10 - Object Oriented Programming

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OOP is suitable for designing large complex systems, representing the **entities** and how they communicate with each other.

Object-Oriented Programming

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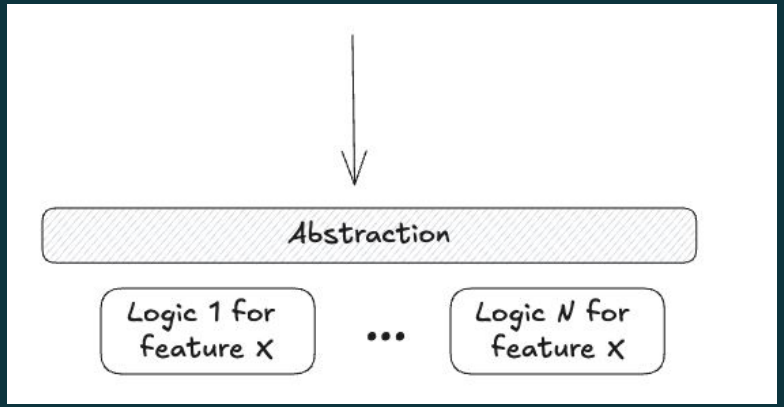
Object-Oriented Programming

OOP consists of four principles:

1. **Abstraction**
2. **Encapsulation**
3. **Inheritance**
4. **Polymorphism**

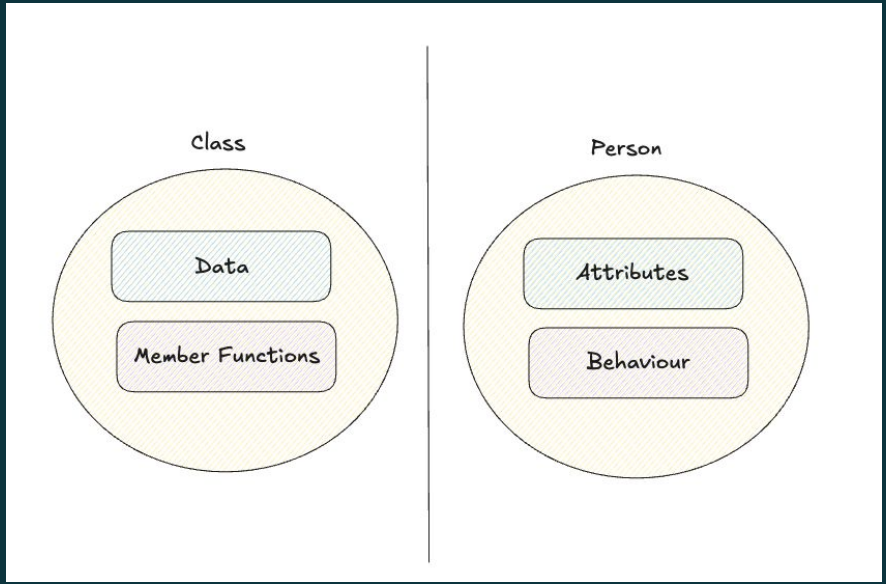
1. Abstraction

Abstracts away details from the user and exposes only essential features to them.



