Getting Started with Object-Oriented Programming in Python

Guest Lectures at TTK University of Applied Sciences, Tallinn, Estonia

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Who’s Teaching Today?

Andy Louwyck

- Master and Doctor in Science: Geology
- Associate Degree in Programming
- Micro Degree in AI & Data Science
- Lecturer in IT at Vives University of Applied Sciences
- AI Coordinator at Flanders Environment Agency

Dominique Stove

- Master in Applied Economics
- Teaching Master’s Degree in Economics, Mathematics, and Physics
- Lecturer in IT at Vives University of Applied Sciences
- IT Consultant in Infrastructure
- Founder and Business Owner of IqPro

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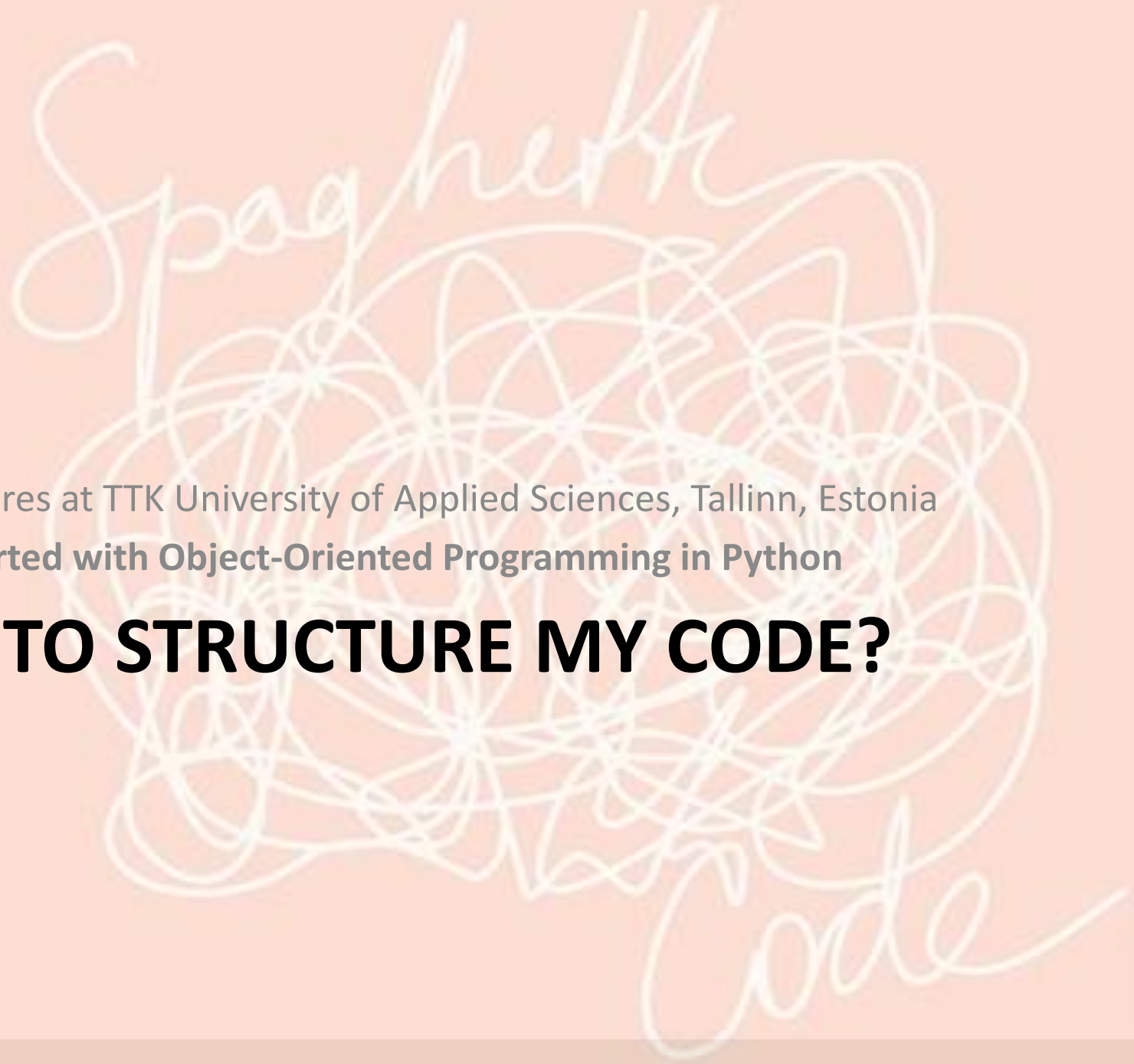
Title	ECTS	hours/week S1	hours/week S2	Semester
Introduction to Artificial Intellingence	5	3	0	1
Programming in Python	3	2	0	1
Digital Workplace	3	2	0	1
Android App Development	5	3	0	1
E-business en E-marketing	3	2	0	1
Introduction to linux	3	2	0	1
Cybersecurity	5	3	0	1
Professional and International Communication 3 (English)	3	2	0	1
	30	**19**	0	
Machine Learning - Fundamentals	6	0	4	2
IT-Project	5	0	3	2
Power Tools	3	0	3	2
Full-Stack Development in .NET	6	0	4	2
Mobile App Development iOS	5	0	4	2
Data Engineering	5	0	3	2
Node.js Development	3	0	2	2
	33	0	23	



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Getting Started with Object-Oriented Programming in Python

HOW TO STRUCTURE MY CODE?

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Which code would you write?

Approach 1

```
1  print(3.14159 * 5 * 2)
2
```

Approach 2

```
1  def calculate_area(radius):
2      pi = 3.14159
3      area = pi * radius ** 2
4      return area
5
6  print(calculate_area(5))
```

Which code would you write?

