OBJECT ORIENTED PROGRAMMING

(download slides and .py files from Stellar to follow along!)

6.0001 LECTURE 7

ANA BELL

OBJECTS

- Python supports many different kinds of data

```
1234      3.14159     "Hello"     [1, 5, 7, 11, 13]
{"CA": "California", "MA": "Massachusetts"}
```

- Each is an **object**, and every object has:
  - An internal **data representation** (primitive or composite)
  - A set of procedures for **interaction** with the object
- An object is an **instance** of a **type**
  - `1234` is an instance of an `int`
  - `"hello"` is an instance of a string

OBJECT ORIENTED PROGRAMMING (OOP)

- **EVERYTHING IN PYTHON IS AN OBJECT** (and has a type)
- Can **create new objects** of some type
- Can **manipulate objects**
- Can **destroy objects**
  - Explicitly using `del` or just "forget" about them
  - Python system will reclaim destroyed or inaccessible objects – called "garbage collection"

WHAT ARE OBJECTS?

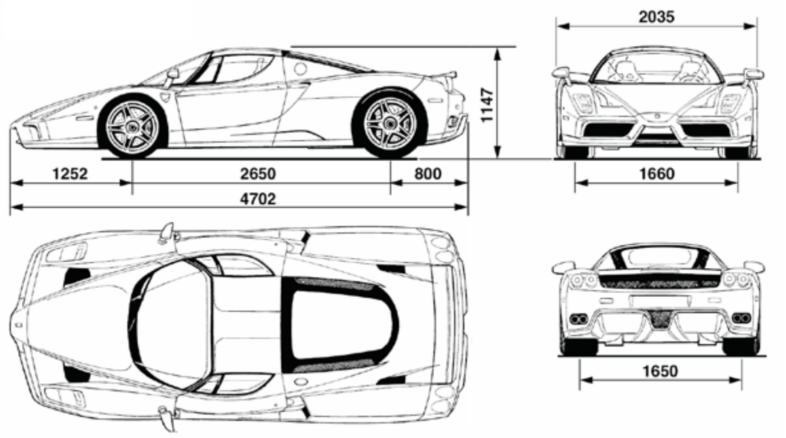
- Objects are **a data abstraction** that captures…

(1) An **internal representation**

- Through data attributes

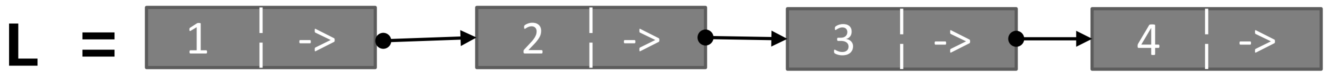
(2) An **interface** for interacting with object

- Through methods (aka procedures/functions)
- Defines behaviors but hides implementation



EXAMPLE:
[1,2,3,4] has type list

- How are lists **represented internally**? linked list of cells



follow pointer to the next index

- How to **manipulate** lists?
  - `L[i], L[i:j], +`
  - `len(), min(), max(), del(L[i])`
  - `L.append(),L.extend(),L.count(),L.index(), L.insert(),L.pop(),L.remove(),L.reverse(), L.sort()`
- Internal representation should be private
- Correct behavior may be compromised if you manipulate internal representation directly

ADVANTAGES OF OOP

- **Bundle data into packages** together with procedures that work on them through well-defined interfaces
- **Divide-and-conquer** development
  - Implement and test behavior of each class separately
  - Increased modularity reduces complexity
- **Classes** make it easy to **reuse** code
  - Many Python modules define new classes
  - Each class has a separate environment (no collision on function names)
  - Inheritance allows subclasses to redefine or extend a selected subset of a superclass' behavior

