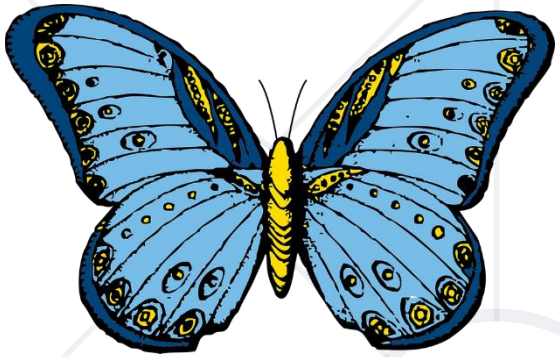
Polymorphism and Abstraction

Having Multiple Forms



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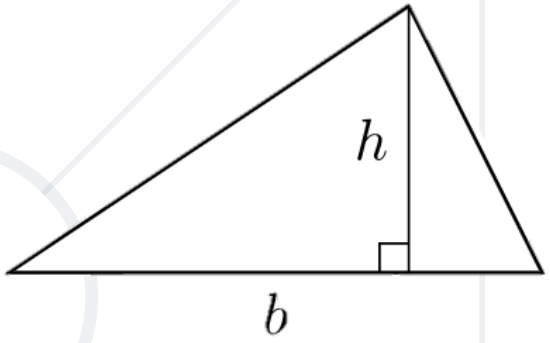
Definition and Examples

Polymorphism Definition

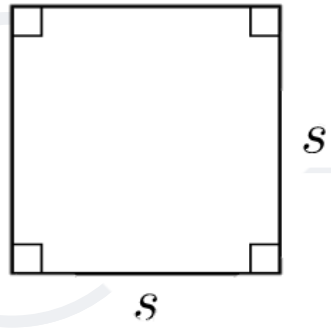
- Polymorphism is based on the Greek words "poly" (**many**) and "morphism" (**forms**)
- It is the ability to present the **same interface** for **differing underlying forms** through the interface of **their base class**
- e.g., **Square**, and **Triangle inherit Shape**, so their instances can be used from an instance of type Shape

Run-Time Polymorphism

- A subclass can **override** a method of its superclass
  - e. g., **both** triangle and square are **shapes** and have **area**



$$A = \frac{b \cdot h}{2}$$



$$A = s^2$$

Example: Run-Time Polymorphism

```
class Shape:
    def calculate_area(self):
        return None

class Square(Shape):
    side_length = 2
    def calculate_area(self):
        return self.side_length * 2

class Triangle(Shape):
    base_length = 4
    height = 3
    def calculate_area(self):
        return 0.5 * self.base_length * self.height
```

Overriding `calculate_area` method

Without Polymorphism

- A **type check** may be required before performing an action on an object to **determine the correct method** to call

```
for obj in Square(), Triangle():
    if isinstance(obj, Square):
        area = obj.calculate_square_area()
    elif isinstance(obj, Triangle):
        area = obj.calculate_triangle_area()
    print(area)
```

If not overriding `calculate_area` method

Compile-Time Polymorphism

- Python **does not** support compile-time polymorphism or **method overloading**
- If a class has multiple methods **with the same name**, the method defined in the **last will override** the earlier one

```
class Person:
    def say_hello():
        return "Hi!"
    def say_hello():
        return "Hello"

print(Person.say_hello()) # Hello
```

Problem: Robots

- **Refactor** the **provided code**, so we do not need to do **any type-checking**. The classes should implement the method, so it returns the number of sensors for **each type** of robot.

