# Hello Python!

INTRODUCTION TO PYTHON

**Hugo Bowne-Anderson**
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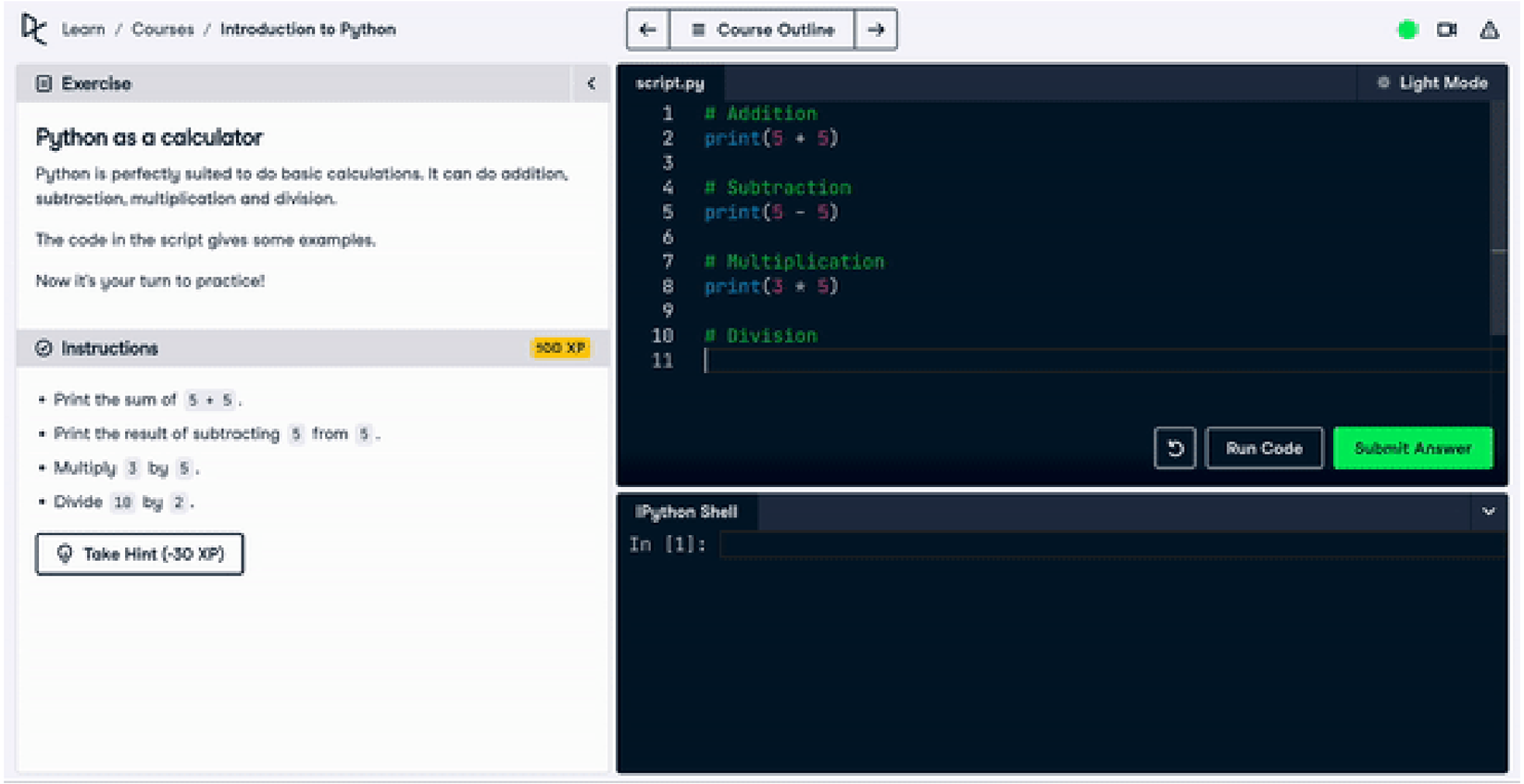
# How you will learn

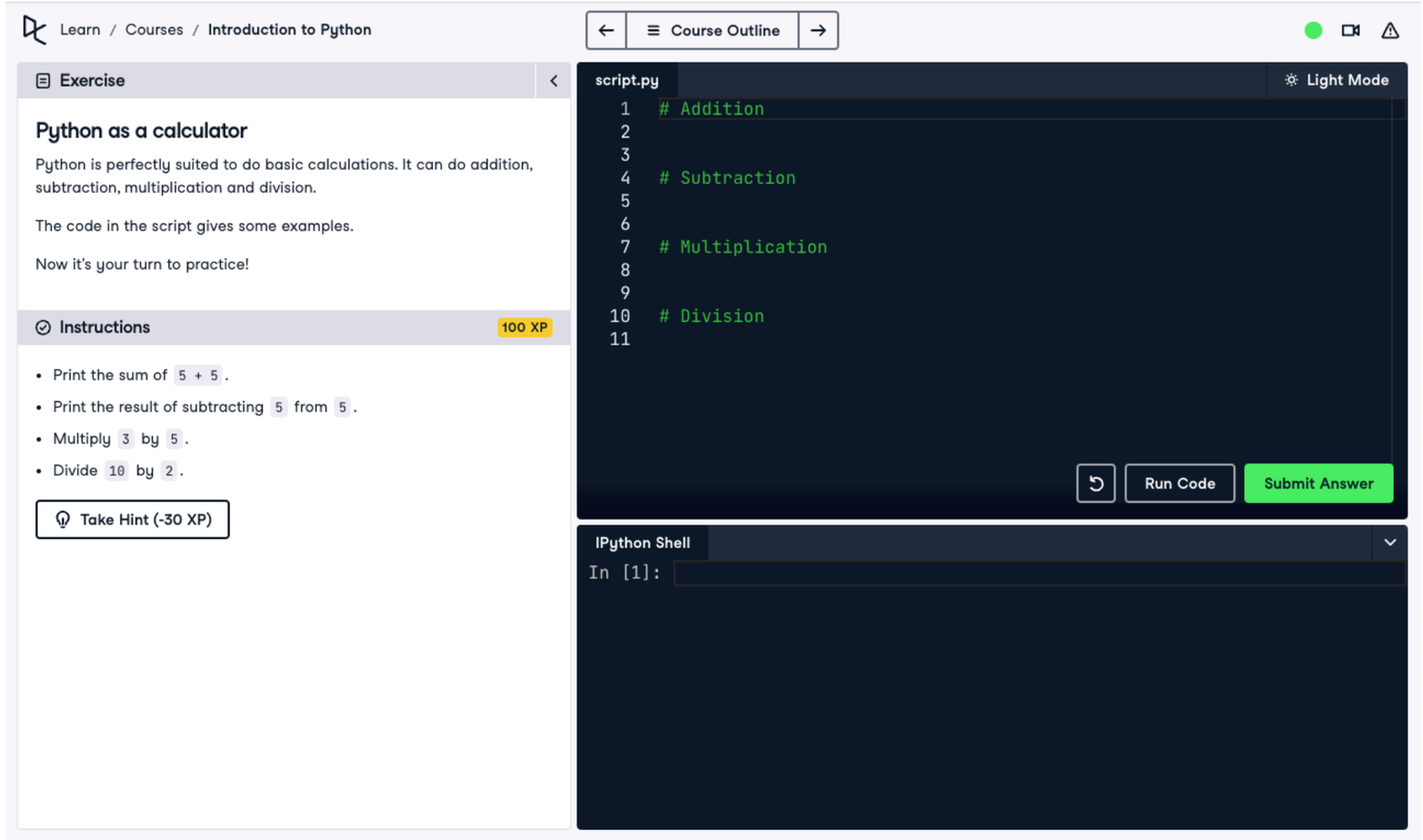


# Python

- General purpose: build anything
- Open source! Free!
- Python packages, also for data science
  - Many applications and fields
- Version 3.x - https://www.python.org/downloads/

