# Python review

# Overview

Jupyter notebook

functions & variables

control flow

data structures

vectorization

# Jupyter notebook on Ed Lesson

side bar

notebook cells (code, text)

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

autocomplete / syntax highlighting

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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 & variables

# Hello to You

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

# Anatomy

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

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

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

# Hello Function

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

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

# def

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

# Arguments

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

# Arguments with default values

```
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 🤔

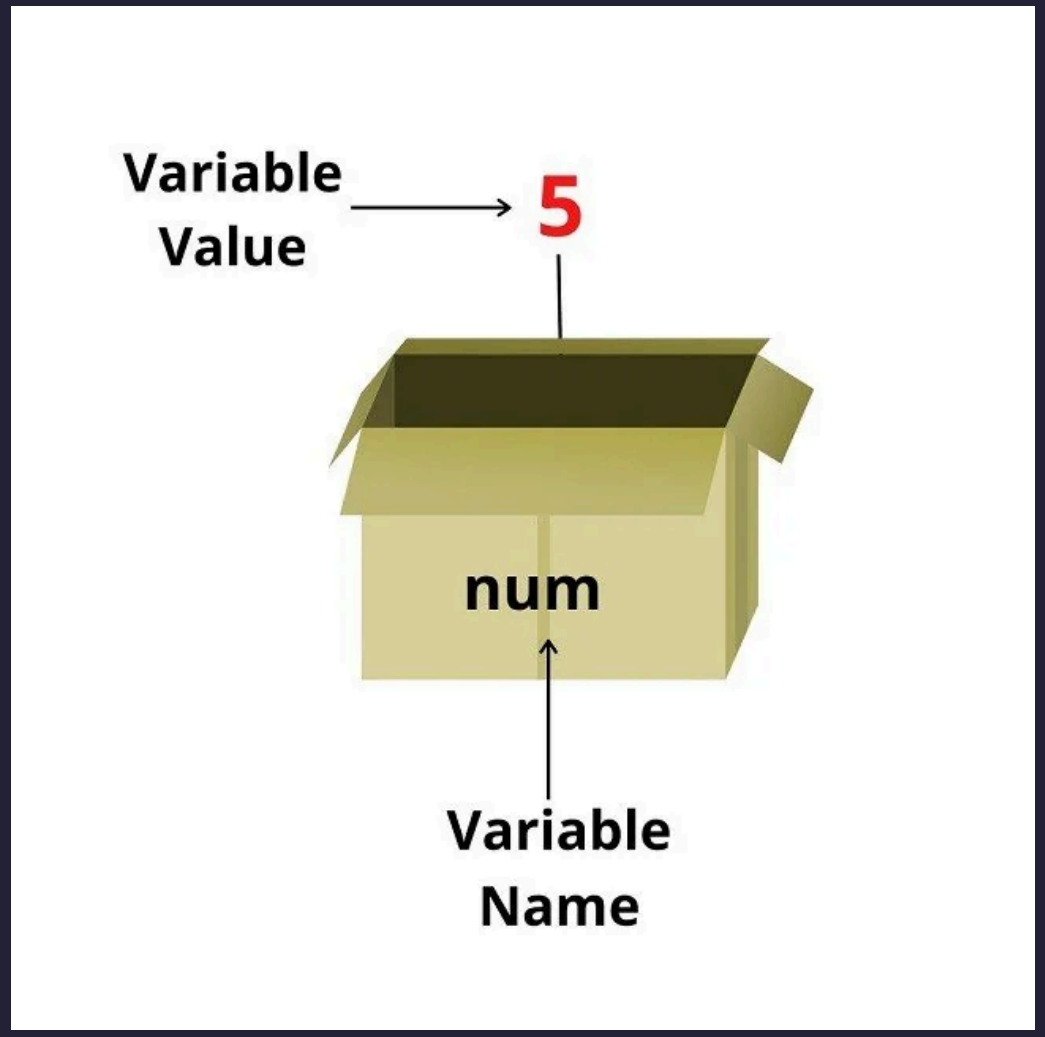
```python
def hello(a, b="Doe"):
    print("Hello", a, "and", b)

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

```
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
10320493481 3

# Scope 🤔

