Module 2-6

Database Design

Objectives

- Database Design Exercise
- Database Definition Language
- Database Control Language

Constraints - Review

Constraints are rules imposed on the table, upon creation, that limits the ability to change the data.

- **NOT NULL:** A value must be specified
- **PRIMARY KEY:** Define that certain column/columns are part of the key
  - **A primary key value cannot be NULL**.
- **FOREIGN KEY:** Defines a foreign key based on a primary key from a different table
- **CHECK:** Only certain values can be inserted or updated
- e.g. CONSTRAINT CHK_duration CHECK (duration >= 20)

Transactions

A large number of SQL statements can be rolled into a single transaction.

The following syntax is observed:

START TRANSACTION; -- or BEGIN TRANSACTION;

// Lots of SQL statements.

COMMIT TRANSACTION; -- or COMMIT;

Your INSERT or UPDATE SQL statements **will only commit (permanently save in the database) if all the SQL statements in the transaction end successfully**.

Transaction Syntax

```
START TRANSACTION
```

Do the UPDATE/INSERT/DELETE statements

`COMMIT` (ends the transaction and saves the changes)

OR

`ROLLBACK` (ends the transaction without saving the changes)

Transactions can be used to safely test a statement that changes the database during development/testing.

Database Design Exercise

Gallery Customer History Form

Customer Name

Jackson, Elizabeth Phone (206) 284-6783
123 – 4th Avenue
Fonthill, ON
L3J 4S4

Purchases Made

Artist	Title	Purchase Date	Sales Price
03 - Carol Channing	Laugh with Teeth	09/17/2000	7000.00
15 - Dennis Frings	South toward Emerald Sea	05/11/2000	1800.00
03 - Carol Channing	At the Movies	02/14/2002	5550.00
15 - Dennis Frings	South toward Emerald Sea	07/15/2003	2200.00

The Gill Art Gallery wishes to maintain data on their customers, artists and paintings. They may have several paintings by each artist in the gallery at one time. Paintings may be bought and sold several times. In other words, the gallery may sell a painting, then buy it back at a later date and sell it to another customer.

Normal Forms

Before a single CREATE statement is run, the tables and their relationships need to be well thought out.
Normalization is the process of organizing a database to reduce data redundancy and improve data integrity.
We normalize data to:

1. Avoid duplicate data
2. Fix anomalies
3. Simplify search queries.

Normal Forms: Before normalization

Gallery Customer History Form

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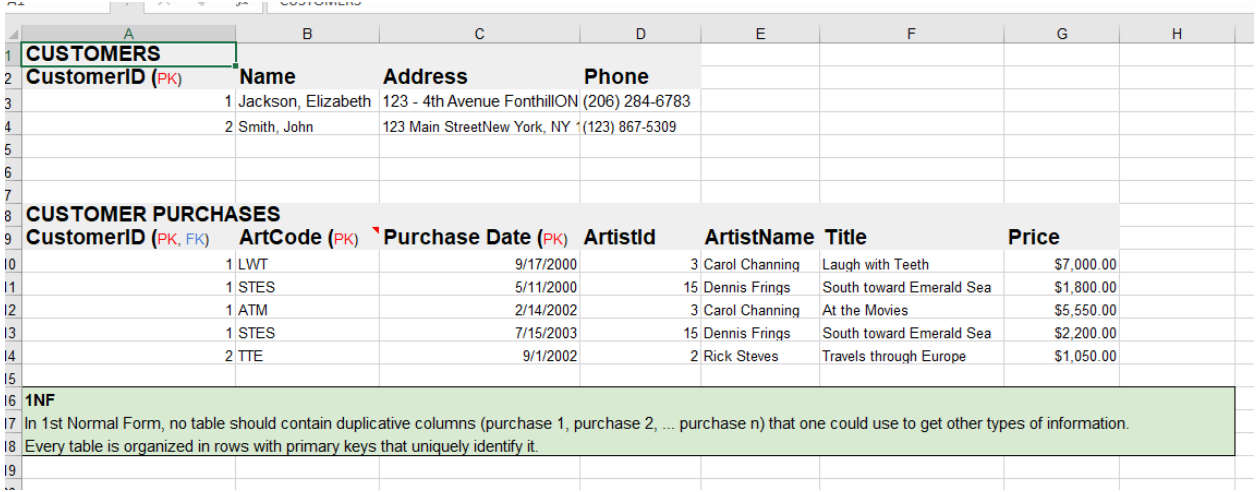
The Gill Art Gallery wishes to maintain data on their customers, artists and paintings. They may have several paintings by each artist in the gallery at one time. Paintings may be bought and sold several times. In other words, the gallery may sell a painting, then buy it back at a later date and sell it to another customer.

