APS106

UNIVERSITY OF TORONTO

objects, classes, and methods.

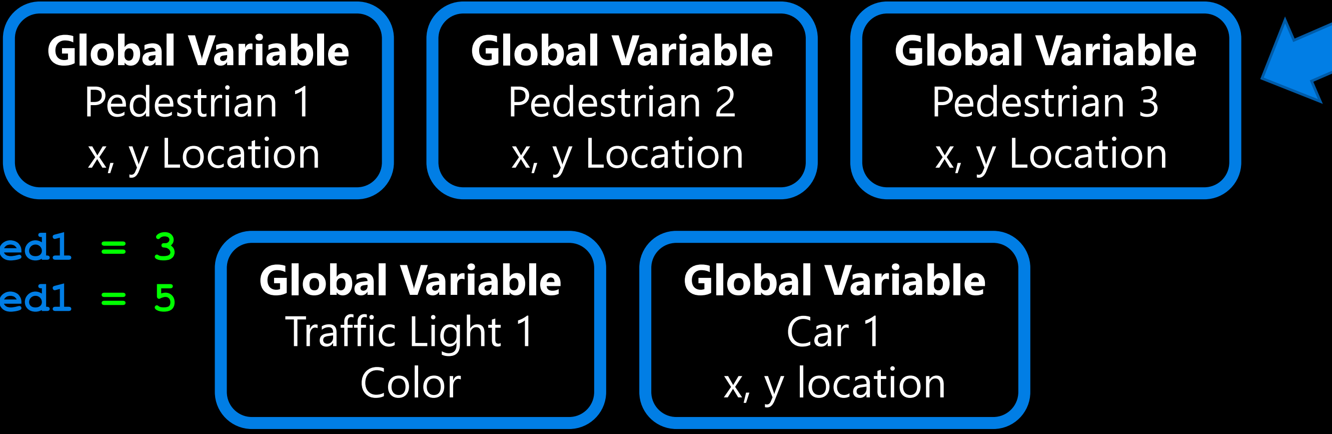
Week 10 | Lecture 1 (10.1)

if nothing else, write #cleancode

This Week's Content

- **Lecture 10.1**
    - **objects, classes, and methods**
    - **Reading: Chapter 14**
- **Lecture 10.2**
    - Classes in Classes, Functions, and Collections
    - Reading: Chapter 14
- **Lecture 10.3**
    - Design Problem: Robot Localization

