

RDBMS and SQL

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Queries in SQL

- `select` columns
 `from` table
 `where` condition
- SQL `select` combines σ and π of relational algebra

<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

Queries in SQL

- `select` columns
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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
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98345	Kim	Elec. Eng.	80000

Queries in SQL

- `select` columns
 `from` table
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<i>ID</i>	<i>name</i>	<i>dept_name</i>	<i>salary</i>
10101	Srinivasan	Comp. Sci.	65000
12121	Wu	Finance	90000
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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

Queries in SQL

- `select` columns
 `from` table
 `where` condition
 - SQL `select` combines σ and π of relational algebra
- ```
select ID,name
from instructor
where dept_name = "Physics"
and salary > 90000
```

$\sigma, \pi$

| <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         |

# Queries in SQL

- `select` does not eliminate duplicates

```
select dept_name
from instructor
```

- Explicitly specify that duplicates should be removed — additional computation, so avoid if not needed

```
select distinct dept_name
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         |

# Queries in SQL

- Select all attributes using \*

```
select *
 from instructor
 where dept_name = "Physics"
```

| <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         |

# Queries in SQL

- Select all attributes using `*`

```
select *
 from instructor
 where dept_name = "Physics"
```

- Can do arithmetic on attributes — get monthly salary

```
select ID,name,salary/12
 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         |



# Queries in SQL

- Multiple tables in `from` — cartesian product

```
select *
 from instructor, 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         |

| <i>ID</i> | <i>course_id</i> | <i>sec_id</i> | <i>semester</i> | <i>year</i> |
|-----------|------------------|---------------|-----------------|-------------|
| 10101     | CS-101           | 1             | Fall            | 2017        |
| 10101     | CS-315           | 1             | Spring          | 2018        |
| 10101     | CS-347           | 1             | Fall            | 2017        |
| 12121     | FIN-201          | 1             | Spring          | 2018        |
| 15151     | MU-199           | 1             | Spring          | 2018        |
| 22222     | PHY-101          | 1             | Fall            | 2017        |
| 32343     | HIS-351          | 1             | Spring          | 2018        |
| 45565     | CS-101           | 1             | Spring          | 2018        |
| 45565     | CS-319           | 1             | Spring          | 2018        |
| 76766     | BIO-101          | 1             | Summer          | 2017        |
| 76766     | BIO-301          | 1             | Summer          | 2018        |
| 83821     | CS-190           | 1             | Spring          | 2017        |
| 83821     | CS-190           | 2             | Spring          | 2017        |
| 83821     | CS-319           | 2             | Spring          | 2018        |
| 98345     | EE-181           | 1             | Spring          | 2017        |

# Queries in SQL

- Multiple tables in **from** — cartesian product

```
select *
 from instructor, teaches
```

- Use **where** to implement join

```
select *
 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         |

| <i>ID</i> | <i>course_id</i> | <i>sec_id</i> | <i>semester</i> | <i>year</i> |
|-----------|------------------|---------------|-----------------|-------------|
| 10101     | CS-101           | 1             | Fall            | 2017        |
| 10101     | CS-315           | 1             | Spring          | 2018        |
| 10101     | CS-347           | 1             | Fall            | 2017        |
| 12121     | FIN-201          | 1             | Spring          | 2018        |
| 15151     | MU-199           | 1             | Spring          | 2018        |
| 22222     | PHY-101          | 1             | Fall            | 2017        |
| 32343     | HIS-351          | 1             | Spring          | 2018        |
| 45565     | CS-101           | 1             | Spring          | 2018        |
| 45565     | CS-319           | 1             | Spring          | 2018        |
| 76766     | BIO-101          | 1             | Summer          | 2017        |
| 76766     | BIO-301          | 1             | Summer          | 2018        |
| 83821     | CS-190           | 1             | Spring          | 2017        |
| 83821     | CS-190           | 2             | Spring          | 2017        |
| 83821     | CS-319           | 2             | Spring          | 2018        |
| 98345     | EE-181           | 1             | Spring          | 2017        |

# Queries in SQL

- Multiple tables in **from** — cartesian product

```
select *
 from instructor, teaches
```

- Use **where** to implement join

```
select *
 from instructor, teaches
 where instructor.ID = teaches.ID
```