	A	B	C	D	E
1	**Name**	**Address**	**Phone**	**Purchases(ArtistId, ArtistName, ArtTitle, PurchaseDate, Price)**	
2	Jackson, Elizabeth	123 - 4th Avenue FonthillO	(206) 284-6783	03, Carol Channing, Laugh with Teeth, 9/17/2000, $7000.00 15, Dennis Frings, South toward Emerald Sea, 5/11/2000, $1800.00 03, Carol Channing, At the Movies, 2/14/2002, $5550.00 15, Dennis Frings, South toward Emerald Sea, 7/15/2003, $2200.00	
3	Smith, John	123 Main StreetNew York, I	(123) 867-5309	02, Rick Steves, Travels through Europe, 9/01/2002, $1050.00	
4					
5					
6					
7					
8					

Normal Forms: 1NF

- No table should contain duplicative columns that one could use to get other types of information.
- Every table should be organized in rows with primary keys that uniquely identify it.



CUSTOMERS

CustomerID (PK)	Name	Address	Phone
1	Jackson, Elizabeth	123 - 4th Avenue FonthillON	(206) 284-6783
2	Smith, John	123 Main StreetNew York, NY 1	(123) 867-5309

CUSTOMER PURCHASES

CustomerID (PK, FK)	ArtCode (PK)	Purchase Date (PK)	ArtistId	ArtistName	Title	Price
1	LWT	9/17/2000	3	Carol Channing	Laugh with Teeth	$7,000.00
1	STES	5/11/2000	15	Dennis Frings	South toward Emerald Sea	$1,800.00
1	ATM	2/14/2002	3	Carol Channing	At the Movies	$5,550.00
1	STES	7/15/2003	15	Dennis Frings	South toward Emerald Sea	$2,200.00
2	TTE	9/1/2002	2	Rick Steves	Travels through Europe	$1,050.00

1NF

In 1st Normal Form, no table should contain duplicative columns (purchase 1, purchase 2, ... purchase n) that one could use to get other types of information.
Every table is organized in rows with primary keys that uniquely identify it.

Normal Forms: 2NF

- Must be in 1NF
- Any non-key attribute must be dependent on the primary key

CUSTOMERS

CustomerID (PK)	Name	Address	Phone
1	Jackson, Elizabeth	123 - 4th Avenue FonthillON	(206) 284-6783
2	Smith, John	123 Main StreetNew York, NY 1	(123) 867-5309

CUSTOMER PURCHASES

CustomerID (PK, FK)	ArtCode (PK, FK)	Purchase Date (PK)	Price
1	LWT	9/17/2000	$7,000.00
1	STES	5/11/2000	$1,800.00
1	ATM	2/14/2002	$5,550.00
1	STES	7/15/2003	$2,200.00
2	TTE	9/1/2002	$1,050.00

ART

ArtCode (PK)	Title	ArtistID	ArtistName
LWT	Laughing with Teeth	3	Carol Channing
STES	South toward Emerald Sea	15	Dennis Frings
ATM	At the Movies	3	Carol Channing
TTE	Travels through Europe	2	Rick Steves

2NF

In 2nd Normal Form, the table must already be in 1NF.
Any Non-key Attribute must be dependent on the primary key.

2nd Normal Form – example2

Supplier#	Part#	City	Quantity
S1	P1	London	1000
S1	P2	London	1500
S1	P3	London	3400
S1	P4	London	2100
S2	P2	Paris	3400
S2	P3	Paris	1000
S4	P1	Nuku alofa	5
S4	P4	Nuku alofa	7

