Database Systems

Spring-2025 Department of

Computer Science

The Islamia University Bahawalpur

Submitted by:

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Section: M8	**Semester:** 2nd
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1. Introduction:

1.1 Background:

Problem

Academic data about professors, their universities, and their connections to different organizations is often stored in one large, flat table. This kind of setup causes problems like repeated data, errors, and difficulty when searching or updating information. As the amount of data grows, managing it becomes slower and more confusing.

Solution

To fix this, we built a relational database using the university_professors dataset. The data is organized into four connected tables: professors, universities, organizations, and affiliations. This design removes duplication, keeps the data accurate, and makes it easier and faster to search or update information. It's also a better solution for handling large datasets in the future

1.2 Goal:

The main objective of this project is to build a relational database system that accurately represents the relationships among university professors, their universities, and affiliated organizations. By the end of the project, the database will allow for easy insertion, retrieval, and updating of academic and organizational data, while maintaining data integrity and avoiding redundancy through normalization and relational modeling.

3 Requirements:

• The system must store professor details like first name, last name, and university.

• It must keep a list of all universities and organizations.

• Professors can be linked to many organizations (many-to-many relationship).

• See which organizations professors are affiliated with

• Users should be able to add, update, or delete records without losing data.

• The system should support join queries (e.g., get professors with their university and organizations).

• Use primary and foreign keys to connect tables and keep data correct.

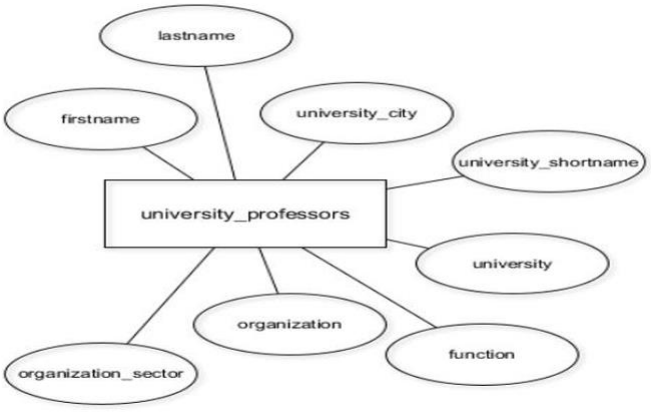
2. Functional Description:

2.1. Method of use:

This system will be used by university staff, teachers, and researchers who need to keep track of information about professors. They can use it to add, update, or view details about professors, the universities they work at, and the organizations they are connected to. This helps keep everything in one place and makes it easier to find and manage the data.

3. Entity Data Model:

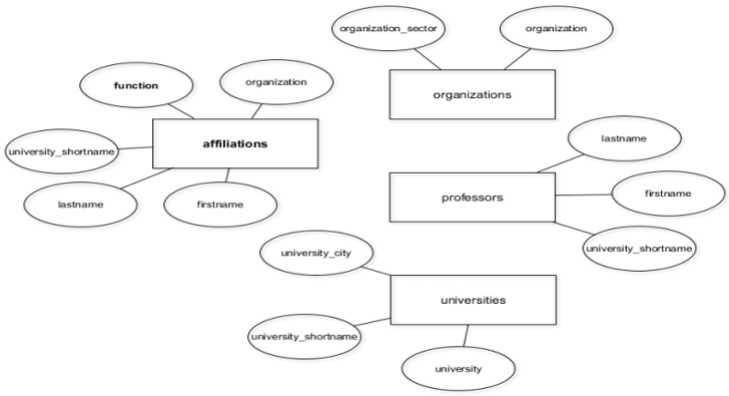
OLD



Problem – Single Table Design:

The original design used one table to store all data about professors, universities, and organizations. This caused repeated data, errors, and made searching or updating information harder

NEW



Solution – Separated Tables Design:

The data was split into four linked tables: professors, universities, organizations, and affiliations. This setup removes duplication, keeps data accurate, and makes the system easier to use and scale.

