

Python

Object-Oriented Programming (OOP)

Thanks to all contributors:

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Computer science is the study of algorithms



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Computer science is the study of algorithms

Computer *programming* is about creating and
composing *abstractions*



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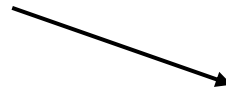
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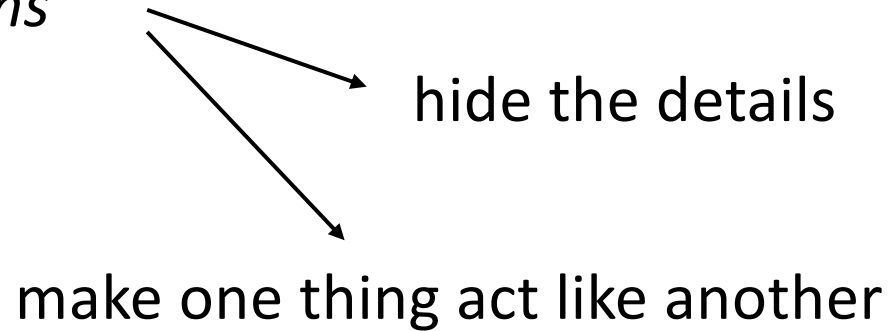
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hide the details

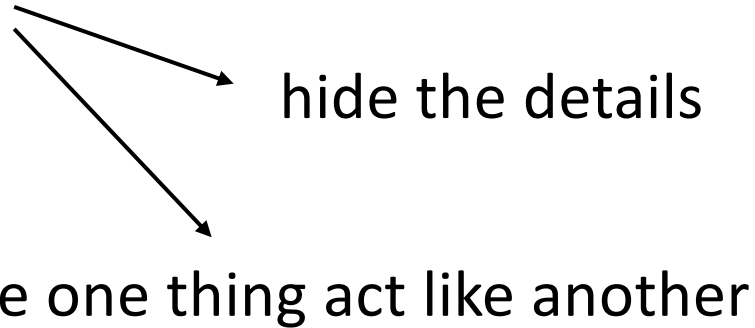
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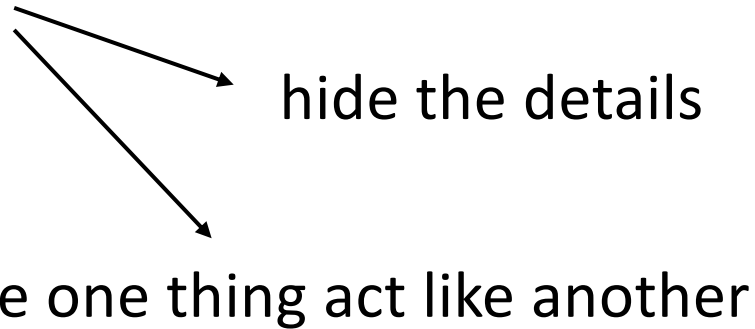
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Functions turn many steps into one (logical) step

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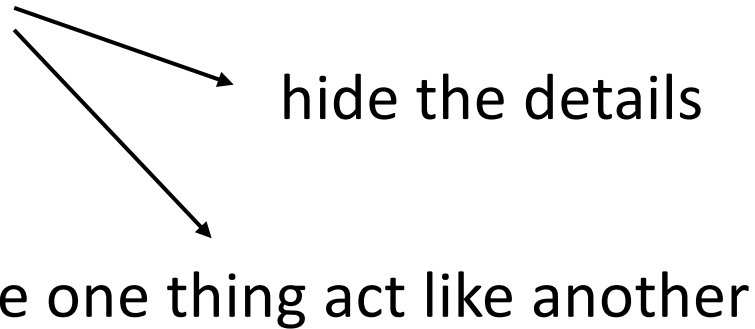


Functions turn many steps into one (logical) step

Libraries group functions to make them manageable

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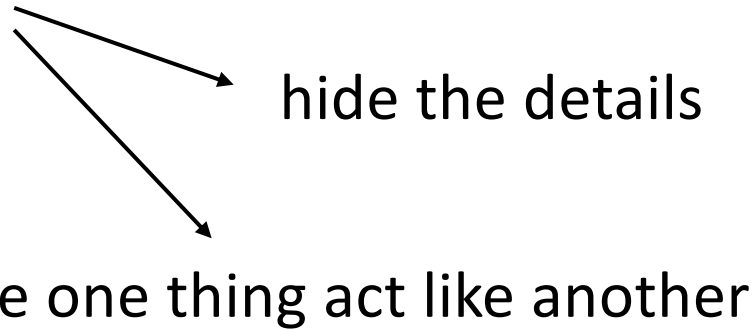
Functions turn many steps into one (logical) step

