Introducing arrays

INTRODUCTION TO NUMPY

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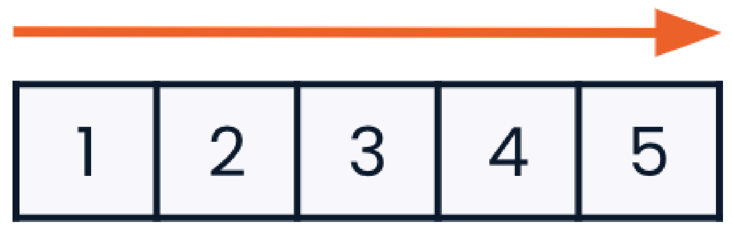
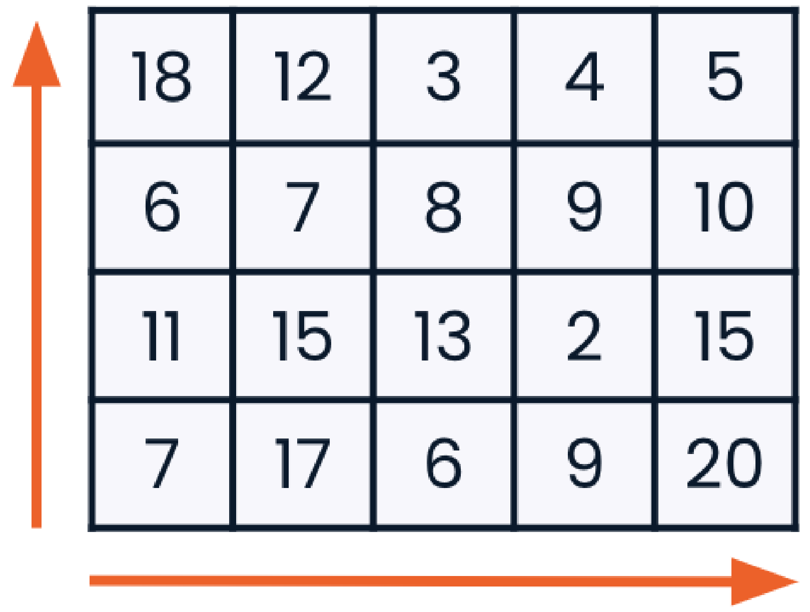
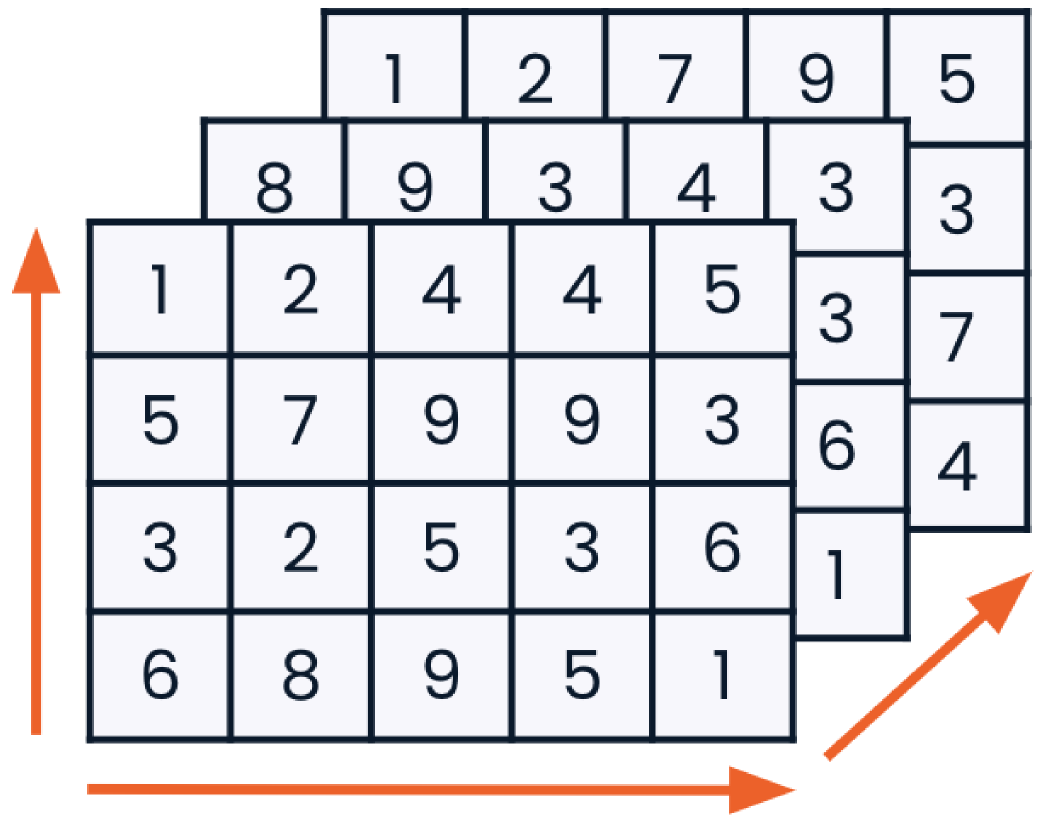
NumPy and the Python ecosystem

