Numpy

INTRODUCTION TO PYTHON

Lists Recap

Lists Recap

- Powerful

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- Collection of values

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- Hold different types

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- Change, add, remove

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- Need for Data Science

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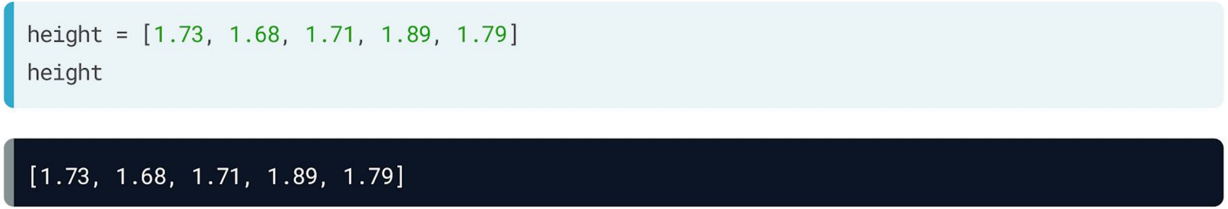
    - Mathematical operations over collections

Lists Recap

- Powerful
- Collection of values
- Hold different types
- Change, add, remove
- Need for Data Science
  - Mathematical operations over collections
  - Speed

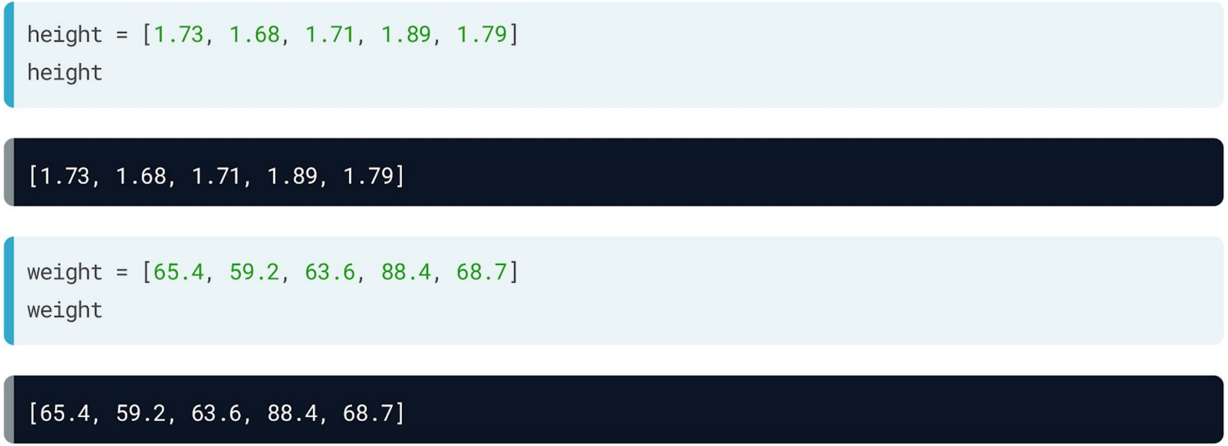
Illustration



```python
height = [1.73, 1.68, 1.71, 1.89, 1.79]
height
```

```
[1.73, 1.68, 1.71, 1.89, 1.79]
```

Illustration



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[1.73, 1.68, 1.71, 1.89, 1.79]
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weight = [65.4, 59.2, 63.6, 88.4, 68.7]
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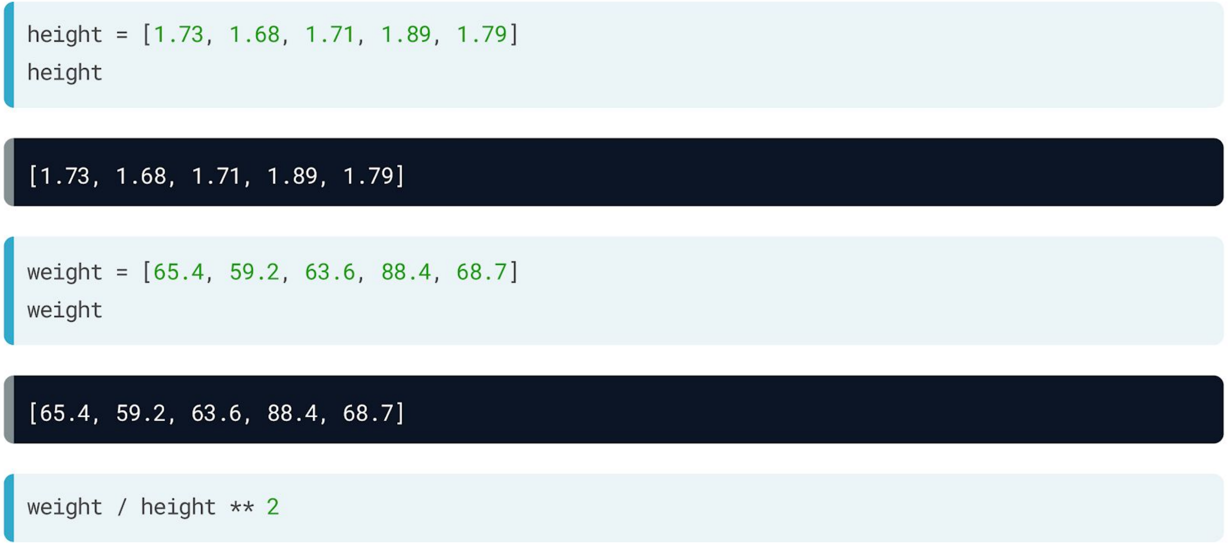
```
[65.4, 59.2, 63.6, 88.4, 68.7]
```

Illustration



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```
[1.73, 1.68, 1.71, 1.89, 1.79]
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```
[65.4, 59.2, 63.6, 88.4, 68.7]
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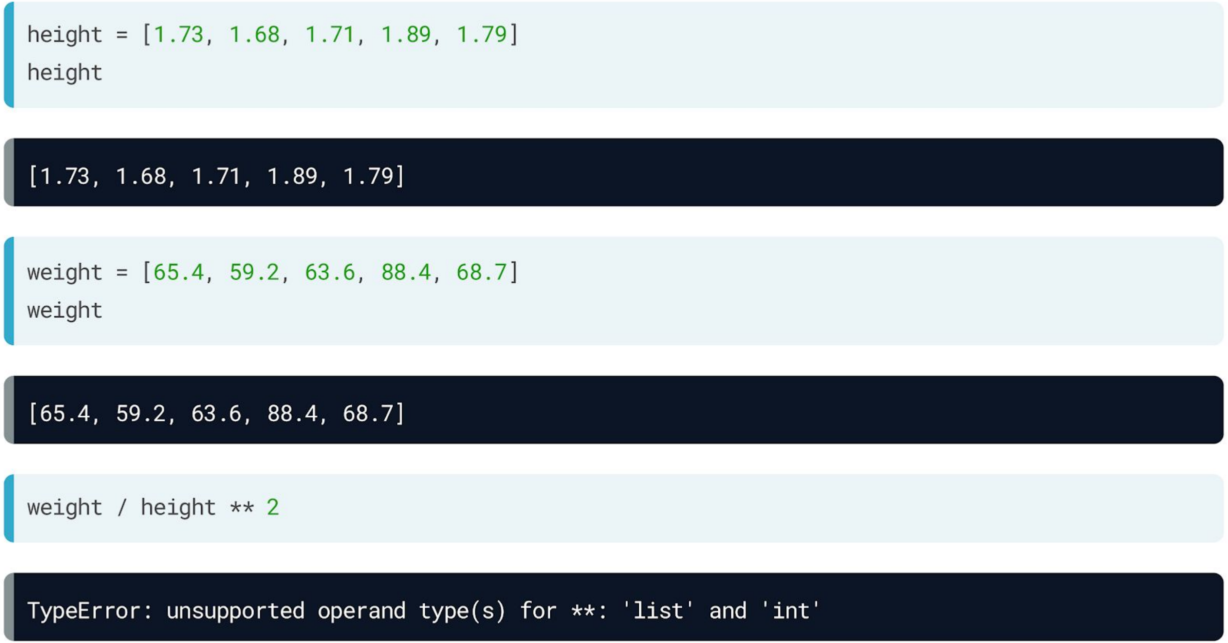
```
weight / height ** 2
```

Illustration



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```
weight / height ** 2
```

