WEEK 02

Instructor: Yanan Wu
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Spring 2025

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LECTURE SESSION

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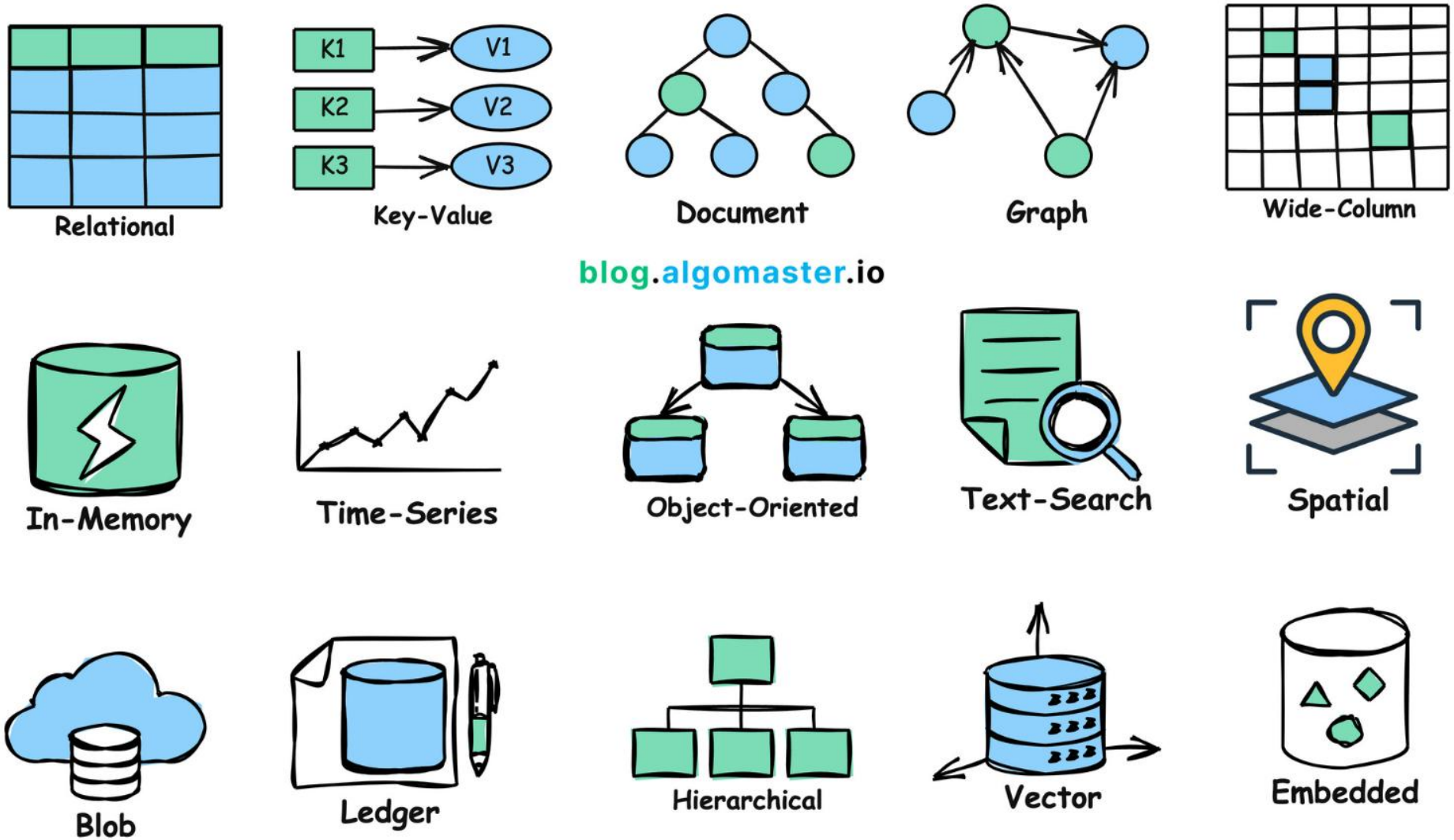
2.1.1
DATABASE AND DBMS

DATABASE

- A database is an organized collection of structured data, or information, typically stored electronically in a computer that can be easily accessed, managed, and updated

Source

TYPES OF DATABASE



Source

DATABASE MANAGEMENT SYSTEM (DBMS)

- A software system that is designed to manage and organize data in a structured manner.

Key features of DBMS

Store large amounts of data systematically

Implements access control to protect data from unauthorized access

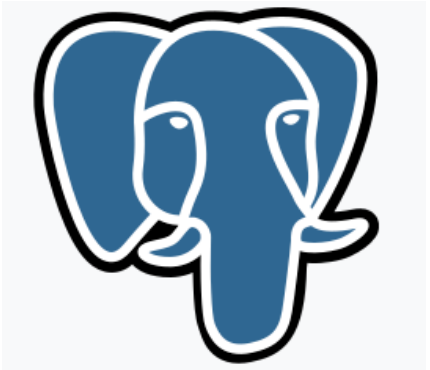
Ensure the consistency of data through constraints

Provide tools to back up the database

OPEN-SOURCE TECHNOLOGIES

- MySQL

- PostgreSQL



- MongoDB

- SQLite

- DynamoDB

- MariaDB

KEY ATTRIBUTES OF A ROBUST DBMS

- Reliability
  - The system can function correctly and consistently over time
  - The system must be able to offer continual uninterrupted service
- Consistency
  - Refers to ensuring that the database remains accurate, valid, and follows defined rules or constraints
- Technology-Proof
  - The system is adapted to evolving technologies and its long-term viability

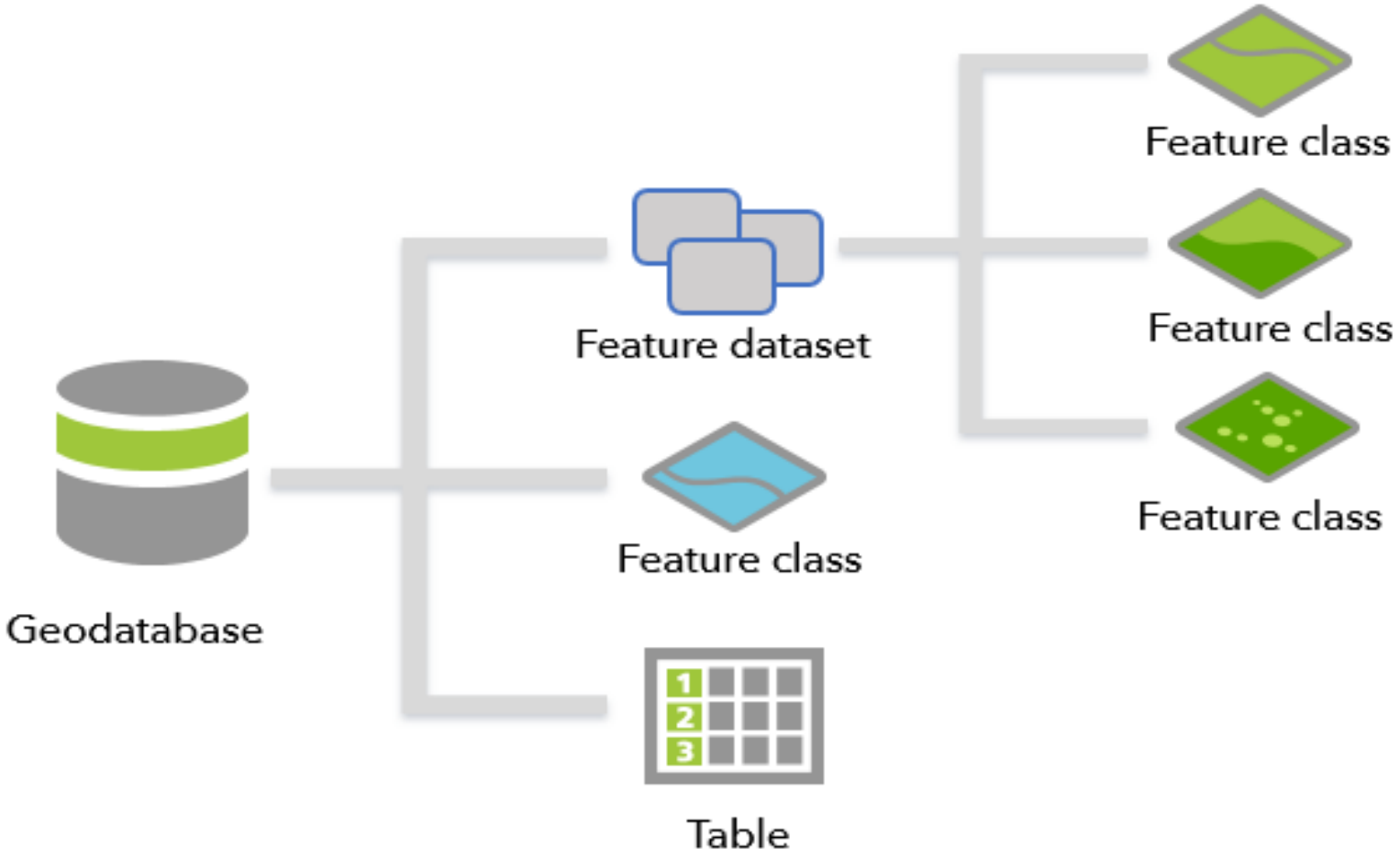
2.1.2 GEODATABASE

GEODATABASE

- A **Geodatabase** is a specialized type of database designed to store, manage, and analyze spatial and geographic data.

