Algorithms and Data Structures for Data Science

Object Oriented Programming

CS 277

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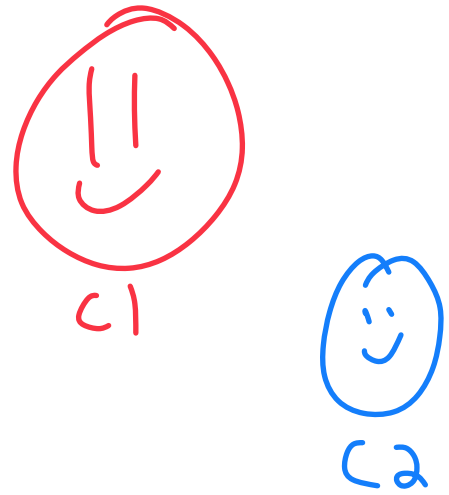


UNIVERSITY OF ILLINOIS URBANA-CHAMPAIGN

Department of Computer Science

circle.radius
circle.face

Learning Objectives

Finish discussing function overloading

Introduce object-oriented programming

Everything is an object

Discuss and practice defining interfaces for computational problems

An overview of common I/O formats in Python

???

↳ Still single script topics

Programming Toolbox: Function Overloading

Two functions are **overloaded** when they have the same name but different parameters.

```
 1  def combine(x, y):
 2      return [x, y]
 3
 4  print(combine(5, 1))
 5
 6  def combine(list1, list2):
 7      return list1+list2
 8
 9  print(combine([1, 2], [3, 4]))
10
11  def combine(x, list1, list2):
12      return [x]+list1+list2
13
14  print(combine(0, [1, 2], [4, 5]))
15
16
17
18
19
```

Programming Toolbox: Function Overloading

To properly define an overloaded function, give default arguments.

```
 1  def combine(x, y=None, list1 = None, list2 = None):
 2      out = [x]
 3      if y:
 4          out+=[y]
 5      if list1:
 6          out+=list1
 7      if list2:
 8          out+=list2
 9      return out
10
11  print(combine(5, 1))
12
13
14  print(combine(0, [1, 2], [4, 5]))
15
16
17  print(combine(0, list1=[1, 2], list2=[4, 5]))
18
19
```

Programming Toolbox: Function Overloading

For true freedom of input, use keyword `*args` and `**kwargs`

```
 1  def combine(*args, **kwargs):
 2      out = []
 3
 4      for a in args:
 5          out.append(a)
 6
 7
 8      for k, v in kwargs.items():
 9          print("{} = {}".format(k, v))
10          out+=v
11      return out
12
13
14  print(combine(0, 1, 2, 3, 4, \
15  list1=[9, 2,3,1], list2=[8,7,2,1], \
16  list3 = [10]))
17
18
19
```

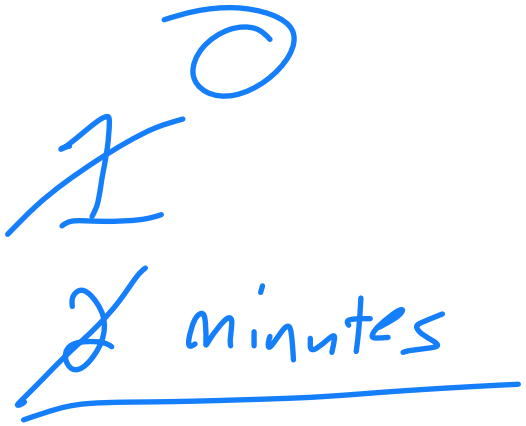
Programming Practice: Function Overloading