Libraries group functions to make them manageable

Classes and objects combine functions and data

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Functions turn many steps into one (logical) step

Libraries group functions to make them manageable

Classes and objects combine functions and data

And, if used properly, do much more as well

Let's see how OOP is useful in everyday Python:

```
>>> s = "some silly string"
>>> s.upper()
'SOME SILLY STRING'
>>> s.find("t")
12
>>> s.replace("silly", "sensible").title()
'Some Sensible String'
```

And you can actually interrogate this **object** s to find out their **methods**:

```
>>> dir(s)
['_add_', '__class__', '__contains__', '__delattr__', '__dir__',
 '__doc__', '__eq__', '__format__', '__ge__', '__getattribute__',
 '__getitem__', '__getnewargs__', '__gt__', '__hash__', '__init__',
 '__init_subclass__', '__iter__', '__le__', '__len__', '__lt__',
 '__mod__', '__mul__', '__ne__', '__new__', '__reduce__',
 '__reduce_ex__', '__repr__', '__rmod__', '__rmul__', '__setattr__',
 '__sizeof__', '__str__', '__subclasshook__', 'capitalize', 'casefold',
 'center', 'count', 'encode', 'endswith', 'expandtabs', 'find',
 'format', 'format_map', 'index', 'isalnum', 'isalpha', 'isascii',
 'isdecimal', 'isdigit', 'isidentifier', 'islower', 'isnumeric',
 'isprintable', 'isspace', 'istitle', 'isupper', 'join', 'ljust',
 'lower', 'lstrip', 'maketrans', 'partition', 'replace', 'rfind',
 'rindex', 'rjust', 'rpartition', 'rsplit', 'rstrip', 'split',
 'splitlines', 'startswith', 'strip', 'swapcase', 'title', 'translate',
 'upper', 'zfill']
```

And you can find out which **class** *s* is an **instance** of:

```
>>> type(s)  
<class 'str'>
```

OOP Terminology (1)

class

Tell Python the definition of a new object.

object

Two meanings: the most basic type of thing, and any instance of a class.

instance

What you get when you tell Python to create a variable of given class.

def

How you define a method of a class.

self

Inside the methods in a class, self is a variable for the instance/object being accessed.

You can build your own **class** for your own domain:

```
class FileAnalyser():  
    """A class above the rest"""  
  
    def __init__(self, path):  
        items = open(path).read().split()  
        self.data = []  
        for item in items:  
            self.data.append(float(item))  
  
    def max(self):  
        return max(self.data)  
  
    def mean(self):  
        return sum(self.data) / len(self.data)
```

Then create an **instance** of your **class** and use it:

```
$ cat some_data.txt Inside the data file...
```

```
1000 750 500 250 0
```



some_data.txt

```
$ python
```

```
>>> from myclass import FileAnalyser
```

```
>>> da = FileAnalyser("some_data.txt")
```

```
>>> da.max()
```

```
1000.0
```

```
>>> da.mean()
```

```
500.0
```

You can make use of `help()` on your own class:

```
>>> help(FileAnalyser)
```

```
Help on class FileAnalyser in module myclass:
```

```
class FileAnalyser(builtins.object)
|   FileAnalyser(path)
|
|   A class above the rest
|
|   Methods defined here:
|
|   __init__(self, path)
|       Initialize self.  See help(type(self)) for accurate
signature.
|
|   max(self)
|
|   mean(self)
|
|   -----
|   Data descriptors defined here:
|
|   __dict__
|       dictionary for instance variables (if defined)
|
|   __weakref__
|       list of weak references to the object (if defined)
```


Let's look in detail at our class...:

```
class FileAnalyser():  
    """A class above the rest"""
```

Class Definition:
Defines the class name.

Optionally include a doc
string below.

Let's look in detail at our class...:

```
class FileAnalyser():  
    """A class above the rest"""  
  
    def __init__(self, path):  
        items = open(path).read().split()  
        self.data = []  
        for item in items:  
            self.data.append(float(item))
```

`__init__` is the
"constructor" method:

- Not necessary
- Very useful
- Always called when class is first created.

Let's look in detail at our class...:

```
class FileAnalyser():  
    """A class above the rest"""  
  
    def __init__(self, path):  
        items = open(path).read().split()  
        self.data = []  
        for item in items:  
            self.data.append(float(item))
```

"self" means "belonging to
this instance/object:

- Needed for all attributes
that you want to be visible
to every part of the object
(shared).