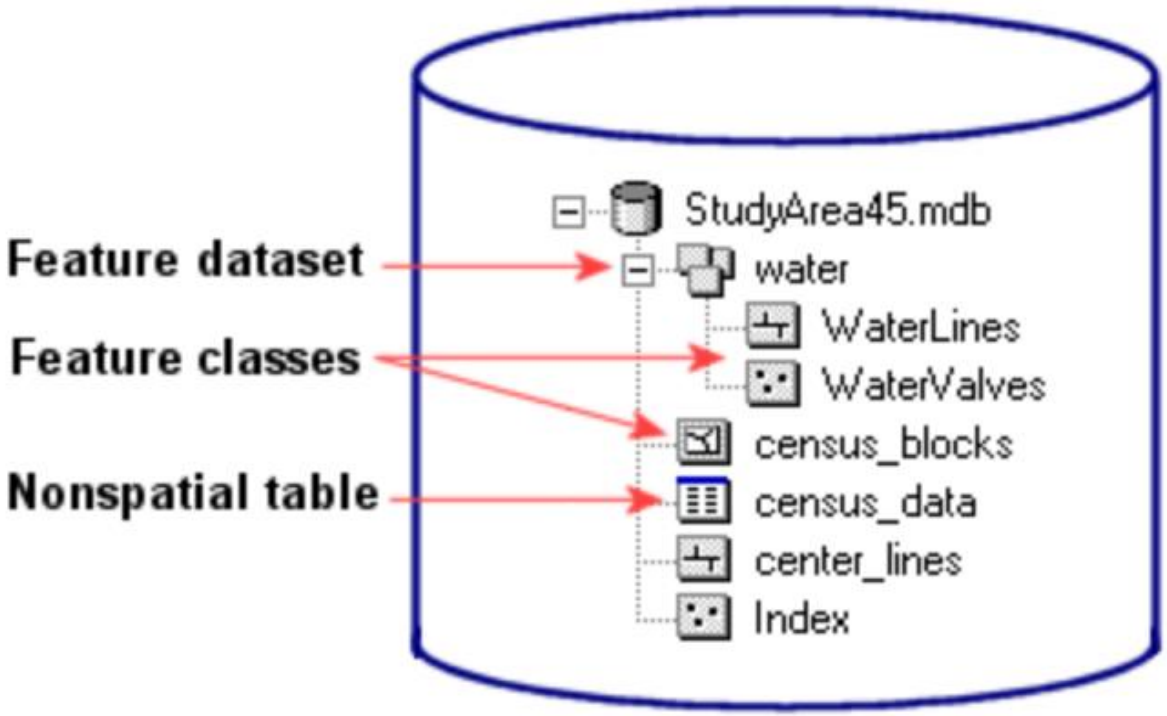
- It serves as a comprehensive framework for organizing spatial data and associated attribute information, allowing users to perform advanced geographic analysis, mapping, and data management tasks.

GEODATABASE IN GIS



FEATURE DATASETS AND FEATURE CLASS

- A feature dataset is composed of feature class
- A feature class is a collection of geographic features with the same geometry type, attributes, and spatial reference.

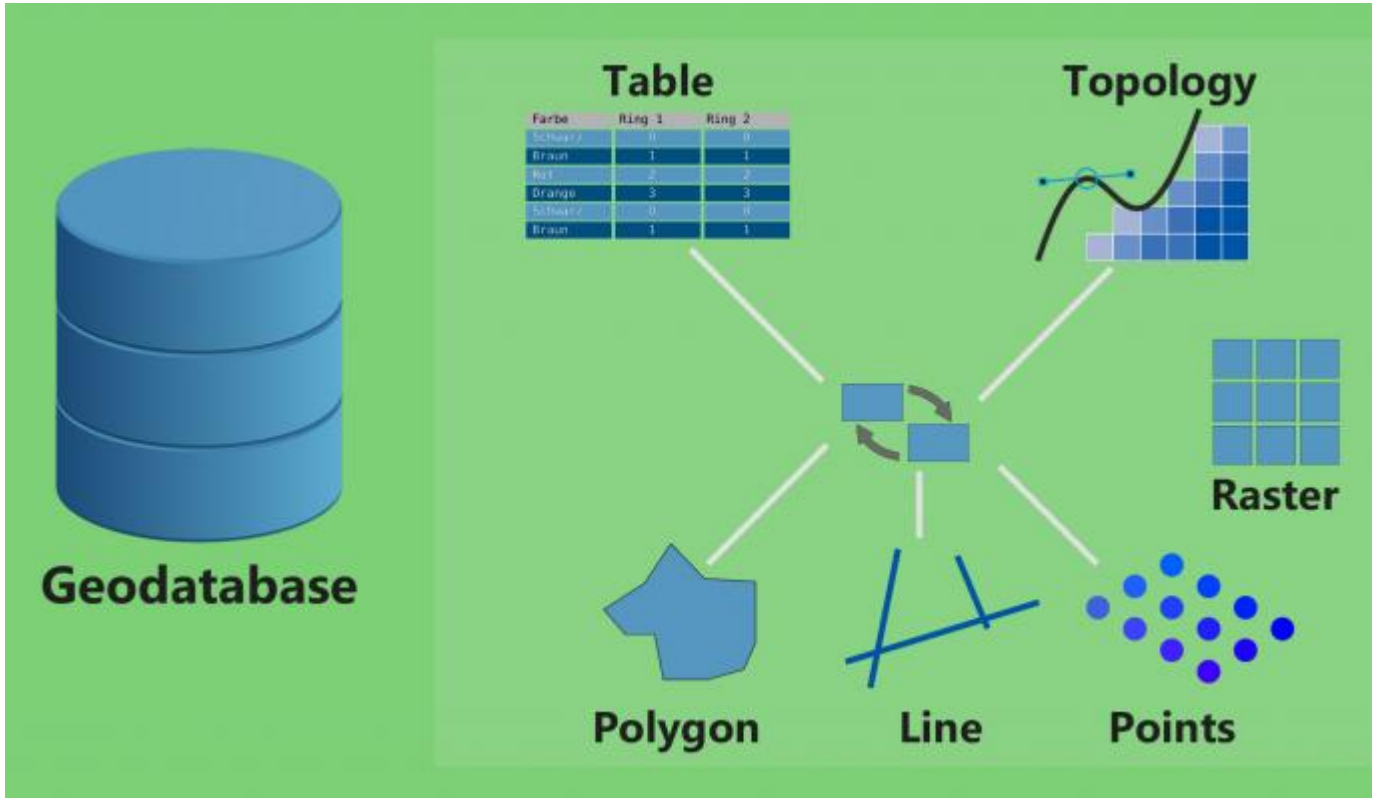


ADVANTAGES OF USING A GEODATABASE

- Centralized Data Management

Combines spatial (maps, shapes) and non-spatial (tabular) data in a single database.

Provides a unified framework for managing diverse data types, including vector, raster, and attribute data.



COMPARING TYPES OF GEODATABASES IN ARCGIS PRO

More detailed comparison of geodatabases

Comparing types of geodatabases

Key characteristics	Enterprise geodatabase	Mobile geodatabase	File geodatabase
Description	A collection of various types of GIS datasets held as tables in a relational database.	A collection of various types of GIS datasets contained within a relational database.	A collection of various types of GIS datasets held in a file system folder.
Number of users	Multiple editors and can support multiple readers.	Single editor and can support multiple readers.	Single editor and can support multiple readers.
Storage format	• Oracle • Microsoft SQL Server • IBM Db2 • PostgreSQL • SAP HANA	All the datasets that belong to one mobile geodatabase are contained in an SQLite database that is stored in a single file.	Each dataset is a separate file on disk. All the datasets that belong to one geodatabase are contained in a single folder.

