



Introduction to Scientific Computation

Lecture 5

Fall 2022

OOP, Python modules, C/C++ in python

OOP

is a programming **paradigm**.

- Imperative programming
 - Object-oriented
 - Procedural
- Declarative programming
 - Functional
 - Logic

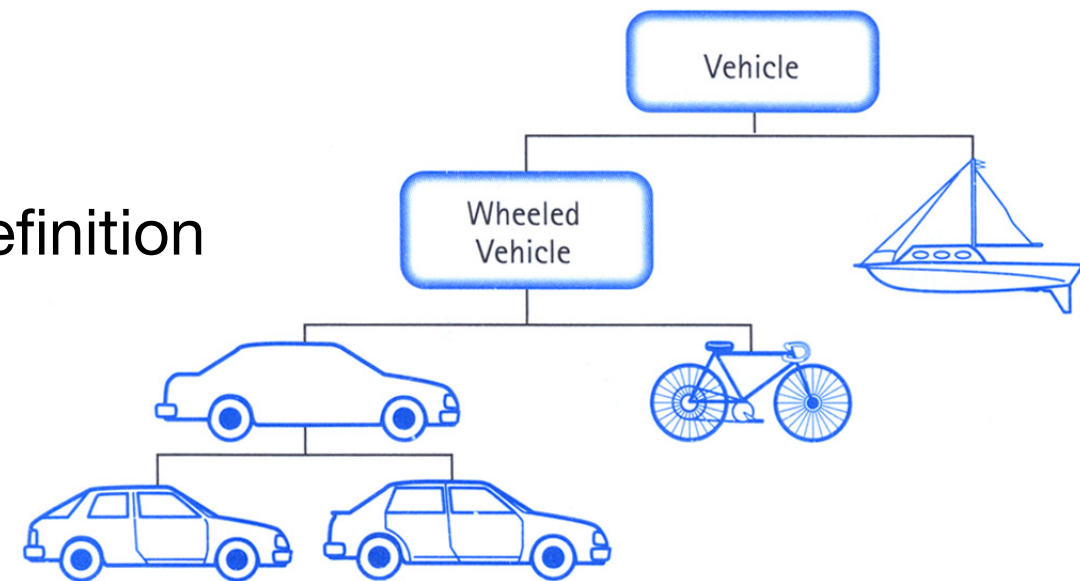
OOP

is good:

- **DRY** do not repeat yourself
- **KIS(S)** keep is simple

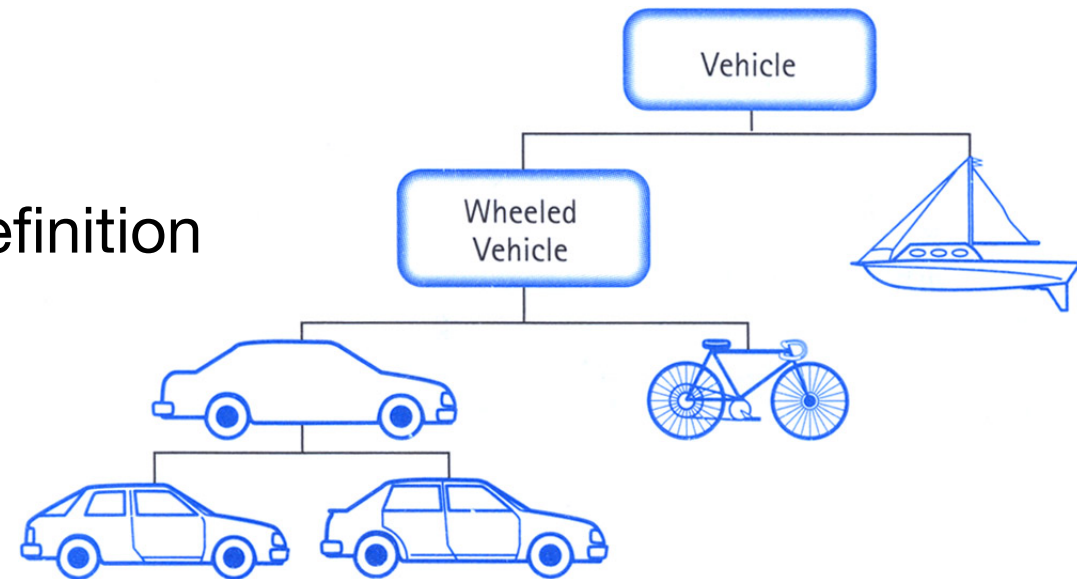
OOP

- Everything is an object
- Object properties are defined by its class definition
- Relations! Relations! Relations! matter