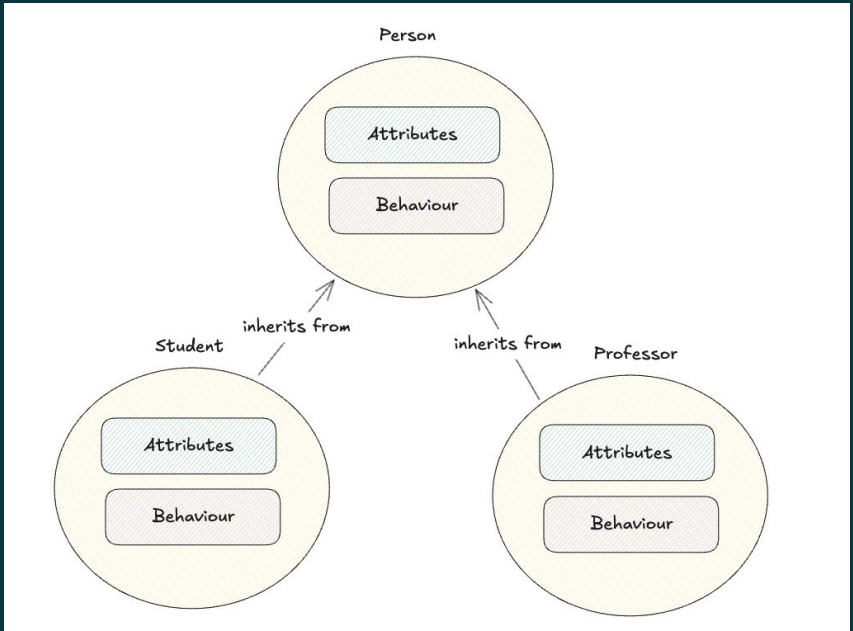
2. Encapsulation

Bundles data and methods that operate on the data into a single unit (entity), protecting data from outside inference.



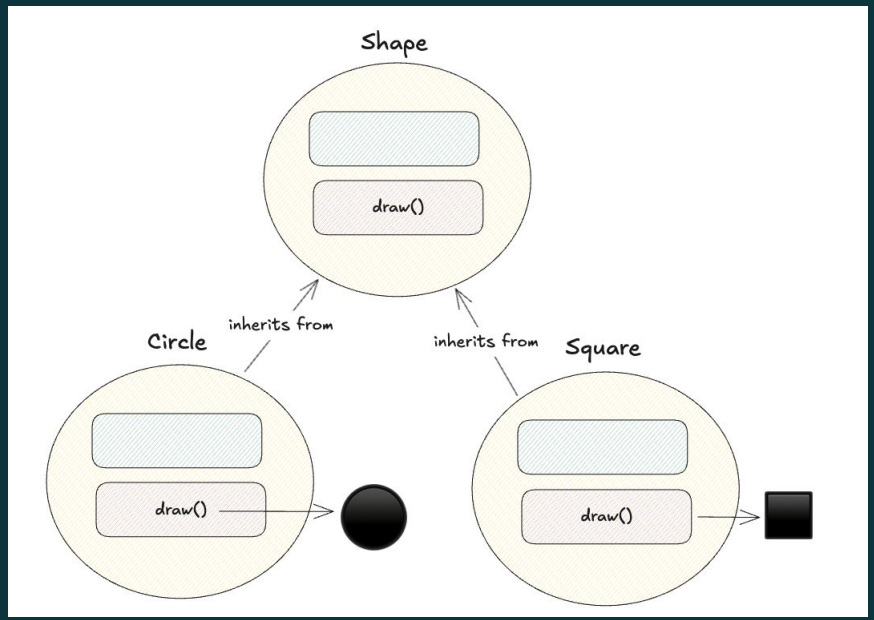
3. Inheritance

Allows a class (subclass) to inherit properties and behaviours from another class (superclass), facilitating code reuse and creating a hierarchy of classes.

