Lecture 9

Objects

Announcements for Today

Assignment 1

- We are starting grading
  - Will take most of the day
  - Grades 5pm tomorrow
- Resubmit until correct
  - Read feedback in CMS
  - Reupload/request regrade
- If you were very **wrong**…
  - You got an e-mail
  - More 1-on-1s this week

Assignment 2

- Posted **Today**
  - Written assignment
  - Do while revising A1
  - Relatively short
- Due next **Tuesday**
  - Submit as a PDF
  - Scan or phone picture

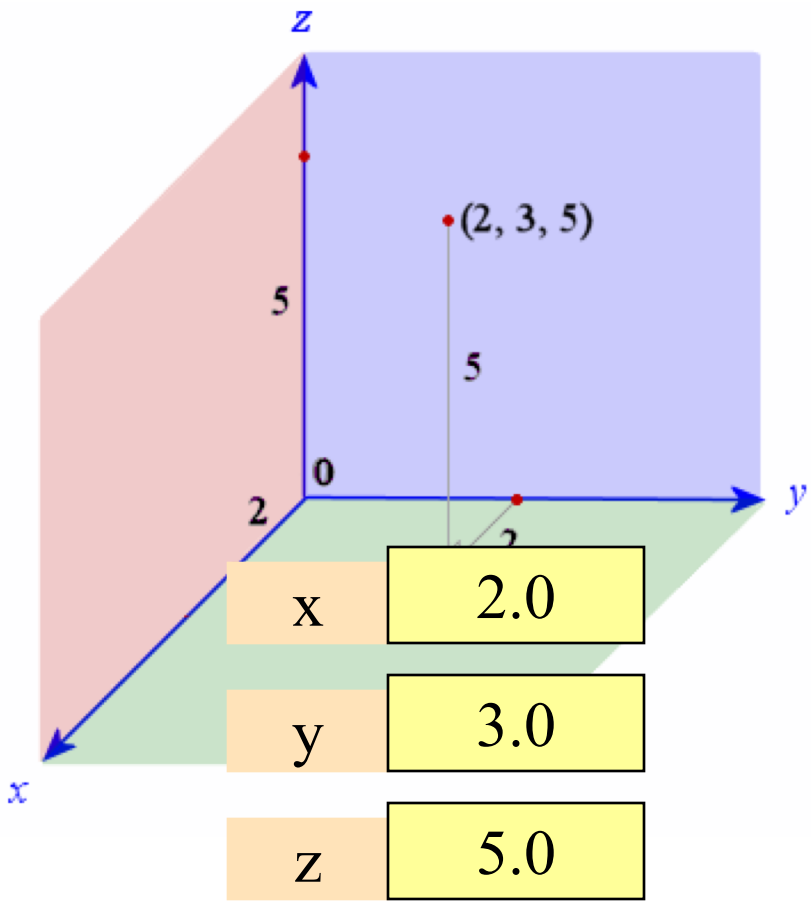
Type: Set of values and the operations on them

- Type **int**:
  - **Values**: integers
  - **Ops**: +, –, *, //, %, **
- Type **float**:
  - **Values**: real numbers
  - **Ops**: +, –, *, /, **
- Type **bool**:
  - **Values**: **True** and **False**
  - **Ops**: not, and, or
- Type **str**:
  - **Values**: string literals
    - Double quotes: `"abc"`
    - Single quotes: `'abc'`
  - **Ops**: + (concatenation)

Are the the only types that exist?

Type: Set of values and the operations on them

- Want a point in 3D space
  - We need three variables
  - x, y, z coordinates
- What if have a lot of points?
  - Vars x0, y0, z0 for first point
  - Vars x1, y1, z1 for next point
  - …
  - This can get really messy
- How about a single variable that represents a point?



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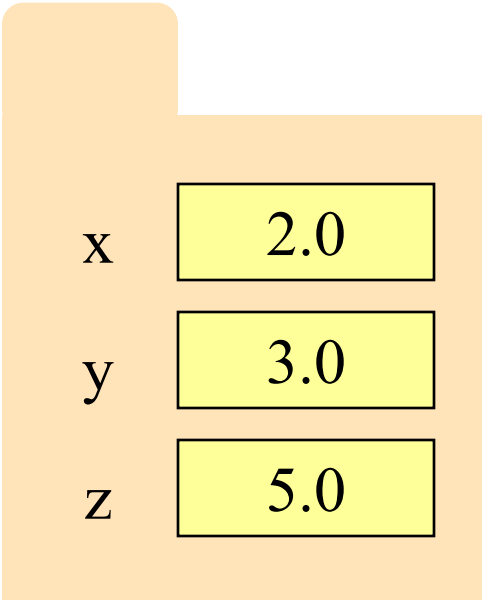
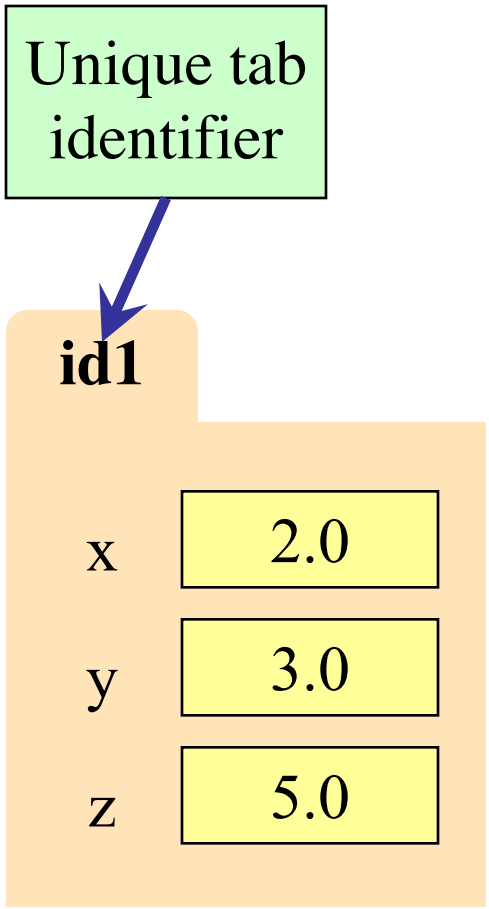
- How about a single variable that represents a point?
- Can we stick them together in a "folder"?
- Motivation for **objects**



