cosmos_python_2018

May 31, 2018

1 Python as calculator

Note: To convert ipynb to pdf file, use command: ipython nbconvert cosmos_python_2015.ipynb --to latex --post pdf

```
In [3]: 1 + 3
```

```
Out[3]: 4
```

```
In [4]: 3 * 90
```

```
Out[4]: 270
```

```
In [7]: 4 + 5 * 6 - 2
```

```
Out[7]: 32
```

```
In [8]: 2/5.0
```

```
Out[8]: 0.4
```

```
In [1]: 2/5
```

```
Out[1]: 0.4
```

1.0.1 New ideas: Modulo and whole value division

```
In [10]: 8 % 3
```

```
Out[10]: 2
```

```
In [11]: 9 % 3
```

```
Out[11]: 0
```

```
In [12]: 8 // 3
```

```
Out[12]: 2
```

```
In [13]: 9 // 3
```

```
Out[13]: 3
```

2 Variables and Assignments

```
In [3]: x = 6
        type(x)

Out[3]: int

In [15]: x = 'My name is Joe'
         x

Out[15]: 'My name is Joe'

In [19]: type(x)

Out[19]: str
```

Note : variables are not "declared" as one type: variable type can change!

```
In [20]: x = 2.345
         type(x)

Out[20]: float

In [21]: x = 1 - 3j
         type(x)

Out[21]: complex

In [22]: x = True
         type(x)

Out[22]: bool

In [5]: x, y = 3 , 4
        print (x,y)

3 4


In [7]: x, y = y , x
        print (x , y)

4 3


In [8]: z = x

In [9]: x = z * y
        print (x , y,  z)

12 3 4
```

```
In [34]: x = z - y
         print x , y, z

1 3 4


In [10]: x = z**y - x
         print (x , y, z)

52 3 4


In [36]: x = 2
         y = 'Bob'
         x  + y


         ---------------------------------------------------------------------------
    TypeError                                 Traceback (most recent call last)

         <ipython-input-36-8d8b7d6f72c6> in <module>()
           1 x = 2
           2 y = 'Bob'
    ----> 3 x  + y


         TypeError: unsupported operand type(s) for +: 'int' and 'str'


In [37]: x = 'Bradley '
         y = 'Cooper'
         x + y

Out[37]: 'Bradley Cooper'

In [12]: x = float(input("Enter value for x:"))
         print ("The value of x is:  ",x)

Enter value for x:5
The value of x is:   5.0


In [16]: x , y = 2 , 3
         print ("The value of x * y =  %d" % (x*y) )

The value of x * y =  6
```

2.1 Packages and modules

```
In [17]: import numpy as np
         print (np.pi, np.cos(np.pi), np.e)

3.141592653589793 -1.0 2.718281828459045
```

```
In [18]: x = np.cos(np.pi) * np.sin(2*np.pi) + np.log(10)
         print ("x = %f" % (x) )

x = 2.302585
```

```
In [19]: import random as random
         #help(random)
         random.randint(0,9)

Out[19]: 6
```

2.2 Lists and Arrays

All variables we have used to this point have had a single value. But we want a variable that supports multiple values at once : Called an "array" in C, python has a few different variable types with multiple values. here we will look at lists and arrays.

Most basic type of container in python is a "list". It's just a list of quantities in a row, one after the other. What's special about python lists, is that all of the "elemnets" in the list do not have to be the same type.

2.2.1 Lists

```
In [23]: r = [ 1, 2, 3, 4 ,5, 10]
         r

Out[23]: [1, 2, 3, 4, 5, 10]
```

```
In [21]: r = [ 'Bob', 6, 78.98, True, 10, 1+8j]
         r

Out[21]: ['Bob', 6, 78.98, True, 10, (1+8j)]
```

To add a new element to end of list, use "append":

```
In [24]: r = [1, 2, 3, 4, 5, 10]
         r.append(6)
         r.append('apples')
         r

Out[24]: [1, 2, 3, 4, 5, 10, 6, 'apples']
```