Procedural Programming



Global Variable
Pedestrian 1
x, y Location

Global Variable
Pedestrian 2
x, y Location

Global Variable
Pedestrian 3
x, y Location

```
x_ped1 = 3
y_ped1 = 5
```

Global Variable
Traffic Light 1
Color

Global Variable
Car 1
x, y location

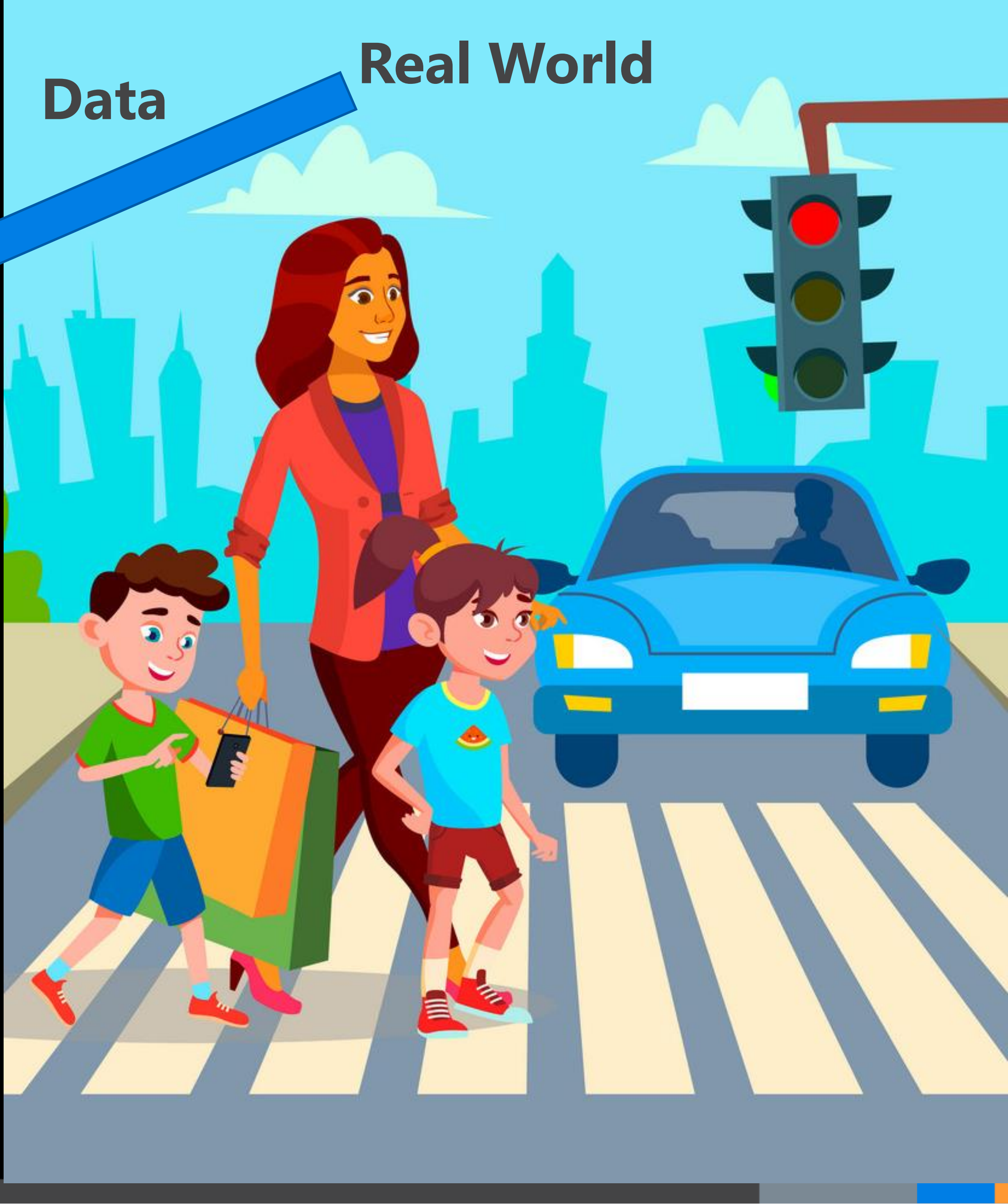
```
traffic_light = 'red'
```

Separation of Data and Functions

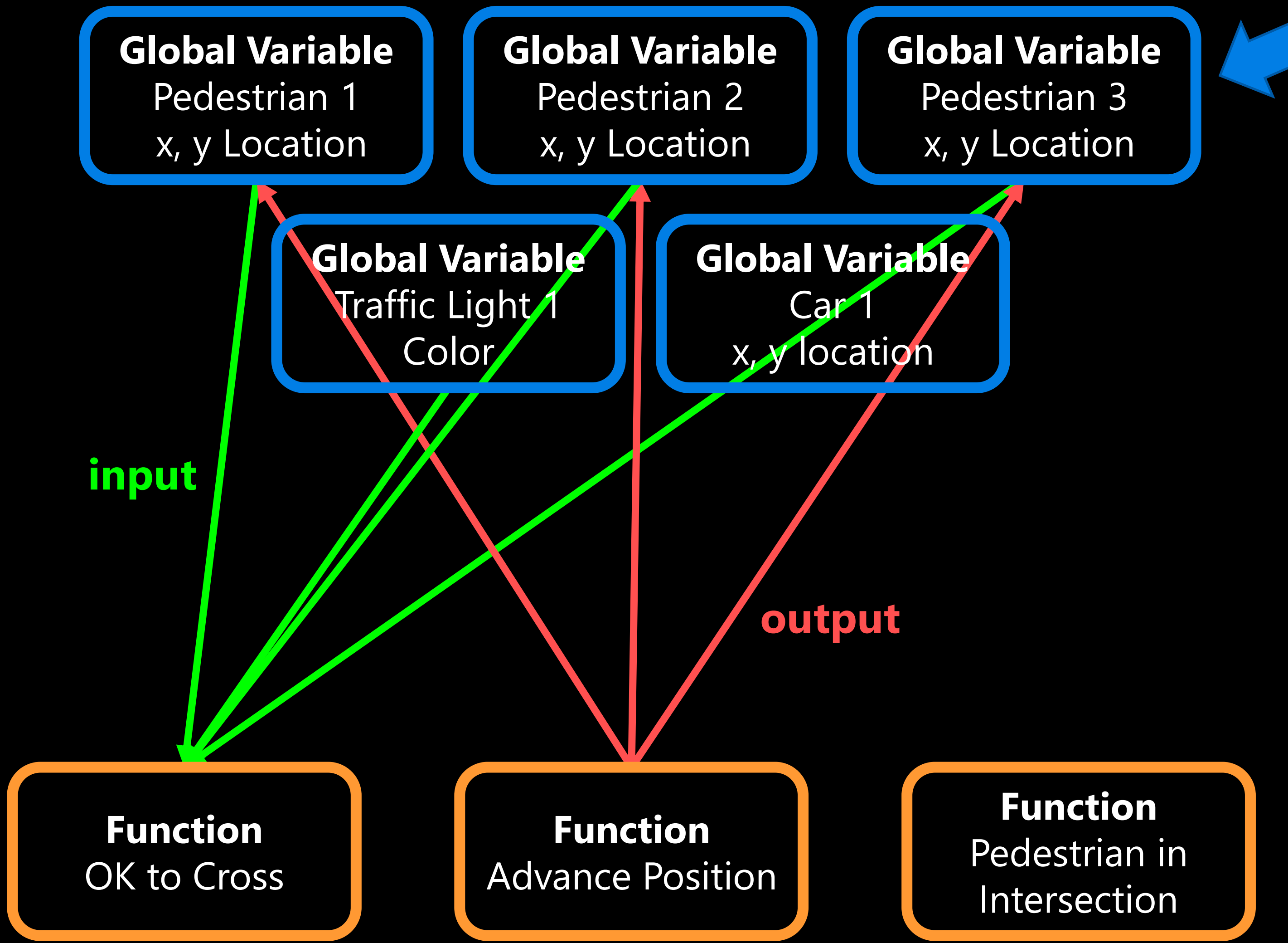
Function
OK to Cross

Function
Advance Position

Function
Pedestrian in Intersection



Procedural Programming



Global Variable
Pedestrian 1
x, y Location

Global Variable
Pedestrian 2
x, y Location

Global Variable
Pedestrian 3
x, y Location

Global Variable
Traffic Light 1
Color

Global Variable
Car 1
x, y location

input

output

Function
OK to Cross

Function
Advance Position

Function
Pedestrian in
Intersection

Data
Real World

Object-Oriented Programming

Car Object
x, y Location
Pedestrian in Intersection
Advance Position

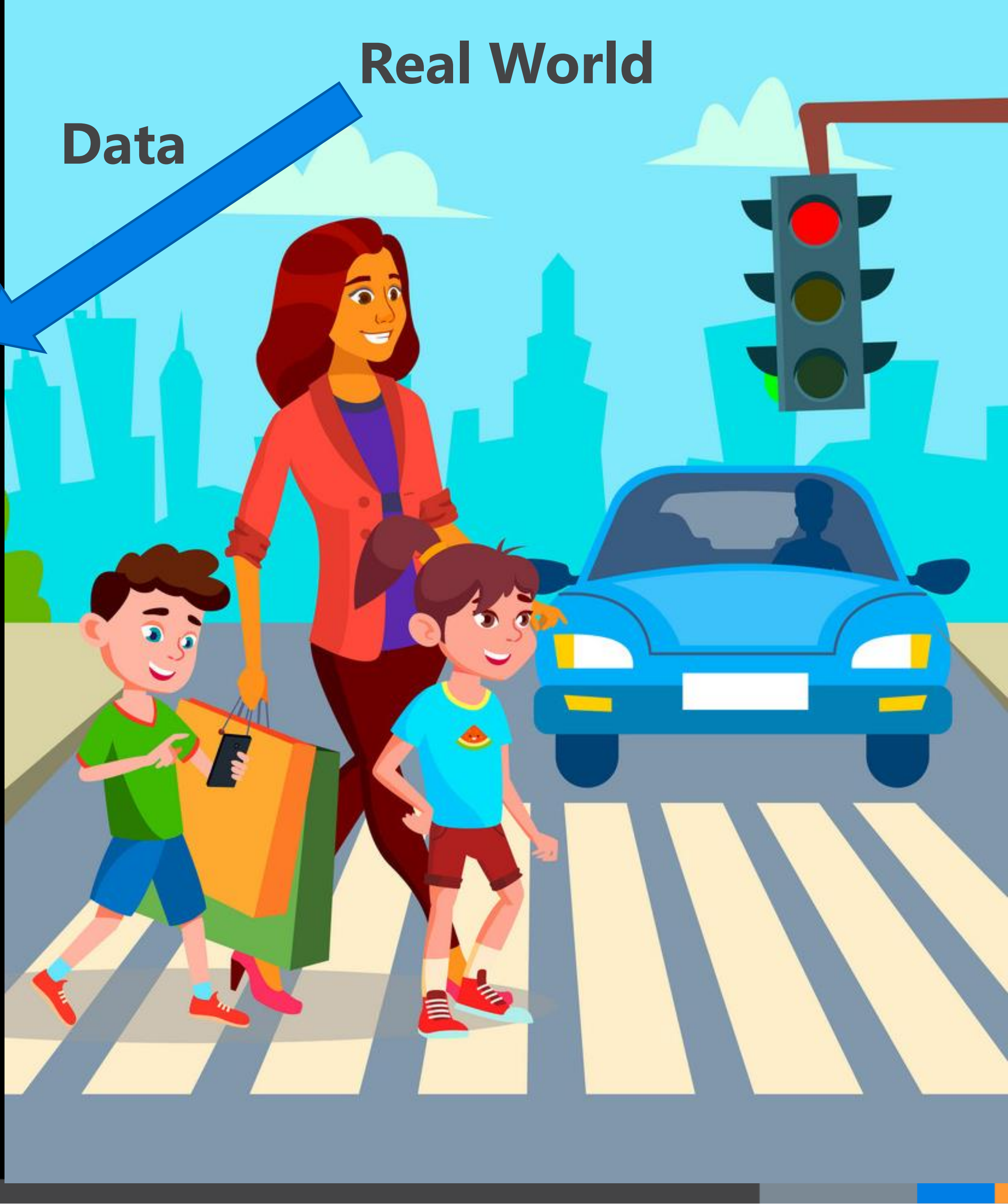
Traffic Light Object
Color
Change Color

Pedestrian Object
x, y Location
Ok to Cross
Advance Position

Pedestrian Object
x, y Location
Ok to Cross
Advance Position

Pedestrian Object
x, y Location
Ok to Cross
Advance Position

Encapsulation of Data and Functions



Object-Oriented Programming

- Often, an object definition corresponds to some object or concept in the real world.
- The functions that operate on that object correspond to the ways real-world objects interact.
- Examples:
    - **Oven Object:** the oven allows several specific operations, e.g., set the temperature, set a timer, etc.
    - **Cellphone Object:** we use a cellphone's own "methods" to send a text message, or to change its state to silent.
    - **Turtle Object:** we use a turtle's own "methods" to move around a 2D space.

Object-Oriented Programming

Data

Functions

Procedural

```
def up(y):
  return y + 1

def goto(x_new, y_new):
  return x_new, y_new

def right(x):
  return x + 1
```

```
x = 0
y = 0

y = up(y)
x, y = goto(-150, 100)
x = right(x)

print(x, y)
```

Object-Oriented

```
alex = Turtle(0, 0)


alex.up()
alex.goto(-150, 100)
alex.right()

print(alex.x, alex.y)
```

Objects in Python

Is **this** an instance of **this** class.

