

# Indexing and slicing arrays

INTRODUCTION TO NUMPY



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# Indexing 1D arrays

```
array = np.array([2, 4, 6, 8, 10])  
array[3]
```

8

# Indexing elements in 2D

0	0	4	3	0	0	2	0	9
0	0	5	0	0	9	0	0	1
0	7	0	0	6	0	0	4	3
0	0	6	0	0	2	0	8	7
1	9	0	0	0	7	4	0	0
0	5	0	0	8	3	0	0	0
6	0	0	0	0	0	1	0	5
0	0	3	5	0	8	6	9	0
0	4	2	9	1	0	3	0	0

```
sudoku_game[2, 4]
```

```
6
```

# Indexing rows in 2D

0	0	4	3	0	0	2	0	9
0	0	5	0	0	9	0	0	1
0	7	0	0	6	0	0	4	3
0	0	6	0	0	2	0	8	7
1	9	0	0	0	7	4	0	0
0	5	0	0	8	3	0	0	0
6	0	0	0	0	0	1	0	5
0	0	3	5	0	8	6	9	0
0	4	2	9	1	0	3	0	0

```
sudoku_game[0]
```

```
array([0, 0, 4, 3, 0, 0, 2, 0, 9])
```

# Indexing columns in 2D

0	0	4	3	0	0	2	0	9
0	0	5	0	0	9	0	0	1
0	7	0	0	6	0	0	4	3
0	0	6	0	0	2	0	8	7
1	9	0	0	0	7	4	0	0
0	5	0	0	8	3	0	0	0
6	0	0	0	0	0	1	0	5
0	0	3	5	0	8	6	9	0
0	4	2	9	1	0	3	0	0

```
sudoku_game[:, 3]
```

```
array([3, 0, 0, 0, 0, 0, 0, 5, 9])
```

# Slicing 1D arrays

```
array = np.array([2, 4, 6, 8, 10])  
array[2:4]
```

```
array([6, 8])
```

# Slicing 2D arrays

0	0	4	3	0	0	2	0	9
0	0	5	0	0	9	0	0	1
0	7	0	0	6	0	0	4	3
0	0	6	0	0	2	0	8	7
1	9	0	0	0	7	4	0	0
0	5	0	0	8	3	0	0	0
6	0	0	0	0	0	1	0	5
0	0	3	5	0	8	6	9	0
0	4	2	9	1	0	3	0	0

```
sudoku_game[3:6, 3:6]
```

```
array([[0, 0, 2],  
       [0, 0, 7],  
       [0, 8, 3]])
```

# Slicing with steps

0	0	4	3	0	0	2	0	9
0	0	5	0	0	9	0	0	1
0	7	0	0	6	0	0	4	3
0	0	6	0	0	2	0	8	7
1	9	0	0	0	7	4	0	0
0	5	0	0	8	3	0	0	0
6	0	0	0	0	0	1	0	5
0	0	3	5	0	8	6	9	0
0	4	2	9	1	0	3	0	0

```
sudoku_game[3:6:2, 3:6:2]
```

