

1. Creating and importing a simple module

Step 1 – Make a module file

`my_print.py`

```
# my_print.py
MY_MESSAGE = "Hello!"
def my_print_func(text: str) -> None:
    print(MY_MESSAGE)
    print(text)
```

This file is a module called `my_print`.

Step 2 – Import the module in another file

```
# main.py
import my_print # import the module (the whole file)

def main():
    my_print.my_print_func("Example.")
    print(my_print.MY_MESSAGE)

if __name__ == "__main__":
    main()
```

Key points:

- `import my_print` loads the **whole module** and runs its top-level code once.
- You use `module_name.thing` to access variables/functions defined inside.
- `if __name__ == "__main__":` makes the `main()` run **only** when you run `python main.py`, not when you import `main` from somewhere else.

Step 3 – Importing specific names

```
#Instead of importing the whole module:
from my_print import MY_MESSAGE, my_print_func

def main():
    my_print_func("Example.")
    print(MY_MESSAGE)
```

- This pulls `MY_MESSAGE` and `my_print_func` **directly** into the current namespace.
- Then you don't need the `my_print.` prefix.

2. Packages, directory structure, and `__init__.py`

A **package** is a folder that Python treats as a “big module.” Classic rule: it has an `__init__.py` inside.

2.1 Example directory structure

Example structure:

```
my_game/          # top-level folder (project)
|__ main.py
|__ constants.py
```

```

display/          # PACKAGE 'display'
    __init__.py
    show_map.py   # MODULE 'show_map'
logic/           # PACKAGE 'logic'
    __init__.py
    computer/    # SUBPACKAGE 'computer'
        __init__.py
        aimbot.py  # MODULE 'aimbot'
    game.py       # MODULE 'game'
    win.py        # MODULE 'win'

```

- Every `.py` file = module.
- **Every folder with `__init__.py` = package.**
- Packages can contain:
 - modules (`game.py`)
 - subpackages (`computer/`).

2.2 Using `__init__.py` to re-export stuff

We use a middle man `__init__.py` to gather all functions / classes / variables we want to import to other files, keeps things clean.

Imagine this simplified structure:

```

logic/
└── __init__.py
    ├── constants/
    │   └── __init__.py
    │   ├── player.py    # NUMBER_PLAYERS_Variable = 10
    │   └── bot.py       # AIMBOT_PRECISION_Variable = 1.0
    └── game.py

```

INSIDE `logic/__init__.py`

```

# logic/__init__.py
from .constants.player import NUMBER_PLAYERS
from .constants.bot import AIMBOT_PRECISION

```

Now in `main.py`: Much more simple to use with all imports in `__init__.py`

```

from logic import NUMBER_PLAYERS, AIMBOT_PRECISION

print(NUMBER_PLAYERS)
print(AMBOT_PRECISION)

```

So:

- Even tho they are going into `init.py` we use `from logic import (var/class/function)`
- When you do `import logic`, Python runs `logic/__init__.py`.
- Whatever you import there becomes available as attributes on the `logic` package.

Absolute vs Relative Imports

```

my_app/
└── main.py

```

```

└── logic/
    ├── __init__.py
    └── constants/
        ├── __init__.py
        └── player.py      # NUMBER_PLAYERS = 10
    └── computer/
        ├── __init__.py
        └── aimbot.py     # we are here

```

We are writing imports inside `logic/computer/aimbot.py`.

Absolute import (start from the top, "normal" way)

```
# logic/computer/aimbot.py
from logic.constants.player import NUMBER_PLAYERS
```

Read as: "From the top-level package `logic`, go into `constants.player`, import `NUMBER_PLAYERS`."

- Always starts with the full package name (`logic`).
- Easy to read, doesn't depend on where this file lives.

Relative import

```
(start from *this* package) .computer.module.func (go down one package), OR ..computer.module.func (go up one package)
```

```
# logic/computer/aimbot.py
from ..constants.player import NUMBER_PLAYERS
```

Read as: "From `logic.computer`, go up one package (`..` → `logic`), then into `constants.player`, import `NUMBER_PLAYERS`." Reasons we use relative imports inside a package:

- They make imports shorter when you're deep in subpackages.
- They keep imports working even if the top-level package gets renamed.
- They're handy in `__init__.py` to pull internal stuff up into a clean public API.

3. Simple rules to remember for Import

```

# absolute import (no leading dots)
import logic
import logic.player

# relative from-import (dots allowed)
from logic import player
from .player import <module/func/variable/class>      # same package
from ..constants import <module/func/variable/class>  # parent package

```

Gotcha: Import runs the module code once

```

# my_mod.py
print("Top level running!")
X = 42
# main.py
import my_mod
import my_mod

```

- "Top level running!" prints **once**, because Python caches the module.

4.2 `__name__ == "__main__"`

```
# script.py
def main():
    print("hi")

if __name__ == "__main__":
    main()
```

- If you run `python script.py` → `__name__` is `"__main__"` → `main()` runs.
- If you `import script` → `__name__` is `"script"` → `main()` does **not** auto-run.