- **Everything in Python is an object.**
- Every value, variable, function, etc., is an object.
- Every time we create a variable we are making a new object.

```
>>> isinstance(4, object)
True

>>> isinstance(max, object)
True

>>> isinstance(“Hello”, object)
True
```

Objects in Python

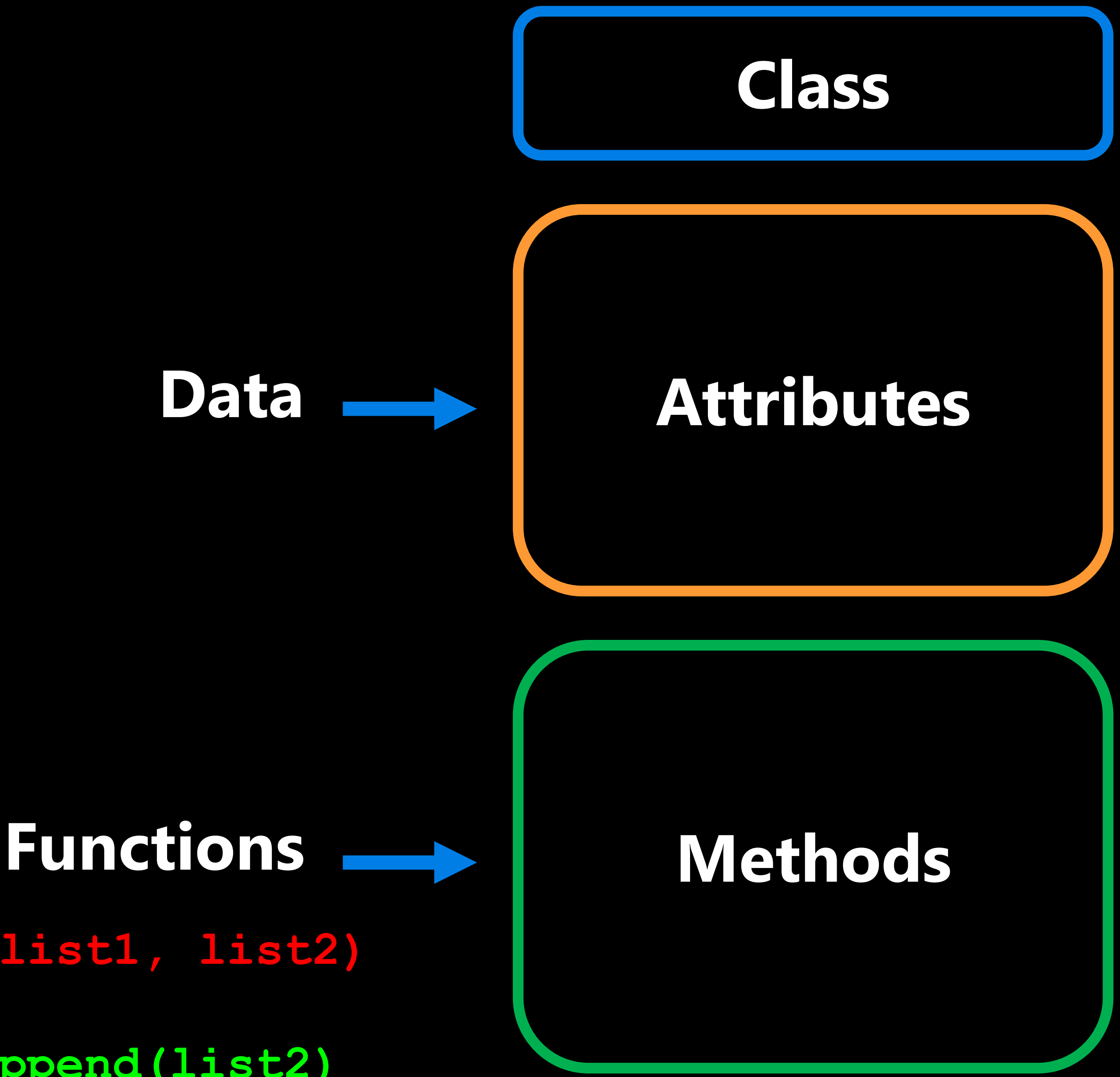
Is **this** an instance of **this** class.

- Each object has a type or **class** it is associated with.

```
>>> isinstance(“Hello”, str)
True
>>> isinstance(4, int)
True
>>> isinstance(4, float)
False
>>> isinstance(4.0, float)
True
>>> isinstance([1, 2], list)
True
```

Classes

- A class can be thought of as a template for the objects that are instances of it.
- An instance of a class refers to an object whose type is defined as the class.
- The words "instance" and "object" are used interchangeably.
- A Class is made up of attributes (**data**) and methods (**functions**).

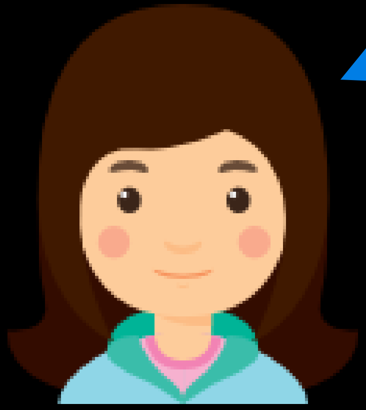

Class
Data
Attributes
Functions
Methods

```
append(list1, list2)

list1.append(list2)
```

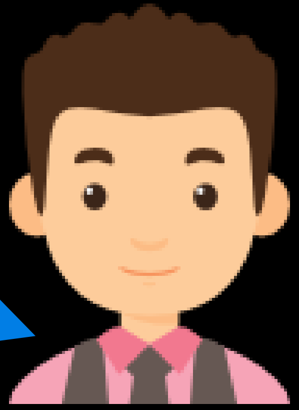
Classes

Instances (objects) of the **Person** class.



name: June
age: 34
city: Ottawa
gender: she/her

name: Ted
age: 31
city: Kingston
gender: he/him



name: Majid
age: 28
city: Toronto
gender: they/them

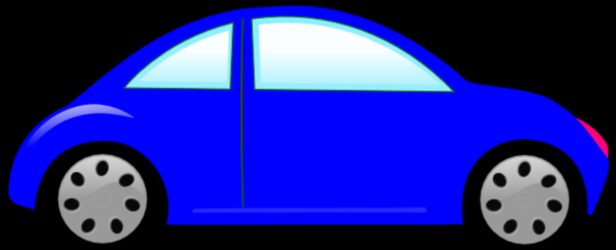
Person

name
age
city
gender

eat
study
sleep
play

Classes

Instances (objects) of the Car class.