OOP

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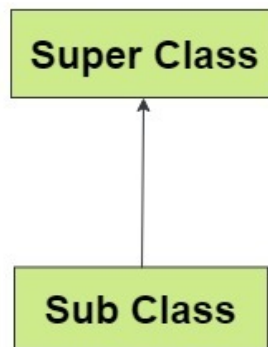
3 main principles

- Inheritance
- Encapsulation
- Polymorphism

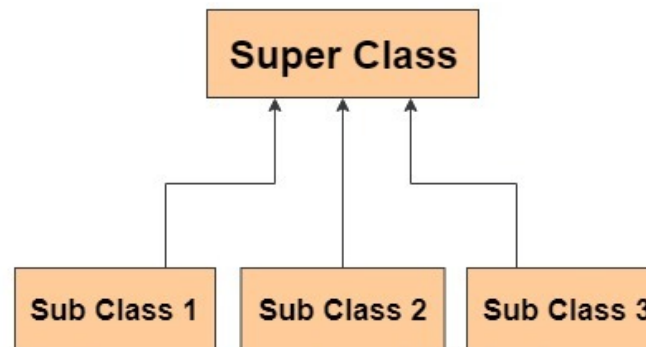
Inheritance

- Possibility to define new classes based on existing

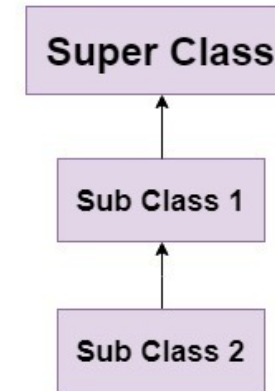
Single Inheritance



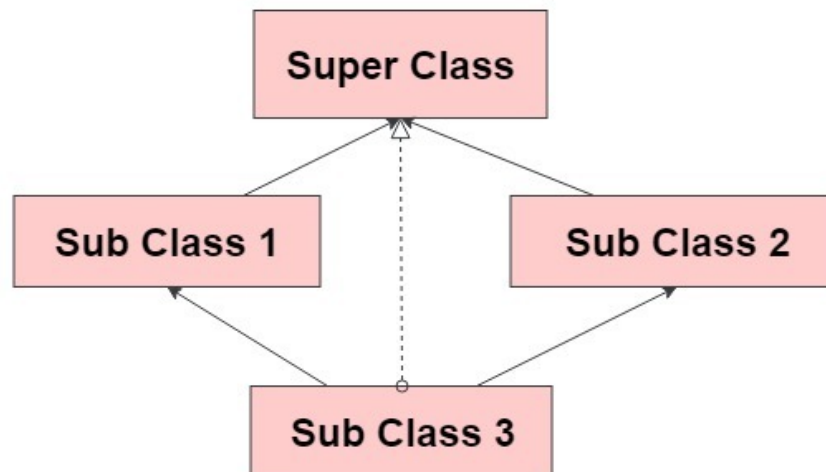
Hierarchial Inheritance



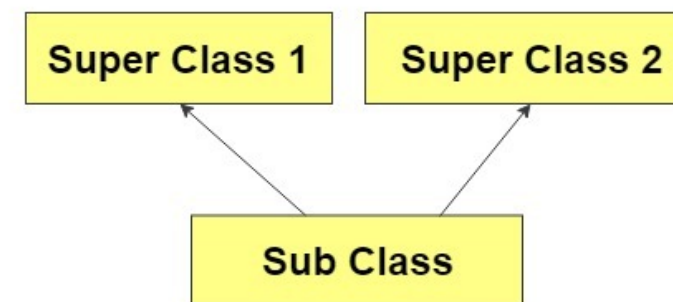
MultiLevel Inheritance



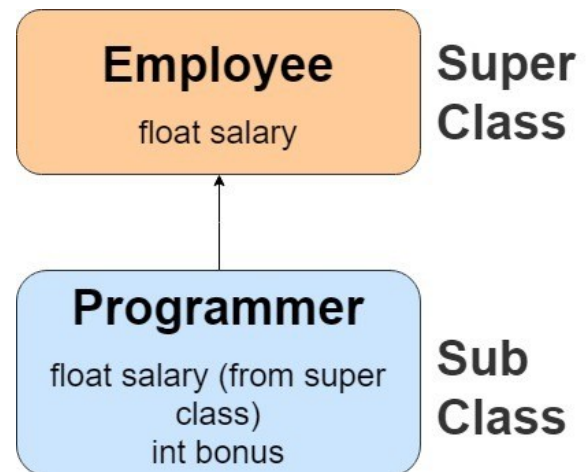
Hybrid Inheritance



Multiple Inheritance



Inheritance

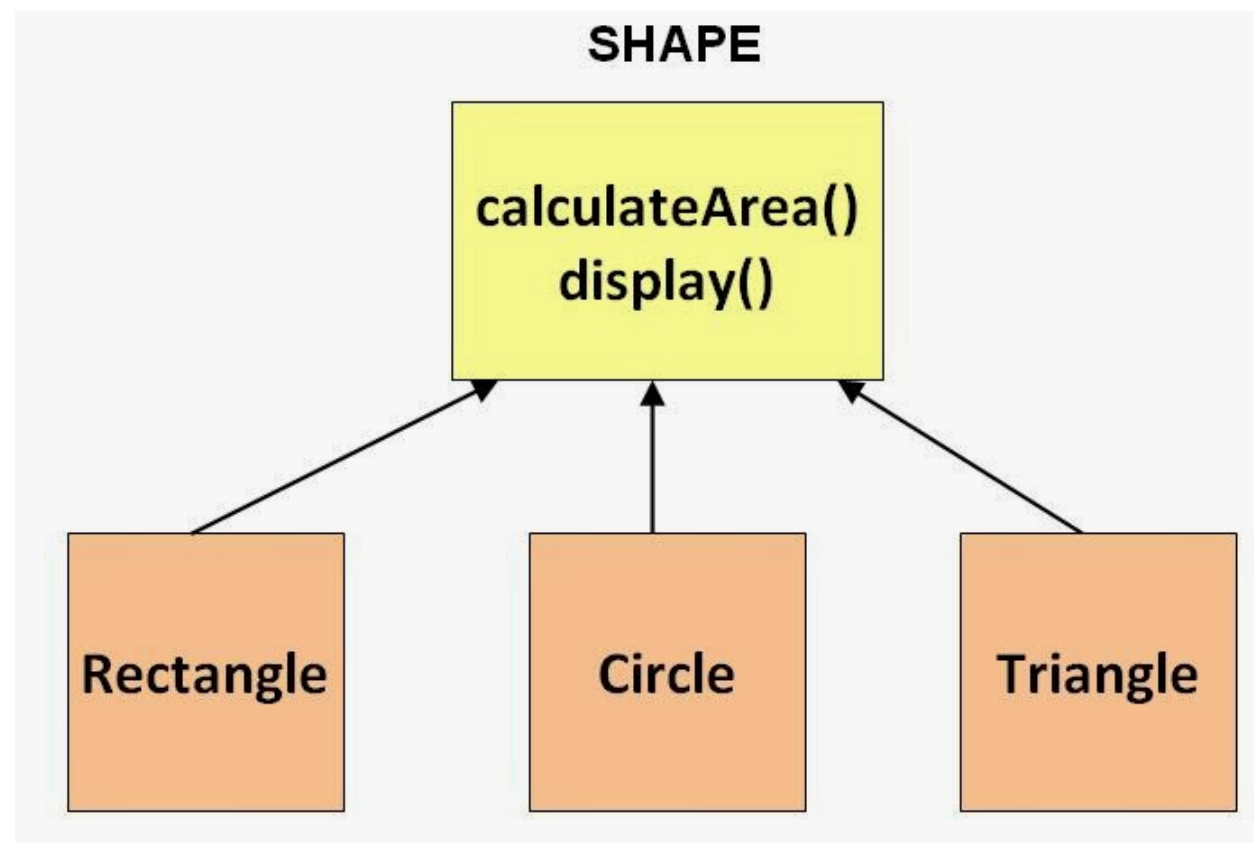


Encapsulation

- All object properties are stored privately
- There should exist methods for accessing the properties
- Implementation details are hidden to provide abstraction
- Abstraction should not leak the implementation details

Polymorphism

- Different classes might (re)-implement abstract inherited method on their own



Advanced OOP

- Multiple inheritance
 - Monkey patching
 - Abstract base classes
 - Metaclasses
-
- In the most cases you do not need these... (KISS)

Multiple inheritance: method resolution order

C3 Linearization Algorithm

enforces following 2 constraints

- Children precede their parents
- If a class inherits from multiple classes, they are kept in the order specified in the tuple of the base class.