Implementing the class

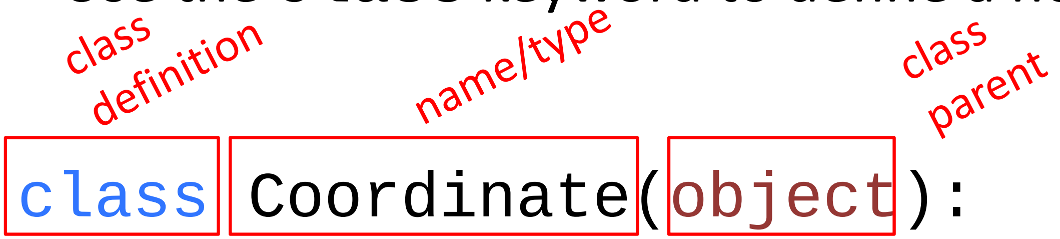
Using the class

CREATING AND USING YOUR OWN TYPES WITH CLASSES

- Make a distinction between **creating a class** and **using an instance** of the class
- **Creating** the class involves
  - Defining the class name
  - Defining class attributes
  - *for example, someone wrote code to implement a list class*
- **Using** the class involves
  - Creating new **instances** of the class
  - Doing operations on the instances
  - *for example, `L=[1,2]` and `len(L)`*

DEFINE YOUR OWN TYPES

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



class definition

name/type

class parent

```
class Coordinate(object):
    #define attributes here
```

- Similar to `def`, indent code to indicate which statements are part of the **class definition**

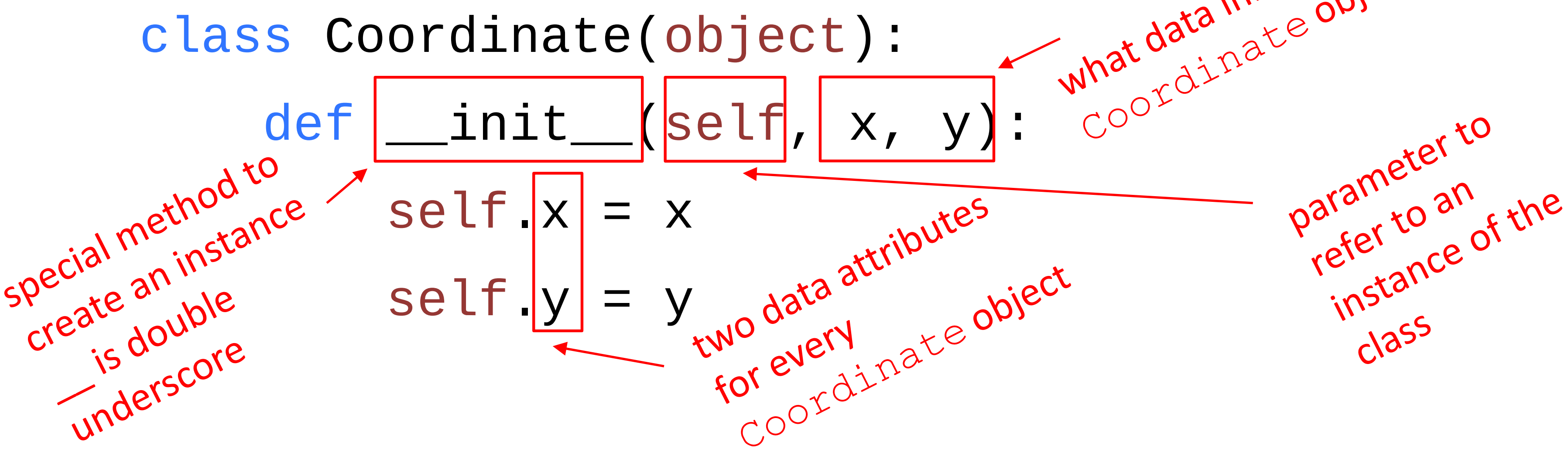
- The word `object` means that `Coordinate` is a Python object and **inherits** all its attributes (inheritance next lecture)
  - `Coordinate` is a subclass of `object`
  - `object` is a superclass of `Coordinate`

WHAT ARE ATTRIBUTES?