TensorFlow
pandas
SciPy
matplotlib
scikit learn
NumPy

NumPy arrays







Importing NumPy

```python
import numpy as np
```

Creating 1D arrays from lists

```
python_list = [3, 2, 5, 8, 4, 9, 7, 6, 1]
array = np.array(python_list)
array
```

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

```
type(array)
```

```
numpy.ndarray
```

Creating 2D arrays from lists

```
python_list_of_lists = [[3, 2, 5],
                        [9, 7, 1],
                        [4, 3, 6]]
np.array(python_list_of_lists)
```

```
array([[3, 2, 5],
       [9, 7, 1],
       [4, 3, 6]])
```

Python lists

- Can contain many different data types

```
python_list = ["beep", False, 56, .945, [3, 2, 5]]
```

NumPy arrays

- Can contain only a single data type
- Use less space in memory

```
numpy_boolean_array = [[True, False], [True, True], [False, True]]

numpy_float_array = [1.9, 5.4, 8.8, 3.6, 3.2]
```

Creating arrays from scratch

There are many NumPy functions used to create arrays from scratch, including:

- `np.zeros()`
- `np.random.random()`
- `np.arange()`

Creating arrays: np.zeros()

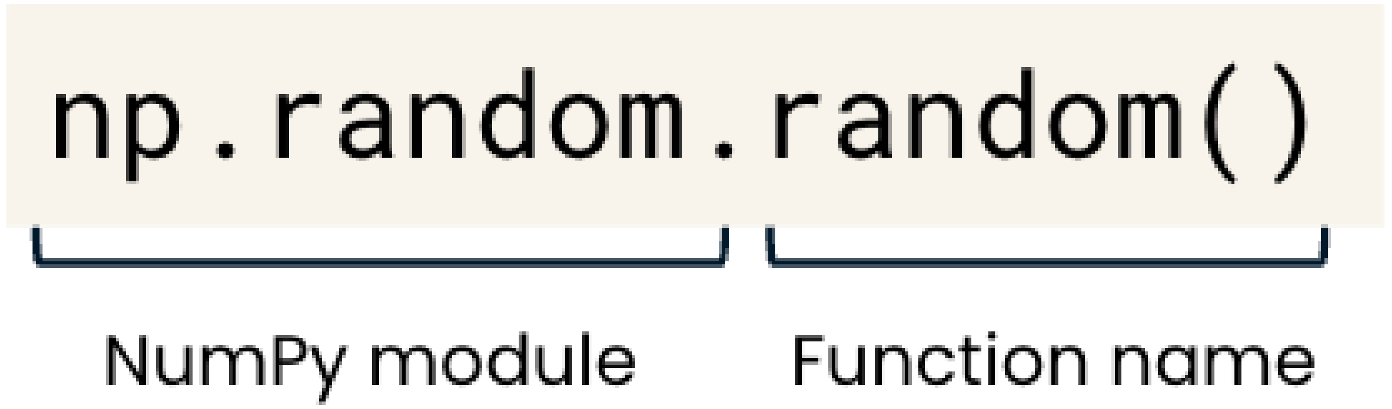
```
np.zeros((5, 3))
```

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

Creating arrays: np.random.random()

```
np.random.random((2, 4))
```

```
array([[0.88524516, 0.85641352, 0.33463107, 0.53337117],
       [0.69933362, 0.09295327, 0.93616428, 0.03601592]])
```



