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# NumPy Operations

## Arithmetic

You can easily perform *array with array* arithmetic, or *scalar with array* arithmetic. Let's see some examples:

In [1]:
```
import numpy as np
arr = np.arange(0,10)
arr
```

Out[1]:
```
array([0, 1, 2, 3, 4, 5, 6, 7, 8, 9])
```

In [2]:
```
arr + arr
```

Out[2]:
```
array([ 0,  2,  4,  6,  8, 10, 12, 14, 16, 18])
```

In [3]:
```
arr * arr
```

Out[3]:
```
array([ 0,  1,  4,  9, 16, 25, 36, 49, 64, 81])
```

In [4]:
```
arr - arr
```

Out[4]:
```
array([0, 0, 0, 0, 0, 0, 0, 0, 0, 0])
```

In [5]:
```
# This will raise a Warning on division by zero, but not an error!
# It just fills the spot with nan
arr/arr
```

```
C:\Anaconda3\envs\tsa_course\lib\site-packages\ipykernel_launcher.py:3: Ru
ntimeWarning: invalid value encountered in true_divide
  This is separate from the ipykernel package so we can avoid doing import
s until
```

Out[5]:
```
array([nan,  1.,  1.,  1.,  1.,  1.,  1.,  1.,  1.,  1.])
```

In [6]:
```
# Also a warning (but not an error) relating to infinity
1/arr
```

```
C:\Anaconda3\envs\tsa_course\lib\site-packages\ipykernel_launcher.py:2: Ru
ntimeWarning: divide by zero encountered in true_divide
```

Out[6]:
```
array([       inf, 1.        , 0.5       , 0.33333333, 0.25      ,
       0.2       , 0.16666667, 0.14285714, 0.125     , 0.11111111])
```

In [7]:
```
arr**3
```

Out[7]:
```
array([  0,   1,   8,  27,  64, 125, 216, 343, 512, 729], dtype=int32)
```

## Universal Array Functions

NumPy comes with many [universal array functions (http://docs.scipy.org/doc/numpy/reference/ufuncs.html)](http://docs.scipy.org/doc/numpy/reference/ufuncs.html), or *ufuncs*, which are essentially just mathematical operations that can be applied across the array.
Let's show some common ones:

In [8]:
```
# Taking Square Roots
np.sqrt(arr)
```

Out[8]:
```
array([0.        , 1.        , 1.41421356, 1.73205081, 2.        ,
       2.23606798, 2.44948974, 2.64575131, 2.82842712, 3.        ])
```

In [9]:
```
# Calculating exponential (e^)
np.exp(arr)
```

Out[9]:
```
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 [10]:
```
# Trigonometric Functions like sine
np.sin(arr)
```

Out[10]:
```
array([ 0.        ,  0.84147098,  0.90929743,  0.14112001, -0.7568025 ,
       -0.95892427, -0.2794155 ,  0.6569866 ,  0.98935825,  0.41211849])
```

In [11]:
```
# Taking the Natural Logarithm
np.log(arr)
```

```
C:\Anaconda3\envs\tsa_course\lib\site-packages\ipykernel_launcher.py:2: Ru
ntimeWarning: divide by zero encountered in log
```

Out[11]:
```
array([      -inf, 0.        , 0.69314718, 1.09861229, 1.38629436,
       1.60943791, 1.79175947, 1.94591015, 2.07944154, 2.19722458])
```

## Summary Statistics on Arrays

NumPy also offers common summary statistics like *sum*, *mean* and *max*. You would call these as methods on an array.

In [12]:
```
arr = np.arange(0,10)
arr
```

Out[12]:
```
array([0, 1, 2, 3, 4, 5, 6, 7, 8, 9])
```

In [13]:
```
arr.sum()
```

Out[13]:
```
45
```

In [14]:
```
arr.mean()
```

Out[14]:
```
4.5
```

In [15]:
```
arr.max()
```

Out[15]:
```
9
```

**Other summary statistics include:**

```
arr.min() returns 0                    minimum
arr.var() returns 8.25                 variance
arr.std() returns 2.8722813232690143   standard deviation
```

## Axis Logic

When working with 2-dimensional arrays (matrices) we have to consider rows and columns. This becomes very important when we get to the section on pandas. In array terms, axis 0 (zero) is the vertical axis (rows), and axis 1 is the horizonal axis (columns). These values (0,1) correspond to the order in which `arr.shape` values are returned.

Let's see how this affects our summary statistic calculations from above.

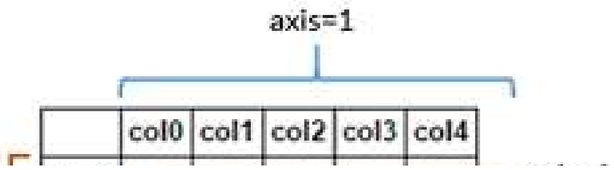
In [16]:
```
arr_2d = np.array([[1,2,3,4],[5,6,7,8],[9,10,11,12]])
arr_2d
```

Out[16]:
```
array([[ 1,  2,  3,  4],
       [ 5,  6,  7,  8],
       [ 9, 10, 11, 12]])
```

In [17]:
```
arr_2d.sum(axis=0)
```

Out[17]:
```
array([15, 18, 21, 24])
```

By passing in `axis=0`, we're returning an array of sums along the vertical axis, essentially `[(1+5+9), (2+6+10), (3+7+11), (4+8+12)]`




In [18]:
```
arr_2d.shape
```

Out[18]:
```
(3, 4)
```

This tells us that `arr_2d` has 3 rows and 4 columns.

In `arr_2d.sum(axis=0)` above, the first element in each row was summed, then the second element, and so forth.

So what should `arr_2d.sum(axis=1)` return?

In [ ]:
```
# THINK ABOUT WHAT THIS WILL RETURN BEFORE RUNNING THE CELL!
arr_2d.sum(axis=1)
```

# Great Job!

That's all we need to know for now!