```
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

```
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. Use `input()` and `float()`.
3. Call the function with the user-provided values and print the area and perimeter.

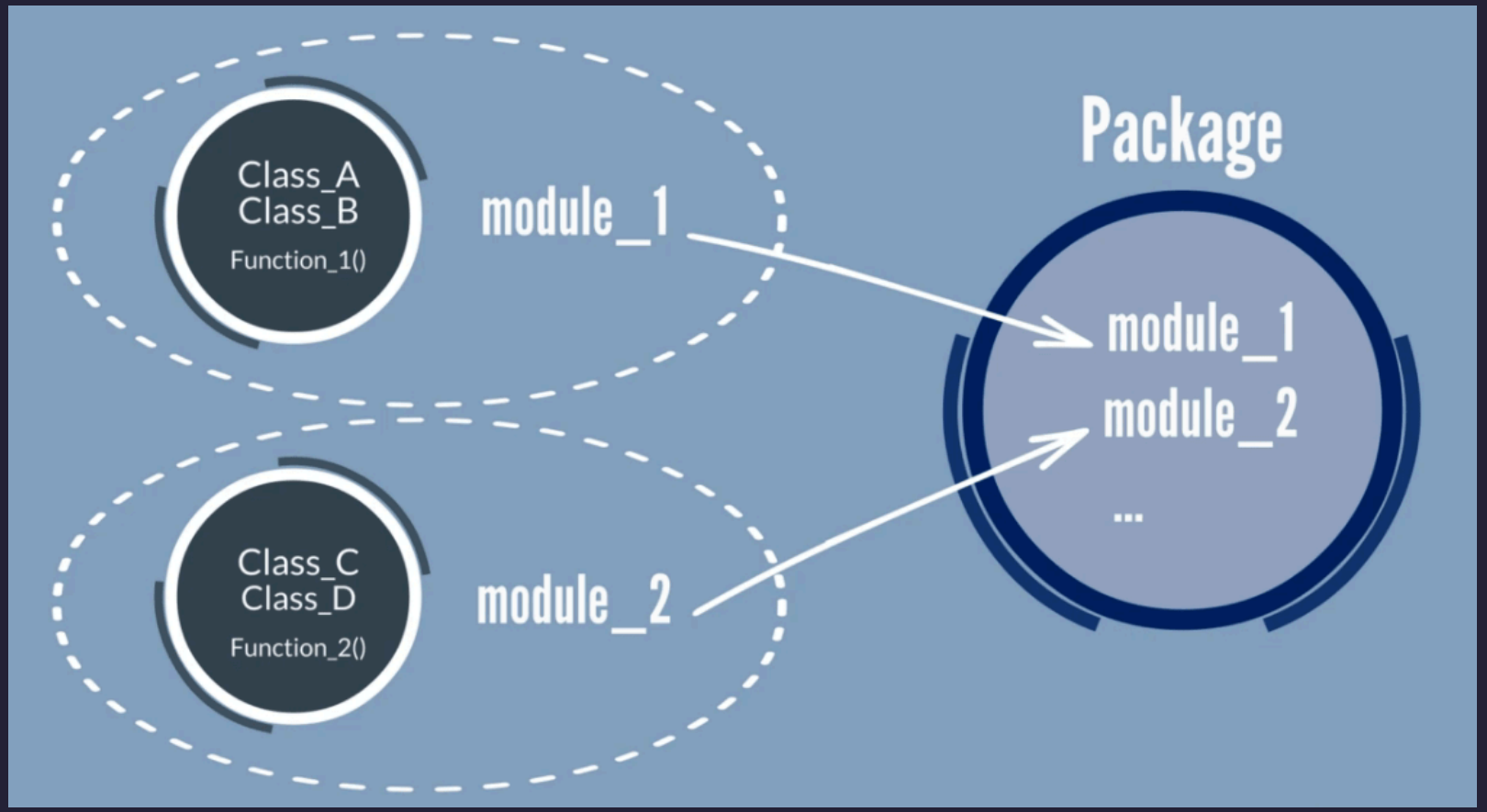
**Expected output:**

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

# 1. Area calculator (solution)

