

Databases and Information Systems

CS303

SQL

18-08-2023

Nested Queries

- Using one query as a subquery for a larger query.

Nested Queries - Subqueries in FROM clause

- Find the average salary of instructors of those departments where the average salary is greater than 40000.

ID	name	dept_name	salary
10101	Srinivasan	Comp. Sci.	65000
12121	Wu	Finance	90000
15151	Mozart	Music	40000
22222	Einstein	Physics	95000
32343	El Said	History	60000
33456	Gold	Physics	87000
45565	Katz	Comp. Sci.	75000
58583	Califieri	History	62000
76543	Singh	Finance	80000
76766	Crick	Biology	72000
83821	Brandt	Comp. Sci.	92000
98345	Kim	Elec. Eng.	80000

- ```
SELECT dept_name, T.avg_salary instructor
FROM (SELECT dept name, avg (salary) as avg_salary
 FROM instructor
 GROUP BY dept_name)
WHERE avg_salary > 42000;
```

# Nested Queries - Subqueries in FROM clause

- Find the average instructors' salaries of those departments where the average salary is greater than 40000.

| ID    | name       | dept_name  | salary |
|-------|------------|------------|--------|
| 10101 | Srinivasan | Comp. Sci. | 65000  |
| 12121 | Wu         | Finance    | 90000  |
| 15151 | Mozart     | Music      | 40000  |
| 22222 | Einstein   | Physics    | 95000  |
| 32343 | El Said    | History    | 60000  |
| 33456 | Gold       | Physics    | 87000  |
| 45565 | Katz       | Comp. Sci. | 75000  |
| 58583 | Califieri  | History    | 62000  |
| 76543 | Singh      | Finance    | 80000  |
| 76766 | Crick      | Biology    | 72000  |
| 83821 | Brandt     | Comp. Sci. | 92000  |
| 98345 | Kim        | Elec. Eng. | 80000  |

- ```
SELECT T.dname, T.avg_sal
FROM ( SELECT dept name, avg (salary)
      FROM instructor
      GROUP BY dept_name) AS T(dname, avg_sal)
WHERE T.avg_sal > 42000;
```

WITH clause

- Way to define temporary tables needed for the query.
- Find those departments with the maximum budget.

<i>dept_name</i>	<i>building</i>	<i>budget</i>
Biology	Watson	90000
Comp. Sci.	Taylor	100000
Elec. Eng.	Taylor	85000
Finance	Painter	120000
History	Painter	50000
Music	Packard	80000
Physics	Watson	70000

department

- WITH max_budget (value) AS
(SELECT max(budget)
FROM department)

SELECT budget

FROM department, max_budget

WHERE department.budget = max_budget.value;

WITH clause

- Way to define temporary tables needed for the query.
- Find all departments where the total salary is greater than the average of the total salary of all departments.

```
WITH dept_total (dept_name, value) AS
  ( SELECT dept_name, sum(salary)
    FROM instructor
    GROUP BY dept_name ),
dept_total_avg(value) AS
  ( SELECT avg(value)
    FROM dept_total )
SELECT dept_name
FROM dept_total, dept_total_avg
WHERE dept_total.value >= dept_total_avg.value ;
```

ID	name	dept_name	salary
10101	Srinivasan	Comp. Sci.	65000
12121	Wu	Finance	90000
15151	Mozart	Music	40000
22222	Einstein	Physics	95000
32343	El Said	History	60000
33456	Gold	Physics	87000
45565	Katz	Comp. Sci.	75000
58583	Califieri	History	62000
76543	Singh	Finance	80000
76766	Crick	Biology	72000
83821	Brandt	Comp. Sci.	92000
98345	Kim	Elec. Eng.	80000

instructor

Scalar subqueries

- SQL allows subqueries to occur in **SELECT**, **WHERE** etc
 - subquery returns only one tuple containing a single attribute

- List all departments along with the number of instructors in each department:

- **SELECT** dept name,
 (**SELECT** count(*)
 FROM instructor
 WHERE department.dept name = instructor.dept name)
AS num_instructors
FROM department;

ID	name	dept_name	salary
10101	Srinivasan	Comp. Sci.	65000
12121	Wu	Finance	90000
15151	Mozart	Music	40000
22222	Einstein	Physics	95000
32343	El Said	History	60000
33456	Gold	Physics	87000
45565	Katz	Comp. Sci.	75000
58583	Califieri	History	62000
76543	Singh	Finance	80000
76766	Crick	Biology	72000
83821	Brandt	Comp. Sci.	92000
98345	Kim	Elec. Eng.	80000

instructor

Scalar subqueries

- Scalar subqueries can occur in **select, where, and having** clauses.
- Scalar subqueries may also be **defined without aggregates**.
- If the result has **more than one tuple** when the subquery is executed, a **run-time error** occurs.

JOIN

NATURAL JOIN

- Retrieve all instructors along with their department names and building.
- ```
SELECT name, course id
FROM instructor, teaches
WHERE instructor.ID= teaches.ID;
```

| <i>id</i> | <i>name</i> | <i>dept_name</i> | <i>salary</i> |
|-----------|-------------|------------------|---------------|
| 10101     | Srinivasan  | Comp. Sci.       | 65000         |
| 12121     | Wu          | Finance          | 90000         |
| 15151     | Mozart      | Music            | 40000         |
| 22222     | Einstein    | Physics          | 95000         |
| 32343     | El Said     | History          | 60000         |
| 33456     | Gold        | Physics          | 87000         |
| 45565     | Katz        | Comp. Sci.       | 75000         |
| 58583     | Califieri   | History          | 62000         |
| 76543     | Singh       | Finance          | 80000         |
| 76766     | Crick       | Biology          | 72000         |
| 83821     | Brandt      | Comp. Sci.       | 92000         |
| 98345     | Kim         | Elec. Eng.       | 80000         |

