Welcome to iPython Notebooks!

In [1]:
```
# Regular Python code can be written and executed:
a = 3
```

In [2]:
```
a ** 3
```

Out[2]: 27

In [3]:
```
def SquareNumber(x):
    return x**2

SquareNumber(4)
```

Out[3]: 16

In [4]:
```
#Tab Complete
SquareNumber(5)
```

Out[4]: 25

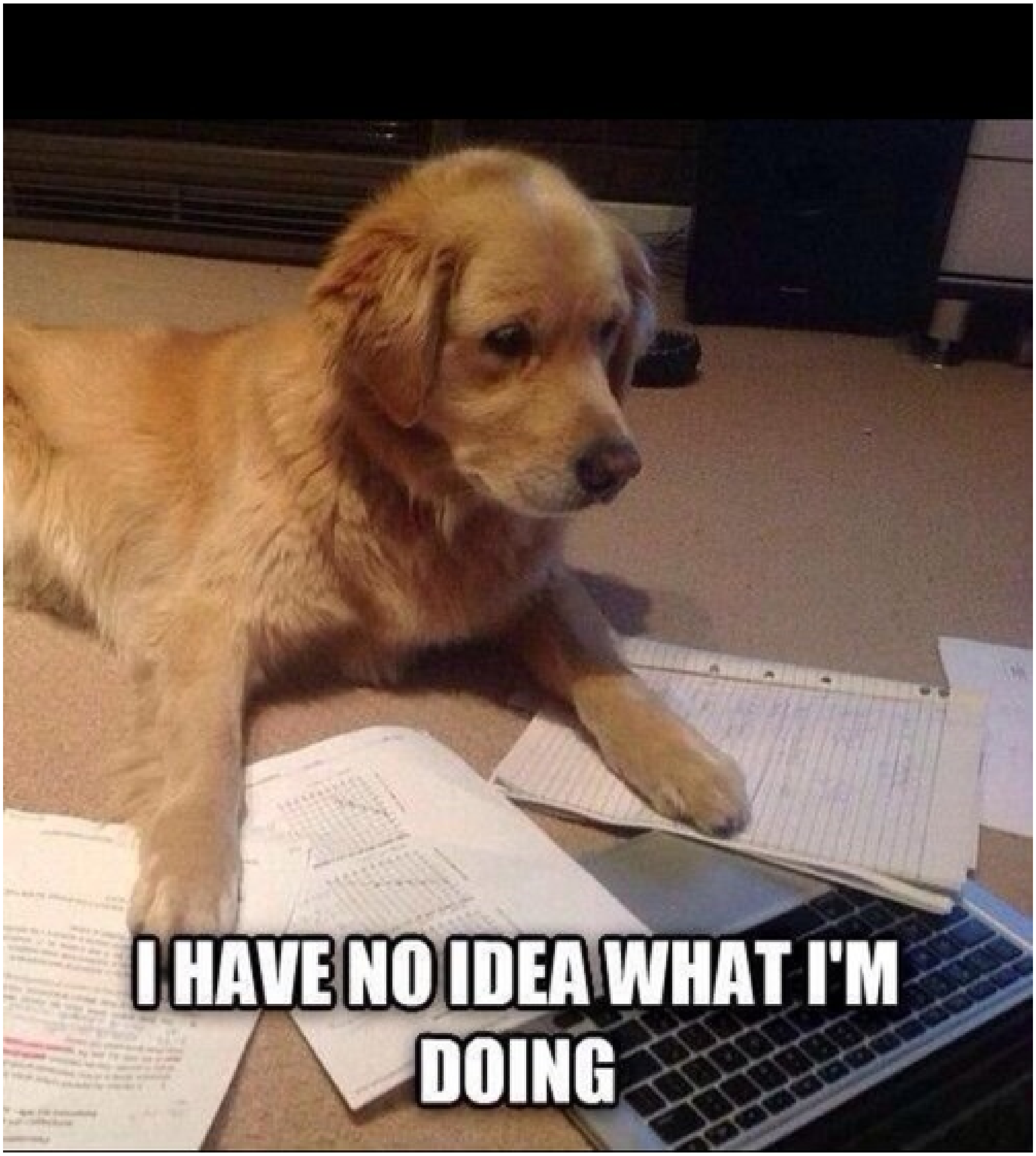
Additionally, you can insert raw text:

in multiple formats

And other comments as well

In [5]:
```
from IPython.core.display import Image
Image(width=600,url='http://funnystack.com/wp-content/uploads/2015/
07/Funny-Books-16.jpg')
```

Out[5]:

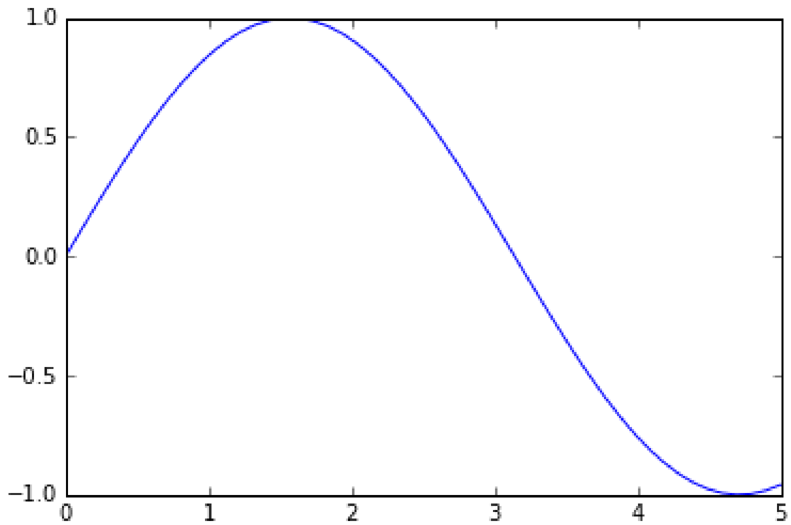


Some Actual Data Uses for iPython

In [6]:
```
%matplotlib inline
import numpy as np
import scipy as sp
import pandas as pd
import matplotlib.pyplot as plt
```

In [7]:
```
x = np.linspace(0,5)
plt.plot(x,np.sin(x))
```

Out[7]: [<matplotlib.lines.Line2D at 0x7f7a30cc3690>]



Using Pandas

In [8]:
```
# Defines an n-dimensional array (ndarray) with 10,000 random numbe
rs in the range [0-500).
values1 = np.random.randint(500, size=10000)

# Defines a pandas Series similar to the above ndarray.
values2 = pd.Series(np.random.randint(500, size=10000))
```

pandas series are implemented as labeled ndarrays, and hence all statistical methods available for ndarrays can be used with this data structure as well. Below, see the first 10 elements generated for each list of values (note the explicit indexing displayed in the pandas series):

In [9]:
```
values1[:10]
```

Out[9]:
```
array([362, 498, 439, 252, 466,  89, 391,   5,  55, 465])
```

In [10]:
```
values2[:10]
```

Out[10]:
```
0    466
1     15
2     97
3    181
4    407
5      9
6     61
7    313
8    423
9    244
dtype: int64
```

In [11]:
```
values2.iloc[5]
```

Out[11]:
```
9
```

In [12]:
```
values2.loc[5]
```

Out[12]:
```
9
```

In [13]:
```
values2.describe()
```

Out[13]:
```
count    10000.000000
mean       246.853100
std        143.745909
min          0.000000
25%        122.000000
50%        246.000000
75%        371.000000
max        499.000000
dtype: float64
```

In [14]:
```
s = pd.Series(['a', 'a', 'b', 'b', 'a', 'a', np.nan, 'c', 'd',
'a'])
s.describe()
```

Out[14]:
```
count     9
unique    4
top       a
freq      5
dtype: object
```

For non-numerical series objects, describe() will return a simple summary of the number of unique values and most frequently occurring ones.

np.nan is used to denote missing values. By default, the statistical methods implemented in pandas skip these values, which is not always the case when we are dealing with ndarrays. This behavior can be altered by including the skipna=False flag when calling a method.

In [15]:
```
np.random.seed(34)
df = pd.DataFrame(np.random.randn(5, 3), index=['a', 'c', 'e', 'f',
'h'], columns=['one', 'two', 'three'])
df
```

Out[15]:

	one	two	three
a	0.243835	-0.747318	-1.561177
c	-0.464253	-0.352062	-1.281492
e	0.289299	0.980029	0.477924
f	0.450818	0.752443	-0.510572
h	-0.705752	-0.424317	-0.232162

In [16]:
```
df.head(2)
```

Out[16]:

	one	two	three
a	0.243835	-0.747318	-1.561177
c	-0.464253	-0.352062	-1.281492

In [17]:
```
df.shape
```

Out[17]:
```
(5, 3)
```

In [18]:
```
#This is one way to index a column in pandas
df['one']
```

Out[18]:
```
a    0.243835
c   -0.464253
e    0.289299
f    0.450818
h   -0.705752
Name: one, dtype: float64
```

In [19]:
```
#This is one way to index a row in pandas
df.loc['a']
```

Out[19]:
```
one      0.243835
two     -0.747318
three   -1.561177
Name: a, dtype: float64
```

In [20]:
```python
#Another way to index (multiple-columns)
df[['one','two','three']]
```

Out[20]:

	one	two	three
a	0.243835	-0.747318	-1.561177
c	-0.464253	-0.352062	-1.281492
e	0.289299	0.980029	0.477924
f	0.450818	0.752443	-0.510572
h	-0.705752	-0.424317	-0.232162