Let's look in detail at our class...:

```
class FileAnalyser():  
    """A class above the rest"""  
  
    def __init__(self, path):  
        items = open(path).read().split()  
        self.data = []  
        for item in items:  
            self.data.append(float(item))  
  
    def max(self):  
        return max(self.data)
```

Now we add more methods:

- "self" is always required as first argument.

Let's look in detail at our class...:

```
class FileAnalyser():  
    """A class above the rest"""  
  
    def __init__(self, path):  
        items = open(path).read().split()  
        self.data = []  
        for item in items:  
            self.data.append(float(item))  
  
    def max(self):  
        return max(self.data)  
  
    def mean(self):  
        return sum(self.data) / len(self.data)
```

Examples of OOP

Most python packages use OOP extensively.

We'll come across many examples in the next sessions.

E.g.:

```
from netCDF4 import Dataset
# Create HDF5 *format*, classic *model*
dataset = Dataset('data/test.nc', 'w', format='NETCDF4_CLASSIC')
print(dataset.file_format)
```

A worked example

```
times = []
measurements = []

for i in range(1,32):
    date = f'2021-05-{i}'
    times, measurements = add_measurement(date, i, times, measurements)

# Print the data
print_measurements(times, measurements)
```

A worked example

```
times = []  
measurements = []
```

Set up shared
data containers

A worked example

```
times = []  
measurements = []  
  
for i in range(1,32):  
    date = f'2021-05-{i}'  
    times, measurements = add_measurement(date, i, times, measurements)
```

Re-assign shared state to
take into account
changes

But also shared
state

Pass in data to
add

A worked example

```
times = []  
measurements = []  
  
for i in range(1,32):  
    date = f'2021-05-{i}'  
    times, measurements = add_measurement(date, i, times, measurements)  
  
# Print the data  
print_measurements(times, measurements)
```

Pass in shared
data

A worked example: Using classes

```
temp_store = DataStore()

for i in range(1,32):
    date = f'2021-05-{i}'
    temp_store.add_measurement(date, i)

# Print the temps
temp_store.print_measurements()
```

A worked example: Using classes

```
temp_store = DataStore()
```

Create instance of DataStore
Shared data contained in class
definition

```
for i in range(1,32):
```

```
    date = f'2021-05-{i}'
```

```
    temp_store.add_measurement(date, i)
```

```
# Print the temps
```

```
temp_store.print_measurements()
```

A worked example: Using classes

```
temp_store = DataStore()
```

Create instance of DataStore
Shared data contained in class
definition

```
for i in range(10):  
    date = '2005-01-01-{:02d}'.format(i)
```

No variable
re-assignment

```
    temp_store.add_measurement(date, i)
```

```
# Print the temps
```

```
temp_store.print_measurements()
```

A worked example: Using classes

```
temp_store = DataStore()
```

Create instance of DataStore
Shared data contained in class
definition

```
for i in range(10):  
    temp_store.add_measurement(date, i)
```

No variable
re-assignment

```
temp_store.add_measurement(date, i)
```

Only need to pass in things
to add

```
# Print the temps
```

```
temp_store.print_measurements()
```

A worked example: Using classes

```
temp_store = DataStore()
```

Create instance of DataStore
Shared data contained in class
definition

```
for i in range(10):  
    temp_store.add_measurement('2005-05-01', i)
```

No variable
re-assignment

```
temp_store.add_measurement(date, i)
```

Only need to pass in things
to add

```
# Print the temps
```

```
temp_store.print_measurements()
```

Don't need shared
state

Number of things you need to remember are reduced

OOP Terminology (2)

inheritance

The concept that one class can inherit traits from another class, much like you and your parents.

attribute

A property that classes have that are from composition and are usually variables.