```python
# Main program
def main():
    # Ask the user for the length and width of the rectangle. Use input() and float().
    length = float(input("Enter the length of the rectangle: "))
    width = float(input("Enter the width of the rectangle: "))

    # Call the functions to calculate area and perimeter
    area = calculate_area(length, width)

    # Print the results
    print(f"The area of the rectangle is: {area}")

# Function to calculate the area of a rectangle
def calculate_area(length, width):
    area = length * width
    return area

# Call the main function to run the program
main()
```

# functions < modules < packages = libraries



# import

```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.

```
from math import pi, sqrt

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

## `as` to give alias

```
import math as m

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

# Import custom modules

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

### Import `my_module`

```
# ./main.py
import my_module

my_module.hello("John")
```

### Import specific functions

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

hello("John")
```

# Control

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

# Is x less than y?

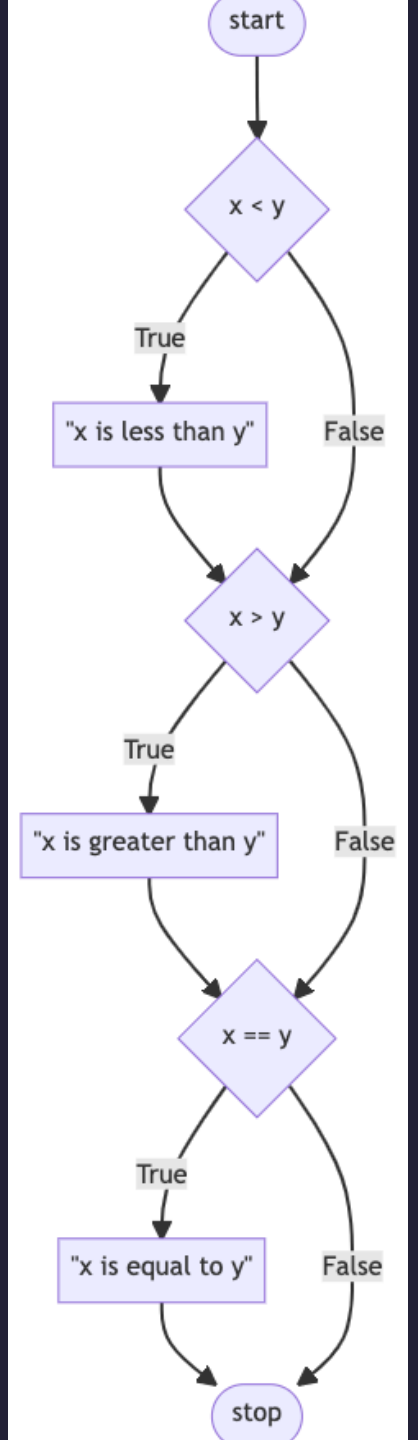
```
Enter a number: 5
Enter another number: 3
x is greater than y