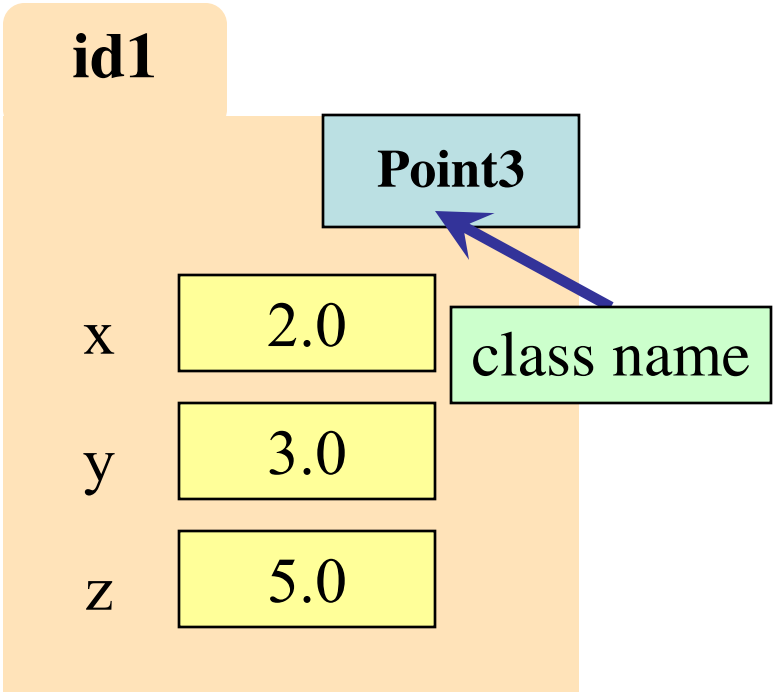
Objects: Organizing Data in Folders

- An object is like a **manila folder**
- It contains other variables
  - Variables are called **attributes**
  - These values can change
- It has an **ID** that identifies it
  - Unique number assigned by Python (just like a NetID for a Cornellian)
  - Cannot ever change
  - Has no meaning; only identifies



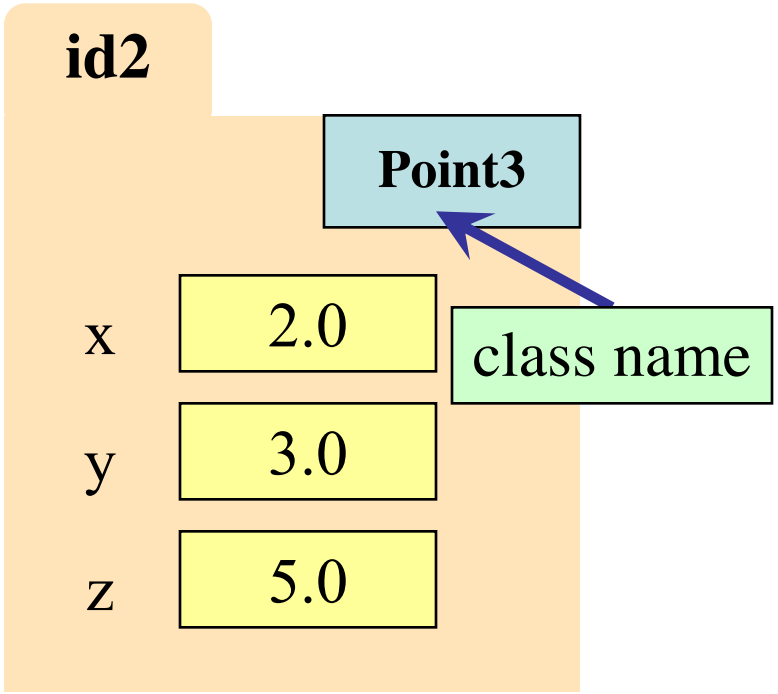
Classes: Types for Objects

- Values must have a type
  - An object is a **value**
  - Type of object is its **class**
- **Modules** provide classes
  - Will show how later
- **Example**: `introcs`
  - Part of CornellExtensions
  - Just need to import it
  - Classes: `Point2`, `Point3`

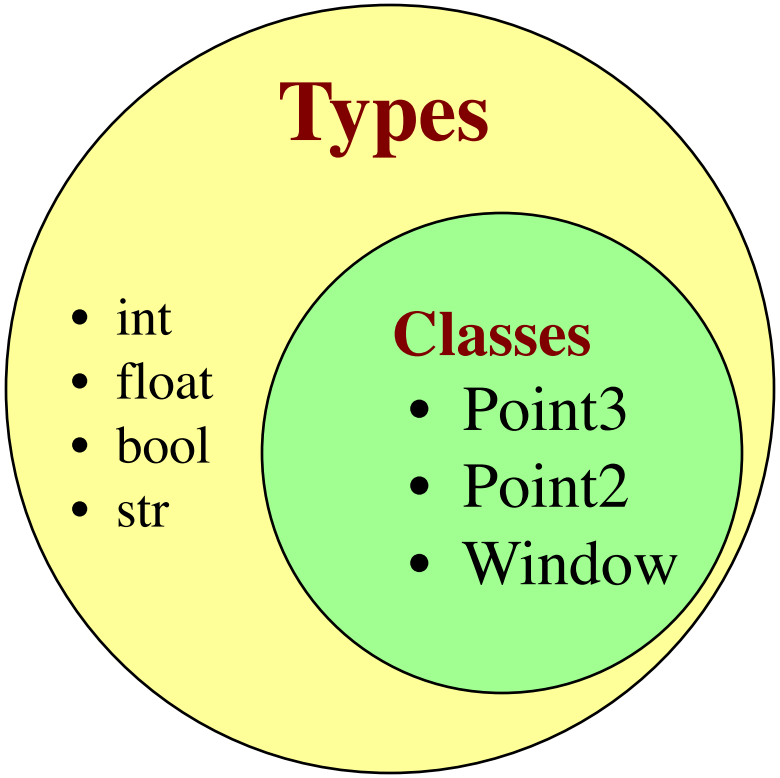


The Old Way: Classes vs Types

- Values must have a type
  - An object is a **value**
  - Object type is a **class**