"Slicing" lets you access elements of the list

```
In [25]: r[3]

Out[25]: 4

In [26]: r[3] = 'oranges'
         r

Out[26]: [1, 2, 3, 'oranges', 5, 10, 6, 'apples']

In [27]: r[0:7]

Out[27]: [1, 2, 3, 'oranges', 5, 10, 6]

In [28]: r[-1]

Out[28]: 'apples'

In [29]: r[-1::-1]

Out[29]: ['apples', 6, 10, 5, 'oranges', 3, 2, 1]

In [36]: r_copy = r
         r_copy

Out[36]: [99, 2, 3, 'oranges', 5, 10, 6, 'apples']

In [37]: r[0] = 86
         r, r_copy

Out[37]: ([86, 2, 3, 'oranges', 5, 10, 6, 'apples'],
          [86, 2, 3, 'oranges', 5, 10, 6, 'apples'])
```

What happened ? "r_copy" is not a separate copy of r. It "points" to r. We must be careful... If we want to separate copy of r, we must use slicing, as shown below.

```
In [35]: # To create separate copy of a list
         r_copy = r[:]
         r_copy
         r[0] = 99
         r, r_copy

Out[35]: ([99, 2, 3, 'oranges', 5, 10, 6, 'apples'],
          [86, 2, 3, 'oranges', 5, 10, 6, 'apples'])

In [38]: # Use range built-in function
         w = range(10)
         w

Out[38]: range(0, 10)

In [40]: w = list(range(1, 11))
         w
```

```
Out[40]: [1, 2, 3, 4, 5, 6, 7, 8, 9, 10]
```

```
In [42]: # get nuber of elements and sum of list
         w = list(range(1,100,10))
         print (w)
         print ("Number of elements of w = ", len(w))
         print ("Sum of all elements of w = ", sum(w))
```

```
[1, 11, 21, 31, 41, 51, 61, 71, 81, 91]
Number of elements of w =  10
Sum of all elements of w =  460
```

```
In [46]: #  Delete last element of list
         w = list(range(10))
         print(w)
         w.pop()
         print(w)
```

```
[0, 1, 2, 3, 4, 5, 6, 7, 8, 9]
[0, 1, 2, 3, 4, 5, 6, 7, 8]
```

2.2.2 Numpy arrays

What if we want a "list" where all the elements are the same type (like in C language)? In python, this is called an array. Arrays use a special module called numpy (for numerical python). Arrays are like vectors/matrices. They are fixed in length and work much faster than lists in python. We will use arrays more than lists.

```
In [47]: # Import numpy module and create array of zeros
         import numpy as np
         array1 = np.zeros(10,float)
         print (array1, len(array1))
```

```
[ 0.  0.  0.  0.  0.  0.  0.  0.  0.  0.] 10
```

```
In [48]: # Create array of ones of type integer
         array2 = np.ones(10,int)
         print (array2)
```

```
[1 1 1 1 1 1 1 1 1 1]
```

```
In [49]: # Convert list to array ( and array to list)
         r = [1.2, 3.4, -1.5]    # This is a list
         r_array = np.array(r)
         print (r_array)
```

```
[ 1.2  3.4 -1.5]
```

```
In [50]: # Create 2D array (matrix)
         array3 = np.zeros((2,3))  # Notice (2,3) inside: 2 x 3 matrix
         print (array3)
```

```
[[ 0.  0.  0.]
 [ 0.  0.  0.]]
```

```
In [51]: # Operations on arrays
         array4 = np.array (range(10))
         print ("Mean value in array =  " , sum(array4)/ len(array4))
         print ("Mean value in array =  " , array4.mean())
```

```
Mean value in array =   4.5
Mean value in array =   4.5
```

```
In [52]: # Convert array to a list : To add onto array
         list4 = list(array4)
         print (list4)
```

```
[0, 1, 2, 3, 4, 5, 6, 7, 8, 9]
```

```
In [53]: # Arithmetic with arrays
         array5 = np.array([0,1,2, 3,4,5])
         x = array5**2
         print (x)
```

```
[ 0  1  4  9 16 25]
```

```
In [54]: x = np.sqrt ( sum(array5**2))
         print (x)
```

```
7.4161984871
```

2.2.3 Strings

A string is a sequence of characters, usually used to store text

```
In [60]: the_string = 'Hello World!'
```

```
In [62]: the_string[4]
         the_string[:4]
```

```
Out[62]: 'Hell'

In [81]: the_string.split()

Out[81]: ['Hello', 'World!']

In [65]: the_string.split('r')

Out[65]: ['Hello Wo', 'ld!']

In [67]: words = ['this', 'is', 'a', 'list', 'of', "strings"]
         ' '.join(words)

Out[67]: 'this is a list of strings'

In [69]: 'ABC'.join(words)

Out[69]: 'thisABCisABCaABClistABCofABCstrings'

In [71]: ''.join(words)

Out[71]: 'thisisalistofstrings'
```