4. Table Design (Schema) Screenshots:

First, we created a table called university_professors in pgAdmin and defined its columns. Then, we imported data into this table from a CSV file. After importing, we normalized the data by creating four separate tables: professors, universities, organizations, and affiliations.

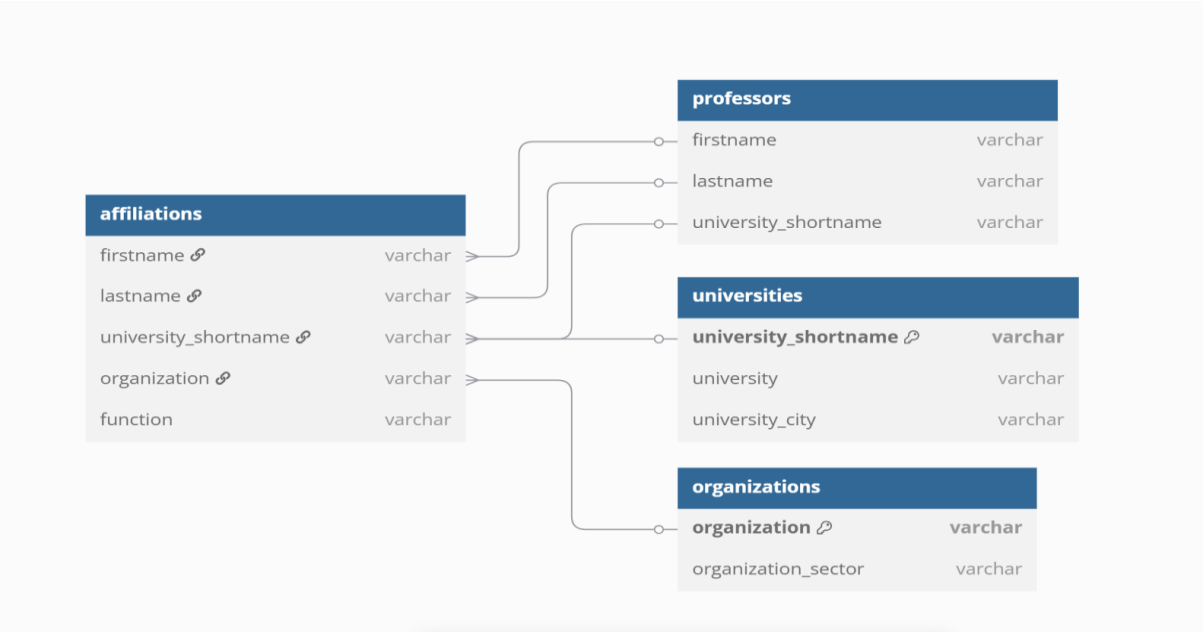
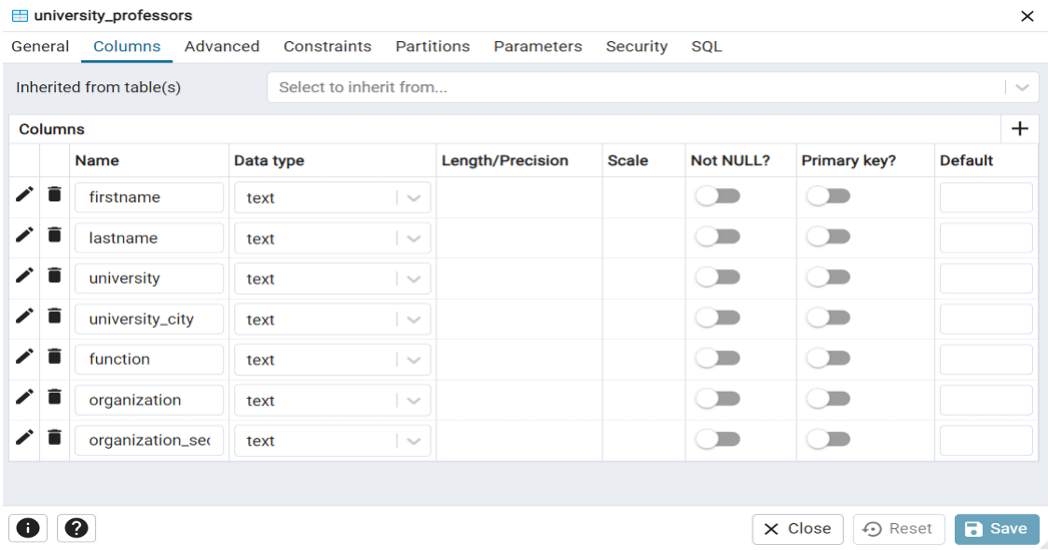
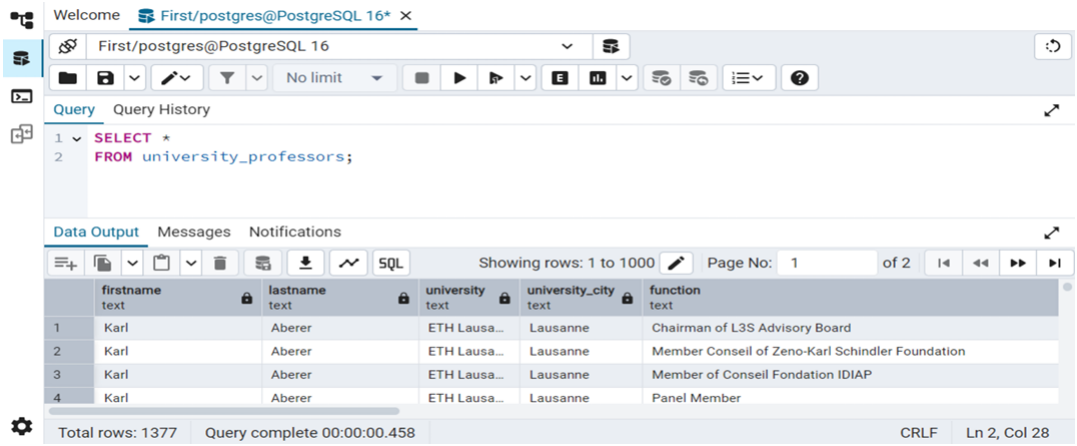