```
TypeError: unsupported operand type(s) for **: 'list' and 'int'
```

Solution: Numpy

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- Numeric Python

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- Alternative to Python List: Numpy Array

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- Calculations over entire arrays

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- Installation

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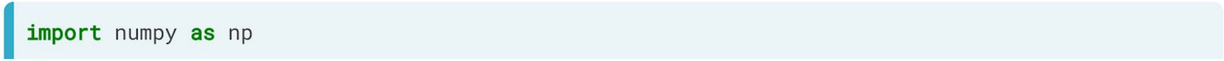
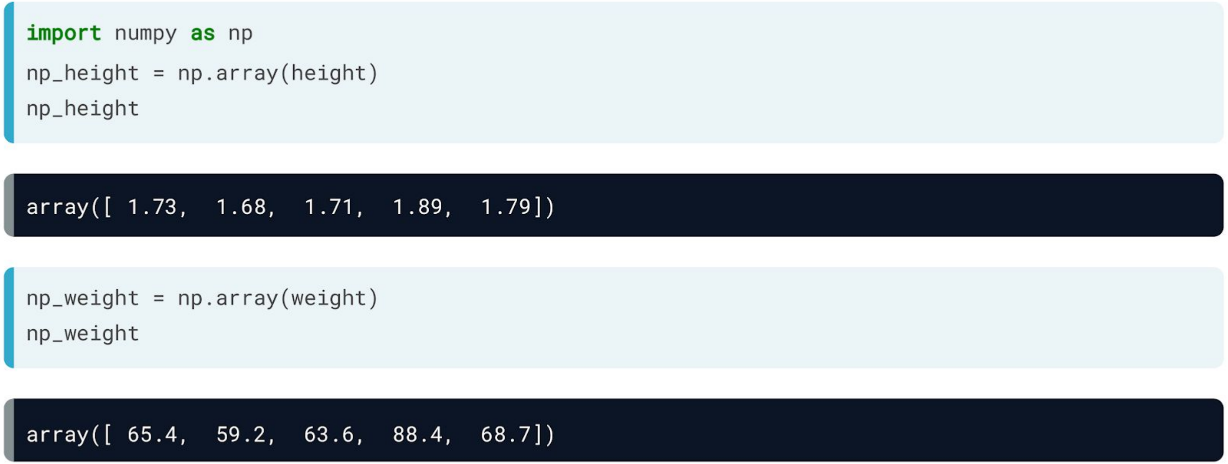
- Numeric Python
- Alternative to Python List: Numpy Array
- Calculations over entire arrays
- Easy and Fast
- Installation
  - In the terminal: pip3 install numpy

Numpy



```
import numpy as np
```

Numpy



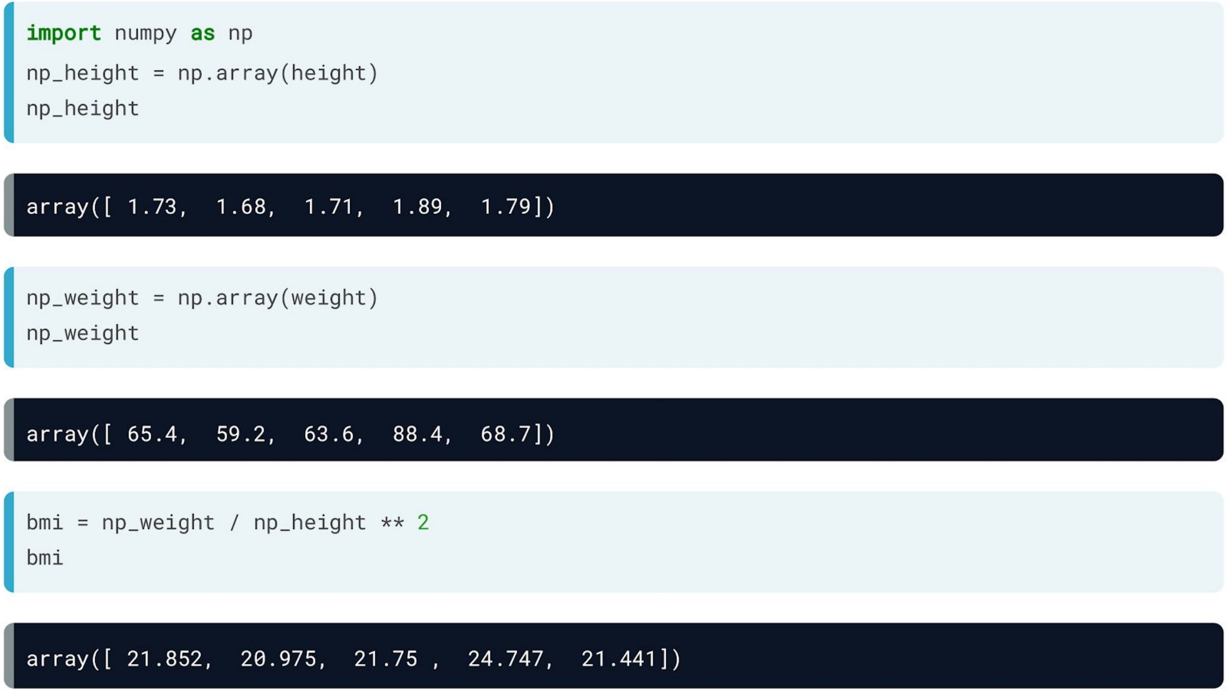
```python
import numpy as np
np_height = np.array(height)
np_height
```

```
array([ 1.73,  1.68,  1.71,  1.89,  1.79])
```

```python
np_weight = np.array(weight)
np_weight
```

```
array([ 65.4,  59.2,  63.6,  88.4,  68.7])
```

Numpy



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np_height = np.array(height)
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```
array([ 1.73,  1.68,  1.71,  1.89,  1.79])
```

```
np_weight = np.array(weight)
np_weight
```

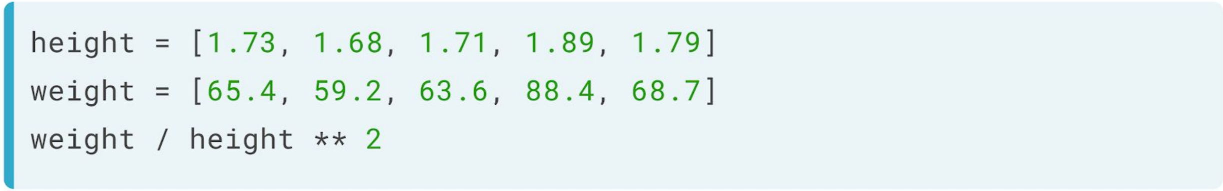
```
array([ 65.4,  59.2,  63.6,  88.4,  68.7])
```

```
bmi = np_weight / np_height ** 2
bmi
```

```
array([ 21.852,  20.975,  21.75 ,  24.747,  21.441])
```

Comparison

Comparison



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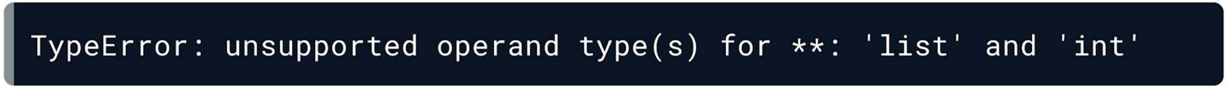
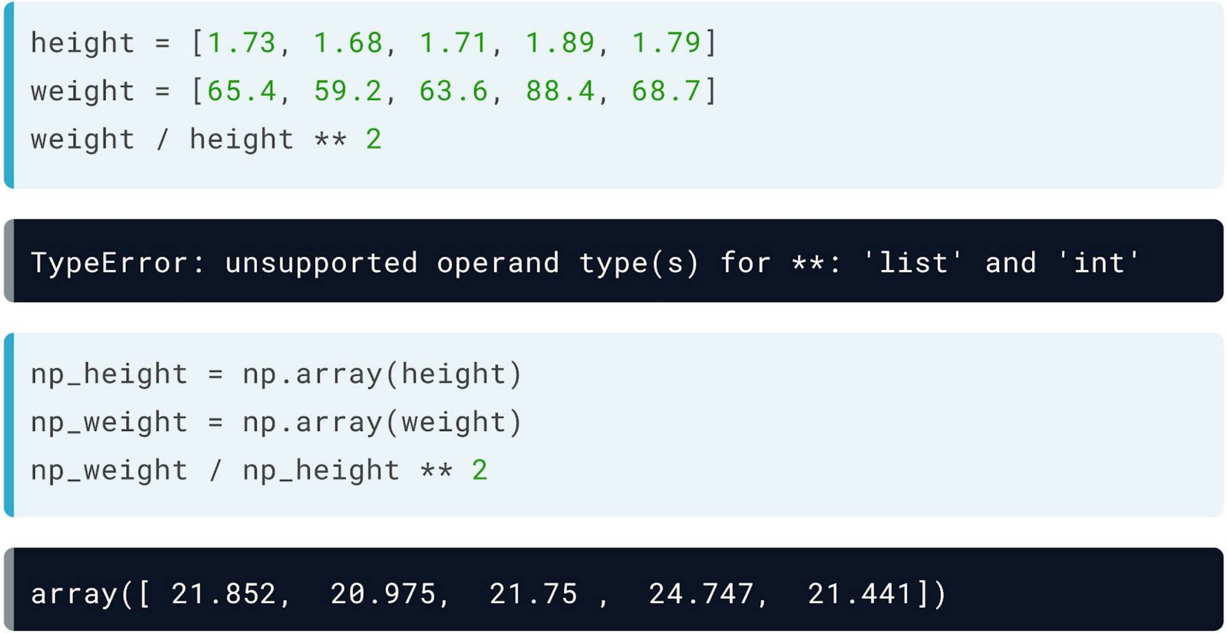
weight = [65.4, 59.2, 63.6, 88.4, 68.7]
weight / height ** 2
```



```
TypeError: unsupported operand type(s) for **: 'list' and 'int'
```

Comparison



```
height = [1.73, 1.68, 1.71, 1.89, 1.79]
weight = [65.4, 59.2, 63.6, 88.4, 68.7]
weight / height ** 2
```

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TypeError: unsupported operand type(s) for **: 'list' and 'int'
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np_height = np.array(height)
np_weight = np.array(weight)
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```