Also known as C3 super-class linearization, it is based on 3 rules

- Consistent extended precedence graph, which in short means how base class is extended from the super class. Inheritance graph determines the structure of method resolution order.
- Preserving local precedence ordering, i.e., visiting the super class only after the method of the local classes are visited.
- Monotonicity

```

In [12]: o = object

class A(o): pass

class B(o): pass

class C(A,B) : pass

class D(B,A): pass

class E(C,D): pass

-----
TypeError                                Traceback (most recent call last)
<ipython-input-12-aaa942304035> in <module>
    15
    16
--> 17 class E(C,D): pass

TypeError: Cannot create a consistent method resolution
order (MRO) for bases A, B

```

Multiple inheritance: method resolution order

1. $C_1 C_2 C_3 \dots C_N$ are the elements of the list of classes $[C_1, C_2, C_3 \dots C_N]$
2. Head of the list is the first element C_1
3. Tail of the list is the rest of the list $C_2 \dots C_N$
4. The sum of the lists $[C] + [C_1, C_2 \dots C_N] = C + (C_1 C_2 \dots C_N) = C C_1 C_2 \dots C_N$

the linearization of C is the sum of C + the merge of the linearizations of the parents and list of parents.

$L[C(B_1 \dots B_N)] = C + \text{merge}(L[B_1] L[B_2] \dots L[B_N])$

$L[\text{object}] = \text{object}$

Merge:

- take the head of the first list, i.e. $L[B_1][0]$;
- if this head is not in the tail of any of the other lists, then add it to the linearization of C and remove it from the lists in the merge, otherwise look at the head of the next list and take it, if it is a good head.
- Then repeat the operation until all the class are removed or it is impossible to find good heads.

$L[B(A)] = B + \text{merge}(L[A], A)$

$L[B(A)] = B + L[A]$

$L[B(A)] = B + A + L[\text{object}]$

Monkey patching

```
# monk.py
class A:
    def func(self):
        print "func() is being called"

import monk
def monkey_f(self):
    print "monkey_f() is being called"

# replacing address of "func" with "monkey_f"
monk.A.func = monkey_f
obj = monk.A()

# calling function "func" whose address got replaced
# with function "monkey_f()"
obj.func()
```

Abstract class

- Abstract class is a class with at least one abstract method
 - Abstract class cannot be instantiated
 - Classes inheriting from Abstract class must implement all its abstract methods
-
- See abc module in python

```
from abc import ABC, abstractmethod

class AbstractClassExample(ABC):

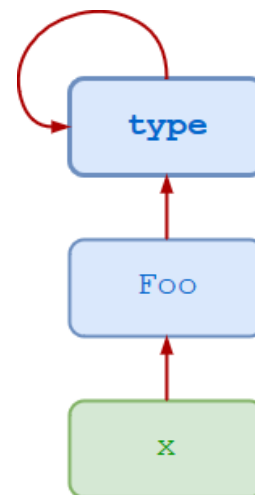
    @abstractmethod
    def do_something(self):
        print("Some implementation!")

class AnotherSubclass(AbstractClassExample):
    def do_something(self):
        super().do_something()
        print("The enrichment from AnotherSubclass")

x = AnotherSubclass()
x.do_something()
```


Metaclass

- Class of class class is class class ...



Pattern

Design Patterns are typical solutions to commonly occurring problems in software **design**. They are blueprints that can be taken and customised to solve a particular **design** problem in your code.

