lowest_Sal, AVG  
                  (Salary) AS Average_Sal  
FROM            EMPLOYEE;
```

Query 20. Find the sum of the salaries of all employees of the 'Research' department, as well as the maximum salary, the minimum salary, and the average salary in this department.

```
Q20:  SELECT      SUM (Salary), MAX (Salary), MIN (Salary), AVG (Salary)  
        FROM      (EMPLOYEE JOIN DEPARTMENT ON Dno=Dnumber)  
        WHERE      Dname='Research';
```

Queries 21 and 22. Retrieve the total number of employees in the company (Q21) and the number of employees in the 'Research' department (Q22).

```
Q21:  SELECT      COUNT (*)  
        FROM      EMPLOYEE;
```

```
Q22:  SELECT      COUNT (*)  
        FROM      EMPLOYEE, DEPARTMENT  
        WHERE      DNO=DNUMBER AND DNAME='Research';
```

GROUP BY - HAVING



GROUP BY – HAVING

- Sometimes we want to **group** tuples in our relations.
- **Example:** Find the age of the youngest sailor for each rating level.
 - We don't know how many rating levels exist
 - Even if we do, we must write a new query to find the age of the youngest sailor for each level
- Instead, we use **GROUP BY – HAVING** clauses.

For $i = 1, 2, \dots, 10$:

```
SELECT MIN (S.age)
FROM Sailors S
WHERE S.rating = i
```

SELECT	<i>[DISTINCT] target-list</i>
FROM	<i>relation-list</i>
WHERE	<i>qualification</i>
GROUP BY	<i>grouping-list</i>
HAVING	<i>group-qualification</i>

```
SELECT  target-list
FROM    relation-list
WHERE   qualification
```

SELECT	[DISTINCT] <i>target-list</i>
FROM	<i>relation-list</i>
WHERE	<i>qualification</i>
GROUP BY	<i>grouping-list</i>
HAVING	<i>group-qualification</i>

HAVING *group-qualification*

GROUP BY *grouping-list*

[illegible]

Conceptual Evaluation

```
FROM Sailors S
WHERE S.age >= 18
```

Age = 20
Age = 25
Age = 19
Age = 70
Age = 60
Age = 40
Age = 33
Age = 32
Age = 18
Age = 22
Age = 39

```
GROUP BY S.rating
```

Rating=4
Rating=2
Rating=3
Rating=2
Rating=3
Rating=5
Rating=1
Rating=4
Rating=3
Rating=4
Rating=1

```
SELECT S.rating, MIN(S.age)
FROM Sailors S
WHERE S.age >= 18
GROUP BY S.rating
HAVING COUNT (*) > 1
```

```
HAVING COUNT (*) > 1
```

gr1

Rating=1
Rating=1

gr2

Rating=2
Rating=2

gr3

Rating=3
Rating=3
Rating=3

gr4

Rating=4
Rating=4
Rating=4

gr5

Rating=5

```
RESULT
```

Rating = 1	33
Rating = 2	25
Rating = 3	18
Rating = 4	20



Exercises

- For sailors with age ≥ 18 and for each rating level with at least two sailors satisfying this age criteria, find the age of the youngest sailor.

```
SELECT S.rating, MIN(S.age)
FROM Sailors S
WHERE S.age  $\geq$  18
GROUP BY S.rating
HAVING COUNT (*)  $>$  1
```

rating	age
1	33.0
7	45.0
7	35.0
8	55.5
10	35.0

rating	
7	35.0

<u>sid</u>	sname	rating	age
22	dustin	7	45.0
31	lubber	8	55.5
71	zorba	10	16.0
64	horatio	7	35.0
29	brutus	1	33.0
58	rusty	10	35.0



Exercises

- Sailors (sid, sname, rating, age)
- Boats (bid, bname, color)
- Reserves (sid, bid, day)
- For each red boat, find the number of reservations for that boat.