Virtual Environments Venv

Purpose:

```
venv = isolated Python env per project
use venv to avoid global package/version conflicts
after activation: only use `python` + `pip`
```

```
Create venv (classic):
# Windows
py -m venv venv

Create venv (uv):
uv venv venv

Activate venv:
# Windows cmd
.\venv\Scripts\activate.bat
# Windows PowerShell
.\venv\Scripts\activate.ps1
```

Use venv:

```
activate venv # `python` now points to venv's Python
python my_app.py      # MUST Use python to run code, not py or python3, will run app using venv's
interpreter + packages
pip install PACKAGE    # classic
uv add PACKAGE        # if using uv
deactivate            # optional
```

Requirements.txt / pyproject.toml:

```
requirements.txt
- plain list of deps + optional versions
- used with: pip install -r requirements.txt

pyproject.toml
- project metadata + deps
- used by modern tools (uv, build, etc.)
```

Example `requirements.txt` (important parts):

```
flask==3.0.0          # exact version
sqlalchemy>=2.0       # minimum version
pytest                # any version
```

Example `pyproject.toml` (important parts):

```
[project]
name = "my_app"
version = "0.1.0"

dependencies = [
    "flask==3.0.0",
    "sqlalchemy>=2.0",
    "pytest",
]
```

Pytest, Unit Test, @pytest.fixtures

Core rules box: pytest

```
pytest
- install: pip install pytest
- run: pytest
- test files: test_*.py or *_test.py
- test funcs: def test_something():

unittest vs pytest
- unittest: built-in, class-based (TestCase, setUp/tearDown)
- pytest: external package, simple function tests, still supports classes + fixtures. Our course focuses on pytest
```

```
def add_values(a, b): # code to test
    return a + b

# test file: test_add_values.py
def test_add_values():
    result = add_values(2, 3) # Act
    assert result == 5        # Assert

# Other Examples
# 1) Simple assert
def test_uppercase():
    assert "abc".upper() == "ABC"

# 2) Multiple asserts
def test_len_and_membership():
    data = [1, 2, 3]
    assert len(data) == 3
    assert 2 in data

# Testing exceptions
import pytest # MUST IMPORT TO USE pytest.raises

def test_add_values_invalid():
    with pytest.raises(TypeError):
        add_values([1], [2]) # invalid type giving list instead of number

def test_parse_int_invalid():
    with pytest.raises(ValueError):
```

```

    parse_int("abc")

def test_divide_by_zero():
    with pytest.raises(ZeroDivisionError):
        1 / 0

# 4) Class-based tests
class TestMath:
    def test_add(self):
        assert 1 + 1 == 2

    def test_minus(self):
        assert 5 - 3 == 2

```

common exception types for `pytest.raises`:

- `ValueError`: wrong *value* CORRECT TYPE (e.g., `int("abc")`) expects a string so CORRECT TYPE, but can't turn the VALUE of abc into an int.)
- `TypeError`: wrong *type* of argument (e.g., `1 + "2"`, `func(expects_list="abc")`)
- `ZeroDivisionError`: dividing by zero (e.g., `1 / 0`)
- `KeyError`: missing key in dict (e.g., `d["missing_key"]`)
- `IndexError`: index out of range in list/string (e.g., `lst[100]` on a short list)

Fixture example (consistent setup)

We use pytest fixtures to set up reusable, consistent test "starting states" instead of copy-pasting setup code into every test. That setup goes in a fixture(the function name below the decorator), and tests just ask for it by name. We use pytest fixtures to set up reusable, consistent test "starting states" instead of copy-pasting setup code into every test.

```

class BankAccount:
    def __init__(self):
        self.balance = 0
    def deposit(self, amount):
        self.balance += amount

# fixture: returns a fresh account with $100 loaded
@pytest.fixture
def account_with_100():
    acct = BankAccount()
    acct.deposit(100)
    return acct

def test_account_starts_with_100(account_with_100):
    assert account_with_100.balance == 100

```

Classes & Objects

OOP core terms:

- class = blueprint / custom type (e.g., `Student`)
- object / instance = concrete thing created from class
- attributes = data on the object (`self.name`, `self.id`)
- methods = functions inside class (behaviour)
- state = current values of attributes

```

# class + __init__ + method
class Student:
    def __init__(self, name, student_number):
        self.name = name          # instance attribute
        self.student_number = student_number

```

```

    self.program = "CIT"           # default value

def display(self):
    print(f"{self.name}, {self.student_number} - {self.program}")

```

instantiation (creating objects)

```

john = Student("John Doe", "A01234567")
bob = Student("Bob", "A07654321")

john.display()  # inside display: self == john
bob.display()  # inside display: self == bob

```

init (initializer):

- special method called right AFTER the instance is created
- receives the new object as self and sets up instance attributes (self.x = ...)
- does NOT create or return the object (constructor is __new__, handled by Python)
- you call it indirectly by doing: obj = ClassName(...)

self:

- first param of instance methods
- refers to the current instance (john, bob, etc.)
- used to read/write attributes: self.name, self.program
- NEVER used outside the class block

Instance vs Class – Attributes & Methods

Definitions

Instance attribute

- stored on the object itself (self.attr)
- usually created in __init__
- each object can have different values

