

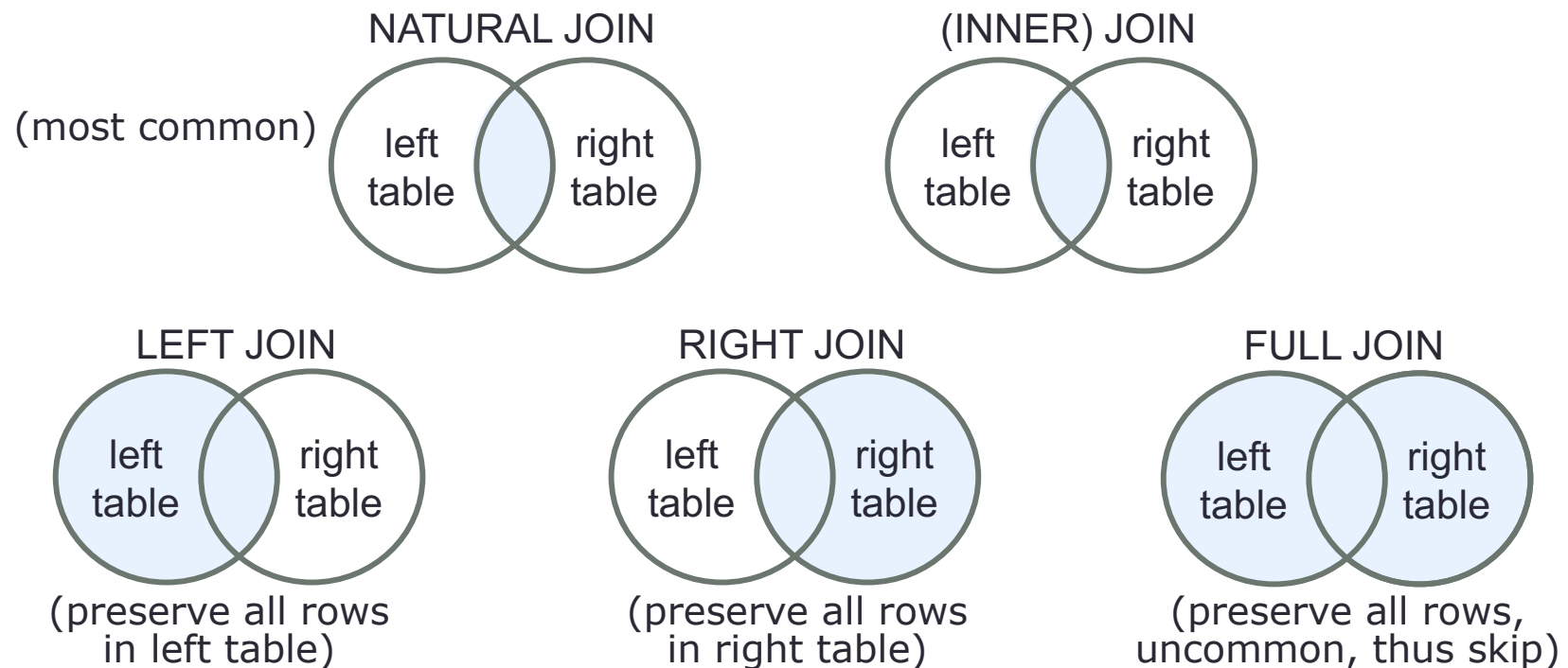
SQL - Join

CS 4750 Database Systems

[A. Silberschatz, H. F. Korth, S. Sudarshan, Database System Concepts, Ch.4.1]
[<https://www.dofactory.com/sql/join>]

JOIN

- **Combine** related tables or sets of data on key values
- All tables (or relations) must have a unique identifier (**primary key**)
- Any related tables must contain a copy of the unique identifier (**foreign key**) from the related table



NATURAL JOIN

Not include the repeated column

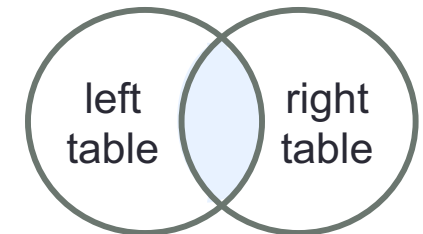
one(p1, colA, colB)

p1	colA	colB
1	A	aa
2	B	bb
3	C	cc
4	D	dd
5	E	ee
7	G	gg
8	H	hh

two(p2, p1, colX, colY)

p2	p1	colX	colY
9001	1	55	ABC
9002	3	77	PQR
9003	3	95	DEF
9004	7	62	GHI
9005	5	50	KLM
9006	2	42	STU
9007	7	83	XYZ