```
SELECT      B.bid, COUNT (*) AS rescount
FROM        Boats B, Reserves R
WHERE       R.bid = B.bid AND B.color = 'red'
GROUP BY    B.bid
```



Exercises

- Employee(Ssn, ..., Salary, Super_Ssn, Dno)
- Department(Dnumber, Dname, Mgr_ssn, Mgr_start_date)
- Project(Pnumber, Pname, Plocation, Dnum)
- Works_On(Essn, Pno, Hours)
- For each department, retrieve the department number, the number of employees in the department, and the average salary of the employees in the department.

```
SELECT      Dno, COUNT (*), AVG (Salary)
FROM        EMPLOYEE
GROUP BY    Dno
```



Exercises

- Employee(Ssn, ..., Salary, Super_Ssn, Dno)
- Department(Dnumber, Dname, Mgr_ssn, Mgr_start_date)
- Project(Pnumber, Pname, Plocation, Dnum)
- Works_On(Essn, Pno, Hours)
- For each project, retrieve the project number, the project name, and the number of employees who work on it.

```
SELECT      Pnumber, Pname, COUNT (*)  
FROM        PROJECT, WORKS_ON  
WHERE       Pnumber = Pno  
GROUP BY    Pnumber, Pname;
```



Exercises

- Employee(Ssn, ..., Salary, Super_Ssn, Dno)
- Department(Dnumber, Dname, Mgr_ssn, Mgr_start_date)
- Project(Pnumber, Pname, Plocation, Dnum)
- Works_On(Essn, Pno, Hours)
- For each project *on which more than two employees work*, retrieve the project number, project name, and the number of employees who work on it.

```
SELECT      Pnumber, Pname, COUNT (*)  
FROM        PROJECT, WORKS_ON  
WHERE       Pnumber = Pno  
GROUP BY    Pnumber, Pname  
HAVING      COUNT (*) > 2;
```





Exercises

- Employee(Ssn, ..., Salary, Super_Ssn, Dno)
 - Department(Dnumber, Dname, Mgr_ssn, Mgr_start_date)
 - Project(Pnumber, Pname, Plocation, Dnum)
 - Works_On(Essn, Pno, Hours)
- For each project, retrieve the project number, project name, and the number of employees from department 5 who work on that project.

```
SELECT    Pnumber, Pname, COUNT (*)  
FROM      PROJECT, WORKS_ON, EMPLOYEE  
WHERE     Pnumber = Pno AND Ssn = Essn AND Dno = 5  
GROUP BY  Pnumber, Pname;
```





Exercises

- Employee(Ssn, ..., Salary, Super_Ssn, Dno)
- Department(Dnumber, Dname, Mgr_ssn, Mgr_start_date)
- Project(Pnumber, Pname, Plocation, Dnum)
- Works_On(Essn, Pno, Hours)
- For each department that has more than 5 employees, retrieve the department number and number of employees who are earning more than \$40,000.

```
SELECT      Dno, COUNT (*)  
FROM        EMPLOYEE  
WHERE       Salary>40000  
GROUP BY   Dno  
HAVING      COUNT (*) > 5
```

**THIS QUERY IS
INCORRECT!**

WHY?



Exercises

- Employee(Ssn, ..., Salary, Super_Ssn, Dno)
- Department(Dnumber, Dname, Mgr_ssn, Mgr_start_date)
- Project(Pnumber, Pname, Plocation, Dnum)
- Works_On(Essn, Pno, Hours)
- For each department that has more than 5 employees, retrieve the department number and number of employees who are earning more than \$40,000.

```
SELECT      Dno, COUNT (*)
FROM        EMPLOYEE
WHERE       Salary>40000 AND Dno IN
            ( SELECT      Dno
              FROM        EMPLOYEE
              GROUP BY    Dno
              HAVING      COUNT (*) > 5)
GROUP BY    Dno
```

Triggers and Views



Triggers

- Sometimes there exist **semantic constraints** that are beyond the scope of the relational model.
 - Salary shouldn't exceed \$100,000.
 - A department cannot have > 1000 employees.
- **CREATE TRIGGER:** Specify automatic actions that the DBMS will perform when certain events and conditions occur. → "**Active databases**"
- A trigger typically consists of 3 parts:
 - Event(s)
 - Condition
 - Action



Triggers

- **Example:** When the salary of an employee exceeds the salary of his/her supervisor, inform the supervisor.
- **INFORM_SUPERVISOR** can be a sequence of SQL statements, a stored procedure, a transaction, or an external program that will be automatically executed.