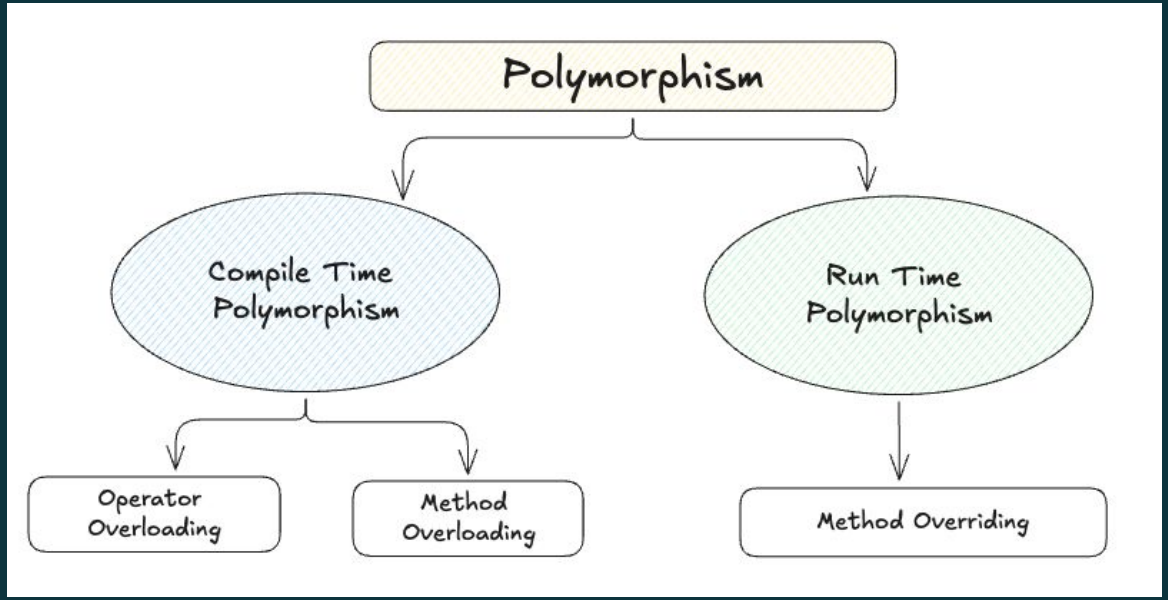


4. Polymorphism

Allows objects of different classes to be treated as objects of a common superclass, enabling flexibility and extensibility in method invocation.