Class attribute

- stored on the class object (ClassName.attr)
- defined once in the class body, outside methods
- shared by all instances

Instance method

- defined with: def method(self, ...)
- self = the instance that called the method
- can use instance attributes (self.x) and class attributes (ClassName.Y)

Class method

- defined with @classmethod + def method(cls, ...)
- cls = the class (Student, BankAccount, etc.)
- usually works with class attributes or used as an alternate constructor

Why we use them

- instance attribute: store data specific to each object (each student has their own name, grade, etc.)
- class attribute: store shared config/constants for all objects (school_name, TAX_RATE, MAX_SIZE)
- instance method: behavior that depends on that object's data (deposit, withdraw, introduce, etc.)
- class method: behavior for the class as a whole (change shared settings, or create objects in special ways like from_string)

Key differences Method vs Instance Attribute:

- `name` is per instance → `s1.name` and `s2.name` can be different.
- `school_name` lives on the class → changing it once affects all students.

Class Method Vs Instance Method

```
class Student:
    school_name = "BCIT" # class attribute

    def __init__(self, name):
        self.name = name # instance attribute

    # instance method (most common)
    def introduce(self):
        # self = specific student (s1, s2, etc.)
        print(f"Hi, I'm {self.name} from {self.school_name}")

    # class method
    @classmethod
    def set_school(cls, new_name):
        # cls = the class Student
        cls.school_name = new_name

    # another class method as "alternate constructor"
    @classmethod
    def from_string(cls, data: str):
        # "Ryan" -> Student("Ryan")
        name = data.strip()
        return cls(name)
```

Usage:

```
s1 = Student("Ryan")
s2 = Student.from_string("Marcus") # uses classmethod as alt constructor

s1.introduce() # self = s1
s2.introduce() # self = s2

Student.set_school("BCIT CIT Program") # change class-wide setting
s1.introduce() # now prints new school name
s2.introduce()
```

Abstract Base Classes

An Abstract Base Class (often referred to as an ABC) is a mechanism used to define "generic classes." These classes define a specific public interface (a set of methods) without actually implementing the logic for them. Like a strict blueprint, tells subclasses what methods they need without telling them how those methods should work.

Why:

- Enforcing interfaces (insures child classes follow a guideline to prevent issues down the line)
- Polymorphism (Allows the use of different objects the same way) --- Example below

```
from abc import ABC, abstractmethod

# 1. Define the Abstract Base Class
class Animal(ABC):

    def __init__(self, name):
        self.name = name
```

```

# 2. Define the abstract method (The Interface)
# This acts as a rule: "All animals must make a sound"
@abstractmethod
def sound(self):
    pass

# 3. Define Child Classes (Concrete Classes)

class Dog(Animal):
    # We MUST implement sound(), or this class will error
    def sound(self):
        return "Woof"

class Cow(Animal):
    def sound(self):
        return "Moo"

# Usage
# my_animal = Animal("Generic") # This would RAISE AN ERROR because you cannot instantiate an ABC

dog = Dog("Buddy")
cow = Cow("Daisy")

print(f"{dog.name} says {dog.sound()}") # Output: Buddy says Woof
print(f"{cow.name} says {cow.sound()}") # Output: Daisy says Moo

# Polymorphism check
print(isinstance(cow, Animal)) # Output: True [2]

```

```

# This is BAD (Not Polymorphic)
if type(my_animal) == Cow:
    my_animal.moo()
elif type(my_animal) == Dog:
    my_animal.bark()

# This below is GOOD (Polymorphic)
# You don't care if it is a Cow or a Dog, you just know it is an "Animal", so it MUST have a .sound()
method.
my_animal.sound()

```

Encapsulation (concept)

- hide internal details, expose a clean public interface
- goal: control how attributes are read/changed, prevent invalid state
- in Python: done by naming conventions + @property, not true hard privacy

Public vs "Private" attributes

Public attribute

- normal name: balance
- meant to be used from outside the class
- no leading underscore

"Protected" attribute (by convention)

- single leading underscore: _balance
- "internal use", but still accessible (obj._balance)
- signals: "don't touch this from outside unless you know what you're doing"

"Private" attribute (name-mangling)

- double leading underscore: __balance
- Python renames it internally to _ClassName__balance
- makes accidental access harder, but still not true security

```
class BankAccount:
    def __init__(self, owner, balance):
        self.owner = owner      # public
        self._balance = balance # "protected" by convention
        self.__pin = "1234"     # "private" (name-mangled)
```

Properties & `@property` (property decoration)

Property (high-level)

- lets you access methods like attributes:
 - `acc.balance` # calls a getter
 - `acc.balance = x` # calls a setter (if defined)
- used to:
 - add validation when setting values
 - compute values on the fly
 - keep a stable attribute name even if internals change

Read-only (getter only, no setter) property example**

```
class BankAccount:
    def __init__(self, owner, balance):
        self._owner = owner
        self._balance = balance

    @property
    def balance(self):
        return self._balance # read-only: no setter
```

Usage:

```
acc = BankAccount("Ryan", 100)
print(acc.balance) # OK, calls getter
# acc.balance = 200 # ERROR: no setter defined
```

Read(getter) & Write(setter) property with validation

```
class BankAccount:
    def __init__(self, owner, balance):
        self._owner = owner
        self._balance = balance

    @property
    def balance(self): # getter
        return self._balance

    @balance.setter
    def balance(self, value): # setter
        if value < 0:
            raise ValueError("Balance cannot be negative")
        self._balance = value
```

Usage:

```

acc = BankAccount("Ryan", 100)
acc.balance = 200          # calls setter, stored in _balance
print(acc.balance)        # 200

# acc.balance = -50       # raises ValueError

```

Why use @property?