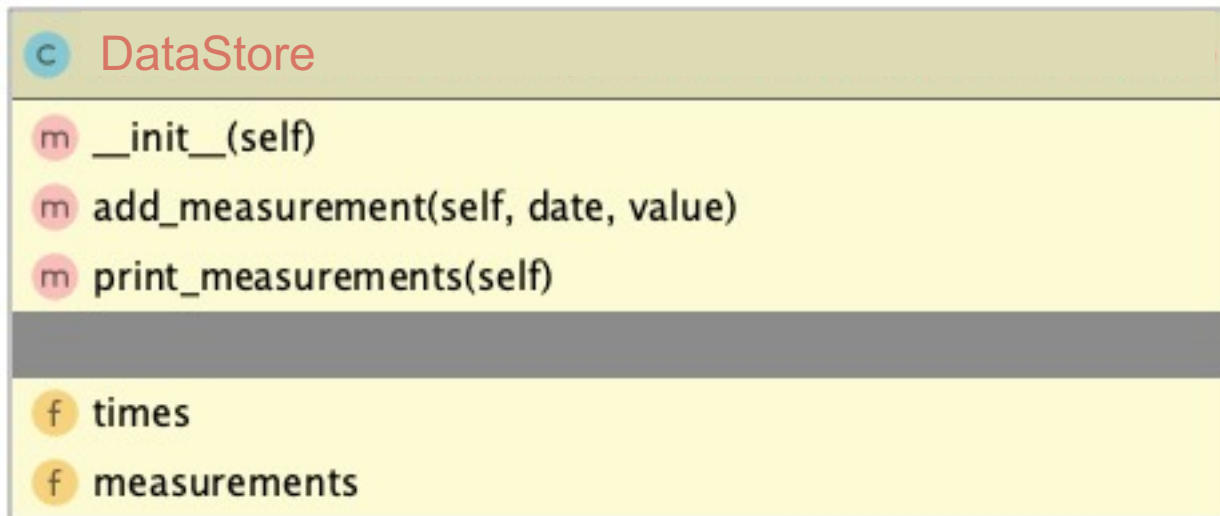
is-a

A phrase to say that something inherits from another, as in a "salmon" is-a "fish."

Inheritance

Classes can inherit from one another

This allows you to share attributes and methods, add, extend, modify.
(very flexible)



Inheritance

Let's make a class which converts Celsius measurements to Kelvin as we add them

```
class TemperatureStore(DataStore):
```

```
    def add_measurement(self, date, value):
```

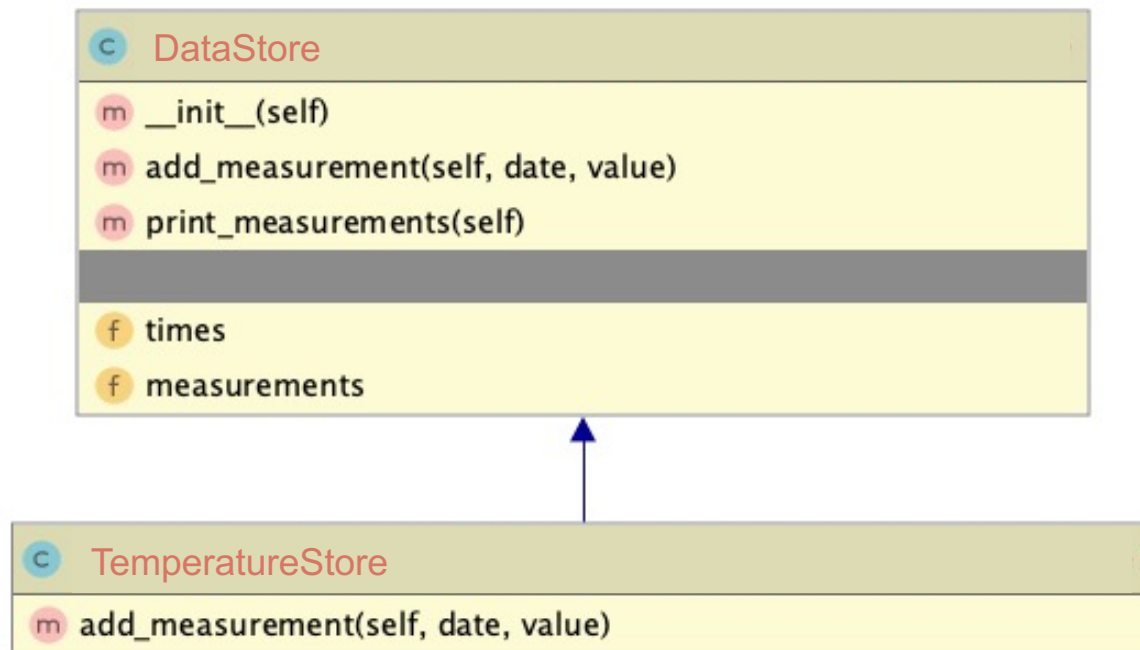
Same method
signature

```
        # Convert to kelvin  
        value += 273.15
```

```
        self.measurements.append(value)  
        self.times.append(date)
```

