Python review

Overview

Jupyter notebook on Ed Lesson

functions and variables

control

data structures

numpy/pandas

Jupyter notebook on Ed Lesson

side bar

notebook cells (code, text)

run (▶️ or `shift+enter` or `ctrl+enter`)

autocomplete / syntax highlighting

---

markdown syntax: https://www.markdownguide.org/basic-syntax/

Guide to Using Lab Notebook

in-class exercises

notes

study guide

to reset: `...` > `Reset to Scaffold`

Functions and Variables

Hello to You

```
What's your name? John
Hello, John!
```

Anatomy

```
answer = input("What's your name? ")

print("Hello answer")          # wrong
print("Hello", answer)         # multiple arguments
print(f"Hello {answer}")       # f-string
```

- **Function**: `input()`
- **Argument**: "What's your name? "
- **Side effect**: prompt the user and wait for input
- **Return values**: user input
- **Variable**: `answer`

Hello Function

```
hello()
# Output: Hello, World!

hello("John")
# Output: Hello, John
```

def

```python
def hello():
    print("Hello world")
answer = input("What's your name? ")
hello()
```

Arguments

```python
def hello(to):
    print("Hello ", to)
answer = input("What's your name? ")
hello(answer)
```

Arguments with default values

```python
def hello(to="world"):

    print("Hello ", to)

answer = input("What's your name? ")

hello(answer)
# Output: Hello {answer}

hello()
# Output: Hello world
```

Positional vs. keyword arguments

```
# positional arguments
hello(answer)

# keyword arguments
hello(to=answer)
```

Arguments 🤔

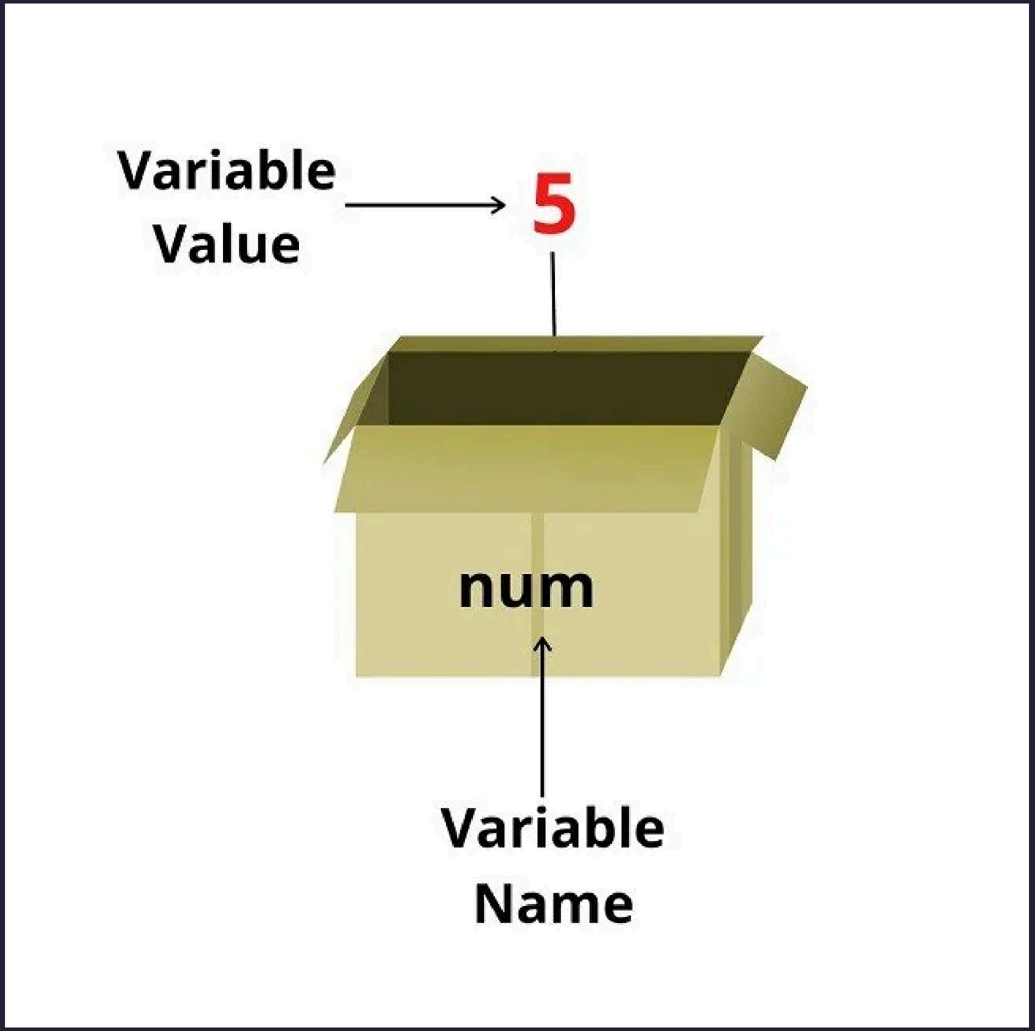
```python
def hello(a, b="Doe"):
    print("Hello", a, "and", b)

hello("John", "Doe")
hello("Doe", "John")
hello(b="Doe", a="John")
hello("John")
hello(b="John")
```

