In [1]:
```
import numpy as np
```

In [2]:
```
a = np.array([1, 2, 3, 4])
a + 1
```

Out[2]:
```
array([2, 3, 4, 5])
```

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

Out[3]:
```
array([ 2,  4,  8, 16])
```

In [4]:
```
b = np.ones(4) + 1
a - b
```

Out[4]:
```
array([-1.,  0.,  1.,  2.])
```

In [5]:
```
a * b
```

Out[5]:
```
array([ 2.,  4.,  6.,  8.])
```

In [6]:
```
j = np.arange(5)
2**(j + 1) - j
```

Out[6]:
```
array([ 2,  3,  6, 13, 28])
```

In [7]:
```
a = np.arange(10000)
%timeit a + 1
```

```
10000 loops, best of 3: 9.34 µs per loop
```

In [8]:
```
l = range(10000)
%timeit [i+1 for i in l]
```

```
1000 loops, best of 3: 323 µs per loop
```

In [9]:
```
c = np.ones((3, 3))
c * c
```

Out[9]:
```
array([[ 1.,  1.,  1.],
       [ 1.,  1.,  1.],
       [ 1.,  1.,  1.]])
```

In [10]:
```
c.dot(c)
```

Out[10]:
```
array([[ 3.,  3.,  3.],
       [ 3.,  3.,  3.],
       [ 3.,  3.,  3.]])
```

In [11]:
```
a = np.array([1, 2, 3, 4])
b = np.array([4, 2, 2, 4])
a == b
```

Out[11]:
```
array([False,  True, False,  True], dtype=bool)
```

In [12]:
```
a > b
```

Out[12]:
```
array([False, False,  True, False], dtype=bool)
```

In [13]:
```
a = np.array([1, 1, 0, 0], dtype=bool)
b = np.array([1, 0, 1, 0], dtype=bool)
np.logical_or(a, b)
```

Out[13]:
```
array([ True,  True,  True, False], dtype=bool)
```

In [14]:

```
np.logical_and(a, b)
```

Out[14]:

```
array([ True, False, False, False], dtype=bool)
```

In [15]:

```
a = np.arange(10)
np.sin(a)
```

Out[15]:

```
array([ 0.        ,  0.84147098,  0.90929743,  0.14112001, -0.7568025 ,
       -0.95892427, -0.2794155 ,  0.6569866 ,  0.98935825,  0.41211849])
```

In [16]:

```
np.log(a)
```

```
-c:1: RuntimeWarning: divide by zero encountered in log
```

Out[16]:

```
array([       -inf,  0.        ,  0.69314718,  1.09861229,  1.38629436,
        1.60943791,  1.79175947,  1.94591015,  2.07944154,  2.19722458])
```

In [17]:

```
np.exp(a)
```

Out[17]:

```
array([  1.00000000e+00,   2.71828183e+00,   7.38905610e+00,
         2.00855369e+01,   5.45981500e+01,   1.48413159e+02,
         4.03428793e+02,   1.09663316e+03,   2.98095799e+03,
         8.10308393e+03])
```

In [18]:

```
a = np.arange(4)
a + np.array([1, 2])
```

```
---------------------------------------------------------------------------
ValueError                                Traceback (most recent call last)
<ipython-input-18-82c1c1d5b8c1> in <module>()
      1 a = np.arange(4)
----> 2 a + np.array([1, 2])

ValueError: operands could not be broadcast together with shapes (4,) (2,)
```

In [19]:

```
a = np.triu(np.ones((3, 3)), 1)   # see help(np.triu)
a
```

Out[19]:

```
array([[ 0.,  1.,  1.],
       [ 0.,  0.,  1.],
       [ 0.,  0.,  0.]])
```

In [20]:

```
a = np.array([1, 2, 3, 4])
b = np.array([4, 2, 2, 4])
c = np.array([1, 2, 3, 4])
np.array_equal(a, b)
```