- Choose output columns

```
select name, course_id
 from instructor, teaches
 where instructor.ID = teaches.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  |

| ID    | course_id | sec_id | semester | year |
|-------|-----------|--------|----------|------|
| 10101 | CS-101    | 1      | Fall     | 2017 |
| 10101 | CS-315    | 1      | Spring   | 2018 |
| 10101 | CS-347    | 1      | Fall     | 2017 |
| 12121 | FIN-201   | 1      | Spring   | 2018 |
| 15151 | MU-199    | 1      | Spring   | 2018 |
| 22222 | PHY-101   | 1      | Fall     | 2017 |
| 32343 | HIS-351   | 1      | Spring   | 2018 |
| 45565 | CS-101    | 1      | Spring   | 2018 |
| 45565 | CS-319    | 1      | Spring   | 2018 |
| 76766 | BIO-101   | 1      | Summer   | 2017 |
| 76766 | BIO-301   | 1      | Summer   | 2018 |
| 83821 | CS-190    | 1      | Spring   | 2017 |
| 83821 | CS-190    | 2      | Spring   | 2017 |
| 83821 | CS-319    | 2      | Spring   | 2018 |
| 98345 | EE-181    | 1      | Spring   | 2017 |

# Queries in SQL

## ■ Renaming for self join

| <i>ID</i> | <i>course_id</i> | <i>sec_id</i> | <i>semester</i> | <i>year</i> |
|-----------|------------------|---------------|-----------------|-------------|
| 10101     | CS-101           | 1             | Fall            | 2017        |
| 10101     | CS-315           | 1             | Spring          | 2018        |
| 10101     | CS-347           | 1             | Fall            | 2017        |
| 12121     | FIN-201          | 1             | Spring          | 2018        |
| 15151     | MU-199           | 1             | Spring          | 2018        |
| 22222     | PHY-101          | 1             | Fall            | 2017        |
| 32343     | HIS-351          | 1             | Spring          | 2018        |
| 45565     | CS-101           | 1             | Spring          | 2018        |
| 45565     | CS-319           | 1             | Spring          | 2018        |
| 76766     | BIO-101          | 1             | Summer          | 2017        |
| 76766     | BIO-301          | 1             | Summer          | 2018        |
| 83821     | CS-190           | 1             | Spring          | 2017        |
| 83821     | CS-190           | 2             | Spring          | 2017        |
| 83821     | CS-319           | 2             | Spring          | 2018        |
| 98345     | EE-181           | 1             | Spring          | 2017        |

# Queries in SQL

## ■ Renaming for self join

```
select *
 from teaches as T1, teaches as T2
 where T1.ID = T2.ID and
 T1.course_id <> T2.course_id
```

original !=

| ID    | course_id | sec_id | semester | year |
|-------|-----------|--------|----------|------|
| 10101 | CS-101    | 1      | Fall     | 2017 |
| 10101 | CS-315    | 1      | Spring   | 2018 |
| 10101 | CS-347    | 1      | Fall     | 2017 |
| 12121 | FIN-201   | 1      | Spring   | 2018 |
| 15151 | MU-199    | 1      | Spring   | 2018 |
| 22222 | PHY-101   | 1      | Fall     | 2017 |
| 32343 | HIS-351   | 1      | Spring   | 2018 |
| 45565 | CS-101    | 1      | Spring   | 2018 |
| 45565 | CS-319    | 1      | Spring   | 2018 |
| 76766 | BIO-101   | 1      | Summer   | 2017 |
| 76766 | BIO-301   | 1      | Summer   | 2018 |
| 83821 | CS-190    | 1      | Spring   | 2017 |
| 83821 | CS-190    | 2      | Spring   | 2017 |
| 83821 | CS-319    | 2      | Spring   | 2018 |
| 98345 | EE-181    | 1      | Spring   | 2017 |

# Queries in SQL

## ■ Renaming for self join

```
select *
 from teaches as T1, teaches as T2
 where T1.ID = T2.ID and
 T1.course_id <> T2.course_id
```

also applies  
to output  
columns

## ■ Filter output

