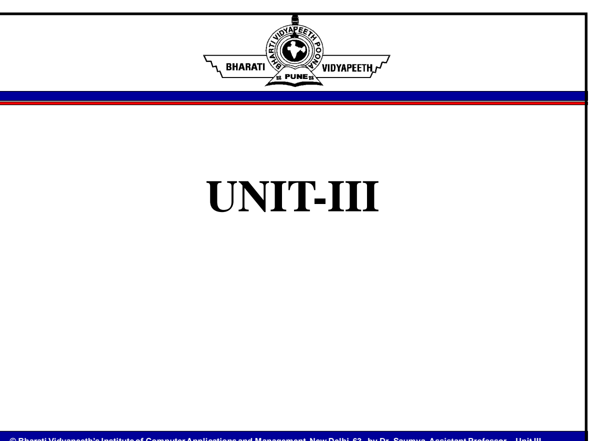

UNIT-III

Learning Objectives

In this unit, we'll cover the following:

- **Object Oriented Programming Concepts**
- **Classes and Objects**
- **Inheritance**
- **Polymorphism**
- **Abstract Classes**
- **Threads**
- **Exception Handling**

Object Oriented Programming Concepts

- **Object-oriented programming** (OOP) is a method of structuring a program by bundling related properties and behaviors into individual **objects**.
- An object could represent a person with **properties** like a name, age, and address and **behaviors** such as walking, talking, breathing, and running. Or it could represent an email with properties like a recipient list, subject, and body and behaviors like adding attachments and sending.
- Object-oriented programming is an approach for modeling concrete, real-world things, like cars, as well as relations between things, like companies and employees, students and teachers, and so on. OOP models real-world entities as software objects that have some data associated with them and can perform certain functions.

OOPS in Python

- Python has been an object-oriented language since it existed. Because of this, creating and using classes and objects are very easy.
- Unlike procedure oriented programming, where the main emphasis is on functions, object oriented programming stresses on objects.
- The key takeaway is that objects are at the center of object-oriented programming in Python, not only representing the data, as in procedural programming, but in the overall structure of the program as well.

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Overview of OOP Terminology

- **Class** − A user-defined prototype for an object that defines a set of attributes that characterize any object of the class. The attributes are data members (class variables and instance variables) and methods, accessed via dot notation.
- **Class variable** − A variable that is shared by all instances of a class. Class variables are defined within a class but outside any of the class's methods. Class variables are not used as frequently as instance variables are.
- **Data member** − A class variable or instance variable that holds data associated with a class and its objects.
- **Function overloading** − The assignment of more than one behavior to a particular function. The operation performed varies by the types of objects or arguments involved.

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Overview of OOP Terminology continued…

- **Instance variable** − A variable that is defined inside a method and belongs only to the current instance of a class.
- **Inheritance** − The transfer of the characteristics of a class to other classes that are derived from it.
- **Instance** − An individual object of a certain class. An object obj that belongs to a class Circle, for example, is an instance of the class Circle.
- **Instantiation** − The creation of an instance of a class.
- **Method** − A special kind of function that is defined in a class definition.
- **Object** − A unique instance of a data structure that's defined by its class. An object comprises both data members (class variables and instance variables) and methods.
- **Operator overloading** − The assignment of more than one function to a particular operator.

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Creating a Class in Python

Problem with primitive and advanced data types:
Aarti=[“Aarti Sharma”,24, “Officer”, 2018]

Supreet=[“Supreet Kaur”, “Sr. Manager”, 2010]

- It can make larger code files more difficult to manage.
- It can introduce errors if not every employee has the same number of elements in the list.

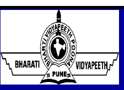
A great way to make this type of code more manageable and more maintainable is to use **classes**.

Classes

- Classes are used to create user-defined data structures. Classes define functions called **methods**, which identify the behaviors and actions that an object created from the class can perform with its data.
- A class is a blueprint for how something should be defined. It doesn't actually contain any data.
- While the class is the blueprint, an **instance** is an object that is built from a class and contains real data. Put another way, a class is like a form or questionnaire. An instance is like a form that has been filled out with information.

Some points on Python class:

- Classes are created by keyword class.
- Attributes are the variables that belong to a class.
- Attributes are always public and can be accessed using the dot (.) operator. Eg.: Myclass.Myattribute



Defining a Class

All class definitions start with the ***class*** keyword, which is followed by the name of the class and a colon. Any code that is indented below the class definition is considered part of the class.