- Data and procedures that "**belong**" to the class
- **Data attributes**
  - Think of data as other objects that make up the class
  - *for example, a coordinate is made up of two numbers*
- **Methods** (procedural attributes)
  - Think of methods as functions that only work with this class
  - How to interact with the object
  - *for example you can define a distance between two coordinate objects but there is no meaning to a distance between two list objects*

DEFINING HOW TO CREATE AN INSTANCE OF A CLASS

- First have to define **how to create an instance** of class
- Use a **special method called `__init__`** to initialize some data attributes or perform initialization operations



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

what data initializes a `Coordinate` object

special method to create an instance is double __ underscore

parameter to refer to an instance of the class

two data attributes for every `Coordinate` object

☆ LIVE EXERCISE

ACTUALLY CREATING AN INSTANCE OF A CLASS

```
c = Coordinate(3,4)
origin = Coordinate(0,0)
print(c.x)
print(origin.x)
```

create a new object of type `Coordinate` and pass in 3 and 4 to the `__init__`

use the dot to access an attribute of instance `c`

- Data attributes of an instance are called **instance variables**
- Don't provide argument for `self`, Python does this automatically

WHAT IS A METHOD?

- Procedural attribute, like a **function that works only with this class**
- Python always passes the object as the first argument
  - Convention is to use **`self`** as the name of the first argument of all methods
- The “**.**” **operator** is used to access any attribute
  - A data attribute of an object
  - A method of an object

☆ LIVE EXERCISE

DEFINE A METHOD FOR THE Coordinate CLASS

```
class Coordinate(object):
    def __init__(self, x, y):
        self.x = x
        self.y = y
    def distance(self, other):
        x_diff_sq = (self.x-other.x)**2
        y_diff_sq = (self.y-other.y)**2
        return (x_diff_sq + y_diff_sq)**0.5
```

use it to refer to any instance

another parameter to method

dot notation to access data

- Other than `self` and dot notation, methods behave just like functions (take params, do operations, return)

☆ LIVE EXERCISE

HOW TO USE A METHOD

```
def distance(self, other):
    # code from prev slide here
```

method def

Using the class:

- Conventional way

```
c = Coordinate(3,4)
zero = Coordinate(0,0)
print(c.distance(zero))
```

object to call method on

name of method

parameters not including self (self is implied to be c)

- Equivalent to

```
c = Coordinate(3,4)
zero = Coordinate(0,0)
print(Coordinate.distance(c, zero))
```