```
select distinct T1.ID
 from teaches as T1, teaches as T2
 where T1.ID = T2.ID and
 T1.course_id <> T2.course_id
```

| ID    | course_id | sec_id | semester | year |
|-------|-----------|--------|----------|------|
| 10101 | CS-101    | 1      | Fall     | 2017 |
| 10101 | CS-315    | 1      | Spring   | 2018 |
| 10101 | CS-347    | 1      | Fall     | 2017 |
| 12121 | FIN-201   | 1      | Spring   | 2018 |
| 15151 | MU-199    | 1      | Spring   | 2018 |
| 22222 | PHY-101   | 1      | Fall     | 2017 |
| 32343 | HIS-351   | 1      | Spring   | 2018 |
| 45565 | CS-101    | 1      | Spring   | 2018 |
| 45565 | CS-319    | 1      | Spring   | 2018 |
| 76766 | BIO-101   | 1      | Summer   | 2017 |
| 76766 | BIO-301   | 1      | Summer   | 2018 |
| 83821 | CS-190    | 1      | Spring   | 2017 |
| 83821 | CS-190    | 2      | Spring   | 2017 |
| 83821 | CS-319    | 2      | Spring   | 2018 |
| 98345 | EE-181    | 1      | Spring   | 2017 |

# Queries in SQL

## ■ Set operations

| <i>course_id</i> | <i>sec_id</i> | <i>semester</i> | <i>year</i> | <i>building</i> | <i>room_number</i> | <i>time_slot_id</i> |
|------------------|---------------|-----------------|-------------|-----------------|--------------------|---------------------|
| BIO-101          | 1             | Summer          | 2017        | Painter         | 514                | B                   |
| BIO-301          | 1             | Summer          | 2018        | Painter         | 514                | A                   |
| CS-101           | 1             | Fall            | 2017        | Packard         | 101                | H                   |
| CS-101           | 1             | Spring          | 2018        | Packard         | 101                | F                   |
| CS-190           | 1             | Spring          | 2017        | Taylor          | 3128               | E                   |
| CS-190           | 2             | Spring          | 2017        | Taylor          | 3128               | A                   |
| CS-315           | 1             | Spring          | 2018        | Watson          | 120                | D                   |
| CS-319           | 1             | Spring          | 2018        | Watson          | 100                | B                   |
| CS-319           | 2             | Spring          | 2018        | Taylor          | 3128               | C                   |
| CS-347           | 1             | Fall            | 2017        | Taylor          | 3128               | A                   |
| EE-181           | 1             | Spring          | 2017        | Taylor          | 3128               | C                   |
| FIN-201          | 1             | Spring          | 2018        | Packard         | 101                | B                   |
| HIS-351          | 1             | Spring          | 2018        | Painter         | 514                | C                   |
| MU-199           | 1             | Spring          | 2018        | Packard         | 101                | D                   |
| PHY-101          | 1             | Fall            | 2017        | Watson          | 100                | A                   |

# Queries in SQL

- Set operations

- Union

```
(select course_id from section
 where sem = "Fall"
 and year = "2017")
union
(select course_id from section
 where sem = "Spring"
 and year = "2018")
```

| course_id | sec_id | semester | year | building | room_number | time_slot_id |
|-----------|--------|----------|------|----------|-------------|--------------|
| BIO-101   | 1      | Summer   | 2017 | Painter  | 514         | B            |
| BIO-301   | 1      | Summer   | 2018 | Painter  | 514         | A            |
| CS-101    | 1      | Fall     | 2017 | Packard  | 101         | H            |
| CS-101    | 1      | Spring   | 2018 | Packard  | 101         | F            |
| CS-190    | 1      | Spring   | 2017 | Taylor   | 3128        | E            |
| CS-190    | 2      | Spring   | 2017 | Taylor   | 3128        | A            |
| CS-315    | 1      | Spring   | 2018 | Watson   | 120         | D            |
| CS-319    | 1      | Spring   | 2018 | Watson   | 100         | B            |
| CS-319    | 2      | Spring   | 2018 | Taylor   | 3128        | C            |
| CS-347    | 1      | Fall     | 2017 | Taylor   | 3128        | A            |
| EE-181    | 1      | Spring   | 2017 | Taylor   | 3128        | C            |
| FIN-201   | 1      | Spring   | 2018 | Packard  | 101         | B            |
| HIS-351   | 1      | Spring   | 2018 | Painter  | 514         | C            |
| MU-199    | 1      | Spring   | 2018 | Packard  | 101         | D            |
| PHY-101   | 1      | Fall     | 2017 | Watson   | 100         | A            |



# Queries in SQL

- Set operations

- Union

- Intersection