model: Model S
company: Tesla
year: 2017
color: blue

model: Corolla
company: Toyota
year: 1980
color: red

model: Bus
company: Volkswagen
year: 1976
color: orange

Car

model
company
year
color

brake
accelerate
change oil
open trunk

Classes

Instances (objects) of the **Turtle** class.

name: **Susmit**
x location: **134**
y location: **45**

name: **Lucy**
x location: **24**
y location: **35**

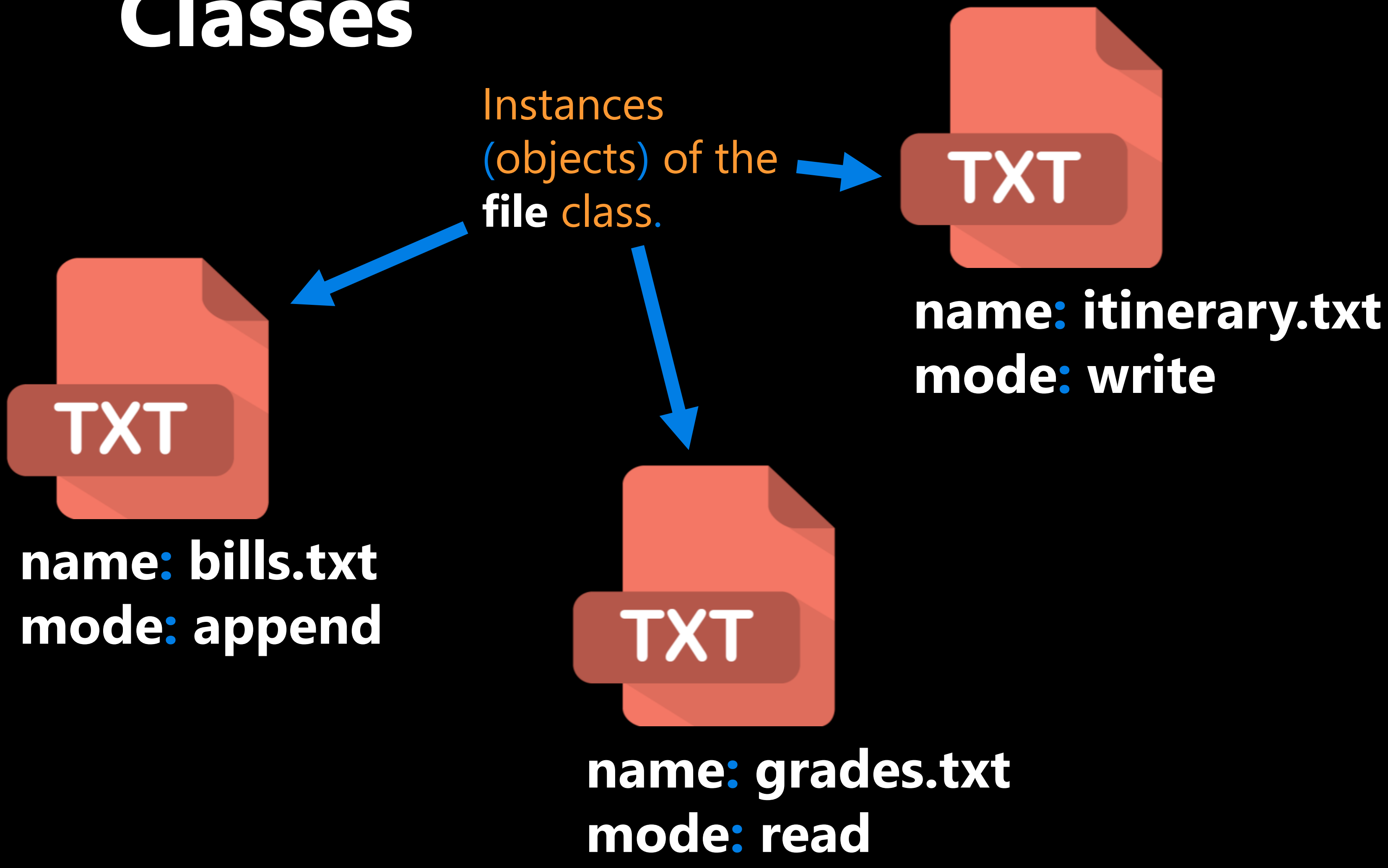
name: **Brian**
x location: **92**
y location: **62**

Turtle

name
x location
y location

move up
move down
move left
move right
go to

Classes



Instances (objects) of the **file** class.

name: itinerary.txt
mode: write

name: bills.txt
mode: append

name: grades.txt
mode: read

File

name
mode

read
readline
readlines

Classes

- General form of a Class:
  - Class Name
    - **CamelCase**
    - CourseGrades
    - BankAccount
    - FlightStatus
    - XRayImage
  - Constructor
  - Methods

```
class Name:

    def __init__(self, param1, param2, …):
        self.param1 = param1
        self.param2 = param2
        …
        body

    def method1(self, parameters):
        body

    def method2(self, parameters):
        body

    def method3(self, parameters):
        body
```

Classes

```
alex = Turtle(0, 0)


alex.up()
alex.goto(-150, 100)
alex.down()

print(alex.x, alex.y)
```

```
class Turtle:

    def __init__(self, x, y):
        self.x = x
        self.y = y

    def up(self):
        body

    def goto(self, x, y):
        body

    def down(self):
        body
```

Definition Recap

- Let's formally cover some important definitions.