Still have access to
the class attributes
of DataStore

Inheritance



TemperatureStore **inherits** from DataStore

TemperatureStore **is-a** DataStore

Inheritance

```
>>> from data_store import DataStore
>>> ds = DataStore()
>>> ds.add_measurement('2021-05-01', 5)
>>> ds.print_measurements()
2021-05-01 5
```

```
>>> ts = TemperatureStore()
>>> ts.add_measurement('2021-05-01', 5)
```

Common interface for both
classes

Inheritance

```
>>> from data_store import DataStore
>>> ds = DataStore()
>>> ds.add_measurement('2021-05-01', 5)
>>> ds.print_measurements()
2021-05-01 5
```

```
>>> ts = TemperatureStore()
>>> ts.add_measurement('2021-05-01', 5)
>>> ts.print_measurements()
2021-05-01 278.15
```

Can still use
print_measurements from
DataStore

Inheritance

```
>>> from data_store import DataStore
>>> ds = DataStore()
>>> ds.add_measurement('2021-05-01', 5)
>>> ds.print_measurements()
2021-05-01 5
```

```
>>> ts = TemperatureStore()
>>> ts.add_measurement('2021-05-01', 5)
>>> ts.print_measurements()
2021-05-01 277.15
```

add_measurement from the *TemperatureStore* class overrides behaviour of *DataStore.add_measurement*

Inheritance

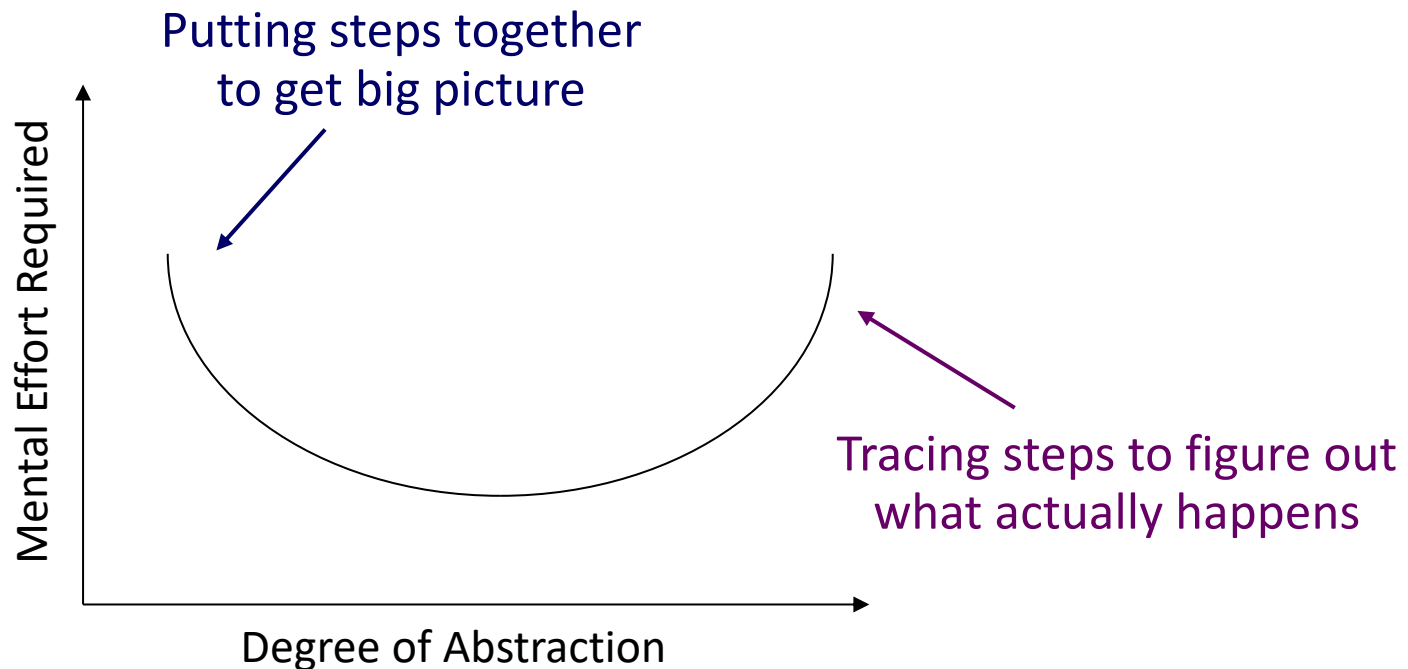
Inheritance is powerful and allows you to write re-useable components

Reducing duplication reduces chance of bugs:

- Code that is repeated in 2 or more places will eventually be wrong in at least one

Inheritance

- Nothing is free
- Simple programs become slightly more complex
- Too much abstraction creates as big a mental burden as too little





Some content created by

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January 2011



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