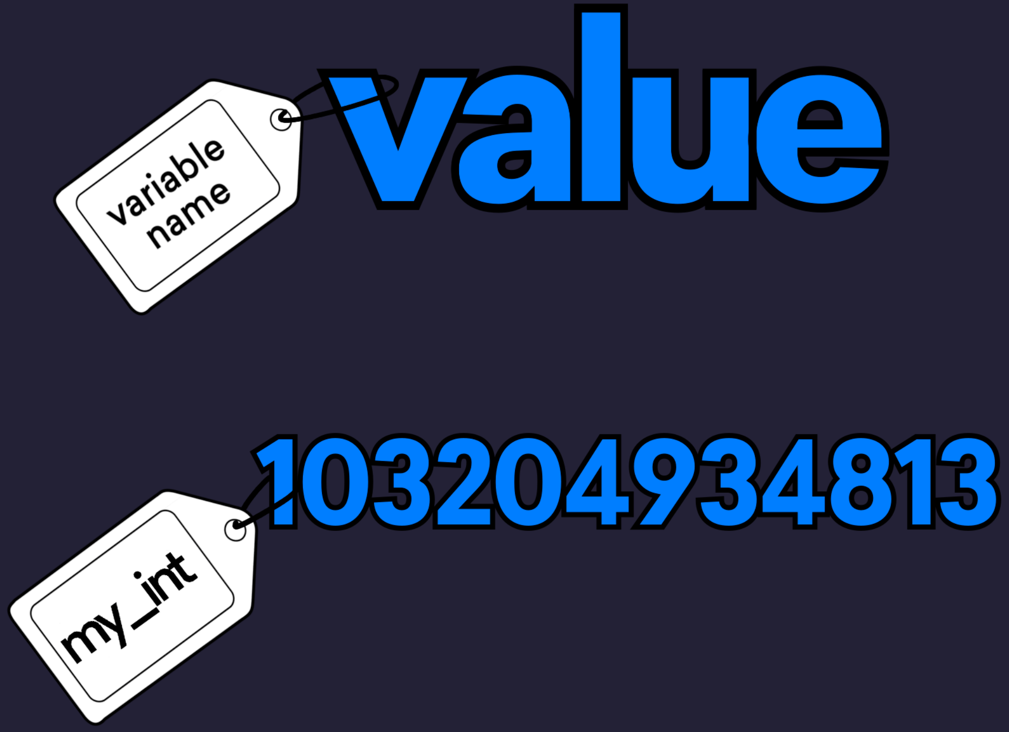
Scope

```
def main():
    answer = input("What's your name? ")
    hello()

def hello():
    print("Hello ", answer)

main()
```

Passing variables to functions

```python
def main():
    answer = input("What's your name? ")
    hello(answer)

def hello(to):
    print("Hello ", to)

main()
```


Variable Value
5
num
Variable Name


variable name
value
my_int
103204934813

Scope 🤔

```python
def func1():
    x = 10
    y = 20
    print(x + y)

def func2(y):
    x = 30
    print(x + y)

func1()

func2(2)

x = 20
func2(x)
```

`return`

```python
def main():
    answer = input("What's your name? ")
    message = hello_message(answer)

    print(message)

def hello_message(to="world"):
    msg = "Hello " + to

    return msg

main()
```

🖥️ 1. Area calculator

1. Define a function calculate_area(length, width) that:

- Takes two parameters: length and width.
- Returns the area of the rectangle (area = length × width).

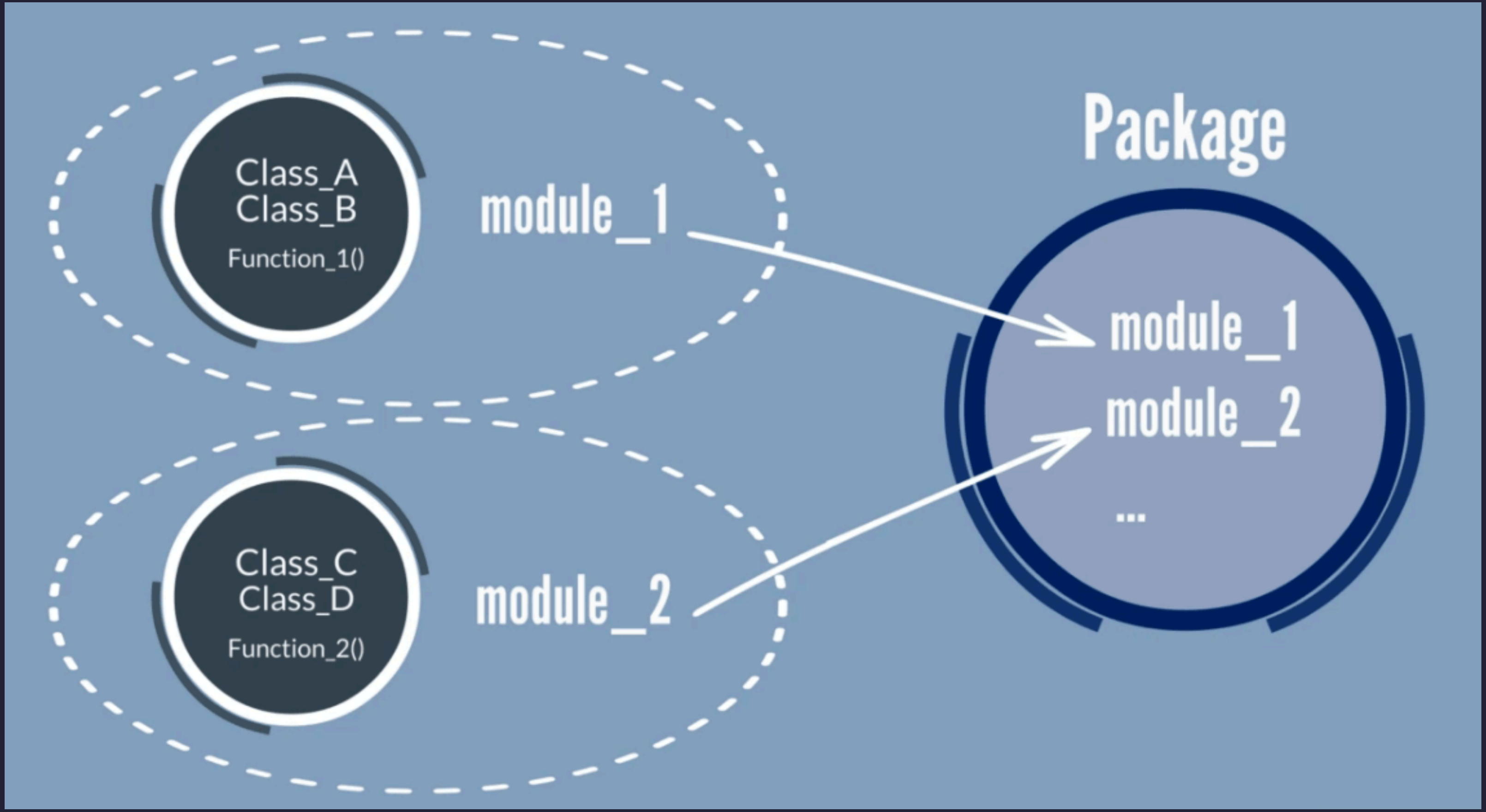
2. Ask the user to input the length and width of the rectangle.
3. Call the function with the user-provided values and print the area and perimeter.