Class

Object

Instantiate

Method

Attribute

Constructor

self

Definition Recap

- Template for creating objects.

```
class Name:

    def __init__(self, param1, param2, …):
        self.param1 = param1
        self.param2 = param2
        …
        body

    def method1(self, parameters):
        body

    def method2(self, parameters):
        body

    def method3(self, parameters):
        body
```

Class

Object

Instantiate

Method

Attribute

Constructor

self

Definitions

- An instance of a class.

```
class Turtle:

    def __init__(self, x, y):
        self.x = x
        self.y = y

    def up(self):
        body

    def goto(self, x, y):
        body

    def down(self):
        body
```

Class

Object

Instantiate

Method

Attribute

Constructor

self

```
alex = Turtle(0, 0)
```

alex is an instance of the **Turtle** class.

Definition Recap

- Creating (constructing) an instance of a class.

```
alex = Turtle(0, 0)
```

This is the process of instantiating.

Class

Object

Instantiate

Method

Attribute

Constructor

self

Definition Recap

- A function defined in a class.

```
def goto(x, y):
    body
```

Function

```
class Turtle:

    def __init__(self, x, y):
        self.x = x
        self.y = y

    def goto(self, x, y):
        body
```

Method

Class

Object

Instantiate

Method

Attribute

Constructor

self

Definitions

- A variable bound to an instance of a class.

```
alex = Turtle(0, 0)
alex.x
alex.y
```

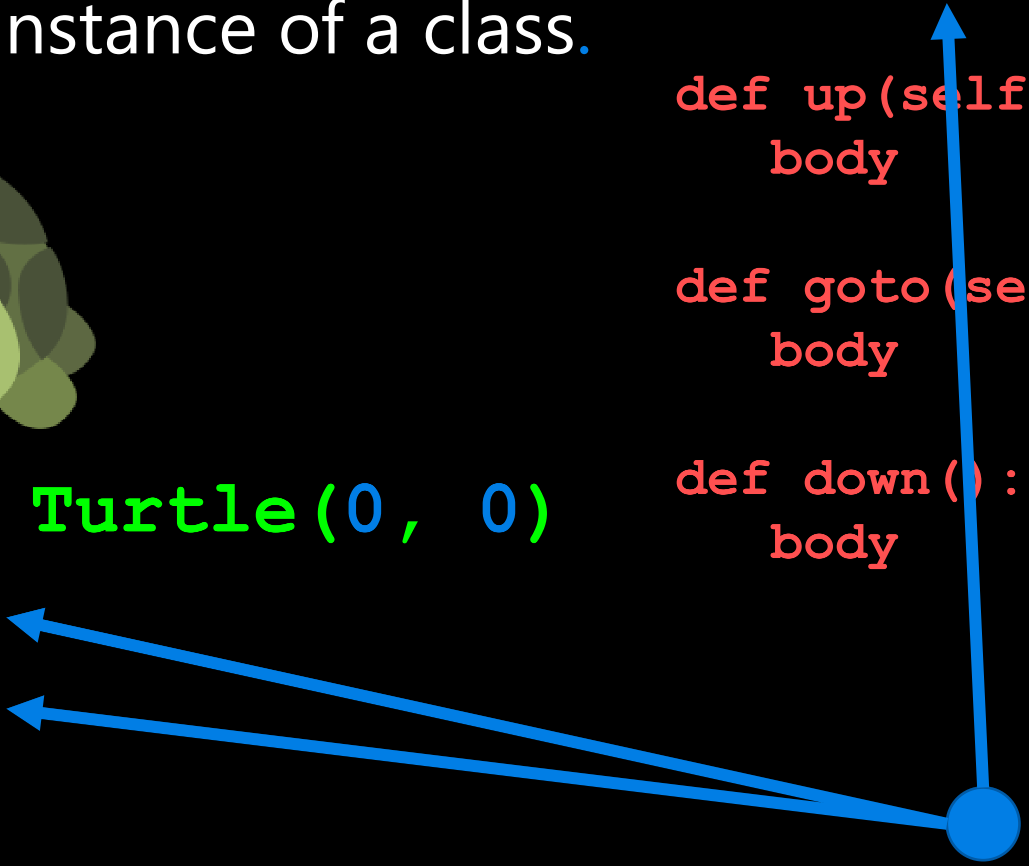
```
class Turtle:

    def __init__(self, x, y):
        self.x = x
        self.y = y

    def up(self):
        body

    def goto(self, x, y):
        body

    def down():
        body
```



Class

Object

Instantiate

Method

Attribute

Constructor

self

Definitions

- Responsible for setting up the initial state of a new instance.

```
alex = Turtle(0, 0)
alex.x
alex.y
```

```
class Turtle:

    def __init__(self, x, y):
        self.x = x
        self.y = y

    def up(self):
        body

    def goto(self, x, y):
        body

    def down(self):
        body
```

__init__ method is automatically run during instantiation.

Class

Object

Instantiate

Method

Attribute

Constructor

self

Definitions

- Reference to the instance of the class.
- Although you do not technically need to use the word self, it is widely adopted and is recommended.
- Understanding `self` is a challenge for most students so don't worry if you're confused.
- More on `self` in Thursday's lecture.

```
class Turtle:

    def __init__(self, x, y):
        self.x = x
        self.y = y

    def up(self):
        body

    def goto(self, x, y):
        body

    def down(self):
        body
```

Class

Object

Instantiate

Method

Attribute

Constructor

self

Definitions

```
katia is self
```

Outside Class

```
katia.attribute
katia.method
```

```
katia = Turtle(0, 0)

katia.up()
```

Inside Class

```
self.attribute
self.method
```

```
class Turtle:

    def __init__(self, x, y):
        self.x = x
        self.y = y

    def up(self):
        ...

    def goto(self, x, y):
        ...
        ...

    def get_position(self):
        ...

    def print_position(self):
        ...
```