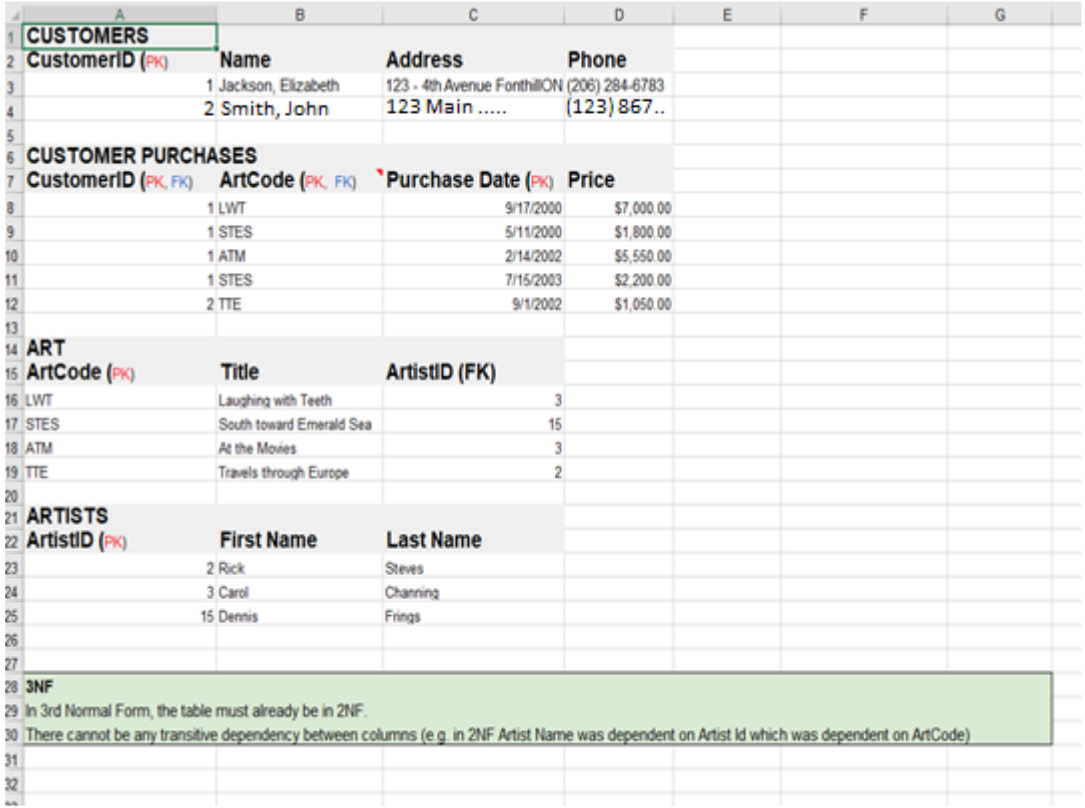
Table in Second Normal Form

Supplier#	City
S1	London
S2	Paris
S4	Nuku alofa

Supplier#	Part#	Quantity
S1	P1	1000
S1	P2	1500
S1	P3	3400
S1	P4	2100
S2	P2	3400
S2	P3	1000
S4	P1	5
S4	P4	7

Normal Forms: 3NF

- Must be in 2NF
- No transitive functional dependency – if column A is dependent on column B and column B is dependent on C, then column A is dependent on C



CUSTOMERS

CustomerID (PK)	Name	Address	Phone
1	Jackson, Elizabeth	123 - 4th Avenue FonthillON	(206) 284-6783
2	Smith, John	123 Main	(123) 867..

CUSTOMER PURCHASES

CustomerID (PK, FK)	ArtCode (PK, FK)	Purchase Date (PK)	Price
1	LWT	9/17/2000	$7,000.00
1	STES	5/11/2000	$1,800.00
1	ATM	2/14/2002	$5,550.00
1	STES	7/15/2003	$2,200.00
2	TTE	9/1/2002	$1,050.00

ART

ArtCode (PK)	Title	ArtistID (FK)
LWT	Laughing with Teeth	3
STES	South toward Emerald Sea	15
ATM	At the Movies	3
TTE	Travels through Europe	2

ARTISTS

ArtistID (PK)	First Name	Last Name
2	Rick	Steves
3	Carol	Channing
15	Dennis	Frings

3NF

In 3rd Normal Form, the table must already be in 2NF.

There cannot be any transitive dependency between columns (e.g. in 2NF Artist Name was dependent on Artist Id which was dependent on ArtCode)

Third Normal Form

A table is in the third normal form if it is the second normal form and there are no *non-key columns* dependant on *other non-key columns* that could not act as the primary key.

Normal Forms: 3NF

There are several levels above 3NF of “normal form” compliance, but generally the third normal form is good enough for 99% of all situations.

An informal intuitive definition of 3NF is as follows:

There are no fields in a table that are not directly determined by the values of the primary key.

Therefore, all fields in a table should be directly related to (determined by) the primary key of that table.