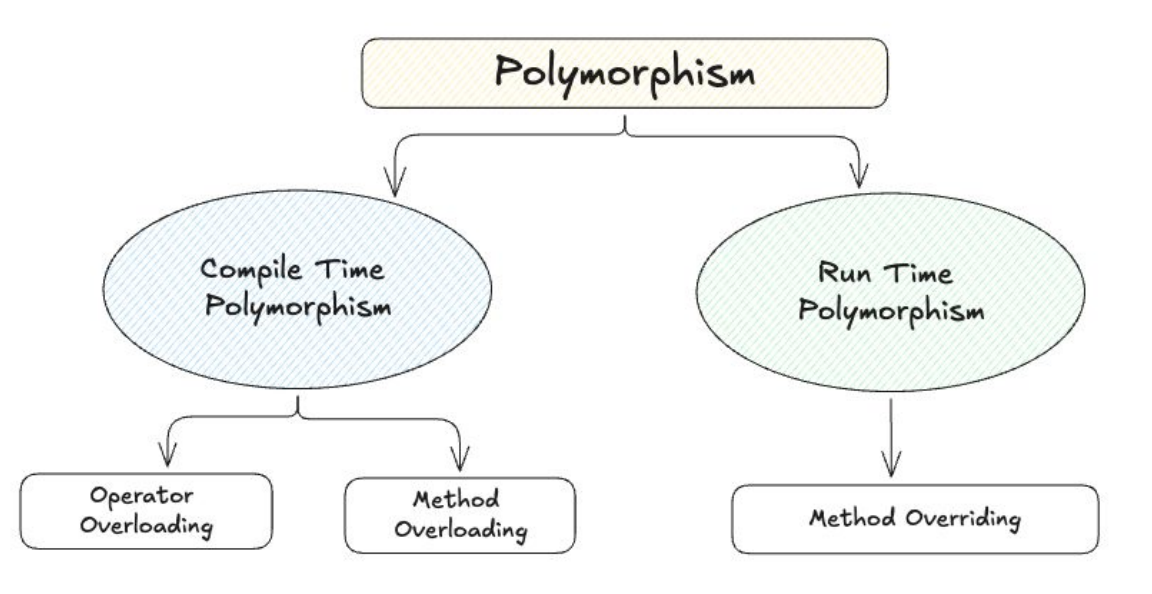


Polymorphism



Polymorphism

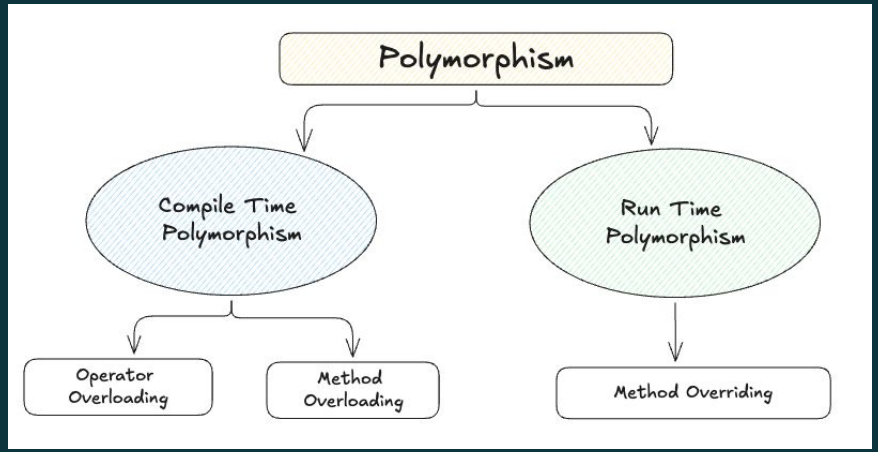
- Overloading happens when you keep the same method name but change the number or type of parameters.
- Overriding occurs when you keep the same method name and signature but change the implementation.



Polymorphism

A note on Polymorphism:

- *Python **does not** support Method Overloading (compile-time polymorphism).*
- *Python **supports** Method Overriding (run-time polymorphism).*
- *Python **supports** Operator Overloading (via dunder methods like `__eq__()`, etc.)*



Object-Oriented Programming

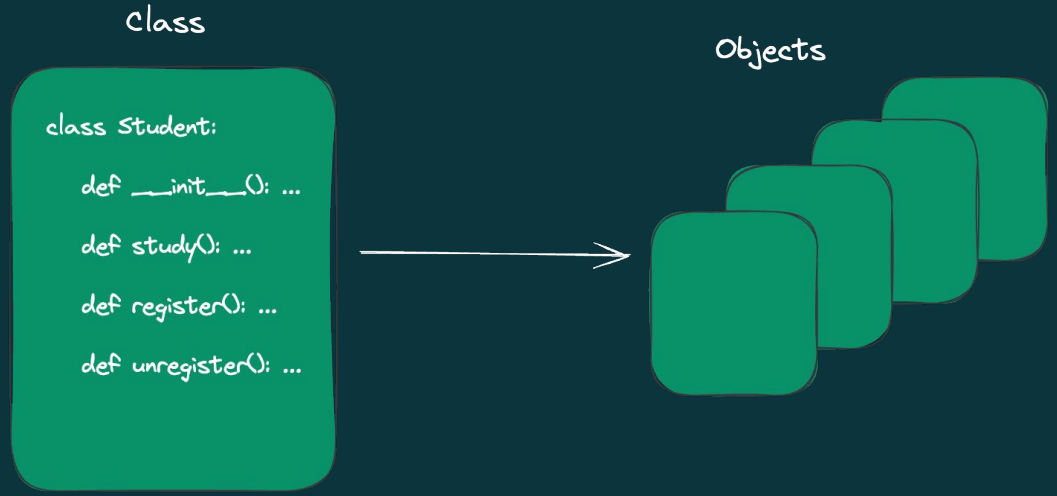
OOP consists of four principles:

1. **Abstraction:** allows information hiding and exposing only essential features to users.
2. **Encapsulation:** bundling data and methods that operate on the data into a single unit, protecting data from outside inference.
3. **Inheritance:** allows a class (subclass) to inherit properties and behaviours from another class (superclass), facilitating code reuse and creating a hierarchy of classes.
4. **Polymorphism:** allows objects of different classes to be treated as objects of a common superclass, enabling flexibility and extensibility in method invocation.