COMPARING TYPES OF GEODATABASES IN ARCMAP

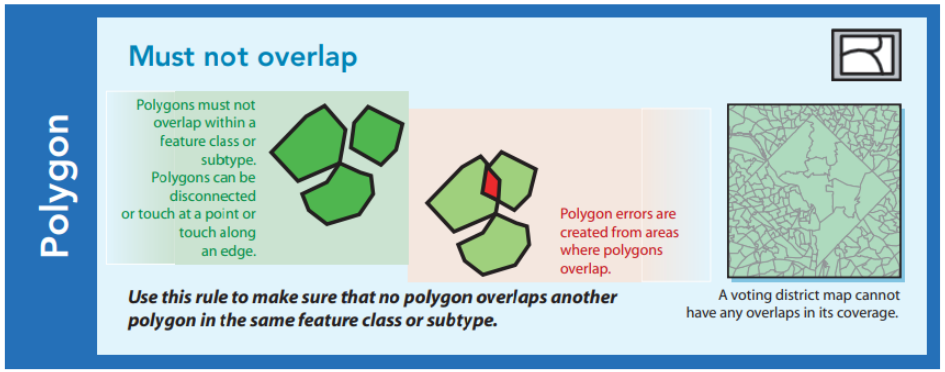
More detailed comparison of geodatabases

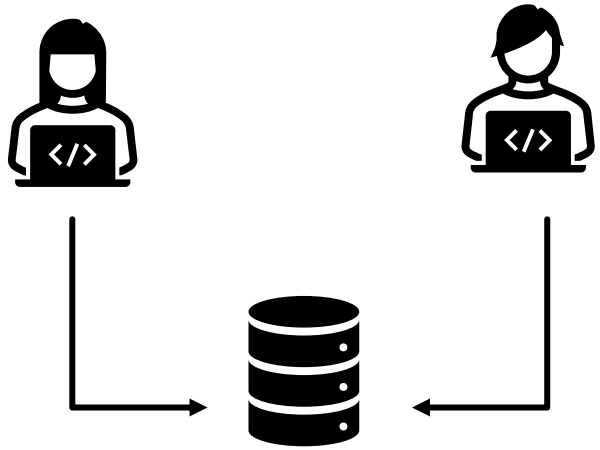
Comparing the three types of geodatabases

Key characteristics	Enterprise geodatabase	File geodatabase	Personal geodatabase
Description	A collection of various types of GIS datasets held as tables in a relational database (This is the recommended native data format for ArcGIS stored and managed in a relational database.)	A collection of various types of GIS datasets held in a file system folder. (This is the recommended native data format for ArcGIS stored and managed in a file system folder.)	Original data format for ArcGIS geodatabases stored and managed in Microsoft Access data files. (This is limited in size and tied to the Windows operating system.)
Number of users	Multiuser: many readers and many writers	Single user and small workgroups: many readers or one writer per feature dataset, stand-alone feature class, or table. Concurrent use of any specific file eventually degrades for large numbers of readers.	Single user and small workgroups with smaller datasets: some readers and one writer. Concurrent use eventually degrades for large numbers of readers.

ADVANTAGES OF USING A GEODATABASE

- Data Integrity and Consistency
  - Supports topology rules to ensure data accuracy (e.g., no overlapping polygons or gaps).
  - Enforces data validation and constraints to maintain reliable relationships between features.
  - Versioning support allows multiple users to work on the same dataset without conflicts.





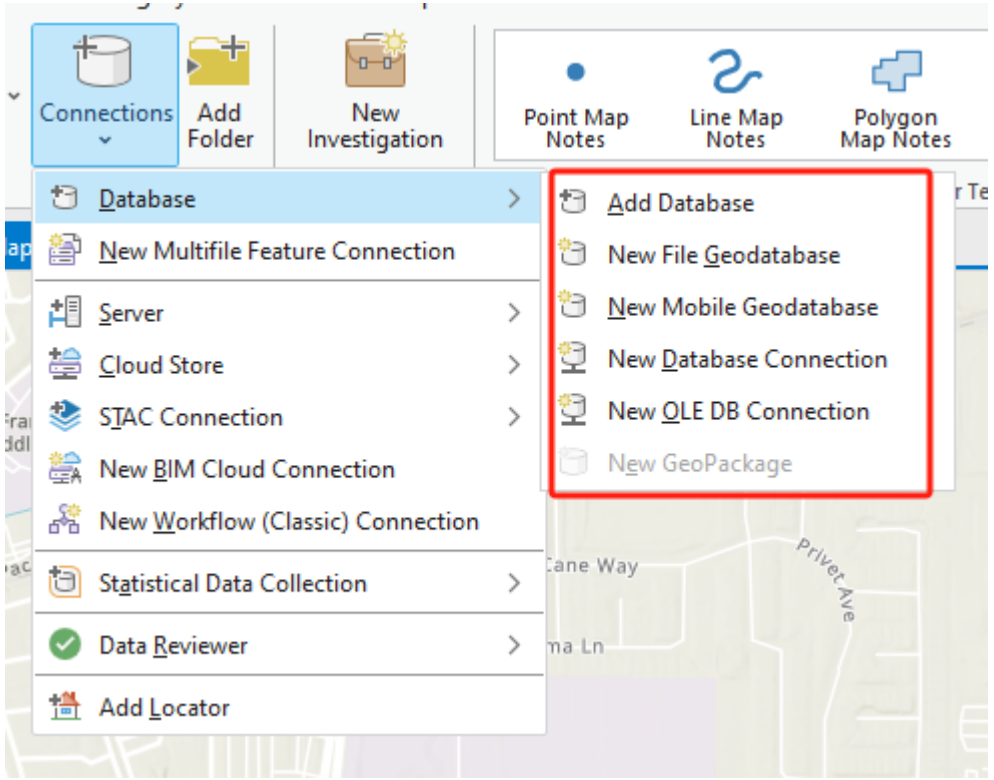
ADVANTAGES OF USING A GEODATABASE

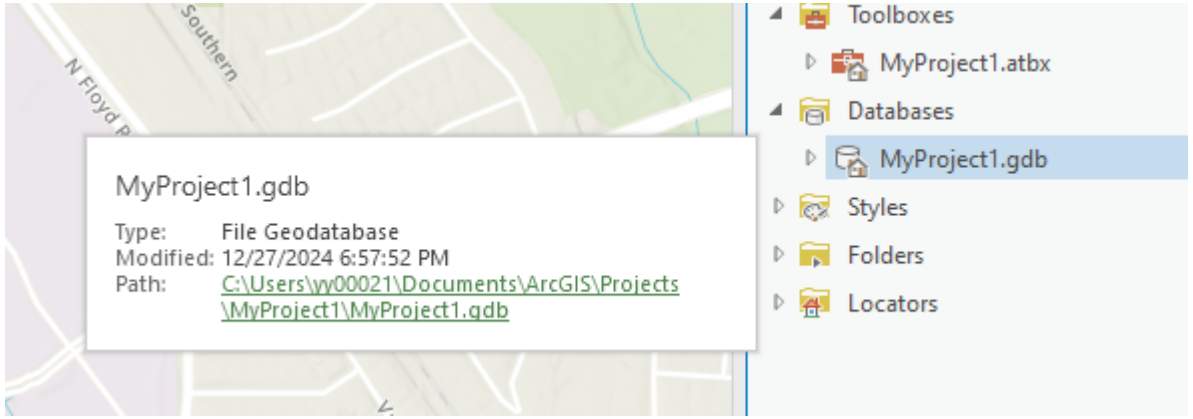
- Cross-Platform Compatibility
  - Compatible with various GIS software tools, such as ArcGIS, QGIS, and GeoServer.
  - Works with relational database systems like PostgreSQL/PostGIS, Oracle, or SQL Server.