instructor

| <i>ID</i> | <i>course_id</i> | <i>sec_id</i> | <i>semester</i> | <i>year</i> |
|-----------|------------------|---------------|-----------------|-------------|
| 10101     | CS-101           | 1             | Fall            | 2009        |
| 10101     | CS-315           | 1             | Spring          | 2010        |
| 10101     | CS-347           | 1             | Fall            | 2009        |
| 12121     | FIN-201          | 1             | Spring          | 2010        |
| 15151     | MU-199           | 1             | Spring          | 2010        |
| 22222     | PHY-101          | 1             | Fall            | 2009        |
| 32343     | HIS-351          | 1             | Spring          | 2010        |
| 45565     | CS-101           | 1             | Spring          | 2010        |
| 45565     | CS-319           | 1             | Spring          | 2010        |
| 76766     | BIO-101          | 1             | Summer          | 2009        |
| 76766     | BIO-301          | 1             | Summer          | 2010        |
| 83821     | CS-190           | 1             | Spring          | 2009        |
| 83821     | CS-190           | 2             | Spring          | 2009        |
| 83821     | CS-319           | 2             | Spring          | 2010        |
| 98345     | EE-181           | 1             | Spring          | 2009        |

teaches

[illegible]

# NATURAL JOIN

- Lot of unwanted tuples
- We only want tuples where ID of instructor is equal to ID of teaches
- **NATURAL JOIN** does exactly this

| <i>id</i> | <i>name</i> | <i>dept_name</i> | <i>salary</i> |
|-----------|-------------|------------------|---------------|
| 10101     | Srinivasan  | Comp. Sci.       | 65000         |
| 12121     | Wu          | Finance          | 90000         |
| 15151     | Mozart      | Music            | 40000         |
| 22222     | Einstein    | Physics          | 95000         |
| 32343     | El Said     | History          | 60000         |
| 33456     | Gold        | Physics          | 87000         |
| 45565     | Katz        | Comp. Sci.       | 75000         |
| 58583     | Califeri    | History          | 62000         |
| 76543     | Singh       | Finance          | 80000         |
| 76766     | Crick       | Biology          | 72000         |
| 83821     | Brandt      | Comp. Sci.       | 92000         |
| 98345     | Kim         | Elec. Eng.       | 80000         |

instructor

| <i>ID</i> | <i>course.id</i> | <i>sec.id</i> | <i>semester</i> | <i>year</i> |
|-----------|------------------|---------------|-----------------|-------------|
| 10101     | CS-101           | 1             | Fall            | 2009        |
| 10101     | CS-315           | 1             | Spring          | 2010        |
| 10101     | CS-347           | 1             | Fall            | 2009        |
| 12121     | FIN-201          | 1             | Spring          | 2010        |
| 15151     | MU-199           | 1             | Spring          | 2010        |
| 22222     | PHY-101          | 1             | Fall            | 2009        |
| 32343     | HIS-351          | 1             | Spring          | 2010        |
| 45565     | CS-101           | 1             | Spring          | 2010        |
| 45565     | CS-319           | 1             | Spring          | 2010        |
| 76766     | BIO-101          | 1             | Summer          | 2009        |
| 76766     | BIO-301          | 1             | Summer          | 2010        |
| 83821     | CS-190           | 1             | Spring          | 2009        |
| 83821     | CS-190           | 2             | Spring          | 2009        |
| 83821     | CS-319           | 2             | Spring          | 2010        |
| 98345     | EE-181           | 1             | Spring          | 2009        |

teaches

[illegible]

# NATURAL JOIN

- Lot of unwanted tuples
- We only want tuples where ID of instructor is equal to ID of teaches
- **NATURAL JOIN** does exactly this

| ID    | name       | dept_name  | salary |
|-------|------------|------------|--------|
| 10101 | Srinivasan | Comp. Sci. | 65000  |
| 12121 | Wu         | Finance    | 90000  |
| 15151 | Mozart     | Music      | 40000  |
| 22222 | Einstein   | Physics    | 95000  |
| 32343 | El Said    | History    | 60000  |
| 33456 | Gold       | Physics    | 87000  |
| 45565 | Katz       | Comp. Sci. | 75000  |
| 58583 | Califieri  | History    | 62000  |
| 76543 | Singh      | Finance    | 80000  |
| 76766 | Crick      | Biology    | 72000  |
| 83821 | Brandt     | Comp. Sci. | 92000  |
| 98345 | Kim        | Elec. Eng. | 80000  |

instructor

| ID    | course_id | sec_id | semester | year |
|-------|-----------|--------|----------|------|
| 10101 | CS-101    | 1      | Fall     | 2009 |
| 10101 | CS-315    | 1      | Spring   | 2010 |
| 10101 | CS-347    | 1      | Fall     | 2009 |
| 12121 | FIN-201   | 1      | Spring   | 2010 |
| 15151 | MU-199    | 1      | Spring   | 2010 |
| 22222 | PHY-101   | 1      | Fall     | 2009 |
| 32343 | HIS-351   | 1      | Spring   | 2010 |
| 45565 | CS-101    | 1      | Spring   | 2010 |
| 45565 | CS-319    | 1      | Spring   | 2010 |
| 76766 | BIO-101   | 1      | Summer   | 2009 |
| 76766 | BIO-301   | 1      | Summer   | 2010 |
| 83821 | CS-190    | 1      | Spring   | 2009 |
| 83821 | CS-190    | 2      | Spring   | 2009 |
| 83821 | CS-319    | 2      | Spring   | 2010 |
| 98345 | EE-181    | 1      | Spring   | 2009 |