Classes and Objects

Classes and Objects

- **Class** - a blueprint for creating objects.
  - An object is a collection of **attributes** and **behaviours**.
- **Object** - an instantiation of the blueprint.



Defining a Class in Python

Class

- Blueprint for creating objects.
- Defines **fields** (variables) and **methods** (functions).

Object

- An instance of a class.
- Represents a specific entity in the real world.

```
class Car:
    def __init__(self, make, model):
        self.make = make
        self.model = model

my_car = Car('Toyota', 'Corolla')
print(my_car.make)  # Output: Toyota
print(my_car.model) # Output: Corolla
```

Instance & Class variables

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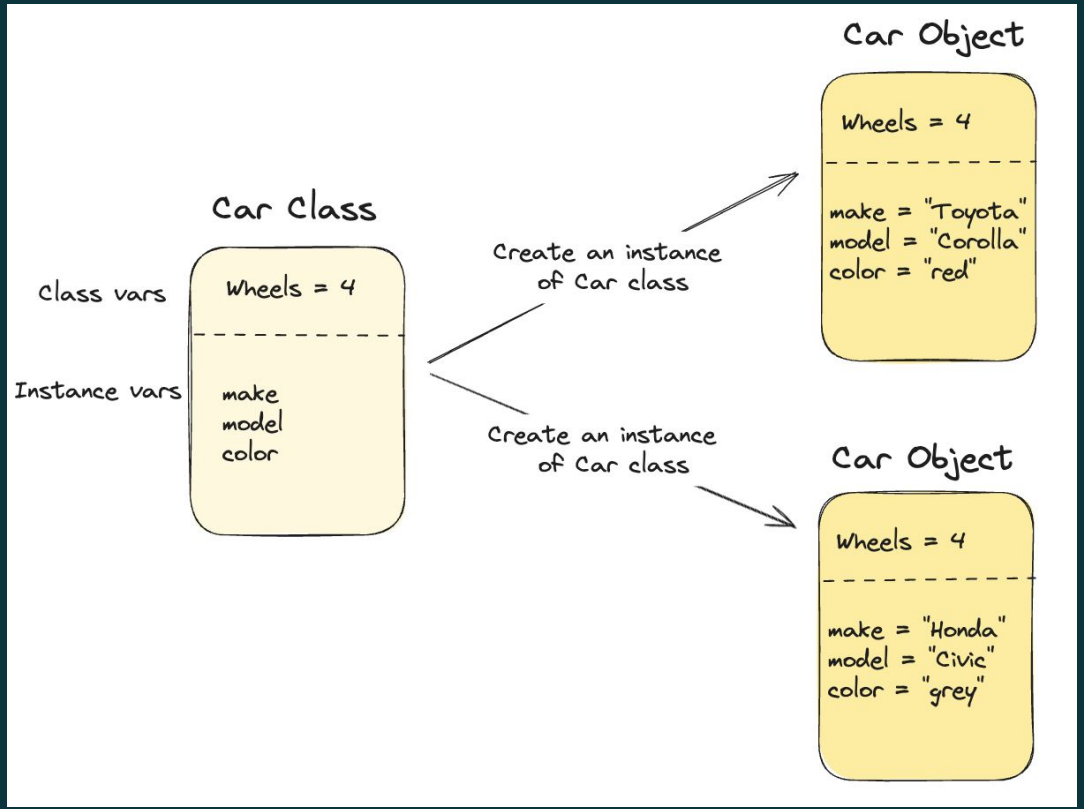
  - Every object or instance created from a class can have its own separate values for instance variables.
- Class variables
  - A class variables is **shared across all instances** of a class.
  - It belongs to the class itself, and not to any specific object.