```
(select course_id from section
 where sem = "Fall"
 and year = "2017")
intersect
(select course_id from section
 where sem = "Spring"
 and year = "2018")
```

| course_id | sec_id | semester | year | building | room_number | time_slot_id |
|-----------|--------|----------|------|----------|-------------|--------------|
| BIO-101   | 1      | Summer   | 2017 | Painter  | 514         | B            |
| BIO-301   | 1      | Summer   | 2018 | Painter  | 514         | A            |
| CS-101    | 1      | Fall     | 2017 | Packard  | 101         | H            |
| CS-101    | 1      | Spring   | 2018 | Packard  | 101         | F            |
| CS-190    | 1      | Spring   | 2017 | Taylor   | 3128        | E            |
| CS-190    | 2      | Spring   | 2017 | Taylor   | 3128        | A            |
| CS-315    | 1      | Spring   | 2018 | Watson   | 120         | D            |
| CS-319    | 1      | Spring   | 2018 | Watson   | 100         | B            |
| CS-319    | 2      | Spring   | 2018 | Taylor   | 3128        | C            |
| CS-347    | 1      | Fall     | 2017 | Taylor   | 3128        | A            |
| EE-181    | 1      | Spring   | 2017 | Taylor   | 3128        | C            |
| FIN-201   | 1      | Spring   | 2018 | Packard  | 101         | B            |
| HIS-351   | 1      | Spring   | 2018 | Painter  | 514         | C            |
| MU-199    | 1      | Spring   | 2018 | Packard  | 101         | D            |
| PHY-101   | 1      | Fall     | 2017 | Watson   | 100         | A            |

SQL is "declarative" – what you want  
vs  
"imperative" – how to do it

# Queries in SQL

- Set operations
- Union
- Intersection
- Set difference

```
(select course_id from section
 where sem = "Fall"
 and year = "2017")
```

except

```
(select course_id from section
 where sem = "Spring"
 and year = "2018")
```

| course_id | sec_id | semester | year | building | room_number | time_slot_id |
|-----------|--------|----------|------|----------|-------------|--------------|
| BIO-101   | 1      | Summer   | 2017 | Painter  | 514         | B            |
| BIO-301   | 1      | Summer   | 2018 | Painter  | 514         | A            |
| CS-101    | 1      | Fall     | 2017 | Packard  | 101         | H            |
| CS-101    | 1      | Spring   | 2018 | Packard  | 101         | F            |
| CS-190    | 1      | Spring   | 2017 | Taylor   | 3128        | E            |
| CS-190    | 2      | Spring   | 2017 | Taylor   | 3128        | A            |
| CS-315    | 1      | Spring   | 2018 | Watson   | 120         | D            |
| CS-319    | 1      | Spring   | 2018 | Watson   | 100         | B            |
| CS-319    | 2      | Spring   | 2018 | Taylor   | 3128        | C            |
| CS-347    | 1      | Fall     | 2017 | Taylor   | 3128        | A            |
| EE-181    | 1      | Spring   | 2017 | Taylor   | 3128        | C            |
| FIN-201   | 1      | Spring   | 2018 | Packard  | 101         | B            |
| HIS-351   | 1      | Spring   | 2018 | Painter  | 514         | C            |
| MU-199    | 1      | Spring   | 2018 | Packard  | 101         | D            |
| PHY-101   | 1      | Fall     | 2017 | Watson   | 100         | A            |

# Nested queries

- Relation in **from** can be output of another query
  - Average salary of instructors with salary above 70,000

| <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         |

# Nested queries

- Relation in **from** can be output of another query
  - Average salary of instructors with salary above 70,000

```
select avg(salary)
 from (select * salary
 from instructor
 where salary > 70000)
```

| <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         |

# Nested queries

- Relation in **from** can be output of another query
  - Average salary of instructors with salary above 70,000
  - MariaDB requires inner relation to be named!