teaches

| ID    | name       | dept_name  | salary | course_id | sec_id | semester | year |
|-------|------------|------------|--------|-----------|--------|----------|------|
| 10101 | Srinivasan | Comp. Sci. | 65000  | CS-101    | 1      | Fall     | 2009 |
| 10101 | Srinivasan | Comp. Sci. | 65000  | CS-315    | 1      | Spring   | 2010 |
| 10101 | Srinivasan | Comp. Sci. | 65000  | CS-347    | 1      | Fall     | 2009 |
| 12121 | Wu         | Finance    | 90000  | FIN-201   | 1      | Spring   | 2010 |
| 15151 | Mozart     | Music      | 40000  | MU-199    | 1      | Spring   | 2010 |
| 22222 | Einstein   | Physics    | 95000  | PHY-101   | 1      | Fall     | 2009 |
| 32343 | El Said    | History    | 60000  | HIS-351   | 1      | Spring   | 2010 |
| 45565 | Katz       | Comp. Sci. | 75000  | CS-101    | 1      | Spring   | 2010 |
| 45565 | Katz       | Comp. Sci. | 75000  | CS-319    | 1      | Spring   | 2010 |
| 76766 | Crick      | Biology    | 72000  | BIO-101   | 1      | Summer   | 2009 |
| 76766 | Crick      | Biology    | 72000  | BIO-301   | 1      | Summer   | 2010 |
| 83821 | Brandt     | Comp. Sci. | 92000  | CS-190    | 1      | Spring   | 2009 |
| 83821 | Brandt     | Comp. Sci. | 92000  | CS-190    | 2      | Spring   | 2009 |
| 83821 | Brandt     | Comp. Sci. | 92000  | CS-319    | 2      | Spring   | 2010 |
| 98345 | Kim        | Elec. Eng. | 80000  | EE-181    | 1      | Spring   | 2009 |

NATURAL JOIN of  
instructor and teaches

# NATURAL JOIN

- Retrieve all instructors along with their department names and building.
- `SELECT name, course_id`  
`FROM instructor, teaches`  
`WHERE instructor.ID= teaches.ID;`
- `SELECT name, course_id`  
`FROM instructor NATURAL JOIN teaches ;`

| <i>ID</i> | <i>name</i> | <i>dept_name</i> | <i>salary</i> |
|-----------|-------------|------------------|---------------|
| 10101     | Srinivasan  | Comp. Sci.       | 65000         |
| 12121     | Wu          | Finance          | 90000         |
| 15151     | Mozart      | Music            | 40000         |
| 22222     | Einstein    | Physics          | 95000         |
| 32343     | El Said     | History          | 60000         |
| 33456     | Gold        | Physics          | 87000         |
| 45565     | Katz        | Comp. Sci.       | 75000         |
| 58583     | Califieri   | History          | 62000         |
| 76543     | Singh       | Finance          | 80000         |
| 76766     | Crick       | Biology          | 72000         |
| 83821     | Brandt      | Comp. Sci.       | 92000         |
| 98345     | Kim         | Elec. Eng.       | 80000         |

*instructor*

| <i>ID</i> | <i>course_id</i> | <i>sec_id</i> | <i>semester</i> | <i>year</i> |
|-----------|------------------|---------------|-----------------|-------------|
| 10101     | CS-101           | 1             | Fall            | 2009        |
| 10101     | CS-315           | 1             | Spring          | 2010        |
| 10101     | CS-347           | 1             | Fall            | 2009        |
| 12121     | FIN-201          | 1             | Spring          | 2010        |
| 15151     | MU-199           | 1             | Spring          | 2010        |
| 22222     | PHY-101          | 1             | Fall            | 2009        |
| 32343     | HIS-351          | 1             | Spring          | 2010        |
| 45565     | CS-101           | 1             | Spring          | 2010        |
| 45565     | CS-319           | 1             | Spring          | 2010        |
| 76766     | BIO-101          | 1             | Summer          | 2009        |
| 76766     | BIO-301          | 1             | Summer          | 2010        |
| 83821     | CS-190           | 1             | Spring          | 2009        |
| 83821     | CS-190           | 2             | Spring          | 2009        |
| 83821     | CS-319           | 2             | Spring          | 2010        |
| 98345     | EE-181           | 1             | Spring          | 2009        |

*teaches*

# NATURAL JOIN

- `SELECT A1 , A2 , . . . , An`  
`FROM r1 NATURAL JOIN r2 NATURAL JOIN . . . NATURAL JOIN rm`  
`WHERE P;`

# NATURAL JOIN

- List the names of instructors along with the titles of courses that they teach.
- SELECT name, title  
FROM instructor NATURAL JOIN teaches, course  
WHERE teaches.course id= course.course id;
- SELECT name, title  
FROM instructor NATURAL JOIN teaches NATURAL  
JOIN course ;

| ID    | name       | dept_name  | salary |
|-------|------------|------------|--------|
| 10101 | Srinivasan | Comp. Sci. | 65000  |
| 12121 | Wu         | Finance    | 90000  |
| 15151 | Mozart     | Music      | 40000  |
| 22222 | Einstein   | Physics    | 95000  |
| 32343 | El Said    | History    | 60000  |
| 33456 | Gold       | Physics    | 87000  |
| 45565 | Katz       | Comp. Sci. | 75000  |
| 58583 | Califieri  | History    | 62000  |
| 76543 | Singh      | Finance    | 80000  |
| 76766 | Crick      | Biology    | 72000  |
| 83821 | Brandt     | Comp. Sci. | 92000  |
| 98345 | Kim        | Elec. Eng. | 80000  |

instructor

| course_id | title                      | dept_name  | credits |
|-----------|----------------------------|------------|---------|
| BIO-101   | Intro. to Biology          | Biology    | 4       |
| BIO-301   | Genetics                   | Biology    | 4       |
| BIO-399   | Computational Biology      | Biology    | 3       |
| CS-101    | Intro. to Computer Science | Comp. Sci. | 4       |
| CS-190    | Game Design                | Comp. Sci. | 4       |
| CS-315    | Robotics                   | Comp. Sci. | 3       |
| CS-319    | Image Processing           | Comp. Sci. | 3       |
| CS-347    | Database System Concepts   | Comp. Sci. | 3       |
| EE-181    | Intro. to Digital Systems  | Elec. Eng. | 3       |
| FIN-201   | Investment Banking         | Finance    | 3       |
| HIS-351   | World History              | History    | 3       |
| MU-199    | Music Video Production     | Music      | 3       |
| PHY-101   | Physical Principles        | Physics    | 4       |