- Classes are how we add new types to Python



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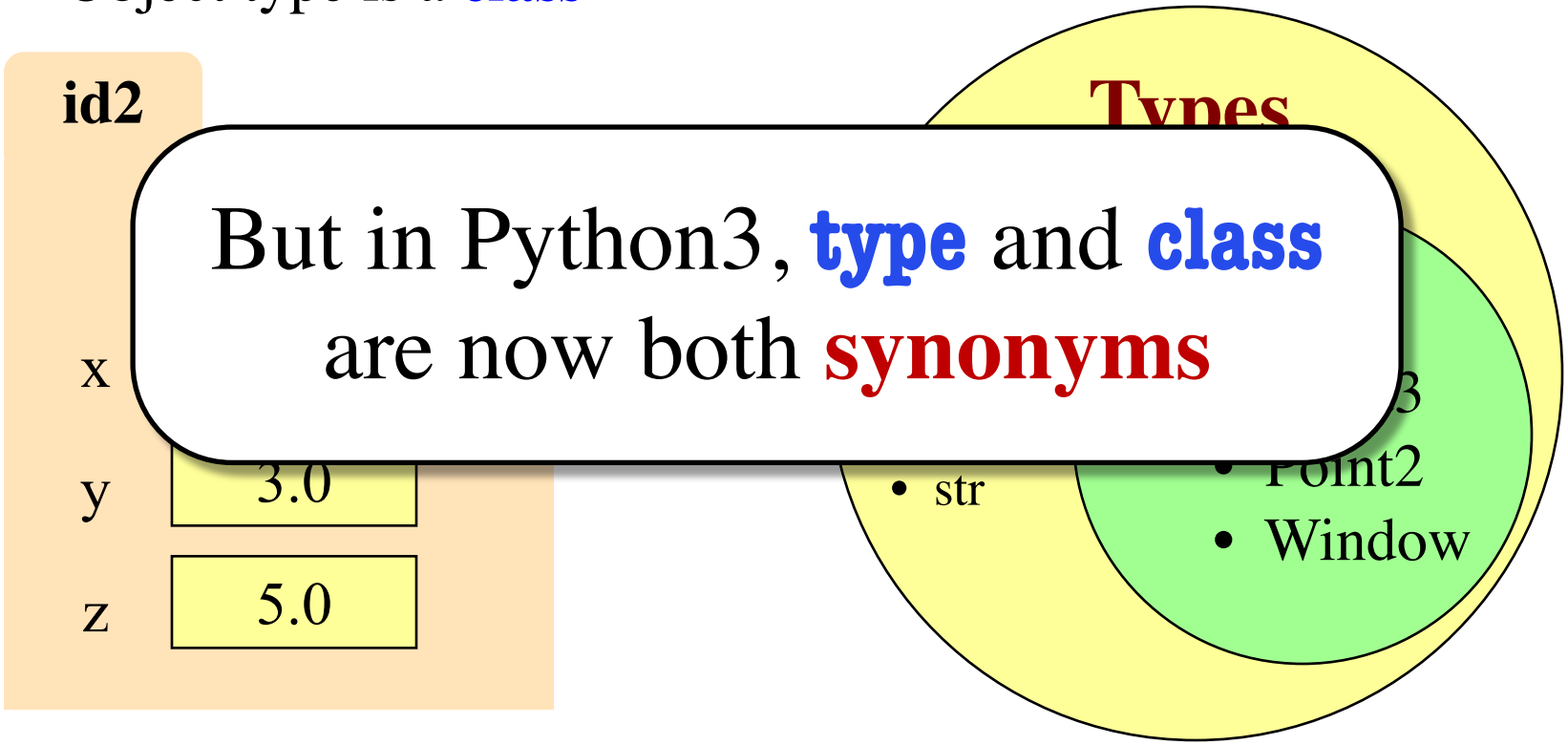
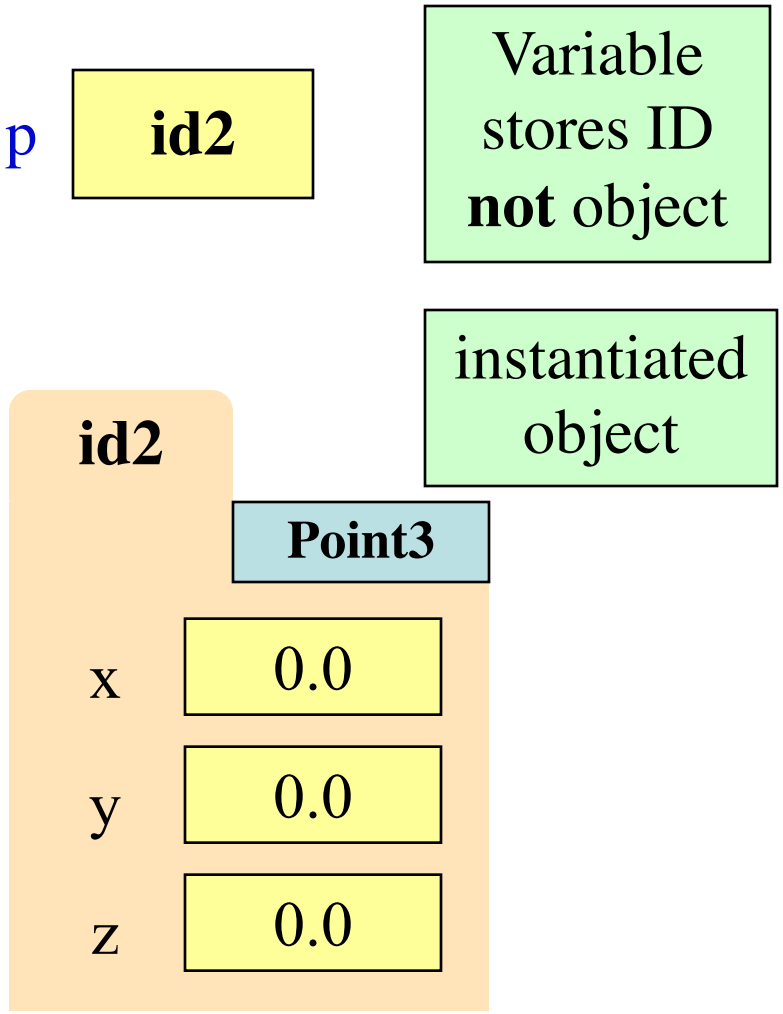


Constructor: Function to make Objects

- How do we create objects?
  - Other types have **literals**
  - **Example**: 1, 'abc', **true**
  - No such thing for objects
- **Constructor Function**:
  - Same name as the class
  - **Example**: `Point3(0,0,0)`
  - Makes an object (manila folder)
  - Returns folder ID as value
- **Example**: `p = Point3(0, 0, 0)`
  - Creates a Point object
  - Stores object's ID in p