```
array([ 21.852,  20.975,  21.75 ,  24.747,  21.441])
```

Numpy: remarks

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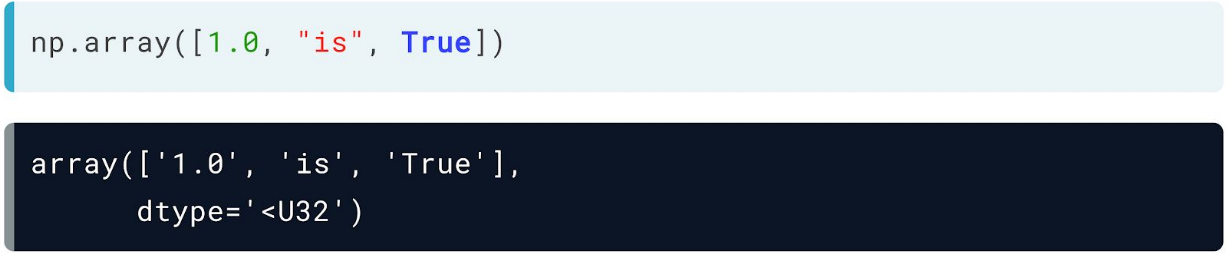
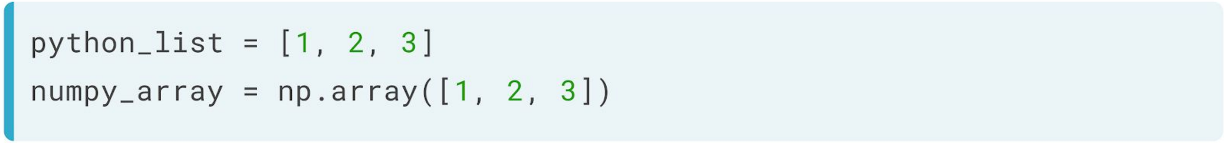


```python
np.array([1.0, "is", True])
```

```
array(['1.0', 'is', 'True'],
      dtype='<U32')
```

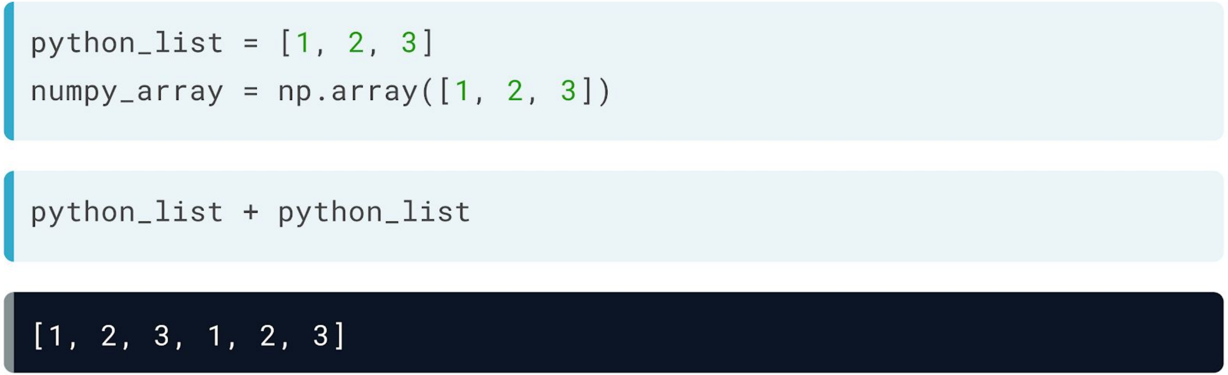
- Numpy arrays: contain only one type

Numpy: remarks



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

Numpy: remarks

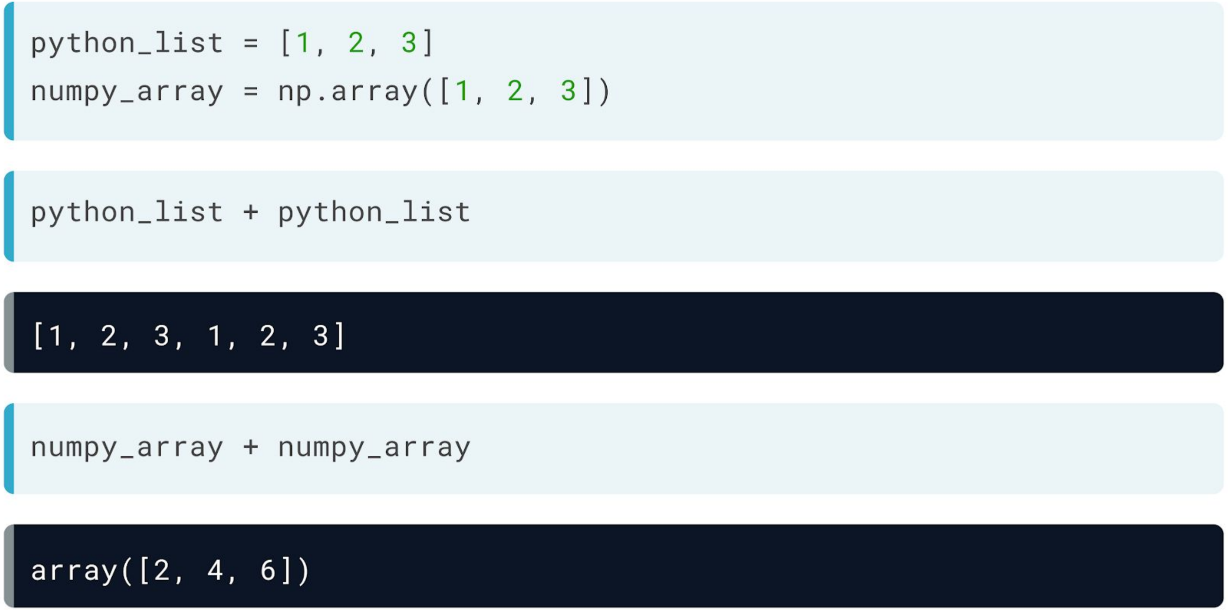


```python
python_list = [1, 2, 3]
numpy_array = np.array([1, 2, 3])
```

```python
python_list + python_list
```

```
[1, 2, 3, 1, 2, 3]
```

Numpy: remarks



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

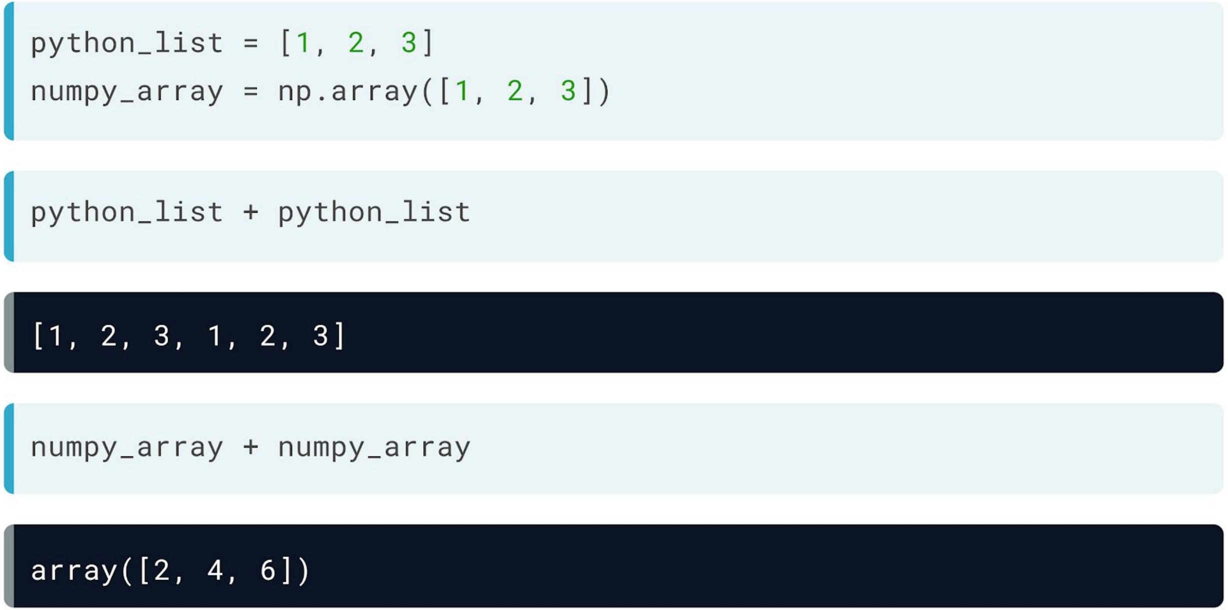
```
python_list + python_list
```

```
[1, 2, 3, 1, 2, 3]
```

```
numpy_array + numpy_array
```

```
array([2, 4, 6])
```

Numpy: remarks



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```
python_list + python_list
```

```
[1, 2, 3, 1, 2, 3]
```

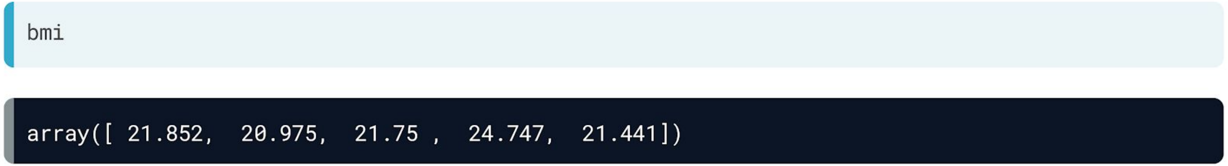
```
numpy_array + numpy_array
```

```
array([2, 4, 6])
```

- Different types: different behavior!