Solution: Robots

```
class MedicalRobot(Robot):
    @staticmethod
    def sensors_amount():
        return 6

class ChefRobot(Robot):
    @staticmethod
    def sensors_amount():
        return 4

class WarRobot(Robot):
    @staticmethod
    def sensors_amount():
        return 12
```

```
def number_of_robot_sensors(robot):
    print(robot.sensors_amount())

basic_robot = Robot('Robo')
da_vinci = MedicalRobot('Da Vinci')
moley = ChefRobot('Moley')
griffin = WarRobot('Griffin')

number_of_robot_sensors(basic_robot)
number_of_robot_sensors(da_vinci)
number_of_robot_sensors(moley)
number_of_robot_sensors(griffin)
```

Overloading Built-in Methods

Overloading Built-in Methods

- **Change the behavior** of functions such as **`len`**, **`abs`**, **`str`**, **`repr`**, and so on
- To do this, you only need to **define** the corresponding **special method in your class**

```
class MyClass:
    def __init__(self, name, size):
        self.name = name
        self.size = size

    def __len__(self):
        return self.size

my_class = MyClass("Class Name", 3)
print(len(my_class)) # 3
```

Operator Overloading

- An operator behaves **differently** based on the **type of the operands**
  - e.g., operator "**+**" is used to add two **integers** as well as join two **strings** and merge two **lists**
  - It is **overloaded** by **int** class, **str** class and **list** class

```
integer = 1 + 1
string = "Hello, " + "SoftUni"
list = ["1", "2"] + ["3", "4"]
```

Operator Magic Methods

Magic Methods	Get Called Using
__add__(self, other)	+
__sub__(self, other)	-
__mul__(self, other)	*
__floordiv__(self, other)	//
__truediv__(self, other)	/
__pow__(self, other[, modulo])	**

Example: Overloading __add__()

- If we have a **class Purchase** and we want to **sum** all expenses using the **+** operator, we can override the **__add__** method

```
class Purchase:
    def __init__(self, product_name, cost):
        self.product_name = product_name
        self.cost = cost

    def __add__(self, other):
        name = f'{self.product_name}, {other.product_name}'
        cost = self.cost + other.cost
        return Purchase(name, cost)

first_purchase = Purchase('sofa', 650)
second_purchase = Purchase('table', 150)
print(first_purchase + second_purchase)  # sofa, table; 800
```

"Rich Comparison" Magic Methods

Magic Methods	Get Called Using
__lt__(self, other)	<
__le__(self, other)	<=
__eq__(self, other)	==
__ne__(self, other)	!=
__gt__(self, other)	>
__ge__(self, other)	>=

Example: Overloading __gt__()

- If we have a **class Person** and we want to **compare** them by their salary using the **>** operator, we can override the **__gt__** method

```
class Person:
    def __init__(self, name, salary):
        self.name = name
        self.salary = salary

    def __gt__(self, other):
        return self.salary > other.salary

person_one = Person('John', 20)
person_two = Person('Natasha', 36)
print(person_one > person_two)  # False
```

Problem: ImageArea

- Create a class called `ImageArea`
- It stores the `width` and the `height` of an image
- Create a method called `get_area()` which returns the area of the image
- Implement all the **magic methods** for the **comparison** of two image areas (>, >=, <, <=, ==, !=) which will compare their areas

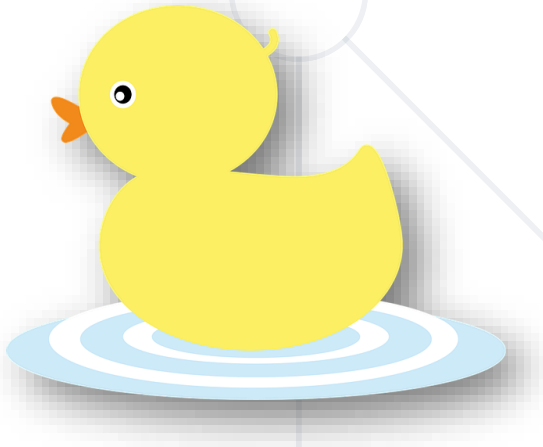
Solution: ImageArea

```
class ImageArea:
    def __init__(self, width, height):
        self.width = width
        self.height = height

    def get_area(self):
        return self.width * self.height

    def __eq__(self, other):
        return self.get_area() == other.get_area()

    # TODO: Implement the other comparison methods
```