Approach 1

Pros:

- Very short and simple
- Quick for one-time use

Cons:

- Hard to reuse
- No clear structure
- Difficult to maintain

Approach 2

Pros:

- Code is reusable
- Better structure
- Easier to maintain and extend
- Hides details by using local variables

Cons:

- Slightly more code
- Requires understanding functions

What do you think of this object-oriented version?

```
1  class Circle:
2
3      def __init__(self, radius):
4          self.radius = radius
5          self.pi = 3.14159
6
7      def area(self):
8          return self.pi * (self.radius ** 2)
9
10 c = Circle(5)
11 print(c.area())
```

What do you think of this object-oriented version?

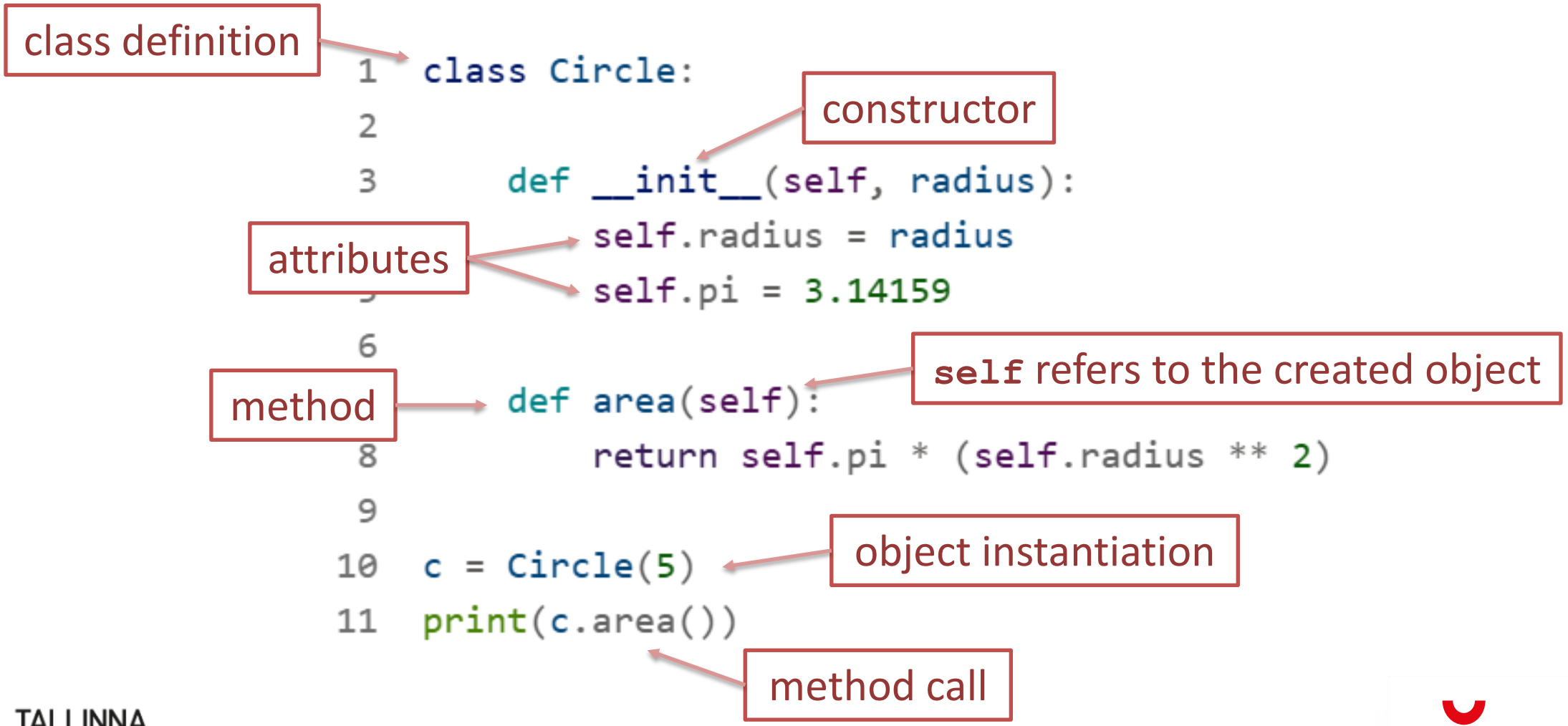
Pros

- Well structured
- Groups data and behavior in one place
- Keeps related details together
- Easy to reuse for many circles
- Easy to maintain
- Easy to extend (e.g. add perimeter)

Cons

- More code than a simple function
- Adds an extra concept: classes and objects
- Slightly harder for beginners to read
- Overkill for very small scripts

Components in this OO example



Class definition — `class Circle:`

The blueprint that groups related **data** and **behavior**.

class definition

```
1  class Circle:
2
3      def __init__(self, radius):
4          self.radius = radius
5          self.pi = 3.14159
6
7      def area(self):
8          return self.pi * (self.radius ** 2)
9
10 c = Circle(5)
11 print(c.area())
```

Constructor (`__init__`) — `def __init__(self, radius):`

Runs when you create an object; **initializes** the object's state.

```
1  class Circle:
2
3      def __init__(self, radius):
4          self.radius = radius
5          self.pi = 3.14159
6
7      def area(self):
8          return self.pi * (self.radius ** 2)
9
10 c = Circle(5)
11 print(c.area())
```

Instantiation — `c = Circle(5)`

Creates a **new object** (an instance of `Circle`).

```
1  class Circle:
2
3      def __init__(self, radius):
4          self.radius = radius
5          self.pi = 3.14159
6
7      def area(self):
8          return self.pi * (self.radius ** 2)
9
10 c = Circle(5)
11 print(c.area())
```

object instantiation

`self` (the object itself)