Constructors and Modules

```
>>> import introcs
```

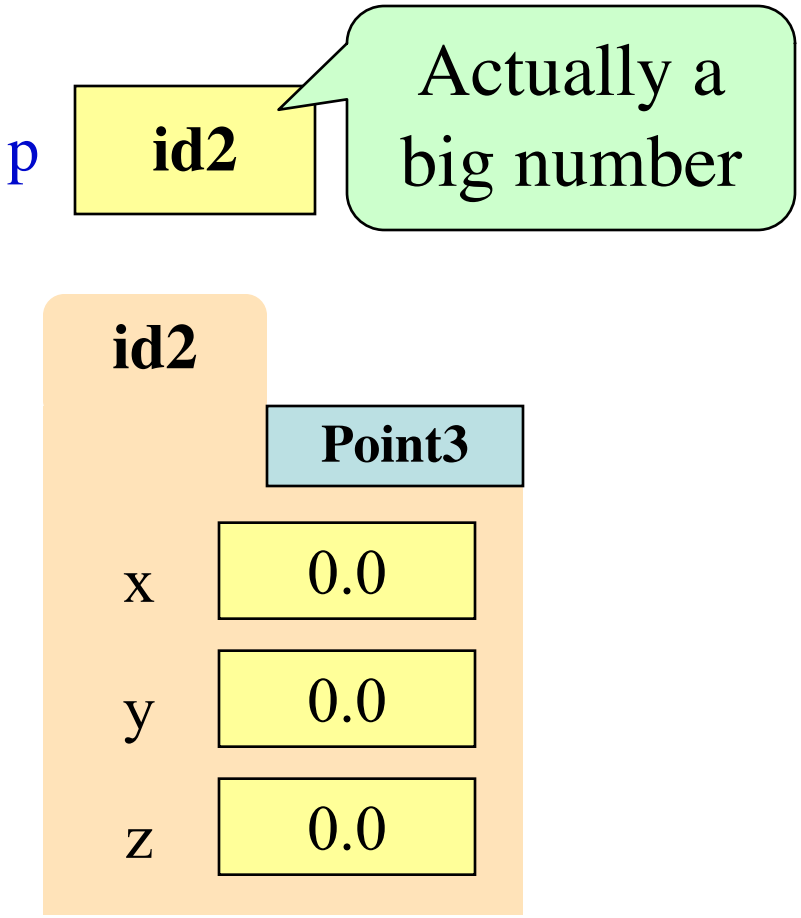
Need to import module that has Point class.

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

Constructor is function. Prefix w/ module name.

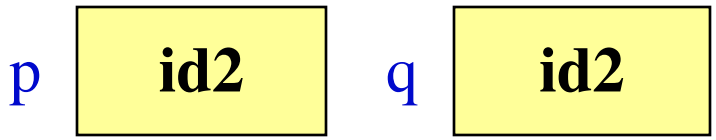
```
>>> id(p)
```

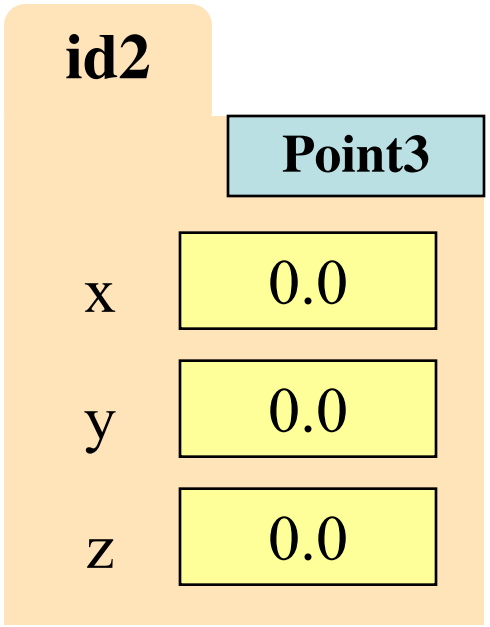
Shows the ID of p.



Object Variables

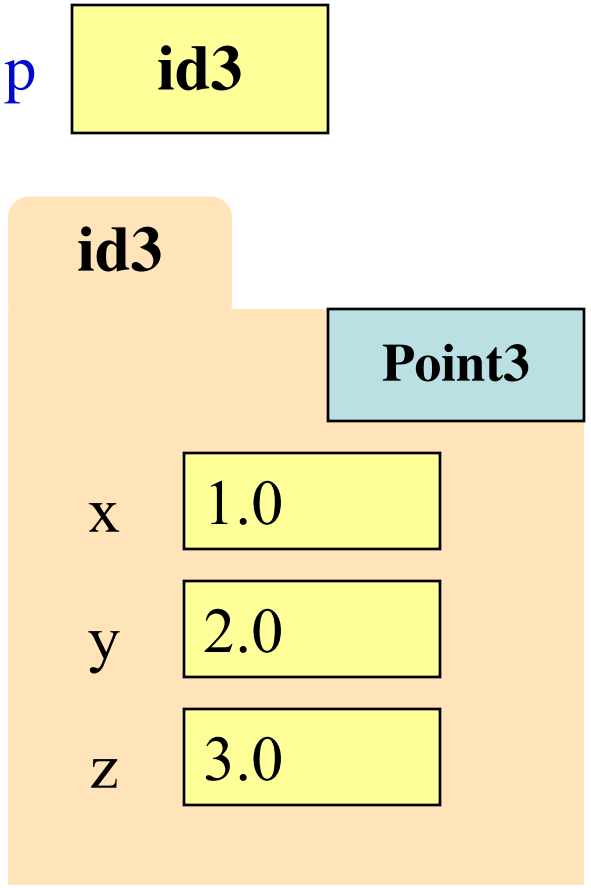
- Variable stores object name
  - **Reference** to the object
  - Reason for folder analogy
- Assignment uses object name
  - **Example**: q = p
  - Takes name from p
  - Puts the name in q
  - Does not make new folder!
- This is the cause of many mistakes in this course





Objects and Attributes

- Attributes are variables that live inside of objects
  - Can **use** in expressions
  - Can **assign** values to them
- **Access**: <variable>.<attr>
  - **Example**: p.x
  - Look like module variables
- Putting it all together
  - p = introcs.Point3(1,2,3)
  - p.x = p.y + p.z



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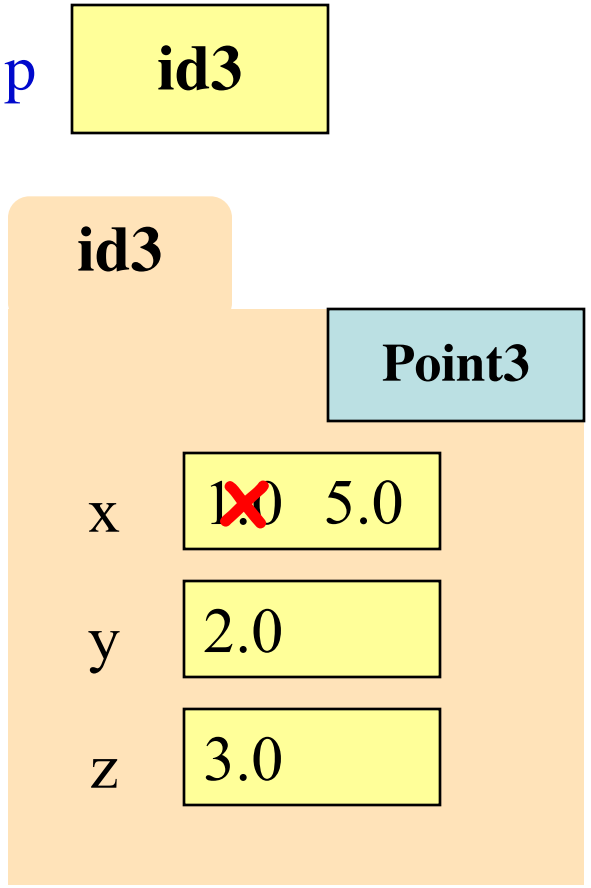