Table: university professors



Now lets take a look at the current table we have

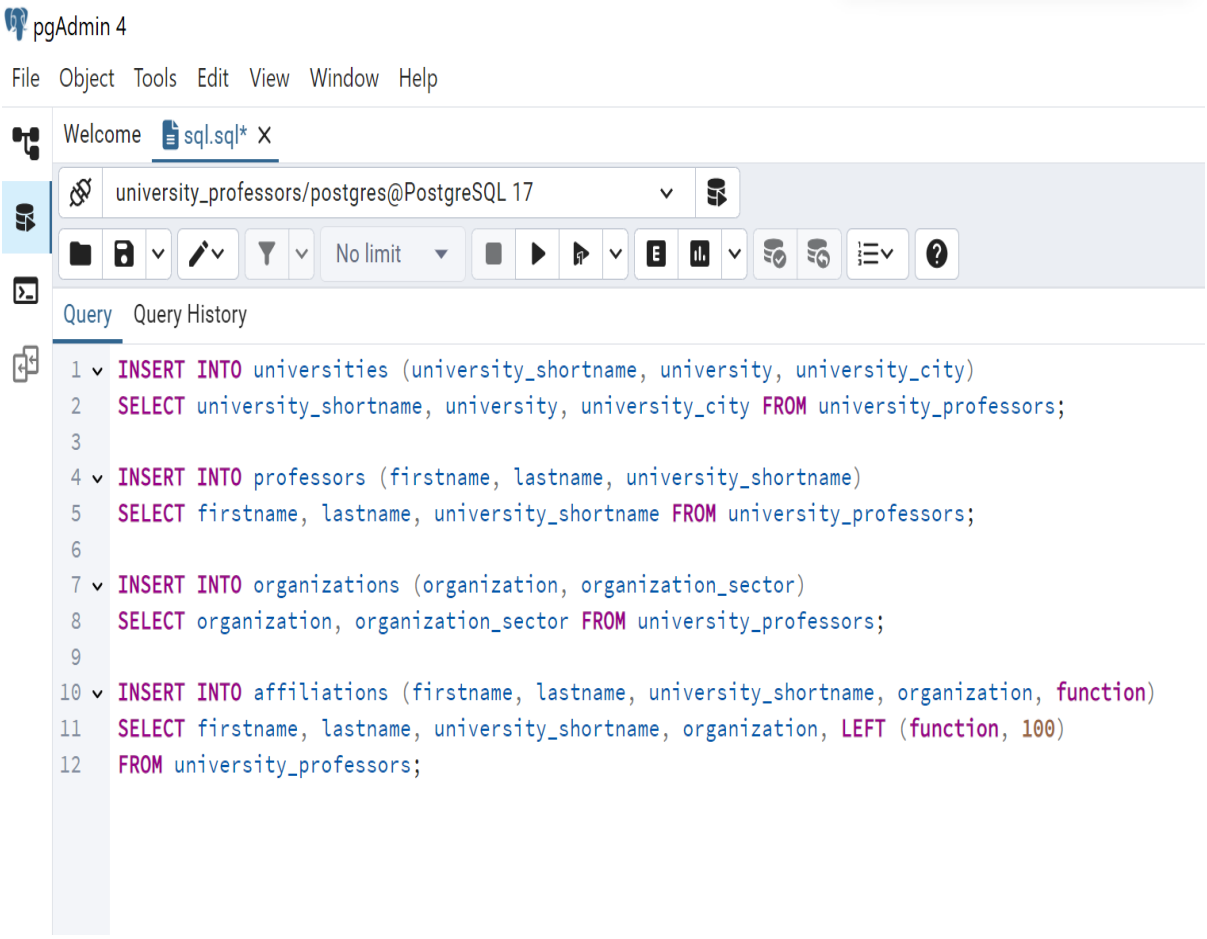


The data is organized into four connected tables: professors, universities, organizations, and affiliations.

Query Query History

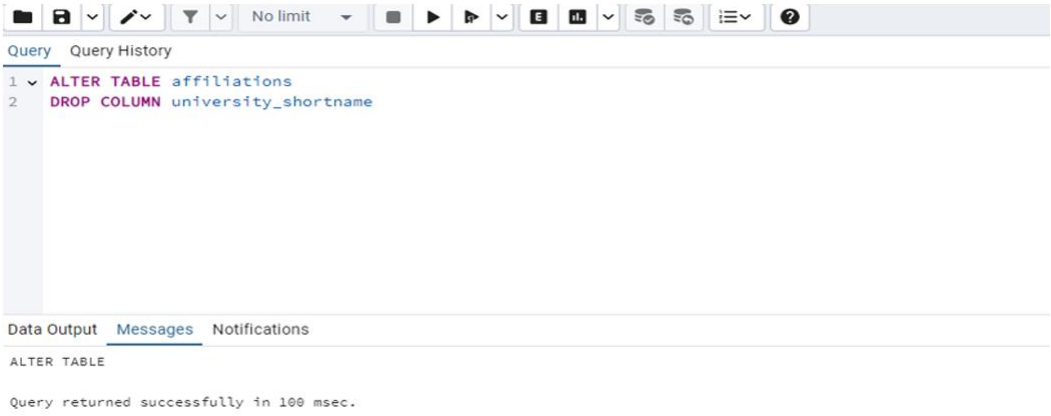
```sql
CREATE TABLE universities (
    university_shortname VARCHAR(50),
    university VARCHAR(255),
    university_city VARCHAR(100)
);
CREATE TABLE professors (
    firstname VARCHAR(100),
    lastname VARCHAR(100),
    university_shortname VARCHAR(50)
);
CREATE TABLE organizations (
    organization VARCHAR(255),
    organization_sector VARCHAR(100)
);
CREATE TABLE affiliations (
    firstname VARCHAR(100),
    lastname VARCHAR(100),
    university_shortname VARCHAR(50),
    organization VARCHAR(255),
    function VARCHAR(255)
);
```