The first string inside the class is called docstring and has a brief description about the class. Although not mandatory, this is highly recommended.

```
Class My_Class:
    ' I am creating my first class in Python'
    x=5
```

A class creates a new local namespace where all its attributes are defined. Attributes may be data or functions.

Creating an Object in Python

An Object is an instance of a Class. A class is like a blueprint while an instance is a copy of the class with *actual values*.

An object consists of :

- **State:** It is represented by the attributes of an object. It also reflects the properties of an object.
- **Behavior:** It is represented by the methods of an object. It also reflects the response of an object to other objects.
- **Identity:** It gives a unique name to an object and enables one object to interact with other objects.

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Creating an Object in Python

Declaring Objects (Also called instantiating a class)

When an object of a class is created, the class is said to be instantiated. All the instances share the attributes and the behavior of the class. But the values of those attributes, i.e. the state are unique for each object. A single class may have any number of instances.

Create an object named p1, and print the value of x:

```
p1 = My_Class()
print(p1.x)
```

The class object could be used to access different attributes. Attributes may be data or method. Methods of an object are corresponding functions of that class.

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The __init__() Function

Class functions that begin with double underscore _ are called special functions as they have special meaning.

Of one particular interest is the _init_() function. This special function gets called whenever a new object of that class is instantiated.

This type of function is also called constructors in Object Oriented Programming (OOP) languages like C++ and Java. We normally use it to initialize all the variables or object state.

Like methods, a constructor also contains a collection of statements(i.e. instructions) that are executed at the time of Object creation. It is run as soon as an object of a class is instantiated.

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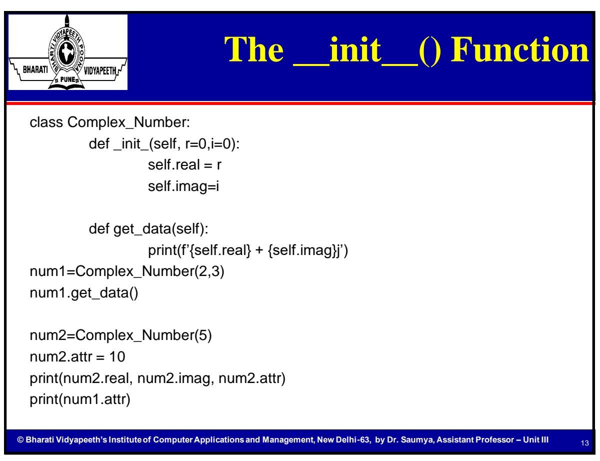
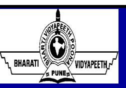


Object Methods

Objects can also contain methods. Methods in objects are functions that belong to the object.

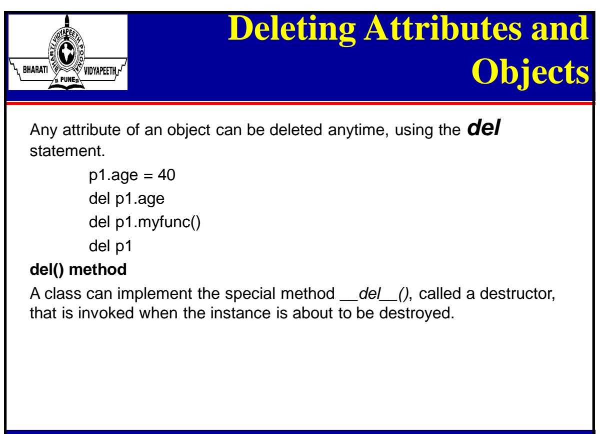
```
class Person:
  def __init__(self, name, age):
    self.name = name
    self.age = age

  def myfunc(self):
    print("Hello my name is " + self.name)

p1 = Person("John", 36)
p1.myfunc()
```

Self Parameter

The self parameter is a reference to the current instance of the class, and is used to access variables that belongs to the class.

- It does not have to be named ***self***, you can call it whatever you like, but it has to be the first parameter of any function in the class
- Class methods must have an extra first parameter in the method definition. We do not give a value for this parameter when we call the method, Python provides it.
- If we have a method that takes no arguments, then we still have to have one argument.
- This is similar to this pointer in C++ and this reference in Java.
- When we call a method of this object as myobject.method(arg1, arg2), this is automatically converted by Python into MyClass.method(myobject, arg1, arg2) – this is all the special self is about.