Expected output:

```
Enter the length of the rectangle: 5
Enter the width of the rectangle: 3
The area of the rectangle is 15
```

Packages

functions < modules < packages = libraries



import module

```python
# math.py
import math

print(math.pi)
print(math.sqrt(4))
print(math.pow(2, 3))
print(math.floor(3.14))
print(math.ceil(3.14))
print(math.factorial(5))
```

`from` module `import` functions, variables, etc.

```python
from math import pi, sqrt

print(pi)
print(sqrt(4))
```

`as` to give alias

```python
import math as m

print(m.pi)
print(m.sqrt(4))
```

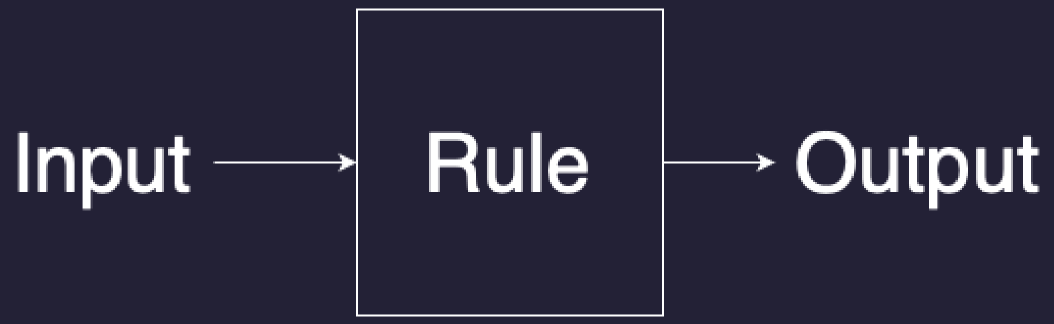
Import custom functions

```python
# ./my_module.py
def hello(to="world"):
    return f"Hello {to}"
```

```python
# ./main.py
from my_module import hello

hello("John")
```

Control

- **conditionals**: branching
- loops: repetition



Is x less than y?

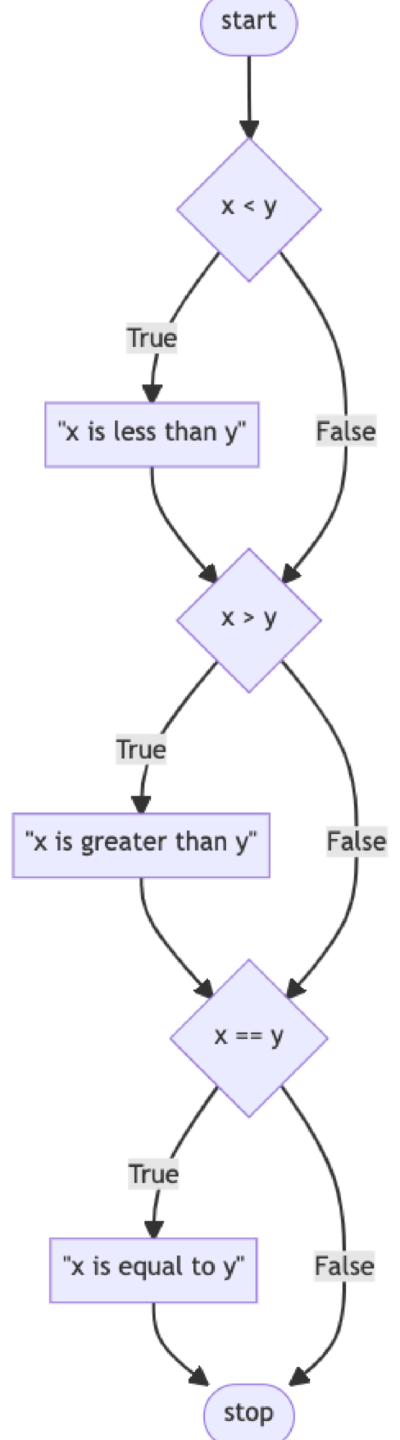
```
Enter a number: 5
Enter another number: 3
x is greater than y

Enter a number: 2
Enter another number: 2
x is equal to y

Enter a number: 1
Enter another number: 4
x is less than y
```