course

| ID    | course_id | sec_id | semester | year |
|-------|-----------|--------|----------|------|
| 10101 | CS-101    | 1      | Fall     | 2009 |
| 10101 | CS-315    | 1      | Spring   | 2010 |
| 10101 | CS-347    | 1      | Fall     | 2009 |
| 12121 | FIN-201   | 1      | Spring   | 2010 |
| 15151 | MU-199    | 1      | Spring   | 2010 |
| 22222 | PHY-101   | 1      | Fall     | 2009 |
| 32343 | HIS-351   | 1      | Spring   | 2010 |
| 45565 | CS-101    | 1      | Spring   | 2010 |
| 45565 | CS-319    | 1      | Spring   | 2010 |
| 76766 | BIO-101   | 1      | Summer   | 2009 |
| 76766 | BIO-301   | 1      | Summer   | 2010 |
| 83821 | CS-190    | 1      | Spring   | 2009 |
| 83821 | CS-319    | 2      | Spring   | 2009 |
| 83821 | CS-319    | 2      | Spring   | 2010 |
| 98345 | EE-181    | 1      | Spring   | 2009 |

teaches



# NATURAL JOIN

- List the names of instructors along with the titles of courses that they teach.

| ID    | name       | dept_name  | salary |
|-------|------------|------------|--------|
| 10101 | Srinivasan | Comp. Sci. | 65000  |
| 12121 | Wu         | Finance    | 90000  |
| 15151 | Mozart     | Music      | 40000  |
| 22222 | Einstein   | Physics    | 95000  |
| 32343 | El Said    | History    | 60000  |
| 33456 | Gold       | Physics    | 87000  |
| 45565 | Katz       | Comp. Sci. | 75000  |
| 58583 | Califieri  | History    | 62000  |
| 76543 | Singh      | Finance    | 80000  |
| 76766 | Crick      | Biology    | 72000  |
| 83821 | Brandt     | Comp. Sci. | 92000  |
| 98345 | Kim        | Elec. Eng. | 80000  |

instructor

- SELECT name, title  
FROM instructor NATURAL JOIN teaches, course  
WHERE teaches.course\_id= course.course\_id;

| course_id | title                      | dept_name  | credits |
|-----------|----------------------------|------------|---------|
| BIO-101   | Intro. to Biology          | Biology    | 4       |
| BIO-301   | Genetics                   | Biology    | 4       |
| BIO-399   | Computational Biology      | Biology    | 3       |
| CS-101    | Intro. to Computer Science | Comp. Sci. | 4       |
| CS-190    | Game Design                | Comp. Sci. | 4       |
| CS-315    | Robotics                   | Comp. Sci. | 3       |
| CS-319    | Image Processing           | Comp. Sci. | 3       |
| CS-347    | Database System Concepts   | Comp. Sci. | 3       |
| EE-181    | Intro. to Digital Systems  | Elec. Eng. | 3       |
| FIN-201   | Investment Banking         | Finance    | 3       |
| HIS-351   | World History              | History    | 3       |
| MU-199    | Music Video Production     | Music      | 3       |
| PHY-101   | Physical Principles        | Physics    | 4       |

course

- (WRONG)  
SELECT name, title  
FROM instructor NATURAL JOIN teaches NATURAL  
JOIN course ;

| ID    | course_id | sec_id | semester | year |
|-------|-----------|--------|----------|------|
| 10101 | CS-101    | 1      | Fall     | 2009 |
| 10101 | CS-315    | 1      | Spring   | 2010 |
| 10101 | CS-347    | 1      | Fall     | 2009 |
| 12121 | FIN-201   | 1      | Spring   | 2010 |
| 15151 | MU-199    | 1      | Spring   | 2010 |
| 22222 | PHY-101   | 1      | Fall     | 2009 |
| 32343 | HIS-351   | 1      | Spring   | 2010 |
| 45565 | CS-101    | 1      | Spring   | 2010 |
| 45565 | CS-319    | 1      | Spring   | 2010 |
| 76766 | BIO-101   | 1      | Summer   | 2009 |
| 76766 | BIO-301   | 1      | Summer   | 2010 |
| 83821 | CS-190    | 1      | Spring   | 2009 |
| 83821 | CS-190    | 2      | Spring   | 2009 |
| 83821 | CS-319    | 2      | Spring   | 2010 |
| 98345 | EE-181    | 1      | Spring   | 2009 |

teaches



# NATURAL JOIN

- List the names of instructors along with the titles of courses that they teach.
- SELECT name, title  
FROM instructor NATURAL JOIN teaches,  
course  
WHERE teaches.course\_id= course.course\_id;
- SELECT name, title  
FROM (instructor NATURAL JOIN teaches) JOIN  
course USING (course\_id);

| ID    | name       | dept_name  | salary |
|-------|------------|------------|--------|
| 10101 | Srinivasan | Comp. Sci. | 65000  |
| 12121 | Wu         | Finance    | 90000  |
| 15151 | Mozart     | Music      | 40000  |
| 22222 | Einstein   | Physics    | 95000  |
| 32343 | El Said    | History    | 60000  |
| 33456 | Gold       | Physics    | 87000  |
| 45565 | Katz       | Comp. Sci. | 75000  |
| 58583 | Califieri  | History    | 62000  |
| 76543 | Singh      | Finance    | 80000  |
| 76766 | Crick      | Biology    | 72000  |
| 83821 | Brandt     | Comp. Sci. | 92000  |
| 98345 | Kim        | Elec. Eng. | 80000  |

instructor

| course_id | title                      | dept_name  | credits |
|-----------|----------------------------|------------|---------|
| BIO-101   | Intro. to Biology          | Biology    | 4       |
| BIO-301   | Genetics                   | Biology    | 4       |
| BIO-399   | Computational Biology      | Biology    | 3       |
| CS-101    | Intro. to Computer Science | Comp. Sci. | 4       |
| CS-190    | Game Design                | Comp. Sci. | 4       |
| CS-315    | Robotics                   | Comp. Sci. | 3       |
| CS-319    | Image Processing           | Comp. Sci. | 3       |
| CS-347    | Database System Concepts   | Comp. Sci. | 3       |
| EE-181    | Intro. to Digital Systems  | Elec. Eng. | 3       |
| FIN-201   | Investment Banking         | Finance    | 3       |
| HIS-351   | World History              | History    | 3       |
| MU-199    | Music Video Production     | Music      | 3       |
| PHY-101   | Physical Principles        | Physics    | 4       |