Creating arrays with np.arange()

```
np.arange(-3, 4)
```

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

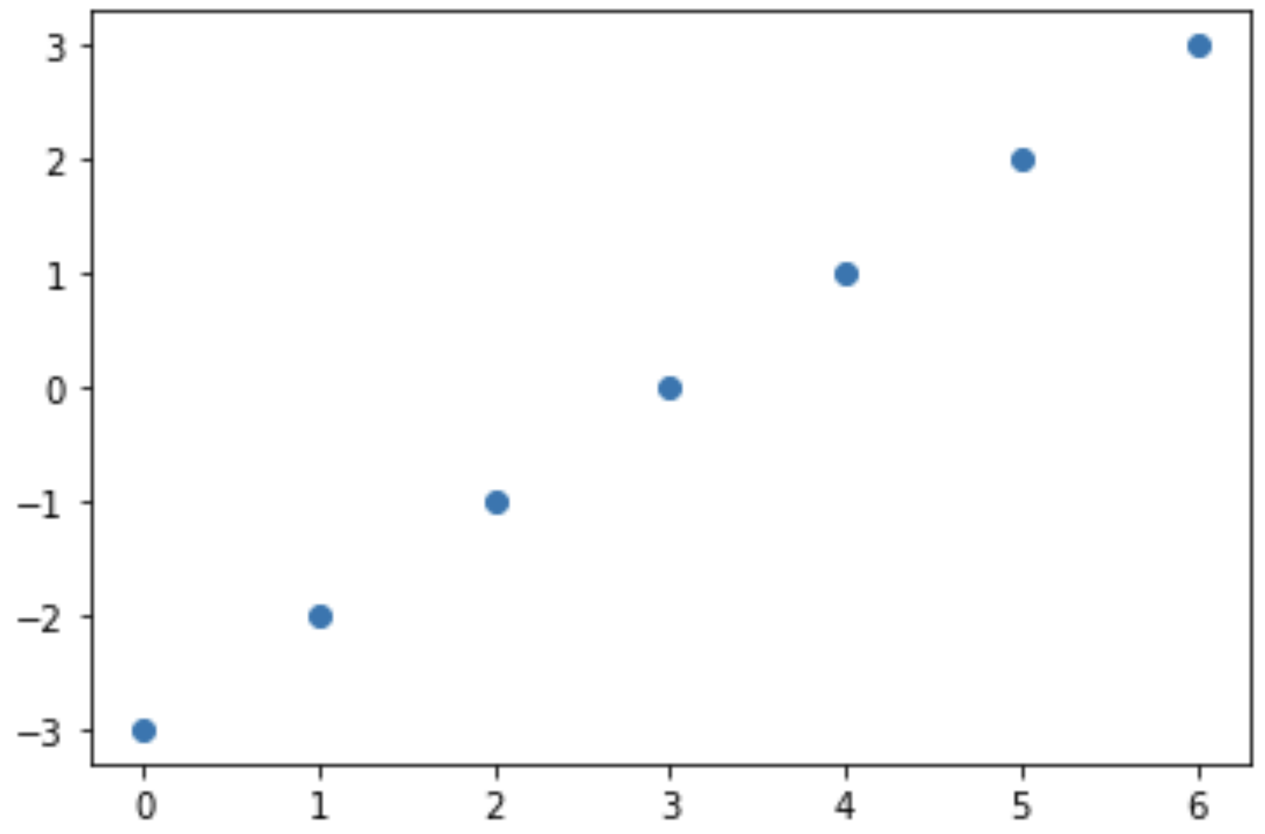
```
np.arange(4)
```

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

```
np.arange(-3, 4, 3)
```

```
array([-3,  0,  3])
```

```
from matplotlib import pyplot as plt
plt.scatter(np.arange(0, 7),
            np.arange(-3, 4))
plt.show()
```



Let's practice!

