Digital Career Institute

Python Course - OOP in Practice

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Goal of the Module

The goal of this submodule is to help the student understand advanced principles and design patterns of Object Oriented Programming (OOP). By the end of this submodule, the learners will be able to understand:

- The abstraction paradigm.
- Abstract base classes in Python and mixins.
- The singleton pattern.
- The factory pattern.
- Overloading and polymorphism.
- Type conversion in Python.
- Magic methods.

Topics

- Abstract classes
- Abstract methods
- Mixins
- The abc Python module
- Singleton pattern
- Factory design method
- Overloading and polymorphism
- Type conversion
- Dunder and magic methods

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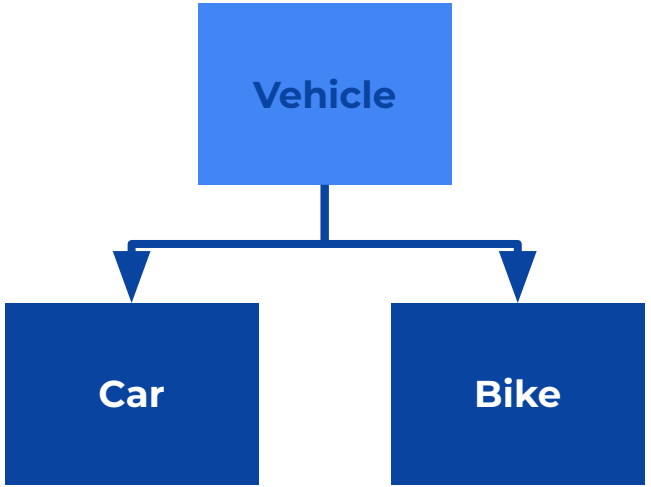
Abstract Classes

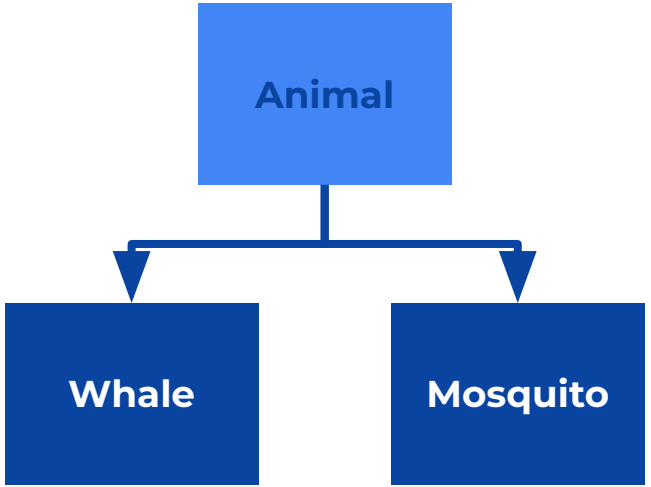
Abstraction in OOP

- So far, it has been mentioned that a class is a pattern from which objects are instantiated.
- This is not always true.
- Sometimes, it can be desirable to define a class that only serves as a base class for other classes to extend.



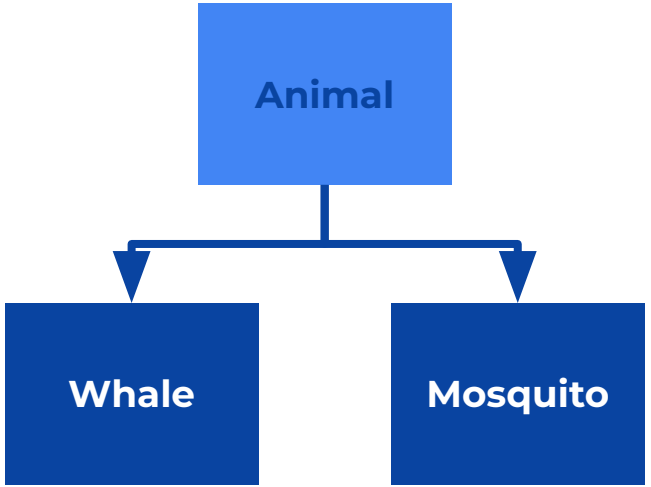
Abstract Classes

- It is not practical to use a class `Animal` to instantiate whales and mosquitoes.
- As animals, they both share common traits (life expectancy, ingestion, excretion,...).
- But defining a whale using the `Animal` class requires having to manually indicate all common traits of whales every time.



