## 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**

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

Why not use the standard Python math operations?

**What We Get**

```
>>> 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!

## Example: Converting Values to Strings

**str() Function**

- **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)'

**Backquotes**

- **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)"

## 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)
```

## 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

```
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

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

```
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
```

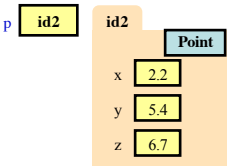
## Issues With Overloading ==

- 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)

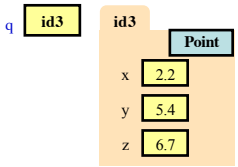
```
class Fraction(object):
    ...
    def __eq__(self,q):
        """Returns: True if self, q equal,
        False if not, or q not a Fraction"""
        if type(q) != Fraction:
            return False
        left = self.numerator*q.denominator
        rght = self.denominator*q.numerator
       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