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Array dimensionality

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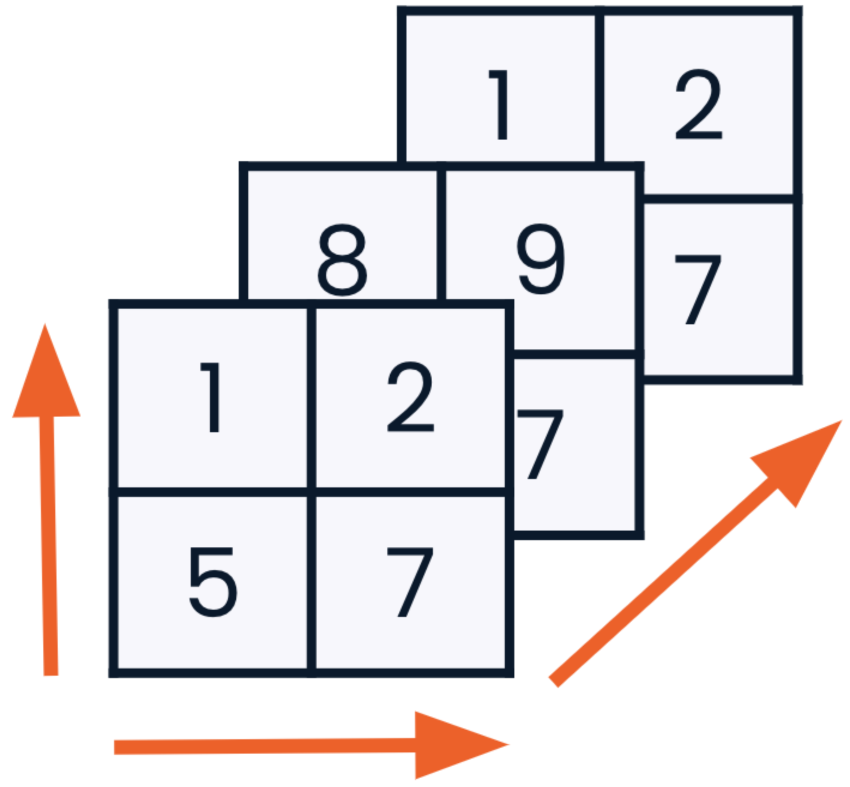
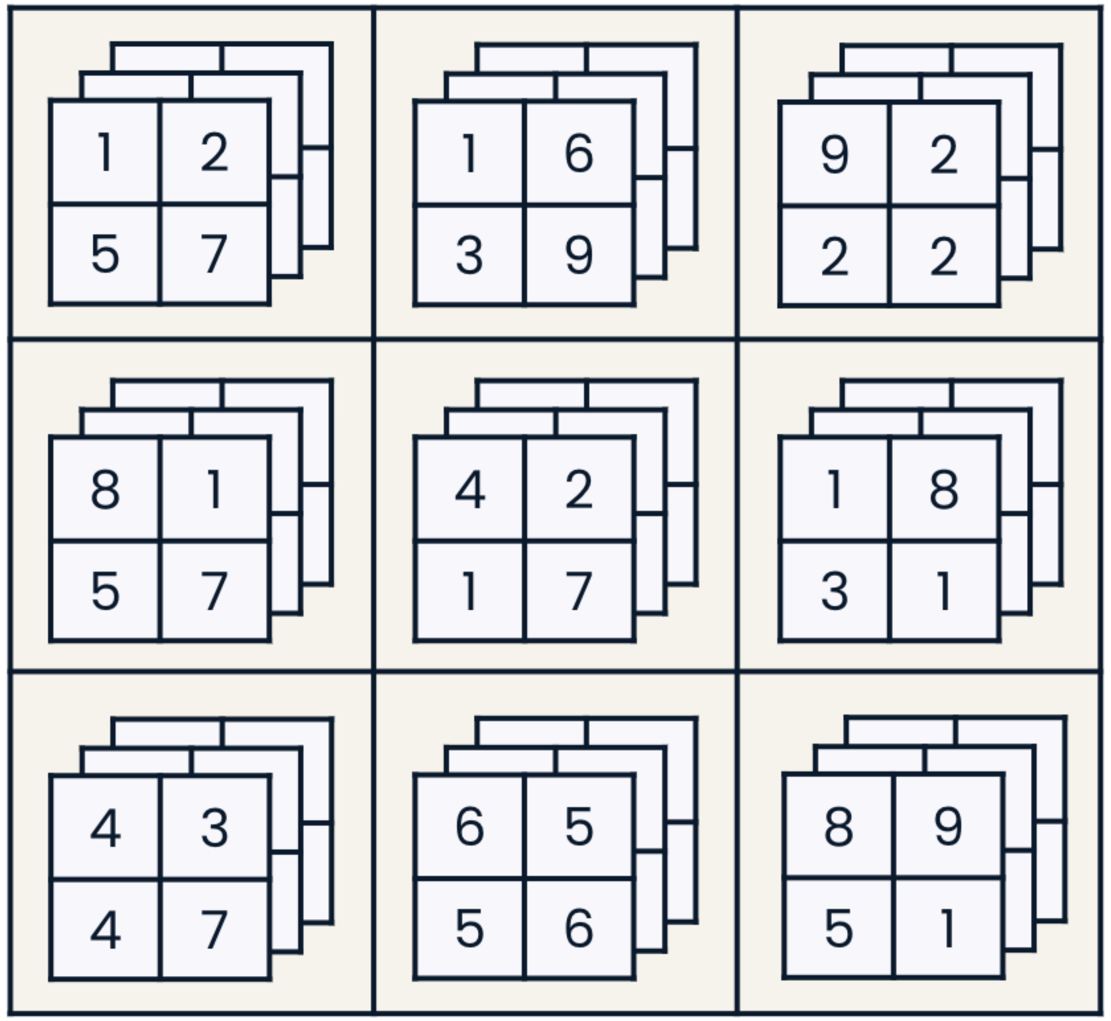
3D arrays

```
array_1_2D = np.array([[1, 2], [5, 7]])
array_2_2D = np.array([[8, 9], [5, 7]])
array_3_2D = np.array([[1, 2], [5, 7]])
array_3D = np.array([array_1_2D, array_2_2D, array_3_2D])
```