Normal Forms: 3NF Example

Suppose we have the following table:

InvoiceNumber (PK)	InvoiceDate	Inventory ID	Inventory Description
1000	10/1/2019	45	Hammer
1001	10/3/2019	28	Nails
1002	10/3/2019	17	Screwdriver
1003	10/4/2019	45	Hammer

Some questions to consider:

- Is an invoice date/inventory ID directly related to an invoiceNumber? → Yes
- Is an inventory description directly related to an invoiceNumber? → No

Normal Forms: 3NF Example

Suppose we need a Spanish version of this database, and we need to value to show *Martillo* instead of Hammer. This would entail an UPDATE statement that targets 2 rows.

InvoiceNumber (PK)	InvoiceDate	Inventory ID	Inventory Description
1000	**10/1/2019**	**45**	Martillo
1001	10/3/2019	28	Nails
1002	10/3/2019	17	Screwdriver
1003	**10/4/2019**	**45**	Martillo

Normal Forms: 3NF Example

In this situation, we could have split up the data into 2 tables, thus we end up with a less risky query, affecting only 1 row:

InvoiceNumber (PK)	InvoiceDate	Inventory ID
1000	**10/1/2019**	**45**
1001	10/3/2019	28
1002	10/3/2019	17
1003	**10/4/2019**	**45**

Inventory ID (pk)	Description
28	Nails
17	Screwdriver
45	Martillo

The Relational Attestment to 3NF

The Database Designer’s Swearing In Ceremony

Raise your left mouse button finger and repeat after me:

“I solemnly swear that all attributes will be related to,
The KEY,
The WHOLE Key,
And NOTHING BUT the Key.

So help me Codd”

Your finger may now be rested

Many to Many relationships

Generally speaking, when there are 2 entities for which there is a “many to many” relationship, we will end up with 3 tables when considering 3NF as part of our design.

Many to Many relationships Example

Consider the MovieDB example:

- An actor can be a cast member of several movies.
  - A movie can have several actors.

This is a “many to many” relationship.

Many to Many Relationships: The Problem

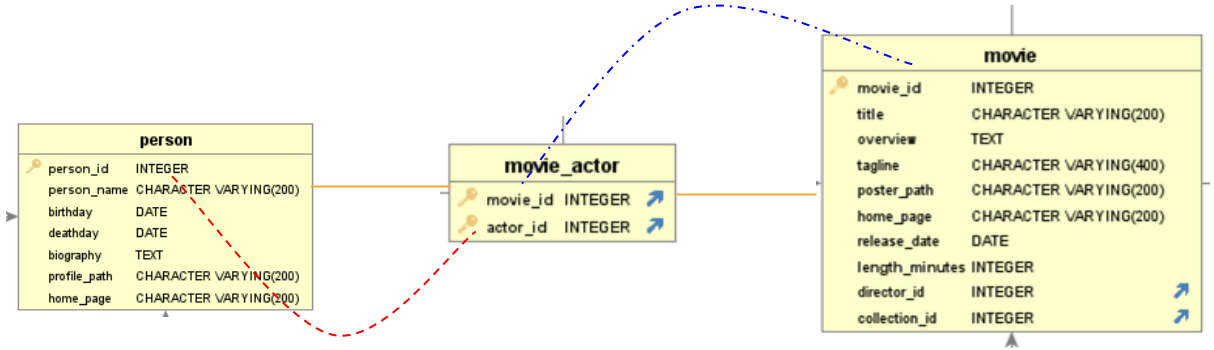
Actor				Film	
Actor_Id	Name			Film_Id	Title
1	Clint Westworld			1	The Ok, Horrible, and Ridiculous
2	Adam Aimy			2	Two Donkeys for Brother Samuel
				3	Departure
				4	Find Me If You Haven't
Actor				Film	
Actor_Id	Film_Id	Name		Film_Id	Title
1	1	Clint Westworld		1	The Ok, Horrible, and Ridiculous
1	2	Clint Westworld		2	Two Donkeys for Brother Samuel
1	3	Clint Westworld		3	Departure
2	3	Adam Aimy		4	Find Me If You Haven't
2	4	Adam Aimy			

Duplicated Data !?

Compound PK Dependent on Another Table !?

Many to Many relationships Example

We use a bridge table to break the Many to Many relationship so that the tables can be in 3rd normal form.