Abstract Classes

- **Abstract classes** are only meant to be extended and not instantiated.
- They are used to define some properties and methods that are common to a series of **subclasses or child classes**.



Abstract Methods

- Abstract classes are used to define properties and methods.
- Abstract methods do not offer an implementation. They are defined but they don't define what the method does. The keyword `pass` is often used to define a block that does nothing.

```
>>> class Animal:
...     def reproduce(self):
...         pass
...
>>> class Whale(Animal):
...     def reproduce(self):
...         return Whale()
...
```

Abstract Classes in Python

- Abstract classes are not built–in in the Python core.
- They may be designed as abstract classes (never instantiated), but the language does not treat them any differently.
- In this example, an instance of the abstract class can be created, just like a whale is created.

```
>>> class Animal:
...     def reproduce(self):
...         pass
...
>>> class Whale(Animal):
...     def reproduce(self):
...         return Whale()
...
>>> willy = Animal()
>>> print(willy.reproduce())
None
```

Abstract Base Classes

But abstract classes can be defined as such using the built-in Python module `abc` (Abstract Base Classes).

Abstract methods must use the `@abstractmethod` decorator.

An abstract class defined this way can never be used to instantiate objects.

```
>>> from abc import ABC, abstractmethod
>>> class Animal(ABC):
...     @abstractmethod
...     def reproduce(self):
...         pass
...
>>> willy = Animal()
TypeError: Can't instantiate abstract
class Animal with abstract method
reproduce
```

Abstract Base Classes: Methods

Subclasses created from the abstract class must provide an implementation for each abstractmethod.

If they do not provide it, objects cannot be instantiated from them.

```
>>> from abc import ABC, abstractmethod
>>> class Animal(ABC):
...     @abstractmethod
...     def reproduce(self):
...         pass
...
>>> class Whale(Animal):
...     pass
...
>>> willy = Whale()
TypeError: Can't instantiate abstract
class Whale with abstract method
reproduce
```

Abstract Base Classes: Methods

Subclasses that provide an implementation for all abstract methods can be used normally.

This is useful to detect bugs earlier, as the code explicitly indicates what the problem is when there is one.

```
>>> from abc import ABC, abstractmethod
>>> class Animal(ABC):
...     @abstractmethod
...     def reproduce(self):
...         pass
...
>>> class Whale(Animal):
...     def reproduce(self):
...         return Whale()
...
>>> willy = Whale()
>>> print(willy)
<__main__.Whale object at 0x7f4363f5aa60>
```

Abstract Base Classes: Methods

Abstract methods can be used to group any set of instructions common to all subclasses that need to be executed every time the method is called.

The `super()` constructor can be used to execute the instructions in the abstract method.

```
>>> from abc import ABC, abstractmethod
>>> class Animal(ABC):
...     @abstractmethod
...     def reproduce(self):
...         print("Good news!")
...
>>> class Whale(Animal):
...     def reproduce(self):
...         super().reproduce()
...         return Whale()
...
>>> willy = Whale()
>>> print(willy.reproduce())
Good news!
<__main__.Whale object at 0x7f4363f5aa60>
```

Abstract Base Classes: Methods

```
from abc import ABC, abstractmethod
from time import time as tt, ctime as ct


class Vehicle(ABC):
    @abstractmethod
    def do(self, action):
        print(f"Start of action: {action}
at {ct(tt())}")


class Bicycle(Vehicle):
    def do(self, action):
        print(f"{action} the bike
peacefully in the park")


class Car(Vehicle):
    def do(self, action, distance):
        super().do(action)
        print(f"{action} the car for
{distance} km")
```

- Abstract methods can have parameters.
- When overridden in the subclasses, the methods must implement those parameters defined in the abstract method and can have more parameters.

Code parts

The abstract method **`do(action)`** is redefined in the children classes.

The code in the abstract method is reused.

Abstract Base Classes: Properties

Class properties can also be defined in the same way and their implementation will also be required when subclassing.

They are defined using both the `@abstractmethod` and `@property` decorators.

The `@abstractmethod` decorator must always be the closest to the method definition.