Comparison operators

```
>
<
>=
<=
==
!=
```

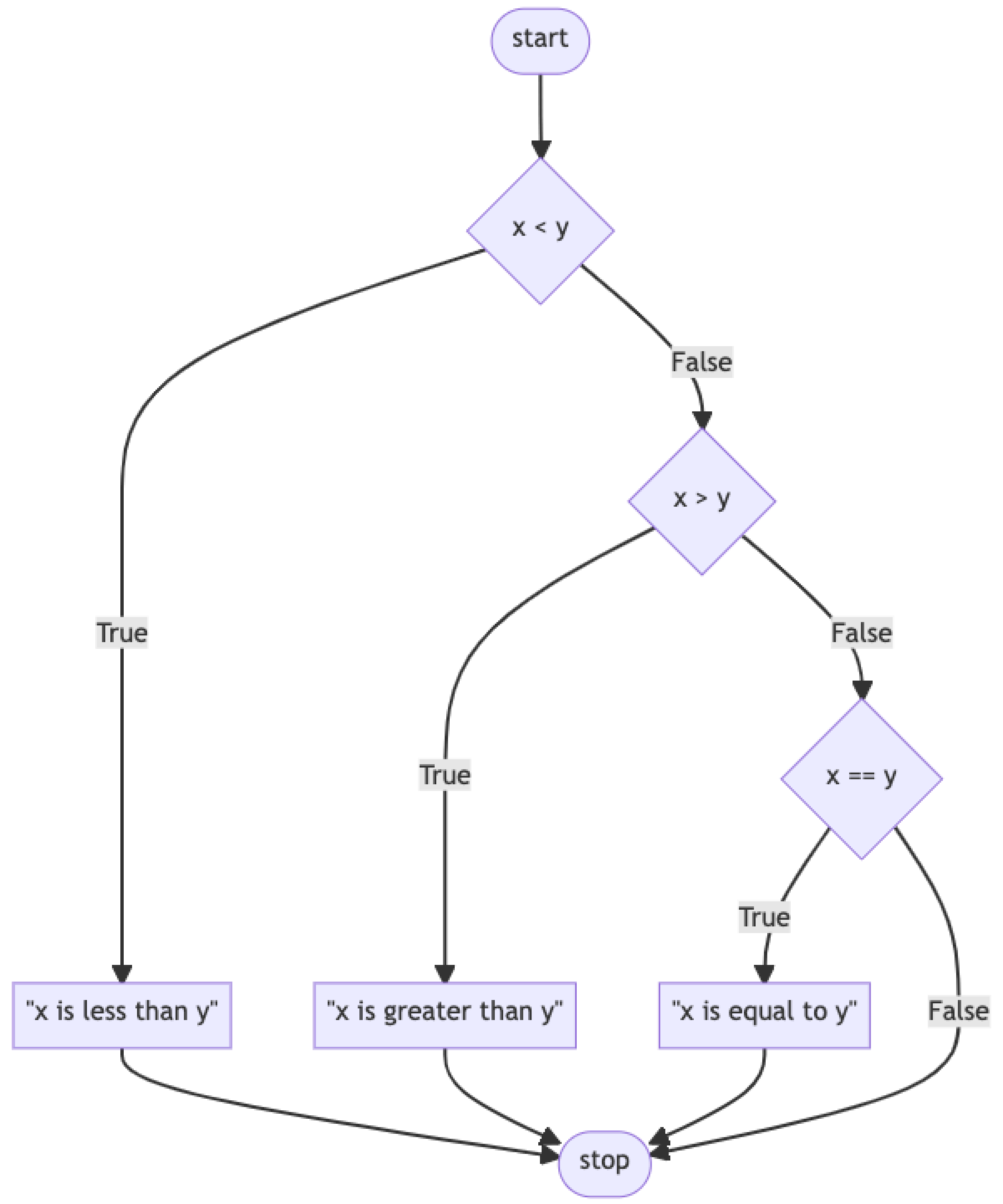
`if`

```python
x = int(input("Enter a number: "))
y = int(input("Enter another number: "))

if x < y:
    print("x is less than y")
if x > y:
    print("x is greater than y")
if x == y:
    print("x is equal to y")
```


start
x < y
True
"x is less than y"
False
x > y
True
"x is greater than y"
False
x == y
True
"x is equal to y"
False
stop

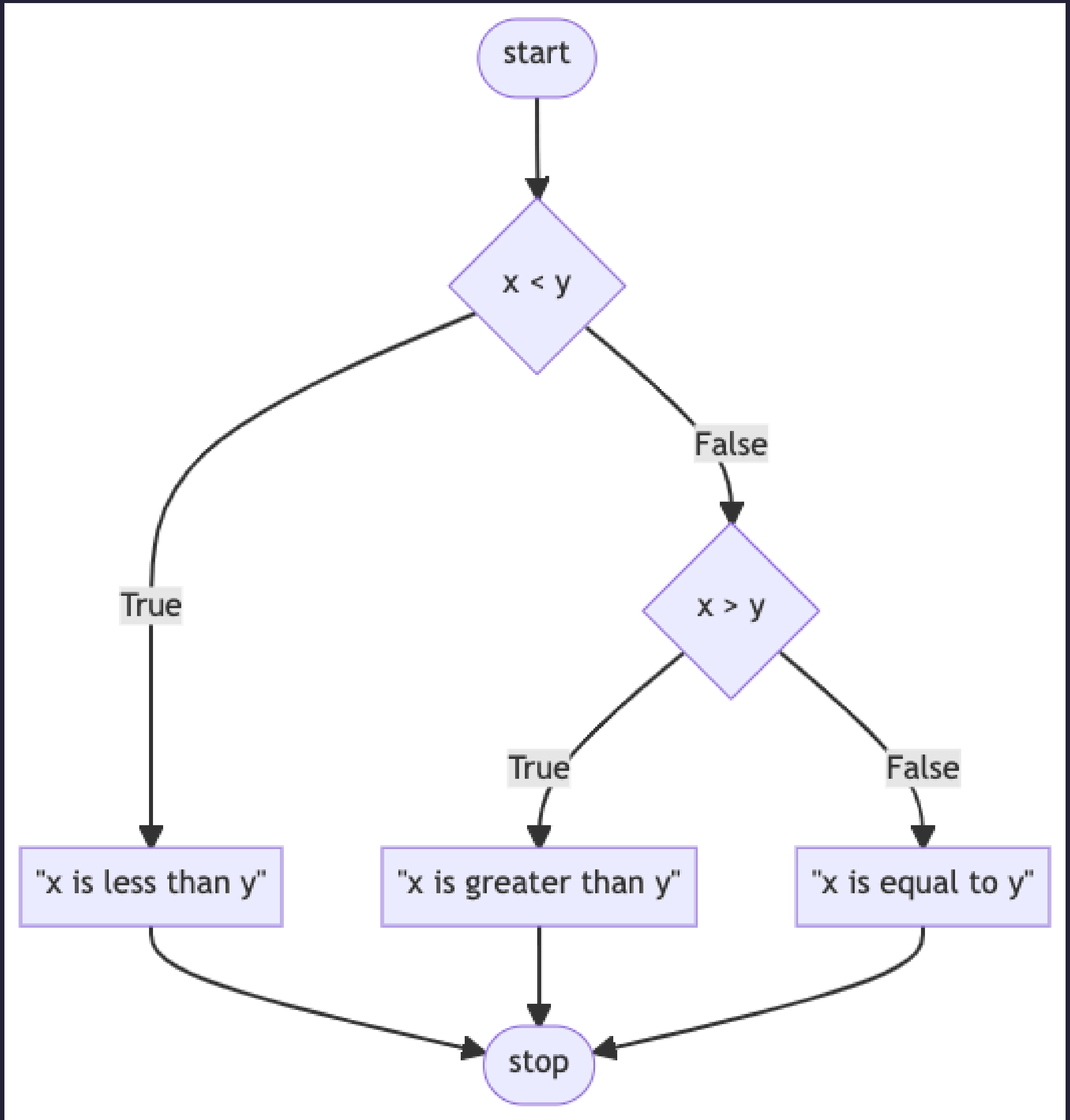
`elif` (else if)

```python
x = int(input("Enter a number: "))
y = int(input("Enter another number: "))

if x < y:
    print("x is less than y")
elif x > y:
    print("x is greater than y")
elif x == y:
    print("x is equal to y")
```