Duck Typing

Duck Typing Definition

- Duck Typing is a **type system** used in dynamic languages
- "If it **looks like a duck** and **quacks like a duck**, **it's a duck**"
  - i.e., we don't care about **objects' types**, but whether **they have the methods** we need



Example: Duck Typing

- We **can create a method** **sound()** and call it, **no matter** what type the object that makes the sound is

```
class Cat:
    def sound(self):
        print("Meow!")

class Train:
    def sound(self):
        print("Sound from wheels slipping!")

for any_type in Cat(), Train():
    any_type.sound()
```

Works for both classes

Problem: Playing

- Create a method called `start_playing` which will receive an instance and will print its `play()` method if it has one

```
# Test Code
class Guitar:
    def play(self):
        return "Playing the guitar"

guitar = Guitar()
start_playing(guitar)
# Playing the guitar
```

```
# Test Code
class Children:
    def play(self):
        return "Children are playing"

piano = Children()
start_playing(piano)
# Children are playing
```

Solution: Playing

```
def start_playing(obj):
    return obj.play()

# Test Code
class Guitar:
    def play(self):
        return "Playing the guitar"

guitar = Guitar()
start_playing(guitar)
```

What is an Abstraction

Definition and Examples

A Word about Abstraction

- In object-oriented programming, abstraction is one of the **four central principles**
- Through abstraction, we hide all but the relevant data about an object to **reduce complexity** and **increase efficiency**
- Abstraction can be achieved by:
  - Functions and methods
  - **Abstract classes**

Abstract Classes

- Abstract classes are classes that contain one or more **abstract methods**
  - An abstract method is a method that is **declared** but contains **no implementation**
- Abstract classes may not be instantiated and require **subclasses** to provide implementations for the abstract methods

Abstract Classes in Python

- It could be achieved using **exceptions**, but it is **not a good practice**

```
class Shape:
    def __init__(self):
        if type(self) is Shape:
            raise Exception('This is an abstract class')

    def area(self):
        raise Exception('This is an abstract class')

    def perimeter(self):
        raise Exception('This is an abstract class')
```

Abstract Classes with ABC Module

- Abstract base classes (ABCs) **enforce** derived classes to implement particular methods from the base class
  - We implement it using the **abc** module

```
class Shape:

    def __init__(self):
        if type(self) == Shape:
            raise Exception('…')

    def area(self):
        raise Exception('…')

    def perimeter(self):
        raise Exception('…')
```

```
from abc import ABC, abstractmethod

class Shape(ABC):

    @abstractmethod
    def area(self):
        pass

    @abstractmethod
    def perimeter(self):
        pass
```

Example: Abstract classes

```
from abc import ABC, abstractmethod

class Animal(ABC):
    def __init__(self, name):
        self.name = name

    @abstractmethod
    def sound(self):
        raise NotImplementedError("Subclass must
implement")

# Continues on next slide
```

Defining an Abstract Class

Making an Abstract Method

Example: Abstract classes

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```
class Dog(Animal):
    def __init__(self, name):
        super().__init__(name)

    def sound(self):
        print("Bark!")

class Cat(Animal):
    def __init__(self, name):
        super().__init__(name)

    def sound(self):
        print("Meow!")
```

Inherit the Abstract Class

Implement the Abstract method