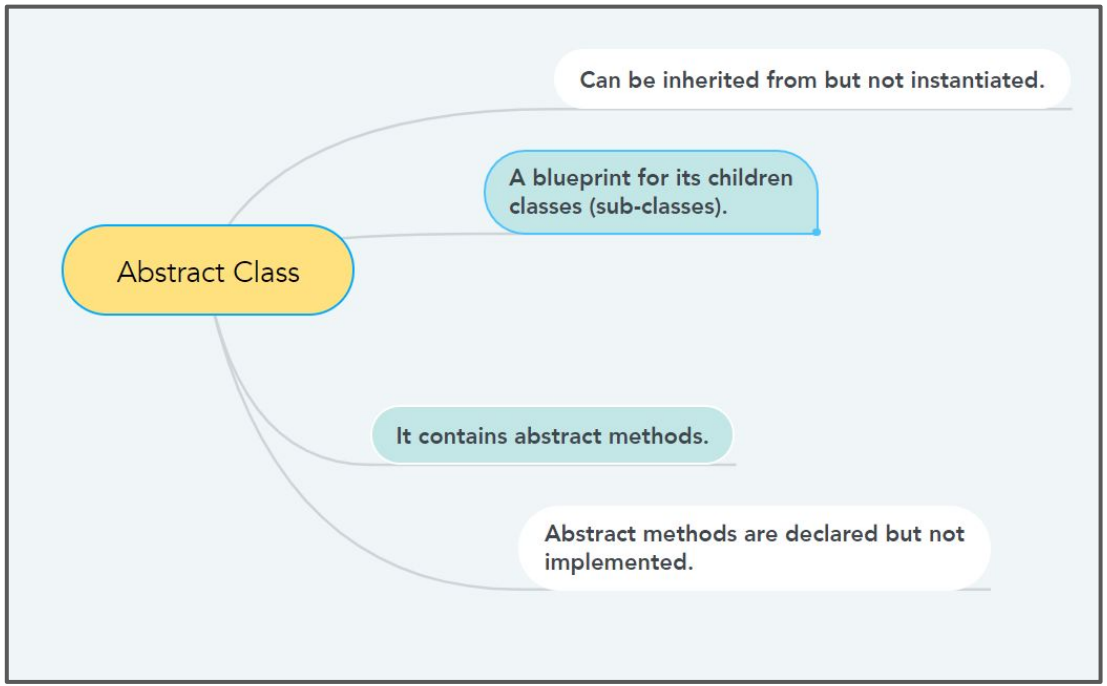
```
>>> from abc import ABC, abstractmethod
>>> class Animal(ABC):
...     @property
...     @abstractmethod
...     def reproduction(self):
...         pass
...
>>> class Whale(Animal):
...     pass
...
>>> willy = Whale()
TypeError: Can't instantiate abstract
class Whale with abstract method
reproduction
```

Abstract Base Classes: Properties

If the subclass has the required properties, no error appears and the class can be used normally to instantiate objects.

```
>>> from abc import ABC, abstractmethod
>>> class Animal(ABC):
...     @property
...     @abstractmethod
...     def reproduction(self):
...         pass
...
>>> class Whale(Animal):
...     reproduction = "sexual"
...
>>> willy = Whale()
>>> print(willy.reproduction)
sexual
```

Abstract Base Classes - Summary



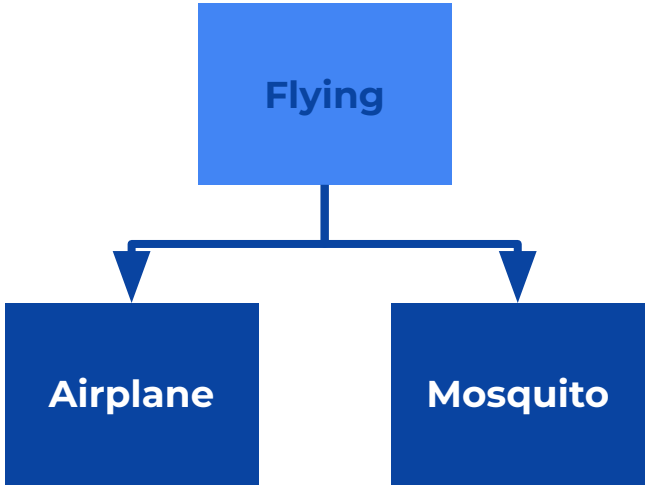
Mixins

Class Mixins

Mixins are similar to abstract classes and are defined and implemented using a special design pattern.