Exercise: Attribute Assignment

- Recall, `q` gets name in `p`

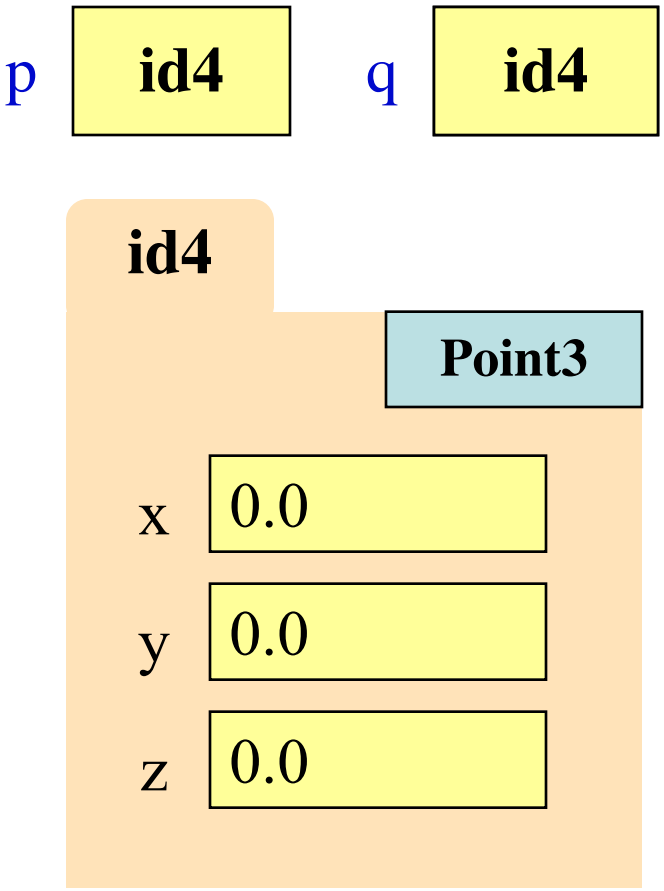
```
>>> p = introcs.Point3(0,0,0)
>>> q = p
```

- Execute the assignments:

```
>>> p.x = 5.6
>>> q.x = 7.4
```

- What is value of `p.x`?

A: 5.6
B: 7.4
C: **id4**
D: I don't know



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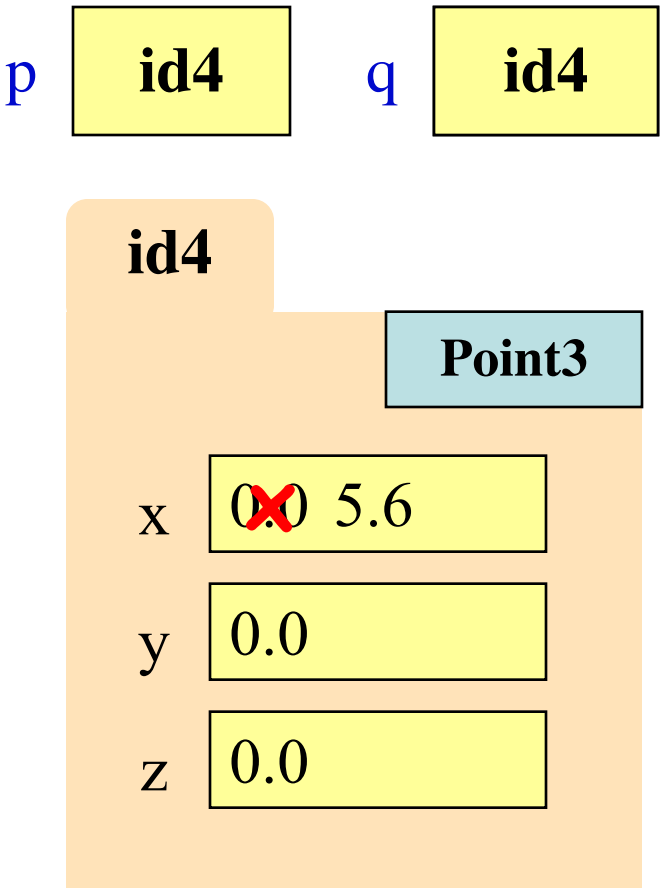

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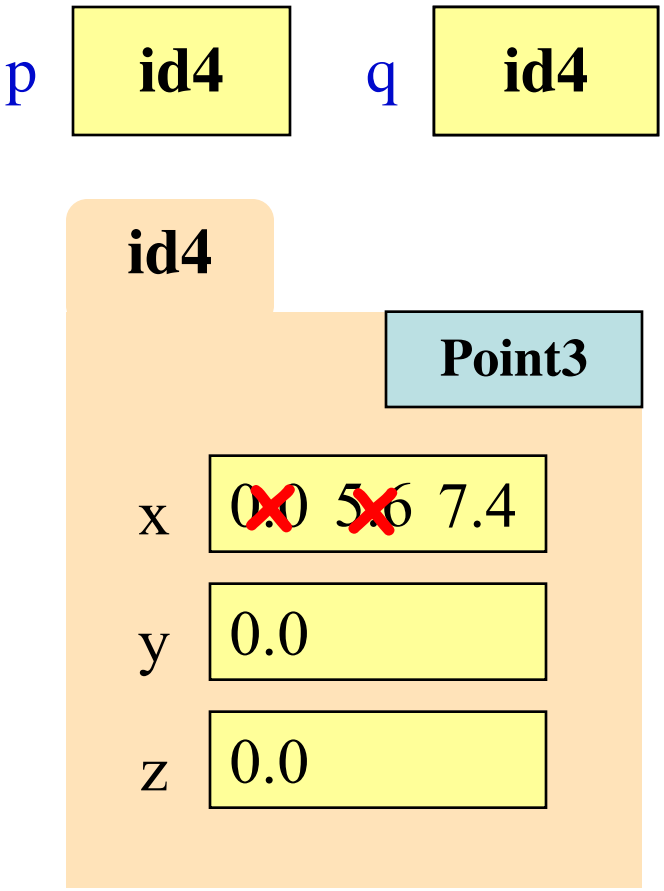


