



# Computational Structures in Data Science

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## Object-Oriented Programming

# 50 Lines of Code That Changed The Word

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- <https://slate.com/technology/2019/10/consequential-computer-code-software-history.html>
- Apollo's Lunar guidance system
- `Printf('Hello, world\n');`
- The origins of email
- Google's PageRank Algorithm
- Your spot here....



# Computational Concepts Toolbox

- Data type: values, literals, operations,
- Expressions, Call expression
- Variables
- Assignment Statement
- Sequences: tuple, list
- Dictionaries
- Data structures
- Tuple assignment
- Function Definition Statement
- Conditional Statement
- Iteration: list comp, for, while
- Lambda function expr.
- Higher Order Functions
  - Functions as Values
  - Functions with functions as argument
  - Assignment of function values
- Higher order function patterns
  - Map, Filter, Reduce
- Function factories – create and return functions
- Recursion
  - Linear, Tail, Tree
- Abstract Data Types
- Generators
- Mutation





# Mind Refresher 1

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- A mutation is...
  - A) A monster from a movie
  - B) A change of state
  - C) Undesirable
  - D) All of the above





# Mind Refresher 2

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- We try to hide states because...

- A) We don't like them
- B) Math doesn't have them
- C) It's easier to program not having to think about them
- D) All of the above





# Mind Refresher 3

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- Where do we hide states?
  - A) Local variables in functions
  - B) Private variables in objects
  - C) Function arguments in recursion
  - D) All of the above



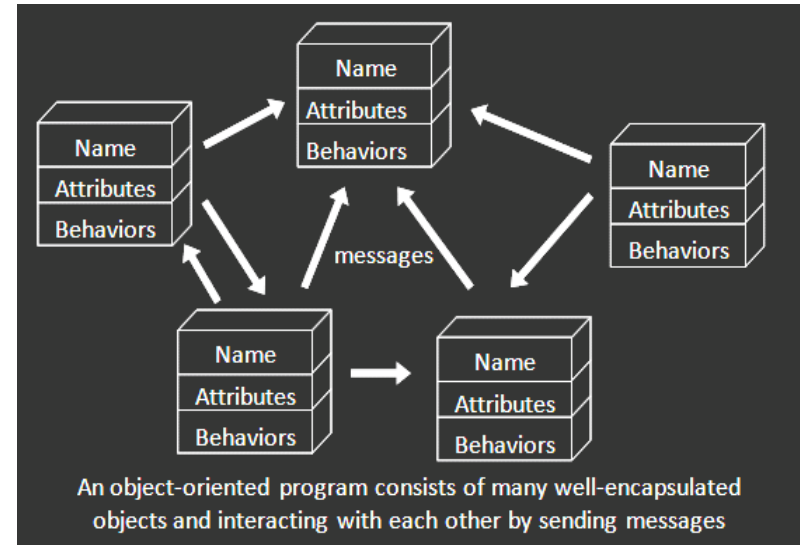
**Solution:**

**D) All of the above**



# Object-Oriented Programming (OOP)

- **Objects** as data structures
  - With **methods** you ask of them
    - » These are the behaviors
  - With **local state**, to remember
    - » These are the attributes
- **Classes** & **Instances**
  - Instance an example of class
  - E.g., Fluffy is instance of Dog
- **Inheritance** saves code
  - Hierarchical classes
  - E.g., pianist special case of musician, a special case of performer
- **Examples (though not pure)**
  - Java, C++