And insert data into four connected tables: professors, universities, organizations, and affiliations

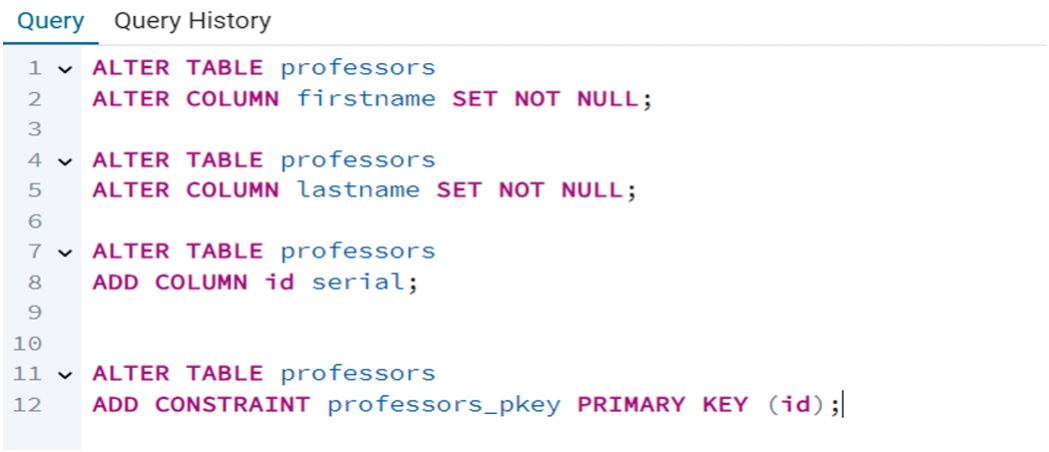


5. Frontend Screenshots

Here a professor is uniquely identified by firstname and lastname columns, so there is no need of university_shortname column in the affiliations table.

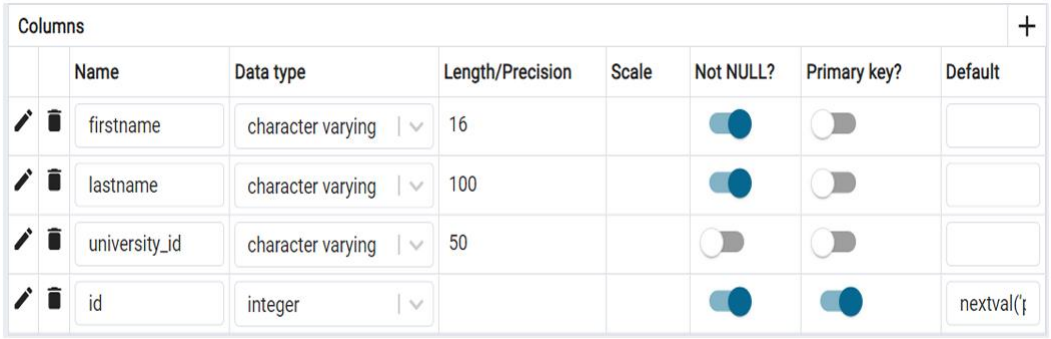


We updated the professors table by setting the firstname and lastname columns to NOT NULL. Then we added an id column with serial to auto-generate unique numbers for each professor and set it as the primary key to uniquely identify each record.

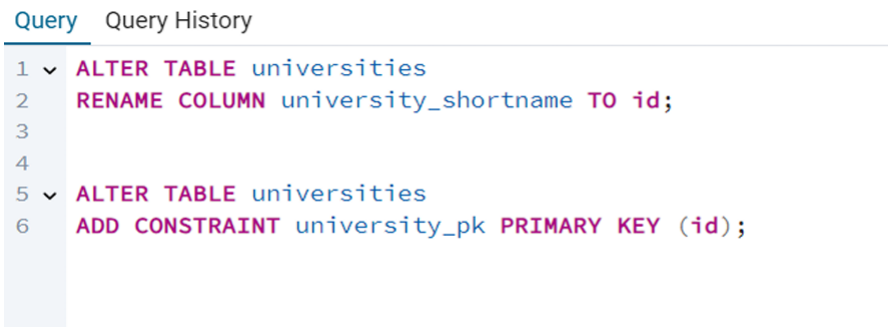


This query first renames the column university_shortname to university_id in the professors table to better reflect its purpose. Then, it adds a foreign key constraint to ensure that the university_id in the professors table must match an existing id in the universities table. This helps maintain a valid link between professors and their universities.