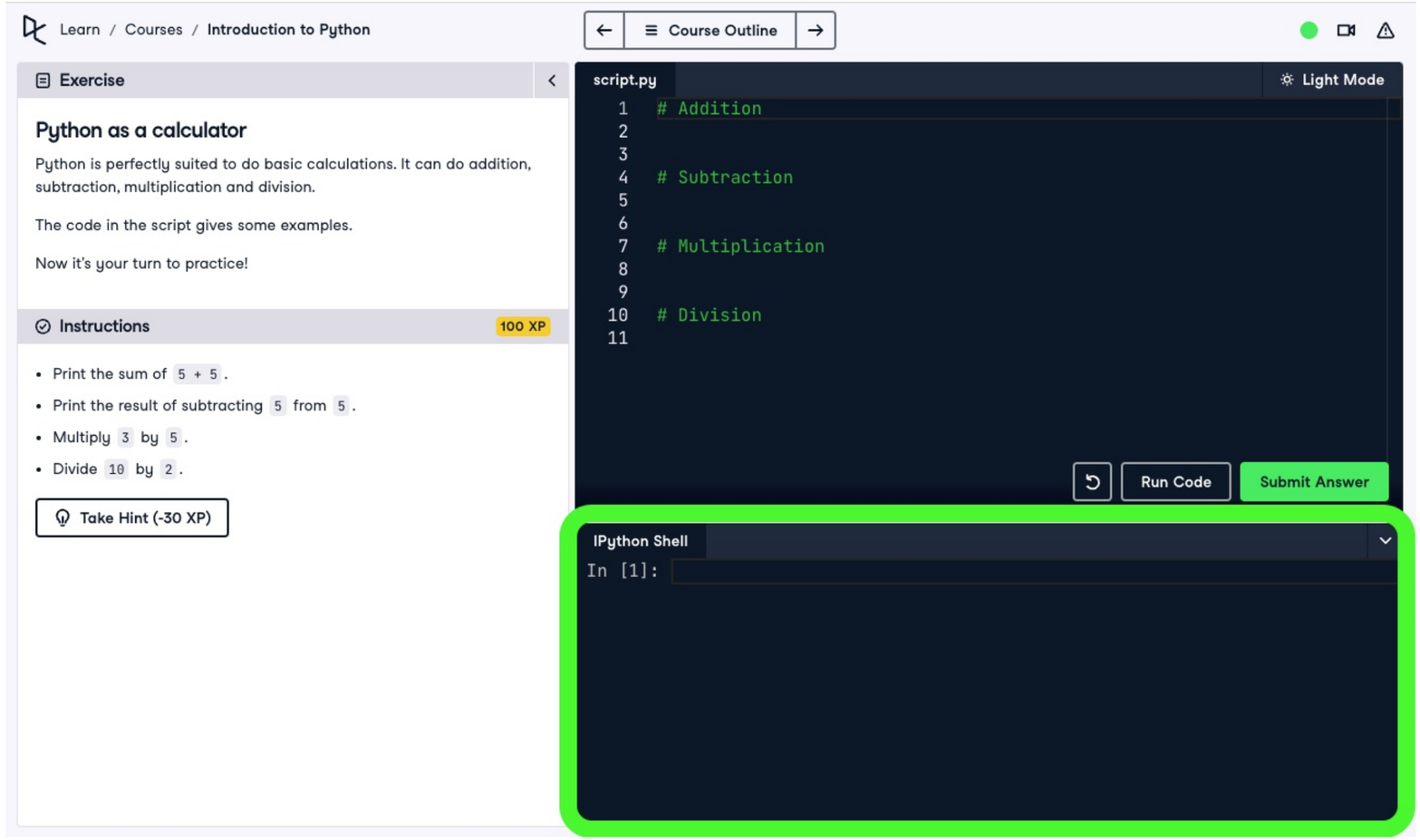
# IPython Shell

## Execute Python commands

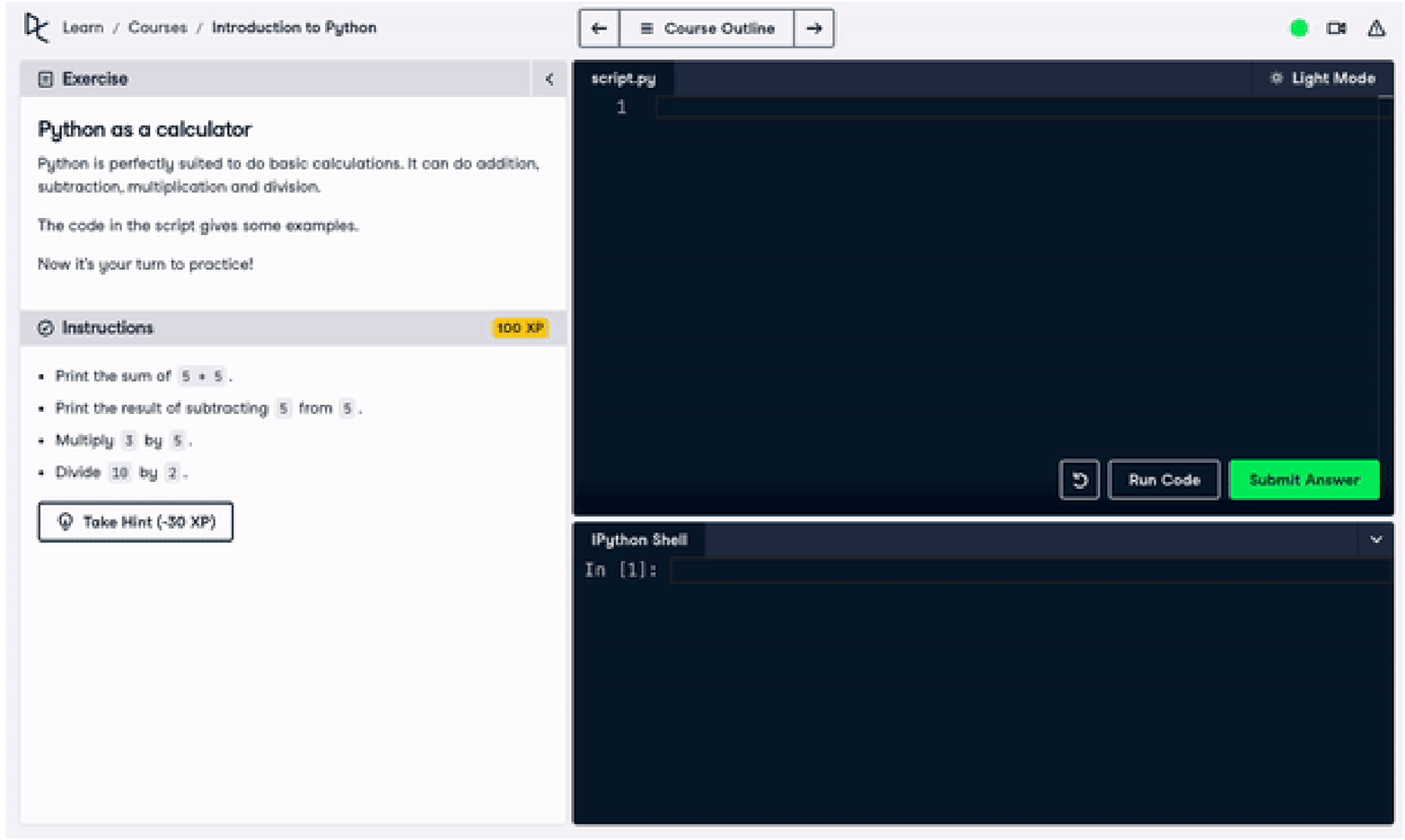


# IPython Shell

## Execute Python commands

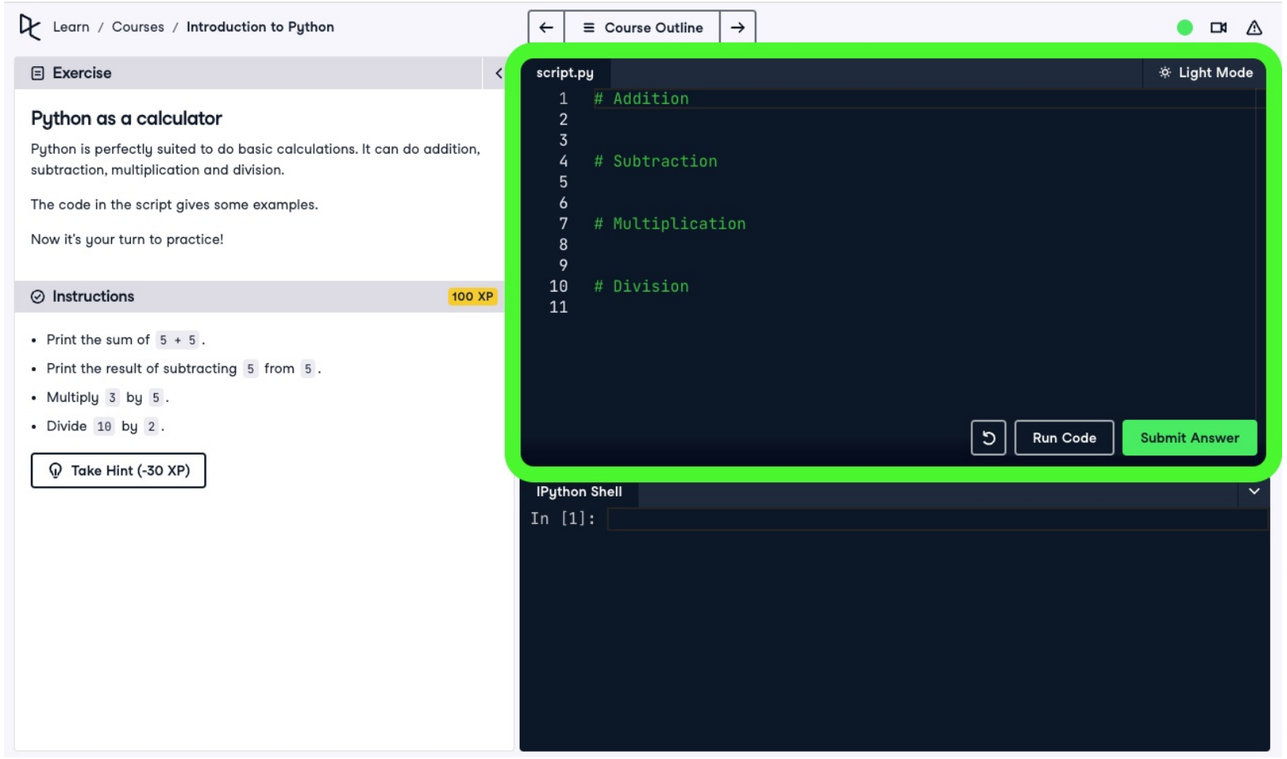


# IPython Shell

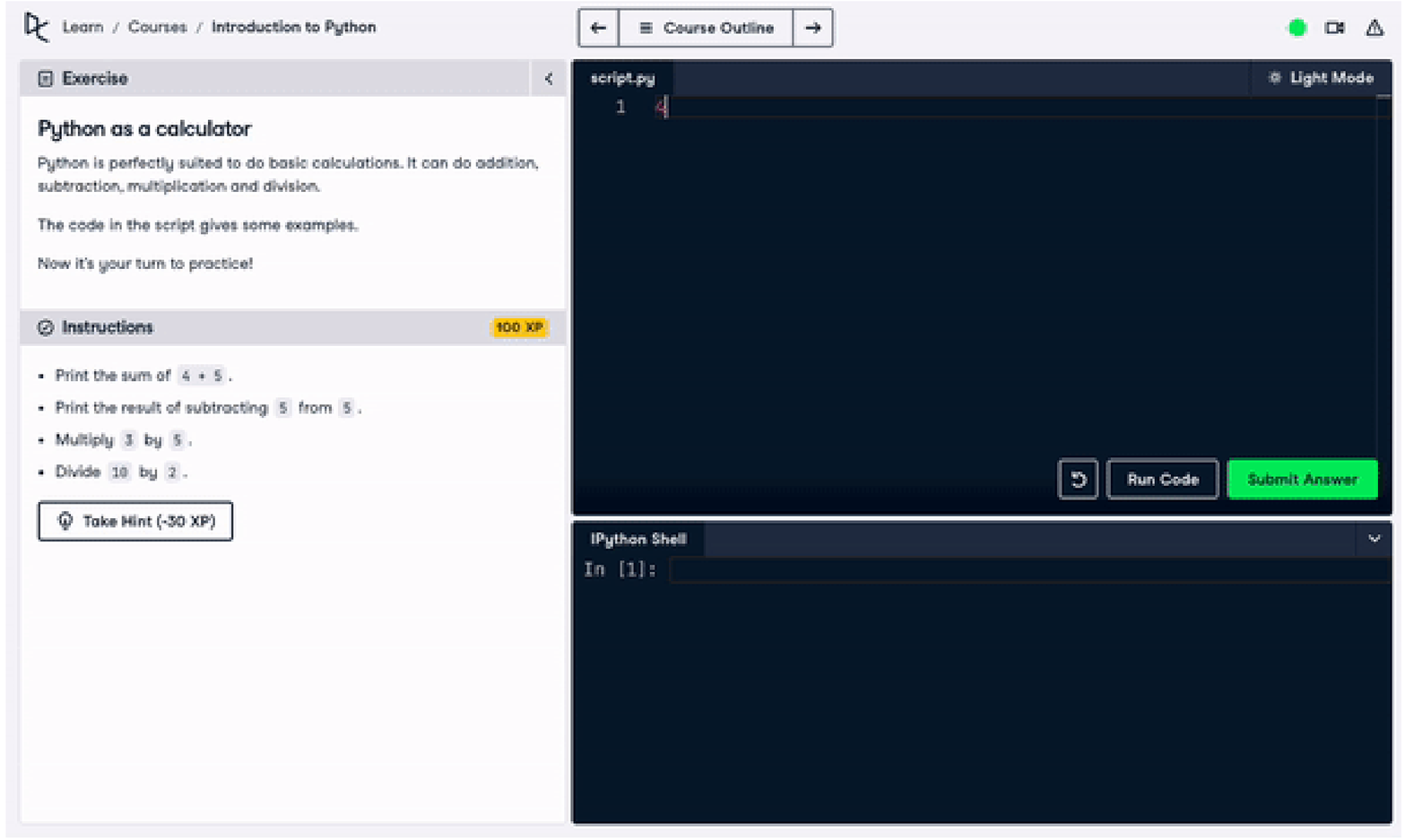


# Python Script

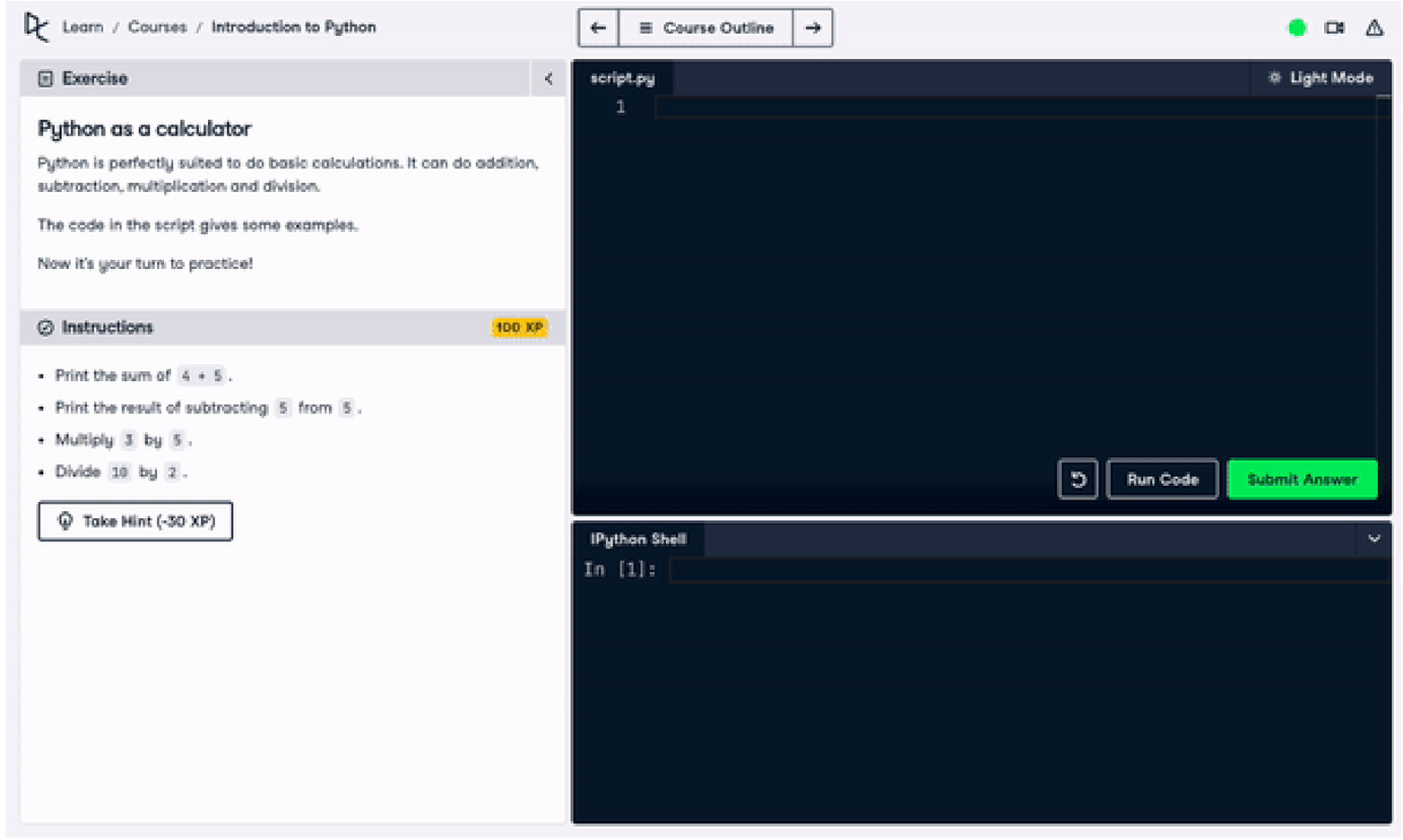
- Text files - `.py`
- List of Python commands
- Similar to typing in IPython Shell



# Python Script

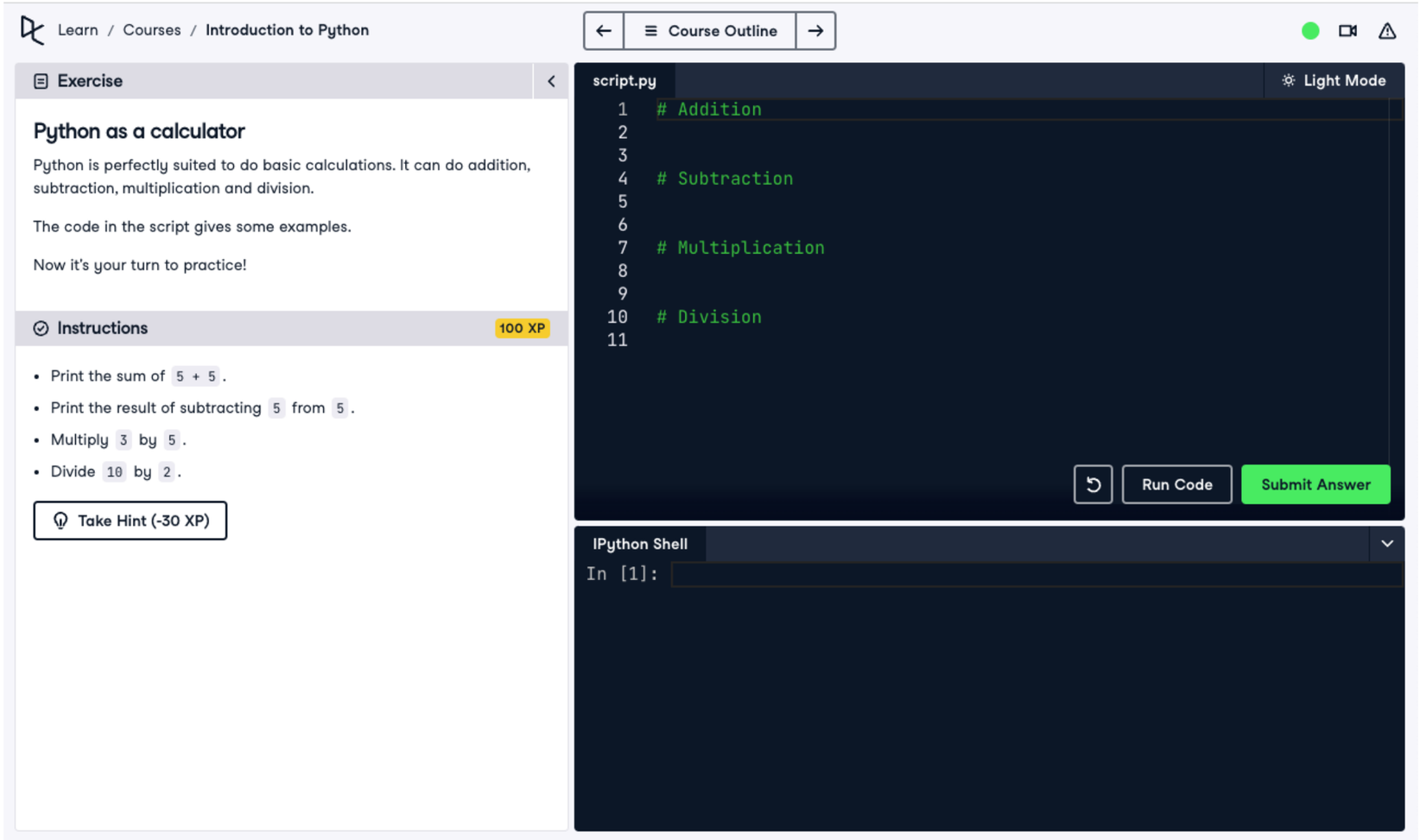


# Python Script




- Use `print()` to generate output from script