```
CREATE TRIGGER SALARY_VIOLATION
BEFORE INSERT OR UPDATE OF SALARY, SUPERVISOR_SSN
ON EMPLOYEE
FOR EACH ROW
WHEN ( NEW.SALARY > ( SELECT SALARY FROM EMPLOYEE
                      WHERE SSN = NEW.SUPERVISOR_SSN ) )
INFORM_SUPERVISOR(NEW.Supervisor_ssn, NEW.Ssn );
```



Views

- Views are like "virtual tables" – they are tables derived from other tables ("real tables").
- Once a view is defined, SQL queries can use the view in their FROM clause.
- Two commands: **CREATE VIEW – DROP VIEW**

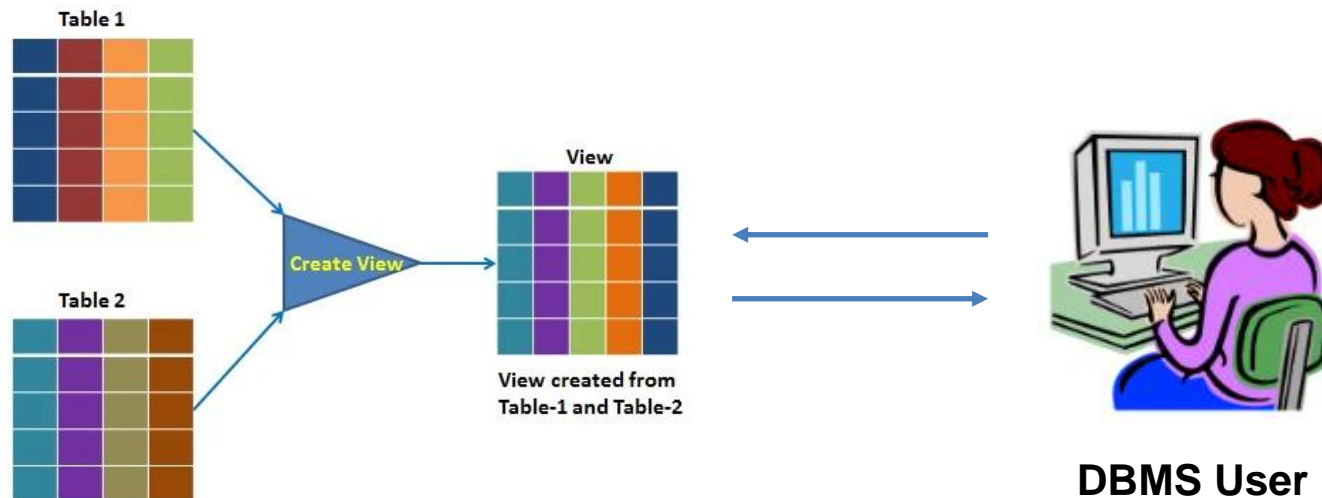
```
V1:  CREATE VIEW  WORKS_ON1
      AS SELECT   Fname, Lname, Pname, Hours
          FROM     EMPLOYEE, PROJECT, WORKS_ON
          WHERE    Ssn=Essn AND Pno=Pnumber;