Here is professors table



We renamed the column to id to make the table more consistent and easier to join with other tables. Adding a PRIMARY KEY ensures that each university can be uniquely identified, which improves data integrity and allows for better relationships between tables.



We added a PRIMARY KEY constraint on the id column in the universities table to uniquely identify each row. Then, we deleted duplicate rows by keeping only one row per id using the ctid system column to remove duplicates and ensure data consistency.

This SQL command adds a foreign key constraint to the professors table. It links the university_id column in professors to the id column in the universities table. This ensures that every university_id in professors must exist in universities, helping maintain referential integrity between the two tables.

Here is universities table

Columns

Name	Data type	Length/Precision	Scale	Not NULL?	Primary key?	Default
id	character varying	50		✓	✓	
university	character varying	255				
university_city	character varying	100				

Here we add some query:

This query finds the last names of professors who work at universities located in the city of Zurich. It joins the professors and universities tables using the university's unique ID to match professors with their universities. The WHERE clause filters the results to only show professors from universities in Zurich. This helps get specific information about professors based on the location of their university.

Query | Query History

```
1  SELECT professors.lastname, universities.id, universities.university_city
2  FROM universities
3  JOIN professors
4  ON professors.university_id = universities.id
5  WHERE universities.university_city = 'Zurich';
```

OUTPUT

Data Output | Messages | Notifications

Showing rows: 1 to 140

	lastname character varying (100)	id character varying (50)	university_city character varying (100)
1	Abhari	ETH	Zurich
2	Axhausen	ETH	Zurich
3	Baschera	ETH	Zurich
4	Baschera	ETH	Zurich
5	Baschera	ETH	Zurich
6	Baschera	ETH	Zurich
7	Baschera	ETH	Zurich
8	Baschera	ETH	Zurich
9	Basin	ETH	Zurich
10	Bechtold	ETH	Zurich

We renamed the column to id to follow a standard naming convention and added a **PRIMARY KEY**, so each organization has a unique identifier for better data management

and relationships with other tables.

Query | Query History

```
1  ALTER TABLE organizations
2  RENAME COLUMN organization TO id;
3
4  ALTER TABLE organizations
5  ADD CONSTRAINT organization_pk PRIMARY KEY (id);
```

This SQL script is used to clean up duplicate records in the organizations table and ensure data integrity going forward. It first identifies and deletes duplicate rows by keeping only one entry for each unique organization using the ctid (a unique row identifier in PostgreSQL).

After the duplicates are removed, it adds a UNIQUE constraint on the organization column to prevent any future duplicate entries from being inserted into the table. This process helps maintain consistent and accurate data in the database.

```
13 ALTER TABLE organizations
14 ADD CONSTRAINT organization_unq UNIQUE(organization);
15
16 SELECT organization, COUNT(*)
17 FROM organizations
18 GROUP BY organization
19 HAVING COUNT(*) > 1;
20
21 DELETE FROM organizations
22 WHERE ctid NOT IN (
23   SELECT MIN(ctid)
24   FROM organizations
25   GROUP BY organization
26 );
```

Here is organizations table

Columns

		Name	Data type	Length/Precision	Scale	Not NULL?	Primary key?	Default
✎	🗑	id	character varying	255		●	●	
✎	🗑	organization_se	character varying	100		○	○	

We DROP columns from affiliation table

Query | Query History

```
1  ALTER TABLE affiliations
2  DROP COLUMN firstname,
3  DROP COLUMN lastname;
```

You added a new column professor_id to the affiliations table to link each affiliation to a specific professor using their unique ID. You renamed the organization column to organization_id to clearly show it stores an ID referencing the organizations table. Then, you

added foreign key constraints to both professor _id and organization_id to make sure these IDs match valid records in their respective tables. Finally, you updated the professor_id column by matching professors' first and last names so that existing affiliation records correctly point to the right professor. These changes improve data accuracy and make it easier to manage relationships between professors, organizations, and their affiliations.