# DataCamp Interface



# Let's practice!

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# Variables and Types

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# Variable

- Specific, case-sensitive name
- Call up value through variable name
- 1.79 m - 68.7 kg

```
height = 1.79
weight = 68.7
height
```

```
1.79
```

# Calculate BMI

```
height = 1.79
weight = 68.7
height
```

```
1.79
```

$$\text{BMI} = \frac{\text{weight}}{\text{height}^2}$$

```
68.7 / 1.79 ** 2
```

```
21.4413
```

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

```
21.4413
```

```
bmi = weight / height ** 2
bmi
```

```
21.4413
```

# Reproducibility

```
height = 1.79
weight = 68.7
bmi = weight / height ** 2
print(bmi)
```

```
21.4413
```

# Reproducibility

```
height = 1.79
weight = 74.2 # <-
bmi = weight / height ** 2
print(bmi)
```

```
23.1578
```

# Python Types

```
type(bmi)
```

```
float
```

```
day_of_week = 5
type(day_of_week)
```

```
int
```

# Python Types (2)

```
x = "body mass index"
y = 'this works too'
type(y)
```

```
str
```

```
z = True
type(z)
```

```
bool
```

# Python Types (3)

```
2 + 3
```

```
5
```

```
'ab' + 'cd'
```

```
'abcd'
```

- Different type = different behavior!