ADVANTAGES OF USING A GEODATABASE

- Scalability
  - Supports various levels of implementation:
    - File Geodatabases: A file geodatabase is stored as multiple files in a folder with a `.gdb` extension. For team collaboration on medium-scale projects.
    - Enterprise Geodatabases: Also known as multiuser geodatabases, enterprise geodatabases are stored in relational databases. They can be virtually unlimited in size and number of users; the limits differ depending on the database management system (DBMS) vendor. For large organizations and multi-user environments.
    - Mobile Geodatabases: A mobile geodatabase is stored in an SQLite database that is entirely contained in a single file and has a `.geodatabase` extension.
- Capable of handling large datasets efficiently in enterprise environments.

GEODATABASE IN ARCGIS PRO





2.1.3 SQL

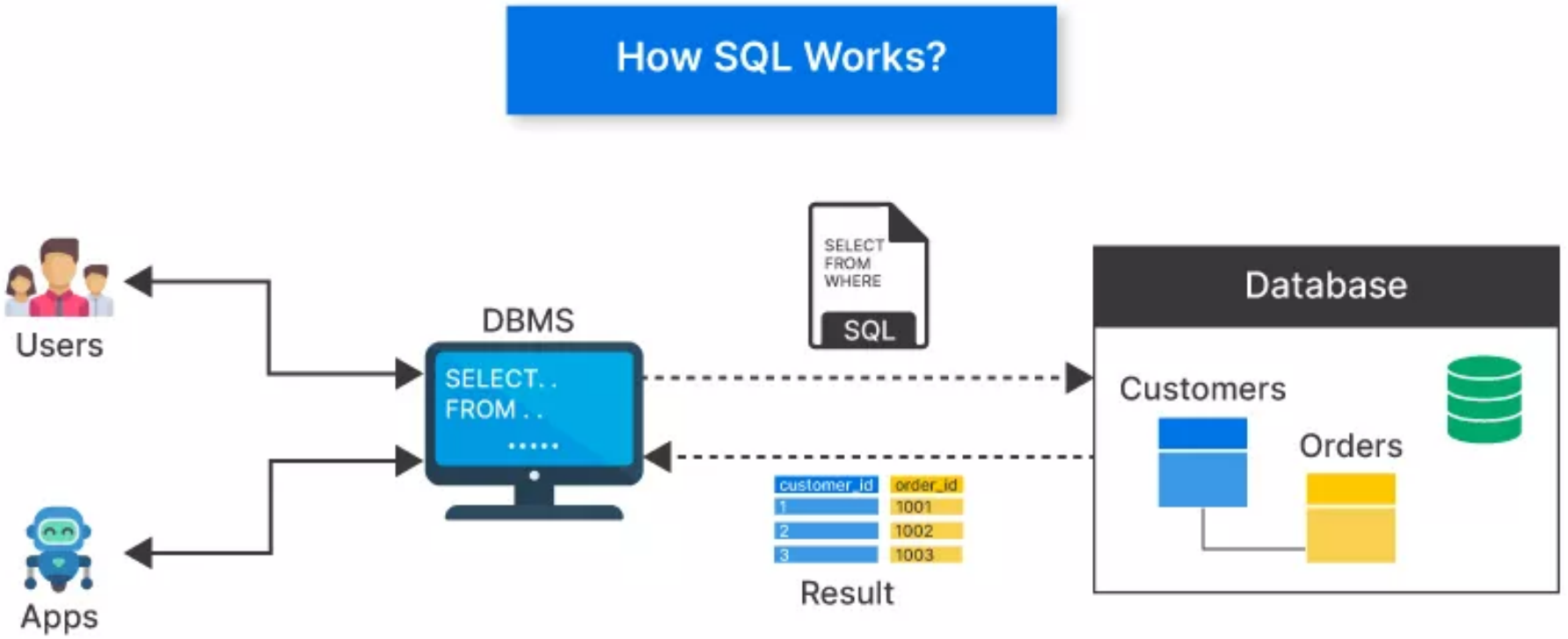
STANDARD QUERY LANGUAGE (SQL)

- SQL is a standard programming language specifically designed for managing and manipulating relational databases.

- It allows users to interact with a DBMS to perform various operations such as querying, updating, and managing database structures.

HOW SQL WORKS

- It serves as a standard interface for interacting with relational database management systems (RDBMS), allowing users to perform a variety of routine tasks and operations on data
  - such as querying, updating, inserting, and deleting records.



Source

KEY POINTS BETWEEN DBMS AND SQL

- SQL is Independent of DBMS: While SQL is a standard, each DBMS may implement it with slight variations or extensions (e.g., PL/SQL in Oracle, T-SQL in SQL Server).
- DBMS Without SQL: Some DBMS types, such as NoSQL databases (e.g., MongoDB), do not rely on SQL but use alternative query languages.
- SQL Requires a DBMS: SQL commands need a DBMS to interpret and execute them. Without a DBMS, SQL commands would have no database to operate on.

2.1.4 SOFTWARE

SOFTWARES

- PostgreSQL
- What is PostgreSQL?
  - An open-source, powerful, object-relational database management system.
  - Known for its reliability, extensibility, and SQL compliance.
- Why PostgreSQL for GIS?
  - Supports structured queries for data management and manipulation.
  - Extensible via plugins, making it adaptable for spatial needs.

POSTGIS REFERENCE USERS - GOVERNMENT

POSTGIS REFERENCE USERS - PRIVATE SECTOR

Ball Aerospace
& Technologies Corp.

SOFTWARE

- What is PostGIS?
  - A spatial database extension for PostgreSQL.
  - Adds support for geographic objects like points, lines, and polygons.

- Key Features of PostGIS:
  - Spatial data types: GEOMETRY and GEOGRAPHY.
  - Spatial functions:
    - Query and manipulate spatial data (ST_Intersects, ST_Buffer, ST_Distance).
    - Perform spatial analyses (e.g., clipping, union, or proximity searches).

POSTGIS 3RD PARTY INTEGRATION

DESKTOP

AND MORE...

MIDDLE

AND MORE...

LANGUAGE

AND MORE...

POSTGIS IS POWERFRUL

- Functions to work with GeoJSON (Geographic JavaScript Object Notation), Keyhole Markup Language (KML), Mapbox Vector Tiles (MVT) allowing web applications to talk directly to PostGIS

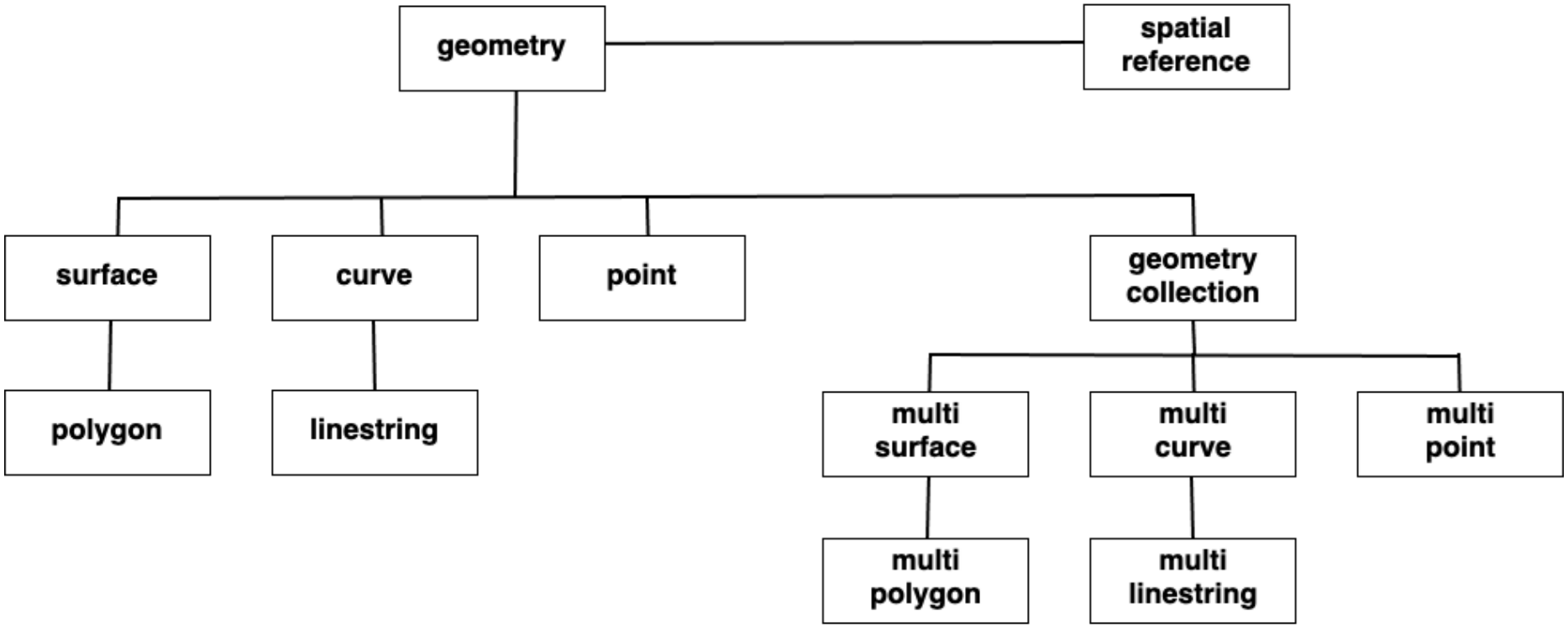
- GeoJSON and KML are two of the older, more popular vector formats used by web mapping applications