In [21]:
```python
#Add new columns
df['four'] = 'bar'
df['five'] = df['one'] > 0
df
```

Out[21]:

	one	two	three	four	five
a	0.243835	-0.747318	-1.561177	bar	True
c	-0.464253	-0.352062	-1.281492	bar	False
e	0.289299	0.980029	0.477924	bar	True
f	0.450818	0.752443	-0.510572	bar	True
h	-0.705752	-0.424317	-0.232162	bar	False

In [22]:
```python
df['one'].apply(lambda x: x+1)
```

Out[22]:
```
a    1.243835
c    0.535747
e    1.289299
f    1.450818
h    0.294248
Name: one, dtype: float64
```

In [23]:
```
#Add new rows
df2 = df.reindex(['a', 'b', 'c', 'd', 'e', 'f', 'g', 'h'])
df2
```

Out[23]:

	one	two	three	four	five
a	0.243835	-0.747318	-1.561177	bar	True
b	NaN	NaN	NaN	NaN	NaN
c	-0.464253	-0.352062	-1.281492	bar	False
d	NaN	NaN	NaN	NaN	NaN
e	0.289299	0.980029	0.477924	bar	True
f	0.450818	0.752443	-0.510572	bar	True
g	NaN	NaN	NaN	NaN	NaN
h	-0.705752	-0.424317	-0.232162	bar	False

In [24]:
```
df['five']
```

Out[24]:
```
a     True
c    False
e     True
f     True
h    False
Name: five, dtype: bool
```

In [25]:
```
df['five'].count()
```

Out[25]:
```
5
```

In [26]:
```
df['five'].unique()
```

Out[26]:
```
array([True, False], dtype=object)
```

In [27]:
```
df['five'].value_counts()
```

Out[27]:
```
True     3
False    2
dtype: int64
```

In [28]:
```
df.dtypes
```

Out[28]:
```
one      float64
two      float64
three    float64
four      object
five        bool
dtype: object
```

Summary Statistics

Summary statistics are the numbers that summarize properties of the data. Summarized properties include frequency, location, and spread. Most summary statistics can be calculated in a single pass through the data. There are multiple ways to obtain summary statistics for your data in Python. Below, we will demonstrate how to do so using pandas and NumPy. First, we import both of these libraries:

In [29]:
```
print 'MIN(values1) = ' + str(values1.min()) + '\t\t\tMIN(values2)
= ' + str(values2.min()) # minimum value
print 'MAX(values1) = ' + str(values1.max()) + '\t\t\tMAX(values2)
= ' + str(values2.max()) # maximum value
print 'RANGE(values1) = ' + str(values1.ptp()) + '\t\t\tRANGE(value
s2) = ' + str(values2.ptp()) #range of the values
print 'MEAN(values1) = ' + str(values1.mean()) + '\t\tMEAN(values2)
= ' + str(values2.mean()) # the mean of the values
print 'STD(values1) = ' + str(values1.std()) + '\t\tSTD(values2) =
' + str(values2.std()) #standard dev of the values
print 'VARIANCE(values1) = ' + str(values1.var()) + '\tVARIANCE(val
ues2) = ' + str(values2.var()) # the variance of
```

```
MIN(values1) = 0                        MIN(values2) = 0
MAX(values1) = 499                      MAX(values2) = 499
RANGE(values1) = 499                    RANGE(values2) = 499
MEAN(values1) = 247.2855                MEAN(values2) = 246.8531
STD(values1) = 143.740176672            STD(values2) = 143.7459091
91
VARIANCE(values1) = 20661.2383897       VARIANCE(values2) = 20662.
886409
```

In [30]:
```
pd.DataFrame(values1).describe()
```

Out[30]:

	0
count	10000.000000
mean	247.285500
std	143.747364
min	0.000000
25%	123.000000
50%	246.000000
75%	372.000000
max	499.000000

In [31]:

```
df = pd.DataFrame(np.random.randn(5, 3), index=['a', 'c', 'e', 'f',
'h'], columns=['one', 'two', 'three'])
df
```

Out[31]:

	one	two	three
a	1.815140	-2.094749	1.035956
c	-1.434141	-0.278229	0.059514
e	-1.308312	-0.001286	1.261047
f	-0.186324	1.429928	-0.791102
h	-0.297739	0.961950	-1.070441

In [32]:

```
#Add new columns
df['four'] = 'bar'
df['five'] = df['one'] > 0
df.describe()
```

Out[32]:

	one	two	three	five
count	5.000000	5.000000	5.000000	5
mean	-0.282275	0.003523	0.098995	0.2
std	1.302703	1.363393	1.047577	0.4472136
min	-1.434141	-2.094749	-1.070441	False
25%	-1.308312	-0.278229	-0.791102	0
50%	-0.297739	-0.001286	0.059514	0
75%	-0.186324	0.961950	1.035956	0
max	1.815140	1.429928	1.261047	True