Query Query History

```sql
ALTER TABLE affiliations
ADD COLUMN professor_id integer REFERENCES professors (id);

ALTER TABLE affiliations
RENAME organization TO organization_id;

ALTER TABLE affiliations
ADD CONSTRAINT affiliations_organization_fkey FOREIGN KEY (organization_id) REFERENCES organizations (id);


UPDATE affiliations
SET professor_id = professors.id
FROM professors
WHERE affiliations.firstname = professors.firstname AND affiliations.lastname = professors.lastname;
```

First, you check all foreign key constraints in the database to find the exact name of the constraint on the affiliations table. Then, you drop the current foreign key constraint on organization_id so you can modify it. After that, you add the foreign key constraint again but this time with ON DELETE CASCADE, which means if a row in the organizations table is deleted, all related rows in affiliations will also be automatically deleted to keep the data consistent.

Query Query History

```sql
SELECT constraint_name, table_name, constraint_type
FROM information_schema.table_constraints
WHERE constraint_type = 'FOREIGN KEY';


ALTER TABLE affiliations
DROP CONSTRAINT affiliations_organization_id_fkey;


ALTER TABLE affiliations
ADD CONSTRAINT affiliations_organization_id_fkey FOREIGN KEY (organization_id) REFERENCES organizations (id) ON DELETE CASCADE;

```

Here is affiliation table

Columns

Name	Data type	Length/Precision	Scale	Not NULL?	Primary key?	Default
organization_id	character varying	255				
function	character varying	100				
professor_id	integer					

Here we add some query

Query | Query History

```
SELECT COUNT(*), professors.university_id
FROM affiliations
JOIN professors
ON affiliations.professor_id = professors.id
GROUP BY professors.university_id
ORDER BY count DESC;
```

OUTPUT

Data Output | Messages | Notifications

	count bigint	university_id character varying (50)
1	572	EPF
2	273	USG
3	162	UBE
4	128	ETH
5	75	UBA
6	40	UFR
7	36	UNE
8	35	ULA
9	33	UGE
10	7	UZH
11	4	USI

Here we add some query

Query | Query History

```
SELECT COUNT(*), organizations.organization_sector,
professors.id, universities.university_city
FROM affiliations
JOIN professors
ON affiliations.professor_id = professors.id
JOIN organizations
ON affiliations.organization_id = organizations.id
JOIN universities
ON professors.university_id = universities.id
WHERE organizations.organization_sector = 'Media & communication'
GROUP BY organizations.organization_sector,
professors.id, universities.university_city
ORDER BY count DESC;
```