Instance & Class variables



Instance & Class variables

- Class variables
  - Useful for sharing data across all instances of the class.
- Instance variables
  - Useful for initialising data specific to the instance of the class.

```
class Car:

    wheels = 4  # Class variable

    def __init__(self, make, model):

        self.make = make  # Instance variable

        self.model = model  # Instance variable

car1 = Car('Toyota', 'Corolla')
car2 = Car('Honda', 'Civic')

print(car1.wheels)  # Output: 4
print(car2.wheels)  # Output: 4
Car.wheels = 5
print(car1.wheels)  # Output: 5
print(car2.wheels)  # Output: 5
```

Instance, Static, and Class Methods

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1. Instance methods

- Operate on an instance of the class.

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- Do not operate on an instance or class. Defined using **@staticmethod**.

3. Class methods

- Operate on the class itself. Defined using **@classmethod**.

Instance, Static, and Class Methods

When defining methods:

- Instance methods **take `self`** as their first argument.
- Class methods **take `cls`** as their first argument.
- Static methods **don't take `self` or `cls`** as their first argument.

Instance, Static, and Class Methods

When to Use Each Method?

Instance, Static, and Class Methods

When to Use Each Method?

- Instance Methods: When you need to work with the object's attributes.
- Class Methods: When you need to work with the class itself (e.g., class-level variables).
- Static Methods: When you need a utility function that relates to the class but doesn't require access to the class or its instances.

Dunder methods

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  - Examples are `__add__`, `__eq__`, `__str__`, etc.
- You'll find a summarised **dunder-methods-cheat-sheet** attached in this lecture.

Inheritance

Technique to create a new class by reusing attributes and methods of an existing class.

Helps reduces code redundancy by reusing the same logic defined in another class.

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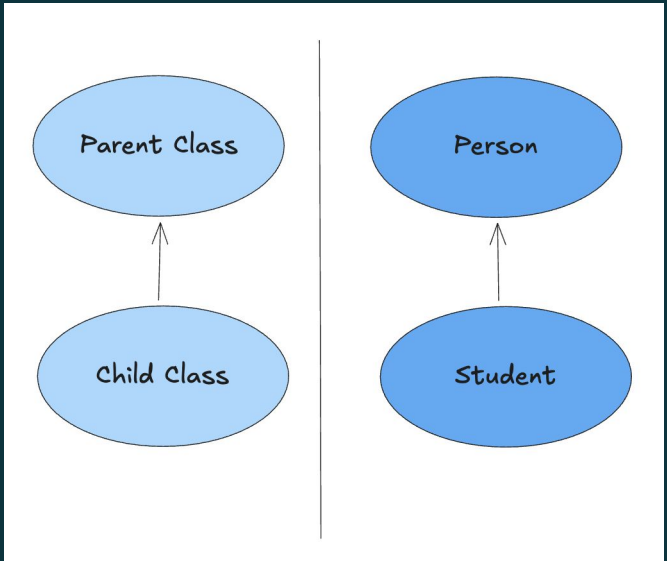