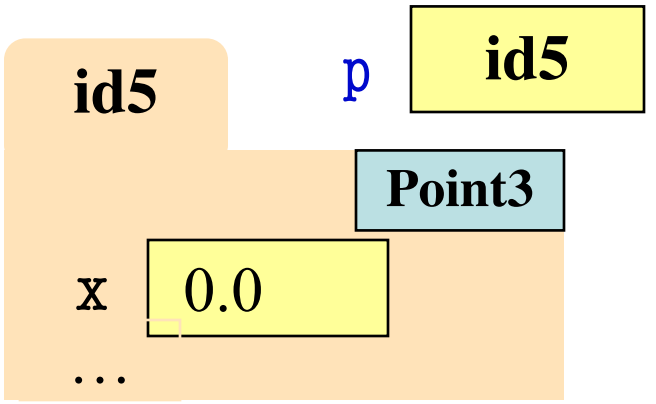
Call Frames and Objects

- Mutable objects can be altered in a function call
  - Object vars hold names!
  - Folder accessed by both global var & parameter
- **Example**:

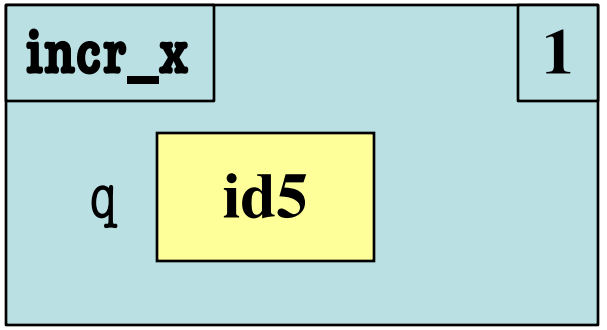
```
def incr_x(q):
    q.x = q.x + 1
```

```
>>> p = introcs.Point3(0,0,0)
>>> incr_x(p)
```

Global **STUFF**



Call Frame



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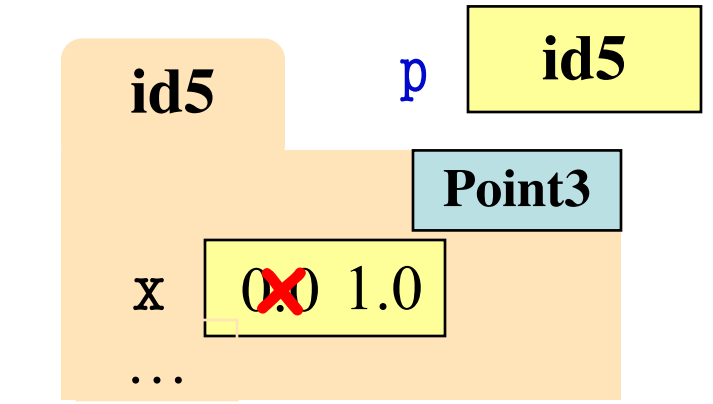

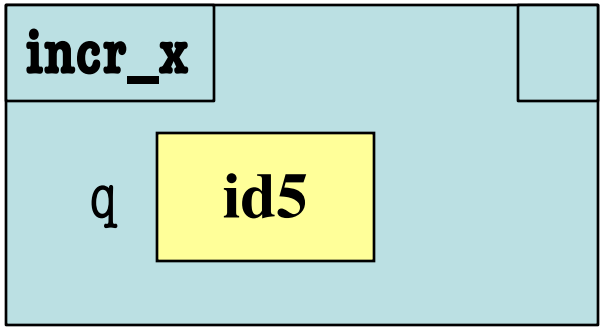

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1

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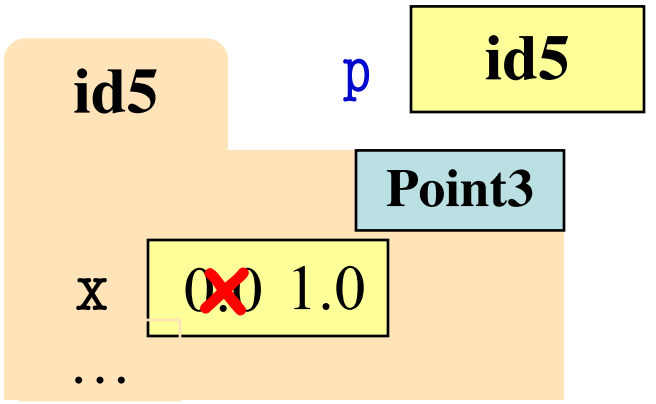


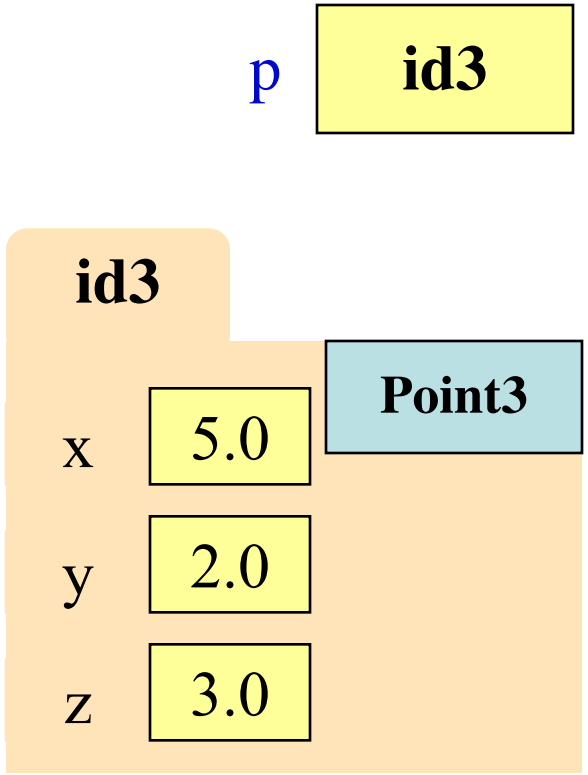
Call Frame

Methods: Functions Tied to Objects

- **Method**: function tied to object
  - Method call looks like a function call preceded by a variable name:

    ⟨*variable*⟩.⟨*method*⟩(⟨*arguments*⟩)

  - **Example**: `p.distance(q)`
  - **Example**: `p.abs()` # makes x,y,z ≥ 0
- Just like we saw for strings
  - `s = 'abracadabra'`
  - `s.index('a')`
- Are strings objects?