name of class

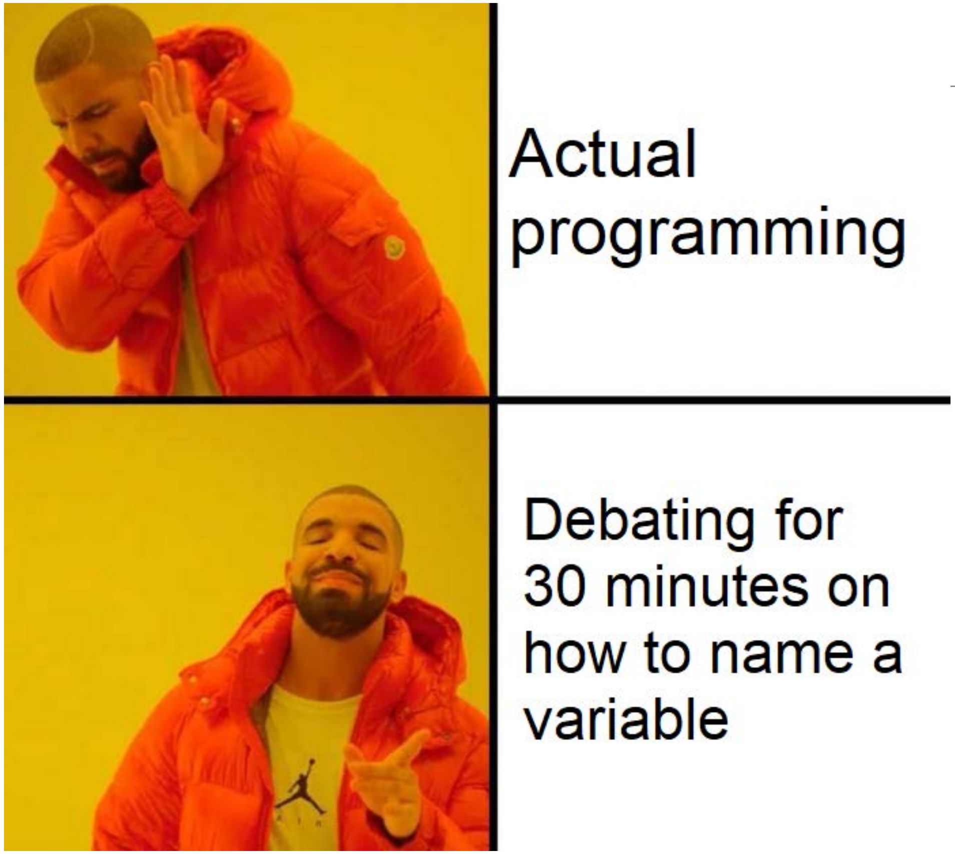
name of method

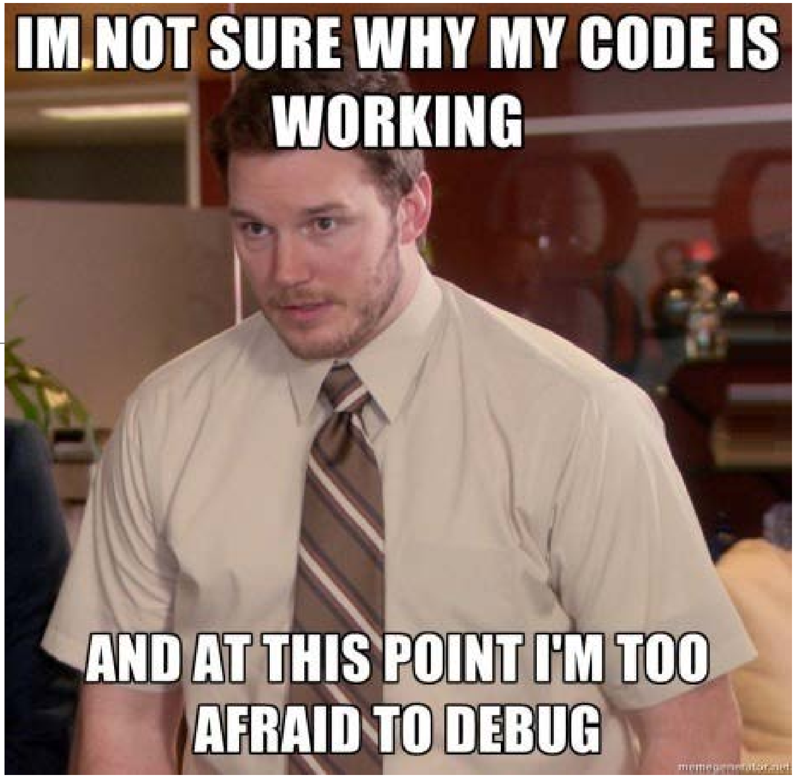
parameters, including an object to call the method on, representing self