start
x < y
True
False
x > y
True
False
x == y
True
False
"x is less than y"
"x is greater than y"
"x is equal to y"
stop

else

```python
x = int(input("Enter a number: "))
y = int(input("Enter another number: "))

if x < y:
    print("x is less than y")
elif x > y:
    print("x is greater than y")
else:
    print("x is equal to y")
```


start
x < y
True
False
x > y
True
False
"x is less than y"
"x is greater than y"
"x is equal to y"
stop

Logical operators

- `or`
- `and`
- `not`

https://www.datacamp.com/tutorial/python-logical-operators-introduction

`or`

```
x = int(input("Enter a number: "))
y = int(input("Enter another number: "))

if x < y or x > y:
    print("x is not equal to y")
else:
    print("x is equal to y")
```

What am I not A? 🤔

```python
score = int(input("Enter your score: "))

if score >= 85:
     print("A")
if score >= 80:
     print("A-")
if score >= 75:
     print("B+")
if score >= 70:
     print("B")
if score >= 65:
     print("B-")
```

Conditions = `bool` expressions (True or False)

```python
print(2 > 1) # True

print(5 % 2 == 0) # False

if x % 2 == 0: # True or False
    print("x is even")

if x > y: # True or False
    print("x is greater than y")

if score >= 85: # True or False
    print("A")

if True:
    print("always get printed")

if False:
    print("never get printed")
```

A or B?

```python
if 2 > 1:
    print("A")

else:
    print("B")
```

A or B?

```python
if 2 == 1:
    print("A")

else:
    print("B")
```

A or B?

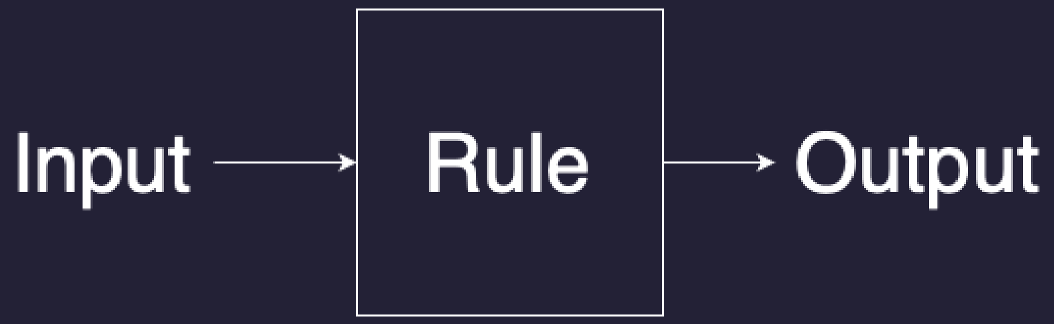
```python
if 2 > 1 or 2 == 1:
    print("A")

else:
    print("B")
```

bool: True or False

```python
def main():
    x = int(input("Enter a number: "))

    x_is_even = is_even(x)

    if x_is_even:   # True or False from is_even()
        print("x is even")
    else:
        print("x is odd")

def is_even(x):
    if x % 2 == 0:
        return True
    else:
        return False

main()
```

Control

- conditionals: branching
- **loops**: repetition



Don't Repeat Yourself (DRY)

```
print("meow")
print("meow")
print("meow")
```

Loop

`while`

`for`

`while`: conditionally repeated

```
i = 3
while i > 0:
    print("meow")
    i = i - 1
    # or
    # i -= 1
```

Assignment operators

- `=`
- `+=`
- `-=`
- `*=`
- `/=`

  ...

https://python-reference.readthedocs.io/en/latest/docs/operators/

`for`: repeat over a sequence (list, string, ...)

```
for i in [0, 1, 2]:
    print("meow")

for i in [0, 0, 0]:
    print("meow")

for i in "abc":
    print("meow")
```

range()

```
for i in range(3):
    print("meow")

for i in range(0, 3):    # range(3)
    print(i)

for i in range(5, 9):
    print(i)
```

🖥️ 2. Printing even numbers between 1 and 20

- Use a `for` loop and the `range` function to iterate from 1 to 20 (inclusive).
- Inside the loop, use an `if` statement to check if the current number is even.
  - To check for evenness, use the modulo operator `%`.
- If the number is even, print it.

```
2
4
6
8
10
12
14
16
18
20
```