- keep attribute-style syntax (acc.balance) BUT add logic/validation
- hide internal storage name (_balance) from outside code
- you can change the internal implementation later without breaking callers

Inheritance – Parent/Child, **super()**, Overriding

Key ideas

- inheritance: child (subclass) IS-A parent (base class)
- parent/base class: common attributes + methods (Vehicle)
- child/subclass: reuses parent + can add/override behavior (Car)
- method overriding: child defines a method with SAME NAME as parent → replaces it
- super(): call the parent version of an overridden method from the child
- polymorphism: same method name, same goal, different behavior per class (Vehicle.start vs Car.start)

Basic inheritance + overriding + **super()**

```

class Vehicle:           # parent class
    def start(self):
        print("Vehicle starting")

class Car(Vehicle):      # Car INHERITS from Vehicle  (Car IS-A Vehicle)
    def start(self):      # override Vehicle.start
        print("Car ignition on")
        super().start()     # call parent (Vehicle) start(), same as Vehicle.start(self)
        print("Car moving")

```

Usage:

```

v = Vehicle()
v.start()
# Vehicle starting

c = Car()
c.start()
# Car ignition on
# Vehicle starting
# Car moving

```

Overriding and Polymorphism are linked

Overriding = the child provides its own version of the method.
 Polymorphism = your code can treat everything as a Vehicle, call start(), and get different behavior depending on whether it's a Vehicle, Car, Truck, etc.

SQLAlchemy ONLY

ORM (Object Relational Mapping)

- Technique that maps Python objects ↔ rows in relational DB tables.
- You work with classes/objects instead of writing raw SQL strings.
- SQLAlchemy ORM: Class = table Instance = row Attribute = column

Mapped Class:

- A normal Python class that SQLAlchemy has registered as a DB table.
- anything that inherits `(Base)` or `(db.Model)`

Mapped types: Integer, String, Text, Boolean, DateTime, Float, etc.

- Tell SQLAlchemy what kind of data the column stores + how to map it to Python.

Column constraints: primary_key=True, nullable=False, unique=True, default=..., server_default=...

```
from sqlalchemy import Integer, String
from sqlalchemy.orm import DeclarativeBase, mapped_column
# Base class for all mapped classes (DeclarativeBase)
class Base(DeclarativeBase):
    pass

class Product(Base): # Product inherits from Base -> mapped class
    __tablename__ = "product" # __tablename__ = "name_of_table"

    # mapped_column(Type, ...) -> define mapped attributes(columns) with mapped types
    id = mapped_column(Integer, primary_key=True) # mapped type: Integer (PK)
    name = mapped_column(String(100), nullable=False) # mapped type: String

    # Product is a mapped class:
    # - Product objects <-> rows in "product" table
    # - id, name attributes <-> columns
```

Folder layout (simple SQLAlchemy project)

```
sqlalchemy_demo/
  app/
    __init__.py
    database.py # engine, Session, Base
    models.py # mapped classes (tables + relationships)
    main.py # create tables, add/query data
```

app/database.py – Engine, Session, DeclarativeBase

```
from sqlalchemy import create_engine # Engine: DB connection + SQL executor
from sqlalchemy.orm import sessionmaker, DeclarativeBase # Session factory + ORM base
engine = create_engine("sqlite:///demo.db", echo=True) # echo=True logs SQL; set False to hide
Session = sessionmaker(bind=engine) # Session() = ORM work unit (rows ↔ objects,
                                  # commit/rollback)
class Base(DeclarativeBase): # Base = parent for all ORM child classes
    pass
                                  # holds metadata + registry of mapped tables
```

NEED TO FINISH SQL ALCHEMY ONLY

Flask

Why Flask?

- * Lightweight, simple, and easy to use for web apps / APIs
- * Lots of libraries and extensions available
- * Great official docs, including a full step-by-step tutorial

What is Flask?

- * A **microframework** that handles most of the HTTP request/response work
- * Implements **WSGI** (Web Server Gateway Interface) → standard way for Python apps to talk to web servers
- * Built-in **JSON** support (easy serialize/deserialize)
- * Comes with a **development server** so you can run and test locally
- * Built on top of **Werkzeug** (powerful underlying library for WSGI, routing, etc.)

Application structure

Flask applications are built on these core concepts:

Application: Central object managing the entire web application

Views: Functions that handle requests and generate responses

Routes: URL patterns that map to view functions

Templates: Jinja2-powered HTML files for dynamic content generation

Blueprints: Modular components for organizing application functionality

Flask Class Instantiation

```
from flask import Flask
app = Flask(__name__) # instantiate the Flask class
```

- **Flask** is a **class** provided by the framework.
- **Flask(__name__)** **creates the application object** your project uses.
- **__name__** helps Flask locate templates, static files, etc.
- **All routes, config, and extensions are handed off to this app instance** (everything attaches to it).