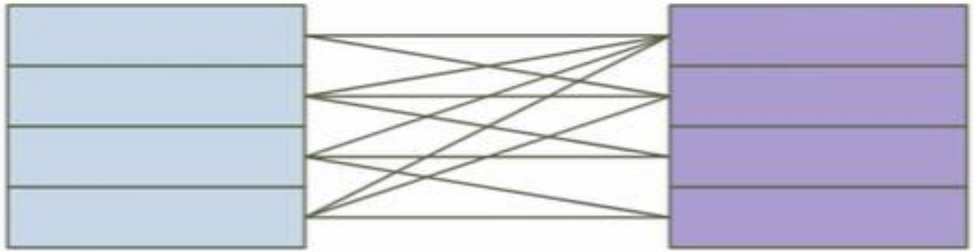
We have defined two foreign keys in the movie_actor table, the primary keys of each of the other two tables.

Many to Many Relationship

Many records in one table

relate to

Many records in another table



Student and Class Tables

student

ID	Name
1	John
2	Mark
3	Sarah
4	Claire

class

ID	Name
2	DB01
5	PH01
7	WEB01
8	WEB02

Student and Class Tables

student

ID	Name	Class ID
1	John	2, 5
2	Mark	5, 7
3	Sarah	8
4	Claire	2, 5, 8

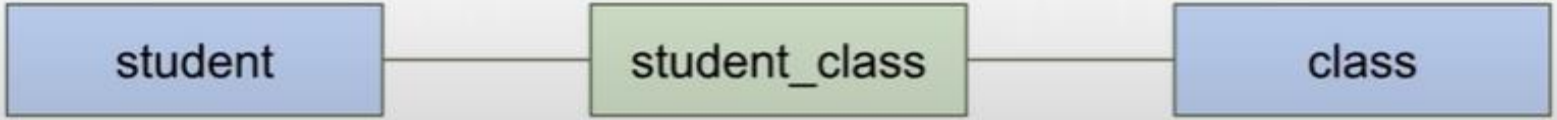
class

ID	Name	Student ID
2	DB01	1, 4
5	PH01	1, 2, 4
7	WEB01	2
8	WEB02	3, 4

Joining Table

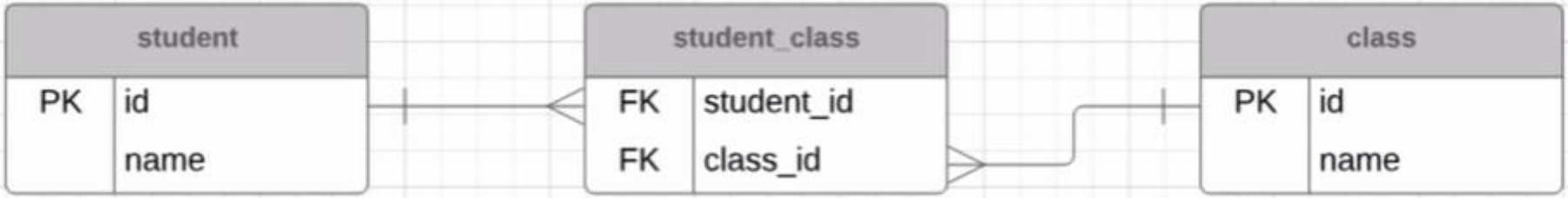
Instead of this:

We have this:



The Joining Table

Captures every instance of student and class


student
PK
id
name
student_class
FK
student_id
FK
class_id
class
PK
id
name

student

ID	Name
1	John
2	Mark
3	Sarah
4	Claire

student_class

Student ID	Class ID
1	2
1	5
2	5
2	7
3	8
4	2
4	5
4	8

class

ID	Name
2	DB01
5	PH01
7	WEB01
8	WEB02

DML vs DDL vs TCL

The SQL statements we have seen so far fall into a number of different categories:

- Data Manipulation Language (**DML**): SELECT, INSERT, UPDATE, DELETE
- Data Definition Language (**DDL**): CREATE, ALTER, DROP
- Transaction Control Language (TCL): BEGIN, TRANSACTION, COMMIT
- Data Control Language (DCL): GRANT, REVOKE

The focus of this lecture will be DDL statements with appropriate constraints.