course

| ID    | course_id | sec_id | semester | year |
|-------|-----------|--------|----------|------|
| 10101 | CS-101    | 1      | Fall     | 2009 |
| 10101 | CS-315    | 1      | Spring   | 2010 |
| 10101 | CS-347    | 1      | Fall     | 2009 |
| 12121 | FIN-201   | 1      | Spring   | 2010 |
| 15151 | MU-199    | 1      | Spring   | 2010 |
| 22222 | PHY-101   | 1      | Fall     | 2009 |
| 32343 | HIS-351   | 1      | Spring   | 2010 |
| 45565 | CS-101    | 1      | Spring   | 2010 |
| 45565 | CS-319    | 1      | Spring   | 2010 |
| 76766 | BIO-101   | 1      | Summer   | 2009 |
| 76766 | BIO-301   | 1      | Summer   | 2010 |
| 83821 | CS-190    | 1      | Spring   | 2009 |
| 83821 | CS-190    | 2      | Spring   | 2009 |
| 83821 | CS-319    | 2      | Spring   | 2010 |
| 98345 | EE-181    | 1      | Spring   | 2009 |

teaches

# JOIN..ON

- **SELECT \***  
**FROM student NATURAL JOIN takes;**
- **SELECT \***  
**FROM student JOIN takes ON student.ID= takes.ID;**
- **SELECT \***  
**FROM student, takes**  
**WHERE student.ID= takes.ID;**

| ID    | name     | dept_name  | tot_cred |
|-------|----------|------------|----------|
| 00128 | Zhang    | Comp. Sci. | 102      |
| 12345 | Shankar  | Comp. Sci. | 32       |
| 19991 | Brandt   | History    | 80       |
| 23121 | Chavez   | Finance    | 110      |
| 44553 | Peltier  | Physics    | 56       |
| 45678 | Levy     | Physics    | 46       |
| 54321 | Williams | Comp. Sci. | 54       |
| 55739 | Sanchez  | Music      | 38       |
| 70557 | Snow     | Physics    | 0        |
| 76543 | Brown    | Comp. Sci. | 58       |
| 76653 | Aoi      | Elec. Eng. | 60       |
| 98765 | Bourikas | Elec. Eng. | 98       |
| 98988 | Tanaka   | Biology    | 120      |

student

| ID    | course_id | sec_id | semester | year | grade |
|-------|-----------|--------|----------|------|-------|
| 00128 | CS-101    | 1      | Fall     | 2009 | A     |
| 00128 | CS-347    | 1      | Fall     | 2009 | A-    |
| 12345 | CS-101    | 1      | Fall     | 2009 | C     |
| 12345 | CS-190    | 2      | Spring   | 2009 | A     |
| 12345 | CS-315    | 1      | Spring   | 2010 | A     |
| 12345 | CS-347    | 1      | Fall     | 2009 | A     |
| 19991 | HIS-351   | 1      | Spring   | 2010 | B     |
| 23121 | FIN-201   | 1      | Spring   | 2010 | C+    |
| 44553 | PHY-101   | 1      | Fall     | 2009 | B-    |
| 45678 | CS-101    | 1      | Fall     | 2009 | F     |
| 45678 | CS-101    | 1      | Spring   | 2010 | B+    |
| 45678 | CS-319    | 1      | Spring   | 2010 | B     |
| 54321 | CS-101    | 1      | Fall     | 2009 | A-    |
| 54321 | CS-190    | 2      | Spring   | 2009 | B+    |
| 55739 | MU-199    | 1      | Spring   | 2010 | A-    |
| 76543 | CS-101    | 1      | Fall     | 2009 | A     |
| 76543 | CS-319    | 2      | Spring   | 2010 | A     |
| 76653 | EE-181    | 1      | Spring   | 2009 | C     |
| 98765 | CS-101    | 1      | Fall     | 2009 | C-    |
| 98765 | CS-315    | 1      | Spring   | 2010 | B     |
| 98988 | BIO-101   | 1      | Summer   | 2009 | A     |
| 98988 | BIO-301   | 1      | Summer   | 2010 | null  |

takes

# OUTER JOIN

- Retrieve list of all students, displaying their **ID**, and **name**, **dept\_name**, and **tot\_cred**, along with the **courses** that they have taken.
- SELECT \***  
**FROM student JOIN takes ON student.ID= takes.ID;**
- What about a student who has not taken any course?

| ID    | name     | dept_name  | tot_cred |
|-------|----------|------------|----------|
| 00128 | Zhang    | Comp. Sci. | 102      |
| 12345 | Shankar  | Comp. Sci. | 32       |
| 19991 | Brandt   | History    | 80       |
| 23121 | Chavez   | Finance    | 110      |
| 44553 | Peltier  | Physics    | 56       |
| 45678 | Levy     | Physics    | 46       |
| 54321 | Williams | Comp. Sci. | 54       |
| 55739 | Sanchez  | Music      | 38       |
| 70557 | Snow     | Physics    | 0        |
| 76543 | Brown    | Comp. Sci. | 58       |
| 76653 | Aoi      | Elec. Eng. | 60       |
| 98765 | Bourikas | Elec. Eng. | 98       |
| 98988 | Tanaka   | Biology    | 120      |