NATURAL JOIN



```
SELECT *  
FROM one NATURAL JOIN two;
```

Join on **common
named
attribute(s)**.
If no match
found, move on.

```
for each row1 in one:  
  for each row2 in two:  
    if (row1.p1 = row2.p1):  
      output (row1.p1, row1.colA, row1.colB,  
              row2.p2, row2.colX, row2.colY)
```

NATURAL JOIN

Not include the repeated column

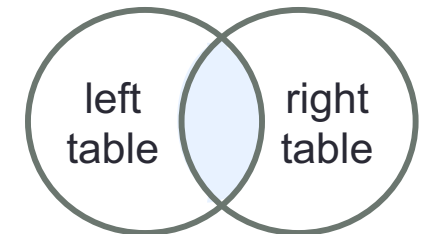
one(p1, colA, colB)

p1	colA	colB
1	A	aa
2	B	bb
3	C	cc
4	D	dd
5	E	ee
7	G	gg
8	H	hh

two(p2, p1, colX, colY)

p2	p1	colX	colY
9001	1	55	ABC
9002	3	77	PQR
9003	3	95	DEF
9004	7	62	GHI
9005	5	50	KLM
9006	2	42	STU
9007	7	83	XYZ

NATURAL JOIN



p1	colA	colB	p2	colX	colY
1	A	aa	9001	55	ABC
2	B	bb	9006	42	STU
3	C	cc	9002	77	PQR
3	C	cc	9003	95	DEF
5	E	ee	9005	50	KLM
7	G	gg	9004	62	GHI
7	G	gg	9007	83	XYZ

```
SELECT *  
FROM one  
NATURAL JOIN two
```

Note the order of the columns; order of rows does not matter

(INNER) JOIN

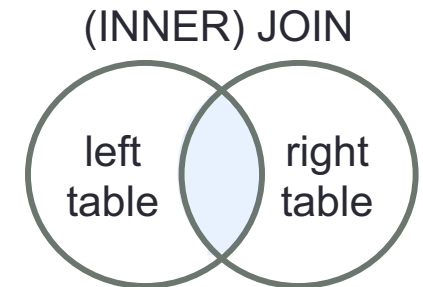
Include the repeated column

one(p1, colA, colB)

p1	colA	colB
1	A	aa
2	B	bb
3	C	cc
4	D	dd
5	E	ee
7	G	gg
8	H	hh

two(p2, p1, colX, colY)

p2	p1	colX	colY
9001	1	55	ABC
9002	3	77	PQR
9003	3	95	DEF
9004	7	62	GHI
9005	5	50	KLM
9006	2	42	STU
9007	7	83	XYZ



Join on **specified attribute(s)**.
If no match found, move on.

```
SELECT *  
FROM one JOIN two ON one.p1 = two.p1;
```

```
for each row1 in one:  
  for each row2 in two:  
    if (row1.p1 = row2.p1):  
      output (row1.p1, row1.colA, row1.colB,  
              row2.p2, row2.p1, row2.colX, row2.colY)
```

(INNER) JOIN

Include the repeated column

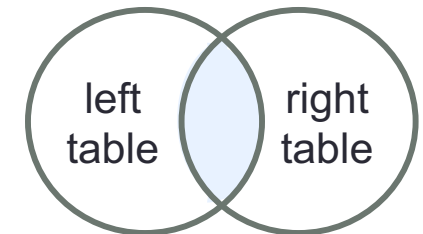
one(p1, colA, colB)

p1	colA	colB
1	A	aa
2	B	bb
3	C	cc
4	D	dd
5	E	ee
7	G	gg
8	H	hh

two(p2, p1, colX, colY)

p2	p1	colX	colY
9001	1	55	ABC
9002	3	77	PQR
9003	3	95	DEF
9004	7	62	GHI
9005	5	50	KLM
9006	2	42	STU
9007	7	83	XYZ