Interactive meow

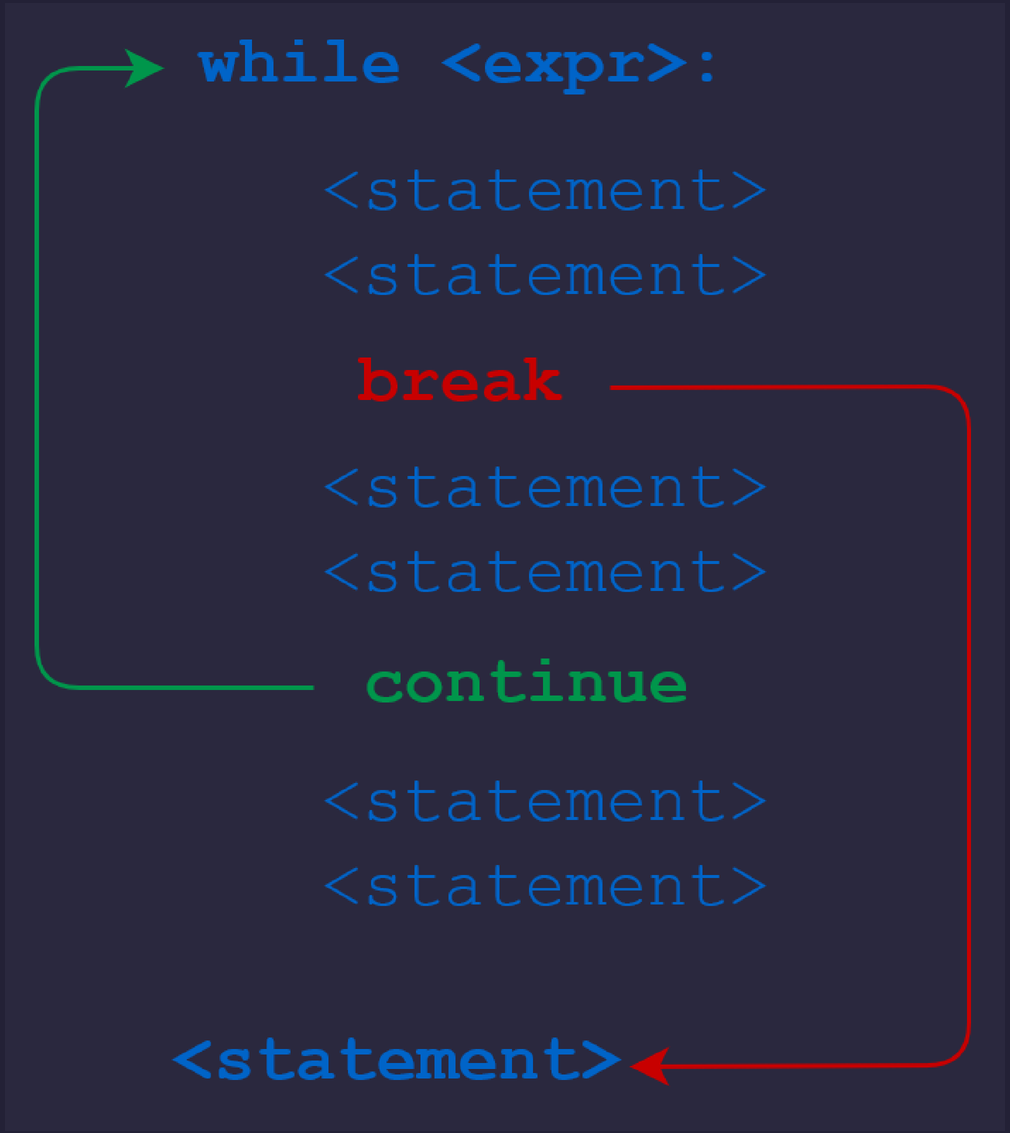
```
Enter a positive number: -3
Enter a positive number: -1
Enter a positive number: 4
meow
meow
meow
meow
```

Infinite loop

```python
while True:
    print("meow")
```

How to get out of a loop? `continue`, `break`

```python
while True:         # infinite loop
    n = int(input("Enter a positive number: "))

    if n < 0:       # if n is negative
        continue    # continue to next iteration
    else:           # if n is positive
        break       # break out of the loop

for _ in range(n):
    print("meow")
```



```
while <expr>:
        <statement>
        <statement>
        break
        <statement>
        <statement>
        continue
        <statement>
        <statement>

<statement>
```

infinite loop `continue`s anyway

```python
while True: # infinite loop
    n = int(input("Enter a positive number: "))

    if n > 0:   # if n is positive
        break   # break out of the loop

for _ in range(n):
    print("meow")
```

`return` to break out of a loop

```python
def main():
    n = get_positive_number()
    meow(n)

def get_positive_number():
    while True:
        n = int(input("Enter a positive number: "))
        if n > 0:
            return n # return the number

def meow(n):
    for _ in range(n):
        print("meow")

main()
```

💻 3. Input Validation for Even Numbers

- Use a `while True` loop to prompt the user to enter a number until an even number is entered.
- Write a function `is_even(n)` that takes an integer `n` and returns `True` if `n` is even and `False` otherwise.
- Use an `if` statement to check whether the entered number is even.
    - If the number is even, return it and break out of the loop.
- Calculate the square of the returned even number and print it.

```
Enter an even number: 3
3 is not an even number. Try again.
Enter an even number: 5
5 is not an even number. Try again.
Enter an even number: 8
64
```

Data structures

`list`

`dict`

`list`: a list of (any) values

```
cities = ["Montreal", "Toronto", "Vancouver", "Detroit"]
numbers = [1, 2, 3, 4, 5]
any_type_you_want = [1, "meow", 3.14, True]
```

https://docs.python.org/3/tutorial/datastructures.html#more-on-lists

Access item using index

```python
# Access
cities = ["Montreal", "Toronto", "Vancouver", "Detroit"]

print(cities)    # ["Montreal", "Toronto", "Vancouver", "Detroit"]
print(cities[0]) # Montreal
print(cities[1]) # Toronto
print(cities[2]) # Vancouver
print(cities[3]) # Detroit
print(cities[4]) # ???

# Update
cities[0] = "New York"

print(cities) # ["New York", "Toronto", "Vancouver", "Detroit"]
```

Add item to list - `append`

```python
cities = ["Montreal", "Toronto", "Vancouver", "Detroit"]
cities.append("New York")

print(cities) # ["Montreal", "Toronto", "Vancouver", "Detroit", "New York"]
```

Delete item from list - `del`

```python
cities = ["Montreal", "Toronto", "Vancouver", "Detroit"]

del cities[0]
print(cities) # ["Toronto", "Vancouver", "Detroit"]

del cities[0]
print(cities) # ["Vancouver", "Detroit"]
```

Search: Is this `in` the list or `not in` the list?