Write a function blackBox() that takes as input 0, 1, 2, or 3 arguments

The default value for the first input arg is 3

The default value for the second input arg is 6

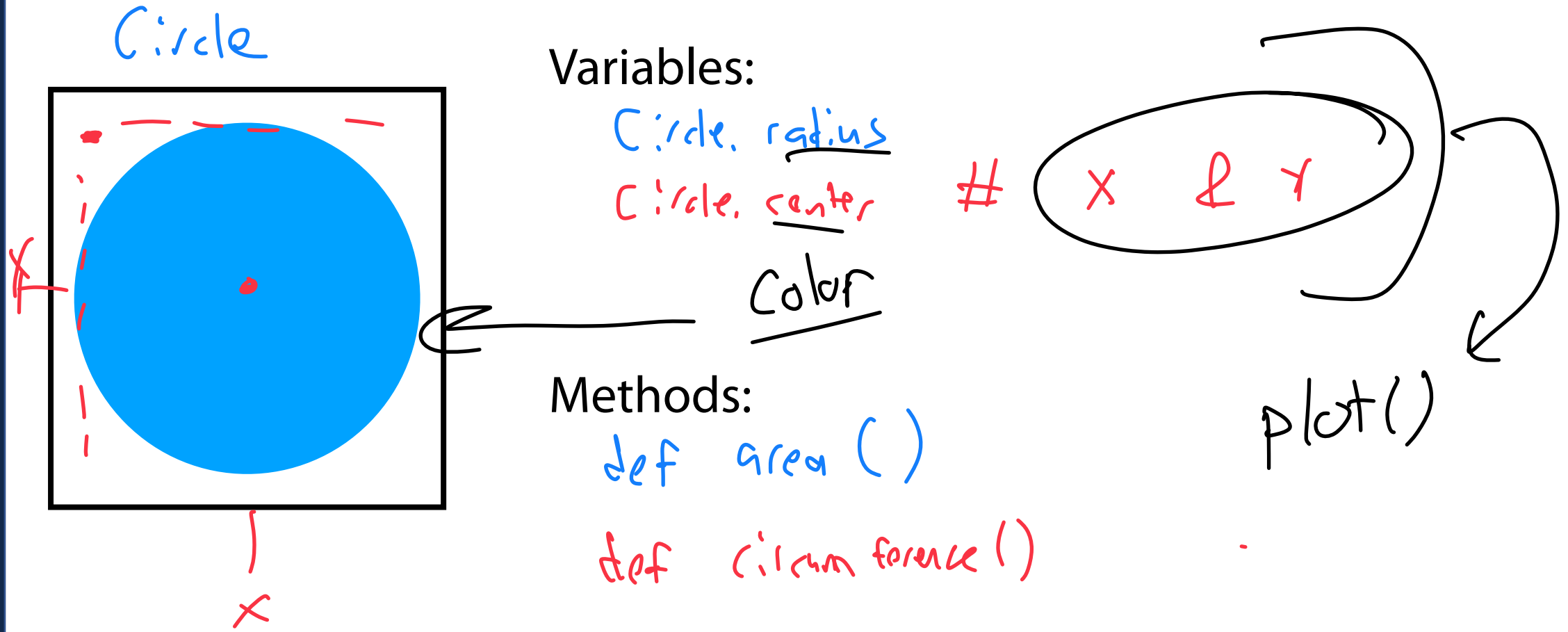
The default value for the third input arg is 0.5



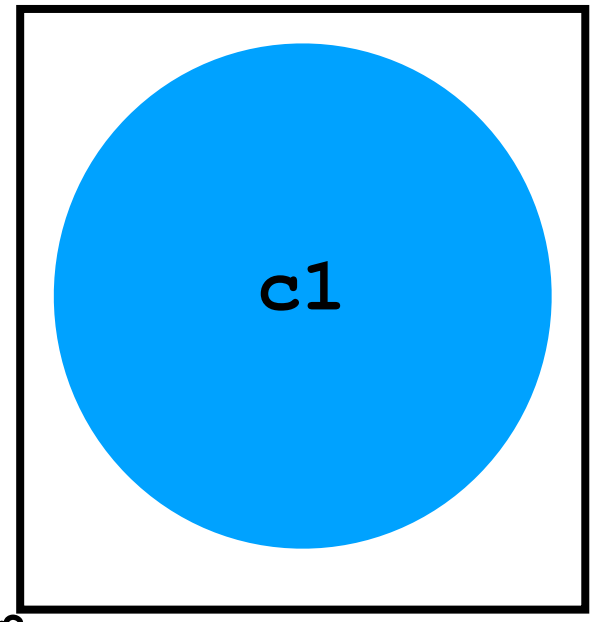

```
Def blackbox( y=3, z=6, f = 0.5):
    Return y+z+f
```

Object-Oriented Programming

An **object** is a conceptual grouping of variables and functions that make use of those variables. A function associated with an object is a **method.**