```
select avg(salary)
 from (select *
 from instructor
 where salary > 70000)
 as newtable
```

(Query 2) as newtable2

| <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         |

# Local definitions using with

- Use `with` for a local definition

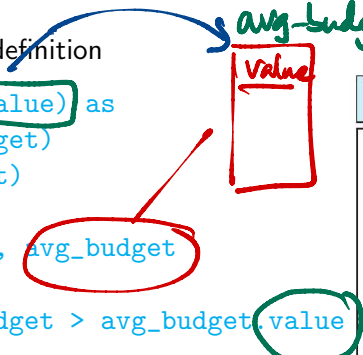
| <i>dept_name</i> | <i>building</i> | <i>budget</i> |
|------------------|-----------------|---------------|
| Biology          | Watson          | 90000         |
| Comp. Sci.       | Taylor          | 100000        |
| Elec. Eng.       | Taylor          | 85000         |
| Finance          | Painter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

instructor

# Local definitions using with

- Use `with` for a local definition

```
with avg_budget(value) as
 (select avg(budget)
 from department)
select dept_name
 from department, avg_budget
 where
 department.budget > avg_budget.value
```



avg-budget

value

| <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         |

instructor

# Queries in SQL — string comparison

- Can match patterns in strings

```
select name
 from instructor
 where dept_name like "Phy%"
```

case insensitive, apparently

anything  
↓

| 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  |



# Queries in SQL — string comparison

- Can match patterns in strings

```
select name
 from instructor
 where dept_name like "Phy%"
```

- % matches any substring (zero or more)
- \_ matches any character

MDS202\_10

MySQL has regular expressions  
regex

| 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  |

# Queries in SQL — string comparison

- Can match patterns in strings

```
select name
 from instructor
 where dept_name like "Phy%"
```

- % matches any substring (zero or more)

- \_ matches any character

- Name containing ri

```
select name
 from instructor
 where name like "%ri%"
```

| <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         |

# Queries in SQL — string comparison

- Can match patterns in strings

```
select name
 from instructor
 where dept_name like "Phy%"
```

- % matches any substring (zero or more)

- \_ matches any character

- Name containing `ri` but not at the end

```
select name
 from instructor
 where name like "%ri_"
```

| <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         |

# Queries in SQL — sorting the output

- Sort in ascending order

```
select name
 from instructor
 where dept_name like "Phy%"
 order by name
```

| <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         |

# Queries in SQL — sorting the output

- Sort in ascending order

```
select name
 from instructor
 where dept_name like "Phy%"
 order by name, salary
```

- Add `desc` for descending order

```
select name
 from instructor
 where dept_name like "Phy%"
 order by name desc, salary desc
```

| <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         |

# Queries in SQL — aggregate operations

- Extract the average value in a column

```
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         |

# Queries in SQL — aggregate operations

- Extract the average value in a column

```
select avg(salary)
 from instructor
```

- Other functions

- `count`

- `sum`

- `min`

- `max`

| <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         |

# Queries in SQL — aggregate operations

- Extract the average value in a column

```
select avg(salary)
 from instructor
```

- Other functions

- `count`

- `sum`

- `min`

- `max`

```
select count(distinct dept_name)
 from instructor
```

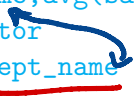
| <i>ID</i> | <i>name</i> | <i>dept_name</i> | <i>salary</i> |
|-----------|-------------|------------------|---------------|
| 10101     | Srinivasan  | Comp. Sci.       | 65000         |
| 12121     | Wu          | Finance          | 90000         |
| 15151     | Mozart      | Music            | 40000         |
| 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         |



# Queries in SQL — grouping

- Extract the average value in each department
  - Group rows by department name
  - Report average in each group of rows

```
select dept_name, avg(salary)
from instructor
group by dept_name
```



| <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         |

# Queries in SQL — grouping

- Extract the average value in each department
  - Group rows by department name
  - Report average in each group of rows

```
select dept_name, avg(salary)
from instructor
group by dept_name
```

- Attributes in `select` must appear in `group by`

- Should be the same across the entire group

or you may get  
a random value

| <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         |

# Queries in SQL — filtering groups

- Use **having** to specify a condition on groups

```
select dept_name, avg(salary)
 from instructor
 group by dept_name
 having max(salary) > 80000
```

Group  $\xrightarrow{\text{max} > 80000}$  Avg

| <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         |

# Queries in SQL — filtering groups

- Use **having** to specify a condition on groups

```
select dept_name, avg(salary)
 from instructor
 group by dept_name
 having max(salary) > 80000
```

- Condition is evaluated with respect to groups

| <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         |