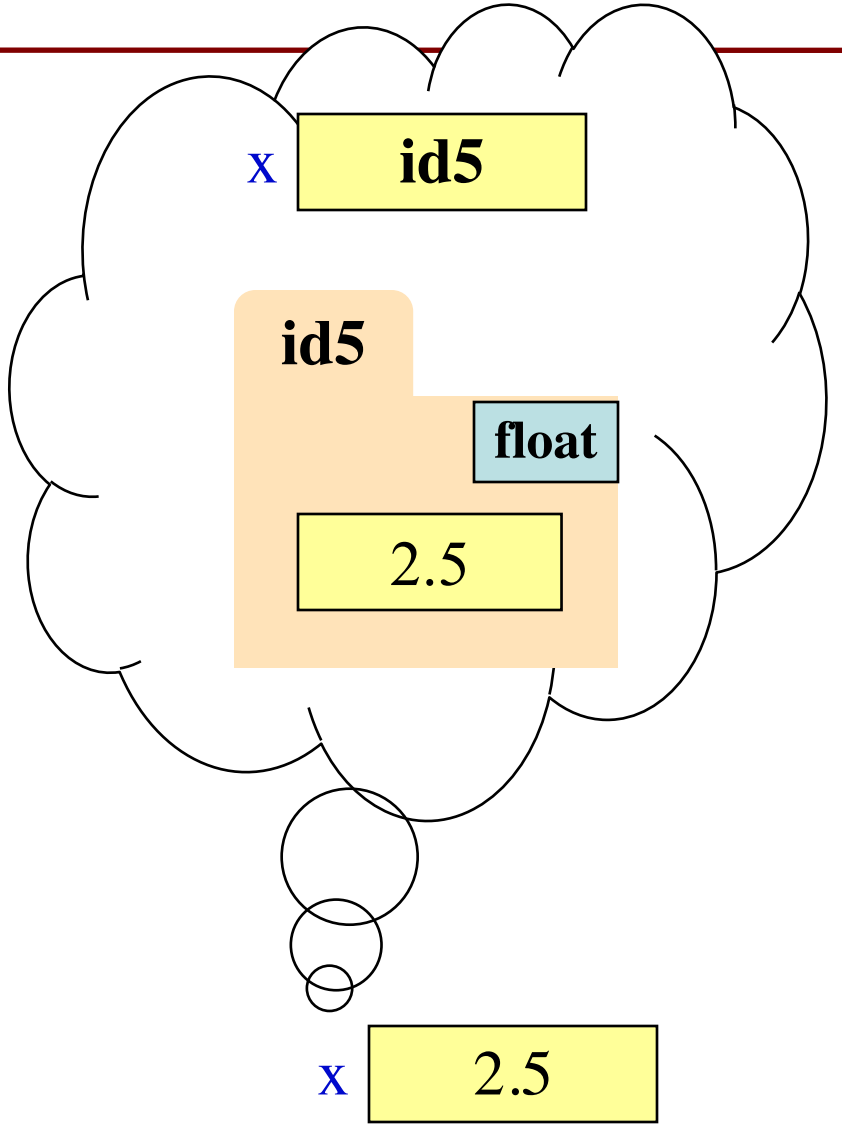


Surprise: All Values are in Objects!

- Including basic values
  - int, float, bool, str
- **Example**:

```
>>> x = 2.5
>>> id(x)
```

- But they are *immutable*
  - Contents cannot change
  - Distinction between *value* and *identity* is immaterial
  - So we can ignore the folder



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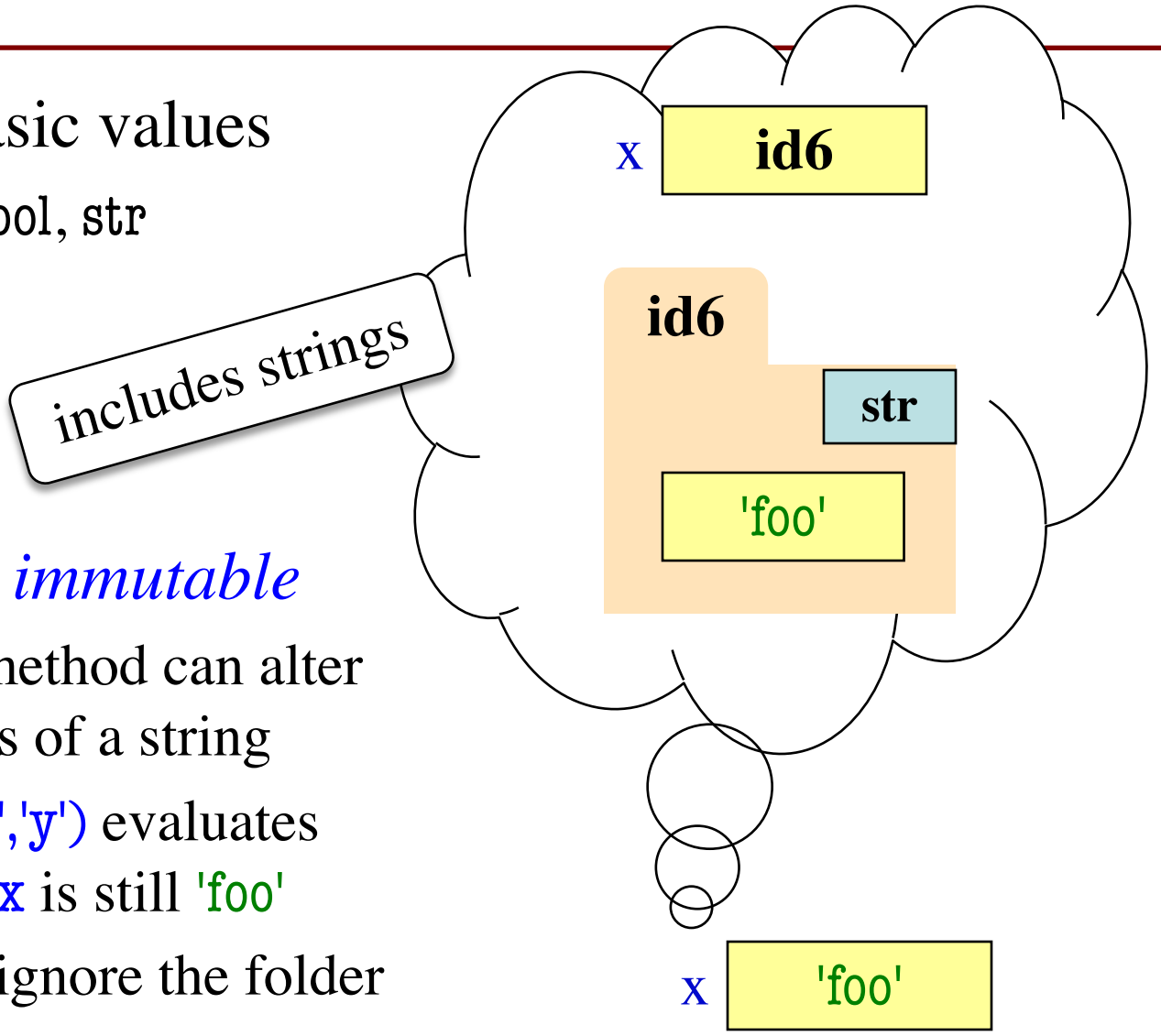
- **Example**:

```
>>> x = 'foo'
>>> id(x)
```