Flask Application

Flask application is the Central object that represents your web application. Its an instance of the **Flask** class and is entry point for handling http requests

Flask application responsibilities:

Initialize the application with configuration
 Register blueprints and routes
 Handle the request/response cycle
 Manage application context and configuration
 Provide access to app-wide resources

Simple Flask Project Folder Example

```
# STRUCTURE
# my_flask_app/
#   |- run.py
#   |- requirements.txt
#   \_ app/
#     |- __init__.py
```

```

#   |- routes.py
#   |- models.py
#   |- templates/
#       |   index.html
#   |- static/
#       |   style.css

```

```

# ===== run.py =====
from app import create_app          # import factory from package
app = create_app()                  # create Flask app instance
if __name__ == "__main__":          # only if file run directly
    app.run(debug=True)             # start dev server

# ===== app/__init__.py ===== APPLICATION FACTORY
from flask import Flask
from flask_sqlalchemy import SQLAlchemy

db = SQLAlchemy()                  # global db object shared by models

def create_app():                  # app factory (returns configured app)
    app = Flask(__name__)          # __name__ = this module path
    app.config["SECRET_KEY"] = "dev-secret-key"      # for sessions/forms
    app.config["SQLALCHEMY_DATABASE_URI"] = "sqlite:///demo.db" # DB URL
    app.config["SQLALCHEMY_TRACK_MODIFICATIONS"] = False      # disable extra overhead
    db.init_app(app)               # bind db to this app
    from .routes import main_bp    # import blueprint AFTER app exists
    app.register_blueprint(main_bp) # attach routes to app
    return app

# ===== app/models.py =====
from . import db                    # use same db as in __init__

class User(db.Model):              # ORM mapped class → users table
    id = db.Column(db.Integer, primary_key=True)           # PK
    username = db.Column(db.String(80), unique=True, nullable=False) # NOT NULL + UNIQUE
    def __repr__(self):
        return f"<User {self.username!r}>"    # nice debug display

# ===== app/routes.py =====
from flask import Blueprint, render_template
from .models import User
from . import db

main_bp = Blueprint("main", __name__) # blueprint = mini app module

@main_bp.route("/")
def index():
    # SQLAlchemy 2.0 style query: select(User) → execute → scalars().all()
    users = db.session.execute(db.select(User)).scalars().all()
    return render_template("index.html", users=users) # pass data to template

```

Application Factory Pattern

App Factory Pattern: rather than have `app = Flask(__name__)` Global, its inside a function

```

from flask import Flask

def create_app(config=None):
    app = Flask(__name__)          # create a new App Factory

    # 1) load config here if needed
    # 2) register blueprints here
    # 3) init extensions (db, login_manager, etc.)

```

```
return app # give the caller the ready-to-use app
```

Why use `create_app()` instead of global `app = Flask(__name__)`?

- Can create **multiple app instances** with different configs (dev/prod/tests).
- Avoids **circular imports** (routes/blueprints live in separate files).
- **Easier testing**: tests just call `create_app(test_config)`.
- Without factory: one global app made at import time = less flexible.
- With factory: call a function that **builds + configures + wires + returns** a fresh app.

Flask Routing

@app.route decorator

`@app.route("/something")` tells Flask: “**When a browser asks for this URL, call this function.**”

HTTP Methods

- “GET” → browser is asking for the page from you (server) (load the form, show HTML).
- “POST” → browser is sending data made by users to you (server) (submitting a form).
- `request.method` = “GET” or “POST”; use it in `if` to choose between “show form” and “handle submitted form”.

```
from flask import Flask, render_template, request

app = Flask(__name__)

@app.route("/feedback", methods=["GET", "POST"])
def feedback():
    if request.method == "GET": # browser is asking for the page
        return render_template("feedback.html") # show the empty form

    if request.method == "POST": # browser is sending form data
        msg = request.form.get("message") # read <input name="message">
        # here you would save msg to a DB, send email, etc.
        return "Thanks for your feedback!" # simple confirmation text
```

Flask Blueprints (Alternate Routing / Modularization)

blueprint is mainly about routing + organizing chunks of your app.

- **What:** A *Blueprint* is a mini Flask module that groups related routes, templates, and logic, but is **not** a full app. It must be plugged into a real app with `app.register_blueprint(...)`.
- **Why**
 - **Organization:** split big apps into chunks, BETTER FOR BIG APPS
 - `pages` → home/about/contact, `auth` → login/logout/register, `api` → JSON endpoints
 - **Reusability:** reuse the same blueprint in different projects.
 - **Scalability:** add features by adding blueprints, not editing one giant `app.py`.
 - **Team-friendly:** each dev owns a blueprint/module.
 - **Namespaces:** avoids name clashes; use `url_for("pages.home")` vs `url_for("auth.login")`.
- **How blueprints modularize the app**
 - Each feature lives in its own file/package (routes, templates, static).
 - The main app (`create_app`) only needs to **register** the pieces.
 - You can enable/disable sections by registering/unregistering blueprints.