Object-Oriented Programming

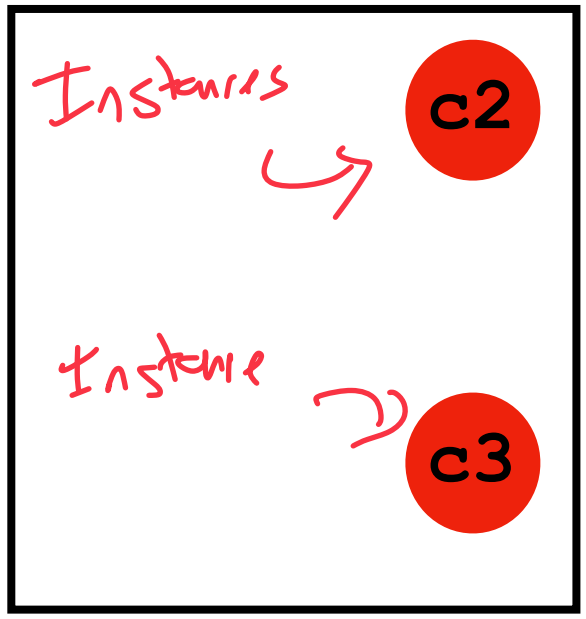


Name

```
c1.area()
```

call class method

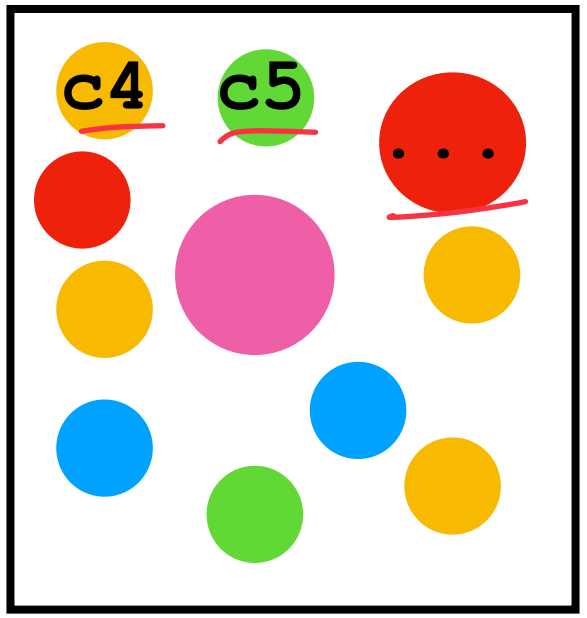
area as float




```
c2.xpos == c3.xpos

c2.ypos == c3.ypos
```

Call ~~class~~ variables instance




```
getTotalArea(c4, c5, ...)
```

Circles as objects

function that takes circle data type as input

Object-Oriented Programming

An **object** is a conceptual grouping of variables and methods that make use of those variables. ***You've been using these the entire time***

Everything in Python is an object

```
1  x = "myString"
2
3  print(x.capitalize())
4
5  print(x.find("String"))
6
7  print(x.upper())
8
9  print(x[3]) # __getitem__()
10
11 print(x) # __str__()
12
13
14
15
16
```

Variables:

Type	String
Value	myString
Ref Count	1

Methods:

split()
↳ takes one string and breaks into list

__add__()

Object-Oriented Programming

Even things that don't have obvious function calls are (secretly) defined as a method of some object.

```
1  a="3"
2  b=3
3  c=3.0
4  d=True
5
6  print(a + b)
7
8  print(b + c)
9
10 print(c > d)
11
12
13
14
15
16
```

```
1  # For objects of type 'string'
2  def __add__(self, o):
3    ...
4
5  # For objects of type 'int'
6  def __add__(self, o):
7    ...
8
9  # For objects of type 'float'
10 def __add__(self, o):
11   ...
12
13
14 def __gt__(self, o):
15
16
```

Object-Oriented Programming

The collection of publicly accessible methods and variables that make up an object is its **interface.** This includes none of the implementation details.

`str.`**`join`**`(`*`iterable`*`)`

Return a string which is the concatenation of the strings in *iterable*. A `TypeError` will be raised if there are any non-string values in *iterable*, including `bytes` objects. The separator between elements is the string providing this method.

`str.`**`ljust`**`(`*`width`*`[, `*`fillchar`*`])`

Return the string left justified in a string of length *width*. Padding is done using the specified *fillchar* (default is an ASCII space). The original string is returned if *width* is less than or equal to `len(s)`.

`str.`**`lower`**`()`

Return a copy of the string with all the cased characters [4] converted to lowercase.

The lowercasing algorithm used is described in section 3.13 of the Unicode Standard.

`str.`**`lstrip`**`([`*`chars`*`])`

Don't need C knowledge to use Python

https://docs.python.org/3/library/stdtypes.html#string-methods

Object-Oriented Programming

The implementation details of an object is defined in a **class** definition.