# Let's practice!

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# Python Lists

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# Python Data Types

- float - real numbers
- int - integer numbers
- str - string, text
- bool - True, False

```
height = 1.73
tall = True
```

- Each variable represents single value

# Problem

- Data Science: many data points
- Height of entire family

```
height1 = 1.73
height2 = 1.68
height3 = 1.71
height4 = 1.89
```

- Inconvenient

# Python List

- `[a, b, c]`

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

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

```
fam = [1.73, 1.68, 1.71, 1.89]
fam
```

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

- Name a collection of values
- Contain any type
- Contain different types

# Python List

- `[a, b, c]`

```
fam = ["liz", 1.73, "emma", 1.68, "mom", 1.71, "dad", 1.89]
fam
```

```
['liz', 1.73, 'emma', 1.68, 'mom', 1.71, 'dad', 1.89]
```

```
fam2 = [["liz", 1.73],
        ["emma", 1.68],
        ["mom", 1.71],
        ["dad", 1.89]]
fam2
```

```
[['liz', 1.73], ['emma', 1.68], ['mom', 1.71], ['dad', 1.89]]
```

# List type

```
type(fam)
```

```
list
```

```
type(fam2)
```

```
list
```

- Specific functionality
- Specific behavior

# Let's practice!

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# Subsetting Lists

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# Subsetting lists

```
fam = ["liz", 1.73, "emma", 1.68, "mom", 1.71, "dad", 1.89]
fam
```

```
['liz', 1.73, 'emma', 1.68, 'mom', 1.71, 'dad', 1.89]
```

```
fam[3]
```

```
1.68
```

# Subsetting lists

```
['liz', 1.73, 'emma', 1.68, 'mom', 1.71, 'dad', 1.89]
```

```
fam[6]
```

```
'dad'
```

```
fam[-1]
```

```
1.89
```

```
fam[7]
```

```
1.89
```

# Subsetting lists

```
['liz', 1.73, 'emma', 1.68, 'mom', 1.71, 'dad', 1.89]
```

```
fam[6]
```

```
'dad'
```

```
fam[-1]  # <-
```

```
1.89
```

```
fam[7] # <-
```

```
1.89
```

# List slicing

```
fam
```

```
['liz', 1.73, 'emma', 1.68, 'mom', 1.71, 'dad', 1.89]
```

```
fam[3:5]
```

```
[1.68, 'mom']
```

```
fam[1:4]
```

```
[1.73, 'emma', 1.68]
```

```
[ start : end ]
```

inclusive exclusive

# List slicing

```
fam
```

```
['liz', 1.73, 'emma', 1.68, 'mom', 1.71, 'dad', 1.89]
```

```
fam[:4]
```

```
['liz', 1.73, 'emma', 1.68]
```

```
fam[5:]
```

```
[1.71, 'dad', 1.89]
```

# Let's practice!

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# Manipulating Lists

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# List Manipulation

- Change list elements
- Add list elements
- Remove list elements

# Changing list elements

```
fam = ["liz", 1.73, "emma", 1.68, "mom", 1.71, "dad", 1.89]
fam
```

```
['liz', 1.73, 'emma', 1.68, 'mom', 1.71, 'dad', 1.89]
```

```
fam[7] = 1.86
fam
```

```
['liz', 1.73, 'emma', 1.68, 'mom', 1.71, 'dad', 1.86]
```

```
fam[0:2] = ["lisa", 1.74]
fam
```

```
['lisa', 1.74, 'emma', 1.68, 'mom', 1.71, 'dad', 1.86]
```

# Adding and removing elements

```
fam + ["me", 1.79]
```

```
['lisa', 1.74,'emma', 1.68, 'mom', 1.71, 'dad', 1.86, 'me', 1.79]
```

```
fam_ext = fam + ["me", 1.79]
del(fam[2])
fam
```

```
['lisa', 1.74, 1.68, 'mom', 1.71, 'dad', 1.86]
```

# Behind the scenes (1)

```
x = ["a", "b", "c"]
```

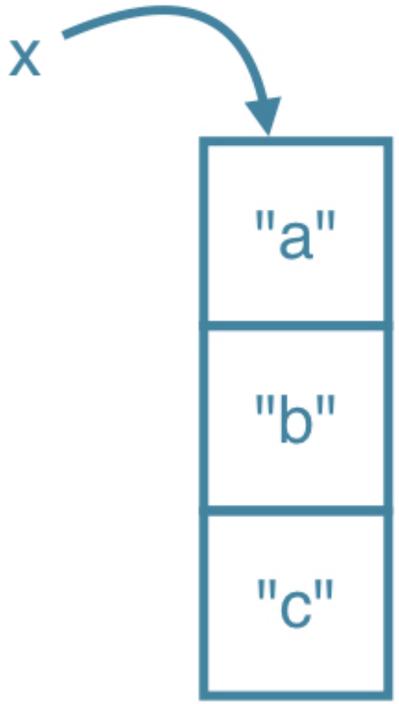
# Behind the scenes (1)

```
x = ["a", "b", "c"]
y = x
y[1] = "z"
y
```

```
['a', 'z', 'c']
```

```
x
```

```
['a', 'z', 'c']
```



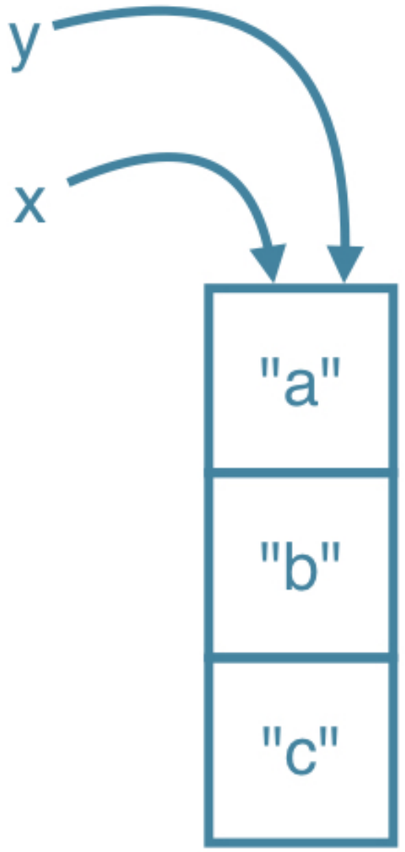
# Behind the scenes (1)

```
x = ["a", "b", "c"]
y = x
y[1] = "z"
y
```

```
['a', 'z', 'c']
```

```
x
```

```
['a', 'z', 'c']
```



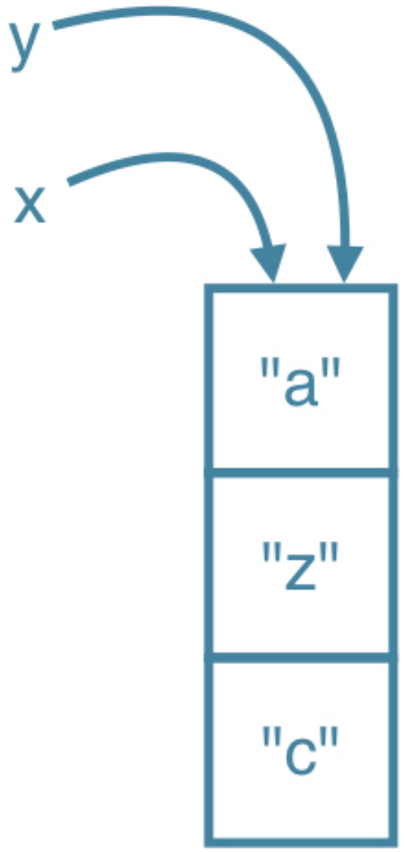
# Behind the scenes (1)

```
x = ["a", "b", "c"]
y = x
y[1] = "z"
y
```

```
['a', 'z', 'c']
```