Decorator

A decorator is the name used for a software design pattern. Decorators dynamically alter the functionality of a function, method, or class without having to directly use subclasses or change the source code of the function being decorated.

```
def my_decorator(func):  
    def wrapper():  
        print("Something is happening before the function is called.")  
        func()  
        print("Something is happening after the function is called.")  
    return wrapper  
  
@my_decorator  
def say_whee():  
    print("Whee!")
```

Modules

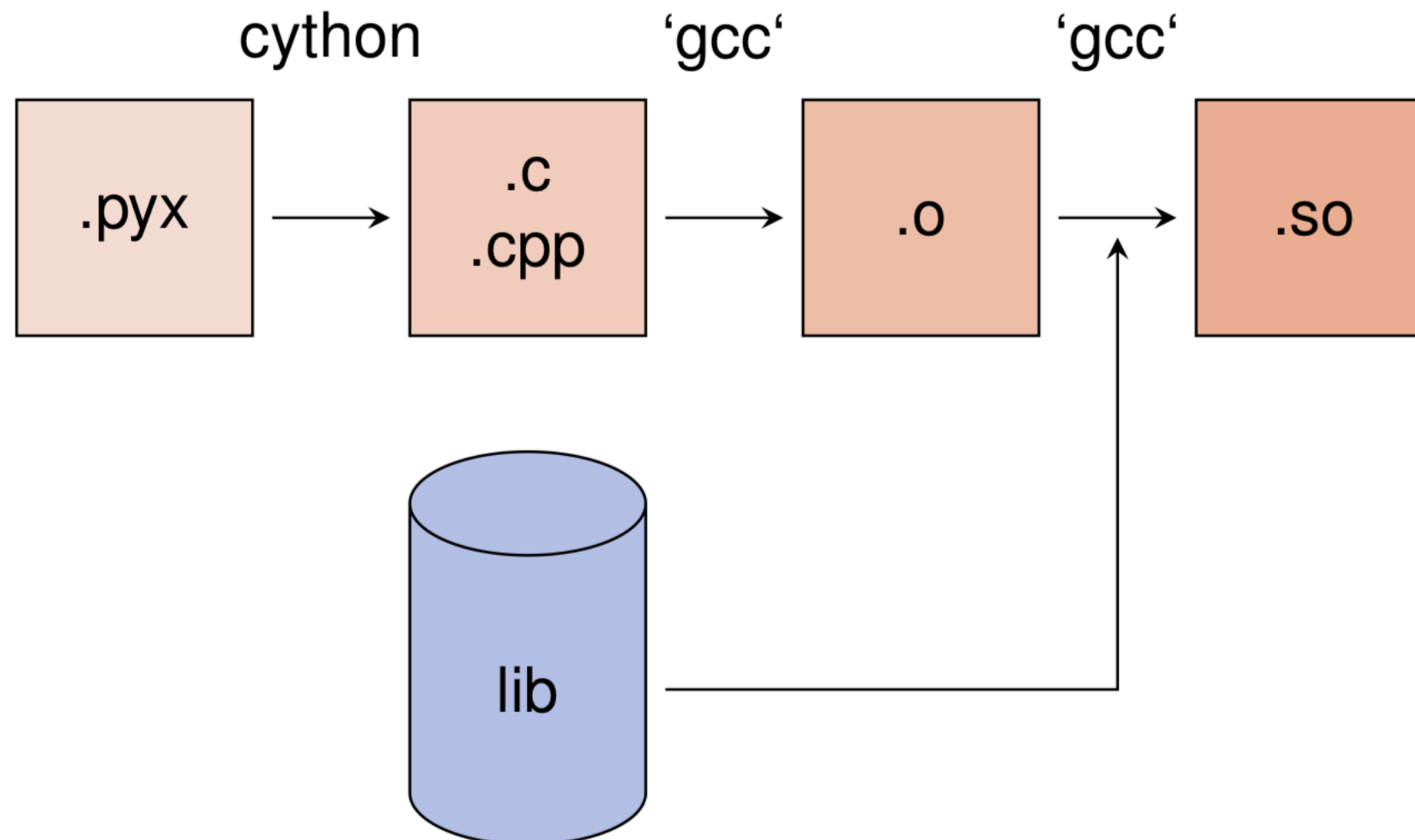
- Each .py file in python is a module
- It contains Python statements and definitions
- `__name__` is the global variable with might be used inside the module to find out its name
- `sys.path` contains search directories for modules
- It is initialised with the current directory and `PYTHON_PATH`
- `__init__.py` file is required to make python treat directory as containing modules

C/C++ bindings

- Cython
- SWIG
- Pybind11

Cython

- A hybrid programming language/compiler
- Python statements are valid
- You have to provide argument types



SWIG

- Simplified Wrapper and Interface Generator
- You have to define interface files, the rest SWIG will do for you