  Example: Analyze Boston has GeoJSON and KML to store vector data

- Mapbox Vector Tiles is a relatively new standard that has gained quite a bit of popularity in the last few years

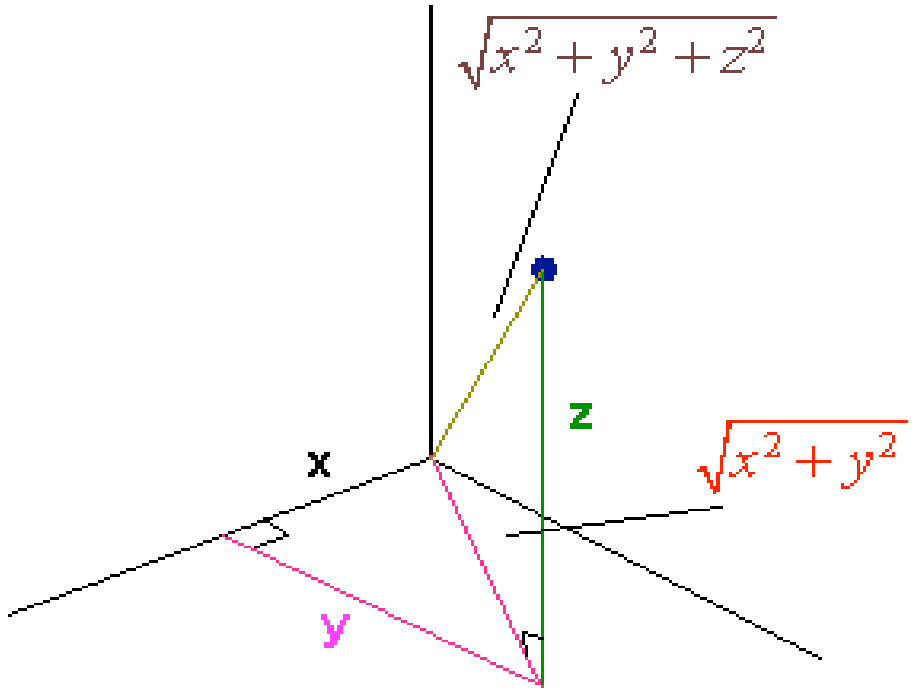
POSTGIS IS POWERFRUL

- Comprehensive geometry processing functions that go far beyond basic geometric operations, including functions for fixing invalid geometries and for simplifying and deconstructing geometries



POSTGIS IS POWERFRUL

- Built-in 3D and Topology Support
  - ST_3DClosestPoint(g1, g2)
  - ST_3DDistance(g1, g2)
  - ST_3DDWithin(g1, g2, r)
  - ST_3DDFullyWithin(g1, g2, r)
  - ST_3DIntersects(g1, g2)
  - ST_3DLongestLine(g1, g2)
  - ST_3DMaxDistance(g1, g2)
  - ST_3DShortestLine(g1, g2)



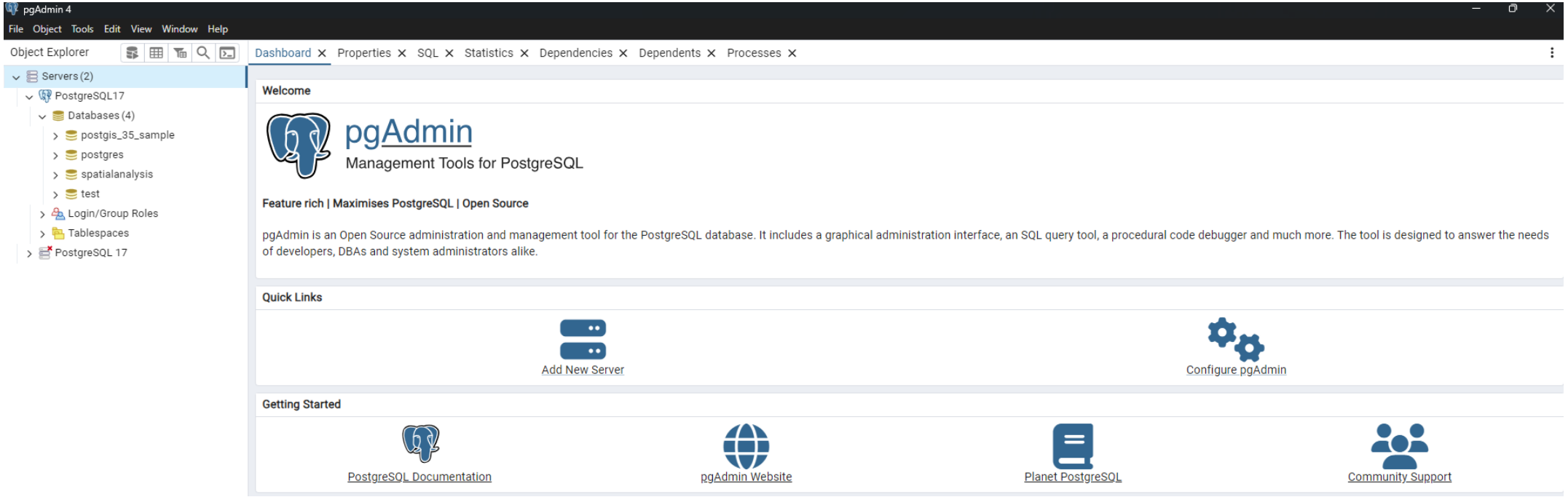
POSTGIS IS POWERFRUL

- Over 300 seamless operations for working with vectors and rasters in tandem, as well as for converting between the two families

2.1.5 PGADMIN

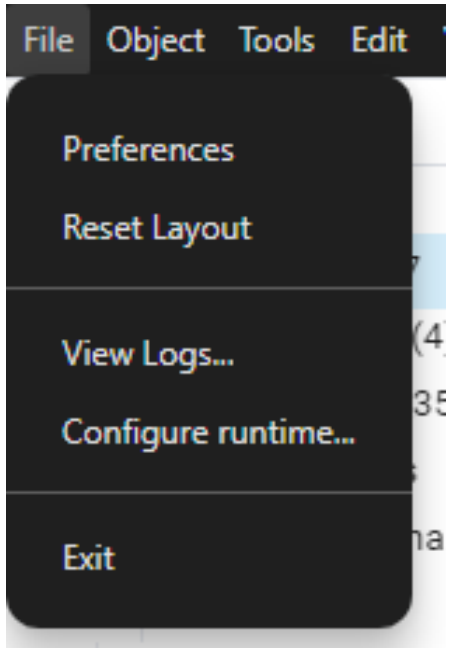
USER INTERFACE

- Add New Server button: Open the Register - Server dialog to add a new server definition.
- Configure pgAdmin button: Open the Preferences dialog to customize your pgAdmin client.
- PostgreSQL Documentation: The Documentation page for the PostgreSQL open-source project.
- pgAdmin Website: The website for pgAdmin releases and other project information.
- Planet PostgreSQL: Postgres related blogs.
- Community Support: information about obtaining support for PostgreSQL features.