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



# Sorting arrays

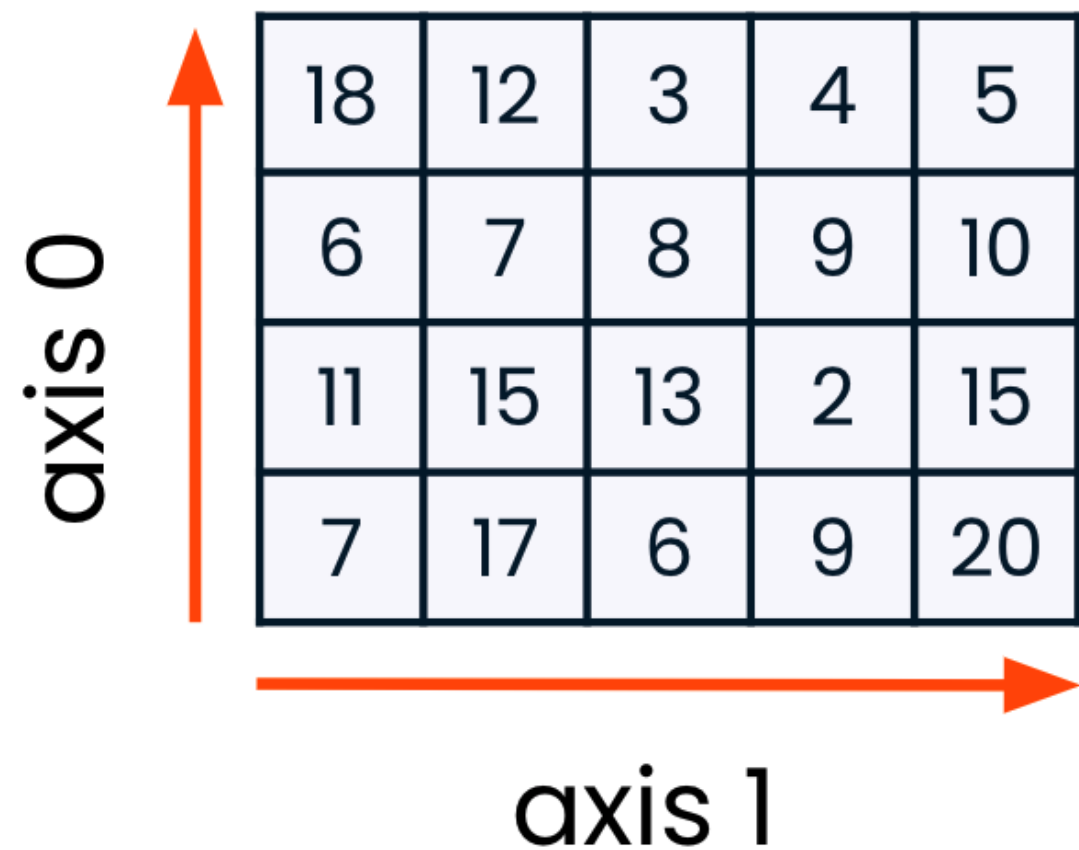
Before sorting:

0	0	4	3	0	0	2	0	9
0	0	5	0	0	9	0	0	1
0	7	0	0	6	0	0	4	3
0	0	6	0	0	2	0	8	7
1	9	0	0	0	7	4	0	0
0	5	0	0	8	3	0	0	0
6	0	0	0	0	0	1	0	5
0	0	3	5	0	8	6	9	0
0	4	2	9	1	0	3	0	0

```
np.sort(sudoku_game)
```

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

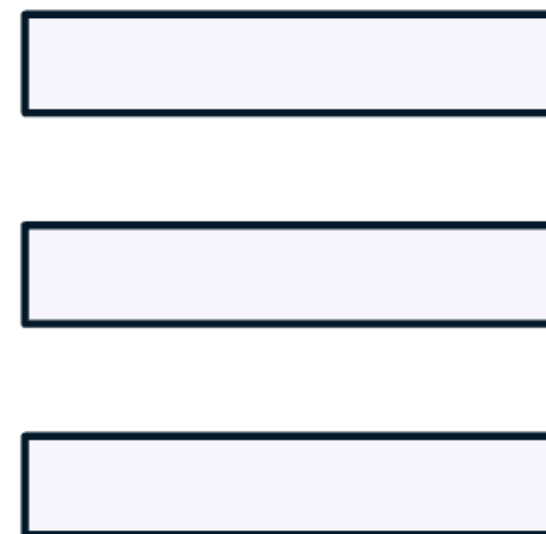
# Axis order



A 4x5 grid of numbers. To the left of the grid is a vertical orange arrow pointing upwards, labeled 'axis 0'. Below the grid is a horizontal orange arrow pointing to the right, labeled 'axis 1'.