Numpy Subsetting

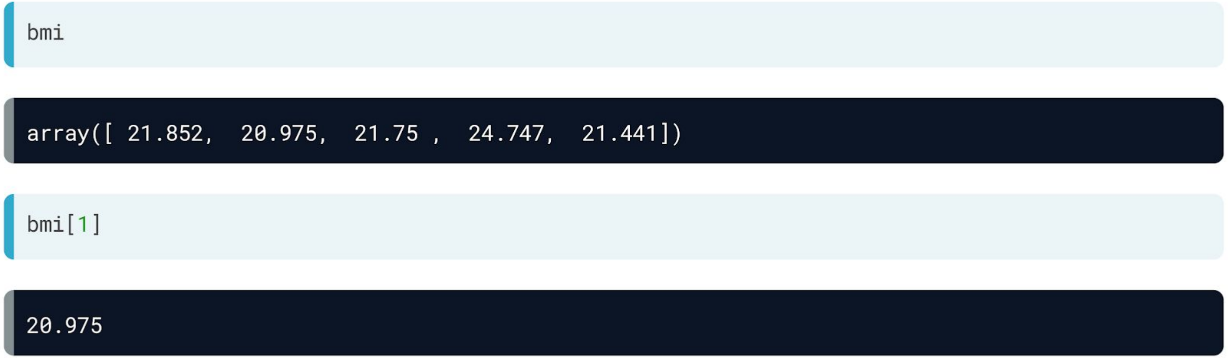
Numpy Subsetting



```
bmi
```

```
array([ 21.852,  20.975,  21.75 ,  24.747,  21.441])
```

Numpy Subsetting



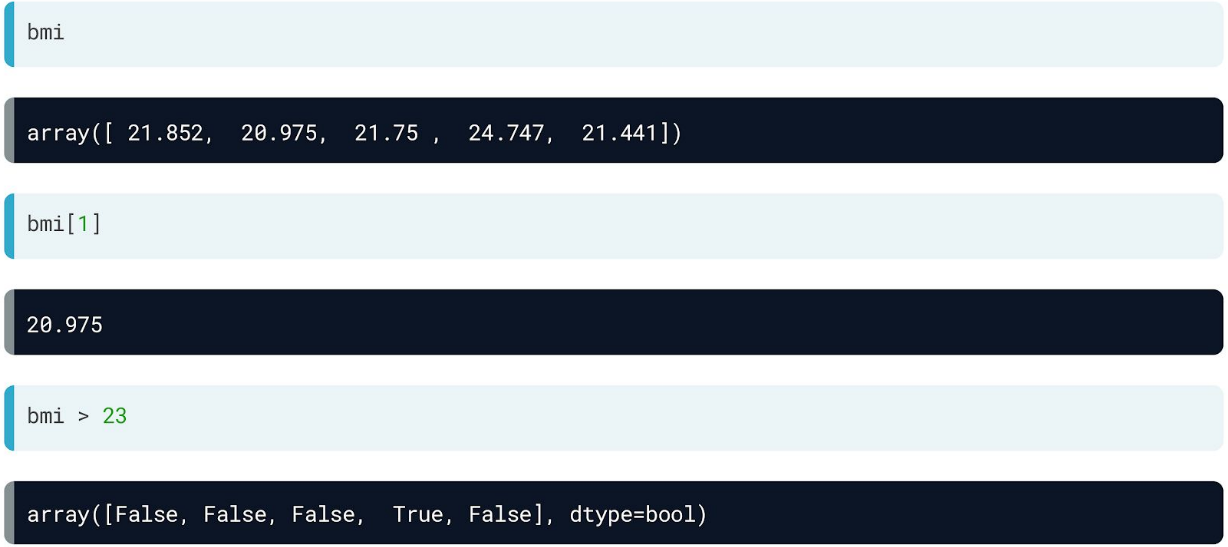
```
bmi
```

```
array([ 21.852,  20.975,  21.75 ,  24.747,  21.441])
```

```
bmi[1]
```

```
20.975
```

Numpy Subsetting



```
bmi
```

```
array([ 21.852,  20.975,  21.75 ,  24.747,  21.441])
```

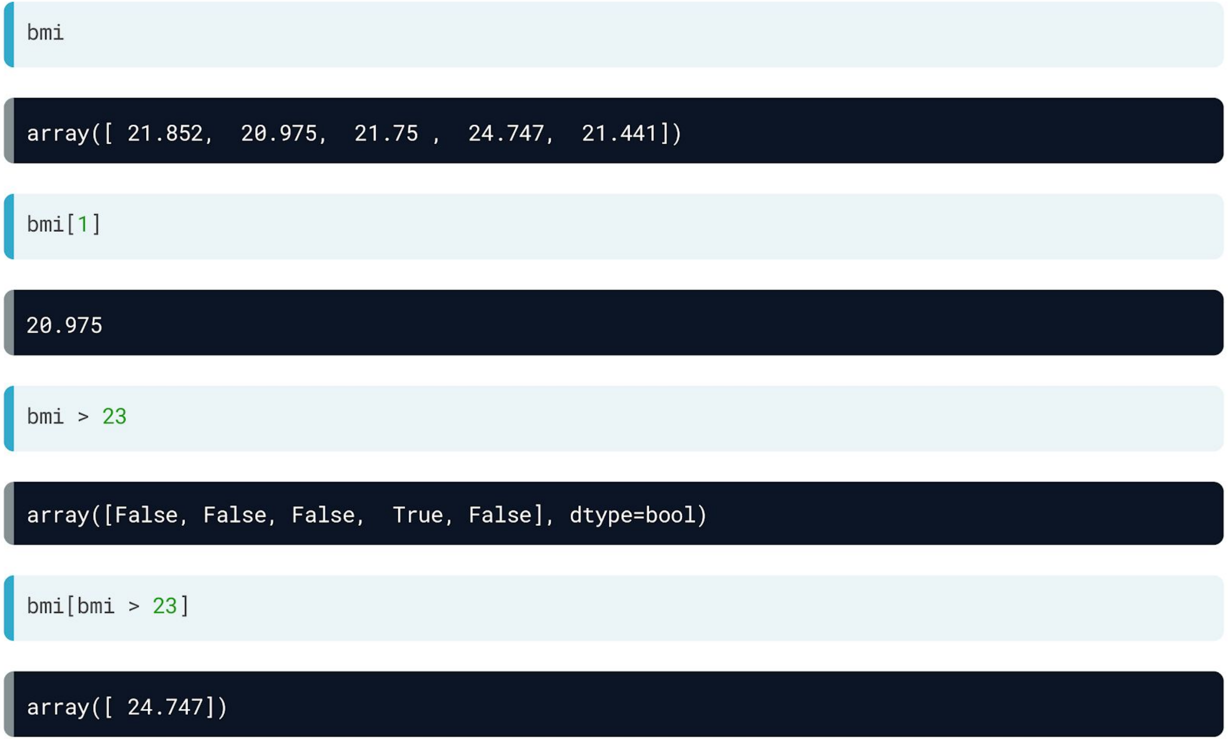
```
bmi[1]
```

```
20.975
```

```
bmi > 23
```

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

Numpy Subsetting



```
bmi
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array([ 21.852,  20.975,  21.75 ,  24.747,  21.441])
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bmi[1]
```

```
20.975
```

```
bmi > 23
```

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

```
bmi[bmi > 23]
```

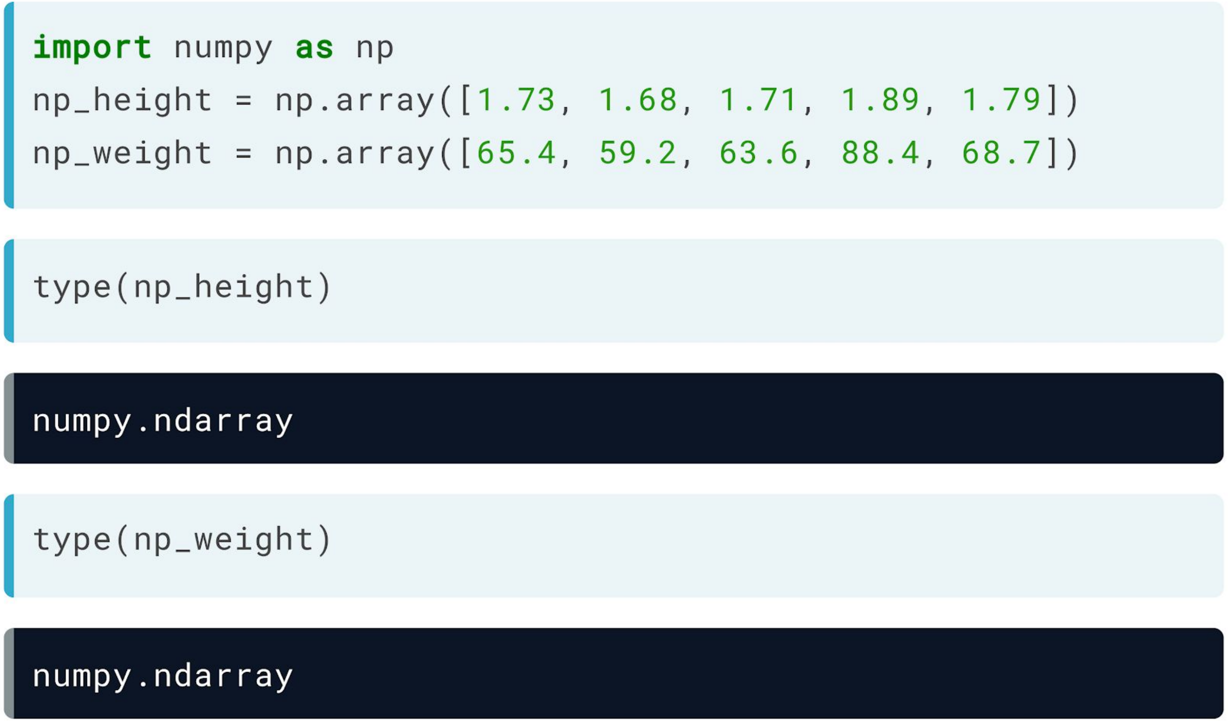
```
array([ 24.747])
```

Let's practice!