student

| ID    | course_id | sec_id | semester | year | grade |
|-------|-----------|--------|----------|------|-------|
| 00128 | CS-101    | 1      | Fall     | 2009 | A     |
| 00128 | CS-347    | 1      | Fall     | 2009 | A-    |
| 12345 | CS-101    | 1      | Fall     | 2009 | C     |
| 12345 | CS-190    | 2      | Spring   | 2009 | A     |
| 12345 | CS-315    | 1      | Spring   | 2010 | A     |
| 12345 | CS-347    | 1      | Fall     | 2009 | A     |
| 19991 | HIS-351   | 1      | Spring   | 2010 | B     |
| 23121 | FIN-201   | 1      | Spring   | 2010 | C+    |
| 44553 | PHY-101   | 1      | Fall     | 2009 | B-    |
| 45678 | CS-101    | 1      | Fall     | 2009 | F     |
| 45678 | CS-101    | 1      | Spring   | 2010 | B+    |
| 45678 | CS-319    | 1      | Spring   | 2010 | B     |
| 54321 | CS-101    | 1      | Fall     | 2009 | A-    |
| 54321 | CS-190    | 2      | Spring   | 2009 | B+    |
| 55739 | MU-199    | 1      | Spring   | 2010 | A-    |
| 76543 | CS-101    | 1      | Fall     | 2009 | A     |
| 76543 | CS-319    | 2      | Spring   | 2010 | A     |
| 76653 | EE-181    | 1      | Spring   | 2009 | C     |
| 98765 | CS-101    | 1      | Fall     | 2009 | C-    |
| 98765 | CS-315    | 1      | Spring   | 2010 | B     |
| 98988 | BIO-101   | 1      | Summer   | 2009 | A     |
| 98988 | BIO-301   | 1      | Summer   | 2010 | null  |

takes

# OUTER JOIN

- **OUTER JOIN** preserves tuples of one table that do not have matching rows in the other table.
  - **LEFT OUTER JOIN** preserves tuples only in the relation named to the left of the left outer join operation.
  - **RIGHT OUTER JOIN** preserves tuples only in the relation named to the right of the right outer join operation.
  - **FULL OUTER JOIN** preserves tuples in both relations.

| ID    | name     | dept_name  | tot_cred |
|-------|----------|------------|----------|
| 00128 | Zhang    | Comp. Sci. | 102      |
| 12345 | Shankar  | Comp. Sci. | 32       |
| 19991 | Brandt   | History    | 80       |
| 23121 | Chavez   | Finance    | 110      |
| 44553 | Peltier  | Physics    | 56       |
| 45678 | Levy     | Physics    | 46       |
| 54321 | Williams | Comp. Sci. | 54       |
| 55739 | Sanchez  | Music      | 38       |
| 70557 | Snow     | Physics    | 0        |
| 76543 | Brown    | Comp. Sci. | 58       |
| 76653 | Aoi      | Elec. Eng. | 60       |
| 98765 | Bourikas | Elec. Eng. | 98       |
| 98988 | Tanaka   | Biology    | 120      |

student

| ID    | course_id | sec_id | semester | year | grade |
|-------|-----------|--------|----------|------|-------|
| 00128 | CS-101    | 1      | Fall     | 2009 | A     |
| 00128 | CS-347    | 1      | Fall     | 2009 | A-    |
| 12345 | CS-101    | 1      | Fall     | 2009 | C     |
| 12345 | CS-190    | 2      | Spring   | 2009 | A     |
| 12345 | CS-315    | 1      | Spring   | 2010 | A     |
| 12345 | CS-347    | 1      | Fall     | 2009 | A     |
| 19991 | HIS-351   | 1      | Spring   | 2010 | B     |
| 23121 | FIN-201   | 1      | Spring   | 2010 | C+    |
| 44553 | PHY-101   | 1      | Fall     | 2009 | B-    |
| 45678 | CS-101    | 1      | Fall     | 2009 | F     |
| 45678 | CS-101    | 1      | Spring   | 2010 | B+    |
| 45678 | CS-319    | 1      | Spring   | 2010 | B     |
| 54321 | CS-101    | 1      | Fall     | 2009 | A-    |
| 54321 | CS-190    | 2      | Spring   | 2009 | B+    |
| 55739 | MU-199    | 1      | Spring   | 2010 | A-    |
| 76543 | CS-101    | 1      | Fall     | 2009 | A     |
| 76543 | CS-319    | 2      | Spring   | 2010 | A     |
| 76653 | EE-181    | 1      | Spring   | 2009 | C     |
| 98765 | CS-101    | 1      | Fall     | 2009 | C-    |
| 98765 | CS-315    | 1      | Spring   | 2010 | B     |
| 98988 | BIO-101   | 1      | Summer   | 2009 | A     |
| 98988 | BIO-301   | 1      | Summer   | 2010 | null  |

takes

# OUTER JOIN

- SELECT \*  
FROM student NATURAL LEFT OUTER JOIN takes;

| ID    | name     | dept_name  | tot_cred | course_id | sec_id | semester | year | grade |
|-------|----------|------------|----------|-----------|--------|----------|------|-------|
| 00128 | Zhang    | Comp. Sci. | 102      | CS-101    | 1      | Fall     | 2009 | A     |
| 00128 | Zhang    | Comp. Sci. | 102      | CS-347    | 1      | Fall     | 2009 | A-    |
| 12345 | Shankar  | Comp. Sci. | 32       | CS-101    | 1      | Fall     | 2009 | C     |
| 12345 | Shankar  | Comp. Sci. | 32       | CS-190    | 2      | Spring   | 2009 | A     |
| 12345 | Shankar  | Comp. Sci. | 32       | CS-315    | 1      | Spring   | 2010 | A     |
| 12345 | Shankar  | Comp. Sci. | 32       | CS-347    | 1      | Fall     | 2009 | A     |
| 19991 | Brandt   | History    | 80       | HIS-351   | 1      | Spring   | 2010 | B     |
| 23121 | Chavez   | Finance    | 110      | FIN-201   | 1      | Spring   | 2010 | C+    |
| 44553 | Peltier  | Physics    | 56       | PHY-101   | 1      | Fall     | 2009 | B-    |
| 45678 | Levy     | Physics    | 46       | CS-101    | 1      | Fall     | 2009 | F     |
| 45678 | Levy     | Physics    | 46       | CS-101    | 1      | Spring   | 2010 | B+    |
| 45678 | Levy     | Physics    | 46       | CS-319    | 1      | Spring   | 2010 | B     |
| 54321 | Williams | Comp. Sci. | 54       | CS-101    | 1      | Fall     | 2009 | A-    |
| 54321 | Williams | Comp. Sci. | 54       | CS-190    | 2      | Spring   | 2009 | B+    |
| 55739 | Sanchez  | Music      | 38       | MU-199    | 1      | Spring   | 2010 | A-    |
| 70557 | Snow     | Physics    | 0        | null      | null   | null     | null | null  |
| 76543 | Brown    | Comp. Sci. | 58       | CS-101    | 1      | Fall     | 2009 | A     |
| 76543 | Brown    | Comp. Sci. | 58       | CS-319    | 2      | Spring   | 2010 | A     |
| 76653 | Aoi      | Elec. Eng. | 60       | EE-181    | 1      | Spring   | 2009 | C     |
| 98765 | Bourikas | Elec. Eng. | 98       | CS-101    | 1      | Fall     | 2009 | C-    |
| 98765 | Bourikas | Elec. Eng. | 98       | CS-315    | 1      | Spring   | 2010 | B     |
| 98988 | Tanaka   | Biology    | 120      | BIO-101   | 1      | Summer   | 2009 | A     |
| 98988 | Tanaka   | Biology    | 120      | BIO-301   | 1      | Summer   | 2010 | null  |