You can think of this as the 'blueprints' to make an object.

```
 1  PyObject * PyString_FromStringAndSize(const char *str, Py_ssize_t size)
 2  {
 3      ...
 4
 5      op = (PyStringObject *)PyObject_MALLOC(PyStringObject_SIZE + size);
 6      if (op == NULL)
 7          return PyErr_NoMemory();
 8      PyObject_INIT_VAR(op, &PyString_Type, size);
 9      op->ob_shash = -1;
10      op->ob_sstate = SSTATE_NOT_INTERNED;
11      if (str != NULL)
12          Py_MEMCPY(op->ob_sval, str, size);
13      op->ob_sval[size] = '\0';
14      /* share short strings */
15      if (size == 0) {
16          PyObject *t = (PyObject *)op;
17          PyString_InternInPlace(&t);
18          op = (PyStringObject *)t;
19          nullstring = op;
20          Py_INCREF(op);
```

This is C code! Don't worry if you cant read this

Object-Oriented Programming

We will discuss and use data structures in the context of their **interface.**

Ex: The string [data type] will have a few properties in any language

```
1  std::string x = "Hello World";
2
3  for(int i = x.length() - 1; i >= 0; --i){
4     std::cout << x[i] << std::endl;
5  }
6
7
8
9
10
11
```

C++

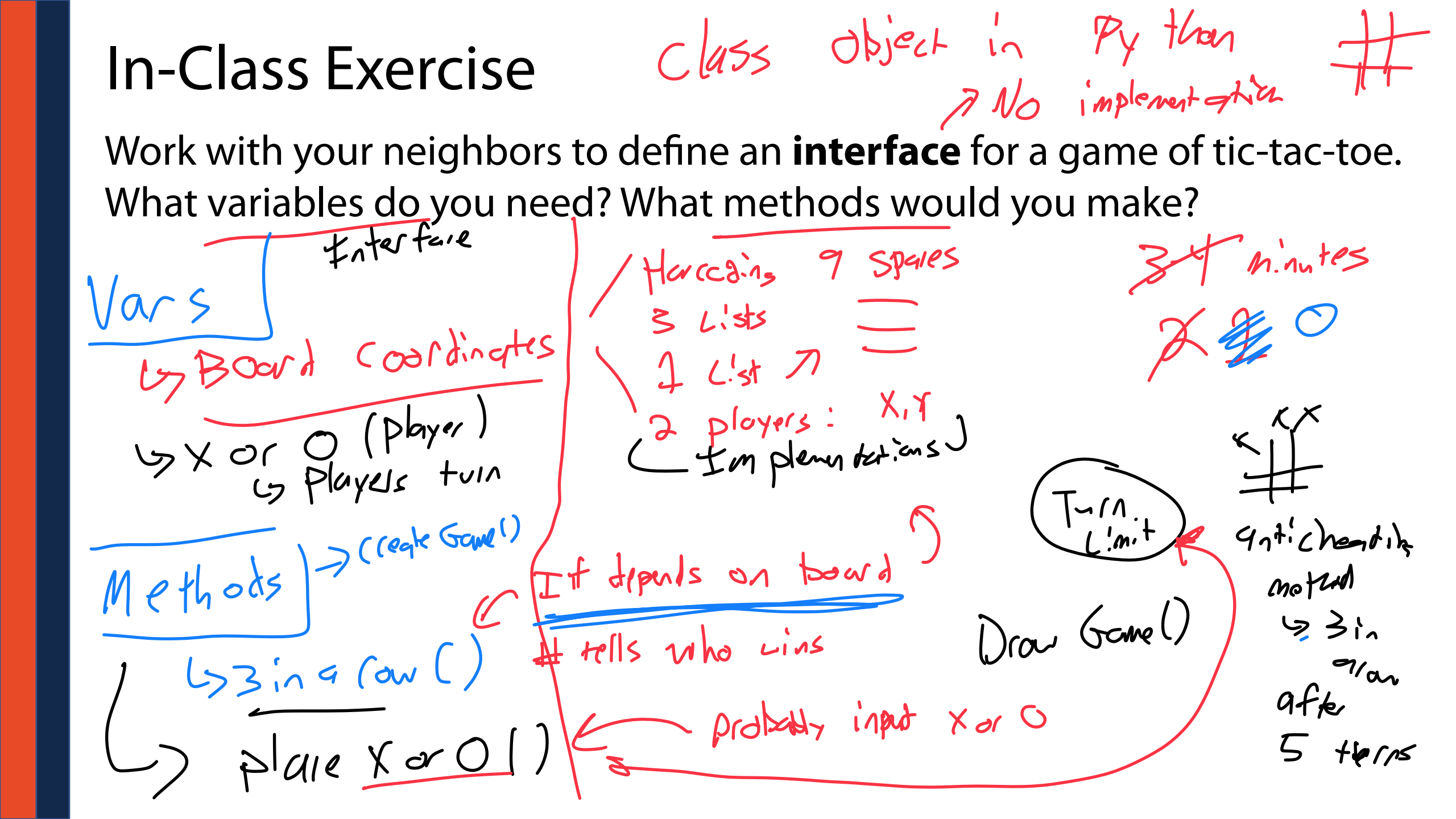
```
1  x = "Hello World"
2
3  i = len(x) - 1
4  while(i >= 0):
5      print(x[i])
6      i-=1
7
8
9
10
11
```