(INNER) JOIN



p1	colA	colB	p2	p1	colX	colY
1	A	aa	9001	1	55	ABC
2	B	bb	9006	2	42	STU
3	C	cc	9002	3	77	PQR
3	C	cc	9003	3	95	DEF
5	E	ee	9005	5	50	KLM
7	G	gg	9004	7	62	GHI
7	G	gg	9007	7	83	XYZ

```
SELECT *  
FROM one JOIN two  
ON one.p1 = two.p1
```



```
SELECT *  
FROM one INNER JOIN two  
ON one.p1 = two.p1
```

Note the order of the columns; order of rows does not matter

Cartesian (Cross) Product

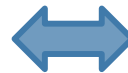
one(p1, colA, colB)

p1	colA	colB
1	A	aa
2	B	bb
3	C	cc
4	D	dd
5	E	ee
7	G	gg
8	H	hh

two(p2, p1, colX, colY)

p2	p1	colX	colY
9001	1	55	ABC
9002	3	77	PQR
9003	3	95	DEF
9004	7	62	GHI
9005	5	50	KLM
9006	2	42	STU
9007	7	83	XYZ

```
SELECT *  
FROM one JOIN two;
```



```
SELECT *  
FROM one, two;
```

```
for each row1 in one:  
  for each row2 in two:  
    output (row1.p1, row1.colA, row1.colB,  
           row2.p2, row2.p1, row2.colX, row2.colY)
```

Cartesian (Cross) Product

one(p1, colA, colB)

p1	colA	colB
1	A	aa
2	B	bb
3	C	cc
4	D	dd
5	E	ee
7	G	gg
8	H	hh

two(p2, p1, colX, colY)

p2	p1	colX	colY
9001	1	55	ABC
9002	3	77	PQR
9003	3	95	DEF
9004	7	62	GHI
9005	5	50	KLM
9006	2	42	STU
9007	7	83	XYZ

one × two

p1	colA	colB	p2	p1	colX	colY
1	A	aa	9001	1	55	ABC
1	A	aa	9005	5	50	KLM
1	A	aa	9004	7	62	GHI
1	A	aa	9003	3	95	DEF
1	A	aa	9007	7	83	XYZ
1	A	aa	9002	3	77	PQR
1	A	aa	9006	2	42	STU
2	B	bb	9002	3	77	PQR
2	B	bb	9006	2	42	STU
2	B	bb	9001	1	55	ABC
2	B	bb	9005	5	50	KLM
2	B	bb	9004	7	62	GHI
2	B	bb	9003	3	95	DEF
2	B	bb	9007	7	83	XYZ
3	C	cc	9003	3	95	DEF
3	C	cc	9007	7	83	XYZ
...



Note the order of the columns; order of rows does not matter

NATURAL LEFT OUTER JOIN

Augment a join by the dangling tuples

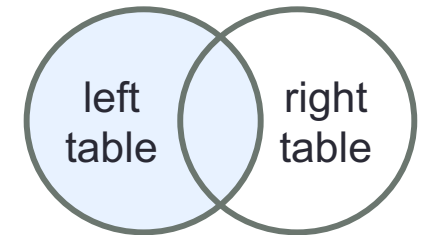
one(p1, colA, colB)

p1	colA	colB
1	A	aa
2	B	bb
3	C	cc
4	D	dd
5	E	ee
7	G	gg
8	H	hh

two(p2, p1, colX, colY)

p2	p1	colX	colY
9001	1	55	ABC
9002	3	77	PQR
9003	3	95	DEF
9004	7	62	GHI
9005	5	50	KLM
9006	2	42	STU
9007	7	83	XYZ

LEFT JOIN



Join on **common named attribute(s)**.
If no match found, pad with NULL values

```
SELECT *  
FROM one NATURAL LEFT OUTER JOIN two;
```

Preserve all rows
in left table

NATURAL LEFT OUTER JOIN

Augment a join by the dangling tuples

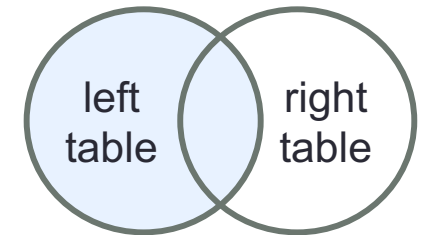
one(p1, colA, colB)


p1	colA	colB
1	A	aa
2	B	bb
3	C	cc
4	D	dd
5	E	ee
7	G	gg
8	H	hh

two(p2, p1, colX, colY)

p2	p1	colX	colY
9001	1	55	ABC
9002	3	77	PQR
9003	3	95	DEF
9004	7	62	GHI
9005	5	50	KLM
9006	2	42	STU
9007	7	83	XYZ