Deleting Attributes and Objects

```
class Point:
        def __init__(self,x=0,y=0)
                self.x=x
                self.y=y
        def __del__(self)
                class_name = self.__class__.__name__
                print class_name, "destroyed"
pt1=point()
pt2 = pt1
pt3 = pt1
print  id(pt1), id(pt2), id(pt3)
del pt1   del pt2   del pt3
```

This __del__() destructor prints the class name of an instance that is about to be destroyed.

Built-In Class Attributes

- Every Python class keeps following built-in attributes and they can be accessed using dot operator like any other attribute −
- **__dict__** − Dictionary containing the class's namespace.
- **__doc__** − Class documentation string or none, if undefined.
- **__name__** − Class name.
- **__module__** − Module name in which the class is defined. This attribute is "__main__" in interactive mode.
- **__bases__** − A possibly empty tuple containing the base classes, in the order of their occurrence in the base class list.

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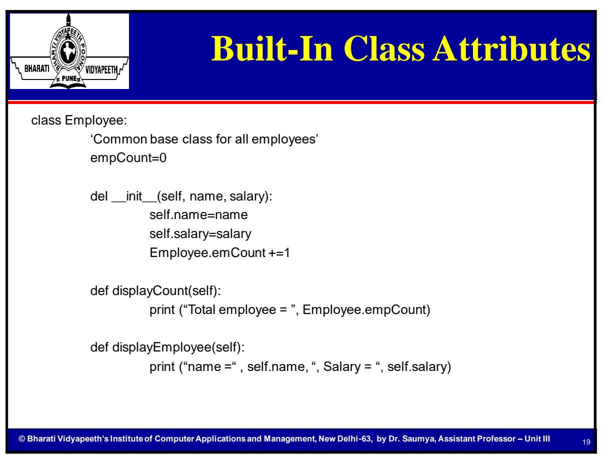

Built-In Class Attributes

```
print "Employee.__doc__:" , Employee.__doc__
print "Employee.__name__:" , Employee.__name__
print "Employee.__module__:" , Employee.__module__
print "Employee.__bases__:" , Employee.__bases__
print "Employee.__dict__:" , Employee.__dict__
```

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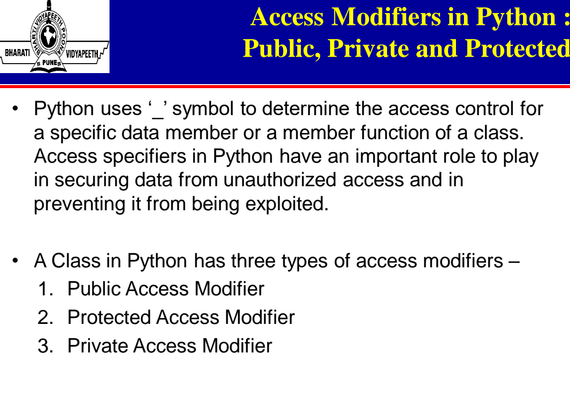


Public Access Modifier

The members of a class that are declared public are easily accessible from any part of the program. All data members and member functions of a class are public by default.

In previous examples :

self.name
self.age
myfunc()

Are all public members.

Protected Access Modifier

The members of a class that are declared protected are only accessible to a class derived from it. Data members of a class are declared protected by adding a single underscore '_' symbol before the data member of that class.

```
class student:
        _name = None
        _roll = None
        _branch = None
def __init__(self, name , roll, branch):
        self._name = name
        self._roll = roll
        self._branch = branch
def _displayRollAndBranch(self):
        print(self._roll)
        print(self._branch)
```