Class

Object

Instantiate

Method

Attribute

Constructor

self

`katia is self`

Definitions

Outside Class

`katia.attribute`

`katia.method`

```
katia = Turtle(0, 0)

katia.up()
```

Inside Class

`self.attribute`

`self.method`

```
class Turtle:

    def __init__(self, x, y):
        self.x = x
        self.y = y

    def up(self):
        self.y += 1

    def goto(self, x, y):
        ...
        ...

    def get_position(self):
        ...

    def print_position(self):
        ...
```

- Class
- Object
- Instantiate
- Method
- Attribute
- Constructor
- **self**

Definitions

`katia is self`

Outside Class

`katia.attribute`

`katia.method`

```
katia = Turtle(0, 0)

katia.up()
katia.goto(-2, 10)
```

```
class Turtle:

    def __init__(self, x, y):
        self.x = x
        self.y = y

    def up(self):
        self.y += 1

    def goto(self, x, y):
        ...
        ...

    def get_position(self):
        ...

    def print_position(self):
        ...
```

Inside Class

`self.attribute`

`self.method`

- Class
- Object
- Instantiate
- Method
- Attribute
- Constructor
- **self**

Definitions

`katia is self`

Inside Class

`self.attribute`

`self.method`

Outside Class

`katia.attribute`

`katia.method`

```
katia = Turtle(0, 0)

katia.up()
katia.goto(-2, 10)
```

```
class Turtle:

    def __init__(self, x, y):
        self.x = x
        self.y = y

    def up(self):
        self.y += 1

    def goto(self, x, y):
        self.x = x
        self.y = y

    def get_position(self):
        ...

    def print_position(self):
        ...
```

Class

Object

Instantiate

Method

Attribute

Constructor

self

Definitions

```
katia is self
```

Outside Class

```
katia.attribute
katia.method
```

```
katia = Turtle(0, 0)

katia.up()
katia.goto(-2, 10)
x, y = katia.get_position()

pint(x, y)
>>> (-1, 10)
```

Inside Class

```
self.attribute
self.method
```

```
class Turtle:

    def __init__(self, x, y):
        self.x = x
        self.y = y

    def up(self):
        self.y += 1

    def goto(self, x, y):
        self.x = x
        self.y = y

    def get_position(self):
        ...

    def print_position(self):
        ...
```

Class

Object

Instantiate

Method

Attribute

Constructor

self

`katia is self`

Definitions

Outside Class

```
katia.attribute
katia.method
```

```
katia = Turtle(0, 0)

katia.up()
katia.goto(-2, 10)
x, y = katia.get_position()

pint(x, y)
>>> (-1, 10)
```

Inside Class

```
self.attribute
self.method
```

```
class Turtle:

    def __init__(self, x, y):
        self.x = x
        self.y = y

    def up(self):
        self.y += 1

    def goto(self, x, y):
        self.x = x
        self.y = y

    def get_position(self):
        return self.x, self.y

    def print_position(self):
        ...
```

Class

Object

Instantiate

Method

Attribute

Constructor

self

Definitions

`katia is self`

Outside Class

```
katia.attribute
katia.method
```

```
katia = Turtle(0, 0)

katia.up()
katia.goto(-2, 10)
x, y = katia.get_position()

pint(x, y)
>>> (-1, 10)

katia.print_position()
>>> -1 10
```

Inside Class

```
self.attribute
self.method
```

```
class Turtle:

    def __init__(self, x, y):
        self.x = x
        self.y = y

    def up(self):
        self.y += 1

    def goto(self, x, y):
        self.x = x
        self.y = y

    def get_position(self):
        return self.x, self.y

    def print_position(self):
        ...
```

- Class
- Object
- Instantiate
- Method
- Attribute
- Constructor
- **self**

Definitions

`katia is self`

Inside Class

`self.attribute`

`self.method`

```
class Turtle:

    def __init__(self, x, y):
        self.x = x
        self.y = y

    def up(self):
        self.y += 1

    def goto(self, x, y):
        self.x = x
        self.y = y

    def get_position(self):
        return self.x, self.y

    def print_position(self):
        print(self.x, self.y)
```

Outside Class

`katia.attribute`

`katia.method`

```
katia = Turtle(0, 0)

katia.up()
katia.goto(-2, 10)
x, y = katia.get_position()

pint(x, y)
>>> (-1, 10)

katia.print_position()
>>> -1 10
```

Class

Object

Instantiate

Method

Attribute

Constructor

self

`katia is self`

Definitions

Inside Class

```
self.attribute
self.method
```

Outside Class

```
katia.attribute
katia.method
```

```
class Turtle:

    def __init__(self, x, y):
        self.x = x
        self.y = y

    def up(self):
        self.y += 1
        self.print_position()
    def goto(self, x, y):
        self.x = x
        self.y = y
        self.print_position()
    def get_position(self):
        return self.x, self.y

    def print_position(self):
       print(self.x, self.y)
```

```
katia = Turtle(0, 0)

katia.up()
katia.goto(-2, 10)
x, y = katia.get_position()

pint(x, y)
>>> (-1, 10)

katia.print_position()
>>> -1 10
```