Define + Register a Blueprint Example

Define

```
# pages.py (feature module)
from flask import Blueprint, render_template

pages_bp = Blueprint("pages", __name__) # name "pages" = url_for("pages.home")

@pages_bp.route("/") # "/" route on this blueprint
def home():
    return render_template("home.html")

@pages_bp.route("/about") # "/about" route on this blueprint
def about():
    return render_template("about.html")
```

Register

```
# __init__.py (application factory)
from flask import Flask
from .pages import pages_bp

def create_app():
    app = Flask(__name__)
    app.register_blueprint(pages_bp) # URLs: "/", "/about"
    # app.register_blueprint(pages_bp, url_prefix="/pages")
    # → URLs: "/pages/", "/pages/about"
    return app
```

URL building with `url_for`

`url_for(endpoint, **values):`

- Builds URLs from view/endpoint name (not hard-coded strings).
- Updates automatically if route path changes.
- Fills dynamic parts: `url_for("pages.profile", user_id=1)` -> `"/user/1"`

```
from flask import url_for, redirect # import in Python files

@app.route("/user/<int:id>") # Dynamic Route
def user_profile(id): ... # endpoint name = "user_profile"
url_for("user_profile", id=3) # "/user/3" (fills <int:id>)

# with blueprint "pages" and def home(): ...
url_for("pages.home") # uses blueprint namespace

redirect(url_for("about")) # build URL then redirect

url_for("pages.profile", user_id=42)
# endpoint = "pages.profile"
# values = {"user_id": 42}
# result = "/user/42"
```

Dynamic URL Parameter

`"/user/<id>"` → # DYNAMIC URL PARAMETER.
 Matches `/user/ryan`, `/user/123`, `/user/anything`.
 The part `in < >` becomes a function argument.

```
"/user/<int:id>" → # DYNAMIC URL PARAMETER WITH TYPE CONVERTER.
```

```
#FLASK WILL CONVERT "5" --> 5
```

```
@app.route("/user/<id>")
def dynamic_example(id):
    return f"User ID is {id}"
```

```
# **Flask: Views and Requests**
## Views: The functions under Routes (`@app.route`, `@pages_bp.route`)
**The same view(function) handles GET and POST, and chooses logic based on request.method**
```python
from flask import request, render_template

@app.route("/feedback", methods=["GET", "POST"])
def feedback(): # ← this is the *view function*
 if request.method == "GET":
 return render_template("feedback.html") # show form
 if request.method == "POST":
 msg = request.form.get("message") # handle form submit
 return "Thanks!"
```

## The `request` object

- Represents the **current HTTP request** (everything the browser sent).
- Import in views: `from flask import request`
- Important:
  - `request.method` → "GET", "POST", etc. (which HTTP method was used)
  - `request.args` → access query parameters in URL (usually with **GET**).
  - `request.form` → form fields sent in request body (usually with **POST**).

### Accessing Query parameters – `request.args`

- Query Parameters: Data in the **URL after ?** (query string), typically on **GET** requests.
- Example URL: `/search?term=cat&limit=10`
- In view:

```
term = request.args.get("term") # "cat"
limit = request.args.get("limit") # "10" (string)
```

### Accessing form data - `request.form`

- Form data: Key-value data sent in the HTTP **request body** (not the URL) from an HTML `<form>`.
- Typically on **POST** requests (`<form method="post">`), but any method with form-encoded body can use it.
- Example flow:
  - HTML: `<form method="post" action="/login">`
  - Browser sends: `POST /login` with body `username=ryan&password=secret`
  - In view: use `request.form` to read `"username" / "password"`.

```
- request.form["field"] # strict, KeyError if missing
- request.form.get("field") # safer, returns None if missing
- request.form.get("field", "") # safer with default
- request.form.getlist("field") # checkbox / multi-select
```

```
@pages_bp.route("/login", methods=["GET", "POST"])
def login():
 if request.method == "POST":
 # ◊ access form data sent from browser
```

```
username = request.form.get("username") # safe, returns None if missing
password = request.form["password"] # raises KeyError if missing
```

Responses: **redirect**, **render\_template**.

In Flask, your view function must return a response. Two super-common helpers for this are **render\_template** and **redirect**

```
from flask import Blueprint, render_template, request, redirect, url_for

bp = Blueprint("pages", __name__)

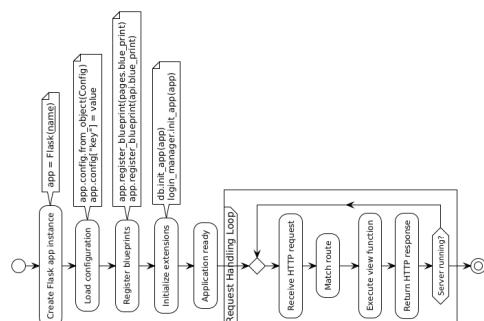
@bp.route("/")
def home():
 # render_template -> load templates/home.html, return HTML response
 return render_template("home.html", title="Home")