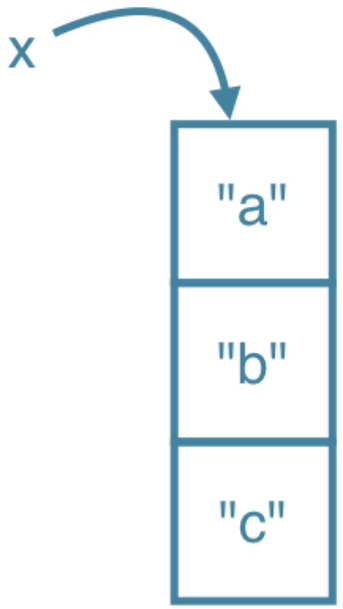
```
x
```

```
['a', 'z', 'c']
```



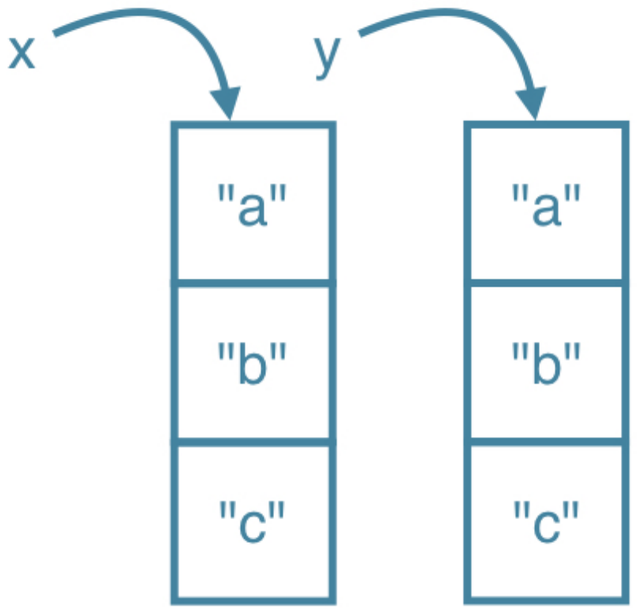
# Behind the scenes (2)

```
x = ["a", "b", "c"]
```



# Behind the scenes (2)

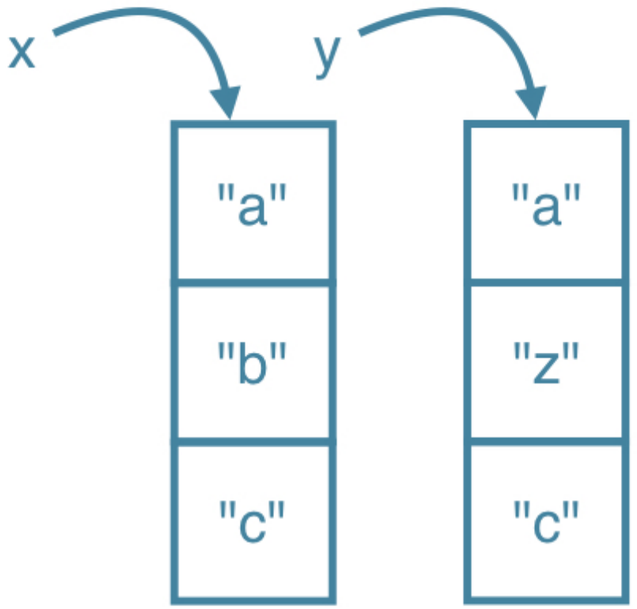
```
x = ["a", "b", "c"]
y = list(x)
y = x[:]
```



# Behind the scenes (2)

```
x = ["a", "b", "c"]
y = list(x)
y = x[:]
y[1] = "z"
x
```

```
['a', 'b', 'c']
```



# Let's practice!

INTRODUCTION TO PYTHON

# Functions

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# Functions

- Nothing new!
- `type()`
- Piece of reusable code
- Solves particular task
- Call function instead of writing code yourself

# Example

```
fam = [1.73, 1.68, 1.71, 1.89]
fam
```

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

```
max(fam)
```

```
1.89
```

# Example

```
fam = [1.73, 1.68, 1.71, 1.89]
fam
```

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

```
max(fam)
```

```
1.89
```

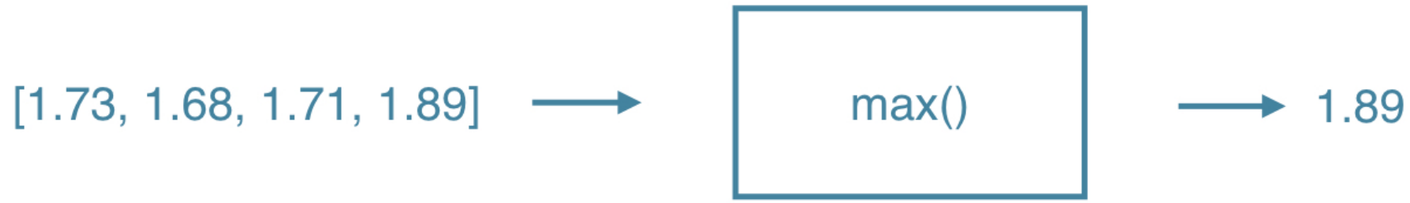
# Example

```
fam = [1.73, 1.68, 1.71, 1.89]
fam
```

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

```
max(fam)
```

```
1.89
```



# Example

```
fam = [1.73, 1.68, 1.71, 1.89]
fam
```

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

```
max(fam)
```

```
1.89
```

```
tallest = max(fam)
tallest
```

```
1.89
```

# round()

```
round(1.68, 1)
```

```
1.7
```

```
round(1.68)
```

```
2
```

```
help(round) # Open up documentation
```

```
Help on built-in function round in module builtins:

round(number, ndigits=None)
    Round a number to a given precision in decimal digits.

    The return value is an integer if ndigits is omitted or None.
    Otherwise the return value has the same type as the number. ndigits may be negative.
```

# round()

```
help(round)
```

```
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# round()

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    The return value is an integer if ndigits is omitted or None.
    Otherwise the return value has the same type as the number. ndigits may be negative.
```

round(1.68, 1)

# round()

```
help(round)
```

```
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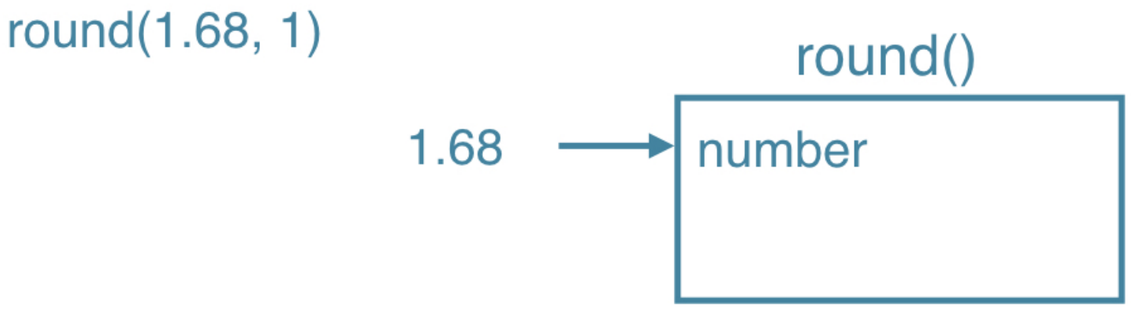
```



