

Classes: Custom Types

- **Class:** Custom type **not built into** Python
 - Just like with functions: built-in & defined
 - Types not built-in are **provided by modules**
- Might seem weird: `type(1) ==> <class 'int'>`
 - In Python 3 type and class are **synonyms**
 - We will use the historical term for clarity

intros provides several **classes**

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Objects: Values for a Class

- **Object:** A specific **value** for a class type
 - Remember, a type is a set of values
 - Class could have infinitely many objects
- **Example:** Class is `Point3`
 - One object is **origin**; another **x-axis** (1,0,0)
 - These objects go in params distance function
- Sometimes refer to objects as **instances**
 - Because a value is an instance of a class
 - Creating an object is called **instantiation**

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Demonstrating Object Instantiation

```
>>> import Point3 from intros # Module with class
>>> p = Point3(0,0,0)         # Create point at origin
>>> p                         # Look at this new point
<class 'intros.geom.point.Point3'>(0.0,0.0,0.0)
>>> type(p) == Point3        # Check the type
True
>>> q = Point3(1,2,3)        # Make new point
>>> q                         # Look at this new point
<class 'intros.geom.point.Point3'>(1.0,2.0,3.0)
```

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Metaphor: Objects are Folders

```
>>> import intros
```

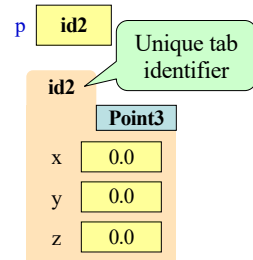
Need to import module that has Point class.

```
>>> p = intros.Point3(0,0,0)
```

Constructor is function. Prefix w/ module name.

```
>>> id(p)
```

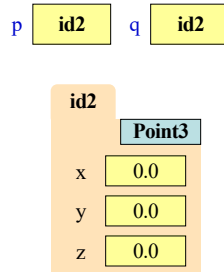
Shows the ID of p.



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Object Variables

- Variable stores object name
 - **Reference** to the object
 - Reason for folder analogy
- Assignment uses object name
 - **Example:** `q = p`
 - Takes name from p
 - Puts the name in q
 - Does not make new folder!
- This is the cause of many mistakes for beginners



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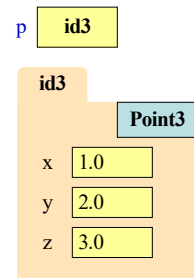
Objects and Attributes

- Attributes live inside objects
 - Can access these attributes
 - Can use them in expressions
- **Access:** `<variable>.<attr>`
 - Look like module variables
 - **Recall:** `math.pi`
- **Example**

```
>>> p = intros.Point3(1,2,3)
```

```
>>> a = p.x + p.y
```

a 3.0



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Objects Allow for Mutable Functions

- **Mutable function:** *alters* the parameters
 - Often a procedure; no return value
- Until now, this was impossible
 - Function calls **COPY** values into new variables
 - New variables erased with call frame
 - Original (global?) variable was unaffected
- But object variables are *folder names*
 - Call frame refers to same folder as original
 - Function may modify the contents of this folder

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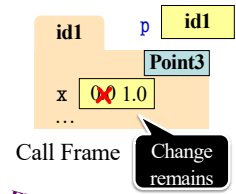
Example: Mutable Function Call

- **Example:**

```
1 def incr_x(q):
2   q.x = q.x + 1

>>> p = Point3(0,0,0)
>>> p.x
0.0
>>> incr_x(p)
>>> p.x
1.0
```

Global **STUFF**



Call Frame

ERASE WHOLE FRAME

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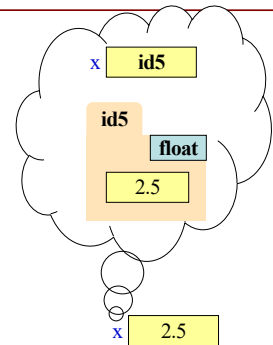
Methods: Functions Tied to Objects

- Have seen object folders contain variables
 - **Syntax:** `<obj>.<attribute>` (e.g. `p.x`)
 - These are called *attributes*
- They can also contain functions
 - **Syntax:** `<obj>.<method>(<arguments>)`
 - **Example:** `p.clamp(-1,1)`
 - These are called *methods*
- Visualizer will not show these inside folders
 - Will see why in **November** (when cover Classes)

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Surprise: All Values are Objects!

- Including basic values
 - `int`, `float`, `bool`, `str`



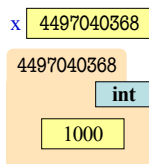
- **Example:**

```
>>> x = 1000
>>> id(x)
```

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But Not Helpful to Think This Way

- Number folders are **immutable**
 - “Variables” have no names
 - No way to reach in folder
 - No way to change contents



Makes a brand new int folder

```
>>> x = 1000
>>> y = 1000
>>> id(x)
4497040368
>>> id(y)
4497040400
>>> y = y+1
>>> id(y)
4497040432
```

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Basic Types vs. Classes

Basic Types

- Built-into Python
- Refer to instances as *values*
- Instantiate with *literals*
- Are all immutable
- Can **ignore the folders**

Classes

- Provided by modules
- Refer to instances as *objects*
- Instantiate w/ *constructors*
- Can alter attributes
- Must **represent with folders**

In doubt? Use the Python Tutor

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