25. Odds and Ends

Topics
- Some numpy details
- More plotting with pylab
- Tuples
- Operator Overloading

More on Numpy Arrays

1-dim Arrays: Subtleties

```
>>> x = zeros(3)
>>> x
array([ 0.,  0.,  0.])
>>> x[1]
0.0
```

X is a 1d array

It has 3 entries

The entries here are floats

x[1] refers to the 1st entry

```
>>> x = zeros((3,1))
>>> x
array([[ 0.],
       [ 0.],
       [ 0.]])
>>> x[1]
array([ 0.])
```

X is a 2d array

It has 3 rows and 1 column

The rows of a 2d array are 1d arrays.

x[1] refers to row 1 of x

1-dim Arrays: Subtleties

```
>>> x = zeros(3)
>>> x
array([ 0.,  0.,  0.])
>>> x[1]
0.0
```

X is a 1d array

It has 3 entries

The entries here are floats

x[1] refers to the 1st entry

```
>>> x = zeros((1,3))
>>> x
array([[ 0.,  0.,  0.]])
>>> x[1]
IndexError: index 1 is
out of bounds for axis 0
with size 1
```

X is a 2d array

It has 1 rows and 3 columns

The rows of a 2d array are 1d arrays.

x[1] refers to row 1 of x

There is no row 1

`int` Arrays

```
>>> A = array([[1,2],[3,4]],dtype=int)
>>> A
array([[1, 2],
       [3, 4]])
>>> A[1,1] = 5.3
>>> A
array([[1, 2],
       [3, 5]])
>>> A[1,1]='12'
>>> A
array([[ 1,  2],
       [ 3, 12]])
>>> A[1,0]='x'
ValueError: invalid literal for long()
```

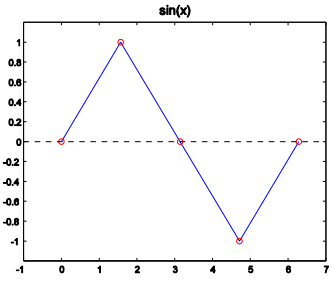
A will only store ints

Plotting a Continuous Function With Pylab

```
Assume:
    from numpy import *
    from pylab import *
```

Table → Plot

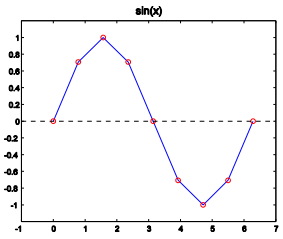
x	sin(x)
0.00	0.0
1.57	1.0
3.14	0.0
4.71	-1.0
6.28	0.0



Plot based on 5 points

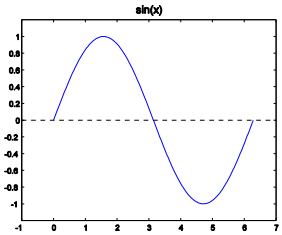
Table → Plot

x	sin(x)
0.000	0.000
0.784	0.707
1.571	1.000
2.357	0.707
3.142	0.000
3.927	-0.707
4.712	-1.000
5.498	-0.707
6.283	0.000



Plot based on 9 points

Table → Plot

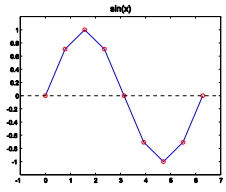


Plot based on 200 points—looks smooth

Generating Tables and Plots

x	sin(x)
0.000	0.000
0.784	0.707
1.571	1.000
2.357	0.707
3.142	0.000
3.927	-0.707
4.712	-1.000
5.498	-0.707
6.283	0.000

```
x = linspace(0,2*pi,9)
y = sin(x)
plot(x,y)
show()
```



The numpy `linspace` function

```
x = linspace(1,3,5)
```

x :	1.0	1.5	2.0	2.5	3.0

`linspace(a,b,n)` is a length-n list of values that are equally spaced from x = a to x = b.

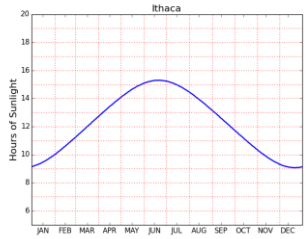
plot(x,y)

`x,y` 1-dim arrays of numbers
That have the same length

`plot(x,y)` "connects the dots":

`(x[0],y[0]) ,..., (x[n-1],y[n-1])`

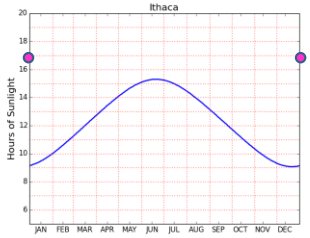
Drawing Lines




```
for k in range(6,20):
    # Draw horizontal line from (0,k) to (365,k)
    plot(array([0,365]),array([k,k]),
                        color='red',linestyle=':')
```

Drawing Lines

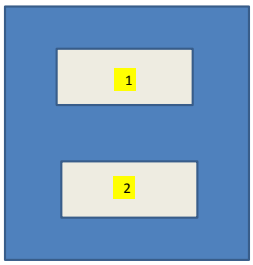
Connect two dots




```
for k in range(6,20):
    # Draw horizontal line from (0,k) to (365,k)
    plot(array([0,365]),array([k,k]),
                        color='red',linestyle=':')
```

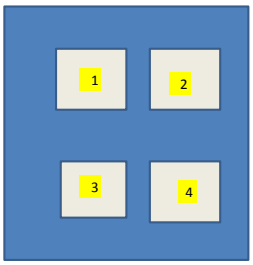
A Note on subplot

```
subplot(2,1,1)
   <code>
subplot(2,1,2)
   <code>

Show()
```