Python

Strings share an interface

In-Class Exercise

Work with your neighbors to define an **interface** for a game of tic-tac-toe. What variables do you need? What methods would you make?



Python Class Definition

A class is defined with the keyword / syntax: **'class <Name>:'**

```
 1  class Circle:
 2      pi = 3.14
 3
 4      def __init__(self,r, c, x, y):
 5          self.radius = r
 6          self.color = c
 7          self.xpos, self.ypos = x, y
 8
 9      def __eq__(self, other):
10          return (self is other)
11
12      def circumference(self):
13          return 2 * Circle.pi * self.radius
14
15      def area(self):
16          return Circle.pi * (self.radius)**2
17
18
19
```

Python Class Definition

A **class variable** is a variable that is shared by ALL instances of the class

```
 1  class Circle:
 2      pi = 3.14
 3
 4      def __init__(self,r, c, x, y):
 5          self.radius = r
 6          self.color = c
 7          self.xpos, self.ypos = x, y
 8
 9      def __eq__(self, other):
10          return (self is other)
11
12      def circumference(self):
13          return 2 * Circle.pi * self.radius
14
15      def area(self):
16          return Circle.pi * (self.radius)**2
17
18
19
```

whitespace & loc is important

A global variable for all objects

Python Class Definition

A Python class constructor is defined by '**__init__(<parameters>)**'

```
 1  class Circle:
 2      pi = 3.14
 3
 4      def __init__(self, r, c, x, y):
 5          self.radius = r
 6          self.color = c
 7          self.xpos, self.ypos = x, y
 8
 9      def __eq__(self, other):
10          return (self is other)
11
12      def circumference(self):
13          return 2 * Circle.pi * self.radius
14
15      def area(self):
16          return Circle.pi * (self.radius)**2
17
18
19
```

Python Class Definition

Member (or instance) variables are defined with **self.<var>**.

Each object has their own *instance* of the variable with its own values.

```
 1  class Circle:
 2      pi = 3.14
 3
 4      def __init__(self, r, c, x, y):
 5          self.radius = r
 6          self.color = c
 7          self.xpos, self.ypos = x, y
 8
 9      def __eq__(self, other):
10          return (self is other)
11
12      def circumference(self):
13          return 2 * Circle.pi * self.radius
14
15      def area(self):
16          return Circle.pi * (self.radius)**2
17
18
19
```

C1.radius()

C2.radius()

differences

self

Circle.circumference(C1)

self

C1.circumference()

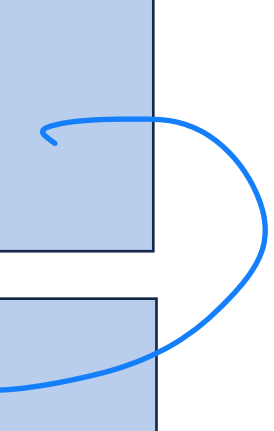
Python Class Definition

Each object has their own *instance* of the variable with its own values.

Given a constructor, we can create new *instances* of objects.

```
1  class Circle:
2      pi = 3.14
3
4      def __init__(self, r, c, x, y):
5          self.radius = r
6          self.color = c
7          self.xpos, self.ypos = x, y
```

```
21 c1 = Circle(2, "Red", 5, 5)
22 c2 = Circle(2, "Blue", 5, 10)
23 c3 = Circle(2, "Red", 5, 5)
24
25
26
27
28
29
30
31
```

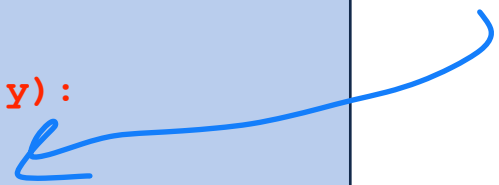


Python Class Definition

It is very common to have multiple possible constructors.