Protected Access Modifier

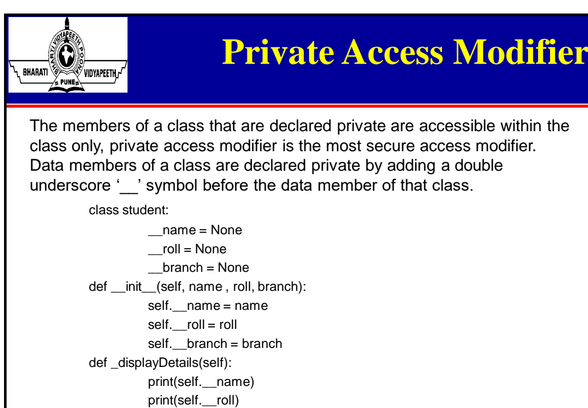
```
Class Derived_Stud(student):
        def __init__(self, name, roll, branch):
                student.__init__(self, name, roll, branch)

        def displayDetails:
                print("Name:", self.name)
                self._displayRollAndBranch()

Obj = Derived_Stud("Anuj", 170334, "Computer Applications")

Obj.displayDetails()
```

In the above program,_name, _roll and _branch are protected data members and _displayRollAndBranch() method is a protected method of the super class **Student**. The displayDetails() method is a public member function of the class **Derived_Stud.**



Private Access Modifier

The members of a class that are declared private are accessible within the class only, private access modifier is the most secure access modifier. Data members of a class are declared private by adding a double underscore '__' symbol before the data member of that class.

```
class student:
        __name = None
        __roll = None
        __branch = None
def __init__(self, name , roll, branch):
        self.__name = name
        self.__roll = roll
        self.__branch = branch
def _displayDetails(self):
        print(self.__name)
        print(self.__roll)
        print(self.__branch)
```

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Private Access Modifier

```
def accessPrivateMethod(self)
        self.__discplayDetails()

Obj = student("Anuj", 170334, "Computer Applications")

Obj.accessPrivateMethod()
```

In the above program,__name, __roll and __branch are private data members and _displayDetails() method is a private member function of the class **student**. acessPrivateMethod() method is a public member function of the class **student** which can be accessed from anywhere within the program. The acessPrivateMethod() method accesses the private members of the class **student**.

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Decorators in Python

- A **decorator** is a design pattern in **Python** that allows a user to add new functionality to an existing object without modifying its structure. Python has an interesting feature called **decorators** to add functionality to an existing code.
- This is also called **metaprogramming** because a part of the program tries to modify another part of the program at compile time.
- Decorators are very powerful and useful tool in Python since it allows programmers to modify the behavior of function or class. Decorators allow us to wrap another function in order to extend the behavior of the wrapped function, without permanently modifying it.
- Functions in Python can be used or passed as arguments.
  - A function is an instance of the Object type.
  - You can store the function in a variable.
  - You can pass the function as a parameter to another function.
  - You can return the function from a function.

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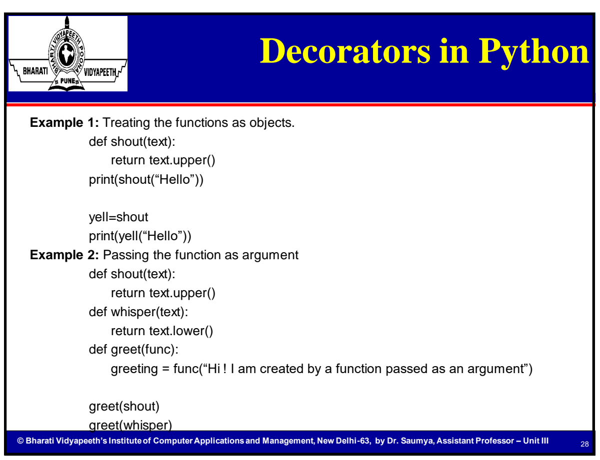


Decorators in Python

Another example:

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

def dec(x):
    return x-1

def operator(func,x):
    result=func(x)
    return result

>>>operator(inc,21)
>>>operator(dec,21)
```


Decorators in Python

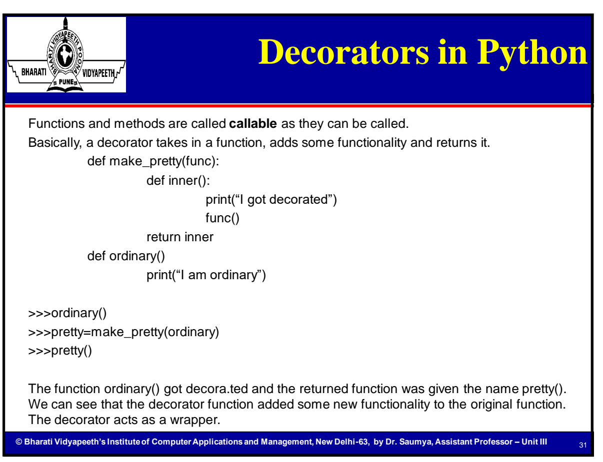
Example 3: Returning functions from another functions.