Like abstract classes, they are not meant to be directly instantiated into objects, but used by the subclasses.

They are used to **mix** a specific feature **in** otherwise unrelated classes.

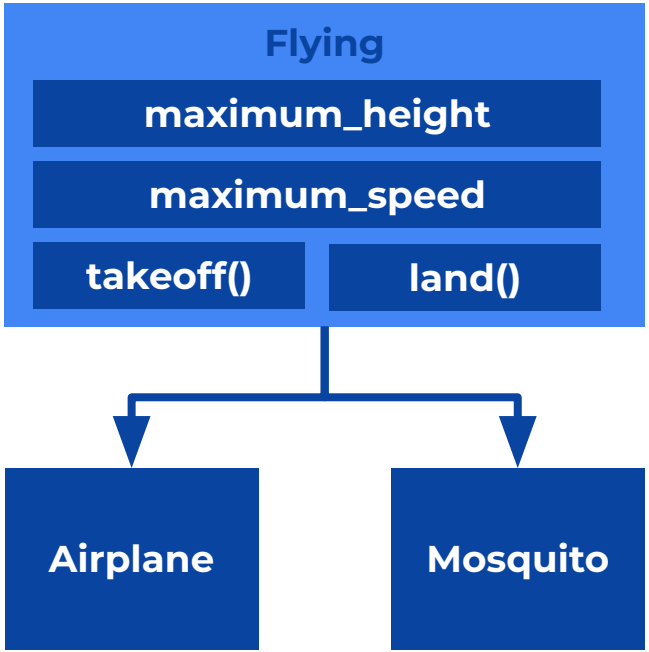


Class Mixins

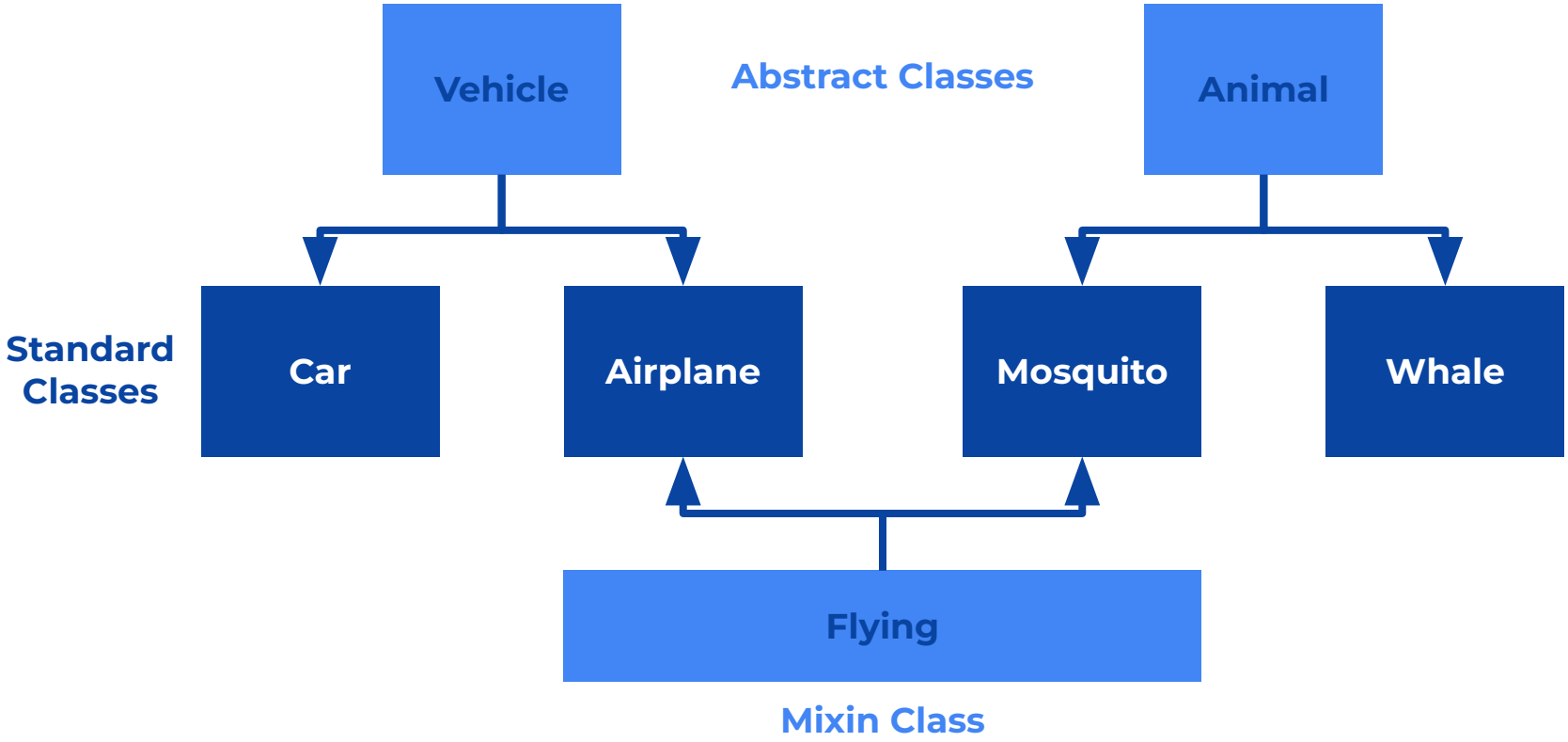
Mixins define and implement a **single, well-defined feature**.