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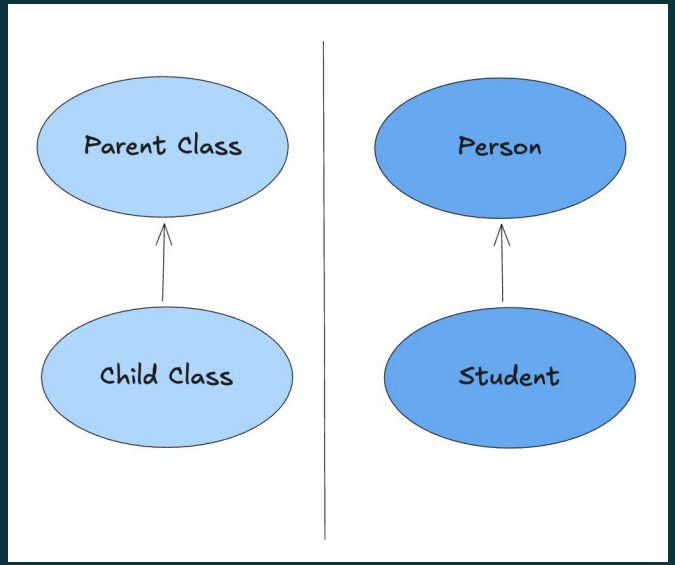
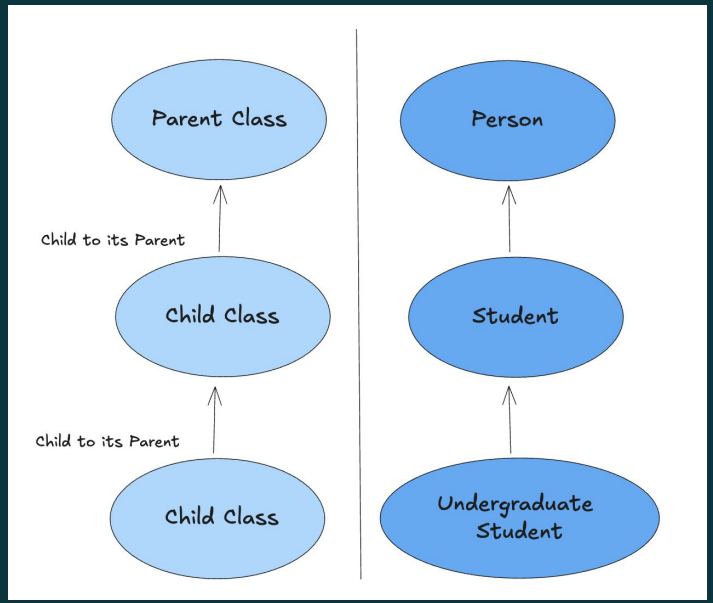
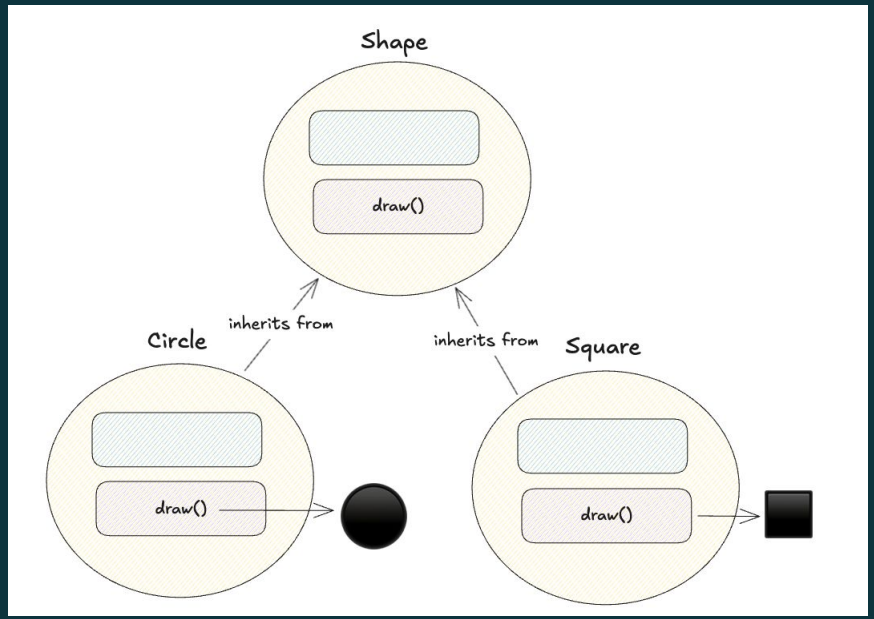




Polymorphism

Ability of different objects to respond, each in its own way, to identical messages (methods).



Abstract Classes

Abstract Classes

- A class that cannot be instantiated.
- Contains abstract methods that must be implemented by derived classes.

Use Case:

- Enforces a contract for subclasses.

Abstract Classes

Example of creating a class called **Animal** with an **abstract method** called **speak()** that cannot be instantiated at runtime.