Refers to the **current instance**; used to access attributes and methods.

```
1   class Circle:
2
3       def __init__(self, radius):
4           self.radius = radius
5           self.pi = 3.14159
6
7       def area(self):
8           return self.pi * (self.radius ** 2)
9
10  c = Circle(5)
11  print(c.area())
```

`self` refers to the created object

Attributes — `self.radius`, `self.pi`

Data stored **inside each object** (the object's state).

```
1   class Circle:
2
3       def __init__(self, radius):
4           self.radius = radius
5           self.pi = 3.14159
6
7       def area(self):
8           return self.pi * (self.radius ** 2)
9
10  c = Circle(5)
11  print(c.area())
```

attributes

Method — `def area(self):`

Behavior that **uses the object's data** to compute a result.

```
1   class Circle:
2
3       def __init__(self, radius):
4           self.radius = radius
5           self.pi = 3.14159
6
7       def area(self):
8           return self.pi * (self.radius ** 2)
9
10  c = Circle(5)
11  print(c.area())
```

method

Method call (dot notation) — `c.area()`

Invokes the object's behavior; returns the computed area.

```
1  class Circle:
2
3      def __init__(self, radius):
4          self.radius = radius
5          self.pi = 3.14159
6
7      def area(self):
8          return self.pi * (self.radius ** 2)
9
10 c = Circle(5)
11 print(c.area())
```

method call

Circles also know their perimeter!

```
1   class Circle:
2
3       def __init__(self, radius):
4           self.radius = radius
5           self.pi = 3.14159
6
7       def area(self):
8           return self.pi * (self.radius ** 2)
9
10      def perimeter(self):
11          return 2 * self.pi * self.radius
12
13  c = Circle(5)
14  print(c.area())
15  print(c.perimeter())
```

methods

method calls

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Which code do you prefer?

Procedural programming

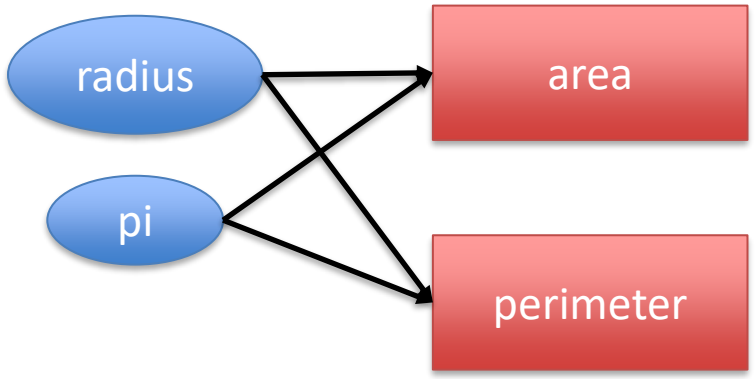
```
1  pi = 3.14159
2
3  def area(radius):
4      return pi * (radius ** 2)
5
6  def perimeter(radius):
7      return 2 * pi * radius
8
9  radius = 5
10 print(area(radius))
11 print(perimeter(radius))
```

Object-oriented programming (OOP)

```
1  class Circle:
2
3      def __init__(self, radius):
4          self.radius = radius
5          self.pi = 3.14159
6
7      def area(self):
8          return self.pi * (self.radius ** 2)
9
10     def perimeter(self):
11         return 2 * self.pi * self.radius
12
13 c = Circle(5)
14 print(c.area())
15 print(c.perimeter())
```

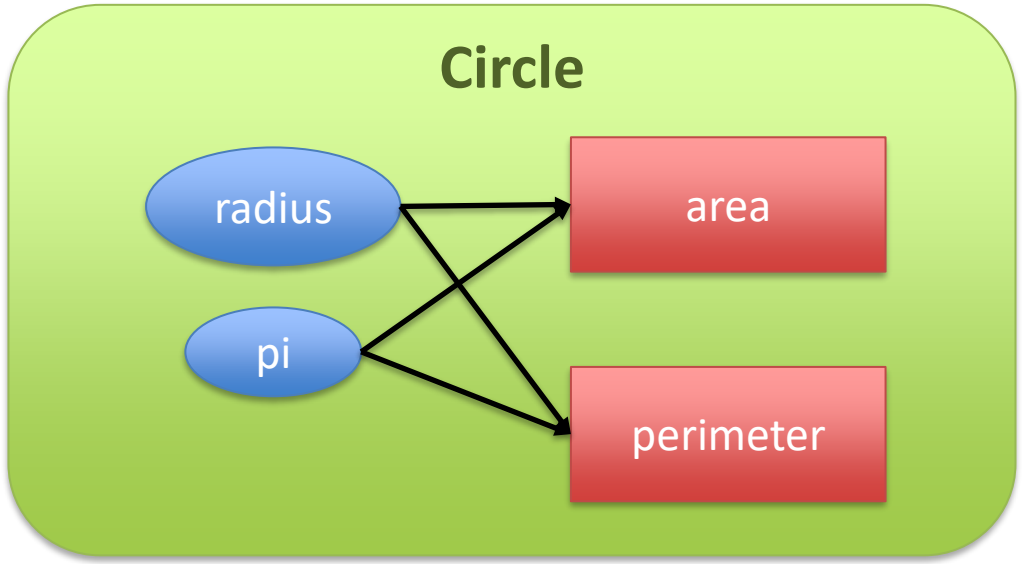
Which code do you prefer?

Procedural programming



Variables (data) and functions (behavior) are separate; they are **not bundled** into a single structure

Object-oriented programming (OOP)



A class that **encapsulates** both variables (data) and functions (behavior) in one single structure

Which code do you prefer?