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```
help(round)
```

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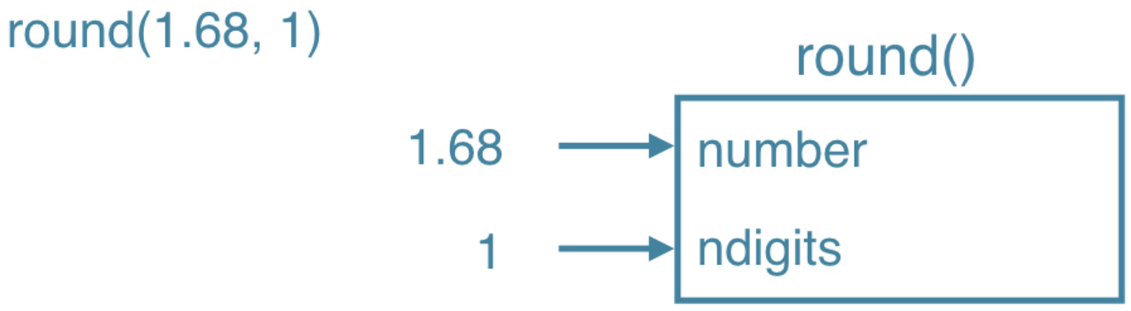

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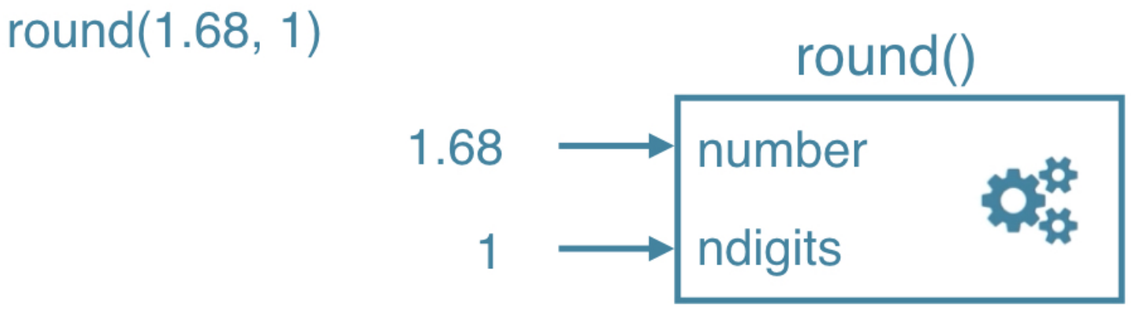

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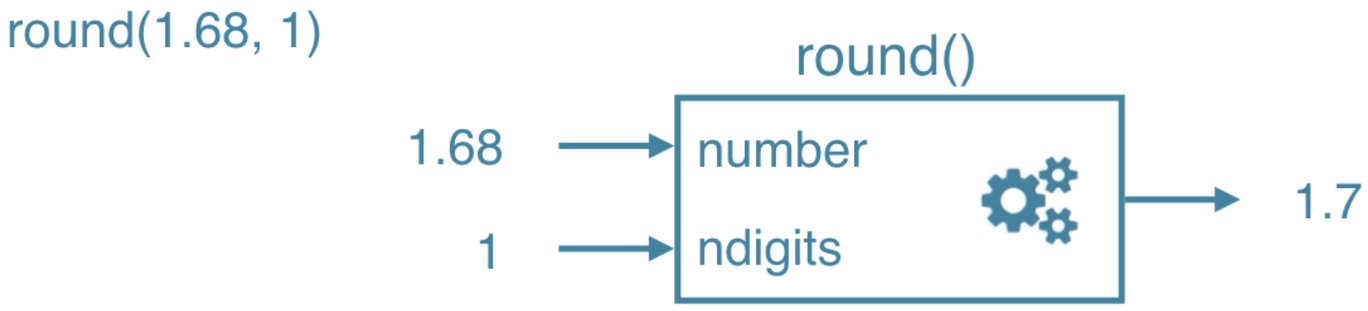

# round()

```
help(round)
```

```
Help on built-in function round in module builtins:

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    The return value is an integer if ndigits is omitted or None.
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```

# round()

```
help(round)
```

```
Help on built-in function round in module builtins:

round(number, ndigits=None)
    Round a number to a given precision in decimal digits.

    The return value is an integer if ndigits is omitted or None.
    Otherwise the return value has the same type as the number. ndigits may be negative.
```

round(1.68)

# round()

```
help(round)
```

```
Help on built-in function round in module builtins:

round(number, ndigits=None)
    Round a number to a given precision in decimal digits.

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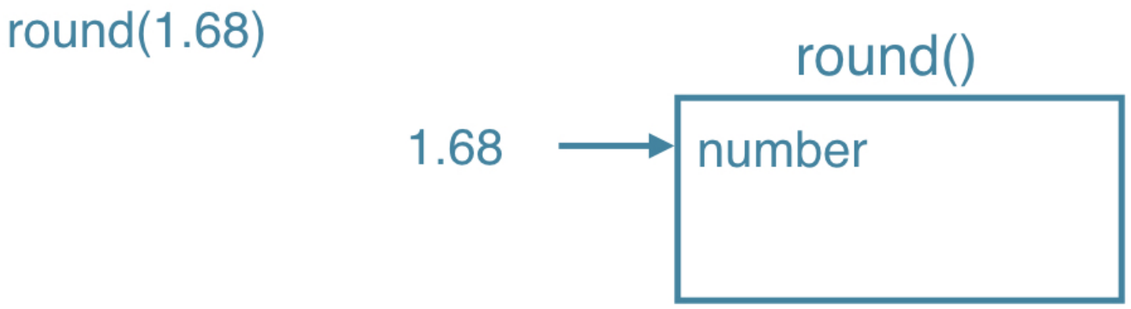
```



# round()

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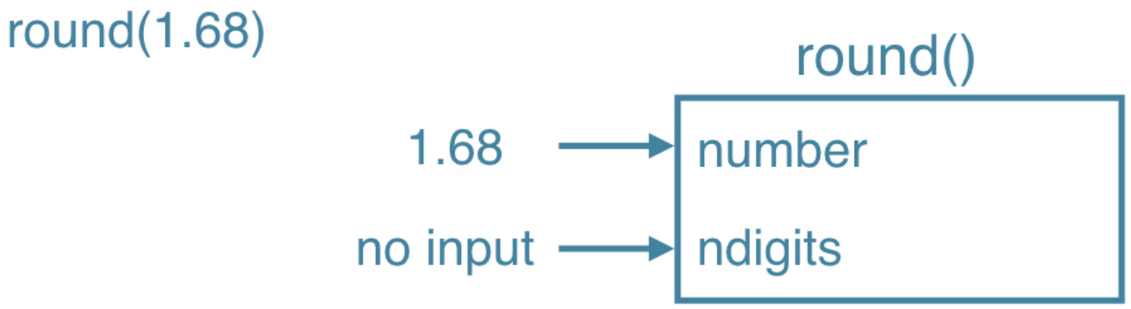