```
def is_called():
    def is_returned():
        print("Hello")
    return is_returned

new = is_called()

new()
```

Here is_retured() is a nested function which is defined and returned each time we call is_called().



Decorators in Python

Generally, we decorate a function and reassign it as,

ordinary = make_pretty(ordinary)

We can use the @symbol along with the name of the decorator function and place it above the definition of the function to be decorated. For example,

```
@make_pretty
def ordinary()
        print("I am ordinary")
```

It is equivalent to following:

```
def ordinary()
        print("I am ordinary")
ordinary = make_pretty(ordinary)
```

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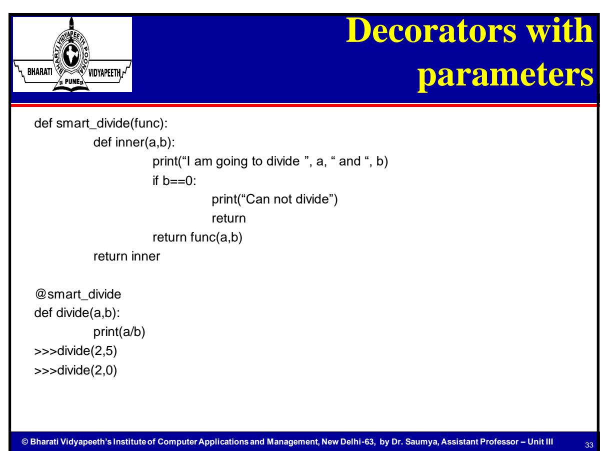


Different Types of Methods

There can be three types of methods in a class:

1. Instance methods
2. Class Methods
3. Static Methods

- The method **MyFunc()** is a regular instance method. That's the basic, no-frills method type you'll use most of the time. You can see the method takes one parameter, self, which points to an instance of class **Person** when the method is called (but of course instance methods can accept more than just one parameter).
- Through the self parameter, instance methods can freely access attributes and other methods on the same object. This gives them a lot of power when it comes to modifying an object's state.
- Not only can they modify object state, instance methods can also access the class itself through the self.__class__ ttribute. This means instance methods can also modify class state.

Class Methods

```
@classmethod
Def classmethod(cls):
        return cls
```

Above method is marked with a **@classmethod** decorator to flag it as a *class method.*

Instead of accepting a **self** parameter, class methods take a **cls** parameter that points to the class—and not the object instance—when the method is called.

Because the class method only has access to this **cls** argument, it can't modify object instance state. That would require access to self. However, class methods can still modify class state that applies across all instances of the class.

Static Methods

```
@staticmethod
Def staticmethod():
        return
```

Above method is marked with a **@staticmethod** decorator to flag it as a *static method.*

This type of method takes neither a **self** or a **cls** parameter (but of course it's free to accept an arbitrary number of other parameters).

Therefore a static method can neither modify object state nor class state. Static methods are restricted in what data they can access - and they're primarily a way to namespace your methods.

Class Vs Static Methods

- A class method takes cls as first parameter while a static method needs no specific parameters.
- A class method can access or modify class state while a static method can't access or modify it.
- In general, static methods know nothing about class state. They are utility type methods that take some parameters and work upon those parameters. On the other hand class methods must have class as parameter.
- We use @classmethod decorator in python to create a class method and we use @staticmethod decorator to create a static method in python.

Class Vs Static Methods

When to use what?

- We generally use class method to create factory methods. Factory methods return class object (similar to a constructor) for different use cases.
- We generally use static methods to create utility functions.

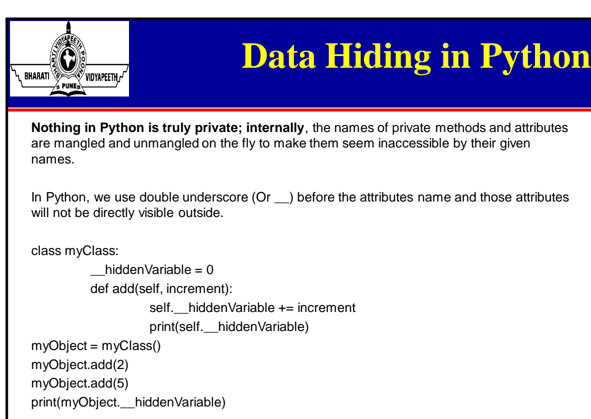
How to define a class method and a static method?

To define a class method in python, we use @classmethod decorator and to define a static method we use @staticmethod decorator.

Class Vs Static Methods