V2:  CREATE VIEW  DEPT_INFO(Dept_name, No_of_emps, Total_sal)
      AS SELECT   Dname, COUNT (*), SUM (Salary)
          FROM     DEPARTMENT, EMPLOYEE
          WHERE    Dnumber=Dno
          GROUP BY Dname;
```



Why Use Views?

- SQL retrieval queries can use views (-> simpler queries)
- Avoid repeating joins that are used very often
- Applications can use views; meanwhile, you can change the underlying tables without affecting the apps
- Privacy & security: Some users/apps can only read/query a view, which contains a limited portion of the whole DB





Updating Views

- As data in the underlying tables change, views must also be maintained and updated.
- Three main update strategies:
 - **Immediate update** – update the view as soon as the base tables have changed
 - **Periodic update** – update the view periodically, e.g., at the end of every day
 - **Lazy update** – update the view when it is necessary, e.g., right before a retrieval query uses the view
- These strategies have **pros and cons**
 - Do all of them guarantee correctness of query results?
 - Which one is fastest?

Exercises



Exercises

EMPLOYEE(NAME, SSN, BDATE, ADDRESS, SALARY, SUPERSSN, *DNO*)
DEPARTMENT(DNAME, DNUMBER, *MGRSSN*, MGRSTARTDATE)
DEPT_LOCATIONS(DNUMBER, DLOCATION)
PROJECT(PNAME, PNUMBER, PLOCATION, *DNUM*)
WORKSON(ESSN, PNO, HOURS)
DEPENDENT(ESSN, DEPENDENT_NAME, SEX, BDATE, RELATIONSHIP)

- List the names of managers with at least one dependent.

```
SELECT  EMPLOYEE.NAME
FROM    EMPLOYEE, DEPARTMENT
WHERE   DEPARTMENT.MGRSSN = EMPLOYEE.SSN  AND
        EMPLOYEE.SSN IN
        (SELECT DISTINCT ESSN
         FROM DEPENDENT)
```

Check "EXISTS", "NOT EXISTS" slide for a different solution



Exercises

EMPLOYEE(NAME, SSN, BDATE, ADDRESS, SALARY, SUPERSSN, *DNO*)
DEPARTMENT(DNAME, DNUMBER, *MGRSSN*, MGRSTARTDATE)
DEPT_LOCATIONS(DNUMBER, DLOCATION)
PROJECT(PNAME, PNUMBER, PLOCATION, *DNUM*)
WORKSON(ESSN, PNO, HOURS)
DEPENDENT(ESSN, DEPENDENT_NAME, SEX, BDATE, RELATIONSHIP)

- List the names of employees who do not work on any of the projects controlled by department number 5.

```
SELECT NAME
FROM EMPLOYEE
WHERE SSN NOT IN (SELECT WORKSON.ESSN
                  FROM WORKSON, PROJECT
                  WHERE WORKSON.PNO = PROJECT.PNUMBER
                    AND PROJECT.DNUM = 5)
```




Exercises

EMPLOYEE(NAME, SSN, BDATE, ADDRESS, SALARY, SUPERSSN, *DNO*)
DEPARTMENT(DNAME, DNUMBER, *MGRSSN*, MGRSTARTDATE)
DEPT_LOCATIONS(DNUMBER, DLOCATION)
PROJECT(PNAME, PNUMBER, PLOCATION, *DNUM*)
WORKSON(*ESSN*, *PNO*, HOURS)
DEPENDENT(*ESSN*, DEPENDENT_NAME, SEX, BDATE, RELATIONSHIP)

- List the names of employees who do not work on all of the projects controlled by department number 5.

```
SELECT E.NAME
FROM WORKSON W, EMPLOYEE E
WHERE E.SSN = W.ESSN
      AND EXISTS ((SELECT P.PNUMBER
                    FROM PROJECT P
                    WHERE P.DNUM = 5)
                  EXCEPT (SELECT W1.PNO
                             FROM WORKSON W1
                             WHERE W1.ESSN = W.ESSN))
```



Exercises

EMPLOYEE(NAME, SSN, BDATE, ADDRESS, SALARY, SUPERSSN, *DNO*)
DEPARTMENT(DNAME, DNUMBER, *MGRSSN*, MGRSTARTDATE)
DEPT_LOCATIONS(DNUMBER, DLOCATION)
PROJECT(PNAME, PNUMBER, PLOCATION, *DNUM*)
WORKSON(ESSN, PNO, HOURS)
DEPENDENT(ESSN, DEPENDENT_NAME, SEX, BDATE, RELATIONSHIP)

- List the names of employees who do not have supervisors.