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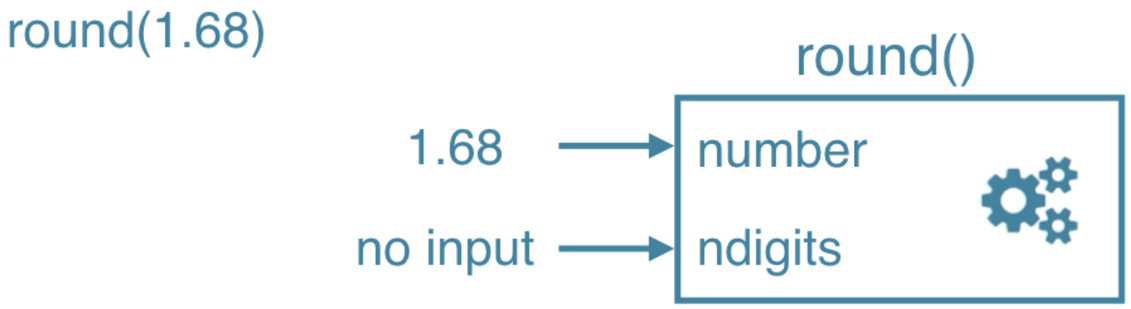
```



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```

```
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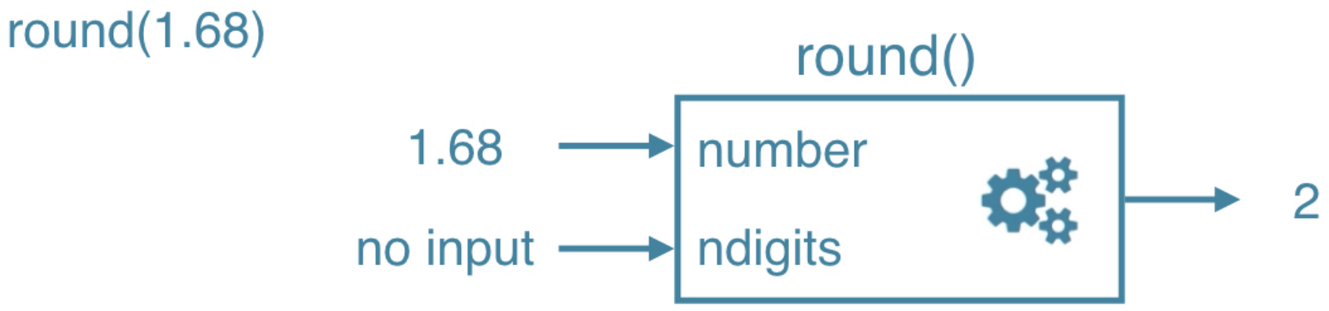
```



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```
help(round)
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```
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    The return value is an integer if ndigits is omitted or None.
    Otherwise the return value has the same type as the number. ndigits may be negative.
```

- `round(number)`
- `round(number, ndigits)`

# Find functions

- How to know?
- Standard task -> probably function exists!
- The internet is your friend

# Let's practice!

INTRODUCTION TO PYTHON

# Methods

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# Built-in Functions

- Maximum of list: max()
- Length of list or string: len()
- Get index in list: ?
- Reversing a list: ?

# Back 2 Basics

```
sister = "liz"
```

Object

```
height = 1.73
```

Object

```
fam = ["liz", 1.73, "emma", 1.68,
       "mom", 1.71, "dad", 1.89]
```

Object

# Back 2 Basics

```
sister = "liz"
```

```
height = 1.73
```

```
fam = ["liz", 1.73, "emma", 1.68,
       "mom", 1.71, "dad", 1.89]
```

| | type |
|---|---|
| Object | str |
| Object | float |
| Object | list |

- Methods: Functions that belong to objects

# Back 2 Basics

```
sister = "liz"
```

```
height = 1.73
```

```
fam = ["liz", 1.73, "emma", 1.68,
       "mom", 1.71, "dad", 1.89]
```

| | type | examples of methods |
|---|---|---|
| Object | str | capitalize()<br>replace() |
| Object | float | bit_length()<br>conjugate() |
| Object | list | index()<br>count() |

- Methods: Functions that belong to objects

# list methods

```
fam
```

```
['liz', 1.73, 'emma', 1.68, 'mom', 1.71, 'dad', 1.89]
```

```
fam.index("mom") # "Call method index() on fam"
```

```
4
```

```
fam.count(1.73)
```

```
1
```

# str methods

```
sister
```

```
'liz'
```

```
sister.capitalize()
```

```
'Liz'
```

```
sister.replace("z", "sa")
```

```
'lisa'
```

# Methods

- Everything = object
- Object have methods associated, depending on type

```
sister.replace("z", "sa")
```

```
'lisa'
```

```
fam.replace("mom", "mommy")
```

```
AttributeError: 'list' object has no attribute 'replace'
```

# Methods

```
sister.index("z")
```

```
2
```

```
fam.index("mom")
```

```
4
```

# Methods (2)

```
fam
```

```
['liz', 1.73, 'emma', 1.68, 'mom', 1.71, 'dad', 1.89]
```

```
fam.append("me")
fam
```

```
['liz', 1.73, 'emma', 1.68, 'mom', 1.71, 'dad', 1.89, 'me']
```

```
fam.append(1.79)
fam
```

```
['liz', 1.73, 'emma', 1.68, 'mom', 1.71, 'dad', 1.89, 'me', 1.79]
```

# Summary

## Functions

```
type(fam)
```

```
list
```

## Methods: call functions on objects

```
fam.index("dad")
```

```
6
```

# Let's practice!

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# Packages

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# Motivation

- Functions and methods are powerful
- All code in Python distribution?
  - Huge code base: messy
  - Lots of code you won't use
  - Maintenance problem

# Packages

- Directory of Python Scripts
- Each script = module
- Specify functions, methods, types
- Thousands of packages available
  - NumPy
  - Matplotlib
  - scikit-learn

```
pkg/
   mod1.py
   mod2.py
   ...
```

# Install package

- http://pip.readthedocs.org/en/stable/installing/
- Download `get-pip.py`
- Terminal:
  - `python3 get-pip.py`
  - `pip3 install numpy`

# Import package

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

```
NameError: name 'array' is not defined
```

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

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

```
import numpy as np
np.array([1, 2, 3])
```

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

```
from numpy import array
array([1, 2, 3])
```

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

# from numpy import array

- `my_script.py`

```
from numpy import array

fam = ["liz", 1.73, "emma", 1.68,
    "mom", 1.71, "dad", 1.89]

...
fam_ext = fam + ["me", 1.79]

...
print(str(len(fam_ext)) + " elements in fam_ext")

...
np_fam = array(fam_ext)
```

- Using NumPy, but not very clear

# import numpy

```
import numpy as np

fam = ["liz", 1.73, "emma", 1.68,
    "mom", 1.71, "dad", 1.89]

...
fam_ext = fam + ["me", 1.79]

...
print(str(len(fam_ext)) + " elements in fam_ext")

...
np_fam = np.array(fam_ext) # Clearly using NumPy
```

# Let's practice!

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# NumPy

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# Lists Recap

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

# Illustration

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

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

```
weight = [65.4, 59.2, 63.6, 88.4, 68.7]
weight
```

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

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

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

# Solution: NumPy

- 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
np_height = np.array(height)
np_height
```

```
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([21.85171573, 20.97505669, 21.75028214, 24.7473475 , 21.44127836])
```

# 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
```

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

```
np_height = np.array(height)
np_weight = np.array(weight)
np_weight / np_height ** 2
```

```
array([21.85171573, 20.97505669, 21.75028214, 24.7473475 , 21.44127836])
```

# NumPy: remarks

```
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])
```

```
python_list + python_list
```

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

```
numpy_array + numpy_array
```

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

- Different types: different behavior!

# NumPy Subsetting

```
bmi
```

```
array([21.85171573, 20.97505669, 21.75028214, 24.7473475 , 21.44127836])
```

```
bmi[1]
```

```
20.975
```

```
bmi > 23
```

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

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

```
array([24.7473475])
```

# Let's practice!

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# 2D NumPy Arrays

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# 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

```
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 ]])
```

```
np_2d.shape
```

```
(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
```

```
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[:, 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!

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# NumPy: Basic Statistics

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# Data analysis

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

# 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

```
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.     ]])
```

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

```
0.1992
```

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

# 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!

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