A Note on subplot

```
subplot(2,2,1)
   <code>
subplot(2,2,2)
   <code>
subplot(2,2,3)
   <code>
subplot(2,2,4)
   <code>

Show()
```



Tuples

A Tuple is a Sequence

```
T = (1,2,3)
```

So it is like a list. But it is immutable

```
>>> x = (1,2,3)
>>> x[1]
2
>>> x[1] = 10
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
TypeError: 'tuple' object does not
support item assignment
```

Returning Multiple Values

A function can only return ``one thing''. But that is not restrictive if we use tuples:

```
def  dailyBill(self):
          :

          :

   return (E,S,C)
```

Functions with Variable Calling Sequences

Tuples are also handy when you have a function that can have an arbirary number of input arguments.

```
A = zeros(10)

B = zeros((10,20))
```

Operator Overloading

Consider Addition

```
s = 'dogs' + 'and' + 'cats'

x = 100 + 200 + 300

y = 1.2 + 3.4 + 5.6
```

What "+" signals depends on the operands.
Python figures it out.
The "+" operation is overloaded.

Let's Define a Type and a "+" Operation for that Type

```
class Fraction:
    """
    Attributes:
        num: the numerator [int]
        den: the denominator [positive int]

    Invariant: num/den is reduced to lowest
    terms
    """
```

A class that support operations with fractions

Review!

```
2/3 + 3/4 = (2*4+3*3)/(3*4)
          = 20/12
          = 5/3

2/3 * 3/4 = (2*3)/(3*4)
          = 6/8
          = 3/4
```

A Note About Greatest Common Divisors

p	q	gcd(p,q)
16	24	8
2	5	1
10	95	5

Reducing a fraction to lowest terms involves finding the gcd of the numerator and denominator and dividing.

Computing the Greatest Common Divisor

```
def gcd(a,b):
    a = abs(a)
    b = abs(b)
    r = a%b
    while r>0:
        a = b
        b = r
        r = a%b
    return b
```

Euclid's Algorithm

300BC

The Constructor

```
def __init__(self,p,q=1):
    d = gcd(p,q)
    self.num = p/d
    self.den = q/d
    if self.den<0:
        self.den = -self.den
        self.num = -self.num
```

```
>>> A = Fraction(10,4)
>>> print A
5/2
```

The gcd of 4 and 10 is 2

The Constructor

```
def __init__(self,p,q=1):
    d = gcd(p,q)
    self.num = p/d
    self.den = q/d
    if self.den<0:
        self.den = -self.den
        self.num = -self.num
```

```
>>> A = Fraction(10)
>>> print A
10/1
```

The default denominator is 1.

The Constructor

```
def __init__(self,p,q=1):
    d = gcd(p,q)
    self.num = p/d
    self.den = q/d
    if self.den<0:
        self.den = -self.den
        self.num = -self.num
```

```
>>> A = Fraction(10,-4)
>>> print A
-5/2
```

If the fraction is negative, make the numerator negative.

Define "+" For Fractions

```
def __add__(self,f):
    N = self.num*f.den + self.den*f.num
    D = self.den*f.den
    return Fraction(N,D)
```

```
>>> A = Fraction(2,3)
>>> B = Fraction(1,4)
>>> C = A + B
>>> print C
11/12
```

By defining __add__ this way we can say
A+B
instead of
A.__add__(B)

Likewise for Multiplication

```
def __mul__(self,f):
    N = self.num*f.num
    D = self.den*f.den
    return Fraction(N,D)
```

```
>>> A = Fraction(2,3)
>>> B = Fraction(1,4)
>>> C = A*B
>>> print C
1/6
```

By defining __mul__ this way we can say
A*B
instead of
A.__mul__(B)

Would Like Some Flexibility

Would like to be able to add an int to a fraction:

2/3 + 5 = 17/3

Python needs to know the type of the operands

A More Flexible __add__

```
def __add__(self,f):
  if isinstance(f,Fraction):
    N = self.num*f.den + self.den*f.num
    D = self.den*f.den
  else:
    N = self.num + self.den*
    D = self.den
  return Fraction(N,D)
```

If f is a Fraction, use (a/b + c/d) = (ad+bc)/(bd)

A More Flexible __add__

```
def __add__(self,f):
  if isinstance(f,Fraction):
    N = self.num*f.den + self.den*f.num
    D = self.den*f.den
  else:
    N = self.num + self.den*
    D = self.den
  return Fraction(N,D)
```

If f is an integer, use (a/b + f) = (a+bf)/b

A More Flexible __mul__

```
def __mul__(self,f):
   if isinstance(f,Fraction):
       N = self.num*f.num
       D = self.den*f.den
   else:
       N = self.num*f
       D = self.den
   return Fraction(N,D)
```

If f is a Fraction, use (a/b)(c/d) = (ac)/(bd)

A More Flexible __mul__

```
def __mul__(self,f):
   if isinstance(f,Fraction):
       N = self.num*f.num
       D = self.den*f.den
   else:
       N = self.num*f
       D = self.den
   return Fraction(N,D)
```

If f is an int, use (a/b)(f) = (af)/b

An Example

Let's compute 1 + 1/2 + 1/3 + … + 1/30

```
n = 30
s = Fraction(0)
for k in range(1,n+1):
    s = s + Fraction(1,k)
print s
```

```
9304682830147/2329089562800
```