Creating Tables Example

We are now ready to evaluate the syntax for table creation and alteration. This is the Create table syntax for all 3 of the previous tables:

```
CREATE TABLE person (
    person_id serial NOT NULL,
    person_name varchar(200) NOT NULL,
    birthday DATE NULL,
    CONSTRAINT pk_person PRIMARY KEY
(person_id)
);
```

```
CREATE TABLE movie_actor (
    actor_id integer NOT NULL,
    movie_id integer NOT NULL,
    CONSTRAINT pk_movie_actor PRIMARY KEY (actor_id, movie_id)
);
```

In movie_actor are actor_id and movie_id foreign keys yet?

No!

```
CREATE TABLE movie (
    movie_id int NOT NULL DEFAULT nextval('movie_serial'),
    title varchar(200) NOT NULL,
    overview text NULL,
    tagline varchar(400) NULL,
    poster_path varchar(200) NULL,
    home_page varchar(200) NULL,
    release_date date NULL,
    length_minutes int NOT NULL,
    director_id int NULL,
    collection_id int NULL,
        CONSTRAINT pk_movie PRIMARY KEY (movie_id)
);
```

Creating Tables Example

We finish by specifying that actor_id and film_id are actually foreign keys. The DBMS does not assume this just because it has the same name, we must use the ALTER command:

```
ALTER TABLE movie_actor
ADD FOREIGN KEY(movie_id)
REFERENCES movie(movie_id);

ALTER TABLE movie_actor
ADD FOREIGN KEY(actor_id)
REFERENCES person(person_id);
```

CREATE/DROP syntax

```
CREATE DATABASE database_name;
DROP DATABASE database_name;
```

```
CREATE TABLE table_name
(
   column_name1 data_type(size),
   column_name2 data_type(size) NOT NULL,
   column_name3 data_type(size),
   CONSTRAINT pk_column_1 PRIMARY KEY (column_name1),
   CONSTRAINT fk_column_2 FOREIGN KEY (column_name2)
      REFERENCES table_name(column_1)
);
```

ALTER syntax

```
ALTER TABLE table_name
   ADD CONSTRAINT pk_constraint_name
   PRIMARY KEY (column_name(s));

ALTER TABLE table_name
   ADD CONSTRAINT fk_constraint_name
   FOREIGN KEY (column_name) REFERENCES
   table(column_name);

ALTER TABLE table_name
   ADD CONSTRAINT chk_constraint_name
   CHECK (column_name = 'value' OR
   column_name IN (values));
```

Data Control Language (DCL)

DCL commands deal with the permissions, rights and other controls for the database system.

- CREATE USER – Allows the creation of a user to the database
  - Users have permission to log in to the database by default
- CREATE ROLE – Allows the creation of a role to the database
  - Roles do not have access to log in to the database (but can be granted this)
- GRANT – allow a role or user access privileges to a database or table
- ALTER ROLE – allows a role to be modified
- REVOKE – remove access privileges to a database or table

Data Control Language (DCL)

DCL commands deal with the permissions, rights and other controls for the database system. Examples are GRANT and REVOKE

```
GRANT privileges
ON object
TO user;

GRANT ALL
  ON Movie_db
  TO margaret;
```

Provides user access privileges to the database

Data Control Language (DCL)

DCL commands deal with the permissions, rights and other controls fo the database system. Examples are GRANT and REVOKE

```
REVOKE privileges
ON object
FROM user;

REVOKE INSERT
  ON Movie_db
  FROM margaret;
```

Removes user access privileges to the database

Data Control Language (DCL)

To change attributes of a role, you use the following form of `ALTER ROLE` statement:

```
ALTER ROLE role_name [WITH] option;
```

The option can be:

- `SUPERUSER` | `NOSUPERUSER` – determine if the role is a `superuser` or not.
- `CREATEDB` | `NOCREATEDB` – allow the role to create new databases.
- `CREATEROLE` | `NOCREATEROLE` – allow the role to create or change roles.
- `INHERIT` | `NOINHERIT` – determine if the role to inherit privileges of roles of which it is a member.
- `LOGIN` | `NOLOGIN` – allow the role to log in.
- `REPLICATION` | `NOREPLICATION` – determine if the role is a replication roles.
- `BYPASSRLS` | `NOBYPASSRLS` – determine if the role to by pass a row-level security (RLS) policy.
- `CONNECTION LIMIT limit` – specify the number of concurrent connection a role can made, -1 means unlimited.
- `PASSWORD 'password'` | `PASSWORD NULL` – change the role's password.
- `VALID UNTIL 'timestamp'` – set the date and time after which the role's password is no long valid.