Have we implemented this correctly?

```
 1  class Circle:
 2      pi = 3.14
 3
 4      def __init__(self, r, x, y):
 5          self.radius = r
 6          self.color = "Black"
 7          self.xpos, self.ypos = x, y
 8
 9      def __init__(self, r, c, x, y):
10          self.radius = r
11          self.color = c
12          self.xpos, self.ypos = x, y
13
14
15  c = Circle(5, 5, 5)
16
17
18  c = Circle(r=5, x=5, y=5)
19
```



Python Class Definition

Remember our lesson from functions! Overloading uses default args.

```
 1  class Circle:
 2      pi = 3.14
 3
 4      def __init__(self,r, x, y, c="Black"):
 5          self.radius = r
 6          self.color = c
 7          self.xpos, self.ypos = x, y
 8
 9
10
11  c = Circle(5, 5, 5)
12  c = Circle(r=5, x=5, y=5)
13
14
15  c1 = Circle(2, 5, 5, "Red")
16  c2 = Circle(2, 5, 10, c="Blue")
17  c3 = Circle(2, 5, 5, "Red")
18
19
```

Python Class Definition

Python classes can have **member functions**.

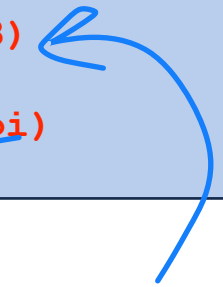
```
 1  class Circle:
 2      pi = 3.14
 3
 4      def __init__(self,r, x, y, c="Black"):
 5          self.radius = r
 6          self.color = c
 7          self.xpos, self.ypos = x, y
 8
 9      def __eq__(self, other):
10          return (self is other)
11
12      def circumference(self):
13          return 2 * Circle.pi * self.radius
14
15      def area(self):
16          return Circle.pi * (self.radius)**2
17
18
19
```

Python Class Definition

Let's breakdown a Python class definition:

```
 1  class Circle:
 2      pi = 3.14
 3
 4      def __init__(self,r, x, y, c="Black"):
 5          self.radius = r
 6          self.color = c
 7          self.xpos, self.ypos = x, y
 8
 9      def __eq__(self, other):
10          return (self is other)
11
12      def circumference(self):
13          return 2 * Circle.pi * self.radius
14
15      def area(self):
16          return Circle.pi * (self.radius)**2
17
18
19
```

```
21  c1 = Circle(2, "Red", 5, 5)
22  c2 = Circle(2, "Blue", 5, 10)
23  c3 = Circle(2, "Red", 5, 5)
24
25  print(c1.radius == c2.radius)
26
27  print(c1.color == c3.color)
28
29  print(c1.area())
30
31  print(c1 is c3)
32
33  print(Circle.pi)
34
```



Interface vs Class vs Object

Unfortunately these are not consistent terms (especially interface)

For this course:

An **interface** is the functions and operations that an object has.

"I expect to be able to print a string or add two strings together."

A **class** is the implementation details — the code that defines all objects

"The Python string class has a method __str__() which defines print()"

An **object** is a specific instance of a class, with unique variables.

"X and Y are two separate strings with different memory addresses and values."

In-Class Exercise

How many unique list objects do we have in the following code?

```
 1  x = [1, 2, 3]
 2  y = x
 3  z = [1, 2, 3]
 4
 5  print(x is y)
 6
 7  print(x is z)
 8
 9  print(x == y)
10
11  print(x == z)
12
13  print(id(x))
14  print(id(y))
15  print(id(z))
16
```

In-Class Exercise

Let’s return to tic-tac-toe. Can we create a Python class for a common interface?

List Abstract Data Type

["str1", "str2", 3, c]

What is a list? What properties does it have? What functions?

ordered

Variables
- Set of objects
  - Index of objects
  - length

??? Implementation

Property
- Mutable

Methods
- length()
- min() → sum
- max() → avg
- add (an object)
- add (two lists)

remove() # at index

pop() # at end

List Abstract Data Type

A list is an **ordered** collection of items

Items can be either **heterogeneous** or **homogenous**

The list can be of a **fixed size** or is **resizable**

List Abstract Data Type

A minimally functional list must have the following functions:

Constructor — to create a new empty list

Insert — add an item

Delete — remove

Index — Look up an index

Size()** — returns length of list