Membership operators

```
cities = ["Montreal", "Toronto", "Vancouver", "Detroit"]

if "Montreal" in cities:
    print("Montreal is in the list")

if "New York" not in cities:
    print("New York is not in the list")
```

`len()`, `min()`, `max()`, `sum()`

```python
numbers = [1, 2, 3, 4, 5]

print(len(numbers))     # 5
print(min(numbers))     # 1
print(max(numbers))     # 5
print(sum(numbers))     # 15
```

https://docs.python.org/3/library/functions.html

Loop over list

1. `for`

```python
cities = ["Montreal", "Toronto", "Vancouver", "Detroit"]

for city in cities:
    print(city)
```

2. `len()` & `range()`

```python
cities = ["Montreal", "Toronto", "Vancouver", "Detroit"]
length = len(cities)

for i in range(length):
    print(cities[i])
```

`dict`ionary: a collection of key-value pairs

```python
cities = {
    "key": "value",
    "name": "Montreal",
    "state": "QC",
    "country": "CA"
}
```

https://docs.python.org/3/tutorial/datastructures.html#dictionaries

Access item in dict using key

```
cities = {
    "name": "Montreal",
    "state": "QC",
    "country": "CA"
}
print(cities["name"])       # Montreal
print(cities["state"])      # QC
print(cities["country"])    # CA

# Update
cities["name"] = "New York"

# Add
cities["continent"] = "NA"
```

Delete item from dict - `del`

```
cities = {
    "name": "Montreal",
    "state": "QC",
    "country": "CA"
}

del cities["state"]

print(cities)
```

`keys()`, `values()`, `items()` return list-like objects

```
cities = {
    "name": "Montreal",
    "state": "QC",
    "country": "CA"
}

print(cities.keys())
# output: dict_keys(['name', 'state', 'country'])

print(cities.values())
# output: dict_values(['Montreal', 'QC', 'CA'])

print(cities.items())
# output: dict_items([('name', 'Montreal'), ('state', 'QC'), ('country', 'CA')])
```

Search: `in`, `not in`

```python
cities = {
    "name": "Montreal",
    "state": "QC",
    "country": "CA"
}

if "name" in cities.keys():
    print("name is in the keys of the dict")

if "Detroit" not in cities.values():
    print("Detroit is not in the values of the dict")
```

`len()`, `min()`, `max()`, `sum()`

```python
numbers = {
    "a": 1,
    "b": 2,
    "c": 3,
    "d": 4,
    "e": 5
}

print(len(numbers))     # 5
print(min(numbers))     # a (key)
print(max(numbers.values()))     # 5 (value)
print(sum(numbers.values()))     # 15
```

https://docs.python.org/3/library/functions.html

loop over dict

```python
cities = {
    "name": "Montreal",
    "state": "QC",
    "country": "CA"
}

for key in cities: # equivalent to cities.keys()
    print(key)

for key in cities: # equivalent to cities.keys()
    print(key, cities[key])

for value in cities.values():
    print(value)

for key, value in cities.items():
    print(key, value)
```

Accessing items in a list/tuple/dict

- list/tuple: `[index]`
- dict: `[key]`

How to access the following items?

```
cities = [
    {"name": "Montreal", "state": "QC", "country": "CA"},
    {"name": "Toronto", "state": "ON", "country": "CA"},
    {"name": "Vancouver", "state": "BC", "country": "CA"},
    {"name": "Detroit", "state": "MI", "country": "US"}
]
```

- `{"name": "Vancouver", "state": "BC", "country": "CA"}`
- `"Vancouver"`
- `"Montreal"`

```
cities = {
    "name": ["Montreal", "Toronto", "Vancouver", "Detroit"],
    "state": ["QC", "ON", "BC", "MI"],
    "country": ["CA", "CA", "CA", "US"]
}
```

- `["Montreal", "Toronto", "Vancouver", "Detroit"]`
- `"Montreal"`

```
cities = {
    "location": {
        "Montreal": {"state": "QC", "country": "CA"},
        "Toronto": {"state": "ON", "country": "CA"},
        ...
    },
    "stats": {
        "Montreal": [
            {"year": 2013, "population": 2000000, "area": 431.5},
            {"year": 2014, "population": 1980000, "area": 431.5}
            ],
        "Toronto": [
            {"year": 2013, "population": 2800000, "area": 630.2},
            ],
        ...
    }
}
```

- `{"year": 2013, "population": 2000000, "area": 431.5}`
- `"QC"`
- `2000000`

	List	Dict
Access	`cities[0]`	`cities["key"]`
Update	`cities[0] = "new item"`	`cities["existing key"] = "new value"`
Add	`cities.append("new item")`	`cities["new key"] = "new value"`
Delete	`del cities[0]`	`del cities["key"]`

	List	Dict
Join	`cities3 = cities1 + cities2`	`cities3 = cities1 | cities2`

Search	`"item" in cities`	`"key" in cities.keys()`
		`"value" in cities.values()`

Loop	`for item in cities:`	`for key in cities.keys():`
		`for value in cities.values():`
		`for item in cities.items():`

Sort	`cities.sort()`	`sorted(cities)`

💻 4. Citybook

- Update the dictionary to include the population and area for Montreal.
    - population: 1704694, area: 431.5
- Write a function `calc_density` that takes a city's population and area as input and returns the population density.
- Update the dictionary to include the population density for Montreal.
- Use a `for` loop to iterate over the dictionary.
    - Print out the city's name, its state/province, country, population, and area.
- Finally, print the total number of fields stored in the dictionary.

```
name: Montreal
state: QC
country: CA
population: 1704694
area: 431.5
density: 3952.0
Total number of fields: 6
```

Vectorization using Numpy and Pandas

`list` and `dict` are not ideal for data analysis

```python
# height and weight
data = [
    [170, 68],
    [180, 70],
    [160, 60],
    [150, 55],
    [175, 65]
]

# average height
total_height = 0
for row in data:
    total_height += row[0]
average_height = total_height / len(data)
print(average_height)

# bmi
for row in data:
    height = row[0]
    weight = row[1]
    bmi = weight / (height / 100) ** 2
    print(bmi)
```

Vectorization

```
import numpy as np

data = np.array([
    [170, 68],
    [180, 70],
    [160, 60],
    [150, 55],
    [175, 65]
])

# select height and weight
height = data[:, 0]
weight = data[:, 1]

# average height
average_height = np.mean(height)

# bmi
bmi = weight / (height / 100) ** 2
```

Numpy array for matrix

$$np_{1d} = \begin{bmatrix} 1 & 2 & 3 & 4 & 5 \end{bmatrix}$$

$$np_{2d} = \begin{bmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \\ 7 & 8 & 9 \end{bmatrix}$$

```
np_1d = np.array([1, 2, 3, 4, 5])
print(np_1d.shape) # (5,)

np_2d = np.array([[1, 2, 3], [4, 5, 6], [7, 8, 9]])
print(np_2d.shape) # (3, 3)
```