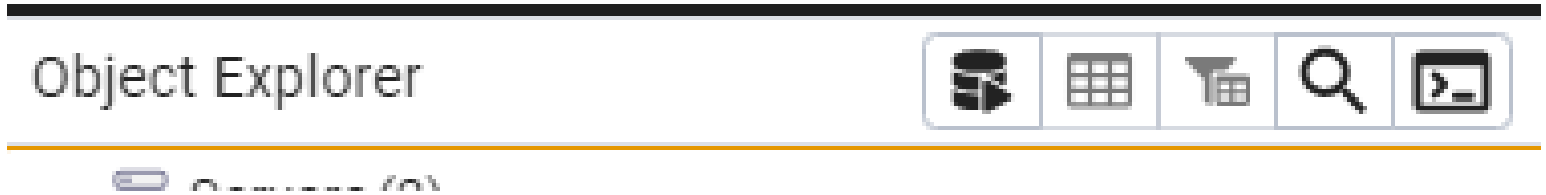
MENU BAR

Option	Action
Preferences	Click to open the Preferences dialog to customize your pgAdmin settings.
Reset Layout	If you have modified the workspace, click to restore the default layout.
Runtime	Click to open a submenu to Configure, View Log and Zoom settings. Only visible when pgAdmin4 runs in desktop mode. To know more about runtime menu click here



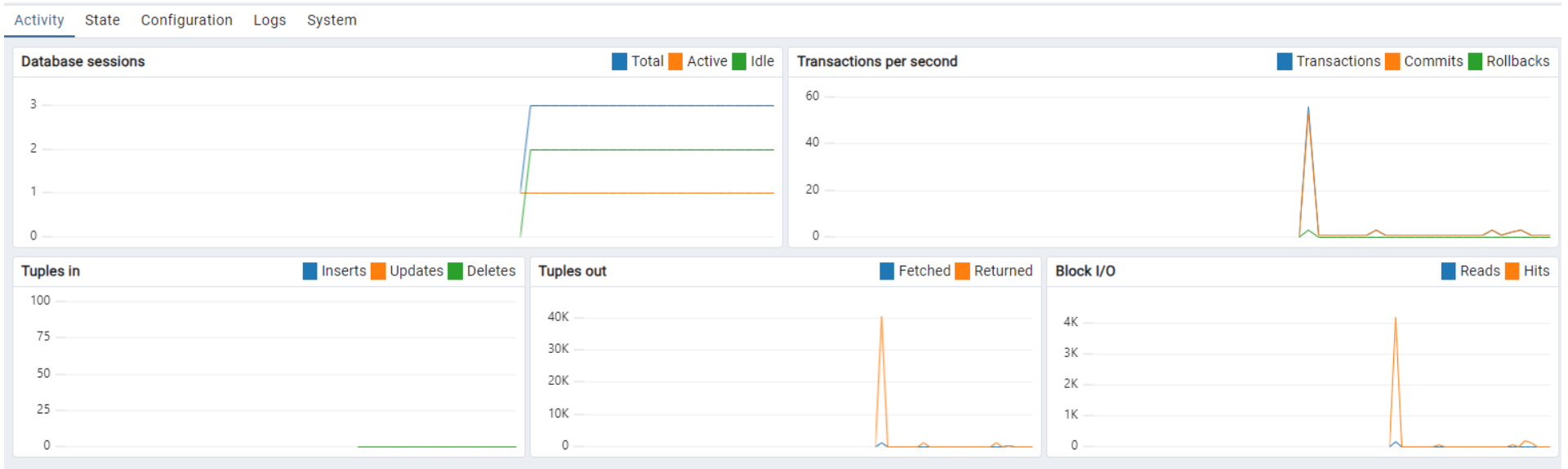
TOOLBAR

- Query button: Open the Query Tool in the current database context.
- View Data button: View/edit the data stored in a selected table.
- Filtered Rows button: Access the Data Filter popup to apply a filter to a set of data for viewing/editing.
- Search objects button: Access the search objects dialog. It helps you search any database object.
- PSQL Tool button: Open the PSQL in the current database context.



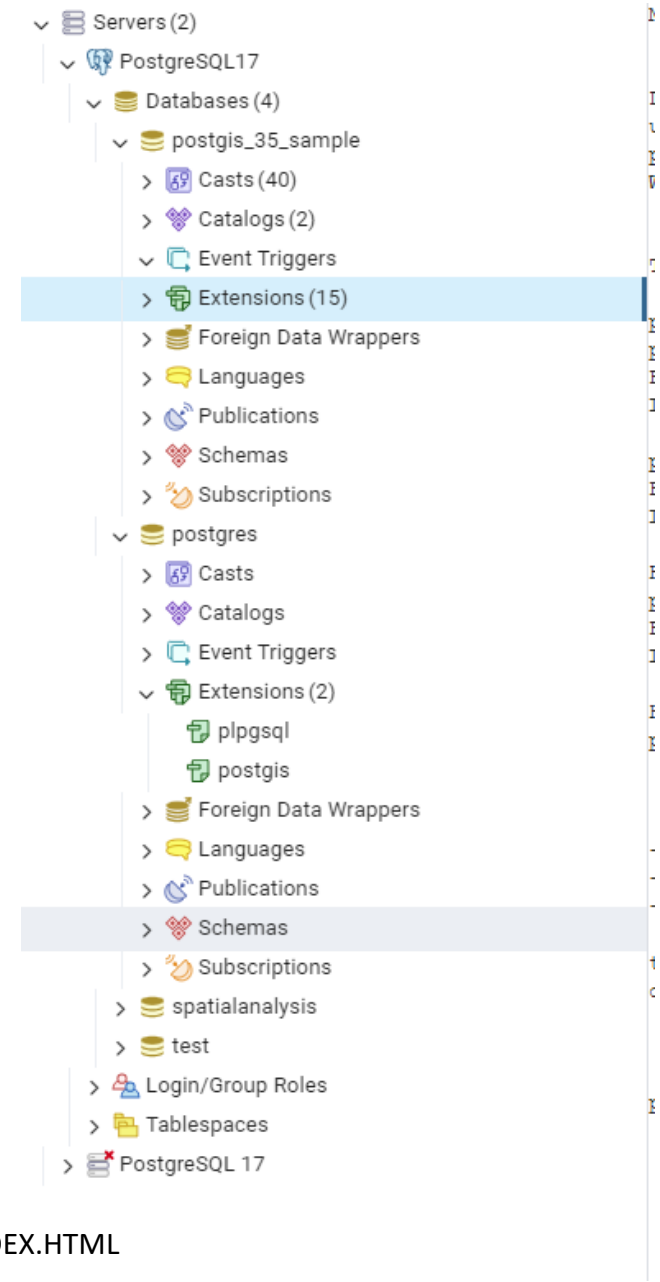
TABBED BROWSER

- The *Server sessions* or *Database sessions*: Display the interactions with the server or database.
- The *Transactions per second*: Display the commits, rollbacks, and total transactions per second that are taking place on the server or database.
- The *Tuples:* Display the number of tuples inserted, updated, and deleted on the server or database.
- The *Tuples out* graph: Display the number of tuples fetched and returned from the server or database.
- The *Block I/O* graph: Display the number of blocks read from the filesystem or fetched from the buffer cache (but not the operating system's file system cache) for the server or database.



TREE CONTROL

- The left pane of the main window displays a tree control (Object explorer) that provides access to the objects that reside on a server.



MORE IN PDADMIN DOCUMENTATION: HTTPS://WWW.PGADMIN.ORG/DOCS/PGADMIN4/DEVELOPMENT/INDEX.HTML

WEEK 02

LAB SESSION

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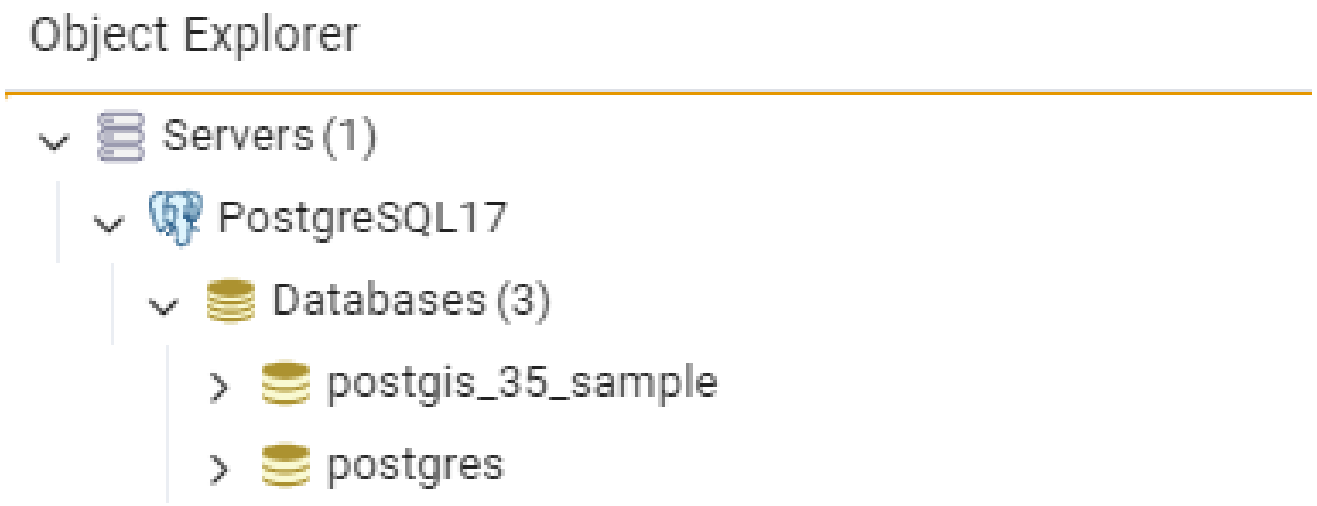
Spring 2025