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

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

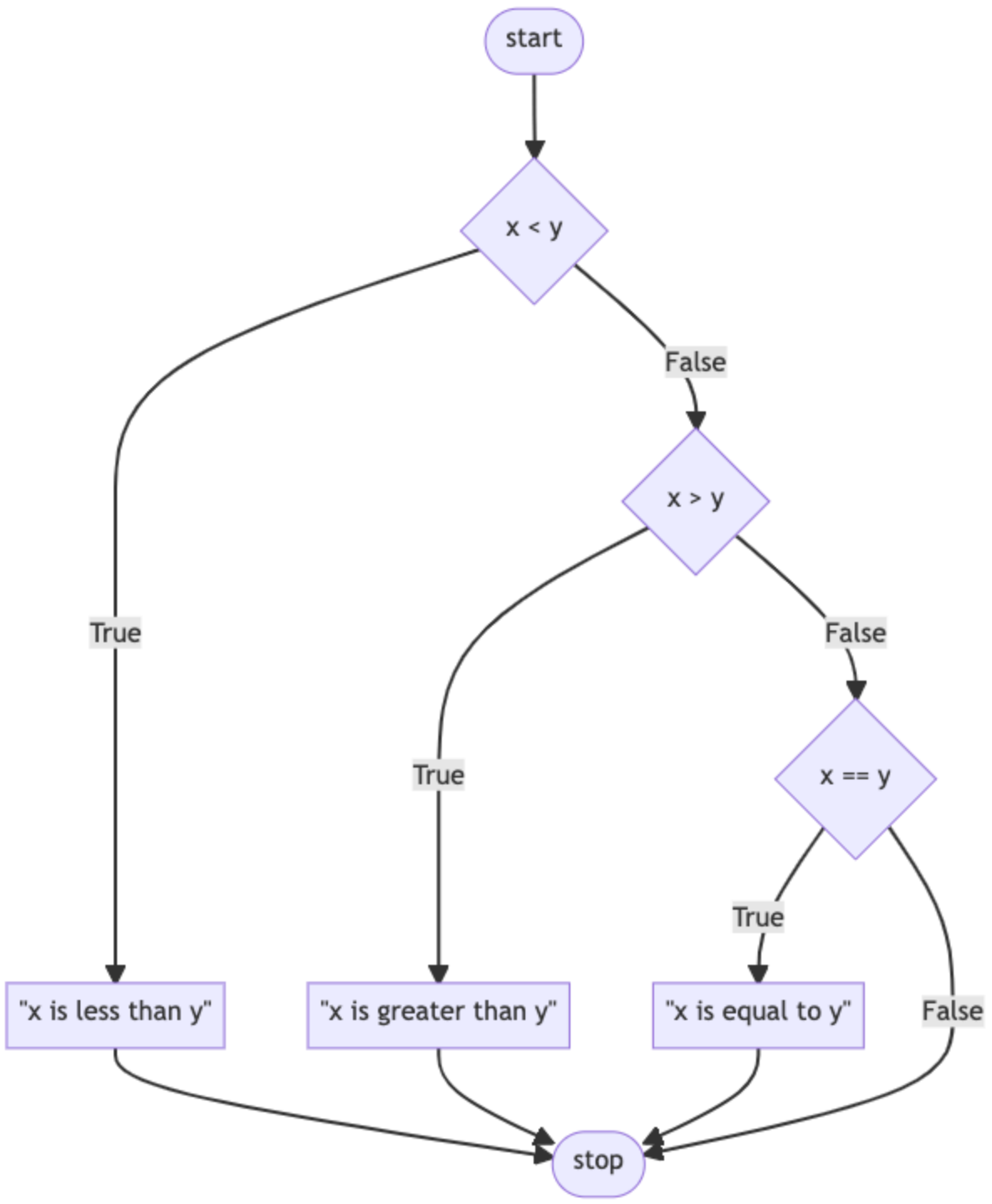