However, class **Dog** inherits from **Animal** and implements the **speak()** method.

Dog Class is what we call a **Concrete Class**. In other words, a Class that can be instantiated at runtime.

```
from abc import ABC, abstractmethod


class Animal(ABC):
    @abstractmethod
    def speak(self):
        pass
class Dog(Animal):
    def speak(self):
        return 'Bark'


dog = Dog()
print(dog.speak())  # Output: Bark
```

Class Generics

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- Generics is a technique to define functions, classes, or methods that can operate on multiple types while maintaining type safety.
- Generics make it is possible to write reusable code that can be used with different data types.
- It ensures promoting code flexibility and type correctness.
- *Python 3.12 offers a newly improved syntax for typing Generics.*

Generics in Python

The syntax **Stack[T]** implies that you're defining a generic class parametrized by T. This implicitly defines **T** as a type variable that you can refer to within the class definition.

```
class Stack(T):
    def __init__(self):
        self.items = []

    def push(self, item: T):
        self.items.append(item)

    def pop(self) -> T:
        return self.items.pop()

stack = Stack[int]()
stack.push(1)
stack.push(2)
print(stack.pop())  # Output: 2
```

Generics in Python

The syntax **Stack[T]** implies that you're defining a generic class parametrized by T. This implicitly defines **T** as a type variable that you can refer to within the class definition.

Prior to Python 3.12, you would need to write more syntax for the same logic by importing **Generic**, **TypeVar** and explicitly define **T** makes your code cleaner and more readable.

This new syntax in Python 3.12 makes your code cleaner and more readable.

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Why Use Enums?

- Clarity: Improves code readability by using meaningful names instead of raw values.
- Type Safety: Ensures that only valid values are assigned to variables.
- Grouping: Groups related constants together in a single data structure.

Enums

Key Features:

- **Enums are iterable:** You can loop through an Enum class.
- **Unique values:** Enum members are unique; two members cannot have the same value.
- **Immutable:** Enum members are constants and cannot be modified.

```
from enum import Enum

class Color(Enum):
    RED = 1
    GREEN = 2
    BLUE = 3


red = Color.RED
green = Color.GREEN

print(red == Color.RED) # True
print(red == green)     # False
print(Color.RED.name)   # RED
print(Color.RED.value)  # 1
```

Duck Typing

Duck Typing

“If it looks like a duck and quacks like a duck, then it probably is a duck."

- Duck Typing means that Python doesn’t check the type of an object. Instead, it checks whether an object has the necessary methods and attributes to perform a task.
- In other words, type checking is determined by methods and properties rather than the actual type.

Protocols

Protocols

- A Protocol defines a set of methods or properties that a class must implement to be considered as "compatible" with that protocol.
- It formalizes the idea of **Duck Typing** by saying, "*If an object implements this set of methods, it can be treated as if it conforms to the Protocol.*"

Protocols introduced in PEP 544: https://peps.python.org/pep-0544/

Duck Typing with Protocols

Duck Typing is a powerful feature of Python that allows us to write flexible code by focusing on the behavior of objects, not their type.

```
from typing import Protocol

class Flyer(Protocol):
    def fly(self) -> str:
        ...

class Bird:
    def fly(self) -> str:
        return 'Bird is flying'

class Airplane:
     def fly(self) -> str:
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def lift_off(flyer: Flyer):
    print(flyer.fly())

bird = Bird()
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lift_off(bird)        # Output: Bird is flying
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Protocols give us a way to formalize Duck Typing by defining clear contracts that objects must adhere to.

Protocols offer the best of both worlds: the flexibility of Python's dynamic typing and the type safety of static typing.

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Conclusion

- OOP Principles
  - Abstraction, Encapsulation, Inheritance, and Polymorphism
- Classes and objects
- Instance and class variables
- Method types (instance, class, static)
- Dunder methods / special methods
- Inheritance and Polymorphism
- Abstract classes
- Class Generics
- Enums
- Protocols