Today is Ada Lovelace Day

Ada Lovelace, born 1815, was a writer, mathematician, and correspondent of Charles Babbage.

Charles Babbage designed the "analytical engine".

Ada wrote its first program (to compute Bernoulli numbers).
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
120000000000000.0
>>> print(repr(12e12))
120000000000000.0
```

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
Message Passing Enables Polymorphic Functions

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

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

str invokes a zero-argument method __str__ on its argument

>>> 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?
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
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)
```
The Rectangular Representation

The `@property` decorator allows zero-argument methods to be called without the standard call expression syntax.

```python
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({}, {})'.format(self.real, self.imag)
```

- `math.atan2(y, x)`: Angle between x-axis and the point (x, y)

**Special 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)

>>> 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://diveintopython3.org/special-method-names.html

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