As opposed to abstract classes, they provide a default implementation of the properties and methods involved in this feature.

Both airplanes and mosquitoes will have a `takeoff` and a `land` method, because they both fly.



Class Mixins

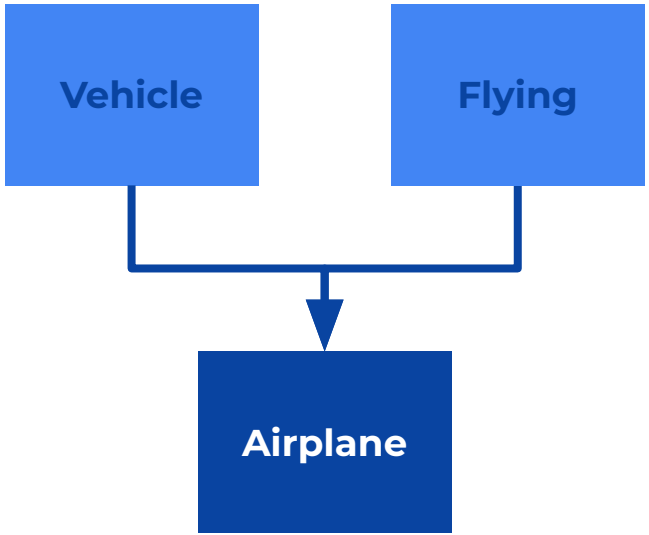


Python Mixins: Multiple Inheritance

In Python, mixins are often used in cases of multiple inheritance.

An airplane is both a vehicle and a flying entity.

In Python, the class `Airplane` will extend both the abstract class `Vehicle` and the mixin `Flying`.



Python Mixins

Python does not implement a specific type for mixins.

It is the programmer's responsibility to design the class as a proper mixin.

Very often, the mixin class is named adding the `Mixin` suffix, so that it is clear the purpose of the class.

```
>>> class Vehicle(ABC):
...     # instructions
...
>>> class Animal(ABC):
...     # instructions
...
>>> class FlyingMixin:
...     # instructions
...
>>> class Airplane(Vehicle, FlyingMixin):
...     # instructions
...
>>> class Mosquito(Animal, FlyingMixin):
...     # instructions
...
```