LEFT JOIN





p1	colA	colB	p2	colX	colY
1	A	aa	9001	55	ABC
2	B	bb	9006	42	STU
3	C	cc	9002	77	PQR
3	C	cc	9003	95	DEF
4	D	dd	NULL	NULL	NULL
5	E	ee	9005	50	KLM
7	G	gg	9004	62	GHI
7	G	gg	9007	83	XYZ
8	H	hh	NULL	NULL	NULL

Note the order of the columns; order of rows does not matter

LEFT OUTER JOIN

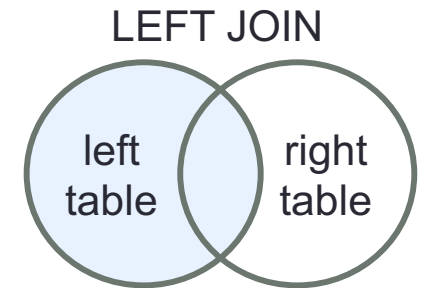
Augment a join by the dangling tuples

one(p1, colA, colB)

p1	colA	colB
1	A	aa
2	B	bb
3	C	cc
4	D	dd
5	E	ee
7	G	gg
8	H	hh

two(p2, p1, colX, colY)

p2	p1	colX	colY
9001	1	55	ABC
9002	3	77	PQR
9003	3	95	DEF
9004	7	62	GHI
9005	5	50	KLM
9006	2	42	STU
9007	7	83	XYZ



Join on **specified attribute(s)**.
If no match found, pad with NULL values

Preserve all rows in left table

```
SELECT *  
FROM one LEFT OUTER JOIN two  
ON one.p1 = two.p1;
```

LEFT OUTER JOIN

Augment a join by the dangling tuples


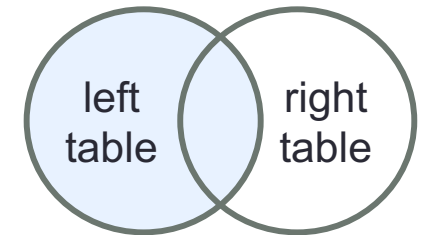
one(p1, colA, colB)

p1	colA	colB
1	A	aa
2	B	bb
3	C	cc
4	D	dd
5	E	ee
7	G	gg
8	H	hh


two(p2, p1, colX, colY)

p2	p1	colX	colY
9001	1	55	ABC
9002	3	77	PQR
9003	3	95	DEF
9004	7	62	GHI
9005	5	50	KLM
9006	2	42	STU
9007	7	83	XYZ

LEFT JOIN



p1	colA	colB	p2	p1	colX	colY
1	A	aa	9001	1	55	ABC
2	B	bb	9006	2	42	STU
3	C	cc	9002	3	77	PQR
3	C	cc	9003	3	95	DEF
4	D	dd	NULL	NULL	NULL	NULL
5	E	ee	9005	5	50	KLM
7	G	gg	9004	7	62	GHI
7	G	gg	9007	7	83	XYZ
8	H	hh	NULL	NULL	NULL	NULL



Note the order of the columns; order of rows does not matter

NATURAL RIGHT OUTER JOIN

Augment a join by the dangling tuples

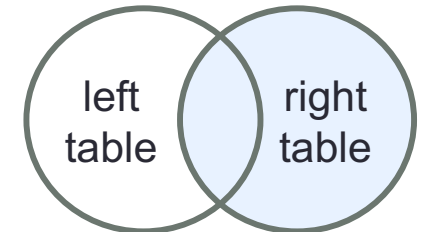
one(p1, colA, colB)

p1	colA	colB
1	A	aa
2	B	bb
3	C	cc
4	D	dd
5	E	ee
7	G	gg
8	H	hh

two(p2, p1, colX, colY)

p2	p1	colX	colY
9001	1	55	ABC
9002	3	77	PQR
9003	3	95	DEF
9004	7	62	GHI
9005	5	50	KLM
9006	2	42	STU
9007	7	83	XYZ

RIGHT JOIN



Join on **common named attribute(s)**.
If no match found, pad with NULL values

```
SELECT *  
FROM one NATURAL RIGHT OUTER JOIN two;
```