```
from datetime import date
class person:
        def __init__(self, name, age):
                self.name=name
                self.age=age
        @classmethod
        def fromBirthYear(cls, name, year):
                return cls(name, date.today().year)

        @staticmethod
        def isAdult(age):
                return age>=18
person1= person("Anuj", 21)
person2= person.fromBirthYear(("Anuj", 2000)
print(person1.age)
print(person2.age)
```



Data Hiding in Python
Nothing in Python is truly private; internally, the names of private methods and attributes are mangled and unmangled on the fly to make them seem inaccessible by their given names.
In Python, we use double underscore (Or __) before the attributes name and those attributes will not be directly visible outside.
class myClass:
__hiddenVariable = 0
def add(self, increment):
self.__hiddenVariable += increment
print(self.__hiddenVariable)
myObject = myClass()
myObject.add(2)
myObject.add(5)
print(myObject.__hiddenVariable)
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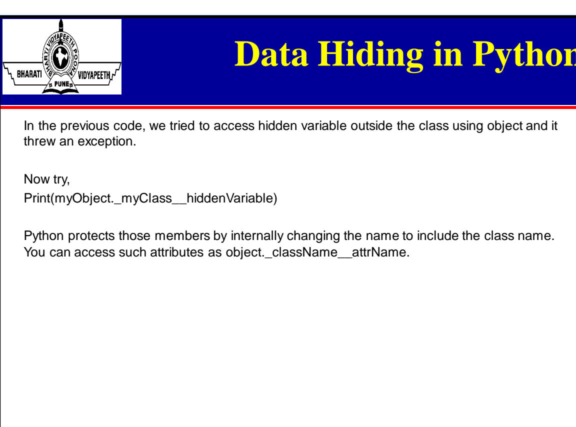

Data Hiding in Python
In the previous code, we tried to access hidden variable outside the class using object and it threw an exception.
Now try,
Print(myObject._myClass__hiddenVariable)
Python protects those members by internally changing the name to include the class name. You can access such attributes as object._className__attrName.
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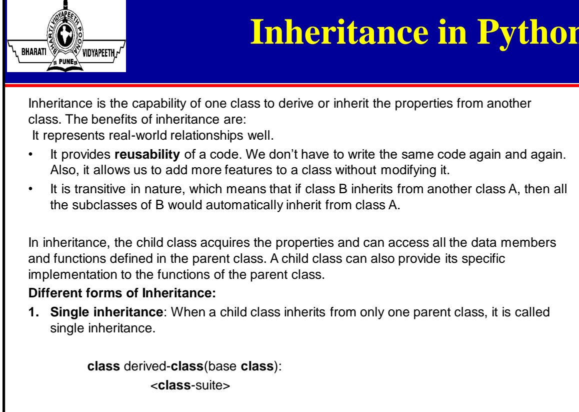

Inheritance in Python
Inheritance is the capability of one class to derive or inherit the properties from another class. The benefits of inheritance are:
It represents real-world relationships well.
It provides reusability of a code. We don't have to write the same code again and again. Also, it allows us to add more features to a class without modifying it.
It is transitive in nature, which means that if class B inherits from another class A, then all the subclasses of B would automatically inherit from class A.
In inheritance, the child class acquires the properties and can access all the data members and functions defined in the parent class. A child class can also provide its specific implementation to the functions of the parent class.
Different forms of Inheritance:
1. Single inheritance: When a child class inherits from only one parent class, it is called single inheritance.
class derived-class(base class):
<class-suite>
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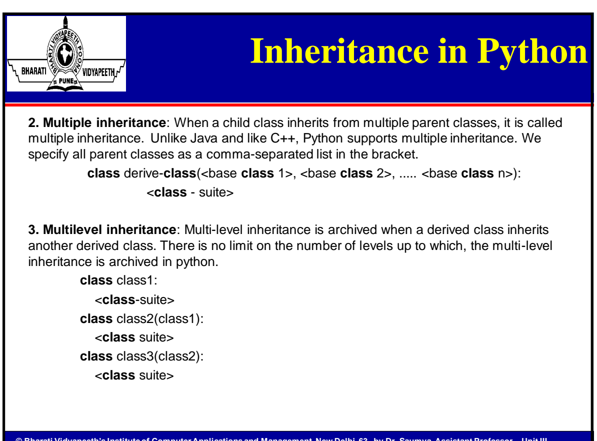
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Inheritance in Python
2. Multiple inheritance: When a child class inherits from multiple parent classes, it is called multiple inheritance. Unlike Java and like C++, Python supports multiple inheritance. We specify all parent classes as a comma-separated list in the bracket.
class derive-class(<base class 1>, <base class 2>, ... <base class n>):
<class - suite>
3. Multilevel inheritance: Multi-level inheritance is archived when a derived class inherits another derived class. There is no limit on the number of levels up to which, the multi-level inheritance is archived in python.
class class1:
<class-suite>
class class2(class1):
<class suite>
class class3(class2):
<class suite>
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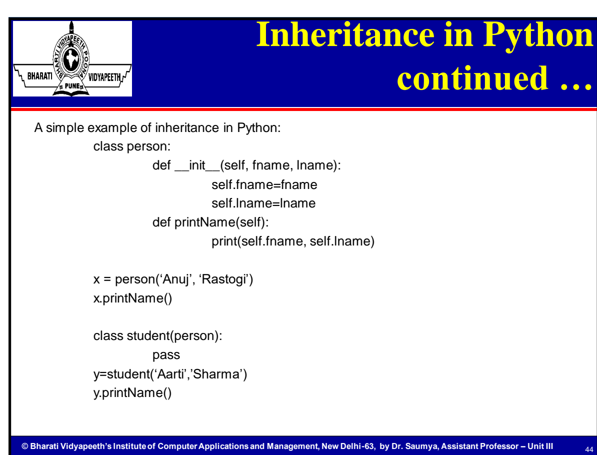
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Inheritance in Python continued …
A simple example of inheritance in Python:
class person:
def __init__(self, fname, lname):
self.fname=fname
self.lname=lname
def printName(self):
print(self.fname, self.lname)
x = person('Anuj', 'Rastogi')
x.printName()
class student(person):
pass
y=student('Aarti','Sharma')
y.printName()
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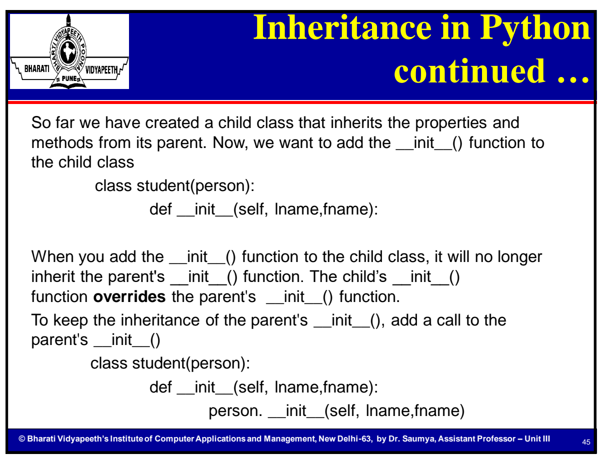
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Inheritance in Python continued …
So far we have created a child class that inherits the properties and methods from its parent. Now, we want to add the __init__() function to the child class
class student(person):
def __init__(self, lname,fname):
When you add the __init__() function to the child class, it will no longer inherit the parent's __init__() function. The child's __init__() function overrides the parent's __init__() function.
To keep the inheritance of the parent's __init__(), add a call to the parent's __init__()
class student(person):
def __init__(self, lname,fname):
person. __init__(self, lname,fname)
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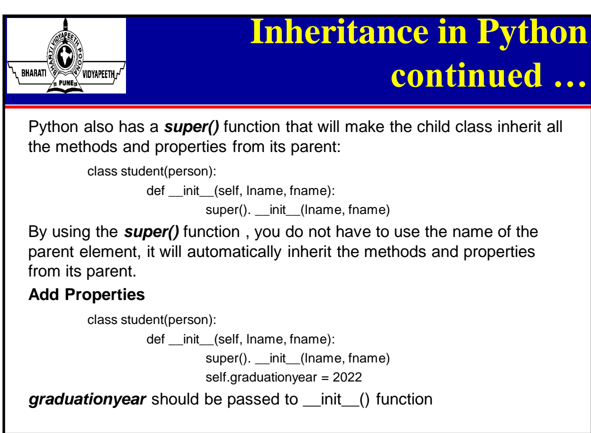


Inheritance in Python continued …

Add Methods