2.2.4 Tuples

Tuple consist of a numer of values separated by commas. They are useful for ordered pairs and returning several values from a funtion.

```
In [89]: point1 = (3, 4, 5)
         print (point1)
         print(point1[0])

(3, 4, 5)
3


In [90]: x1 ,y1 ,z1 = point1    # Unpacking a tuple
         print(x1,y1,z1)

3 4 5
```

2.2.5 Dictionaries

Dictionaries are special types of python lists which allow lookup. We will use a dictionary when we look at converting DNA sequences to protein.

```
In [91]: # Creating dictionaries
         num_dict = { 1: 'one', 2: 'two', 3: 'three', 4: 'four' }
         num_dict[3]
         #num_dict[5]
         num_dict[5]= 'five'
         num_dict[20] = 'twenty'
         print (num_dict.keys())
         print (num_dict.values())
```

```
dict_keys([1, 2, 3, 4, 5, 20])
dict_values(['one', 'two', 'three', 'four', 'five', 'twenty'])
```

```
In [92]: print(num_dict.items())
         for key,value in num_dict.items():
             print (key,value)
         l = list(num_dict.items())
         print(l)
```

```
dict_items([(1, 'one'), (2, 'two'), (3, 'three'), (4, 'four'), (5, 'five'), (20, 'twenty')])
1 one
2 two
3 three
4 four
5 five
20 twenty
[(1, 'one'), (2, 'two'), (3, 'three'), (4, 'four'), (5, 'five'), (20, 'twenty')]
```

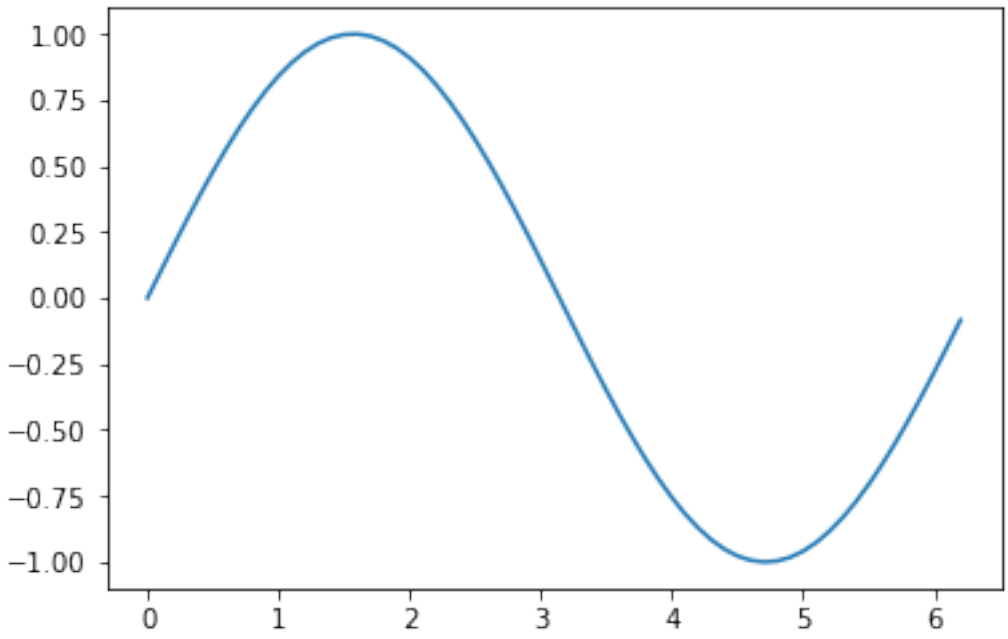
2.3 Simple plotting with "matplotlib"

```
In [56]: # Define x-axis and y-axis with arrays of points
         import numpy as np
         x = np.arange(0, 2*np.pi, .1) # Like range for lists
         print (x)
         y = np.sin(x)
         print (y)
```