2.2.1 BASIC OPERATIONS IN POSTGRESQL

DATABASES UNDER SERVER

- The server contains two databases
  - One is the default postgresql database
  - The other one is the database we created while installing PostgreSQL
  - If one of the servers has a red cross on it means that it is not connected
    - You can click on it to have access
    - Sometimes you are required to provide the password

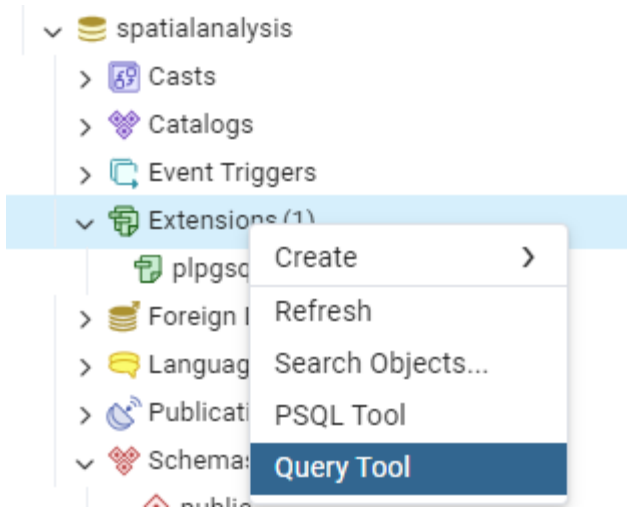


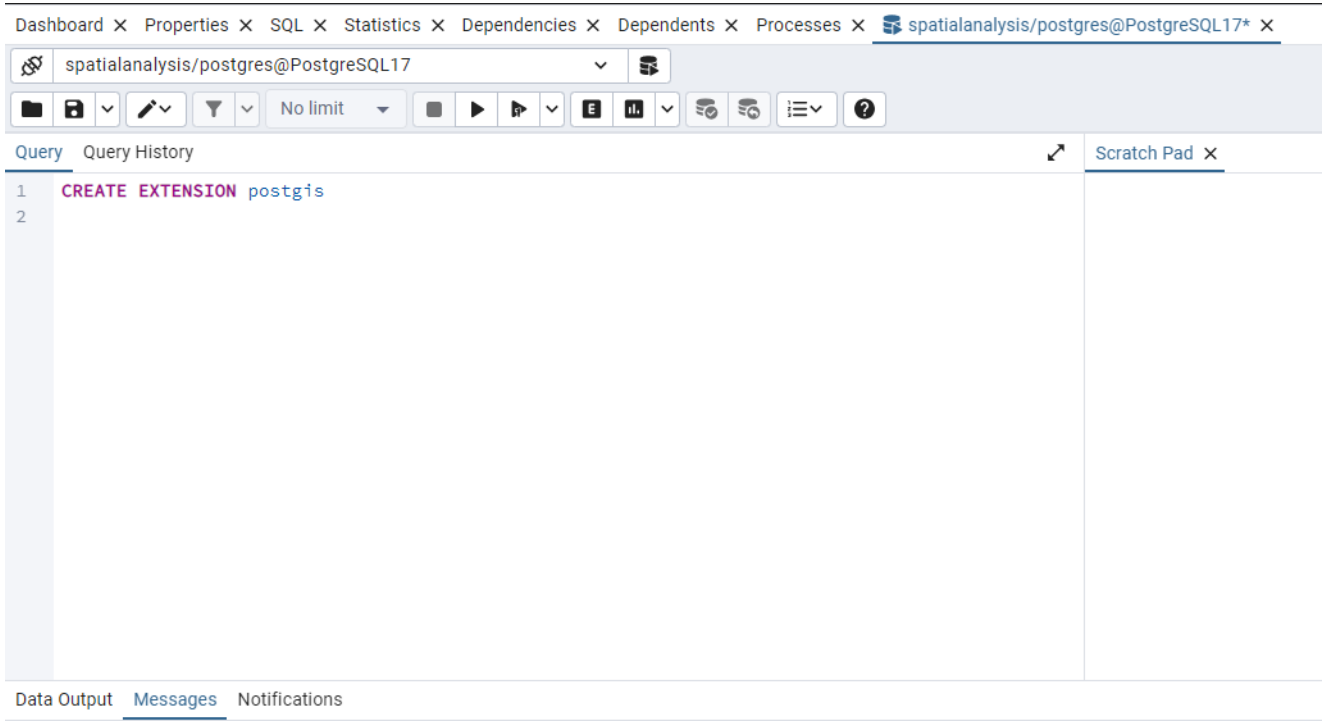
CREATE A DATABASE

- Create a new Database per you need

CHECK EXTENSION

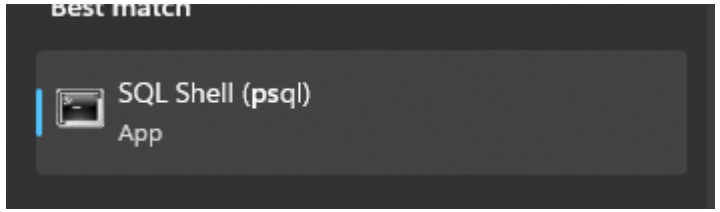
- The default extension is plpgsql
- Adding postgis extension through Query tool
- Type ‘’CREATE EXTENSION postgis’’ in Query
- Then the postgis extension was created under Extensions

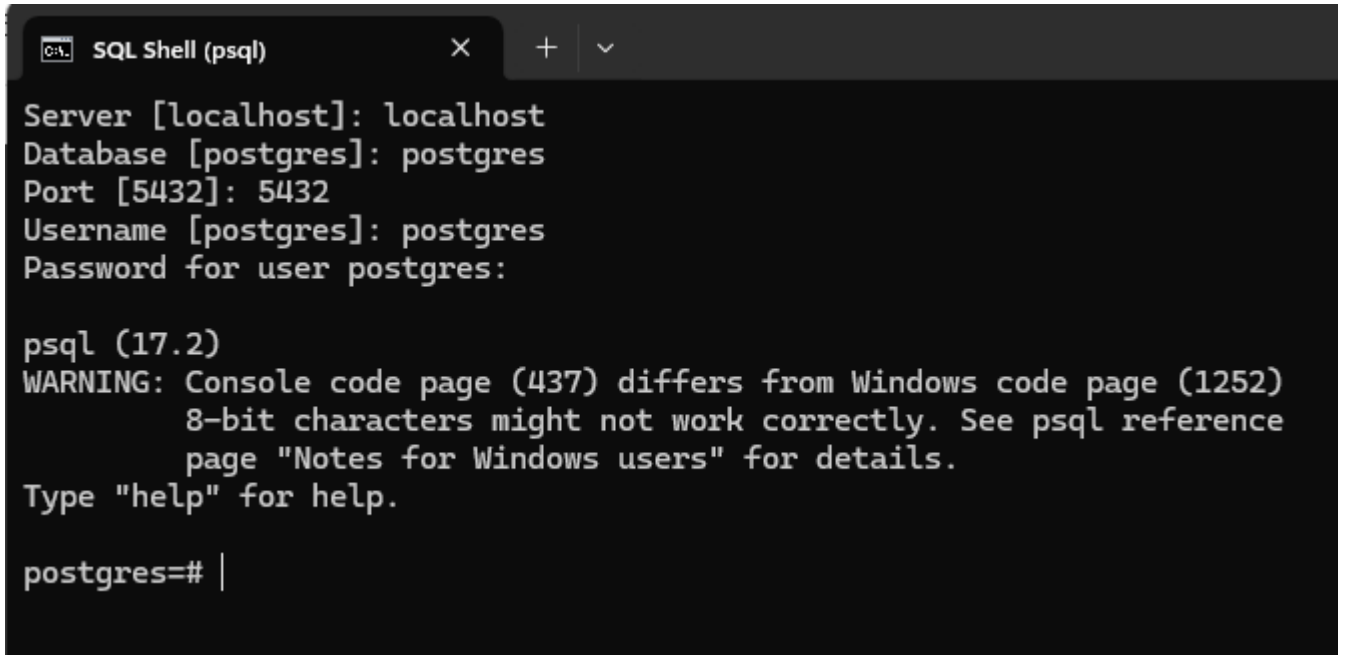




SQL SHELL

- What if I do not want to use pgAdmin?
  - SQL shell (psql) is your second option
- The suggested server is localhost, Database is postgres,port is 5432, username is postgres
- Start executing SQL statements