| ID    | name     | dept_name  | tot_cred |
|-------|----------|------------|----------|
| 00128 | Zhang    | Comp. Sci. | 102      |
| 12345 | Shankar  | Comp. Sci. | 32       |
| 19991 | Brandt   | History    | 80       |
| 23121 | Chavez   | Finance    | 110      |
| 44553 | Peltier  | Physics    | 56       |
| 45678 | Levy     | Physics    | 46       |
| 54321 | Williams | Comp. Sci. | 54       |
| 55739 | Sanchez  | Music      | 38       |
| 70557 | Snow     | Physics    | 0        |
| 76543 | Brown    | Comp. Sci. | 58       |
| 76653 | Aoi      | Elec. Eng. | 60       |
| 98765 | Bourikas | Elec. Eng. | 98       |
| 98988 | Tanaka   | Biology    | 120      |

student

| ID    | course_id | sec_id | semester | year | grade |
|-------|-----------|--------|----------|------|-------|
| 00128 | CS-101    | 1      | Fall     | 2009 | A     |
| 00128 | CS-347    | 1      | Fall     | 2009 | A-    |
| 12345 | CS-101    | 1      | Fall     | 2009 | C     |
| 12345 | CS-190    | 2      | Spring   | 2009 | A     |
| 12345 | CS-315    | 1      | Spring   | 2010 | A     |
| 12345 | CS-347    | 1      | Fall     | 2009 | A     |
| 19991 | HIS-351   | 1      | Spring   | 2010 | B     |
| 23121 | FIN-201   | 1      | Spring   | 2010 | C+    |
| 44553 | PHY-101   | 1      | Fall     | 2009 | B-    |
| 45678 | CS-101    | 1      | Fall     | 2009 | F     |
| 45678 | CS-101    | 1      | Spring   | 2010 | B+    |
| 45678 | CS-319    | 1      | Spring   | 2010 | B     |
| 54321 | CS-101    | 1      | Fall     | 2009 | A-    |
| 54321 | CS-190    | 2      | Spring   | 2009 | B+    |
| 55739 | MU-199    | 1      | Spring   | 2010 | A-    |
| 76543 | CS-101    | 1      | Fall     | 2009 | A     |
| 76543 | CS-319    | 2      | Spring   | 2010 | A     |
| 76653 | EE-181    | 1      | Spring   | 2009 | C     |
| 98765 | CS-101    | 1      | Fall     | 2009 | C-    |
| 98765 | CS-315    | 1      | Spring   | 2010 | B     |
| 98988 | BIO-101   | 1      | Summer   | 2009 | A     |
| 98988 | BIO-301   | 1      | Summer   | 2010 | null  |

takes

# INNER JOIN

- Does not preserve non-matched tuples

● **SELECT \***  
**FROM student INNER JOIN takes USING (ID);**

● **SELECT \***  
**FROM student JOIN takes USING (ID);**

| ID    | name     | dept_name  | tot_cred |
|-------|----------|------------|----------|
| 00128 | Zhang    | Comp. Sci. | 102      |
| 12345 | Shankar  | Comp. Sci. | 32       |
| 19991 | Brandt   | History    | 80       |
| 23121 | Chavez   | Finance    | 110      |
| 44553 | Peltier  | Physics    | 56       |
| 45678 | Levy     | Physics    | 46       |
| 54321 | Williams | Comp. Sci. | 54       |
| 55739 | Sanchez  | Music      | 38       |
| 70557 | Snow     | Physics    | 0        |
| 76543 | Brown    | Comp. Sci. | 58       |
| 76653 | Aoi      | Elec. Eng. | 60       |
| 98765 | Bourikas | Elec. Eng. | 98       |
| 98988 | Tanaka   | Biology    | 120      |

student

| ID    | course_id | sec_id | semester | year | grade |
|-------|-----------|--------|----------|------|-------|
| 00128 | CS-101    | 1      | Fall     | 2009 | A     |
| 00128 | CS-347    | 1      | Fall     | 2009 | A-    |
| 12345 | CS-101    | 1      | Fall     | 2009 | C     |
| 12345 | CS-190    | 2      | Spring   | 2009 | A     |
| 12345 | CS-315    | 1      | Spring   | 2010 | A     |
| 12345 | CS-347    | 1      | Fall     | 2009 | A     |
| 19991 | HIS-351   | 1      | Spring   | 2010 | B     |
| 23121 | FIN-201   | 1      | Spring   | 2010 | C+    |
| 44553 | PHY-101   | 1      | Fall     | 2009 | B-    |
| 45678 | CS-101    | 1      | Fall     | 2009 | F     |
| 45678 | CS-101    | 1      | Spring   | 2010 | B+    |
| 45678 | CS-319    | 1      | Spring   | 2010 | B     |
| 54321 | CS-101    | 1      | Fall     | 2009 | A-    |
| 54321 | CS-190    | 2      | Spring   | 2009 | B+    |
| 55739 | MU-199    | 1      | Spring   | 2010 | A-    |
| 76543 | CS-101    | 1      | Fall     | 2009 | A     |
| 76543 | CS-319    | 2      | Spring   | 2010 | A     |
| 76653 | EE-181    | 1      | Spring   | 2009 | C     |
| 98765 | CS-101    | 1      | Fall     | 2009 | C-    |
| 98765 | CS-315    | 1      | Spring   | 2010 | B     |
| 98988 | BIO-101   | 1      | Summer   | 2009 | A     |
| 98988 | BIO-301   | 1      | Summer   | 2010 | null  |