Preserve all rows
in right table

NATURAL RIGHT OUTER JOIN

Augment a join by the dangling tuples

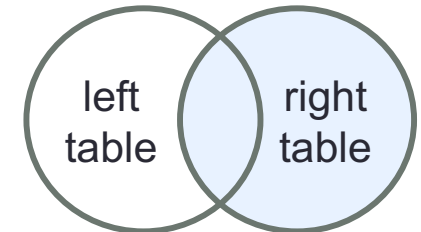
one(p1, colA, colB)

p1	colA	colB
1	A	aa
2	B	bb
3	C	cc
4	D	dd
5	E	ee
7	G	gg
8	H	hh

two(p2, p1, colX, colY)

p2	p1	colX	colY
9001	1	55	ABC
9002	3	77	PQR
9003	3	95	DEF
9004	7	62	GHI
9005	5	50	KLM
9006	2	42	STU
9007	7	83	XYZ

RIGHT JOIN



Since two.p1 is a foreign key referencing one.p1, matches are always founded

↗

p1	colA	colB	p2	colX	colY
1	A	aa	9001	55	ABC
2	B	bb	9006	42	STU
3	C	cc	9002	77	PQR
3	C	cc	9003	95	DEF
5	E	ee	9005	50	KLM
7	G	gg	9004	62	GHI
7	G	gg	9007	83	XYZ

Note the order of the columns; order of rows does not matter

RIGHT OUTER JOIN

Augment a join by the dangling tuples

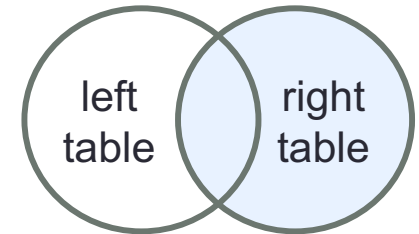
one(p1, colA, colB)

p1	colA	colB
1	A	aa
2	B	bb
3	C	cc
4	D	dd
5	E	ee
7	G	gg
8	H	hh

two(p2, p1, colX, colY)

p2	p1	colX	colY
9001	1	55	ABC
9002	3	77	PQR
9003	3	95	DEF
9004	7	62	GHI
9005	5	50	KLM
9006	2	42	STU
9007	7	83	XYZ

RIGHT JOIN



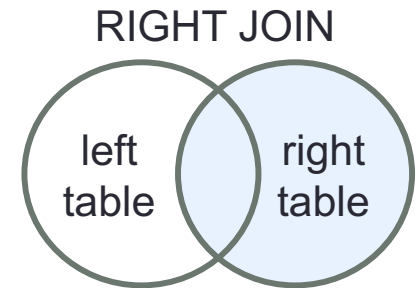
Join on **specified attribute(s)**.
If no match found, pad with NULL values

```
SELECT *  
FROM one RIGHT OUTER JOIN two  
ON one.p1 = two.p1;
```

Preserve all rows
in right table

RIGHT OUTER JOIN

Augment a join by the dangling tuples



one(p1, colA, colB)

p1	colA	colB
1	A	aa
2	B	bb
3	C	cc
4	D	dd
5	E	ee
7	G	gg
8	H	hh

two(p2, p1, colX, colY)

p2	p1	colX	colY
9001	1	55	ABC
9002	3	77	PQR
9003	3	95	DEF
9004	7	62	GHI
9005	5	50	KLM
9006	2	42	STU
9007	7	83	XYZ

p1	colA	colB	p2	p1	colX	colY
1	A	aa	9001	1	55	ABC
2	B	bb	9006	2	42	STU
3	C	cc	9002	3	77	PQR
3	C	cc	9003	3	95	DEF
5	E	ee	9005	5	50	KLM
7	G	gg	9004	7	62	GHI
7	G	gg	9007	7	83	XYZ

Since two.p1 is a foreign key referencing one.p1, matches are always founded

Note the order of the columns; order of rows does not matter

Self Joins

- Join with itself
- Useful when the table has a FOREIGN KEY which references its own PRIMARY KEY
- Can be viewed as joining two copies of the same table
- To do self join, use aliases

(Challenging) Example: Self Joins

Find names of all TAs who are assigned to Database Systems and Software Analysis

Hiring(TA_id, Name, Year, Two_week_hours)

TA_id	Name	Year	Two_week_hours
1234	Minnie	4	20
2345	Humpty	3	24
3456	Dumpty	4	30
3333	Minnie	3	12
5678	Mickey	2	16

TA_Assignment(TA_id, Course)

TA_id	Course
1234	Database Systems
2345	Database Systems
3456	Cloud Computing
1234	Software Analysis
5678	Web Programming Lang.
2345	Software Analysis

How should we write SQL?