Python Mixins

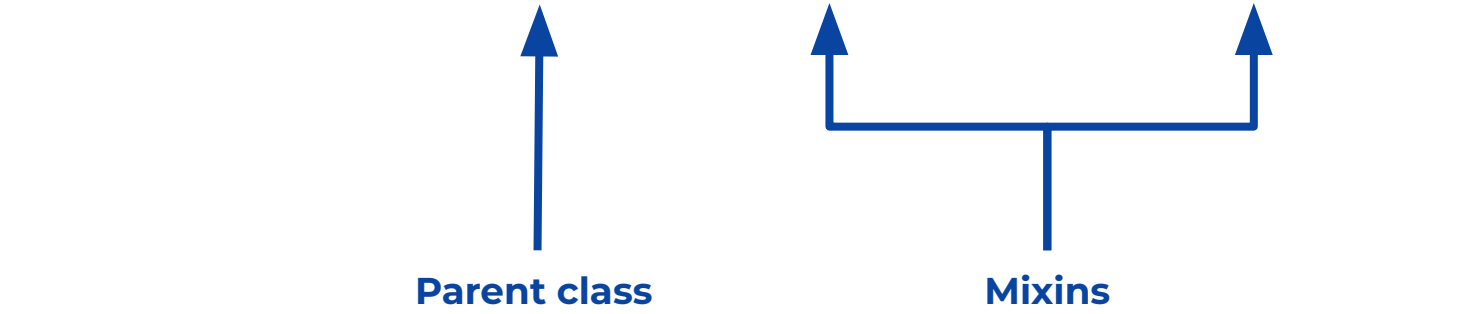
Multiple mixins can be used to extend a class.

This way, an airplane will have the method `takeoff` but not the method `bite`. Spiders will have the method `bite` but not the `takeoff` method, and mosquitoes will have both methods.

```
>>> class Airplane(Vehicle, FlyingMixin):
...     # instructions
...
>>> class Spider(Animal, BitingMixin):
...     # instructions
...
>>> class Mosquito(Animal, FlyingMixin
...                BitingMixin):
...     # instructions
...
```

Python Mixins

```
class Mosquito(Animal, FlyingMixin, BitingMixin):
```



First, all the features of the parent class are loaded,
then each of the mixins is merged into it
in order from left to right.

Mixins & Interfaces

In computer science an **interface** is often similar to a **mixin**. Interfaces are also meant to provide the definition of a feature.

As opposed to mixins, interfaces don’t implement the declared methods and it is the child classes who must do so.

In most programming languages, interfaces cannot be used with multiple inheritance.

Python does not have a type implementation for interfaces.

We learned ...

- That abstract classes are declared and extended but never instantiated.
- That abstract classes are used to group a set of features that are common for all the subclasses.
- That the `abc` module of Python is used to enforce the correct behavior of abstract classes.
- That there are different design patterns in OOP.
- That mixins are used to extend classes with some well-defined and specific features that are not specific to those classes or their parent classes.

Polymorphism

Polymorphism

The word polymorphism means multiple forms or shapes.

In computer programming it is the ability of a method, a function or an operator to behave differently depending on the context.

Overloading is one way of defining polymorphism and it has to do with the arguments passed to the functions or the operands used in the operators.

```
>>> 1 + 3
4
>>> "ab" + "Fg"
'abFg'

>>> 3 * 5
15
>>> "Hello" * 3
'HelloHelloHello'

v1 = 10
v2 = "Hello Berlin"
v3 = [5, True, "Grass"]
v4 = {"name": "Rafael", "age": 35}

print(v1)  # 10
print(v2)  # Hello Berlin
print(v3)  # [5, True, 'Grass']
print(v4)  # {'name': 'Rafael', 'age': 35}
```

Polymorphic Classes

Another way of polymorphism are **Polymorphic Classes** and they involve *class inheritance* and *method overriding*.

Different subclasses of the same parent class may provide different implementations of the same method.

This way, the same interface **`travel`** can be used to operate on different types of objects and do different things (**`gallop`** or **`slither`**) depending on the type and without the developer having to manually code this logic on the main script.

```
from abc import ABC, abstractmethod

class Animal(ABC):
   @abstractmethod
   def move(self):
       pass

class Snake(Animal):
   def move(self):
       return "Snake Slithers"

class Horse(Animal):
   def move(self):
       return "Horse Gallops"

def travel(obj, point_a, point_b):
   print(obj.move(), "From", point_a, "To", point_b)


travel(Horse(), "Forest", "Desert")
# >>> Horse Gallops From Forest To Desert
travel(Snake(), "Hole", "Top of the rock")
# >>> Snake Slithers From Hole To Top of the rock
```

