Lecture 18

Methods and Operations

Announcements for This Lecture

Assignments

- **A4** Due Thursday at midnight
  - Hopefully you are on Task 4
  - Extra consultants available
- Will post **A5** on Thursday
  - Written assignment like A2
  - Needs material from next Tues
- Will also post **A6** as well
  - Not due until November 19
  - Want to avoid exam crunch

Lab this Week

- Simple class exercise
  - Fill in predefined methods
  - Setting you up for A6…

Exams

- Moved to handback room
  - Located in Gates 216
  - Open 12-4:30 daily
- Regrades still open this week

Important!

YES

```
class Point3(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 Point3:
"""Instances are 3D points
    Attributes:
        x: x-coord [float]
        y: y-coord [float]
        z: z-coord [float]"""
    …
```

“Old-Style” Classes
Very, Very Bad

Case Study: Fractions

- Want to add a new *type*
  - Values are fractions: ½ , ¾
  - Operations are standard multiply, divide, etc.
  - **Example**: ½*¾ = ⅜
- Can do this with a class
  - Values are fraction objects
  - Operations are methods
- **Example**: simplefrac.py

```
class Fraction(object):
    """Instance is a fraction n/d

    Attributes:
      numerator:    top        [int]
      denominator:  bottom [int > 0]
    """

    def __init__(self,n=0,d=1):
        """Init: makes a Fraction"""
        self.numerator = n
        self.denominator = d
```

Problem: Doing Math is Unwieldy

What We Want	What We Get

$\left(\frac{1}{2}+\frac{1}{3}+\frac{1}{4}\right)*\frac{5}{4}$	`>>> p = Fraction(1,2)`
	`>>> q = Fraction(1,3)`
	`>>> r = Fraction(1,4)`
	`>>> s = Fraction(5,4)`
	`>>> (p.add(q.add(r))).mult(s)`

This is confusing!

Problem: Doing Math is Unwieldy

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Why not use the standard Python math operations?

This is confusing!

Recall: The __init__ Method

two underscores

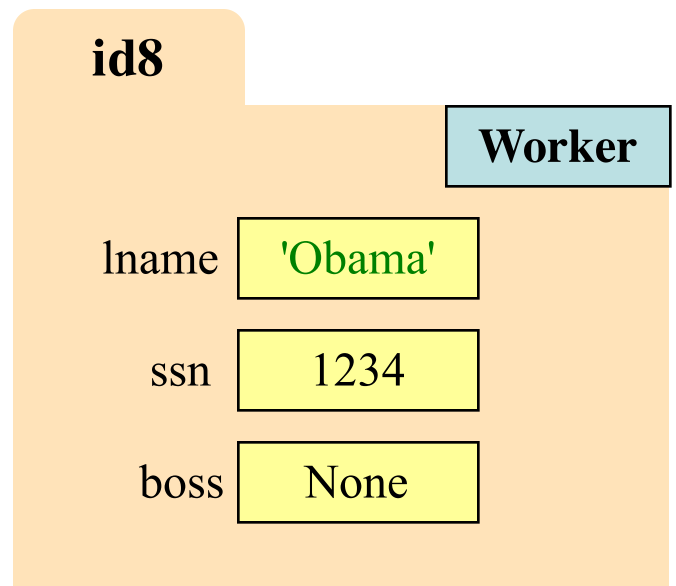
```
w = Worker('Obama', 1234, None)
```

```
def __init__(self, n, s, b):
    """Initializer: creates a Worker

    Has last name n, SSN s, and boss b

    Precondition: n a string, s an int in
    range 0..999999999, and b either
    a Worker or None.
    self.lname = n
    self.ssn  = s
    self.boss = b
```

Called by the constructor



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    self.lname = n
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    self.boss = b
```

Are there other special methods that we can use?

Example: Converting Values to Strings

str() Function	**Backquotes**
• **Usage**: str(<expression>) ▪ Evaluates the expression ▪ Converts it into a string • How does it convert? ▪ str(2) → '2' ▪ str(True) → 'True' ▪ str('True') → 'True' ▪ str(Point3()) → '(0.0,0.0,0.0)'	• **Usage**: \`<expression>\` ▪ Evaluates the expression ▪ Converts it into a string • How does it convert? ▪ \`2\` → '2' ▪ \`True\` → 'True' ▪ \`'True'\` → "'True'" ▪ \`Point3()\` → "<class 'Point3'> (0.0,0.0,0.0)"

Example: Converting Values to Strings

str() Function

- **Usage**: str(<expression>)
  - Evaluates the expression
  - Converts it into a string
- How does it con
  - str(2) → '2'
  - str(True) → 'True
  - str('True') → 'True'
  - str(Point3()) → '(0.0,0.0,0.0)'

What type is this value?

Backquotes

Backquotes are for *unambigious* representation

- How does it co
  - `2` → '2'
  - `True` → 'Tr
  - `'True'` → "'True'"
  - `Point3()` →
    "<class 'Point3'> (0.0,0.0,0.0)"

The value's type is clear

What Does str() Do On Objects?

- Does **NOT** display contents
  - `>>> p = Point3(1,2,3)`
  - `>>> str(p)`
  - `'<Point3 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 Point3(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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>>> p = Point3(1,2,3)
>>> str(p)
'<Point3 object at 0x1007a90>'
```

