Lecture 17

Methods and Encapsulation

Announcements for This Lecture

Assignment 4

- Due on Sunday at midnight
  - Turned on in CMS today
- Looking at Consultant Hours
  - Thursday was very busy
  - Sat. hours might be possible
- Survey extra important!
- Will post A5 at end of week
  - Written assignment like A2
  - Can do at the same time

Lab this Week

- Simple class exercise
  - Fill in predefined methods
  - Setting you up for A6…
- **Exams** are handed back
  - Organized by lab section
  - Unclaimed exams will go to handback room on Thurs
- Regrades turned on in CMS
  - For major mistakes only

Recursion and A4

Wrong

- Recursion on pmap keys
  - Argument must get smaller
  - pmap should never change
- Also do not loop over keys
- **Example**: Autocomplete

```
keys = pmap.keys()
accum = []
for word in keys:
    # Add word if it extends prefix
return accum
```

Right

- Recursion on prefix
  - Extend prefix via pmap
  - Compute extended answer
  - Combine with others
- Example: Autocomplete
  - pmap = { 'a':['t','x',''], ...
  - Extensions of 'a' are
    - 'a', plus
    - Extensions of 'at', plus
    - Extensions of 'ax'

Important!

YES

```
class Point(object):
    """Instances are 3D points
    Attributes:
        x: x-coord [float]
        y: y-coord [float]
        z: z-coord [float]"""
    …
```

3.0-Style Classes
Well-Designed

NO

```
class Point:
    """Instances are 3D points
        Attributes:
            x: x-coord [float]
            y: y-coord [float]
            z: z-coord [float]"""
    …
```

“Old-Style” Classes
Very, Very Bad

Converting Values to Strings

str() Function

- **Usage**: str(<expression>)
  - Evaluates the expression
  - Converts it into a string
- How does it convert?
  - str(1) → '1'
  - str(True) → 'True'
  - str('abc') → 'abc'
  - str(Point()) → '(0.0,0.0,0.0)'

Backquotes

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  - `Point()` → "<class 'Point'> (0.0,0.0,0.0)"

Converting Values to Strings

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What type is this value?

Backquotes

- **Us**
  -
  -
- Ho
  - `1` → '1'
  - `True` -
  - `'abc'` -
  - `Point()` -

"<class 'Point'> (0.0,0.0,0.0)"

Backquotes are for *unambigious* representation

The value's type is clear

What Does str() Do On Objects?

- Does **NOT** display contents

```
>>> p = Point(1,2,3)
>>> str(p)
'<Point object at 0x1007a90>'
```

- Must add a special method
  - __str__ for str()
  - __repr__ for backquotes
- Could get away with just one
  - Backquotes require __repr__
  - str() can use __repr__ (if __str__ is not there)

```
class Point(object):
    """Instances are points in 3d space"""
    …
    def __str__(self):
        """Returns: string with contents"""
        return '('+self.x + ',' +
                   self.y + ',' +
                   self.z + ')'

    def __repr__(self):
        """Returns: unambiguous string"""
        return str(self.__class__)+
                 str(self)
```

What Does str() Do On Objects?

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                 str(self)
```

Gives the class name

__repr__ using __str__ as helper

Special Methods in Python

- Have seen three so far
  - __init__ for initializer
  - __str__ for str()
  - __repr__ for backquotes
- Start/end w/ two underscores
  - This is standard in Python
  - Used in all special methods
  - Also for special attributes
- For a complete list, see

  http://docs.python.org/reference/datamodel.html

```
class Point(object):
    """Instances are points in 3D space"""
    …

    def __init__(self,x=0,y=0,z=0):
        """Initializer: makes new Point"""
        …

    def __str__(self,q):
        """Returns: string with contents""”
        …

    def __repr__(self,q):
        """Returns: unambiguous string""”
        …
```

Challenge: Implementing Fractions

- Python has many built-in math types, but not all
  - Want to add a new type
  - Want to be able to add, multiply, divide etc.
  - Example: ½*¾ = ⅜
- Can do this with a class
  - Objects are fractions
  - Have built-in methods to implement +, *, /, etc…
  - **Operator overloading**

```
class Fraction(object):
    """Instance attributes:
        numerator:   top       [int]
        denominator: bottom [int > 0]"""

    def __init__(self,n=0,d=1):
        """Initializer: makes a Frac"""
        self.numerator = n
        self.denominator = d

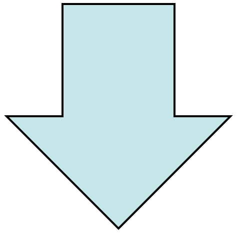
    def __str__(self):
        """Returns: Fraction as string"""
        return (str(self.numerator)
                +'/'+str(self.denominator))
```

Operator Overloading: Multiplication

```
class Fraction(object):
    """Instance attributes:
        numerator:    top        [int]
        denominator: bottom [int > 0]""”

    def __mul__(self,q):
        """Returns: Product of self, q
        Makes a new Fraction; does not
        modify contents of self or q
        Precondition: q a Fraction"""
        assert type(q) == Fraction
        top = self.numerator*q.numerator
        bot = self.denominator*q.denominator
        return Fraction(top,bot)
```

```
>>> p = Fraction(1,2)
>>> q = Fraction(3,4)
>>> r = p*q
```



Python converts to

```
>>> r = p.__mul__(q)
```

Operator overloading uses method in object on left.

Operator Overloading: Addition

```
class Fraction(object):
   """Instance attributes:
       numerator:    top       [int]
       denominator: bottom [int > 0]""”

   def __add__(self,q):
      """Returns: Sum of self, q
      Makes a new Fraction
      Precondition: q a Fraction"""
      assert type(q) == Fraction
      bot = self.denominator*q.denominator
      top = (self.numerator*q.denominator+
                self.denominator*q.numerator)
      return Fraction(top,bot)
```