Procedural programming

Pros:

- Simple for small scripts
- Easy to understand for beginners
- Quick to implement

Cons:

- Data and behavior are separate
- Harder to maintain when many related functions
- No clear structure for scaling

Object-oriented programming (OOP)

Pros:

- Groups data and behavior together
- Easier to reuse and extend
- Better structure for complex systems

Cons:

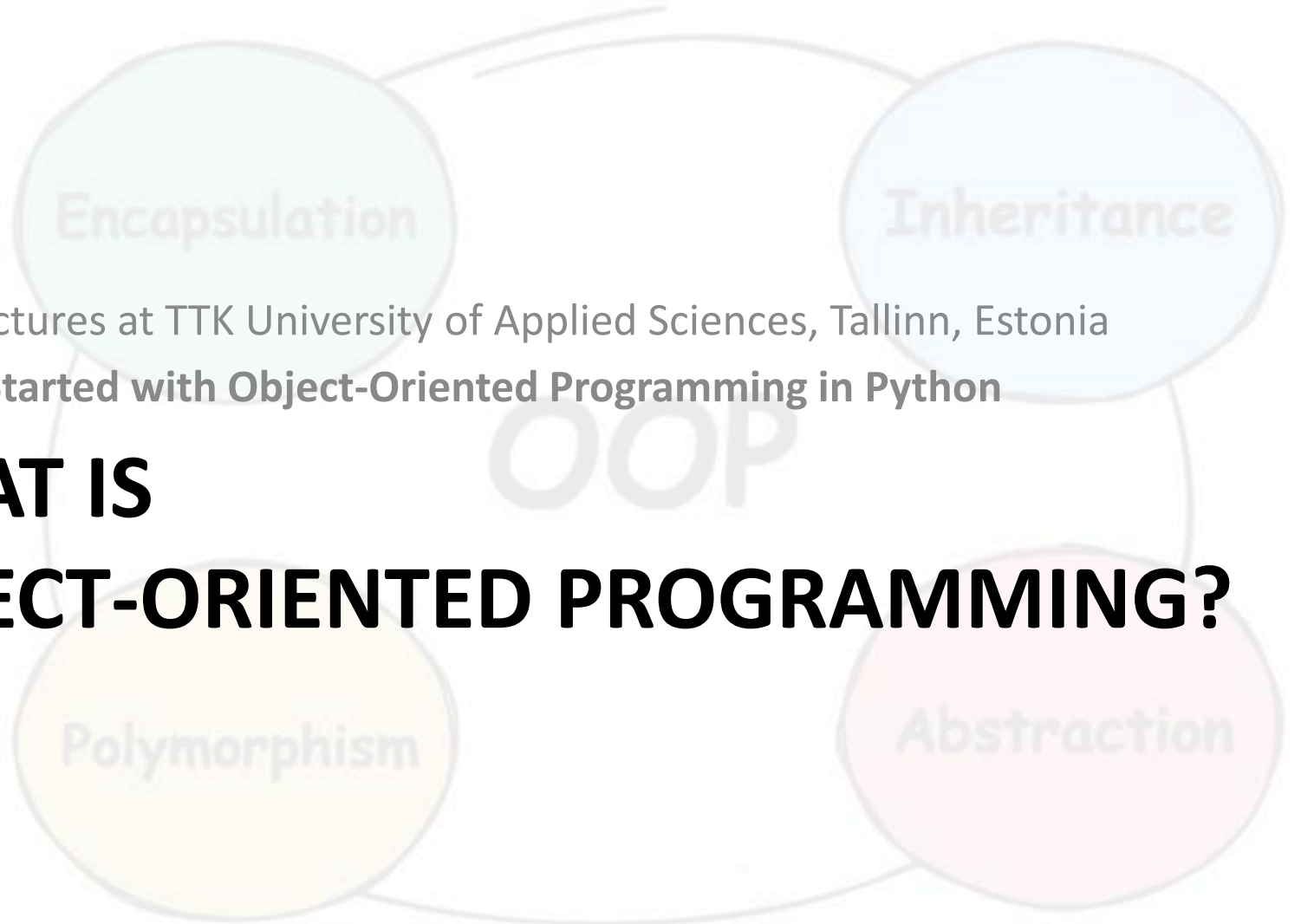
- More code for simple tasks
- Slightly more overhead
- Requires understanding of classes and objects

There is a third approach…

Besides procedural and object-oriented programming, Python also supports **functional programming** (which is beyond the scope of this lecture):

```
1  import math
2
3  radii = [2, 3.5, 5]
4
5  areas = list(map(lambda r: math.pi * (r ** 2), radii))
6  perimeters = list(map(lambda r: 2 * math.pi * r, radii))
7
8  print(areas)
9  print(perimeters)
```

"No state, just transform a list of radii into a list of areas/perimeters"



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WHAT IS OBJECT-ORIENTED PROGRAMMING?