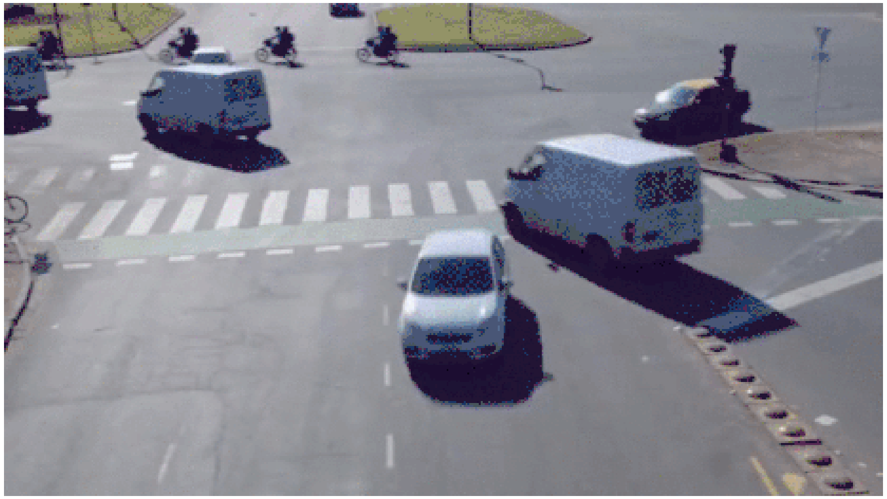
EXAMPLE: FRACTIONS

- Create a **new type** to represent a number as a fraction
- **Internal representation** is two integers
  - Numerator
  - Denominator
- **Interface** a.k.a. **methods** a.k.a **how to interact** with `Fraction` objects
  - Add, subtract
  - Invert the fraction
- Let's write it together!

5 Minute Break




IM NOT SURE WHY MY CODE IS WORKING
AND AT THIS POINT I'M TOO AFRAID TO DEBUG



When my code somehow just works

PRINT REPRESENTATION OF AN OBJECT

```
>>> c = Coordinate(3,4)
>>> print(c)
<__main__.Coordinate object at 0x7fa918510488>
```

- **Uninformative** print representation by default
- Define a **`__str__` method** for a class
- Python calls the `__str__` method when used with `print` on your class object
- You choose what it does! Say that when we print a `Coordinate` object, want to show

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

DEFINING YOUR OWN PRINT METHOD

```
class Coordinate(object):
    def __init__(self, x, y):
        self.x = x
        self.y = y
    def distance(self, other):
        x_diff_sq = (self.x-other.x)**2
        y_diff_sq = (self.y-other.y)**2
        return (x_diff_sq + y_diff_sq)**0.5
    def __str__(self):
        return "<"+str(self.x)+","+str(self.y)+">"
```

name of special method

must return a string

WRAPPING YOUR HEAD AROUND TYPES AND CLASSES

- Can ask for the type of an object instance

```
>>> c = Coordinate(3,4)
>>> print(c)
<3,4>
>>> print(type(c))
<class __main__.Coordinate>
```

return of the __str__ method

the type of object c is a class Coordinate

- This makes sense since

```
>>> print(Coordinate)
<class __main__.Coordinate>
>>> print(type(Coordinate))
<type 'type'>
```

a Coordinate is a class

a Coordinate class is a type of object

- Use `isinstance()` to check if an object is a `Coordinate`

```
>>> print(isinstance(c, Coordinate))
True
```

☆ LIVE EXERCISE

SPECIAL OPERATORS

- +, -, ==, <, >, len(), print, and many others

https://docs.python.org/3/reference/datamodel.html#basic-customization

- Like `print`, can override these to work with your class
- Define them with double underscores before/after

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

... and others

EXAMPLE: FRACTIONS

- Create a **new type** to represent a number as a fraction
- **Internal representation** is two integers
  - Numerator
  - Denominator
- **Interface** a.k.a. **methods** a.k.a **how to interact** with `Fraction` objects
  - Add, sub, mult, div to work with +, -, *, /
  - Print representation, convert to a float
  - Invert the fraction
- Let's write it together!

THE POWER OF OOP

- **Bundle together objects** that share
  - Common attributes and
  - Procedures that operate on those attributes
- Use **abstraction** to make a distinction between how to implement an object vs how to use the object
- Build **layers** of object abstractions that inherit behaviors from other classes of objects
- Create our **own classes of objects** on top of Python’s basic classes