```
>>> p = Fraction(1,2)
>>> q = Fraction(3,4)
>>> r = p+q
```

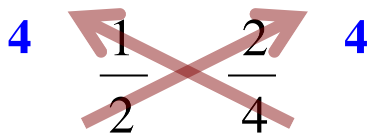
Python converts to

```
>>> r = p.__add__(q)
```

Operator overloading uses method in object on left.

Comparing Objects for Equality

- Earlier in course, we saw == compare object contents
    - This is not the default
    - **Default**: folder names
- Must implement __eq__
    - Operator overloading!
    - Not limited to simple attribute comparison
    - **Ex**: cross multiplying



```
class Fraction(object):
    """Instance attributes:
        numerator:    top       [int]
        denominator: bottom [int > 0]"""

    def __eq__(self,q):
        """Returns: True if self, q equal,
        False if not, or q not a Fraction"""
        if type(q) != Fraction:
            return False
        left = self.numerator*q.denominator
        rght = self.denominator*q.numerator
        return left == rght
```

Issues With Overloading ==

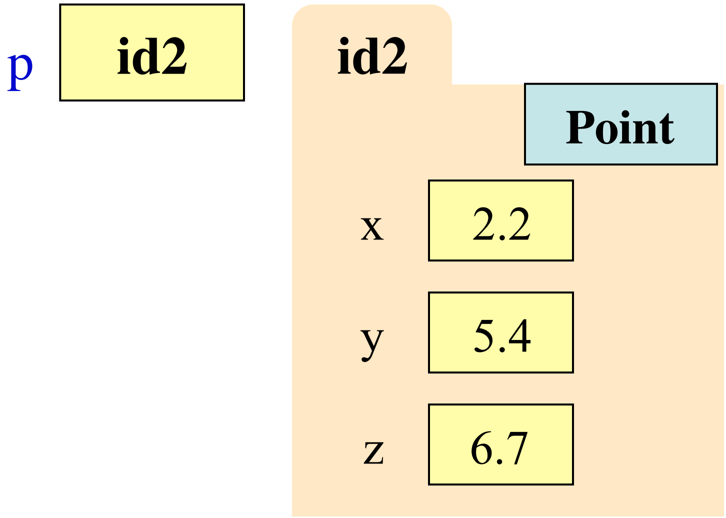
- Overloading == **does not** also overload comparison !=
  - Must implement __ne__
  - Why? Will see later
  - But (not x == y) is okay!
- What if you still want to compare Folder names?
  - Use is operator on variables
  - (x is y) True if x, y contain the same folder name
  - Check if variable is empty: x is None (x == None is bad)

```
class Fraction(object):
    …
    def __eq__(self,q):
        """Returns: True if self, q equal,
        False if not, or q not a Fraction"""
        if type(q) != Fraction:
            return False
        left = self.numerator*q.denominator
        rght = self.denominator*q.numerator
        return left == rght

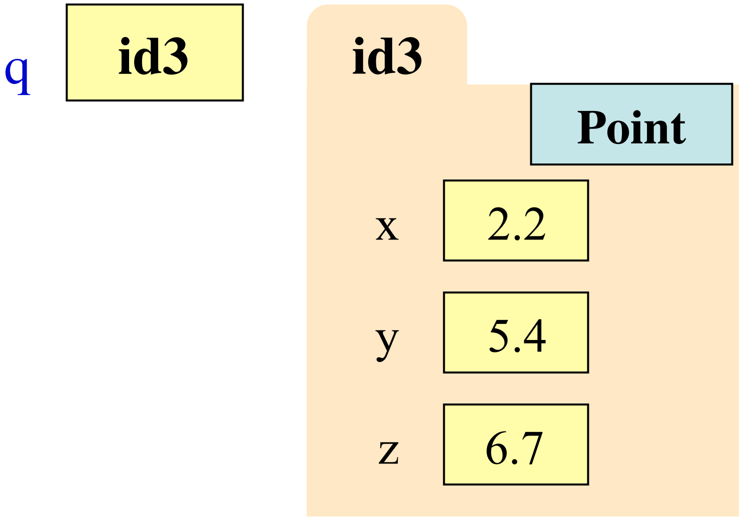
    def __ne__(self,q):
        """Returns: False if self, q equal,
        True if not, or q not a Fraction"””
        return not self == q
```

is Versus ==

- p is q evaluates to False
  - Compares folder names
  - Cannot change this



- p == q evaluates to True
  - But only because method __eq__ compares contents



Always use (x is None) **not** (x == None)

Getting Information About a Class

- Recall the help() function shows module contents
  - Works on classes too
  - **Example**: help(Point)
- Can even use on object
  - In that case, runs help on the class of that object
  - Example: help(p)
- Shows all methods
  - And **class** attributes

```
class Fraction(__builtin__.object)
 |  Instance is a fraction n/d
 |  Instance Attributes:
 |      numerator:   top part    [int]
 |      denominator: bottom part [int > 0]
 |
 |  Methods defined here:
 |
 |  __add__(self, other)
 |      Returns: Sum of self and other as a
 |      new Fraction. Does not modify
 |      contents of self or other.
 |
 |     Precondition: other is a Fraction
…
```

Summary + Files

- Methods with double underscores are special
  - Used to implement **operators** (e.g. +, ==, <)
  - Great for implementing mathematical objects
  - **Example**: fraction.py
- Attributes cannot enforce invariants
  - Want to wrap them in getters, setters
  - Setters use asserts to enforce invariants
  - **Example**: betterfraction.py
- **But how does class RGB work?**
  - No setters, getters but enforces its invariants
  - **Advanced programming topic.** Ask outside of class.