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Classes and Objects

Class

- A **blueprint** for creating objects
- Defines **attributes** and **methods**
- Example:

```
class Circle:
    def __init__(self, radius):
        self.radius = radius
    def area(self):
        return 3.14159 * (self.radius ** 2)
```

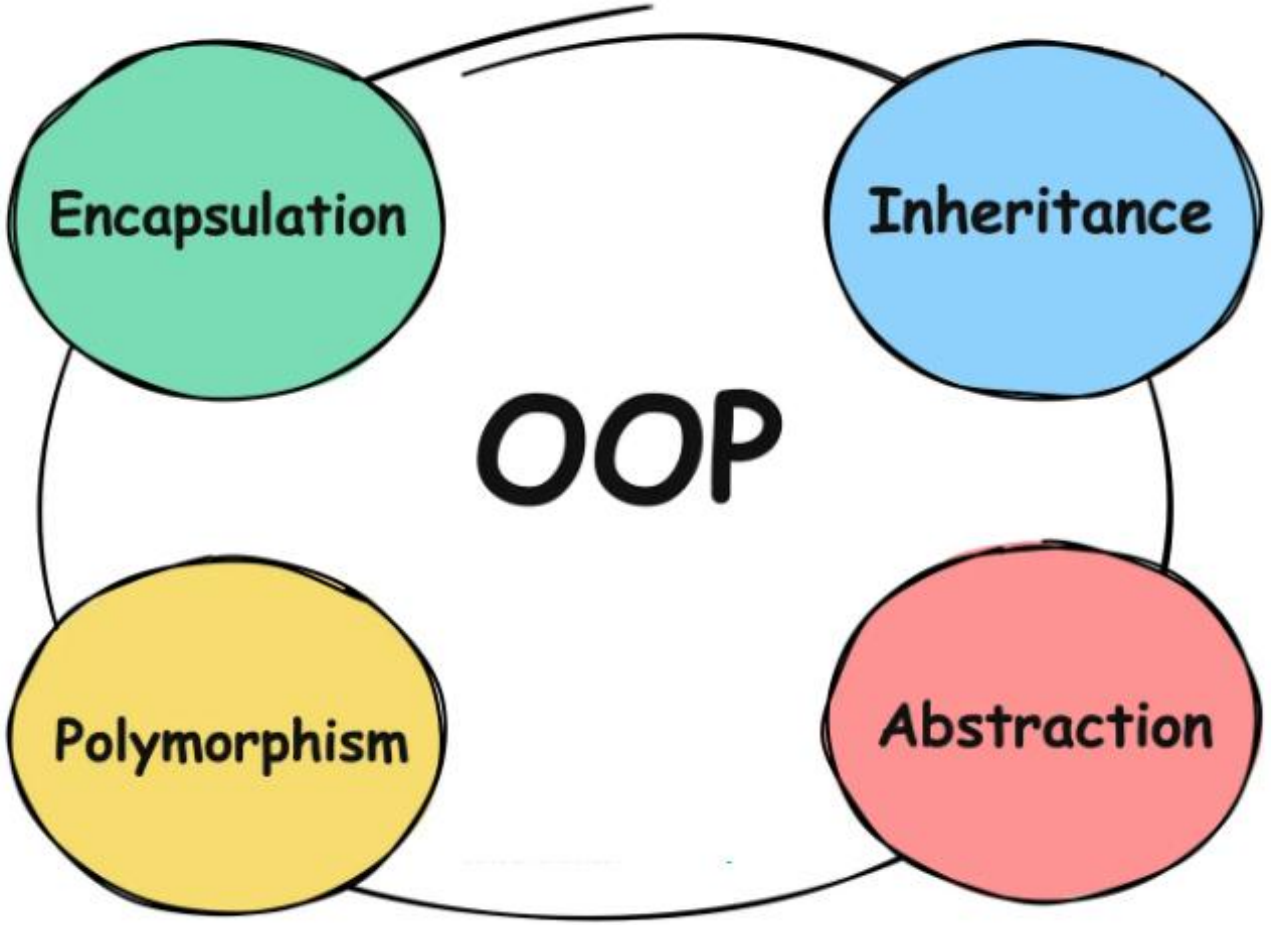
Object

- An **instance** of a class
- Has its own **state** (= attribute values)
- Example:

```
c = Circle(5)
print(c.area())
```

*"**c** is an object of class **Circle** and its state is defined by a radius of 5"*

The 4 Main Features of Object-Oriented Programming



The 4 Main Features of Object-Oriented Programming

1. **Encapsulation**
   - **Bundling data** (attributes) **and behavior** (methods) inside a single unit (class).
   - Controls access to internal details, exposing only what's necessary.
2. **Inheritance**
   - Creating new classes based on existing ones, **reusing and extending functionality**.
   - Example: the circle class could inherit from a cilinder class and adopt the area method
3. **Polymorphism**
   - Same interface, **different implementations**.
   - Example: the area method is implemented for circle and cilinder classes each with its own logic.
4. **Abstraction**
   - Hiding implementation details and showing only the **essential interface**.
   - Example: you call the area method from a circle object without worrying about the formula

Encapsulation

Definition:

Encapsulation means bundling data and methods inside a class and restricting direct access to some attributes to protect the integrity of the data.

Example:

```python
class BankAccount:
    def __init__(self, balance):
        self.__balance = balance  # private attribute

    def deposit(self, amount):
        self.__balance += amount

    def get_balance(self):
        return self.__balance

account = BankAccount(100)
account.deposit(50)
print(account.get_balance())  # Output: 150
```

Inheritance

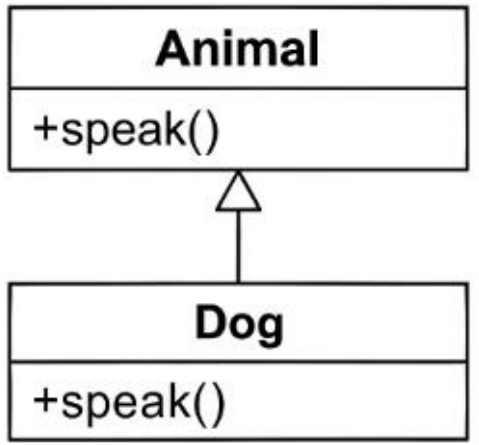
Definition:

Inheritance allows a class to acquire properties and methods from another class, promoting code reuse.