```
SELECT NAME  
FROM EMPLOYEE  
WHERE SUPERSSN IS NULL
```



Exercises

EMPLOYEE(NAME, SSN, BDATE, ADDRESS, SALARY, SUPERSSN, *DNO*)
DEPARTMENT(DNAME, DNUMBER, *MGRSSN*, MGRSTARTDATE)
DEPT_LOCATIONS(DNUMBER, DLOCATION)
PROJECT(PNAME, PNUMBER, PLOCATION, *DNUM*)
WORKSON(*ESSN*, *PNO*, HOURS)
DEPENDENT(*ESSN*, DEPENDENT_NAME, SEX, BDATE, RELATIONSHIP)

- Find the total, maximum, minimum, and average salary of employees working in the Research department.

```
SELECT SUM(SALARY) AS SALARY_SUM, MAX(SALARY) AS MAX_SALARY,  
       MIN(SALARY) AS MIN_SALARY, AVG(SALARY) AS AVERAGE_SALARY  
FROM EMPLOYEE, DEPARTMENT  
WHERE EMPLOYEE.DNO = DEPARTMENT.DNUMBER  
      AND DEPARTMENT.DNAME = 'RESEARCH'
```



Exercises

EMPLOYEE(NAME, SSN, BDATE, ADDRESS, SALARY, SUPERSSN, *DNO*)
DEPARTMENT(DNAME, DNUMBER, *MGRSSN*, MGRSTARTDATE)
DEPT_LOCATIONS(DNUMBER, DLOCATION)
PROJECT(PNAME, PNUMBER, PLOCATION, *DNUM*)
WORKSON(ESSN, PNO, HOURS)
DEPENDENT(ESSN, DEPENDENT_NAME, SEX, BDATE, RELATIONSHIP)

- Find the number of employees in the Research department and print it to the screen with title "Employee_Count".

```
SELECT COUNT(*) AS EMPLOYEE_COUNT
FROM EMPLOYEE, DEPARTMENT
WHERE EMPLOYEE.DNO = DEPARTMENT.DNUMBER
      AND DEPARTMENT.DNAME = 'RESEARCH'
```



Exercises

EMPLOYEE(NAME, SSN, BDATE, ADDRESS, SALARY, SUPERSSN, *DNO*)
DEPARTMENT(DNAME, DNUMBER, *MGRSSN*, MGRSTARTDATE)
DEPT_LOCATIONS(DNUMBER, DLOCATION)
PROJECT(PNAME, PNUMBER, PLOCATION, *DNUM*)
WORKSON(ESSN, PNO, HOURS)
DEPENDENT(ESSN, DEPENDENT_NAME, SEX, BDATE, RELATIONSHIP)

- How many different employee salary values exist?

```
SELECT COUNT(DISTINCT SALARY)
FROM EMPLOYEE
```



Exercises

EMPLOYEE(NAME, SSN, BDATE, ADDRESS, SALARY, SUPERSSN, *DNO*)
DEPARTMENT(DNAME, DNUMBER, *MGRSSN*, MGRSTARTDATE)
DEPT_LOCATIONS(DNUMBER, DLOCATION)
PROJECT(PNAME, PNUMBER, PLOCATION, *DNUM*)
WORKSON(ESSN, PNO, HOURS)
DEPENDENT(ESSN, DEPENDENT_NAME, SEX, BDATE, RELATIONSHIP)

- Find the names of employees who have more than 5 children.

```
SELECT NAME  
FROM EMPLOYEE  
WHERE SSN IN (SELECT ESSN  
              FROM DEPENDENT  
              WHERE RELATIONSHIP = 'Child'  
              GROUP BY ESSN  
              HAVING COUNT(*) > 5)
```