OUTPUT

Data Output | Messages | Notifications

Showing rows: 1 to 35

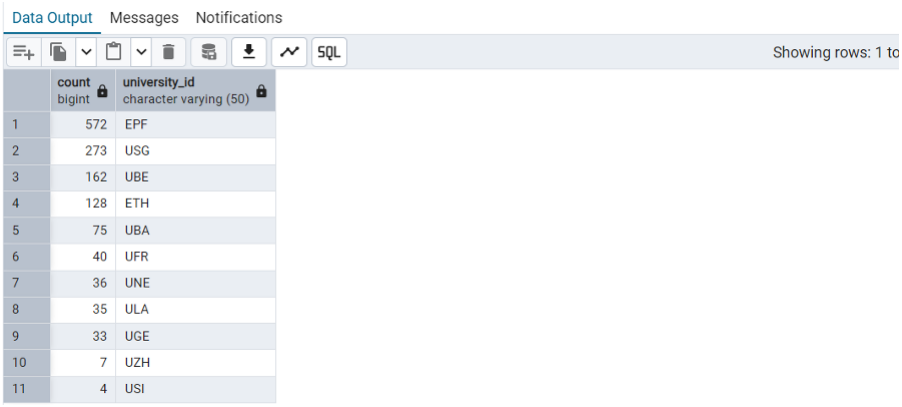
	count bigint	organization_sector character varying (100)	id integer	university_city character varying (100)
1	4	Media & communication	1357	Lausanne
2	3	Media & communication	95	Lausanne
3	3	Media & communication	928	Saint Gallen
4	2	Media & communication	1059	Lausanne
5	2	Media & communication	861	Saint Gallen
6	2	Media & communication	1316	Saint Gallen
7	2	Media & communication	828	Zurich
8	2	Media & communication	106	Saint Gallen
9	2	Media & communication	1267	Lausanne
10	1	Media & communication	76	Lausanne
11	1	Media & communication	975	Lausanne
12	1	Media & communication	949	Lausanne
13	1	Media & communication	745	Basel

Here we add some query

Query | Query History

```
SELECT COUNT(*), professors.university_id
FROM affiliations
JOIN professors
ON affiliations.professor_id = professors.id
GROUP BY professors.university_id
ORDER BY count DESC;
```

OUTPUT


Data Output Messages Notifications

Showing rows: 1 to

	count bigint	university_id character varying (50)
1	572	EPF
2	273	USG
3	162	UBE
4	128	ETH
5	75	UBA
6	40	UFR
7	36	UNE
8	35	ULA
9	33	UGE
10	7	UZH
11	4	USI

Referential Integrity:

The process of making a relationship between tables by using FOREIGN KEY which is the PRIMARY KEY of any table is known as referential integrity

Why?

It will allow us to maintain data between related tables i-e we can't ADD or DELETE rows in the table containing FOREIGN KEY unless we don't DELETE or UPDATE the PRIMARY KEY of the table

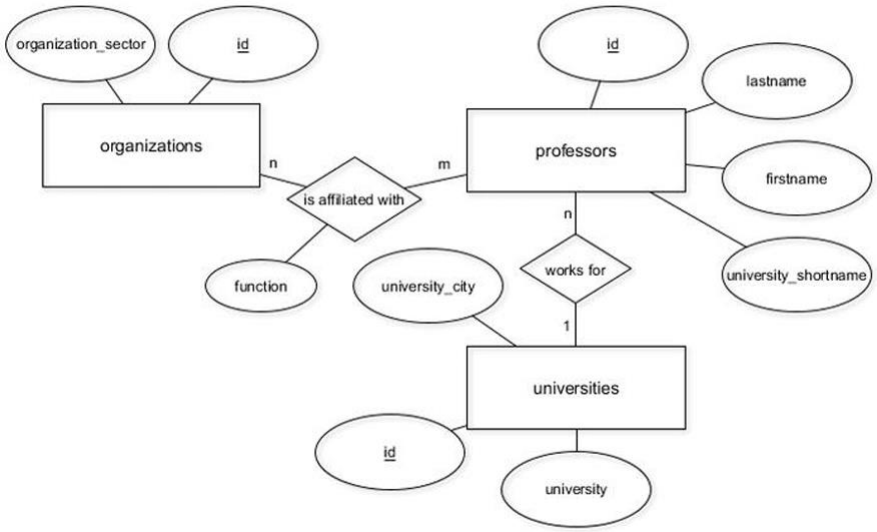
For this purpose, we use the format:

• ALTER TABLE b_table

• ADD CONSRAINT constraint_name FOREIGN KEY (b_table_column) REFERENCES a_table (a_table_column) ON DELETE CASCADE

So we can only use this format during the formation of FOREIGN KEY so that we are required to DROP previous FOREIGN CONSTRAINTS and add new ones.

At last, the ER diagram of our database


organization_sector
id
organizations
n
is affiliated with
m
professors
id
lastname
firstname
university_shortname
n
works for
1
function
university_city
universities
id
university