@bp.route("/login", methods=["GET", "POST"])
def login():
 if request.method == "POST":
 username = request.form.get("username") # form data from POST body
 password = request.form.get("password")
 # (check creds, maybe flash error, etc.)
 return redirect(url_for("pages.home")) # redirect -> new GET to "/"
 # first visit or failed login: show form
 return render_template("login.html")
```

#### Responses (Flask)

- render\_template("file.html", x=1)
  - > uses Jinja2 template in templates/ dir
  - > injects vars as {{ x }} and returns HTML response
- redirect("/path") / redirect(url\_for("pages.home"))
  - > returns 3xx response with Location header
  - > browser does NEW GET to that URL
  - > used after POST (Post/Redirect/Get)

#### Flask Application Lifecycle



## Flask-SQLAlchemy

In a typical Flask + SQLAlchemy app, they “meet” in 3 places:

- 1) **app/init.py** → **configure DB + init SQLAlchemy with Flask app**
- 2) **app/models.py** → **define models that inherit from db.Model**
- 3) **app/views.py or app/routes.py** → **use models + db.session to query/save**

1.) **app/init.py: CONFIG + DB SETUP**

```
Plain SQLAlchemy init.py
- You must create everything manually:
 engine = create_engine("sqlite:///db.db")
 Session = sessionmaker(bind=engine)
 class Base(DeclarativeBase): pass
 class Product(Base): # ALL Models inherit from Base
```

```
Flask-SQLAlchemy init.py (Does the same as above)
- The SQLAlchemy() extension builds all of this for you, Instead You just do:
 db = SQLAlchemy()
 db.init_app(app)
 class Product(db.Model): # ALL Models inherit from db.model
```

```
from flask import Flask
from flask_sqlalchemy import SQLAlchemy
from sqlalchemy import select

db = SQLAlchemy() # db = engine + session + Model base. Flask allows
us to skip

def create_app(): # APPLICATION FACTORY
 app = Flask(__name__)
 app.config["SQLALCHEMY_DATABASE_URI"] = "sqlite:///taskmanager.db" # DB URL (driver://path)
 app.config["SQLALCHEMY_ECHO"] = True # log SQL in console (dev only)
 db.init_app(app) # bind db to app
 with app.app_context(): db.create_all() # create tables for all db.Model subclasses
 return app
```

## 2.) app/models.py: Where we define our DB tables as Python classes.

**SQLalchemy only:** models inherit from `Base`, use bare `Column`, `Integer`, etc.

**Flask + SQLalchemy:** models inherit `db.Model` and use `db.Column`, `db.Integer`,

```
This file = where we define our DB tables as Python classes.

from . import db # db = SQLAlchemy() created in app/__init__.py

class Product(db.Model):
 """Single table example: products in a store."""

 __tablename__ = "product" # actual table name in the database

 id = db.Column(db.Integer, primary_key=True) # PK: unique row id
 name = db.Column(db.String(100), nullable=False) # NOT NULL name
 price = db.Column(db.Float, nullable=False) # NOT NULL price
 in_stock = db.Column(db.Boolean, default=True) # default True

 def __repr__(self):
 # nice string when you print(Product(...))
 return f"<Product id={self.id} name={self.name!r}>"
```

## 3.) app/views.py (or app/routes.py): Use models + db.session to query/save data.

**SQLalchemy only:** you instantiate `Session()` yourself and pass it around. No HTTP, just Python code.

**Flask + SQLalchemy:** you use the global `db.session` provided by the extension inside views/routes, and also handle HTTP (`request`, `render_template`, `redirect`).

```
from flask import Blueprint, render_template, request, redirect, url_for
from . import db
```

```

from .models import Product # our model class

store_bp = Blueprint("store", __name__)

@store_bp.route("/products")
def list_products():
 # READ: query all products from the DB
 products = db.session.query(Product).all()
 return render_template("products/list.html", products=products)

@store_bp.route("/products/new", methods=["GET", "POST"])
def create_product():
 if request.method == "POST":
 # READ form data from POST body
 name = request.form.get("name")
 price = float(request.form.get("price", 0))