INTRODUCTION TO PYTHON

2D Numpy Arrays

Type of Numpy Arrays



```
import numpy as np
np_height = np.array([1.73, 1.68, 1.71, 1.89, 1.79])
np_weight = np.array([65.4, 59.2, 63.6, 88.4, 68.7])
```

```
type(np_height)
```

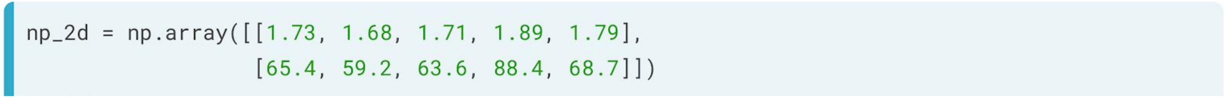
```
numpy.ndarray
```

```
type(np_weight)
```

```
numpy.ndarray
```

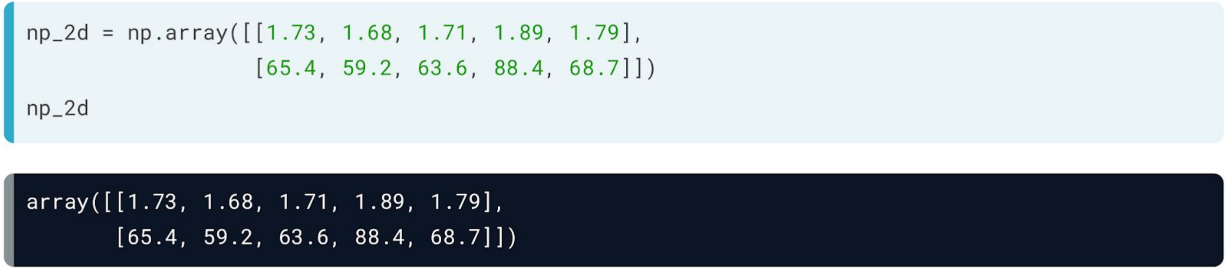
2D Numpy Arrays

2D Numpy Arrays



```
np_2d = np.array([[1.73, 1.68, 1.71, 1.89, 1.79],
                  [65.4, 59.2, 63.6, 88.4, 68.7]])
```

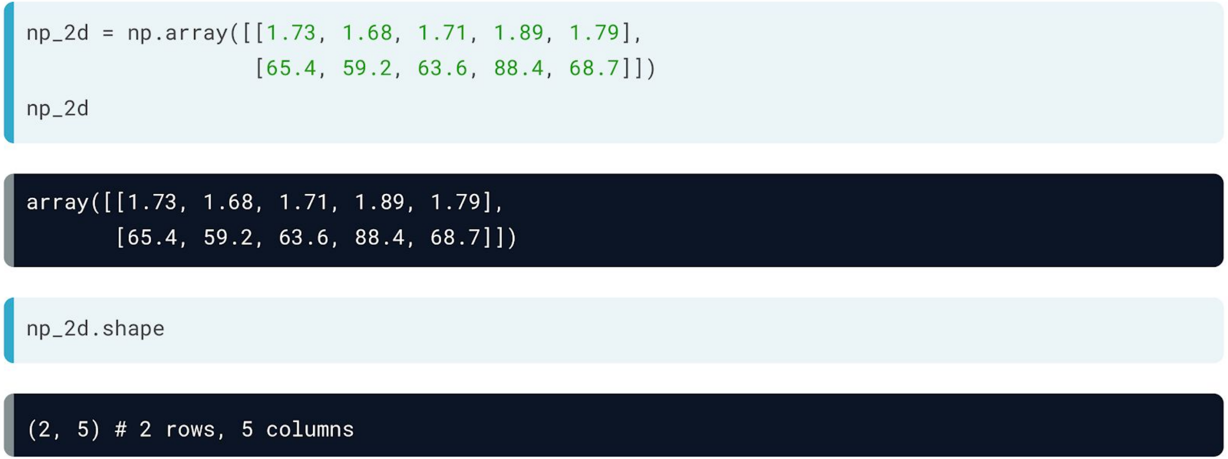
2D Numpy Arrays



```
np_2d = np.array([[1.73, 1.68, 1.71, 1.89, 1.79],
                  [65.4, 59.2, 63.6, 88.4, 68.7]])
np_2d
```

```
array([[1.73, 1.68, 1.71, 1.89, 1.79],
       [65.4, 59.2, 63.6, 88.4, 68.7]])
```

2D Numpy Arrays



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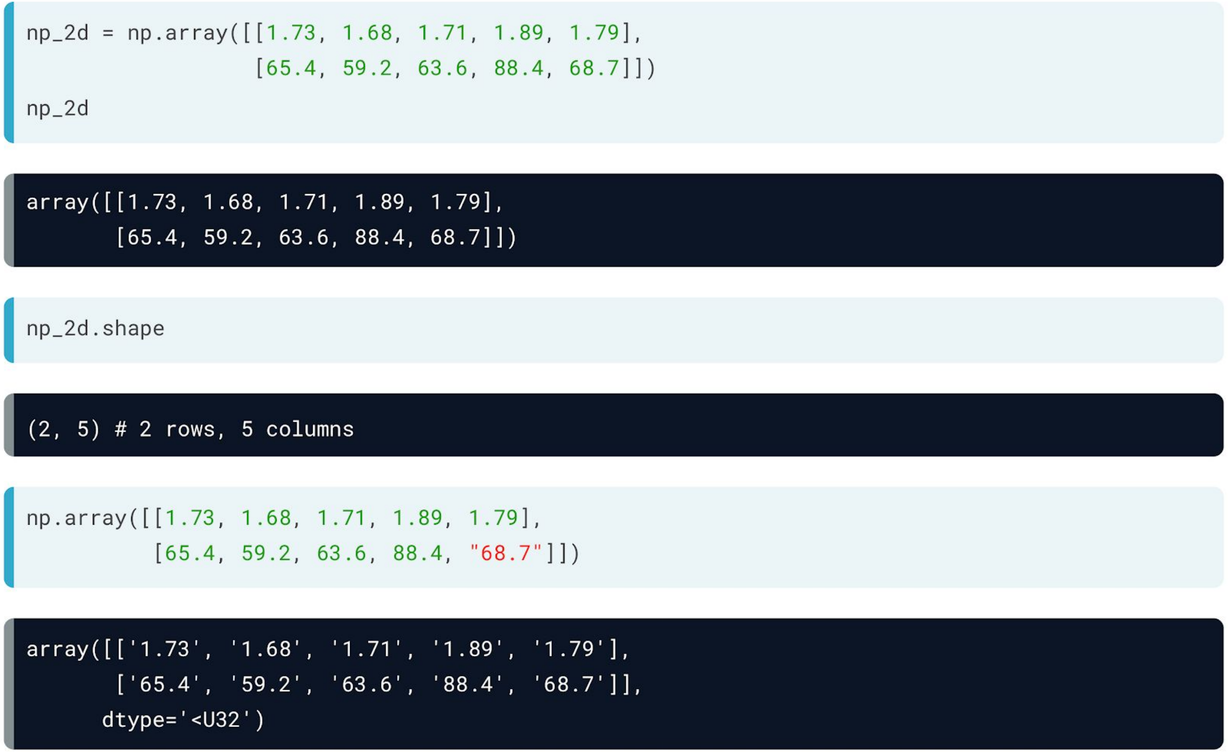
                  [65.4, 59.2, 63.6, 88.4, 68.7]])
np_2d
```

```
array([[1.73, 1.68, 1.71, 1.89, 1.79],
       [65.4, 59.2, 63.6, 88.4, 68.7]])
```

```
np_2d.shape
```

```
(2, 5) # 2 rows, 5 columns
```

2D Numpy Arrays



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```
np_2d.shape
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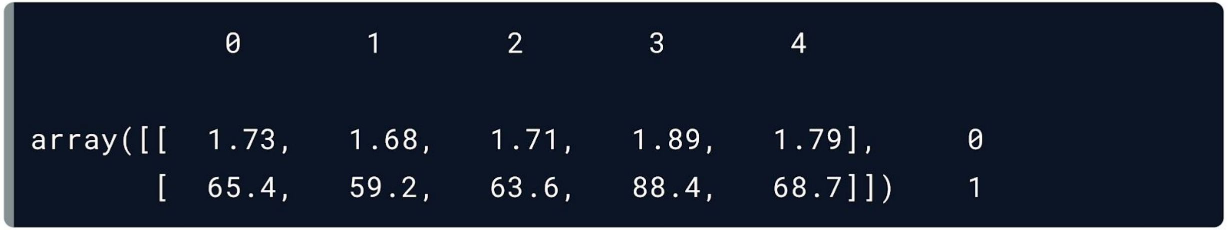
(2, 5) # 2 rows, 5 columns
```

```
np.array([[1.73, 1.68, 1.71, 1.89, 1.79],
          [65.4, 59.2, 63.6, 88.4, "68.7"]])
```