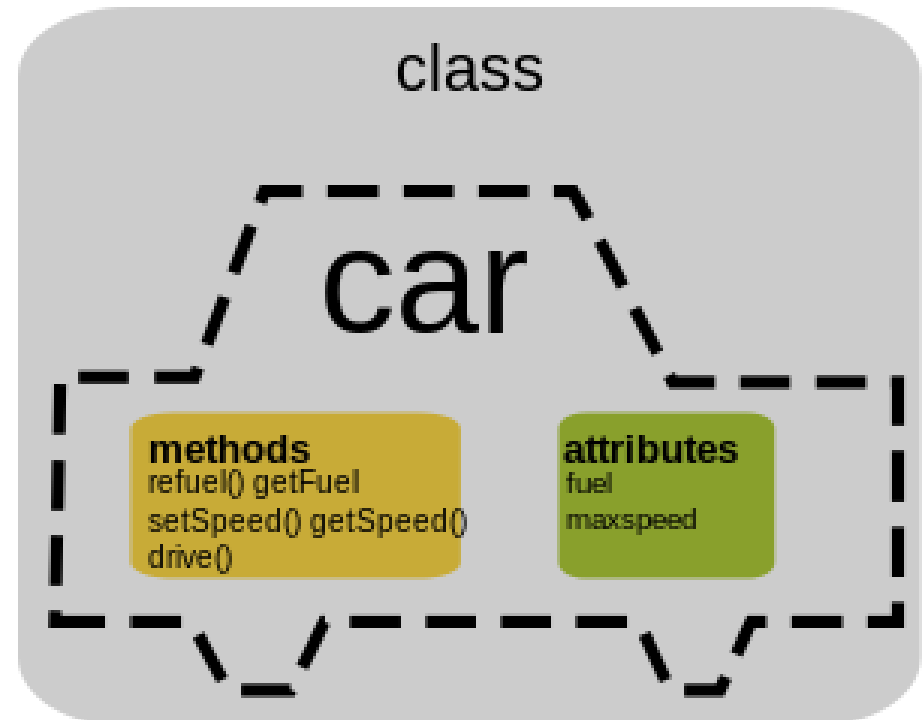


[www3.ntu.edu.sg/home/ehchua/programming/java/images/OOP-Objects.gif](http://www3.ntu.edu.sg/home/ehchua/programming/java/images/OOP-Objects.gif)



# Classes

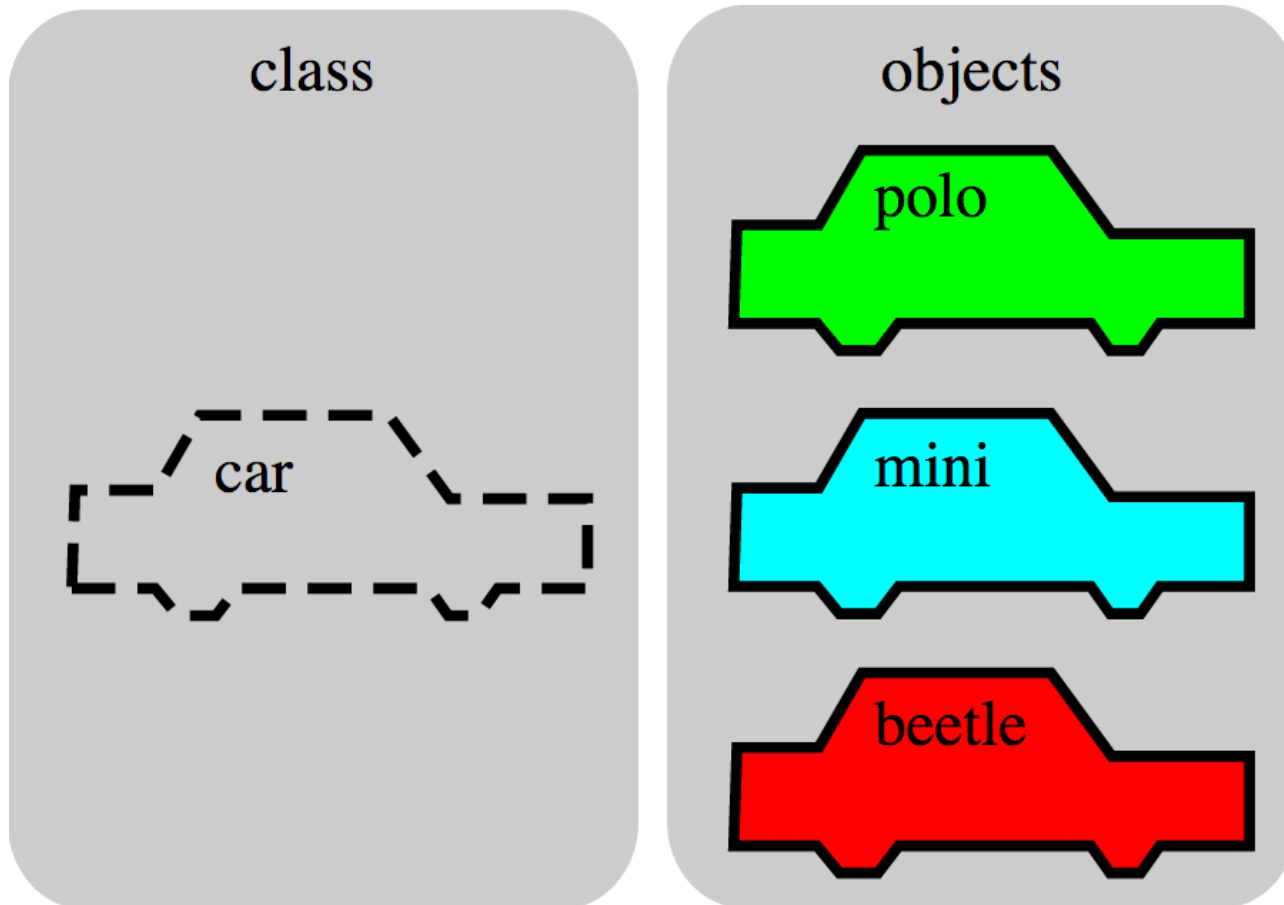
- **Consist of data and behavior, bundled together to create abstractions**
  - Abstract Data Types
- **A class has**
  - attributes (variables)
  - methods (functions)**that define its behavior.**