Out[20]:

```
False
```

In [21]:

```
np.array_equal(a, c)
```

Out[21]:

```
True
```

In [22]:

```
x = np.array([1, 2, 3, 4])
np.sum(x)
```

Out[22]:

```
10
```

In [23]:

```
x.sum()
```

Out[23]:

```
10
```

In [24]:

```
from IPython.display import Image
Image(filename='images/reductions.png')
```

```
---------------------------------------------------------------------------
IOError                                   Traceback (most recent call last)
<ipython-input-24-6353959f60df> in <module>()
      1 from IPython.display import Image
----> 2 Image(filename='images/reductions.png')

/usr/lib/python2.7/dist-packages/IPython/core/display.pyc in __init__(self, data, url, filename, format, embed, width, height, retina)
    599         self.height = height
    600         self.retina = retina
--> 601         super(Image, self).__init__(data=data, url=url, filename=filename)
    602 
    603         if retina:

/usr/lib/python2.7/dist-packages/IPython/core/display.pyc in __init__(self, data, url, filename)
    303         self.filename = None if filename is None else unicode(filename)
    304 
--> 305         self.reload()
    306 
    307     def reload(self):

/usr/lib/python2.7/dist-packages/IPython/core/display.pyc in reload(self)
    621         """Reload the raw data from file or URL."""
    622         if self.embed:
--> 623             super(Image,self).reload()
    624             if self.retina:
    625                 self._retina_shape()

/usr/lib/python2.7/dist-packages/IPython/core/display.pyc in reload(self)
    308         """Reload the raw data from file or URL."""
    309         if self.filename is not None:
--> 310             with open(self.filename, self._read_flags) as f:
    311                 self.data = f.read()
    312         elif self.url is not None:

IOError: [Errno 2] No such file or directory: u'images/reductions.png'
```

In [25]:

```
x = np.array([[1, 1], [2, 2]])
x
```

Out[25]:

```
array([[1, 1],
       [2, 2]])
```

In [26]:

```
x.sum(axis=0)
```

Out[26]:

```
array([3, 3])
```

In [27]:

```
x[:, 0].sum(), x[:, 1].sum()
```

Out[27]:

```
(3, 3)
```

In [28]:

```
x.sum(axis=1)
```

Out[28]:

```
array([2, 4])
```

In [29]:

```
x[0, :].sum(), x[1, :].sum()
```

Out[29]:

```
(2, 4)
```

In [30]:

```
x = np.random.rand(2, 2, 2)
x.sum(axis=2)[0, 1]
```

Out[30]:

```
0.36156951645842483
```

In [31]:

```
x[0, 1, :].sum()
```

Out[31]:

```
0.36156951645842483
```

In [32]:
```
x = np.array([1, 2, 3, 1])
y = np.array([[1, 2, 3], [5, 6, 1]])
x.mean()
```

Out[32]:
```
1.75
```

In [33]:
```
np.median(x)
```

Out[33]:
```
1.5
```

In [34]:
```
np.median(y, axis=-1)
```

Out[34]:
```
array([ 2.,  5.])
```

In [35]:
```
x.std()
```

Out[35]:
```
0.82915619758884995
```

In [36]:
```
x = np.array([1, 3, 2])
x.min()
```

Out[36]:
```
1
```

In [37]:
```
x.max()
```

Out[37]:
```
3
```

In [38]:
```
x.argmin()
```

Out[38]:
```
0
```

In [39]:
```
x.argmax()
```

Out[39]:
```
1
```

In [40]:
```
np.all([True, True, False])
```

Out[40]:
```
False
```

In [41]:
```
np.any([True, True, False])
```

Out[41]:
```
True
```

In [42]:
```
a = np.zeros((100, 100))
np.any(a != 0)
```

Out[42]:
```
False
```

In [43]:
```
np.all(a == a)
```

Out[43]:
```
True
```

In [44]:
```
a = np.array([1, 2, 3, 2])
b = np.array([2, 2, 3, 2])
c = np.array([6, 4, 4, 5])
((a <= b) & (b <= c)).all()
```

Out[44]:
```
True
```

THe other function will be total the difference of cumsum and sum is the cumsum works like a fibonacci while the sum is just a straight forward addition