(Challenging) Example: Self Joins

Find names of all TAs who are assigned to Database Systems and Software Analysis

Hiring(TA_id, Name, Year, Two_week_hours)

TA_id	Name	Year	Two_week_hours
1234	Minnie	4	20
2345	Humpty	3	24
3456	Dumpty	4	30
3333	Minnie	3	12
5678	Mickey	2	16

TA_Assignment(TA_id, Course)

TA_id	Course
1234	Database Systems
2345	Database Systems
3456	Cloud Computing
1234	Software Analysis
5678	Web Programming Lang.
2345	Software Analysis

```
SELECT H.Name
From Hiring AS H, TA_Assignment AS T
WHERE H.TA_id = T.TA_id AND
      T.Course = "Database Systems" AND
      T.Course = "Software Analysis";
```

Will this work?

No.
Returns empty set

(Challenging) Example: Self Joins

Find names of all TAs who are assigned to Database Systems and Software Analysis

Hiring(TA_id, Name, Year, Two_week_hours)

TA_id	Name	Year	Two_week_hours
1234	Minnie	4	20
2345	Humpty	3	24
3456	Dumpty	4	30
3333	Minnie	3	12
5678	Mickey	2	16

TA_Assignment(TA_id, Course)

TA_id	Course
1234	Database Systems
2345	Database Systems
3456	Cloud Computing
1234	Software Analysis
5678	Web Programming Lang.
2345	Software Analysis

```
SELECT H.Name
From Hiring AS H, TA_Assignment AS T1,
      TA_Assignment AS T2
WHERE H.TA_id = T1.TA_id AND
      H.TA_id = T2.TA_id AND
      T1.Course = "Database Systems" AND
      T2.Course = "Software Analysis";
```

Will this work?

Name
Minnie
Humpty

(Challenging) Example: Self Joins

Find names of all TAs who are assigned to Database Systems and Software Analysis

Hiring(TA_id, Name, Year, Two_week_hours)

TA_id	Name	Year	Two_week_hours
1234	Minnie	4	20
2345	Humpty	3	24
3456	Dumpty	4	30
3333	Minnie	3	12
5678	Mickey	2	16

TA_Assignment(TA_id, Course)

TA_id	Course
1234	Database Systems
2345	Database Systems
3456	Cloud Computing
1234	Software Analysis
5678	Web Programming Lang.
2345	Software Analysis

```
SELECT H.Name
From Hiring AS H, TA_Assignment AS T1,
      TA_Assignment AS T2
WHERE H.TA_id = T1.TA_id AND
      H.TA_id = T2.TA_id AND
      T1.Course = "Database Systems" AND
      T2.Course = "Software Analysis";
```

Let's consider each part of the query

All pairs of courses a TA is assigned

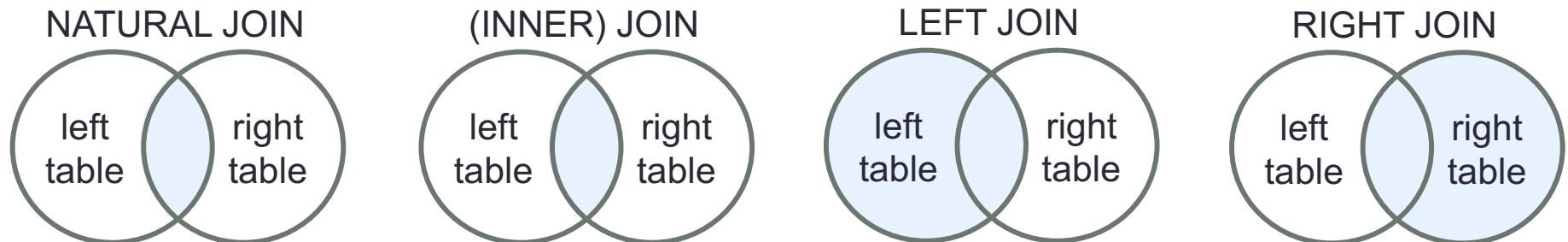
For each pair, check for courses

Wrap-Up

Join combines data across tables

- Nested-loop
- Natural join (most common)
- Inner join (filter Cartesian product)
- Outer joins (preserve non-matching tuples)
- Self join pattern

Different joining techniques can be used to achieve particular goals



What's next?

- SQL – subqueries