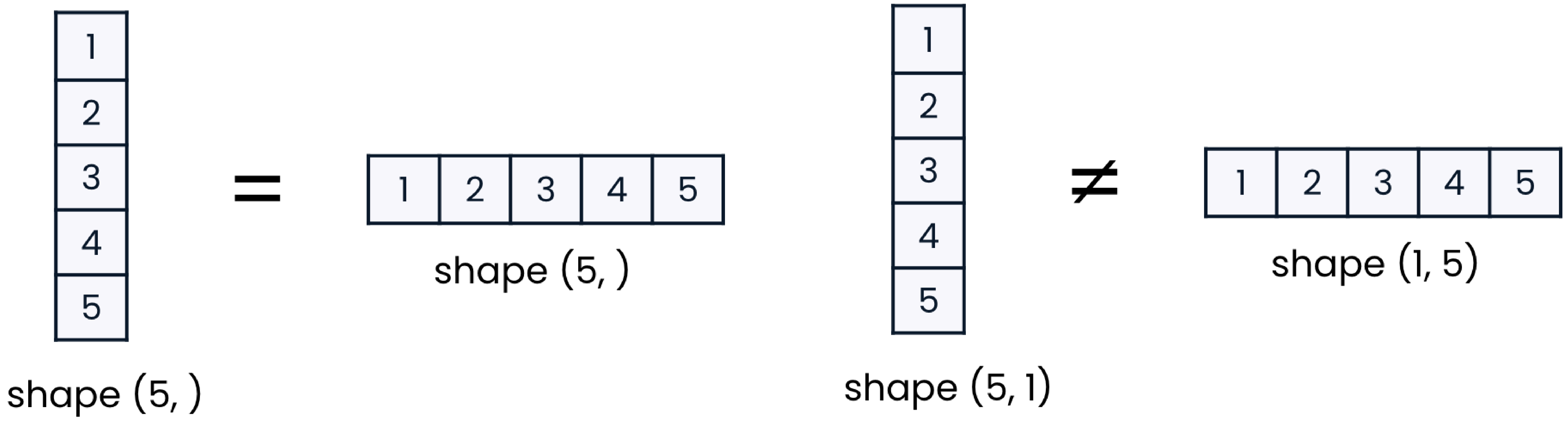


4D arrays

```
array_4D = np.array([array_A_3D, array_B_3D, array_C_3D, array_D_3D, array_E_3D,
                     array_F_3D, array_G_3D, array_H_3D, array_I_3D])
```