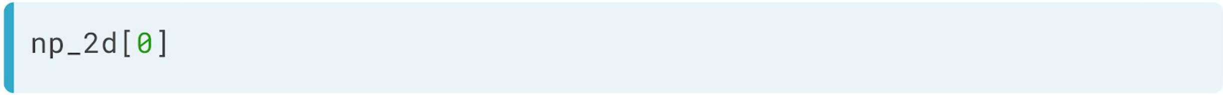
```
array([['1.73', '1.68', '1.71', '1.89', '1.79'],
       ['65.4', '59.2', '63.6', '88.4', '68.7']],
      dtype='<U32')
```

Subsetting

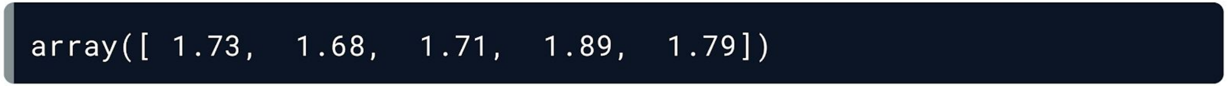


```
          0       1       2       3       4

array([[ 1.73,   1.68,   1.71,   1.89,   1.79],      0
       [ 65.4,   59.2,   63.6,   88.4,   68.7]])     1
```

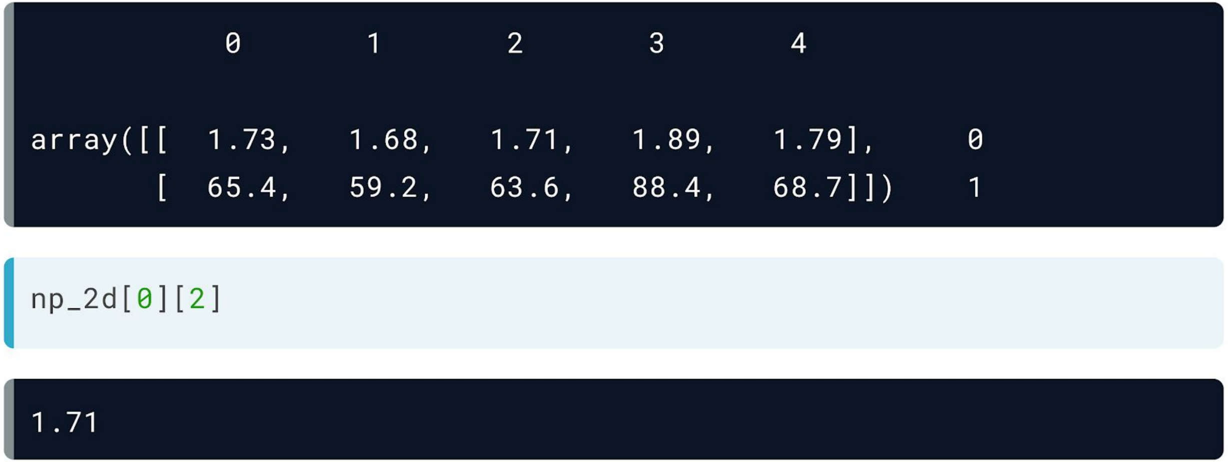


```
np_2d[0]
```



```
array([ 1.73,  1.68,  1.71,  1.89,  1.79])
```

Subsetting



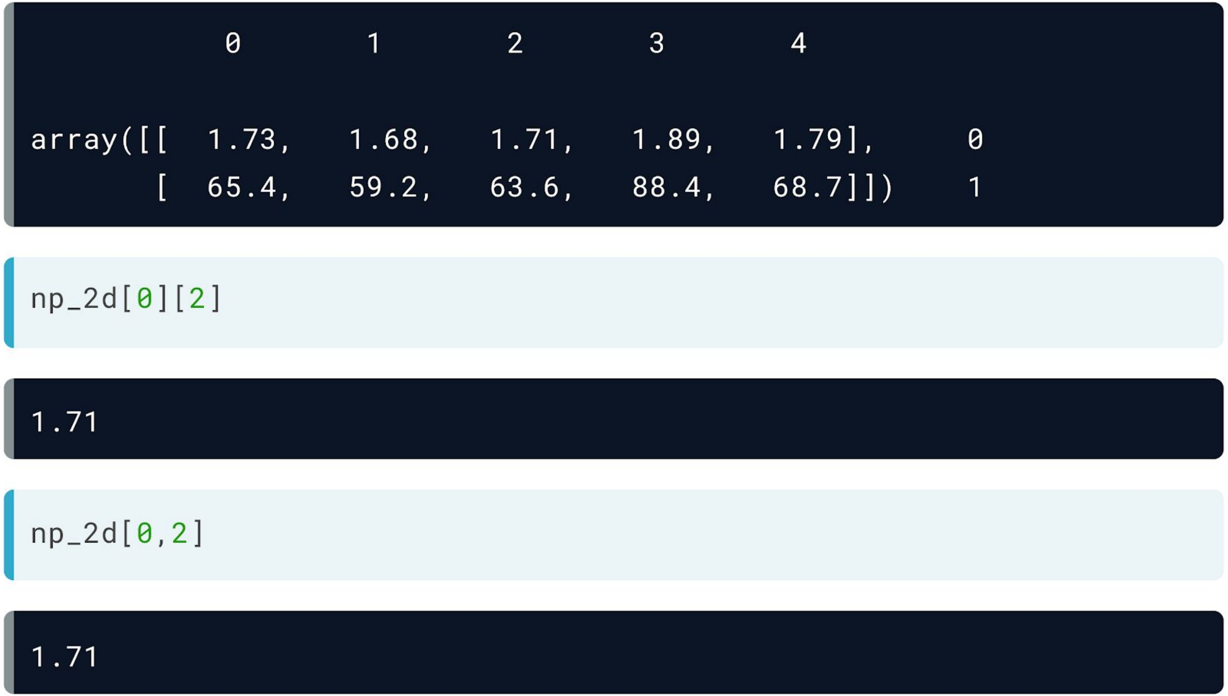
```
          0       1       2       3       4

array([[  1.73,   1.68,   1.71,   1.89,   1.79],     0
       [  65.4,   59.2,   63.6,   88.4,   68.7]])    1
```

```
np_2d[0][2]
```

```
1.71
```

Subsetting



```
            0       1       2       3       4

array([[  1.73,   1.68,   1.71,   1.89,   1.79],      0
       [  65.4,   59.2,   63.6,   88.4,   68.7]])     1
```

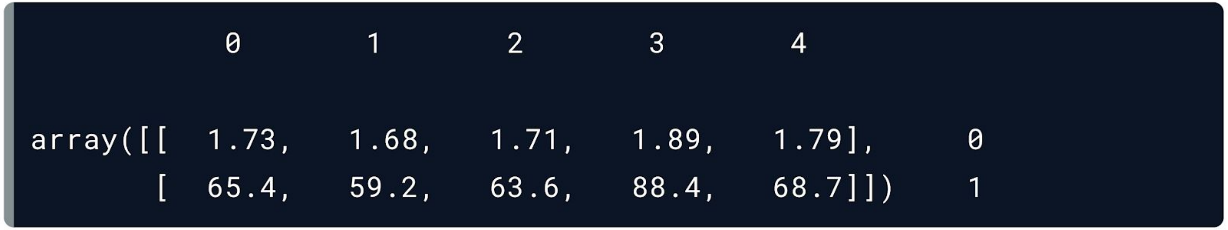
```
np_2d[0][2]
```

```
1.71
```

```
np_2d[0,2]
```

```
1.71
```

Subsetting



```
                0        1        2        3        4

array([[  1.73,    1.68,    1.71,    1.89,    1.79],      0
       [  65.4,    59.2,    63.6,    88.4,    68.7]])     1
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Subsetting

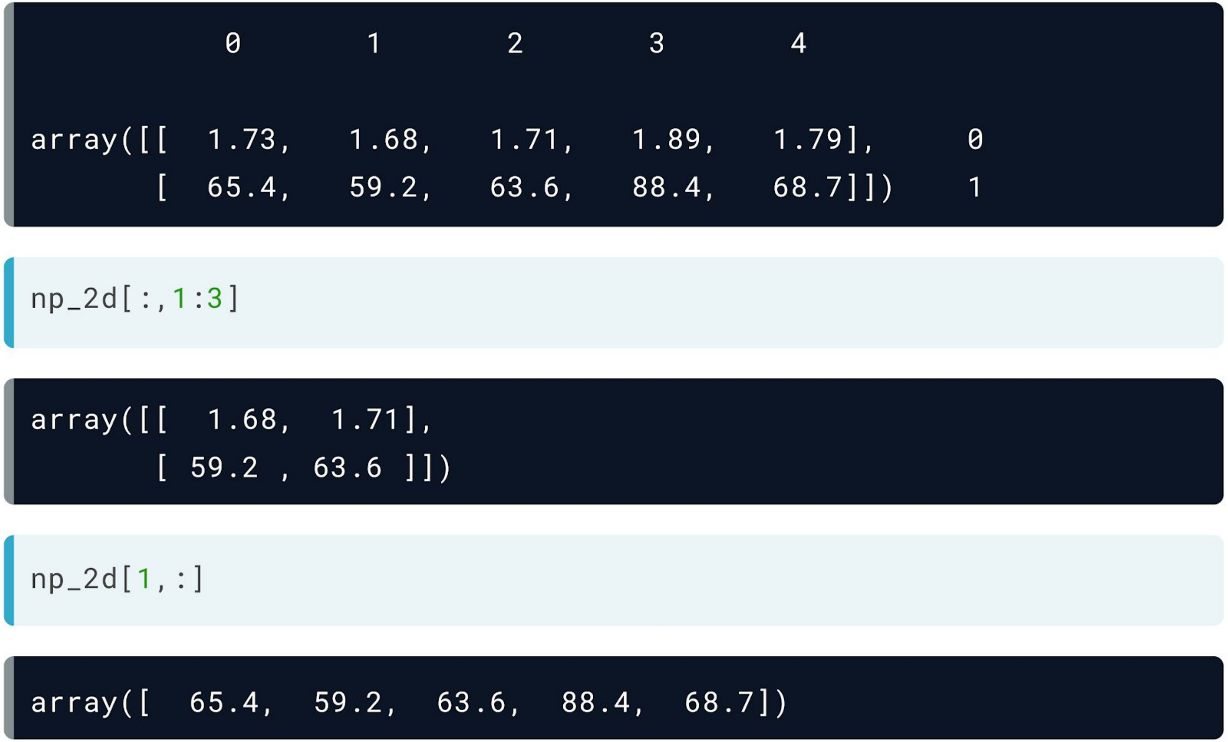
```
               0        1        2        3        4