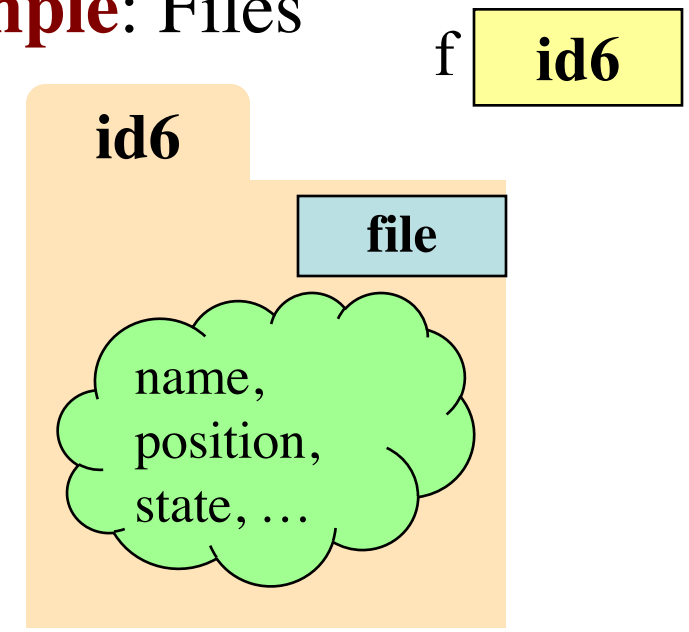
- But they are *immutable*
  - No string method can alter the contents of a string
  - x.replace('o','y') evaluates to 'fyy' but x is still 'foo'
  - So we can ignore the folder



Class Objects

- Use name **class object** to distinguish from other values
  - Not int, float, bool, str
- Class objects are **mutable**
  - You can change them
  - Methods can have effects besides their return value
- **Example**:
  - p = Point(3,-3,0)
  - p.clamp(-1,1)

Example: Files




```
f = open('jabber.txt')
s = f.read()
f.close()
```

Opens a file on your disk; returns a **file object** you can read

Base Types vs. Classes

Base Types

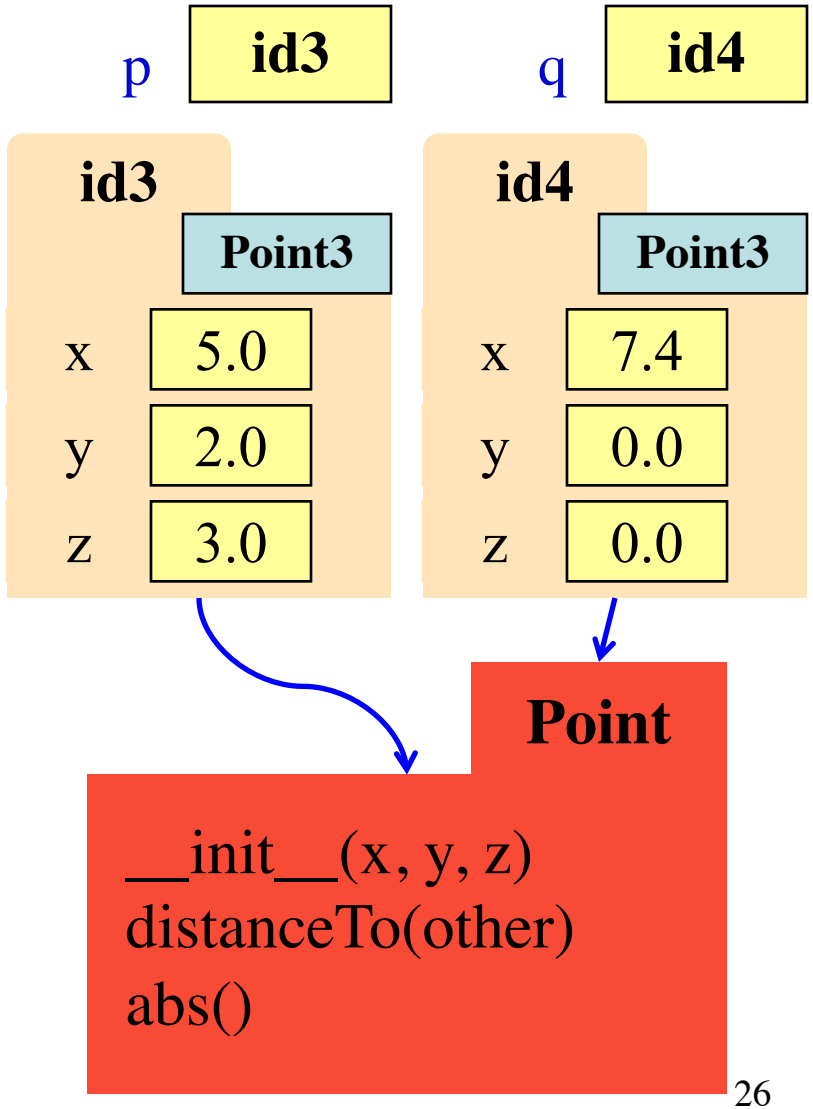
- Built-into Python
- Refer to instances as *values*
- Instantiate with *literals*
- Are all immutable
- Can ignore the folders

Classes

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

Aside: Name Resolution

- ⟨*object*⟩.⟨*name*⟩ means
  - Go the folder for *object*
  - Look for attr/method *name*
  - If missing, check *class folder*
- Class folder is a **shared folder**
  - Only one for the whole class
  - Shared by all objects of class
  - Stores common features
  - Typically where methods are
- Do not worry about this yet



Where To From Here?

- Right now, just try to understand **objects**
  - All Python programs use objects
  - Most small programs use objects of classes that are part of the Python Library
- OO Programming is about **creating classes**
  - Eventually you will make your own classes
  - Classes are the primary tool for organizing more complex Python programs
  - But we need to learn other basics first