Example:

```
1  class Animal:
2      def speak(self):
3          print("I am an animal")
4
5  class Dog(Animal):
6      def speak(self):
7          print("Woof!")
8
9  dog = Dog()
10 dog.speak()  # Output: Woof!
```

UML Class Diagram



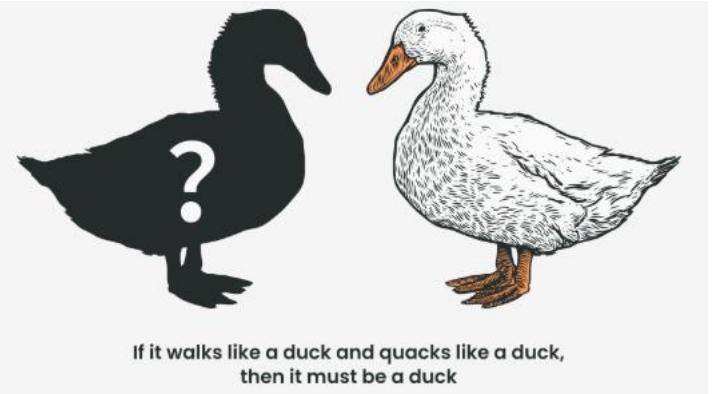
Polymorphism

Definition:

Polymorphism means the same method name can behave differently depending on the object.

Example:

```
1  class Cat:
2      def speak(self):
3          return "Meow"
4
5  class Dog:
6      def speak(self):
7          return "Woof"
8
9  def animal_sound(animal):
10     print(animal.speak())
11
12 animal_sound(Cat())  # Output: Meow
13 animal_sound(Dog())  # Output: Woof
```



Abstraction

Definition:

Abstraction hides complex implementation details and exposes only the essential features. This is often done using **abstract base classes** (which is out of scope).

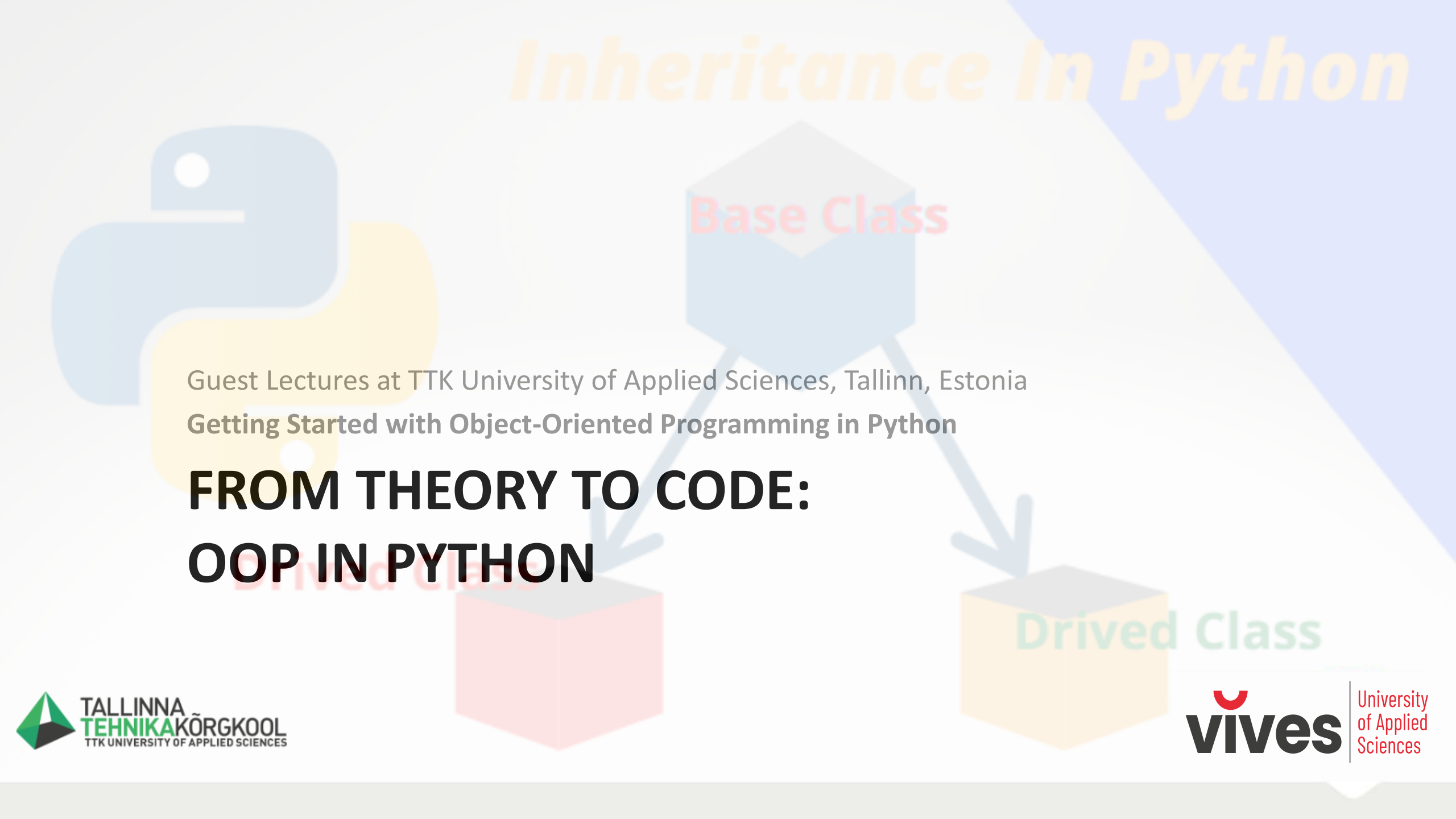
Example:

```python
from abc import ABC, abstractmethod

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

class Circle(Shape):
    def __init__(self, radius):
        self.radius = radius

    def area(self):
        return 3.14 * self.radius ** 2

circle = Circle(5)
print(circle.area())  # Output: 78.5
```

Why Use Object-Oriented Programming?