Polymorphism in OOP and Python

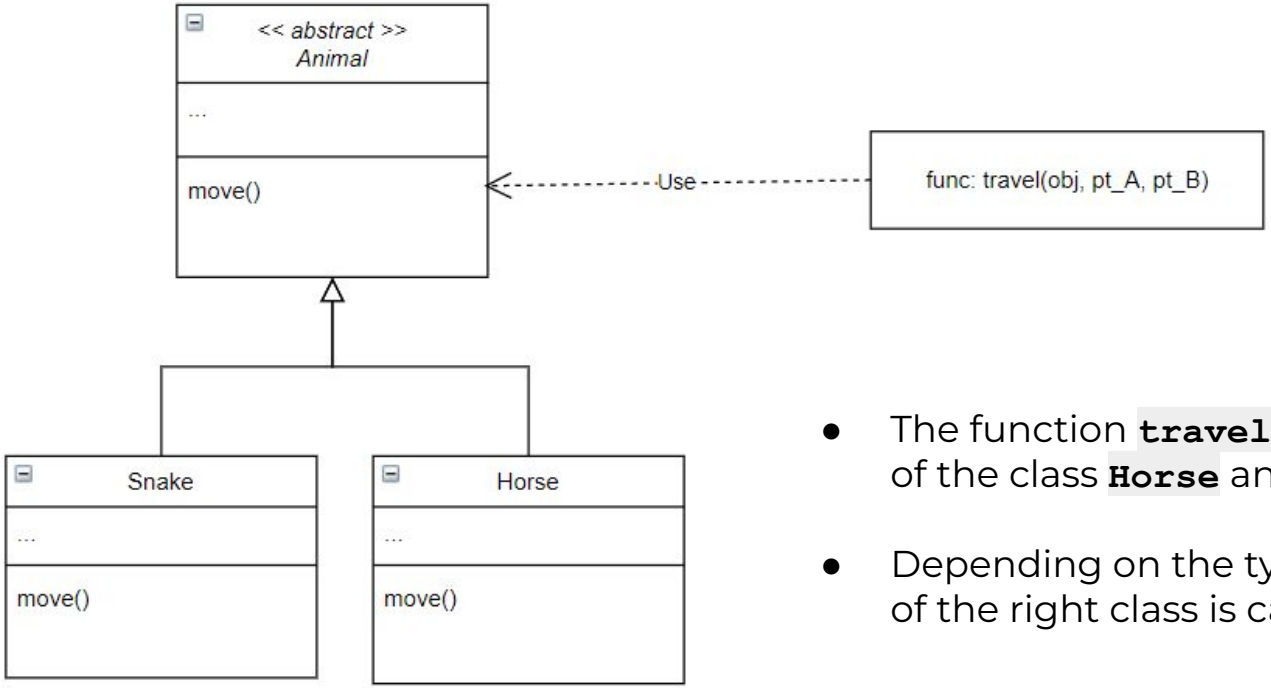
```
from abc import ABC, abstractmethod

class Animal(ABC):
    @abstractmethod
    def move(self):
        pass

class Snake(Animal):
    def move(self):
        return "Snake Slither"

class Horse(Animal):
    def move(self):
        return "Horse Gallop"

def travel(obj, point_a, point_b):
    print(obj.move(), "From", point_a, "To", point_b)


travel(Horse(), "Forest", "Desert")
# >>> Horse Gallop From Forest To Desert
travel(Snake(), "Hole", "Top of the rock")
# >>> Snake Slither From Hole To Top of the rock
```

Polymorphism in OOP

Abstract class **`Animal`** and its subclasses **`Snake`** and **`Horse`**. The abstract method **`move()`** is implemented in both subclasses.

The function **`travel`** is defined to deal with any type that implements a **`move()`** method.

Polymorphic Classes



- The function **`travel()`** uses the method **`move()`** of the class **`Horse`** and **`Snake`**.
- Depending on the type of obj, the right method of the right class is called.