array([[  1.73,    1.68,    1.71,    1.89,    1.79],      0
        [  65.4,    59.2,    63.6,    88.4,    68.7]])     1
```

```
np_2d[:,1:3]
```

```
array([[  1.68,   1.71],
        [ 59.2 ,  63.6 ]])
```

Subsetting



```
                0       1       2       3       4

array([[  1.73,   1.68,   1.71,   1.89,   1.79],      0
       [  65.4,   59.2,   63.6,   88.4,   68.7]])     1
```

```
np_2d[:,1:3]
```

```
array([[  1.68,   1.71],
       [ 59.2 ,  63.6 ]])
```

```
np_2d[1,:]
```

```
array([  65.4,   59.2,   63.6,   88.4,   68.7])
```

Let's practice!

Numpy: Basic Statistics

Data analysis

Data analysis

- Get to know your data

Data analysis

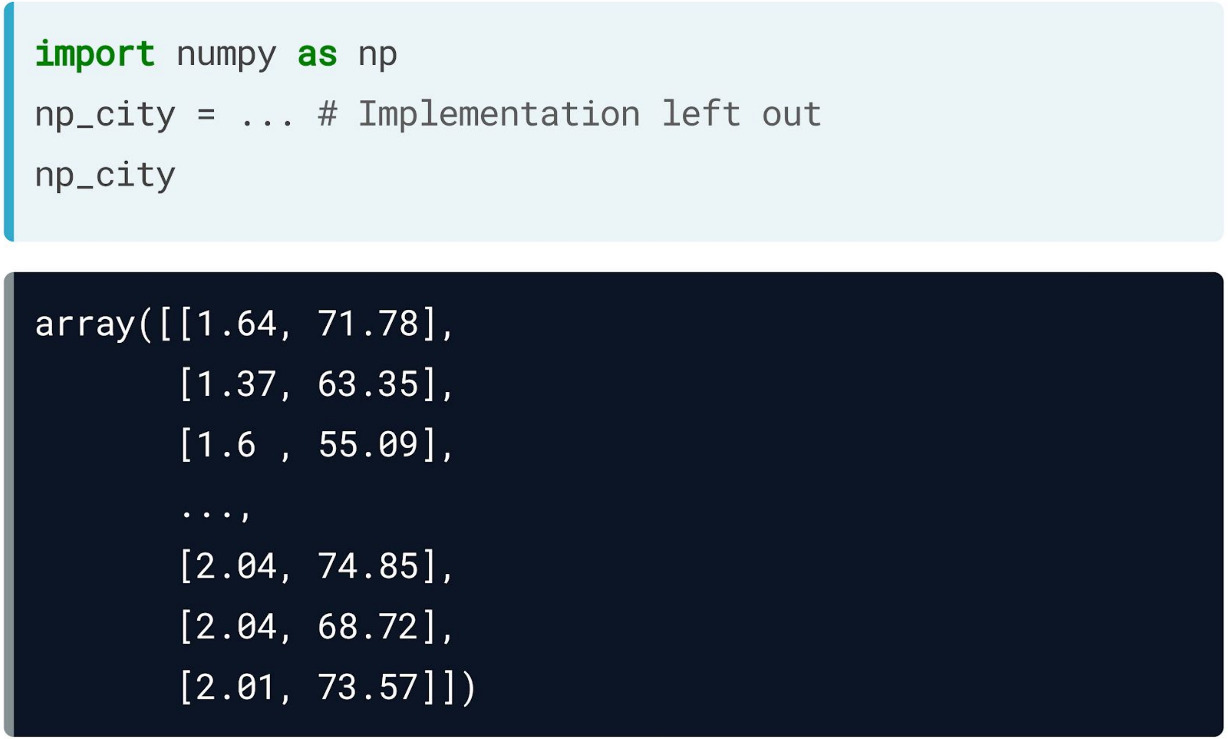
- Get to know your data
- Little data -> simply look at it

Data analysis

- Get to know your data
- Little data -> simply look at it
- Big data -> ?

City-wide survey

City-wide survey

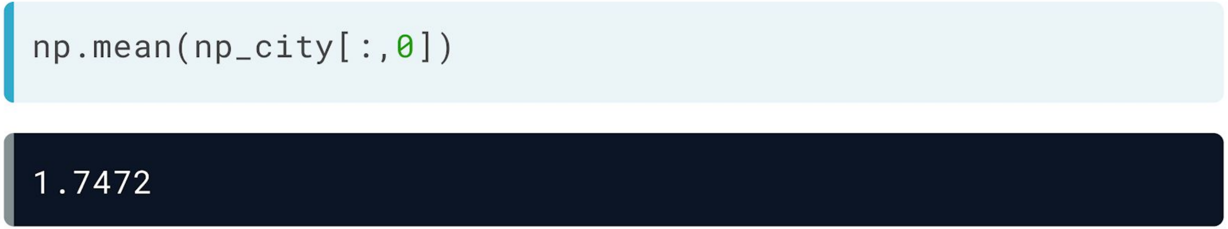


```
import numpy as np
np_city = ... # Implementation left out
np_city
```

```
array([[1.64, 71.78],
       [1.37, 63.35],
       [1.6 , 55.09],
       ...,
       [2.04, 74.85],
       [2.04, 68.72],
       [2.01, 73.57]])
```

Numpy

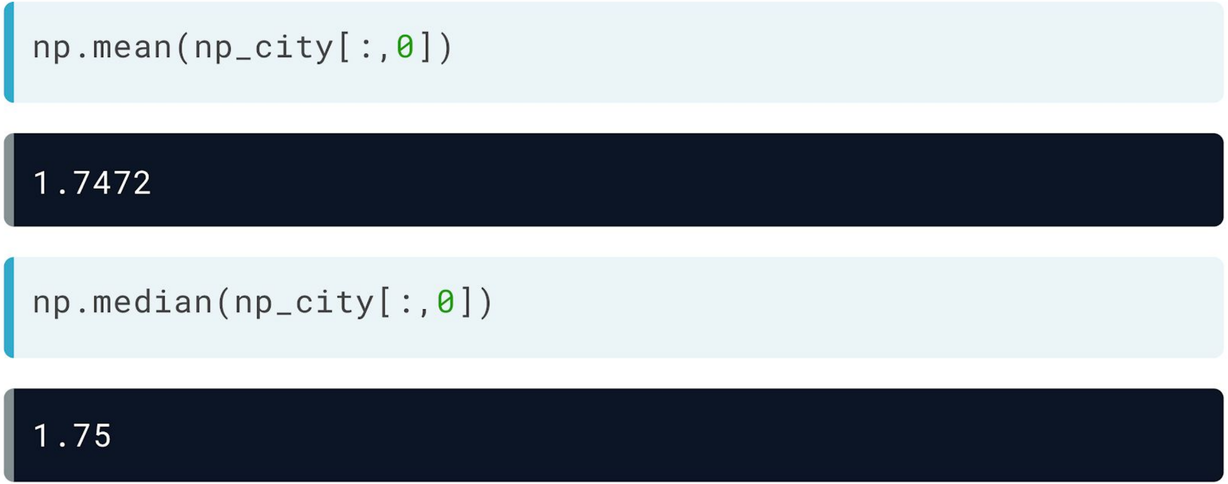
Numpy



```
np.mean(np_city[:,0])
```

```
1.7472
```

Numpy



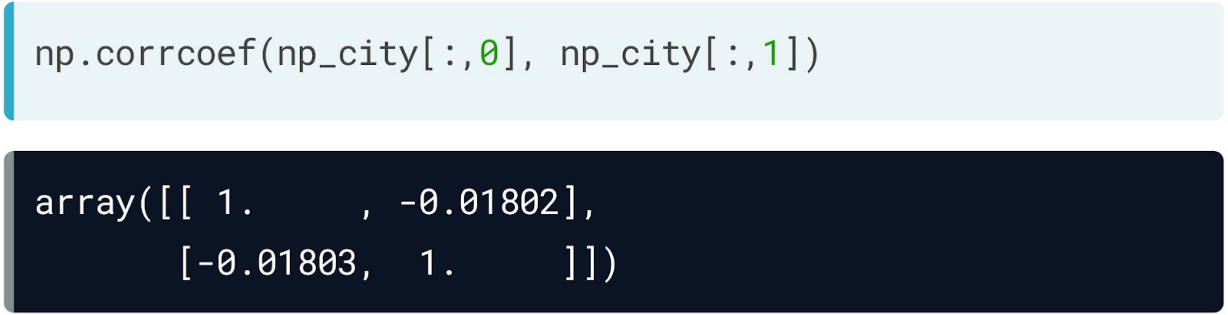
```
np.mean(np_city[:,0])
```