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

axis 0



axis 1



# Sorting by axis

```
np.sort(sudoku_game)
```

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

```
np.sort(sudoku_game, axis=0)
```

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

# Let's practice!

INTRODUCTION TO NUMPY

# Filtering arrays

INTRODUCTION TO NUMPY



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# Two ways to filter

1. Masks and fancy indexing
2. `np.where()`

# Boolean masks

```
one_to_five = np.arange(1, 6)  
one_to_five
```

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

```
mask = one_to_five % 2 == 0  
mask
```

```
array([False,  True, False,  True, False])
```

# Filtering with fancy indexing

```
one_to_five = np.arange(1, 6)
mask = one_to_five % 2 == 0
one_to_five[mask]
```

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



# 2D fancy indexing

```
classroom_ids_and_sizes = np.array([[1, 22], [2, 21], [3, 27], [4, 26]])  
classroom_ids_and_sizes
```

```
array([[ 1, 22],  
       [ 2, 21],  
       [ 3, 27],  
       [ 4, 26]])
```

```
classroom_ids_and_sizes[:, 1] % 2 == 0
```

# 2D fancy indexing

```
classroom_ids_and_sizes = np.array([[1, 22], [2, 21], [3, 27], [4, 26]])  
classroom_ids_and_sizes
```

```
array([[ 1, 22],  
       [ 2, 21],  
       [ 3, 27],  
       [ 4, 26]])
```

```
classroom_ids_and_sizes[:, 0][classroom_ids_and_sizes[:, 1] % 2 == 0]
```

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

# Fancy indexing vs. `np.where()`

## Fancy indexing

- Returns array of elements

## `np.where()`

- Returns array of indices
- Can create an array based on whether elements do or don't meet condition

# Filtering with np.where()

```
classroom_ids_and_sizes
```

```
array([[ 1, 22],  
       [ 2, 21],  
       [ 3, 27],  
       [ 4, 26]])
```

```
np.where(classroom_ids_and_sizes[:, 1] % 2 == 0)
```

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

# np.where() element retrieval

sudoku\_game

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

# A tuple of indices

```
row_ind, column_ind = np.where(sudoku_game == 0)
row_ind, column_ind
```

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

# Find and replace

```
np.where(sudoku_game == 0, "", sudoku_game)
```

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

# Let's practice!

INTRODUCTION TO NUMPY



# Adding and removing data

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# Concatenating in NumPy

18	12	3	7	1
6	7	8	23	18
11	15	13	4	11

# Concatenating rows

```
classroom_ids_and_sizes = np.array([[1, 22], [2, 21], [3, 27], [4, 26]])  
new_classrooms = np.array([[5, 30], [5, 17]])  
np.concatenate((classroom_ids_and_sizes, new_classrooms))
```

```
array([[ 1, 22],  
       [ 2, 21],  
       [ 3, 27],  
       [ 4, 26],  
       [ 5, 30],  
       [ 5, 17]])
```

- `np.concatenate()` concatenates along the first axis by default.

# Concatenating columns

```
classroom_ids_and_sizes = np.array([[1, 22], [2, 21], [3, 27], [4, 26]])  
grade_levels_and_teachers = np.array([[1, "James"], [1, "George"], [3, "Amy"],  
                                       [3, "Meehir"]])  
  
np.concatenate((classroom_ids_and_sizes, grade_levels_and_teachers), axis=1)
```

```
array([[ '1', '22', '1', 'James'],  
       [ '2', '21', '1', 'George'],  
       [ '3', '27', '3', 'Amy'],  
       [ '4', '26', '3', 'Meehir']])
```

# Shape compatibility

18	12	3		7	1
6	7	8	+	23	18
11	15	13		4	11
			=	14	7

**ValueError:** all the input array dimensions for the concatenation axis must match exactly

18	12	3		7	1	
6	7	8	+	23	18	=
11	15	13		4	11	
18	12	3		7	1	
6	7	8		23	18	
11	15	13		4	11	

# Dimension compatibility

18	12	3
6	7	8
11	15	13

shape (3, 3)

+

7
23
4

shape (3, )

=

**ValueError:** all the input arrays must have same number of dimensions

←

18	12	3
6	7	8
11	15	13

shape (3, 3)