# if

```
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

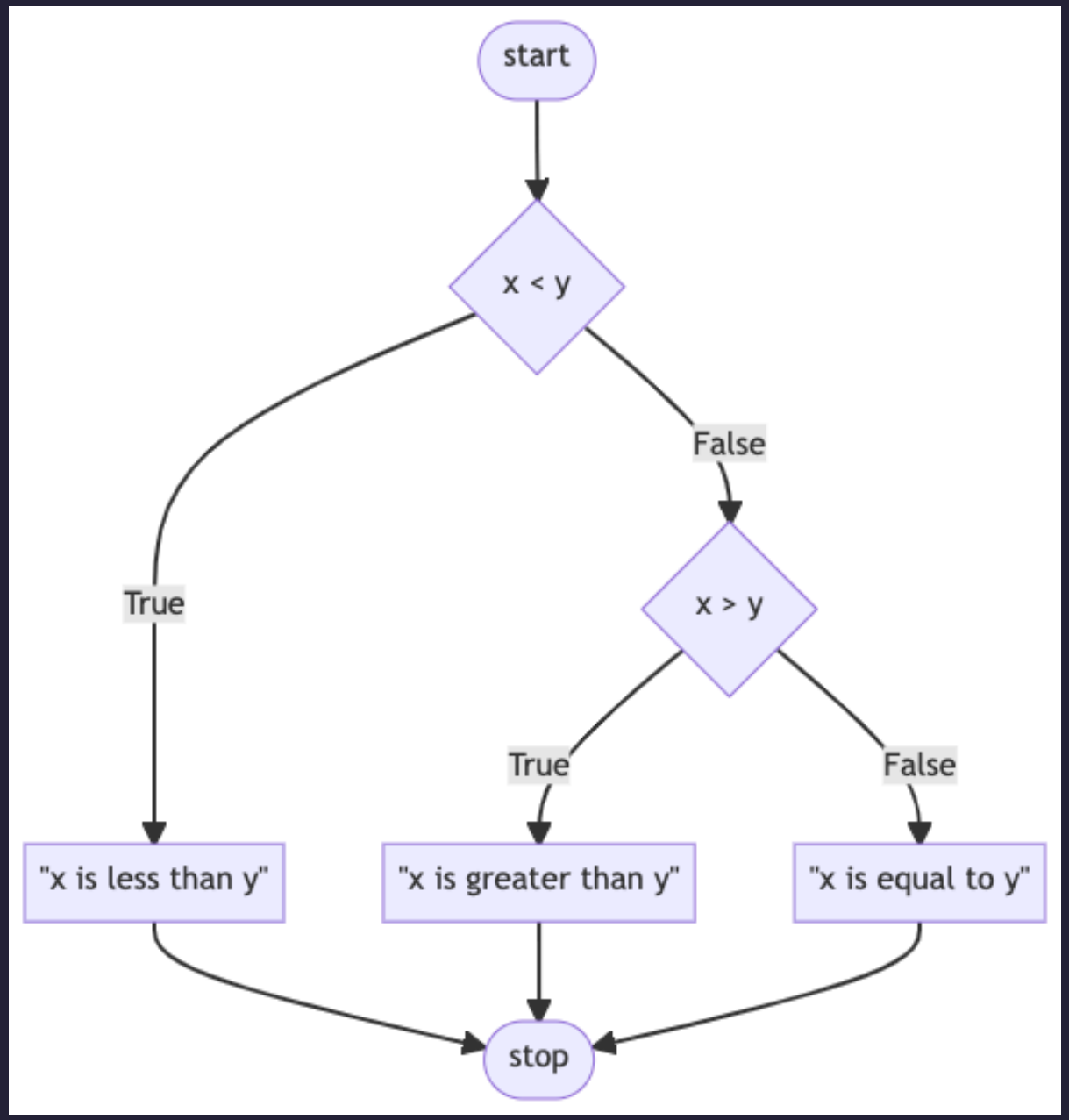
# `elif` (else if)