# Objects

- An object is the instance of a class.





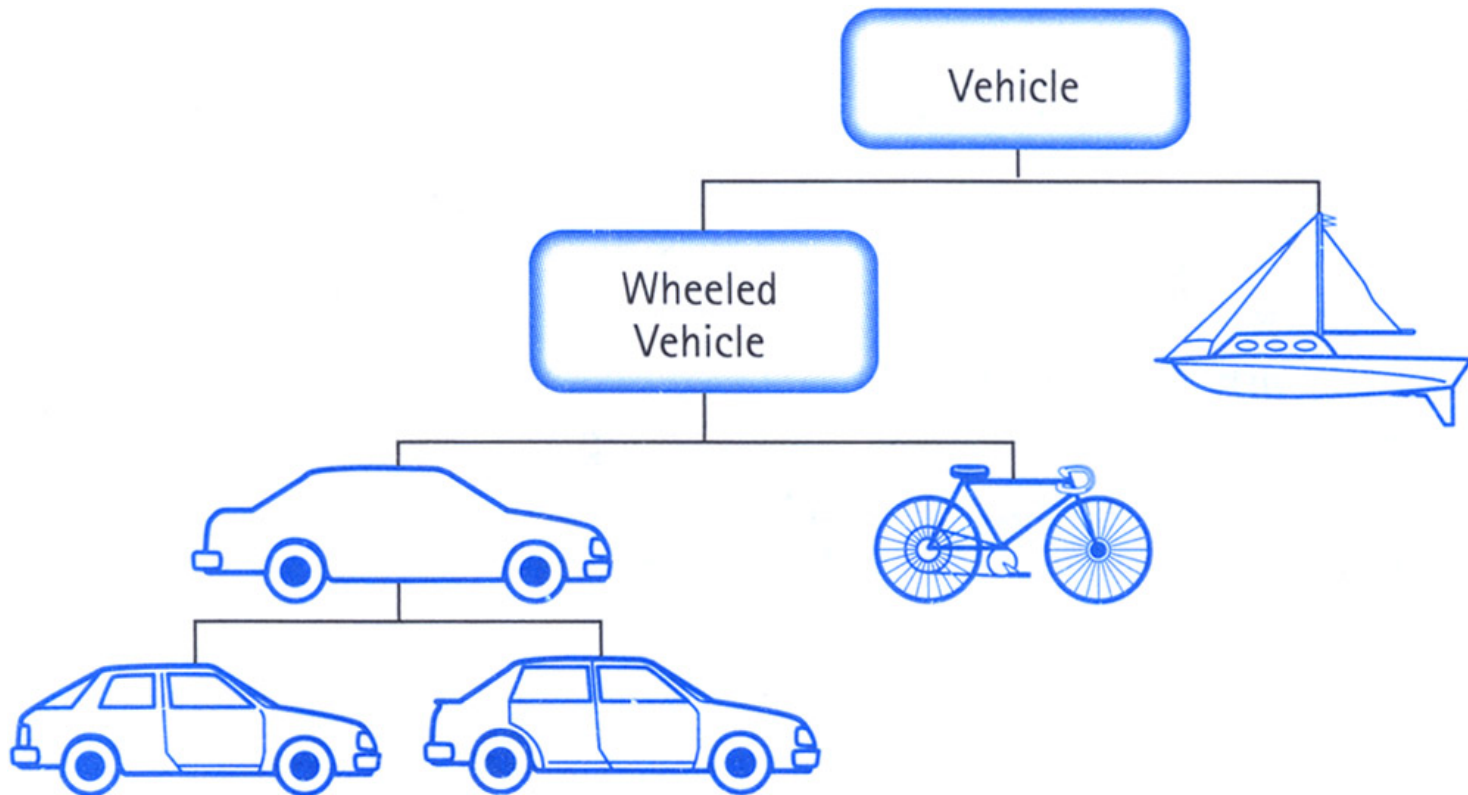
# Objects

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- **Objects are concrete instances of classes in memory.**
- **They can have state**
  - mutable vs immutable
- **Functions do one thing (well)**
  - Objects do a collection of related things
- **In Python, everything is an object**
  - All **objects** have **attributes**
  - Manipulation happens through **methods**

# Class Inheritance

- **Classes can inherit methods and attributes from parent classes but extend into their own class.**





# Inheritance

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- **Define a class as a specialization of an existing class**
- **Inherent its attributes, methods (behaviors)**
- **Add additional ones**
- **Redefine (specialize) existing ones**
  - **Ones in superclass still accessible in its namespace**



# Baseline: Bank account using dictionary

```
account_number_seed = 1000

def account(name, initial_deposit):
    global account_number_seed
    account_number_seed += 1
    return {'Name' : name, 'Number': account_number_seed,
            'Balance' : initial_deposit}

def account_name(acct):
    return acct['Name']

def account_balance(acct):
    return acct['Balance']

def account_number(acct):
    return acct['Number']

def deposit(acct, amount):
    acct['Balance'] += amount
    return acct['Balance']

def withdraw(acct, amount):
    acct['Balance'] -= amount
    return acct['Balance']
```

```
>>> my_acct = account('David Culler', 100)
>>> my_acct
{'Name': 'John Doe', 'Balance': 100,
 'Number': 1001}
>>> account_number(my_acct)
1001
>>> your_acct = account("Fred Jones", 475)
>>> account_number(your_acct)
1002
>>>
```



# Python class statement

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```
class ClassName:  
    <statement-1>  
    .  
    .  
    .  
    <statement-N>
```

```
class ClassName ( inherits ):  
    <statement-1>  
    .  
    .  
    .  
    <statement-N>
```



# Example: Account

```
class BaseAccount:
```

new namespace

```
    def init(self, name, initial_deposit):  
        self.name = name  
        self.balance = initial_deposit
```