+

7
23
4

shape (3, 1)

=

18	12	3	7
6	7	8	23
11	15	13	4

←

# Creating compatibility

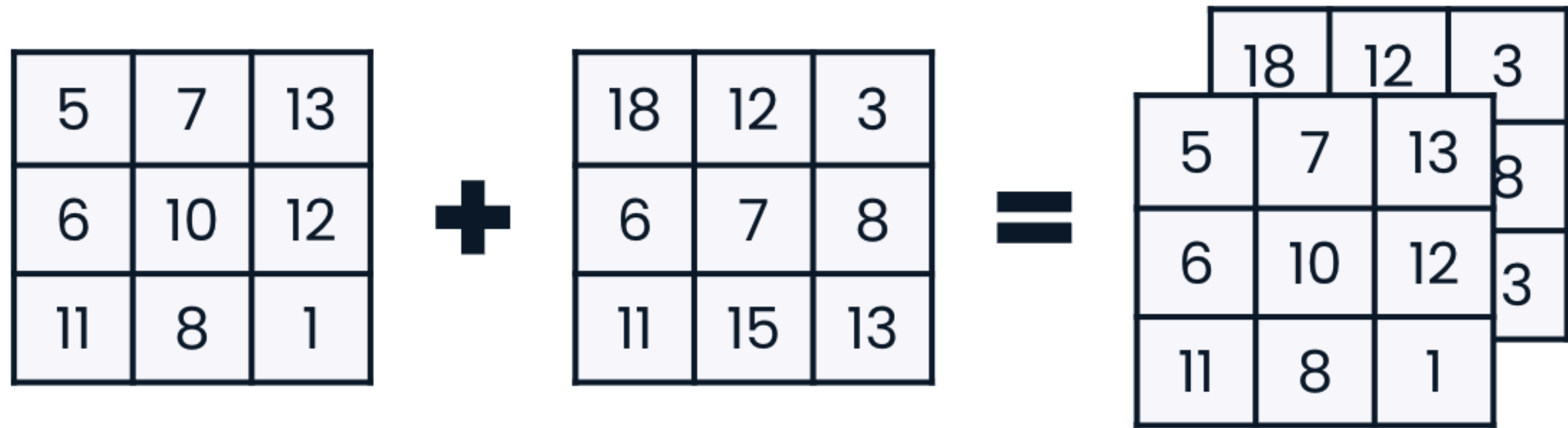
```
array_1D = np.array([1, 2, 3])  
column_array_2D = array_1D.reshape((3, 1))  
column_array_2D
```

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

```
row_array_2D = array_1D.reshape((1, 3))  
row_array_2D
```

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

# Concatenating new dimensions



- ✓ While this can be done...
- ✗ Not with concatenate!



# Deleting with np.delete()

```
classroom_data
```

```
array([[ '1', '22', '1', 'James'],  
      [ '2', '21', '1', 'George'],  
      [ '3', '27', '3', 'Amy'],  
      [ '4', '26', '3', 'Meehir']])
```

```
np.delete(classroom_data, 1, axis=0)
```

```
array([[ '1', '22', '1', 'James'],  
      [ '3', '27', '3', 'Amy'],  
      [ '4', '26', '3', 'Meehir']])
```

# Deleting columns

```
np.delete(classroom_data, 1, axis=1)
```

```
array([[ '1', '1', 'James'],  
      [ '2', '1', 'George'],  
      [ '3', '3', 'Amy'],  
      [ '4', '3', 'Meehir']])
```

# Deleting without an axis

```
classroom_data
```

```
array([[ '1', '22', '1', 'James'],  
       [ '2', '21', '1', 'George'],  
       [ '3', '27', '3', 'Amy'],  
       [ '4', '26', '3', 'Meehir']],)
```

```
np.delete(classroom_data, 1)
```

```
array([ '1', '1', 'James', '2', '21', '1', 'George', '3', '27', '3', 'Amy',  
       '4', '26', '3', 'Meehir'])
```

# Let's practice!

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