 # CREATE: make a Product object (not in DB yet)
 product = Product(name=name, price=price)

 # ADD + COMMIT = insert row into DB
 db.session.add(product)
 db.session.commit()

 # go back to list page after saving
 return redirect(url_for("store.list_products"))

 # GET: show the form
 return render_template("products/new.html")

```

## db.relationship(), db.foreignkey(), cascade behaviours

db.ForeignKey("user.id"):  
 "what is a ForeignKey?" → a referential / relationship constraint that links two tables.  
 A FK is constraint on a column that says: "This column must match a primary key in another table."  
 - Used inside db.Column on CHILD model. CHILD MODEL ALWAYS HAS FOREIGN KEY  
 - DB constraint: child value must exist in parent table.  
 - Defines direction: Task is child, User is parent.  
 Example: user\_id = db.Column(db.Integer, db.ForeignKey("user.id"))  
 db.ForeignKey("user.id") → "user" = parent table, "id" = parent column, and whichever model defines this column is the CHILD.

db.relationship("Model")  
 - Python-side link between models (no DB column created).  
 - Lets you access related objects (parent→children / child→parent).  
 - Must match the ForeignKey on the other model.  
 Example: tasks = db.relationship("Task", back\_populates="assignee")

back\_populates  
 - back\_populates is used inside your model classes, specifically inside each db.relationship() call, to connect two sides of a relationship (see below)  
 ONE TO MANY: One child and One parent. The parent is the model that has one, and the child is the model that has many. CHILD IS ALWAYS THE MODEL WITH THE FOREIGN KEY (SEE BELOW)  
 MANY TO MANY: no child no parents they are equals

Cascade behaviors  
 - Tell SQLAlchemy what happens to children when parent changes.  
 "delete" = delete children when parent deleted  
 "delete-orphan" = delete children if parent deleted OR relationship broken  
 "all" = all major cascades enabled  
 "save-update" = If you add ONLY the parent to the session, SQLAlchemy also saves the new children, useful when parent + new children are created before the same commit. Works because the children are linked to the parent via relationship()

```
#EXAMPLE OF ALL 4
class User(db.Model):
 id = db.Column(db.Integer, primary_key=True)
 tasks = db.relationship(
 "Task",
 back_populates="assignee",
 cascade="all, delete-orphan" #Cascade goes inside parent
)

class Task(db.Model):
 id = db.Column(db.Integer, primary_key=True)
 user_id = db.Column(db.Integer, db.ForeignKey("user.id")) # Child defines user table and points to id column
 assignee = db.relationship("User", back_populates="tasks")
```

## Database Operations (CRUD)

---

### Session

In SQLAlchemy, a Session is like a temporary staging area for your database changes.

```
db.session.add(obj) # takes python object and adds it as a row to the DB staged changes
db.session.commit() # Pushes staged changes to database

user = User(name="Ryan", email="ryan@example.com") # call the User class to create a NEW User object in memory → __init__ sets user.name and user.email to these values
this only makes the Python object; it's NOT in the database until db.session.add(user) +
db.session.commit() # stage it in the session (pending insert)
db.session.add(user) # send all staged changes as 1 transaction → write to DB
db.session.commit()
```

---

### Building a `select()` query

```
Construct a complex query
stmt = select(User).where(User.role == "admin").order_by(User.username)

This translates roughly to:
SELECT * FROM user WHERE role = 'admin' ORDER BY username;
```

`select()` : Just like we did in data base it Selects from a specific table. and what it rutern is the selected coloumn in that specific table

```
from sqlalchemy import select
Construct the query (nothing happens in the DB yet)
stmt = select(User)
stmt is just a varibale
```

`.where()` : Adds a SQL WHERE clause to filter results. `.orderby()`:Adds a SQL ORDER BY clause to sort the results.

```
Construct a complex query
stmt = select(User).where(User.role == "admin").order_by(User.username)

This translates roughly to:
SELECT * FROM user WHERE role = 'admin' ORDER BY username;
```

## Execution

once you have your statement ready (`.select()`,`.where(...)`) you must explicitly run it using the session. `db.session.execute(stmt)`: It sends the SQL statement to the database, runs it, and returns a Result object

```
stmt = select(User).where(User.id == 1)
Run the query
result = db.session.execute(stmt)
```

## Retrieving Results

The `Result` object returned by `execute()` is flexible. You must tell SQLAlchemy how you want to format that data.

```
.scalars(): convert row tuples → ORM objects, returns a lazy iterable (you can loop over it, but it's not a plain list)
.scalars().all(): same objects, but forces the query + builds a regular Python list of them
```

```
stmt = select(User)
users = db.session.execute(stmt).scalars().all()
users is now a list: [<User 1>, <User 2>, ...]
```

```
.scalar_one() expect exactly 1 row; 0 or >1 rows = error (use when "missing/duplicate = BUG", e.g.
primary key)
.scalar_one_or_none(): expect 0 or 1 row; >1 rows = error (MultipleResultsFound) # 0 rows -> None, 1
row -> object
```

```
Use case: Checking if a user exists (e.g., for login).
stmt = select(User).where(User.email == "missing@example.com")
user = db.session.execute(stmt).scalar_one_or_none()
if user is None:
 print("User not found")
```

## Special Helper

- `db.get_or_404(Model, id)` : What it does: This is a Flask-SQLAlchemy convenience method (not pure SQLAlchemy). It attempts to retrieve a row by its primary key. Behavior:
  - If found: Returns the object. If not found: Immediately aborts the request and returns a **404 Not Found HTTP error** to the browser.

```
In a Flask route
@app.route('/user/<int:user_id>')
def get_user(user_id):
 # If user_id doesn't exist, the code stops here and sends a 404 to the user
 user = db.get_or_404(User, user_id)
 return {"username": user.username}
```

## Relationship patterns

### One-to-Many:

- Example: User -> Task

- One User has many Tasks
- Each Task has exactly ONE User
- Implemented with FK on the "many" side: Task.user\_id -> User.id

**Many-to-Many:**

- Example: Task <-> Tag
- One Task: many Tags
- One Tag: many Tasks
- Implemented with association table: task\_tag(task\_id FK -> task.id, tag\_id FK -> tag.id)