Relationship to the Python Object System

Object attributes are stored as dictionaries.

Some special names, __<name>__, require special handling.

An object has an "attribute" called __dict__ that is a dictionary of its user-defined instance attributes.

In Python, classes have classes too.

The equivalent of init_instance can be customized (metaclass).
Generic Functions

An abstraction might have more than one representation
• Python has many sequence types: tuples, ranges, lists, etc.

An abstract data type might have multiple implementations
• Some representations are better suited to some problems

A function might want to operate on multiple data types

Today's Topics:
• Generic functions using message passing
• String representations of objects
• Multiple representations of abstract data types
• Property methods
String Representations

An object value should **behave** like the kind of data it is meant to represent.

For instance, by **producing a string** representation of itself.

Strings are important: they represent *language* and *programs*.

In Python, all objects produce two string representations:

- The "str" is legible to **humans**.
- The "repr" is legible to the **Python interpreter**.

When the "str" and "repr" **strings are the same**, we're doing **something right** in our programming language!
The "repr" String for an Object

The repr function returns a Python expression (as a string) that evaluates to an equal object

    repr(object) -> string

    Return the canonical string representation of the object. For most object types, eval(repr(object)) == object.

The result of calling repr on the value of an expression is what Python prints in an interactive session

    >>> 12e12
    12000000000000.0
    >>> print(repr(12e12))
    12000000000000.0

Some objects don't have a simple Python-readable string

    >>> repr(min)
    '<built-in function min>'
The "str" String for an Object

Human interpretable strings are useful as well

```python
>>> import datetime
>>> today = datetime.date(2011, 10, 7)
>>> repr(today)
'datetime.date(2011, 10, 7)'
>>> str(today)
'2011-10-07'
```

Demo
Polymorphic function: A function that can be applied to many (poly) different forms (morph) of data

str and repr are both polymorphic; they apply to anything

repr invokes a zero-argument method __repr__ on its argument

```python
>>> today.__repr__()
'datetime.date(2011, 10, 7)'
```

str invokes a zero-argument method __str__ on its argument

```python
>>> today.__str__()
'2011-10-07'
```
Implementing repr and str

The behavior of repr is slightly more complicated than invoking `__repr__` on its argument:

- An instance attribute called `__repr__` is ignored (demo)
- **Question:** How would we implement this behavior?

The behavior of str:

- An instance attribute called `__str__` is ignored
- If no `__str__` attribute is found, uses repr string (demo)
- **Question:** How would we implement this behavior?
- `str` is a class, not a function
Interfaces

Message passing allows **different data types** to respond to the **same message**

A shared message that elicits similar behavior from different object classes is a powerful method of abstraction

An *interface* is a **set of shared messages**, along with a specification of **what they mean**

Classes that implement `__repr__` and `__str__` methods that *return Python- and human-readable strings* thereby **implement an interface** for producing Python string representations
Multiple Representations of Abstract Data

Rectangular and polar representations for complex numbers

Most operations don't care about the representation

Some mathematical operations are easier on one than the other
Arithmetic Abstraction Barriers

Complex numbers in the problem domain

add_complex  mul_complex

Complex numbers as two-dimensional vectors

real  imag  magnitude  angle

Rectangular representation  Polar representation
An Interface for Complex Numbers

All complex numbers should produce real and imag components

All complex numbers should produce a magnitude and angle

Demo

Using this interface, we can implement complex arithmetic

```python
>>> def add_complex(z1, z2):
    return ComplexRI(z1.real + z2.real,
                     z1.imag + z2.imag)

>>> def mul_complex(z1, z2):
    return ComplexMA(z1.magnitude * z2.magnitude,
                     z1.angle + z2.angle)
```
Often, we want the value of instance attributes to be linked:

```python
>>> f = Fraction(3, 5)
>>> f.float_value
0.6
>>> f.numer = 4
>>> f.float_value
0.8
>>> f.denom -= 3
>>> f.float_value
2.0
```

The `@property` decorator on a method designates that it will be called whenever it is looked up on an instance.

It allows zero-argument methods to be called without the standard call expression syntax.

Demo
class ComplexRI(object):

    def __init__(self, real, imag):
        self.real = real
        self.imag = imag

    @property
    def magnitude(self):
        return (self.real ** 2 + self.imag ** 2) ** 0.5

    @property
    def angle(self):
        return math.atan2(self.imag, self.real)

    def __repr__(self):
        return 'ComplexRI({0}, {1})'.format(self.real, self.imag)

math.atan2(y,x): Angle between x-axis and the point (x,y)
Property decorator: "Call this function on attribute look-up"
class ComplexMA(object):
    def __init__(self, magnitude, angle):
        self.magnitude = magnitude
        self.angle = angle

    @property
def real(self):
        return self.magnitude * cos(self.angle)

    @property
def imag(self):
        return self.magnitude * sin(self.angle)

def __repr__(self):
    return 'ComplexMA({0}, {1})'.format(self.magnitude, self.angle)
Using Complex Numbers

Either type of complex number can be passed as either argument to add_complex or mul_complex

```python
def add_complex(z1, z2):
    return ComplexRI(z1.real + z2.real, z1.imag + z2.imag)

def mul_complex(z1, z2):
    return ComplexMA(z1.magnitude * z2.magnitude, z1.angle + z2.angle)
```

```python
>>> from math import pi
>>> add_complex(ComplexRI(1, 2), ComplexMA(2, pi/2))
ComplexRI(1.0000000000000002, 4.0)
>>> mul_complex(ComplexRI(0, 1), ComplexRI(0, 1))
ComplexMA(1.0, 3.141592653589793)
```
Special Methods

Adding instances of user-defined classes use __add__ method

Demo

```python
>>> ComplexRI(1, 2) + ComplexMA(2, 0)
ComplexRI(3.0, 2.0)

>>> ComplexRI(0, 1) * ComplexRI(0, 1)
ComplexMA(1.0, 3.141592653589793)
```


http://docs.python.org/py3k/reference/datamodel.html#special-method-names