Subsetting

$$np_{2d} = \begin{bmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \\ 7 & 8 & 9 \end{bmatrix}$$

```
np_2d = np.array([[1, 2, 3], [4, 5, 6], [7, 8, 9]])

print(np_2d[0])      # [1 2 3]
print(np_2d[0, 1])   # 2
print(np_2d[:, 1])   # [2 5 8]
print(np_2d[0, :])   # [1 2 3]
print(np_2d[1:, :]) # [[4 5 6] [7 8 9]]
```

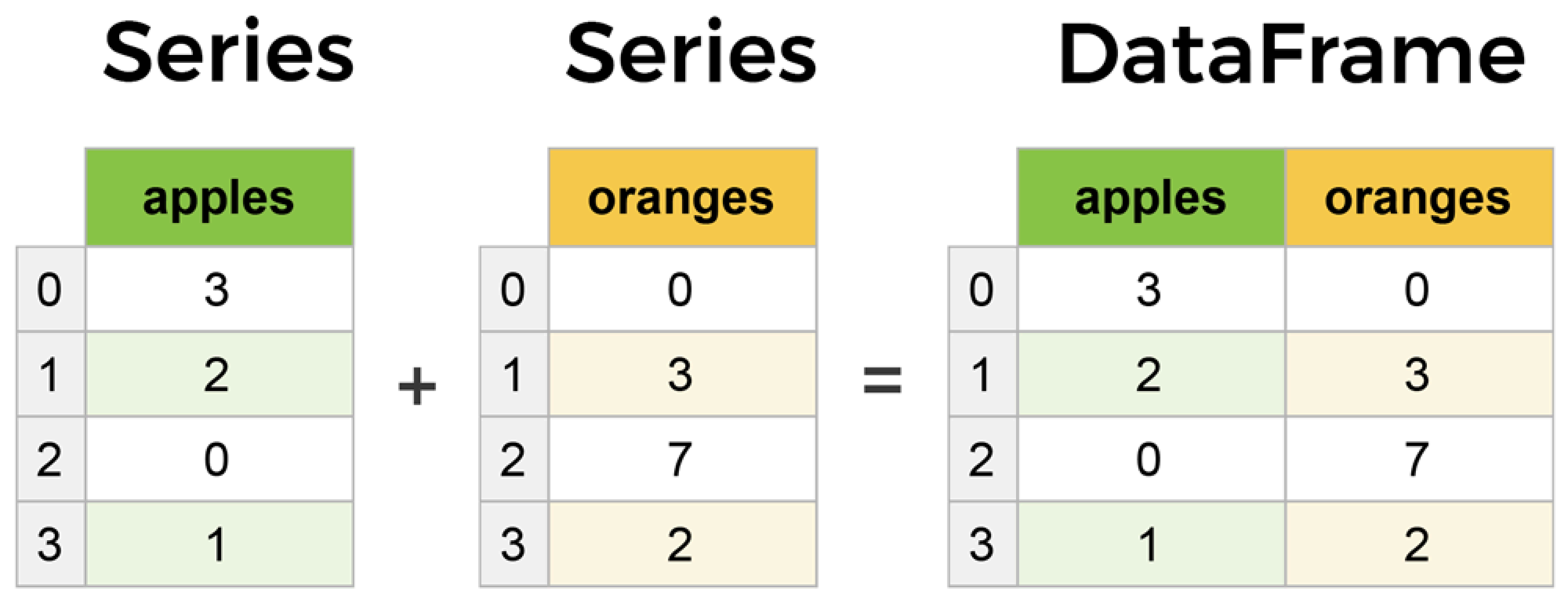
Filtering

```
np_1d = np.array([1, 2, 3, 4, 5])

cond = np_1d > 3   # [False False False  True  True]
print(np_1d[cond]) # [4 5]
```

Mathematical operations

```
np_1da = np.array([1, 2, 3, 4, 5])
np_1db = np.array([6, 7, 8, 9, 10])

print(np_1da + np_1db) # [ 7  9 11 13 15]
print(np_1da - np_1db) # [-5 -5 -5 -5 -5]
print(np_1da * np_1db) # [ 6 14 24 36 50]

print(np.mean(np_1da)) # 3.0
print(np.sum(np_1da))  # 15
print(np.std(np_1da))  # 1.4142135623730951
```

Pandas Series and DataFrame



Series

	apples
0	3
1	2
2	0
3	1

+

Series

	oranges
0	0
1	3
2	7
3	2

=

DataFrame

	apples	oranges
0	3	0
1	2	3
2	0	7
3	1	2

Pandas DataFrame for tabular data

```
import pandas as pd

data = {
    'name': ['John', 'Jane', 'Mary'],
    'age': [25, 30, 27]
}
df = pd.DataFrame(data)

print(df.index)
print(df.columns)
print(df.head())
```

Subsetting

Selecting columns

```
df['name']
df[['name', 'age']]
```

Selecting rows

```
df.loc[0]
df.loc[0:2]
```

Selecting rows and columns

```
df.loc[0, 'name']
df.loc[0:2, ['name', 'age']]
```

Filtering

```
cond = df['age'] > 25
df[cond]
df.loc[cond]
cond2 = (df['age'] > 25) & (df['name'] == 'John')
df.loc[cond2, 'name']
```

Mathematical operations

```
df['age'] + 5
df['age'] * 2

df['age'].mean()
df['age'].sum()

df['bmi'] = df['weight'] / (df['height'] / 100) ** 2
```

💻 5. HR Data Analysis (`pandas` or `numpy`)

1. Create a Pandas DataFrame (or Numpy array) from the employee data.
2. Use filtering to select employees from the “IT” department.
3. Use another filter to select employees with a salary greater than $60,000.
4. Calculate the average salary of all employees.
5. Calculate the average salary of the employees in the “IT” department.

Name	Age	Department	Salary
John	28	IT	55000
Alice	34	HR	62000
Bob	45	IT	70000