- **Why OOP?**
  - Organizes code into **classes and objects**, making it easier to manage.
  - Models real-world entities, improving **readability and understanding**.

- **Key Benefits:**
  - **Reusability**: Use existing classes through inheritance.
  - **Maintainability**: Easier to update and extend code.
  - **Encapsulation**: Keeps data and behavior together, reducing complexity.
  - **Scalability**: Ideal for large applications with many interacting components.



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FROM THEORY TO CODE: OOP IN PYTHON

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Defining Classes and Creating Objects

Explanation:

In Python, classes are created using the `class` keyword.

Objects are instances of classes.

Code example:

```python
# Define a class
class Car:
    def __init__(self, brand, model):
        self.brand = brand
        self.model = model

# Create an object
my_car = Car("Tesla", "Model 3")
print(my_car.brand)  # Output: Tesla
```

Constructor and Attributes

Explanation:

The `__init__` method acts as a constructor and initializes object attributes when an instance is created.

Code example:

```python
class Student:
    def __init__(self, name, age):
        self.name = name
        self.age = age

student = Student("Alice", 21)
print(student.name, student.age)  # Output: Alice 21
```

Methods in Python Classes

Explanation:

Methods are functions that belong to a class and are defined using the `def` keyword.

- **Instance methods**: Operate on object attributes and require `self`
- **Static methods**: Don't require `self` as they don't need object attributes; use `@staticmethod`

Code example:

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

    def greet(self):  # instance method
        return "Hello, my name is " + self.name

    @staticmethod
    def info():  # static method
        return "I am a person."

# Usage
p = Person("Alice")
print(p.greet())       # Output: Hello, my name is Alice
print(Person.info())   # Output: I am a person.
```

Access Modifiers

Explanation:

Python uses naming conventions for access control:

- **Public**: `self.attribute`
- **Private**: `self.__attribute`

Code example:

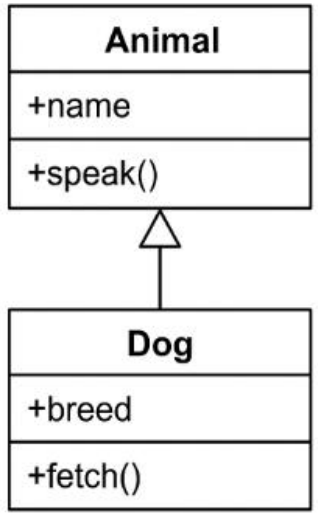
```python
class BankAccount:
    def __init__(self, owner, balance):
        self.owner = owner          # public
        self.__balance = balance    # private

    def deposit(self, amount):
        self.__balance += amount

# Usage
account = BankAccount("Alice", 100)
print(account.owner)          # OK
# print(account.__balance)    # Error: Attribute is private
account.deposit(50)
```

Inheritance

Explanation:

Inheritance allows a subclass to reuse attributes and methods from a superclass. The subclass can **add new attributes or methods** beyond what is inherited.

Code example:




```python
# Parent class
class Animal:
    def __init__(self, name):
        self.name = name

    def speak(self):
        print(self.name + " makes a sound.")

# Child class (inherits from Animal)
class Dog(Animal):
    def __init__(self, name, breed):
        super().__init__(name)  # Call parent constructor
        self.breed = breed      # New attribute

    def fetch(self):
        print(self.name + " is fetching the ball!")
        print("Breed: " + self.breed)

# Usage
dog = Dog("Buddy", "Golden Retriever")
dog.speak()   # Inherited method
dog.fetch()   # New method
```

- Use `class Child(Parent):` to inherit.
- `super().__init__()` calls the parent constructor.
- Subclass can add **extra attributes** and **methods**.

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More than one subclass

Explanation:

A superclass can have **multiple subclasses**, each of which can have its own subclasses.

Code example:

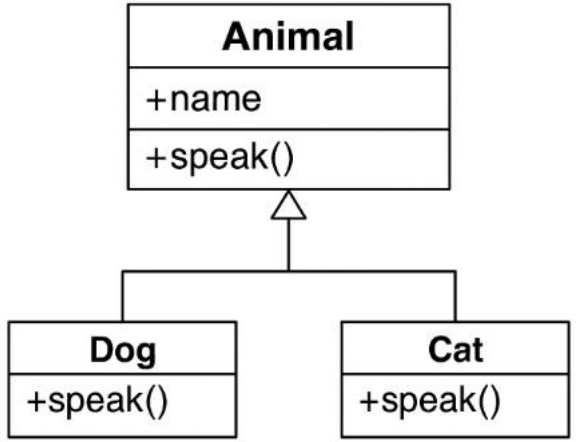
```python
# Parent class
class Animal:
    def __init__(self, name):
        self.name = name

    def speak(self):
        print(self.name + " makes a sound.")

# First child class
class Dog(Animal):
    def speak(self):
        print(self.name + " barks!")

# Second child class
class Cat(Animal):
    def speak(self):
        print(self.name + " meows!")

# Usage
dog = Dog("Buddy"); dog.speak()  # Buddy barks!
cat = Cat("Whiskers"); cat.speak()  # Whiskers meows!
```



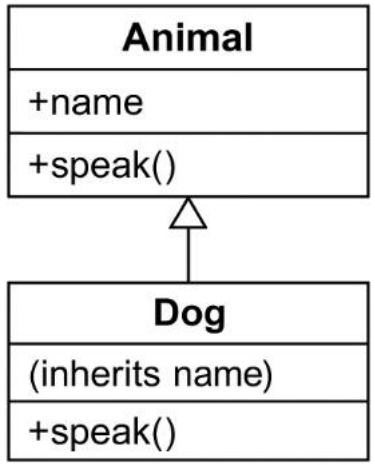
Subclasses override the `speak` method

Method overriding

Explanation:

A subclass can **redefine a method** from its parent class. The new method replaces the inherited one when called on the child object.

Code example:




```python
# Parent class
class Animal:
    def __init__(self, name):
        self.name = name

    def speak(self):
        print(self.name + " makes a sound.")