```
1.7472
```

```
np.median(np_city[:,0])
```

```
1.75
```

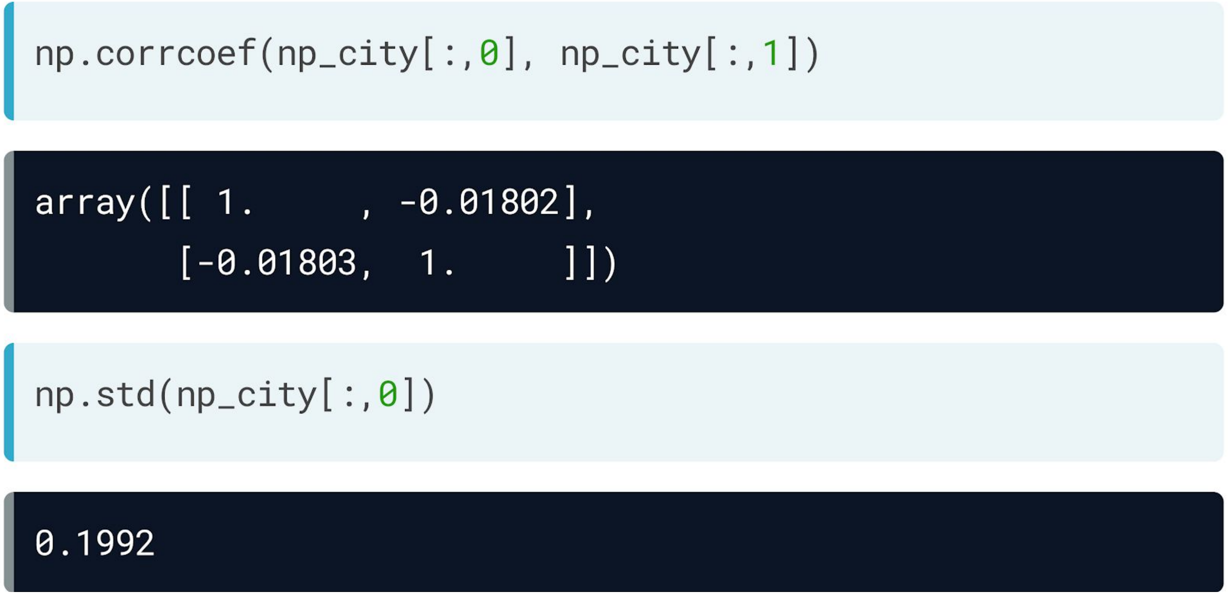
Numpy



```
np.corrcoef(np_city[:,0], np_city[:,1])
```

```
array([[ 1.      , -0.01802],
       [-0.01803,  1.      ]])
```

Numpy



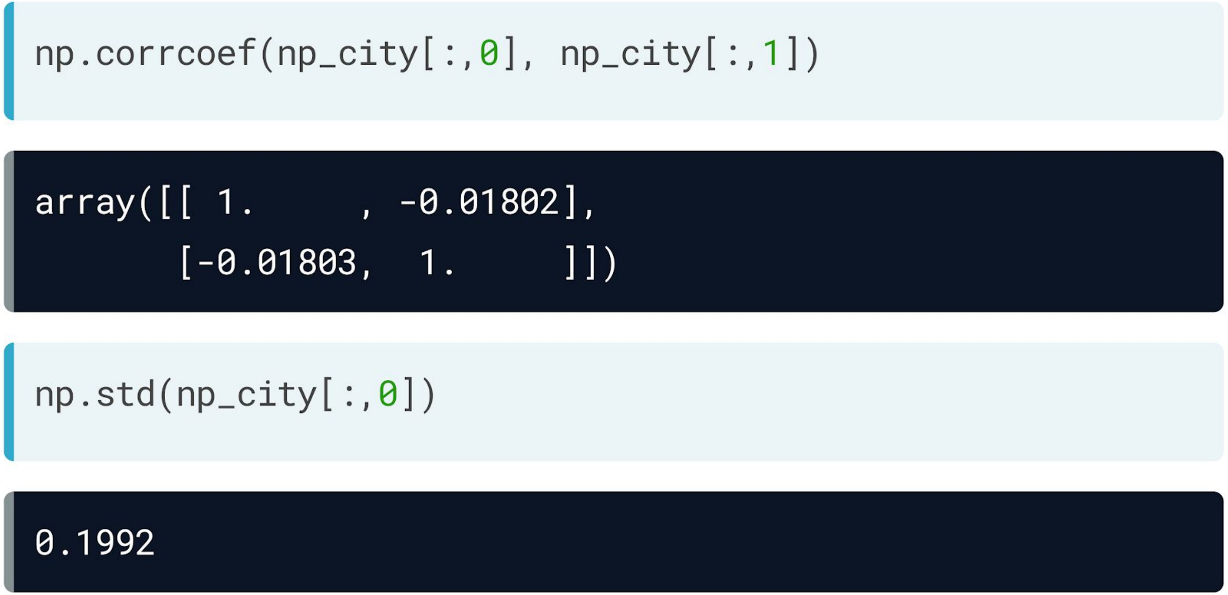
```
np.corrcoef(np_city[:,0], np_city[:,1])
```

```
array([[ 1.     , -0.01802],
       [-0.01803,  1.     ]])
```

```
np.std(np_city[:,0])
```

```
0.1992
```

Numpy



```
np.corrcoef(np_city[:,0], np_city[:,1])
```

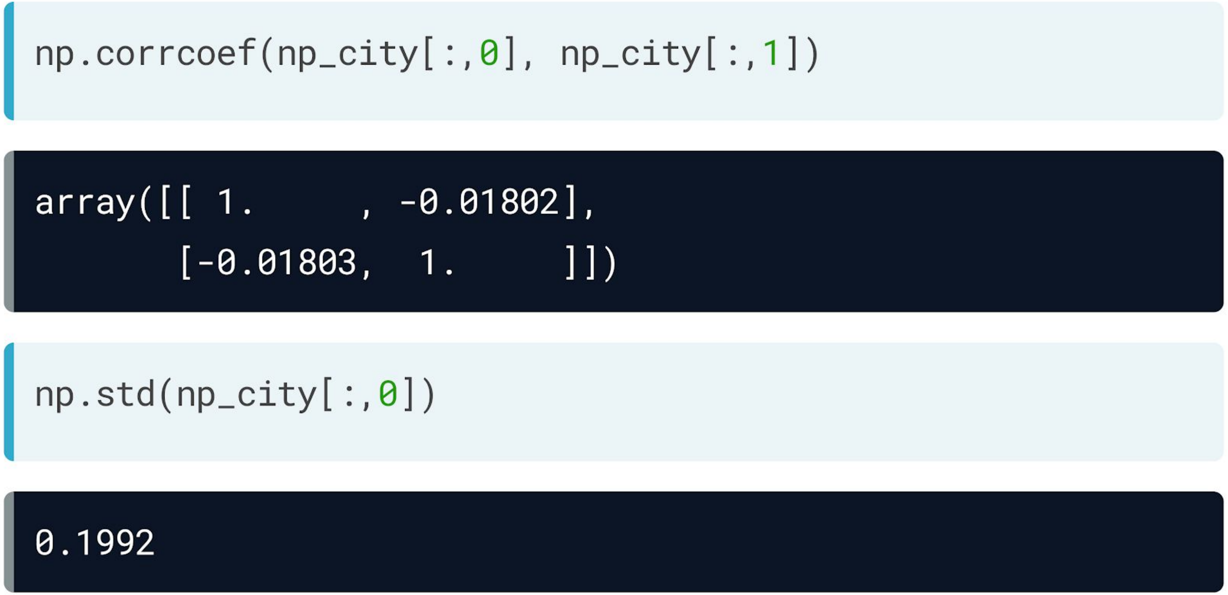
```
array([[ 1.      , -0.01802],
       [-0.01803,  1.      ]])
```

```
np.std(np_city[:,0])
```

```
0.1992
```

- sum(), sort(), ...

Numpy



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array([[ 1.      , -0.01802],
       [-0.01803,  1.      ]])
```

```
np.std(np_city[:,0])
```

```
0.1992
```

- sum(), sort(), ...
- Enforce single data type: speed!

Generate data

Generate data

- Arguments for `np.random.normal()`
  - distribution mean
  - distribution standard deviation
  - number of samples

```
height = np.round(np.random.normal(1.75, 0.20, 5000), 2)

weight = np.round(np.random.normal(60.32, 15, 5000), 2)
```

Generate data

- Arguments for `np.random.normal()`
  - distribution mean
  - distribution standard deviation
  - number of samples

```
height = np.round(np.random.normal(1.75, 0.20, 5000), 2)

weight = np.round(np.random.normal(60.32, 15, 5000), 2)
np_city = np.column_stack((height, weight))
```

Let's practice!

INTRODUCTION TO PYTHON