```
cat = Cat("Willy")
cat.sound()
dog = Dog("Willy")
dog.sound()
animal = Animal("Willy")
animal.sound()
# Meow!
# Bark!
# Error!
```

Problem: Shapes

- Create an abstract class **`Shape`** with abstract methods **`calculate_area`** and **`calculate_perimeter`**
- Create classes that implement the methods:
  - **`Circle`** - receives **radius** upon initialization
  - **`Rectangle`** - receives **height** and **width** upon initialization
  - The **fields** of Circle and Rectangle should be **private**

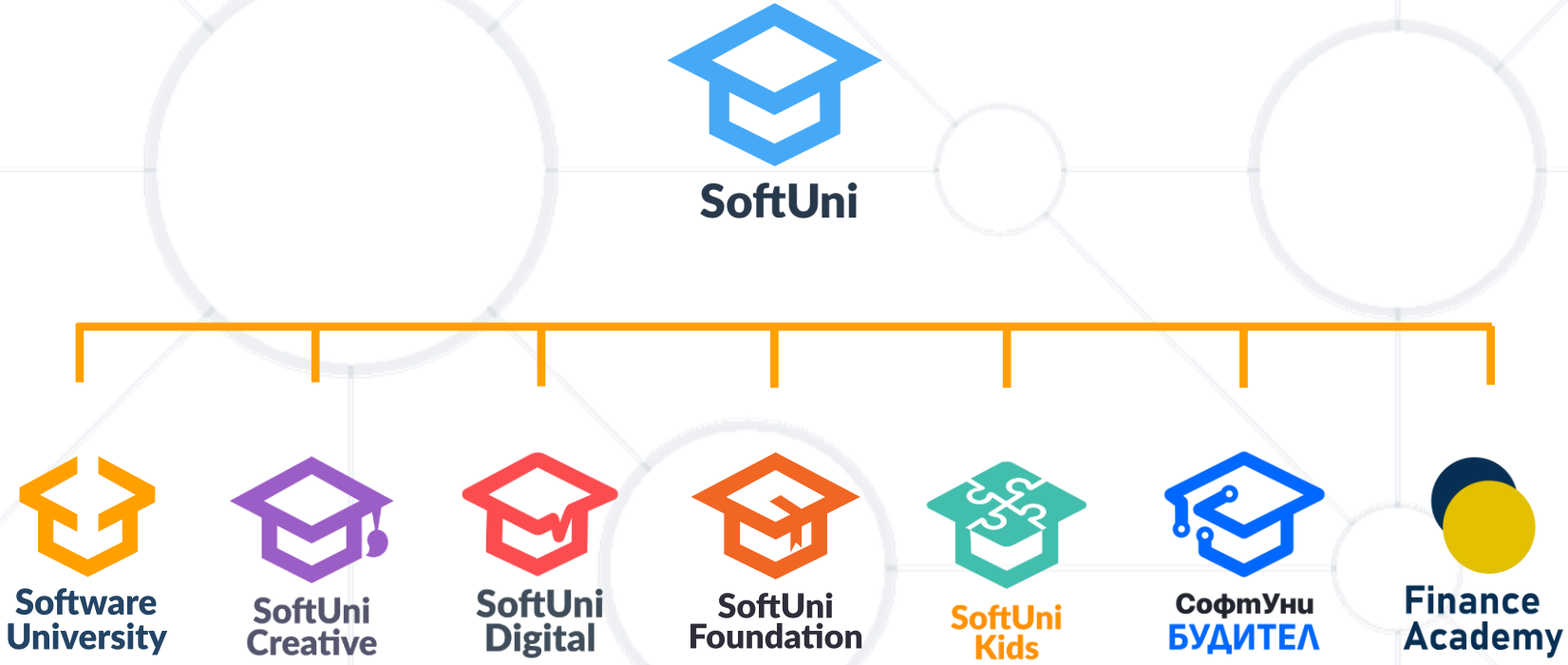
Solution: Shapes

```
from abc import ABC, abstractmethod
from math import pi

class Shape(ABC):
    @abstractmethod
    def calculate_perimeter(self):
        pass

    @abstractmethod
    def calculate_area(self):
        pass
# TODO: Implement Circle and Rectangle
```

Summary

- Polymorphism means the same function name is used for different types
- Through abstraction, we hide all but the relevant data about an object
- Abstract classes may not be instantiated, and require subclasses

Questions?



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