

Object Oriented Programming

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Organizing data

- Lists:

```
vectors_x = [0, 1, 2]
vectors_y = [0, 1, 1]
>>> (vectors_x[2], vectors_y[2])
(2, 1)
```

- Nested lists:

```
vectors = [[0, 0], [1, 1], [2, 1]]
>>> vectors[2]
[2, 1]
```

- Dictionaries:

```
vectors = [{'x': 0, 'y': 0},
            {'x': 1, 'y': 1},
            {'x': 2, 'y': 1}]
>>> vectors[2]
{'y': 1, 'x': 2}
```

Everything is an object

- Python supports many different kinds of data:

42 3.14159 'Hello World!' [1, 1, 2, 3, 5, 8]
{ 'name': 'Jack', 'age': 25 } True

- every object has:
 - a type;
 - an internal data representation (primitive or composite);
 - a set of procedures (functions) for interaction.
- an object is an instance of a type:
 - 42 is an instance of type `int`;
 - 'Hello World!' is an instance of type `str`.

Object oriented programming

- **create** new objects;
- **manipulate** objects;
- **destroy** objects:
 - explicitly **del**;
 - or just “forget” about them: Python will destroy inaccessible objects in a process called **garbage collection**.

Objects are **data abstraction**:

1. internal data representation using **attributes** (member variables);
2. an interface (for interaction):
 - procedures (member functions);
 - defines behaviour, but hides implementation.

Working with objects

1. creating a `class`:

- define the `class` name;
- define the `class` attributes (member functions).

2. using the `class`:

- create new `instances` of a class;
- manipulating these instances.

Define your own types

Use the keyword `class` to define a new type:

- with as parent the `object` type;
- and `Vector` as name.

```
class Vector(object):  
    """2d vector class."""  
  
    def __init__(self, x=0, y=0):  
        """Initializes a new 2d vector; default: (0, 0)."""  
        self.x = x  
        self.y = y
```

More on attributes

Data and procedures (functions) that “belong” to the class:

- **Data** attributes: the objects that make up the class:
 - a 2d vector is made up of two numbers (x and y).
- **Methods** (procedures):
 - functions that *only* work with this class;
 - how to interact with the object;
 - e.g., calculate the length of a vector.

`self` is the current instance of a class.

`def __init__(self, ...)` is a special method to create new instances of a class.

Creating an instance of a class

```
origin = Vector()  
v1 = Vector(2, 1)  
print(v1.x, origin.y)
```

- don't provide anything for the `self` argument; Python does that automatically;
- use the `dot` to access an attribute of an instance;
- `.x` is a member variable.

Hiding information — separation of concerns

- Sometimes we would like to **hide** attributes to the outside world, i.e., only usable inside the class.
- in Python we prefix an attribute with `_` (underscore) to make it **private**:

```
class Vector(object):  
    def __init__(self, x=0, y=0):  
        self.x = x  
        self.y = y  
        self._secret = 42      # this is allowed
```

- we agree not to access this attribute directly:

```
>>> v1 = Vector(1, 2)  
>>> print(v1._secret)      # this is forbidden
```

Add a method to the Vector class

```
class Vector(object):  
    def __init__(self, x=0, y=0):  
        self.x = x  
        self.y = y  
  
    def distance(self, other):  
        dx = (self.x - other.x) ** 2  
        dy = (self.y - other.y) ** 2  
        return (dx + dy) ** .5
```

To use the newly created method:

```
origin.distance(v1)
```

Print representation of an object

```
>>> v1 = Vector(4, 3)
>>> print(v1)
<__main__.Vector object at 0x7f41ab878450>
```

- per default **uninformative**;
- define the special method `def __str__(self);`
- Python class the `__str__` method automatically when using the `print` function;
- we are in control of what is printed, e.g., for the vector class:

```
>>> print(v1)
<4, 3>
```

Own print method

The `__str__` function must return a string.

```
class Vector(object):
    def __init__(self, x=0, y=0):
        self.x = x
        self.y = y

    def distance(self, other):
        dx = (self.x - other.x) ** 2
        dy = (self.y - other.y) ** 2
        return (dx + dy) ** .5

    def __str__(self):
        return '<' + str(self.x) + ', ' + str(self.y) + '>'
```

More on types

- get the type of an instance:

```
>>> v1 = Vector(4, 3)
>>> print(type(v1))
<class '__main__.Vector'>
```

- that also works for the class:

```
>>> print(type(Vector))
<type 'type'>
```

- use `isinstance()` to check if an object is a vector:

```
>>> print(isinstance(v1, Vector))
True
```

- what happens here:

```
>>> print(v1.distance(4))
```

Special operators

- define special operators like: `+`, `-`, `==`, `<`, `>`, `len()`, ... see: <https://docs.python.org/3/reference/datamodel.html#basic-customization>
- these can be **overloaded** to work with your class (keep it sensible);
- using the double underscore notation:

```
__add__(self, other)    # self + other
__sub__(self, other)    # self - other
__eq__(self, other)     # self == other
__lt__(self, other)     # self < other
__len__(self)           # len(self)
```

Example of an overloaded operator

```
class Vector(object):  
    ...  
  
    def __add__(self, other):  
        return Vector(self.x + other.x, self.y + other.y)  
  
>>> v1 = Vector(1, -6)  
>>> v2 = Vector(3, 4.5)  
>>> print(v1 + v2)  
<4, -1.5>
```

The power of OOP

- **Bundle** together objects that share:
 - common (data) attributes;
 - methods that manipulate these attributes.
- **Abstract away** implementation by specifying interfaces and behaviour;
- Use **inheritance** (not covered here) to give an even nicer (layered) abstraction;
- **Create** own data type on top of what Python provides;
- **Reuse** code: wrapping code in classes prevents collision of function names;
- Many **libraries** heavily use classes.

Questions?

Assignment

```
class Fraction(object):  
    def __init__(self, numerator, denominator=1):  
        self.numerator = numerator  
        self.denominator = denominator
```

Use the skeleton to implement a **Fraction** type containing two integers: numerator and denominator.

- add, subtract, e.g., $\frac{1}{2} + \frac{2}{3} = \frac{7}{6}$;
- print representation, convert to **float**;
- invert a fraction;
- ...

see: <https://github.com/lumc-python/oop>

or go directly to: <https://classroom.github.com/a/8BnbL9fD>