Class

Object

Instantiate

Method

Attribute

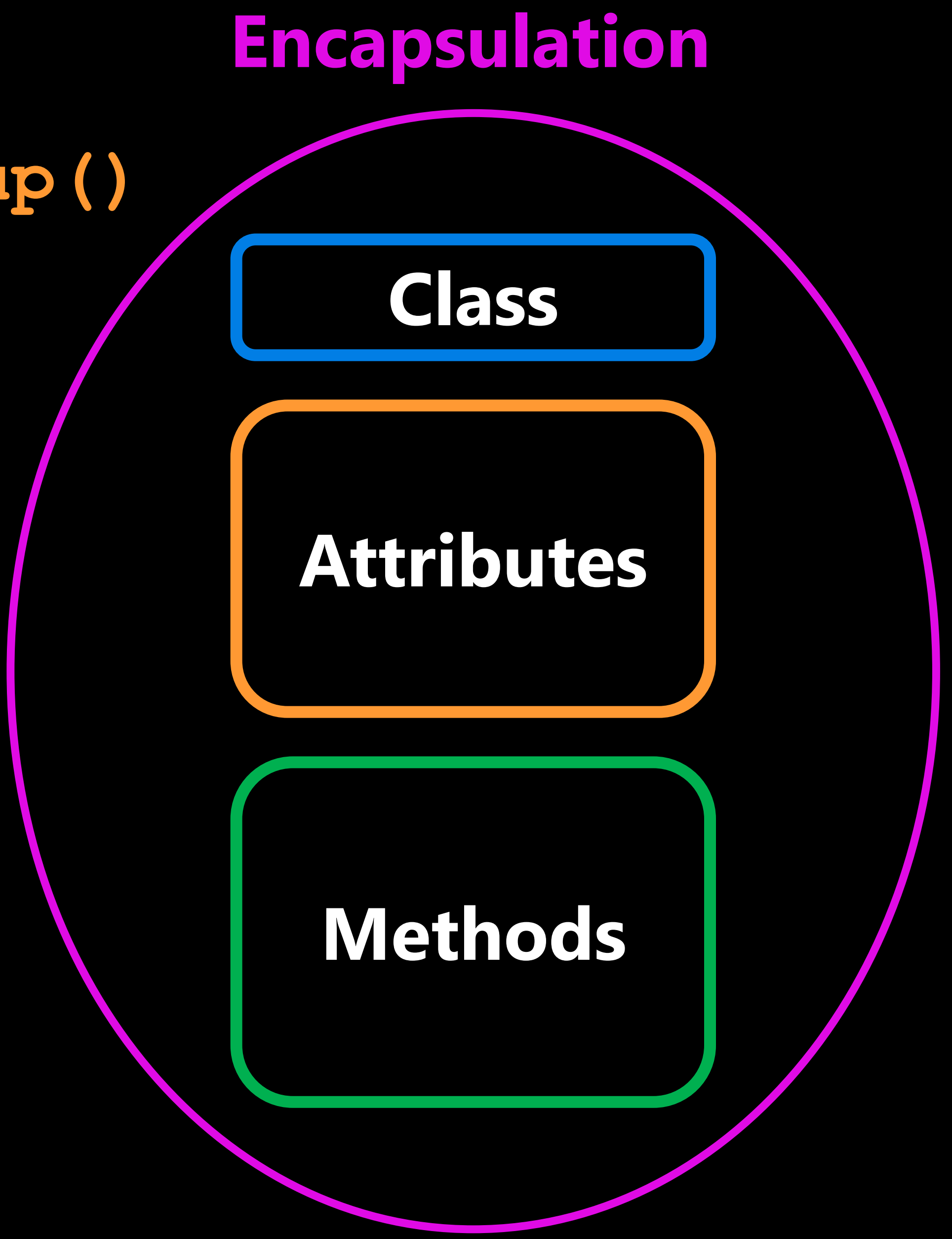
Constructor

self

Encapsulation

`y = up(y)`   `alex.up()`

- The core of object-oriented programming is the organization of the program by **encapsulating** related data and functions together in an object.
- To encapsulate something means to enclose it in some kind of container.
- In programming, encapsulation means keeping **data** and the **code** that uses it in one place and hiding the details of exactly how they work together.



Point Class: Constructor

- Our Point class needs to:
  - Contain data about the location of a Point instance.
  - Be able to calculate the distance between the Point instance and another point.

Point

x
y

distance between points

Point Class: Constructor

- Our Point class needs to:
  - Contain data about the location of a Point instance.
- Let's start with the attributes and the constructor.

Open your notebook

Click Link:
2. Write a Point Class: Constructor

Point Class: Methods

- Our Point class needs to:
  - Be able to calculate the distance between the Point instance and another point.
- Let's now write the method.

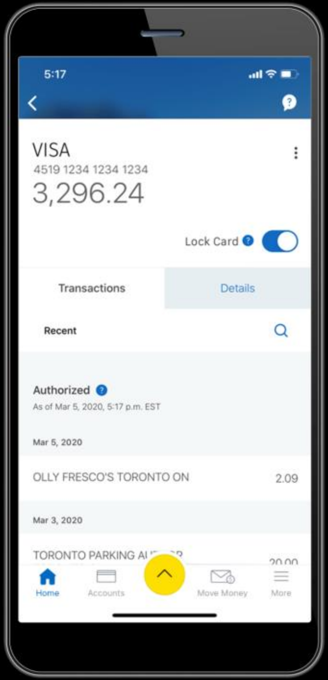
Open your notebook

Click Link:

3. Write a Point Class: Methods

Encapsulation

- Let's highlight the value of encapsulation with a bank **Account** class.
- Attributes:
  - Account owner's name.
  - Current account balance.
- Methods:
  - Deposit money.
  - Withdraw money.
  - Print account balance.


5:17
VISA
Lock Card
Transactions
Details
Recent
Home
Accounts
Move Money
More

4519 1234 1234 1234
3,296.24

Authorized
As of Mar 5, 2020, 5:17 p.m. EST

Mar 5, 2020
OLLY FRESCO'S TORONTO ON 2.09

Mar 3, 2020
TORONTO PARKING AU 20.00

Open your notebook

Click Link:
4. Bank Account Class

APS106

objects, classes, and methods.

Week 10 | Lecture 1 (10.1)

if nothing else, write #cleancode