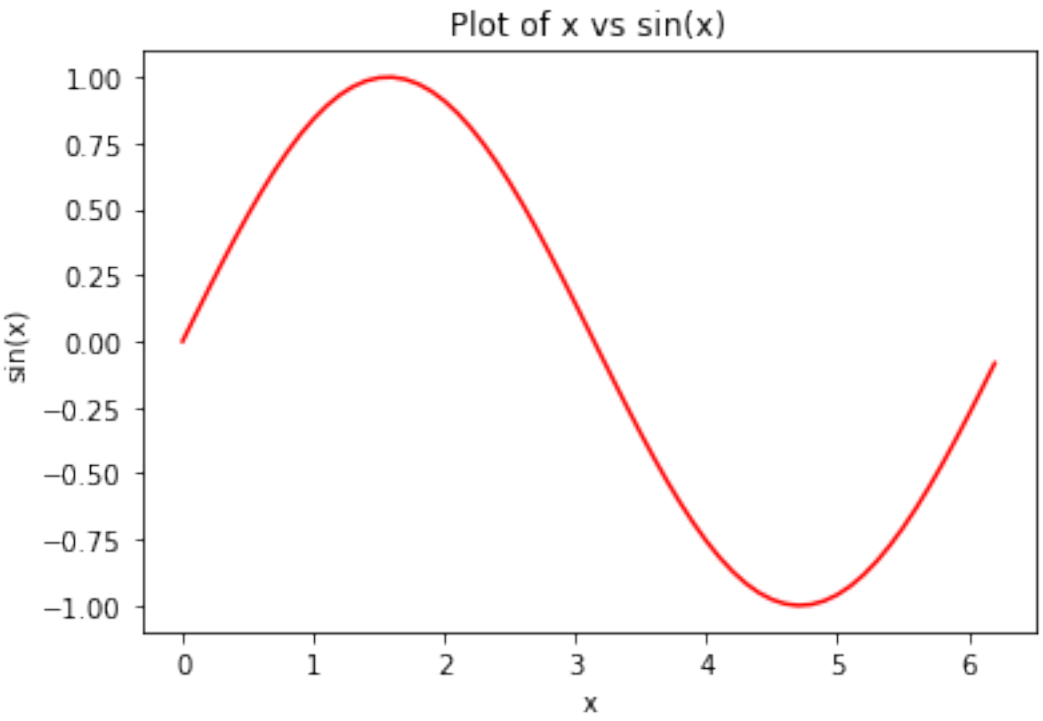
```
[ 0.   0.1  0.2  0.3  0.4  0.5  0.6  0.7  0.8  0.9  1.   1.1  1.2  1.3  1.4
  1.5  1.6  1.7  1.8  1.9  2.   2.1  2.2  2.3  2.4  2.5  2.6  2.7  2.8  2.9
  3.   3.1  3.2  3.3  3.4  3.5  3.6  3.7  3.8  3.9  4.   4.1  4.2  4.3  4.4
  4.5  4.6  4.7  4.8  4.9  5.   5.1  5.2  5.3  5.4  5.5  5.6  5.7  5.8  5.9
  6.   6.1  6.2]
[ 0.          0.09983342  0.19866933  0.29552021  0.38941834  0.47942554
  0.56464247  0.64421769  0.71735609  0.78332691  0.84147098  0.89120736
  0.93203909  0.96355819  0.98544973  0.99749499  0.9995736   0.99166481
  0.97384763  0.94630009  0.90929743  0.86320937  0.8084964   0.74570521
  0.67546318  0.59847214  0.51550137  0.42737988  0.33498815  0.23924933
  0.14112001  0.04158066 -0.05837414 -0.15774569 -0.2555411  -0.35078323
 -0.44252044 -0.52983614 -0.61185789 -0.68776616 -0.7568025  -0.81827711
 -0.87157577 -0.91616594 -0.95160207 -0.97753012 -0.993691   -0.99992326
 -0.99616461 -0.98245261 -0.95892427 -0.92581468 -0.88345466 -0.83226744
 -0.77276449 -0.70554033 -0.63126664 -0.55068554 -0.46460218 -0.37387666
 -0.2794155  -0.1821625  -0.0830894 ]
```

```
In [57]: # Now import matplotlib library and plot
         import matplotlib.pyplot as plt
```

```
plt.plot(x,y)
plt.show()
```



In [58]:
```
# Make plot fancier with title, labels
plt.plot(x,y, 'r')
plt.title('Plot of x vs sin(x)')
plt.xlabel('x')
plt.ylabel('sin(x)')
plt.show()
```



Go to matplotlib gallery on internet for examples !!