In [49]:
```
!cat data/populations.txt
```

In [50]:
```
!cat data/populations.txt
```

In [51]:
```
data = np.loadtxt('data/populations.txt')
year, hares, lynxes, carrots = data.T  # trick: columns to variables
```

```
---------------------------------------------------------------------------
ValueError                                Traceback (most recent call last)
<ipython-input-51-e063cf00a973> in <module>()
      1 data = np.loadtxt('data/populations.txt')
----> 2 year, hares, lynxes, carrots = data.T  # trick: columns to variables

ValueError: need more than 0 values to unpack
```

```
/usr/lib/python2.7/dist-packages/numpy/lib/npyio.py:816: UserWarning: loadtxt: Empty input file: "data/populations.txt"
  warnings.warn('loadtxt: Empty input file: "%s"' % fname)
```

In [52]:
```
mileposts = np.array([0, 198, 303, 736, 871, 1175, 1475, 1544,
       1913, 2448])
distance_array = np.abs(mileposts - mileposts[:, np.newaxis])
distance_array
```

Out[52]:
```
array([[   0,  198,  303,  736,  871, 1175, 1475, 1544, 1913, 2448],
       [ 198,    0,  105,  538,  673,  977, 1277, 1346, 1715, 2250],
       [ 303,  105,    0,  433,  568,  872, 1172, 1241, 1610, 2145],
       [ 736,  538,  433,    0,  135,  439,  739,  808, 1177, 1712],
       [ 871,  673,  568,  135,    0,  304,  604,  673, 1042, 1577],
       [1175,  977,  872,  439,  304,    0,  300,  369,  738, 1273],
       [1475, 1277, 1172,  739,  604,  300,    0,   69,  438,  973],
       [1544, 1346, 1241,  808,  673,  369,   69,    0,  369,  904],
       [1913, 1715, 1610, 1177, 1042,  738,  438,  369,    0,  535],
       [2448, 2250, 2145, 1712, 1577, 1273,  973,  904,  535,    0]])
```

In [53]:
```
from IPython.display import Image
Image(filename='images/route66.png')
```

```
---------------------------------------------------------------------------
IOError                                   Traceback (most recent call last)
<ipython-input-53-18d14b338b24> in <module>()
      1 from IPython.display import Image
----> 2 Image(filename='images/route66.png')

/usr/lib/python2.7/dist-packages/IPython/core/display.pyc in __init__(self, data, url, filename, format, embed, width, height, retina)
    599         self.height = height
    600         self.retina = retina
--> 601         super(Image, self).__init__(data=data, url=url, filename=filename)
    602 
    603         if retina:

/usr/lib/python2.7/dist-packages/IPython/core/display.pyc in __init__(self, data, url, filename)
    303         self.filename = None if filename is None else unicode(filename)
    304 
--> 305         self.reload()
    306 
    307     def reload(self):

/usr/lib/python2.7/dist-packages/IPython/core/display.pyc in reload(self)
    621         """Reload the raw data from file or URL."""
    622         if self.embed:
--> 623             super(Image,self).reload()
    624             if self.retina:
    625                 self._retina_shape()


/usr/lib/python2.7/dist-packages/IPython/core/display.pyc in reload(self)
    308         """Reload the raw data from file or URL."""
    309         if self.filename is not None:
--> 310             with open(self.filename, self._read_flags) as f:
```

```
--> 310         with open(self.filename, self._read_flags) as f:
    311             self.data = f.read()
    312         elif self.url is not None:

IOError: [Errno 2] No such file or directory: u'images/route66.png'
```

In [54]:

```
x, y = np.arange(5), np.arange(5)[:, np.newaxis]
distance = np.sqrt(x ** 2 + y ** 2)
distance
```

Out[54]:

```
array([[ 0.        ,  1.        ,  2.        ,  3.        ,  4.        ],
       [ 1.        ,  1.41421356,  2.23606798,  3.16227766,  4.12310563],
       [ 2.        ,  2.23606798,  2.82842712,  3.60555128,  4.47213595],
       [ 3.        ,  3.16227766,  3.60555128,  4.24264069,  5.        ],
       [ 4.        ,  4.12310563,  4.47213595,  5.        ,  5.65685425]])
```

In [55]:

```
plt.pcolor(distance)
plt.colorbar()
```

Out[55]:

```
<matplotlib.colorbar.Colorbar instance at 0x7f7d748c1fc8>
```

In [56]:

```
x, y = np.ogrid[0:5, 0:5]
x, y
```

Out[56]:

```
(array([[0],
       [1],
       [2],
       [3],
       [4]]),
 array([[0, 1, 2, 3, 4]]))
```