# Child class overrides speak()
class Dog(Animal):
    def speak(self):
        super().speak()  # Call parent method
        print(self.name + " barks!")  # Custom behavior

# Usage
animal = Animal("Generic Animal"); animal.speak()  # Generic Animal makes a sound.
dog = Dog("Buddy"); dog.speak()  # Buddy makes a sound. Buddy barks!
```

- `self` refers to the current object instance.
- `super().method()` calls the parent's implementation.
- Overriding allows **custom behavior** for subclasses.

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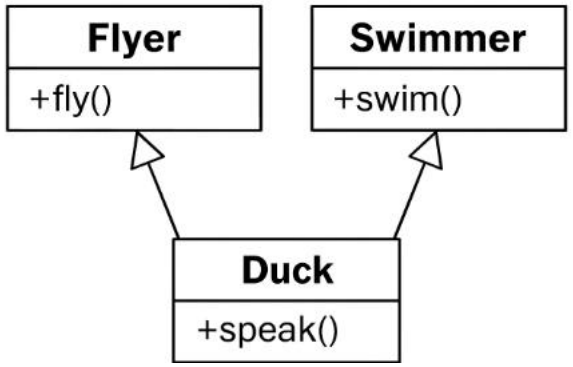
Multiple inheritance

Explanation:

A class can inherit from **more than one parent class**. This allows combining functionality from multiple sources. But use with care as it can lead to complexity!

Code example:




```python
# First parent class
class Flyer:
    def fly(self):
        print("I can fly!")

# Second parent class
class Swimmer:
    def swim(self):
        print("I can swim!")

# Child class inherits from both
class Duck(Flyer, Swimmer):
    def speak(self):
        print("Quack!")

# Usage
duck = Duck()
duck.fly()    # I can fly!
duck.swim()   # I can swim!
duck.speak()  # Quack!
```

- Syntax: `class Child(Parent1, Parent2):`
- Methods from both parents are available in the child.

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OOP IN PYTHON: EXERCISES

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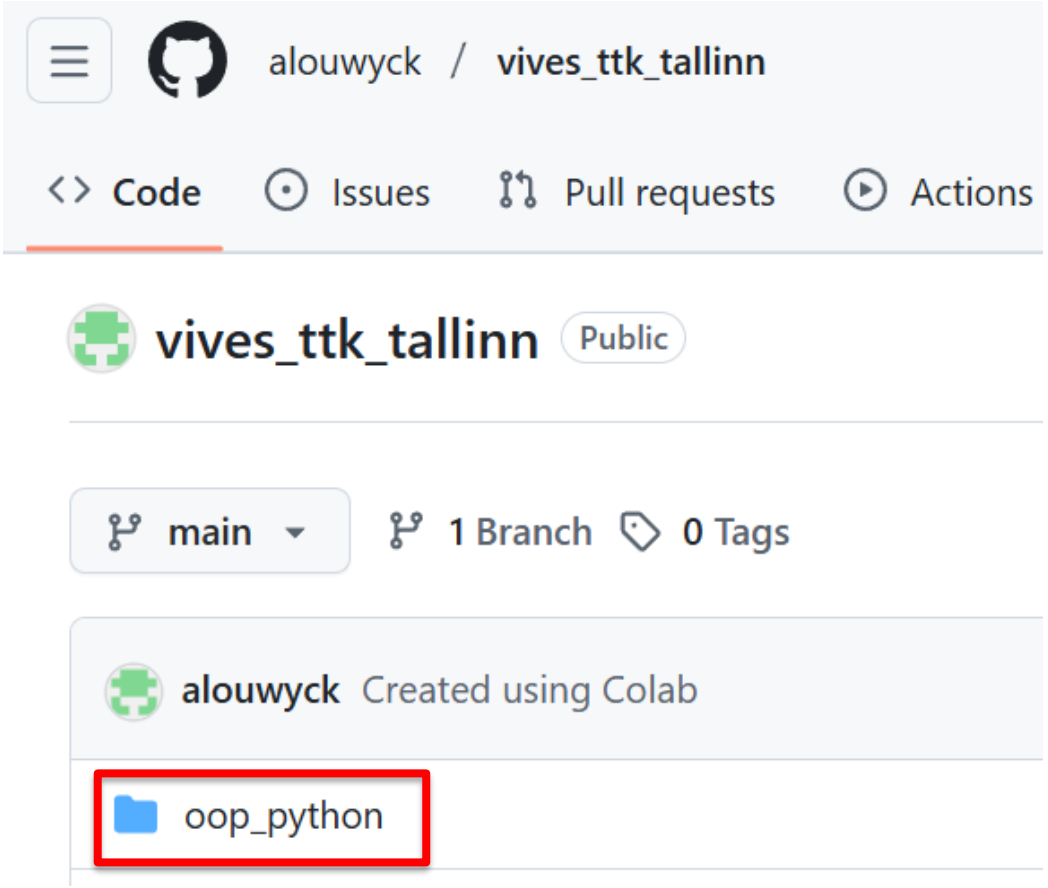
GitHub Repo

https://github.com/alouwyck/vives_ttk_tallinn



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Sources

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- https://www.geeksforgeeks.org/python/python-classes-and-objects
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