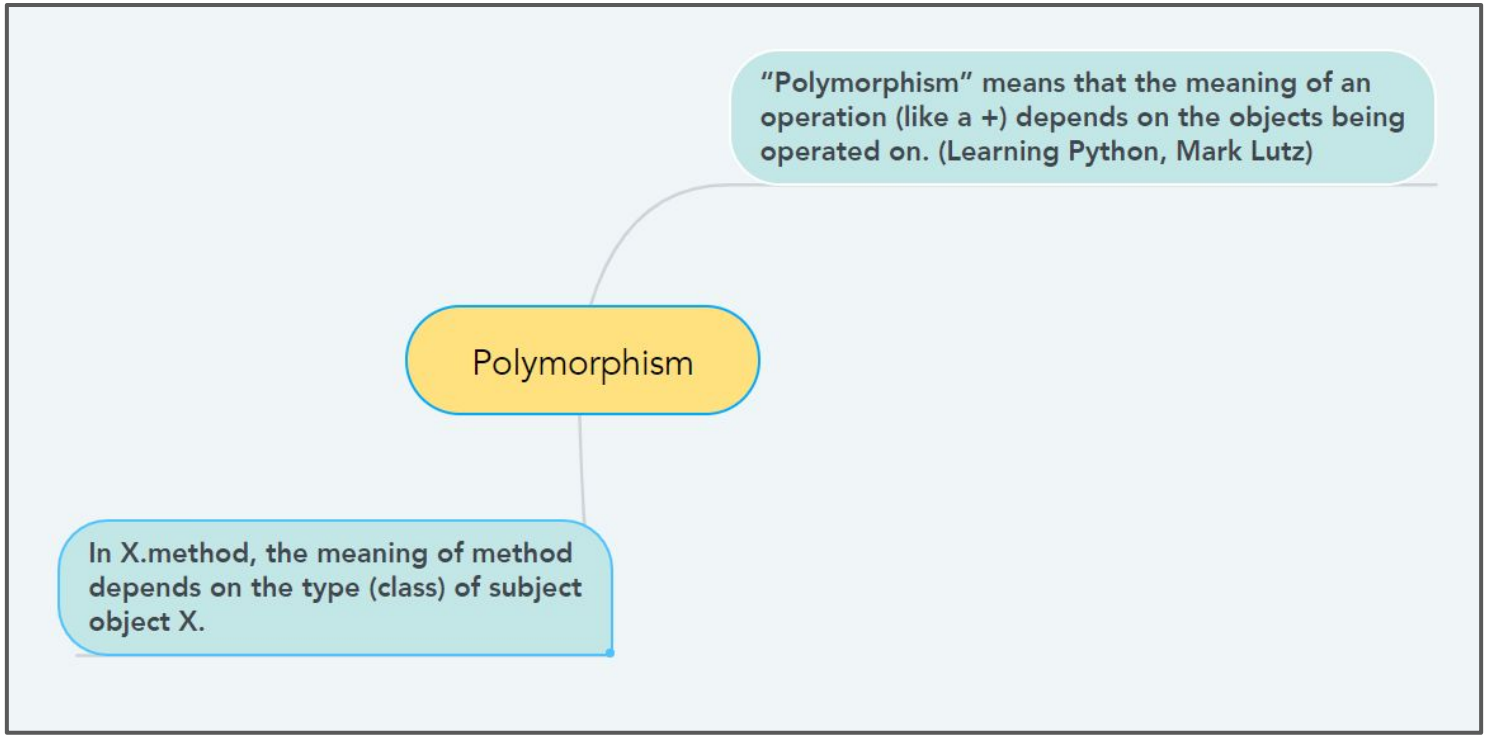
Polymorphism in Python

Since Python is a ‘dynamic types’ language, Polymorphism is rampant in it. This represent the one the strengths of this language.

As long as the object type has an interface (protocol) that fits the function or operator applied, the instruction will run without error.

Even more powerful; The polymorphism allows multi-type in function and operations e.g. **print(“a” , 5)**, **3 * “more”.**

Conclusion


"Polymorphism" means that the meaning of an operation (like a +) depends on the objects being operated on. (Learning Python, Mark Lutz)
Polymorphism
In X.method, the meaning of method depends on the type (class) of subject object X.

We learned ...

- **Overloading** is a type of polymorphism that allows for different types of arguments or operands to change the behavior of a function or operator.
- **Polymorphism** means that the behavior of a method, function or operator depends on the context.
- **Polymorphic Classes** allow for a same method to do different things depending on the class they belong to.
- **Polymorphic classes** use class inheritance and method overriding to achieve this goal.
- **Overloading** and **Polymorphism** are techniques used to provide a cleaner and more readable and bug-free code.