Lecture 12

Methods and Operations

Important!

YES	NO
class Point3(object): """Instances are 3D points Attributes: x: x-coord [float] y: y-coord [float] z: z-coord [float]""" …	**class** Point3: """Instances are 3D points Attributes: x: x-coord [float] y: y-coord [float] z: z-coord [float]""" …
3.0-Style Classes Well-Designed	"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

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

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!

Problem: Doing Math is Unwieldy

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Why not use the standard Python math operations?

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```

This is confusing!

Recall: The __init__ Method

two underscores

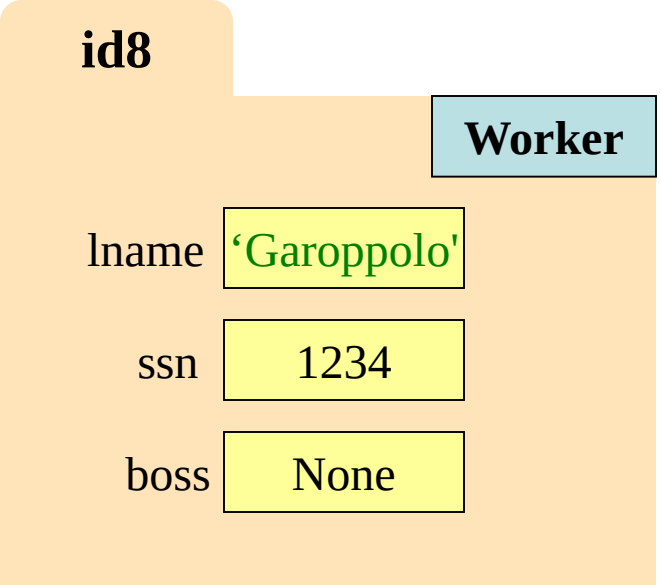
```
w = Worker('Garoppolo', 1234, None)
```

```
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



Recall: The __init__ Method

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    a Worker or None.
    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

- **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)"

Example: Converting Values to Strings

str() Function

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  - Converts it into a string
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What type is this value?

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  - str(True) → 'True'
  - str('True') → 'True'
  - str(Point3()) → '(0.0,0.0,0.0)'

Backquotes

- U
  -
  -

Backquotes are for *unambigious* representation

How does it conv

The value's type is clear

  - `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)
```

What Does str() Do On Objects?

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>>> str(p)
'<Point3 object at 0x1007a90>'
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        """Returns: unambiguous string"""
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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 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

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

```
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 ==

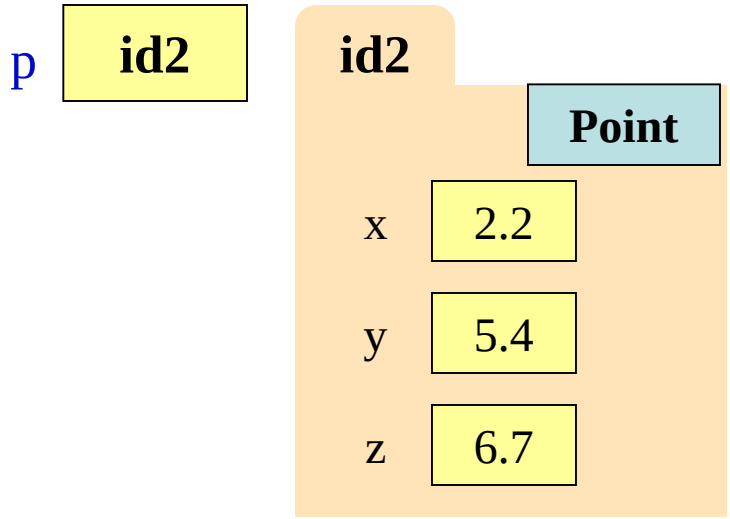
- Overloading == **does not** also overload comparison !=
  - Must implement __ne__
  - Why? Will see later
  - But (not x == y) is okay!
- What if you still want to compare Folder names?
  - Use is operator on variables
  - (x is y) True if x, y contain the same folder name
  - Check if variable is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

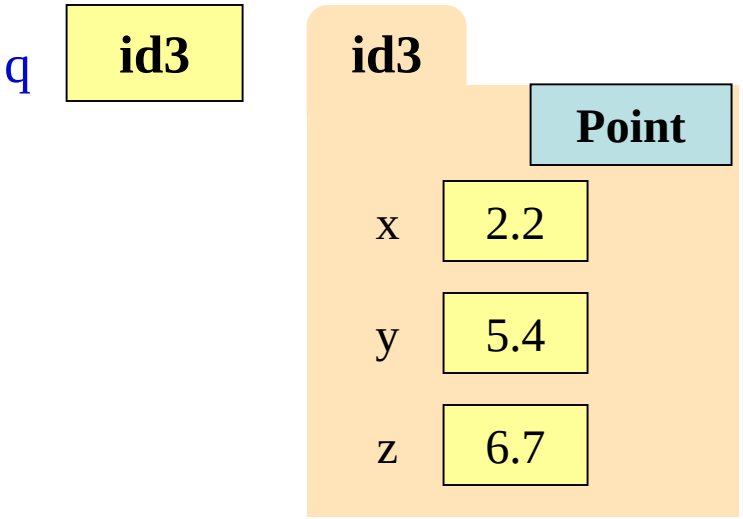
```
class Fraction(object):
    …
    def __eq__(self,q):
        """Returns: True if self, q equal,
        False if not, or q not a Fraction"""
        if type(q) != Fraction:
            return False
        left = self.numerator*q.denominator
        rght = self.denominator*q.numerator
        return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