```
    def account_name(self):  
        return self.name
```

```
    def account_balance(self):  
        return self.balance
```

```
    def withdraw(self, amount):  
        self.balance -= amount  
        return self.balance
```

attributes

The object

da dot

methods



# Creating an object, invoking a method

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The Class Constructor

```
my_acct = BaseAccount()  
my_acct.init("John Doe", 93)  
my_acct.withdraw(42)
```

da dot





# Special Initialization Method

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```
class BaseAccount:

    def __init__(self, name, initial_deposit):
        self.name = name
        self.balance = initial_deposit

    def account_name(self):
        return self.name

    def account_balance(self):
        return self.balance

    def withdraw(self, amount):
        self.balance -= amount
        return self.balance
```

*return None*



# More on Attributes

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- Attributes of an object accessible with 'dot' notation  
`obj.attr`
- You can distinguish between "public" and "private" data.
  - Used to clarify to programmers how you class should be used.
  - In Python an `_` prefix means "this thing is private"
  - `_foo` and `__foo` do different things inside a class.
  - More for the curious.
- Class variables vs Instance variables:
  - Class variable set for all instances at once
  - Instance variables per instance value



# Example

---

```
class BaseAccount:

    def __init__(self, name, initial_deposit):
        self.name = name
        self.balance = initial_deposit

    def name(self):
        return self.name

    def balance(self):
        return self.balance

    def withdraw(self, amount):
        self.balance -= amount
        return self.balance
```



# Example: “private” attributes

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```
class BaseAccount:

    def __init__(self, name, initial_deposit):
        self._name = name
        self._balance = initial_deposit

    def name(self):
        return self._name

    def balance(self):
        return self._balance

    def withdraw(self, amount):
        self._balance -= amount
        return self._balance
```



# Example: class attribute

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```
class BaseAccount:
    account_number_seed = 1000

    def __init__(self, name, initial_deposit):
        self._name = name
        self._balance = initial_deposit
        self._acct_no = BaseAccount.account_number_seed

        BaseAccount.account_number_seed += 1

    def name(self):
        return self._name

    def balance(self):
        return self._balance

    def withdraw(self, amount):
        self._balance -= amount
        return self._balance
```



# More class attributes

---

```
class BaseAccount:
    account_number_seed = 1000
    accounts = []
    def __init__(self, name, initial_deposit):
        self._name = name
        self._balance = initial_deposit
        self._acct_no = BaseAccount.account_number_seed

        BaseAccount.account_number_seed += 1
        BaseAccount.accounts.append(self)

    def name(self):
        ...

    def show_accounts():
        for account in BaseAccount.accounts:
            print(account.name(),
                  account.account_no(), account.balance())
```



# Example

---

```
class Account(BaseAccount):  
    def deposit(self, amount):  
        self._balance += amount  
        return self._balance
```



# More special methods

```
class Account(BaseAccount):
    def deposit(self, amount):
        self._balance += amount
        return self._balance

    def __repr__(self):
        return '<' + str(self._acct_no) +
            '[' + str(self._name) + ']' >'

    def __str__(self):
        return 'Account: ' + str(self._acct_no) +
            '[' + str(self._name) + ']'

    def show_accounts():
        for account in BaseAccount.accounts:
            print(account)
```

Goal: unambiguous

Goal: readable





# Classes using classes

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```
class Bank:
    accounts = []

    def add_account(self, name, account_type,
                    initial_deposit):
        assert (account_type == 'savings') or
            (account_type == 'checking'), "Bad Account type"
        assert initial_deposit > 0, "Bad deposit"
        new_account = Account(name, account_type,
                               initial_deposit)
        Bank.accounts.append(new_account)

    def show_accounts(self):
        for account in Bank.accounts:
            print(account)
```



# Thoughts for the Wandering Mind

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**Consider the following Python3 code:**

```
__='__=%r;print __(%%)__';print __(%).__
```

What does it do?

Can you find other ways to do the same?