In [33]:
```
df.describe(include='all')
```

Out[33]:

	one	two	three	four	five
count	5.000000	5.000000	5.000000	5	5
unique	NaN	NaN	NaN	1	NaN
top	NaN	NaN	NaN	bar	NaN
freq	NaN	NaN	NaN	5	NaN
mean	-0.282275	0.003523	0.098995	NaN	0.2
std	1.302703	1.363393	1.047577	NaN	0.4472136
min	-1.434141	-2.094749	-1.070441	NaN	False
25%	-1.308312	-0.278229	-0.791102	NaN	0
50%	-0.297739	-0.001286	0.059514	NaN	0
75%	-0.186324	0.961950	1.035956	NaN	0
max	1.815140	1.429928	1.261047	NaN	True

In [34]:
```
#Even more stats!
import scipy as sp
from scipy import stats
```

In [35]:
```
#Not all functions are robust to all data types (scipy can't ignore categorical data and fails)
stats.describe(df)
```

```
---------------------------------------------------------------------------
TypeError                                 Traceback (most recent call last)
<ipython-input-35-c2387d4ddae3> in <module>()
      1 #Not all functions are robust to all data types (scipy can't ignore categorical data and fails)
----> 2 stats.describe(df)

/afs/crc.nd.edu/user/k/kfeldman/anaconda/lib/python2.7/site-packages/scipy/stats/stats.pyc in describe(a, axis, ddof)
   1135     n = a.shape[axis]
   1136     mm = (np.min(a, axis=axis), np.max(a, axis=axis))
-> 1137     m = np.mean(a, axis=axis)
   1138     v = np.var(a, axis=axis, ddof=ddof)
   1139     sk = skew(a, axis)

/afs/crc.nd.edu/user/k/kfeldman/anaconda/lib/python2.7/site-packages/numpy/core/fromnumeric.pyc in mean(a, axis, dtype, out, keepdims)
   2940 
   2941     return _methods._mean(a, axis=axis, dtype=dtype,
-> 2942                             out=out, **kwargs)
   2943 
   2944 

/afs/crc.nd.edu/user/k/kfeldman/anaconda/lib/python2.7/site-packages/numpy/core/_methods.pyc in _mean(a, axis, dtype, out, keepdims)
     66     if isinstance(ret, mu.ndarray):
     67         ret = um.true_divide(
---> 68                 ret, rcount, out=ret, casting='unsafe', subok=False)
     69     elif hasattr(ret, 'dtype'):
     70         ret = ret.dtype.type(ret / rcount)

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

In [36]:
```
#You have to filter the dataframe yourself
b = df[['one','two','three']]
stats.describe(b)
```

Out[36]:
```
DescribeResult(nobs=5, minmax=(array([-1.43414066, -2.09474937, -1.07044067]), array([ 1.81514048,  1.42992772,  1.26104693])), mean=array([-0.28227511,  0.00352259,  0.09899498]), variance=array([ 1.69703603,  1.85884151,  1.09741798]), skewness=array([ 0.83689138, -0.60415334,  0.0211987 ]), kurtosis=array([-0.58877776, -0.7955926 , -1.67868048]))
```

In [37]:
```
y = np.sort(values1)
percentile_25th = y[round(0.25 * y.shape[0]) + 1]
percentile_25th
```

```
/afs/crc.nd.edu/user/k/kfeldman/anaconda/lib/python2.7/site-packag
es/ipykernel/__main__.py:2: VisibleDeprecationWarning: using a non
-integer number instead of an integer will result in an error in t
he future
  from ipykernel import kernelapp as app
```

Out[37]: 123

In [38]:
```
percentile_75th = y[round(0.75 * y.shape[0]) - 1]
percentile_75th
```

```
/afs/crc.nd.edu/user/k/kfeldman/anaconda/lib/python2.7/site-packag
es/ipykernel/__main__.py:1: VisibleDeprecationWarning: using a non
-integer number instead of an integer will result in an error in t
he future
  if __name__ == '__main__':
```

Out[38]: 372

In [39]:
```
np.percentile(values1, q=[25, 75], interpolation='lower')
```

Out[39]: array([123, 372])

Probability

In [40]:
```
import scipy.special as special
n = 100  # number of coin flips
h = 61  # number of heads
q = .5  # null-hypothesis of fair coin
```

In [41]:
```
xbar = float(h)/n
z = (xbar - q) * np.sqrt(n / (q*(1-q)))
z
```

Out[41]: 2.1999999999999997

In [42]:
```
pval = 2 * (1 - stats.norm.cdf(z))
pval
```

Out[42]: 0.02780689502699718