takes

# Modifying the database

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# Deletion

- DELETE FROM instructor;
- DELETE FROM instructor  
WHERE dept\_name= 'Finance';
- DELETE FROM instructor  
WHERE dept\_name IN ( SELECT dept\_name  
FROM department  
WHERE building = 'Watson');

| <i>ID</i> | <i>name</i> | <i>dept_name</i> | <i>salary</i> |
|-----------|-------------|------------------|---------------|
| 10101     | Srinivasan  | Comp. Sci.       | 65000         |
| 12121     | Wu          | Finance          | 90000         |
| 15151     | Mozart      | Music            | 40000         |
| 22222     | Einstein    | Physics          | 95000         |
| 32343     | El Said     | History          | 60000         |
| 33456     | Gold        | Physics          | 87000         |
| 45565     | Katz        | Comp. Sci.       | 75000         |
| 58583     | Califieri   | History          | 62000         |
| 76543     | Singh       | Finance          | 80000         |
| 76766     | Crick       | Biology          | 72000         |
| 83821     | Brandt      | Comp. Sci.       | 92000         |
| 98345     | Kim         | Elec. Eng.       | 80000         |

*instructor*

| <i>dept_name</i> | <i>building</i> | <i>budget</i> |
|------------------|-----------------|---------------|
| Biology          | Watson          | 90000         |
| Comp. Sci.       | Taylor          | 100000        |
| Elec. Eng.       | Taylor          | 85000         |
| Finance          | Painter         | 120000        |
| History          | Painter         | 50000         |
| Music            | Packard         | 80000         |
| Physics          | Watson          | 70000         |

*department*



# Deletion

- `DELETE FROM instructor;`
- `DELETE FROM instructor`  
`WHERE dept name= 'Finance';`
- `DELETE FROM instructor`  
`WHERE dept name IN ( SELECT dept_name`  
`FROM department`  
`WHERE building = 'Watson');`
- Should the test be done first and then delete should be executed?  
Or should it be done for every row?

| <i>ID</i> | <i>name</i> | <i>dept_name</i> | <i>salary</i> |
|-----------|-------------|------------------|---------------|
| 10101     | Srinivasan  | Comp. Sci.       | 65000         |
| 12121     | Wu          | Finance          | 90000         |
| 15151     | Mozart      | Music            | 40000         |
| 22222     | Einstein    | Physics          | 95000         |
| 32343     | El Said     | History          | 60000         |
| 33456     | Gold        | Physics          | 87000         |
| 45565     | Katz        | Comp. Sci.       | 75000         |
| 58583     | Califieri   | History          | 62000         |
| 76543     | Singh       | Finance          | 80000         |
| 76766     | Crick       | Biology          | 72000         |
| 83821     | Brandt      | Comp. Sci.       | 92000         |
| 98345     | Kim         | Elec. Eng.       | 80000         |

*instructor*

| <i>dept_name</i> | <i>building</i> | <i>budget</i> |
|------------------|-----------------|---------------|
| Biology          | Watson          | 90000         |
| Comp. Sci.       | Taylor          | 100000        |
| Elec. Eng.       | Taylor          | 85000         |
| Finance          | Painter         | 120000        |
| History          | Painter         | 50000         |
| Music            | Packard         | 80000         |
| Physics          | Watson          | 70000         |

*department*

# Deletion

- Delete the records of all instructors with salary below the average at the university.

- **DELETE FROM instructor**  
**WHERE salary < ( SELECT avg (salary)**  
**FROM instructor );**

| <i>ID</i> | <i>name</i> | <i>dept_name</i> | <i>salary</i> |
|-----------|-------------|------------------|---------------|
| 10101     | Srinivasan  | Comp. Sci.       | 65000         |
| 12121     | Wu          | Finance          | 90000         |
| 15151     | Mozart      | Music            | 40000         |
| 22222     | Einstein    | Physics          | 95000         |
| 32343     | El Said     | History          | 60000         |
| 33456     | Gold        | Physics          | 87000         |
| 45565     | Katz        | Comp. Sci.       | 75000         |
| 58583     | Califieri   | History          | 62000         |
| 76543     | Singh       | Finance          | 80000         |
| 76766     | Crick       | Biology          | 72000         |
| 83821     | Brandt      | Comp. Sci.       | 92000         |
| 98345     | Kim         | Elec. Eng.       | 80000         |

**instructor**

# Updates

- UPDATE instructor  
SET salary= salary \* 1.05;
- UPDATE instructor  
SET salary = CASE  
    WHEN salary <= 100000 THEN salary \* 1.05  
    ELSE salary \* 1.03  
END
- UPDATE instructor  
SET salary = CASE  
    WHEN C1 THEN U1  
    WHEN C2 THEN U2  
    .....  
    ELSE Un  
END

| ID    | name       | dept_name  | salary |
|-------|------------|------------|--------|
| 10101 | Srinivasan | Comp. Sci. | 65000  |
| 12121 | Wu         | Finance    | 90000  |
| 15151 | Mozart     | Music      | 40000  |
| 22222 | Einstein   | Physics    | 95000  |
| 32343 | El Said    | History    | 60000  |
| 33456 | Gold       | Physics    | 87000  |
| 45565 | Katz       | Comp. Sci. | 75000  |
| 58583 | Califieri  | History    | 62000  |
| 76543 | Singh      | Finance    | 80000  |
| 76766 | Crick      | Biology    | 72000  |
| 83821 | Brandt     | Comp. Sci. | 92000  |
| 98345 | Kim        | Elec. Eng. | 80000  |

instructor