```
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
True
False
"x is less than y"
"x is greater than y"
"x is equal to y"
stop

# else

```
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? 🤔

```
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`ean expressions (True or False)

```
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?

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

else:
    print("B")
```

# A or B?

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

else:
    print("B")
```

# A or B?

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

else:
    print("B")
```

# `bool`: True or False

```
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()
```

# `bool`: True or False

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

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

def is_even(x):
    return x % 2 == 0

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
    # 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
```

# 💻 2. Printing even numbers between 1 and 20 (solution)

```
for i in range(1, 21):
    if i % 2 == 0:
        print(i)
```

# Interactive meow

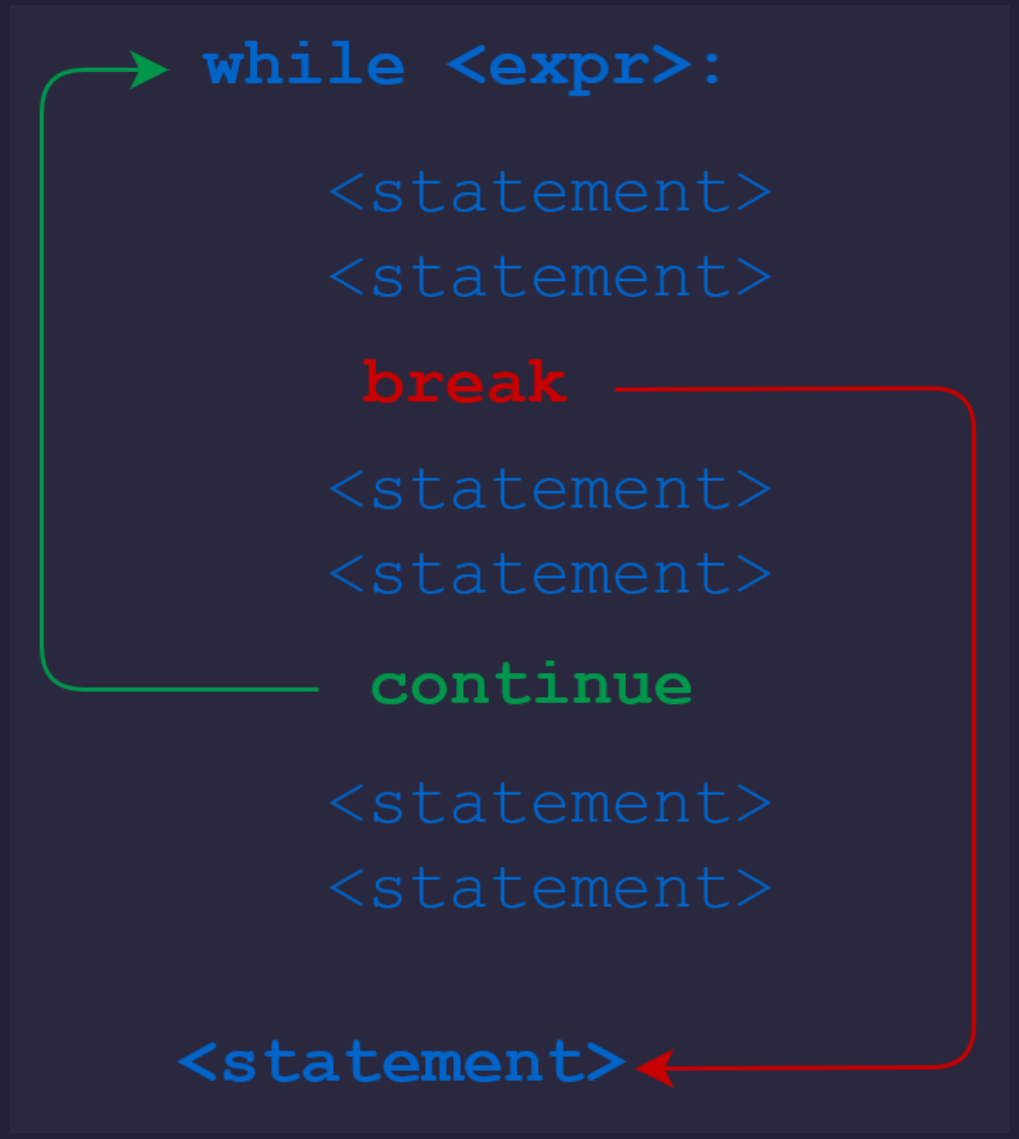
```
Enter a positive number: -3
Enter a positive number: -1
Enter a positive number: 4
meow
meow
meow
meow
```

# Infinite loop

```
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

```
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

```
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()
```

# Hello or goodbye? 🤔

```
def main():
    print("Hello World!")
    return  # equivalent to "return None"
    print("Goodbye World!")

main()

print(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
```

# 💻 3. Input Validation for Even Numbers (solution)

```python
def main():
    number = get_even_number()
    print(number ** 2)

def get_even_number():
    while True:
        n = int(input("Enter an even number: "))
        if is_even(n):
            return n
        print(f"{n} is not an even number. Try again.")

def is_even(n):
    return n % 2 == 0

main()
```

# 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

```
# 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`

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

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

## Delete item from list - `del`

```
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()`

```
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`

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

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

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

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

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

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

```
cities = [  # list
    "value",
    "Montreal",
    "QC",
    "CA"
]
```

```
cities = {  # dict
    "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`

```
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()`

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

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

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

# loop over dict

```
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)
```

# 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()`<br>`"value" in cities.values()` |
| Loop | `for item in cities:` | `for key in cities.keys():`<br>`for value in cities.values():`<br>`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
```

# 4. Citybook (solution)

```
def calc_density(pop, area):
    return pop/area

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

pop = 1704694
area = 431.5
density = calc_density(pop, area)

cities["population"] = pop
cities["area"] = area
cities["density"] = density

for key, value in cities.items():
    print(key + ": " + str(value))

print("Total number of keys:", len(cities))
```