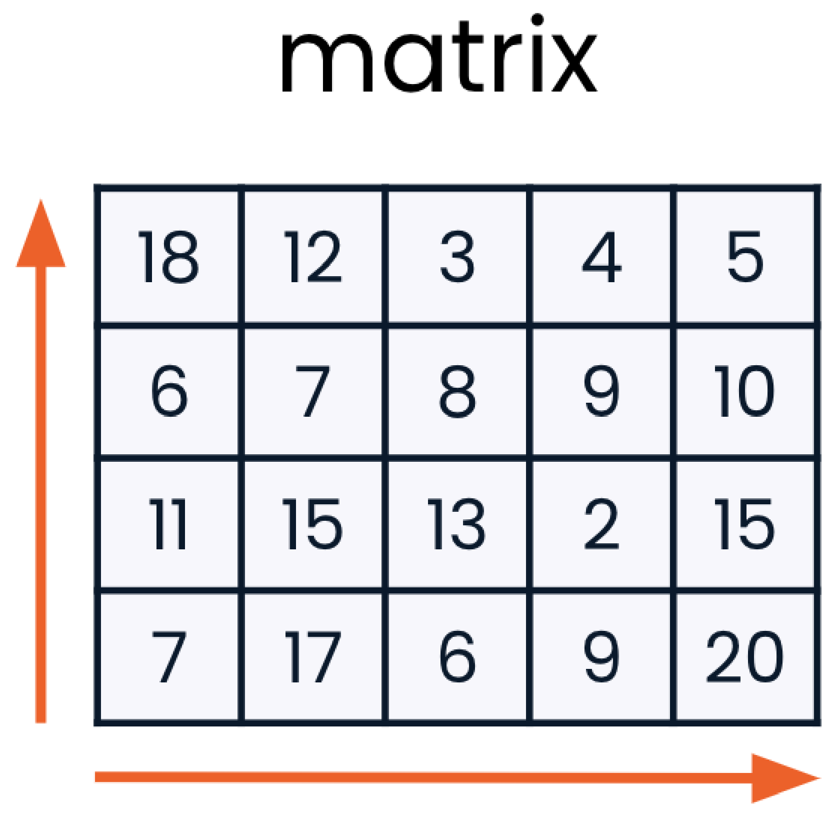


Vector arrays

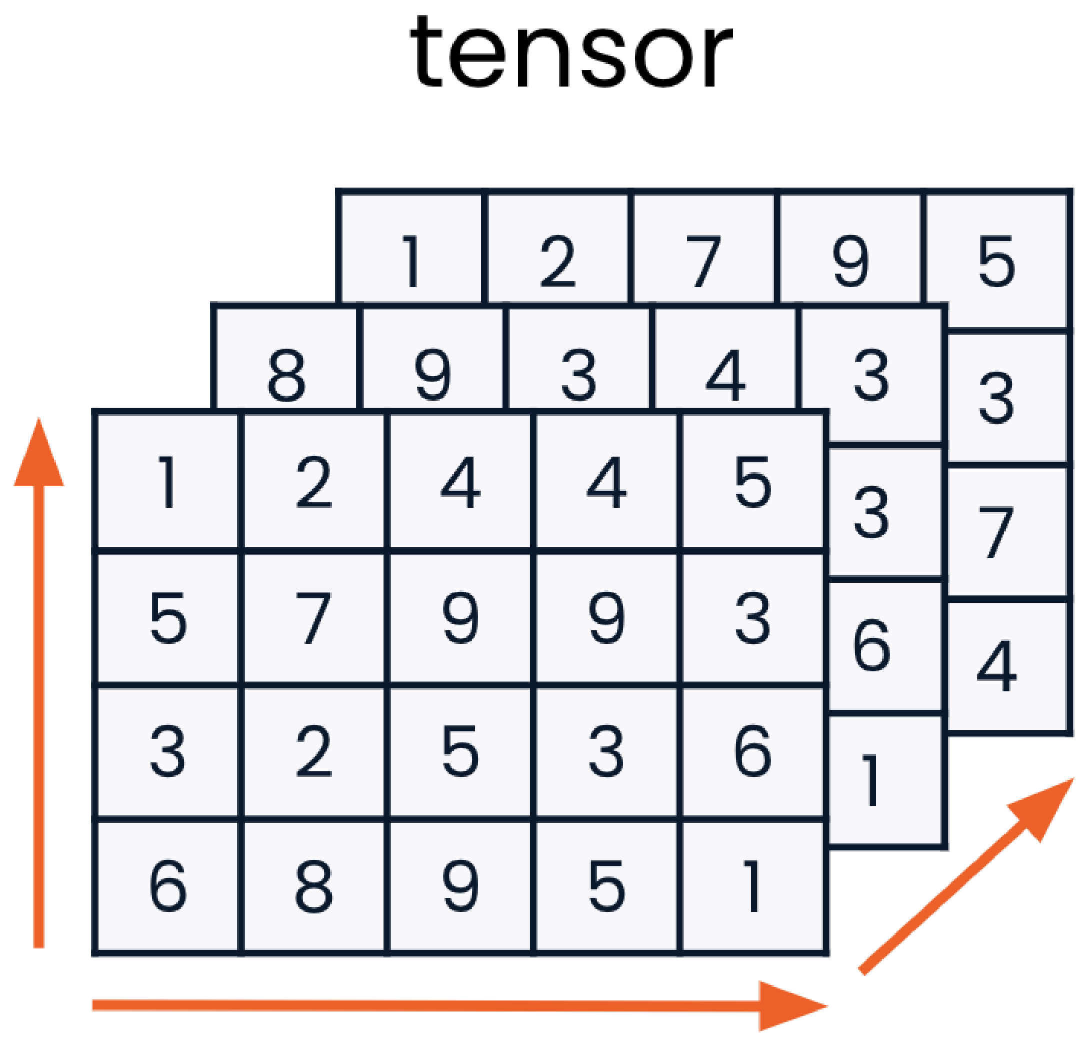


Matrix and tensor arrays

- A matrix has two dimensions



- A tensor has three or more dimensions



Shapeshifting

Array attribute:

- `.shape`

Array methods:

- `.flatten()`
- `.reshape()`

Finding an array's shape

```
array = np.zeros((3, 5))
print(array)
```

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

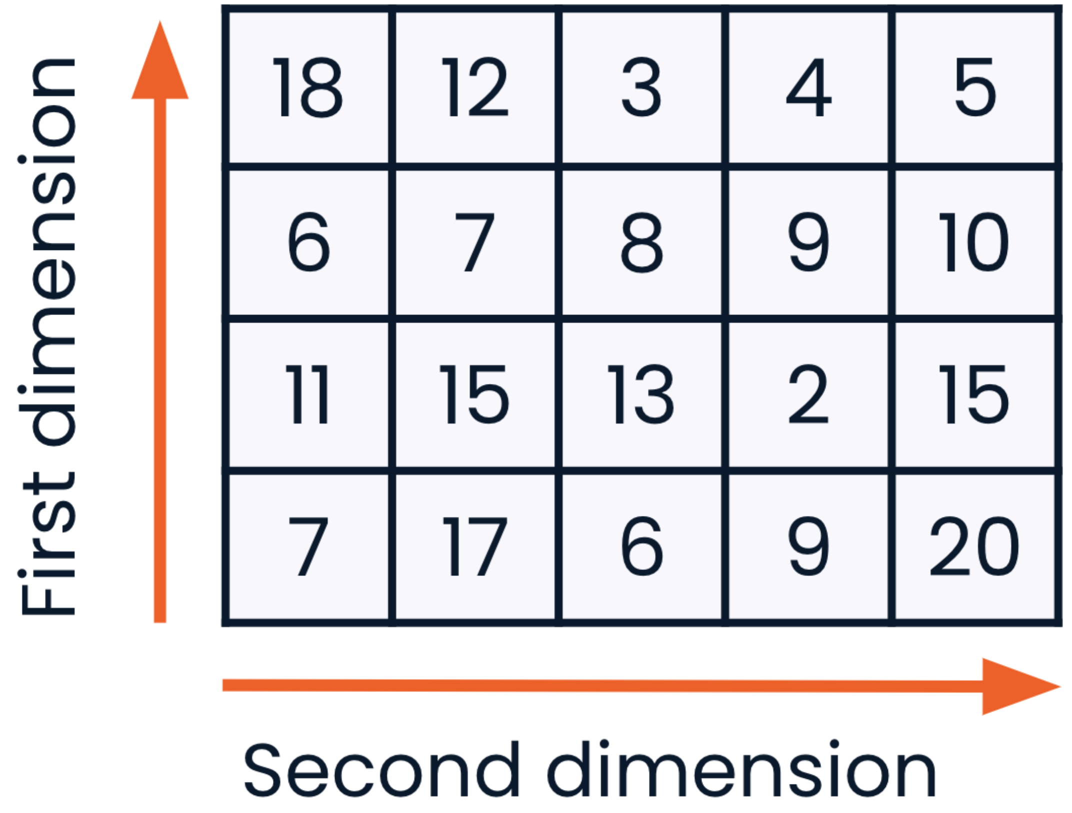
```
array.shape
```

```
(3, 5)
```

Rows and columns

In 2D arrays...

- Rows are the first dimension
- Columns are the second dimension



18	12	3	4	5
6	7	8	9	10
11	15	13	2	15
7	17	6	9	20

Flattening an array

```
array = np.array([[1, 2], [5, 7], [6, 6]])
array.flatten()
```

```
array([1, 2, 5, 7, 6, 6])
```

Reshaping an array

```python
array = np.array([[1, 2], [5, 7], [6, 6]])
array.reshape((2, 3))
```

```
array([[1, 2, 5],
       [7, 6, 6]])
```

```python
array.reshape((3, 3))
```

```
ValueError: cannot reshape array of size 6 into shape (3,3)
```

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NumPy data types

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NumPy vs. Python data types

Sample Python data types:

- `int`
- `float`

Sample NumPy data types:

- `np.int64`
- `np.int32`
- `np.float64`
- `np.float32`

Bits and bytes

The number 10436 represented in binary is:

$$\underbrace{00101000}_{\text{8 bits = 1 byte}}\underbrace{11000100}_{\text{8 bits = 1 byte}}$$

`np.int32` can store 4,294,967,296 integers:

$$\overleftrightarrow{\qquad 2^{32} = 4{,}294{,}967{,}296 \qquad}$$

Bits and bytes

The number 10436 represented in binary is:

$$\underbrace{00101000}_{8 \text{ bits} = 1 \text{ byte}}\underbrace{11000100}_{8 \text{ bits} = 1 \text{ byte}}$$

`np.int32` can store 4,294,967,296 integers:

$$-2{,}147{,}483{,}648 \longleftrightarrow 2{,}147{,}483{,}647$$

$$2^{32} = 4{,}294{,}967{,}296$$

The .dtype attribute

```
np.array([1.32, 5.78, 175.55]).dtype
```

```
dtype('float64')
```

Default data types

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

```
dtype('int64')
```

String data

```python
np.array(["Introduction", "to", "NumPy"]).dtype
```

```
dtype('<U12')
```

dtype as an argument

```python
float32_array = np.array([1.32, 5.78, 175.55], dtype=np.float32)
float32_array.dtype
```

```
dtype('float32')
```

Type conversion

```python
boolean_array = np.array([[True, False], [False, False]], dtype=np.bool_)
boolean_array.astype(np.int32)
```

```
array([[1, 0],
       [0, 0]], dtype=int32)
```

Type coercion

```python
np.array([True, "Boop", 42, 42.42])
```

```
array(['True', 'Boop', '42', '42.42'], dtype='<U5')
```

Type coercion hierarchy

Adding a float to an array of integers will change all integers into floats:

```
np.array([0, 42, 42.42]).dtype
```

```
dtype('float64')
```

Adding an integer to an array of booleans will change all booleans in to integers:

```
np.array([True, False, 42]).dtype
```

```
dtype('int64')
```

Let's practice!

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