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    def __repr__(self):
        """Returns: unambiguous string"""
        return str(self.__class__)+
               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 with 2 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 Point3(object):
    """Instances are points in 3D space"""
    …

    def __init__(self,x=0,y=0,z=0):
        """Initializer: makes new Point3"""
        …

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

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

Returning to Fractions

What We Want

$$\left(\frac{1}{2}+\frac{1}{3}+\frac{1}{4}\right)*\frac{5}{4}$$

Why not use the standard Python math operations?

Operator Overloading

- Python has methods that correspond to built-in ops
  - `__add__` corresponds to +
  - `__mul__` corresponds to *
  - Not implemented by default
- Implementing one allows you to use that op on your objects
  - Called operator overloading
  - Changes operator meaning

Operator Overloading: Multiplication

```python
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

$$4 \quad \frac{1}{2} \quad \frac{2}{4} \quad 4$$

```
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 ==

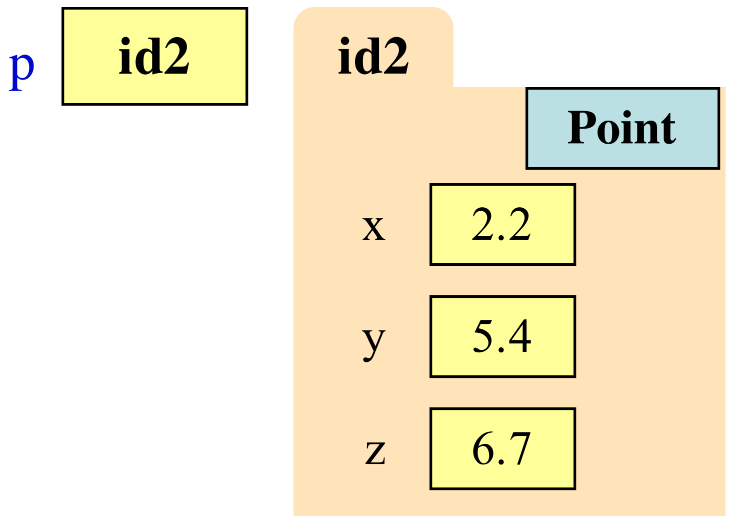
- Overloading == **does not** also overload comparison !=
  - Must implement __ne__
  - Why? Will see later
  - But (not x == y) is okay!
- What if you still want to compare Folder names?
  - Use is operator on variables
  - (x is y) True if x, y contain the same folder name
  - Check if variable is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

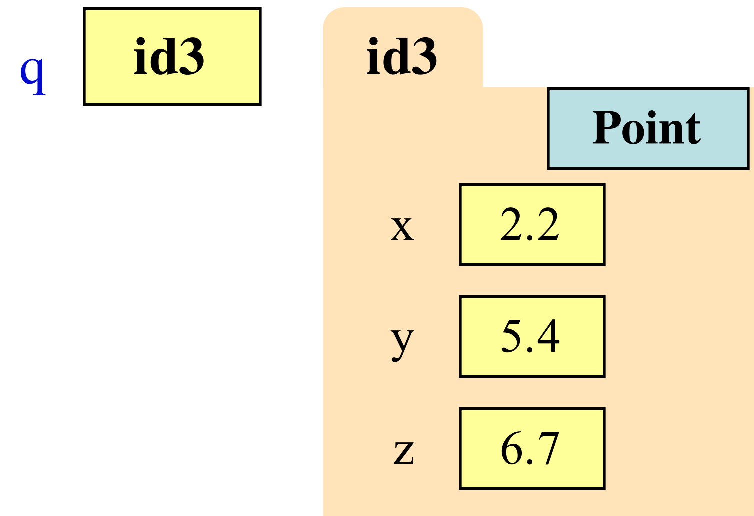
```
class Fraction(object):
    …
    def __eq__(self,q):
        """Returns: True if self, q equal,
        False if not, or q not a Fraction"""
        if type(q) != Fraction:
            return False
        left = self.numerator*q.denominator
        rght = self.denominator*q.numerator
        return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