In [57]:

```
x.shape, y.shape
```

Out[57]:

```
((5, 1), (1, 5))
```

In [58]:

```
distance = np.sqrt(x ** 2 + y ** 2)
```

In [59]:

```
x, y = np.mgrid[0:4, 0:4]
x
```

Out[59]:

```
array([[0, 0, 0, 0],
       [1, 1, 1, 1],
       [2, 2, 2, 2],
       [3, 3, 3, 3]])
```

In [60]:

```
y
```

Out[60]:

```
array([[0, 1, 2, 3],
       [0, 1, 2, 3],
       [0, 1, 2, 3],
       [0, 1, 2, 3]])
```

In [61]:

```
a = np.array([[1, 2, 3], [4, 5, 6]])
a.ravel()
```

Out[61]:

```
array([1, 2, 3, 4, 5, 6])
```

In [62]:

```
a.T
```

Out[62]:

```
array([[1, 4],
       [2, 5],
       [3, 6]])
```

In [63]:

```
a.T.ravel()
```

Out[63]:

```
array([1, 4, 2, 5, 3, 6])
```

In [64]:

```
a.shape
```

Out[64]:

```
(2, 3)
```

In [65]:

```
b = a.ravel()
b = b.reshape((2, 3))
b
```

Out[65]:

```
array([[1, 2, 3],
       [4, 5, 6]])
```

In [66]:

```
a.reshape((2, -1))    # unspecified (-1) value is inferred
```

Out[66]:

```
array([[1, 2, 3],
       [4, 5, 6]])
```

In [67]:

```
b[0, 0] = 99
a
```

Out[67]:

```
array([[99,  2,  3],
       [ 4,  5,  6]])
```

In [68]:

```
a = np.zeros((3, 2))
b = a.T.reshape(3*2)
b[0] = 9
a
```

Out[68]:

```
array([[ 0.,  0.],
       [ 0.,  0.],
       [ 0.,  0.]])
```

In [69]:

```
z = np.array([1, 2, 3])
z
```

Out[69]:

```
array([1, 2, 3])
```

In [70]:

```
z[:, np.newaxis]
```

Out[70]:

```
array([[1],
       [2],
       [3]])
```

In [71]:

```
z[np.newaxis, :]
```

Out[71]:

```
array([[1, 2, 3]])
```

In [72]:

```
a = np.arange(4*3*2).reshape(4, 3, 2)
a.shape
```

Out[72]:

```
(4, 3, 2)
```

In [73]:

```
a[0, 2, 1]
```

Out[73]:

```
5
```

In [74]:

```
b = a.transpose(1, 2, 0)
b.shape
```

Out[74]:

```
(3, 2, 4)
```

In [75]:

```
b[2, 1, 0]
```

Out[75]:

```
5
```

In [76]:

```
b[2, 1, 0] = -1
```

```
a[0, 2, 1]
```

Out[76]:

```
-1
```

In [77]:

```
a = np.arange(4)
a.resize((8,))
a
```

Out[77]:

```
array([0, 1, 2, 3, 0, 0, 0, 0])
```

In [78]:

```
b = a
a.resize((4,))
```

```
---------------------------------------------------------------------------
ValueError                                Traceback (most recent call last)
<ipython-input-78-fa61239db0dc> in <module>()
      1 b = a
----> 2 a.resize((4,))

ValueError: cannot resize an array references or is referenced
by another array in this way.  Use the resize function
```

In [79]:

```
a = np.array([[4, 3, 5], [1, 2, 1]])
b = np.sort(a, axis=1)
b
```

Out[79]:

```
array([[3, 4, 5],
       [1, 1, 2]])
```

In [80]:

```
a.sort(axis=1)
a
```

Out[80]:

```
array([[3, 4, 5],
       [1, 1, 2]])
```

In [81]:

```
a = np.array([4, 3, 1, 2])
j = np.argsort(a)
j
```

Out[81]:

```
array([2, 3, 1, 0])
```

In [82]:

```
a[j]
```

Out[82]:

```
array([1, 2, 3, 4])
```

In [83]:

```
a = np.array([4, 3, 1, 2])
j_max = np.argmax(a)
j_min = np.argmin(a)
j_max, j_min
```

Out[83]:

```
(0, 2)
```

In []:

```

```