Hiding Methods From Access

- Put underscore in front of a method will make it **hidden**
  - Will not show up in help()
  - But it is still there…
- Hidden methods
  - Can be used as **helpers** inside of the same class
  - But it is bad style to use them outside of this class
- Can do same for attributes
  - Underscore makes it hidden
  - Do not use outside of class

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

    def _is_denominator(self,d):
        """Return: True if d valid denom"""
        return type(d) == int and d > 0

    def __init__(self,n=0,d=1):
        assert self._is_denominator(d)
        self.numerator = n
        self.denominator = d
```

HIDDEN

Helper method

Enforcing Invariants

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

Invariants: Properties that are always true.

- These are just comments!

```
>>> p = Fraction(1,2)
>>> p.numerator = 'Hello'
```

- How do we prevent this?

- **Idea**: Restrict direct access
  - Only access via methods
  - Use asserts to enforce them
- Examples:

```
def getNumerator(self):
    """Returns: numerator"""
    return self.numerator

def setNumerator(self,value):
    """Sets numerator to value"""
    assert type(value) == int
    self.numerator = value
```

Data Encapsulation

- **Idea**: Force the user to only use methods
- Do not allow direct access of attributes

Setter Method

- Used to change an attribute
- Replaces all assignment statements to the attribute
- **Bad**:

```
>>> f.numerator = 5
```

- **Good**:

```
>>> f.setNumerator(5)
```

Getter Method

- Used to access an attribute
- Replaces all usage of attribute in an expression
- **Bad**:

```
>>> x = 3*f.numerator
```

- **Good**:

```
>>> x = 3*f.getNumerator()
```

Data Encapsulation

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

    def getDenomenator(self):
        """Returns: numerator attribute"""
        return self._denomenator

    def setDenomenator(self, d):
        """Alters denomenator to be d
        Pre: d is an int > 0"""
        assert type(d) == int
        assert 0 < d
        self._denominator = d
```

Do this for all of your attributes

Getter

Setter

Naming Convention

The underscore means "should not access the attribute directly."

Precondition is same as attribute invariant.

Mutable vs. Immutable Attributes

Mutable

- Can change value directly
  - If class invariant met
  - **Example**: t.color
- Has both getters and setters
  - Setters allow you to change
  - Enforce invariants w/ asserts

Immutable

- Can't change value directly
  - May change "behind scenes"
  - **Example**: t.x
- Has only a getter
  - No setter means no change
  - Getter allows limited access

May ask you to differentiate on the exam

Structure of a Proper Python Class

```
class Fraction(object):
    """Instances represent a Fraction
       Attributes:
          _numerator: [int]
         _denominator: [int > 0]"""

    def getNumerator(self):
        """Returns: Numerator of Fraction"""
    …
    def __init__(self,n=0,d=1):
        """Initializer: makes a Fraction"""
    …
    def __add__(self,q):
        """Returns: Sum of self, q"""
    …
    def normalize(self):
        """Puts Fraction in reduced form"""
    …
```

Docstring describing class
Attributes are all **hidden**

Getters and Setters.

Initializer for the class.
Defaults for parameters.

Python operator overloading

Normal method definitions