VERSION OF POSTGIS AND POSTGRESQL

- *SELECT postgis_full_version()*

POSTGIS="3.5.0 3.5.0" [EXTENSION]
PGSQL="170" GEOS="3.13.0-CAPI-1.19.0" PROJ="8.2.1 NETWORK_ENABLED=OFF
URL_ENDPOINT=https://cdn.proj.org
USER_WRITABLE_DIRECTORY=C:\WINDOWS\ServiceProfiles\NetworkService\AppData\Local/proj
DATABASE_PATH=D:\PostgreSQL\share\contrib\postgis-3.5\proj\proj.db" (compiled against PROJ 8.13.0)
LIBXML="2.12.5" LIBJSON="0.12" LIBPROTOBUF="1.2.1" WAGYU="0.5.0 (Internal)"

CHECK VERSION IN SQL SHELL

```
postgres=# SELECT version();
                                 version
-------------------------------------------------------------------------
 PostgreSQL 17.2 on x86_64-windows, compiled by msvc-19.42.34435, 64-bit
(1 row)
```

- psql waits for the semicolon and executes all line as one SQL statement
- A multiple lines SQL statement is not executed before we include a semicolon at the end
- I prefer the UPPERCASE syntax for SQL commands

CREATE DATABASE IN SQL SHELL

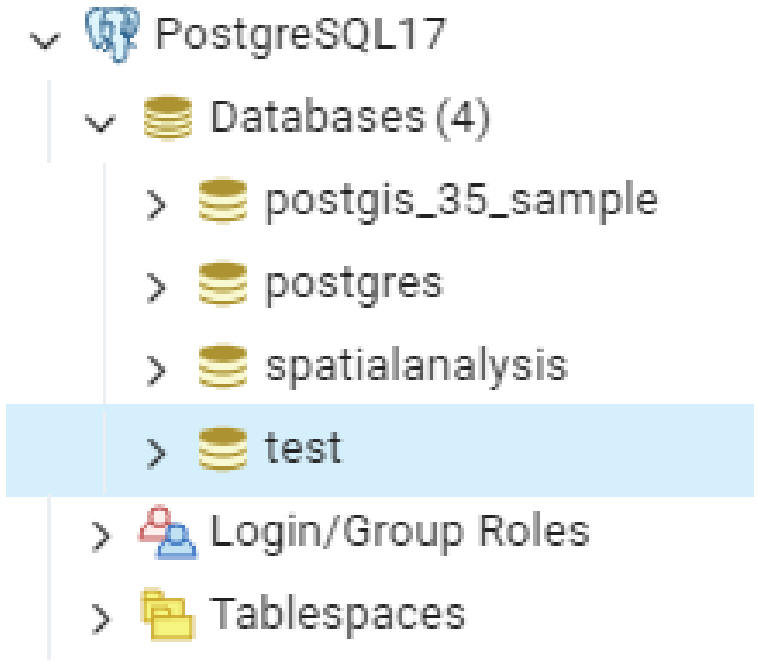
```
CREATE DATABASE test;
```

```
\l
```

```
postgres=# CREATE DATABASE test;
CREATE DATABASE
postgres=# \l
                                                    List of databases
      Name        |  Owner   | Encoding | Locale Provider |         Collate           |           Ctype           | Locale | ICU Rules |   Access privileges
------------------+----------+----------+-----------------+---------------------------+---------------------------+--------+-----------+-----------------------
-
 postgis_35_sample | postgres | UTF8     | libc            | English_United States.1252 | English_United States.1252 |        |           |
 postgres          | postgres | UTF8     | libc            | English_United States.1252 | English_United States.1252 |        |           |
 spatialanalysis   | postgres | UTF8     | libc            | English_United States.1252 | English_United States.1252 |        |           |
 template0         | postgres | UTF8     | libc            | English_United States.1252 | English_United States.1252 |        |           | =c/postgres
+
                   |          |          |                 |                           |                           |        |           | postgres=CTc/postgres
 template1         | postgres | UTF8     | libc            | English_United States.1252 | English_United States.1252 |        |           | =c/postgres
+
                   |          |          |                 |                           |                           |        |           | postgres=CTc/postgres
 test              | postgres | UTF8     | libc            | English_United States.1252 | English_United States.1252 |        |           |
(6 rows)
```

CHECK NEW DATABASE IN PGADMIN

- Refresh the Database under your server



CONNECT DATABASE IN PSQL

```
psql (17.2)
WARNING: Console code page (437) differs from Windows code page (1252)
         8-bit characters might not work correctly. See psql reference
         page "Notes for Windows users" for details.
Type "help" for help.

test=# \c postgres
You are now connected to database "postgres" as user "postgres".
postgres=#
```

CONNECT TO DATABASE USING COMMAND LINE

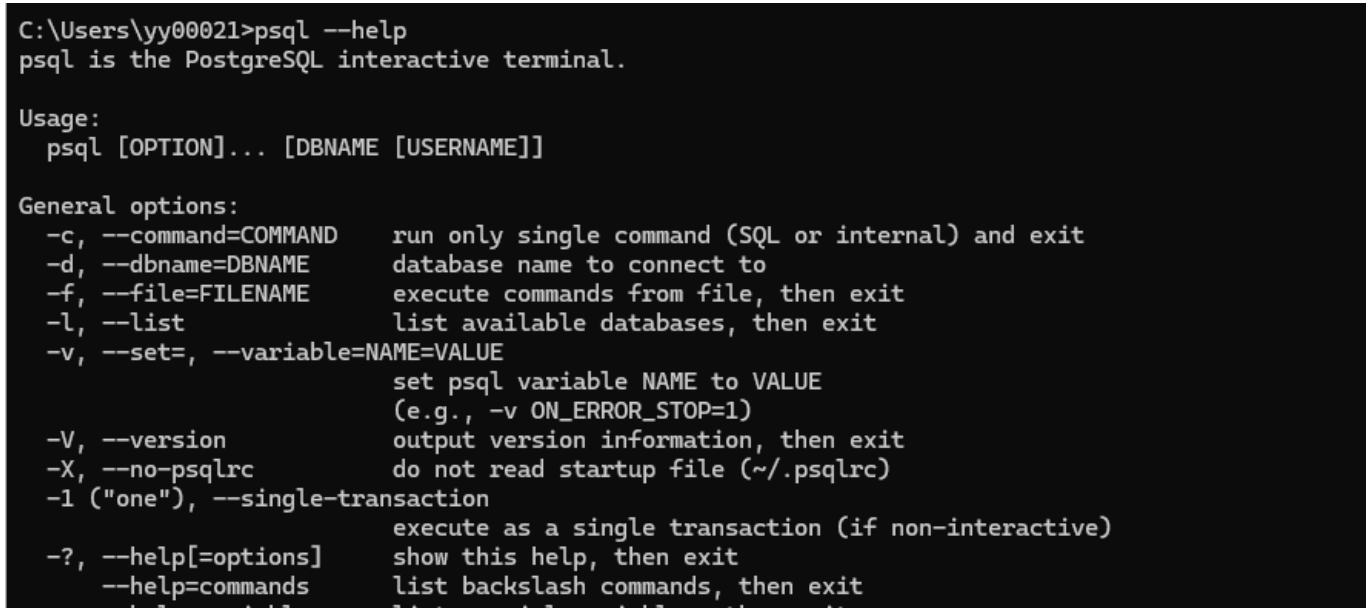
- Using command line to check the documentation for command in psql
- Open command line and type

  psql --help

  where psql

  If you have this error message: 'psql' is not recognized as an internal or external command.

  Then you need to add PATH of psql to your window path:



DANGEROUS COMMAND


- DROP DATABASE test;