```
class student(person):
        def __init__(self, lname, fname):
                super(). __init__(lname, fname)
                self.graduationyear = 2022
def welcome(self):
        print("Welcome", self.firstname, self.lastname, "to the
class of", self.graduationyear)
```

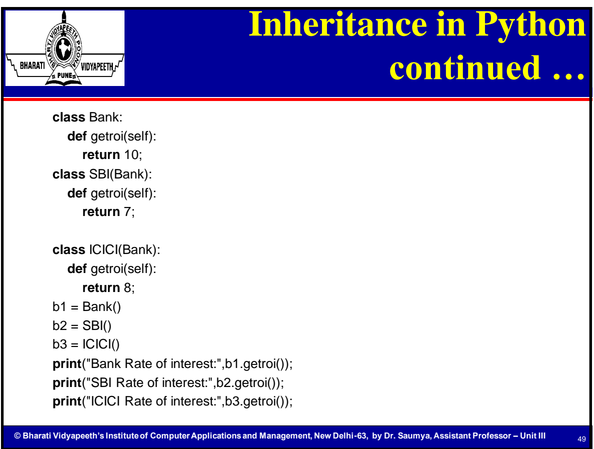
If you add a method in the child class with the same name as a function in the parent class, the inheritance of the parent method will be overridden.

Two built-in functions ***isinstance()*** and ***issubclass()*** are used to check inheritances.

Inheritance in Python continued …

Method Overriding

- We can provide some specific implementation of the parent class method in our child class.
- When the parent class method is defined in the child class with some specific implementation, then the concept is called method overriding.
- We may need to perform method overriding in the scenario where the different definition of a parent class method is needed in the child class.



Inheritance in Python continued …

```
class Bank:
   def getroi(self):
      return 10;
class SBI(Bank):
   def getroi(self):
      return 7;

class ICICI(Bank):
   def getroi(self):
      return 8;
b1 = Bank()
b2 = SBI()
b3 = ICICI()
print("Bank Rate of interest:",b1.getroi());
print("SBI Rate of interest:",b2.getroi());
print("ICICI Rate of interest:",b3.getroi());
```

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Polymorphism in Python

The word polymorphism means having many forms. In programming, polymorphism means same function name (but different signatures) being used for different types.

Polymorphism is a very important concept in programming. It refers to the use of a single type entity (method, operator or object) to represent different types in different scenarios.

Polymorphism and Inheritance

- The child classes in Python also inherit methods and attributes from the parent class. We can redefine certain methods and attributes specifically to fit the child class, which is known as **Method Overriding**.
- Polymorphism allows us to access these overridden methods and attributes that have the same name as the parent class.

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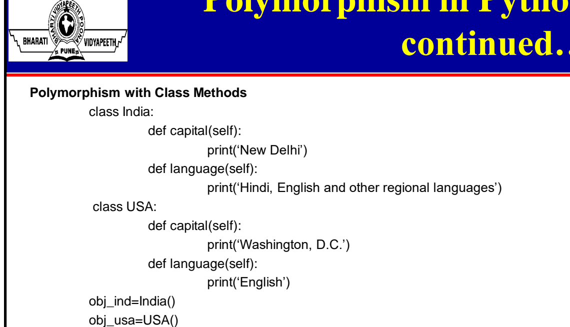
Polymorphism in Python continued…

Polymorphism with Class Methods



```
class India:
        def capital(self):
                print('New Delhi')
        def language(self):
                print('Hindi, English and other regional languages')
class USA:
        def capital(self):
                print('Washington, D.C.')
        def language(self):
                print('English')
obj_ind=India()
obj_usa=USA()
for country in (obj_ind, obj_usa):
        country.capital()
        country.language()
```

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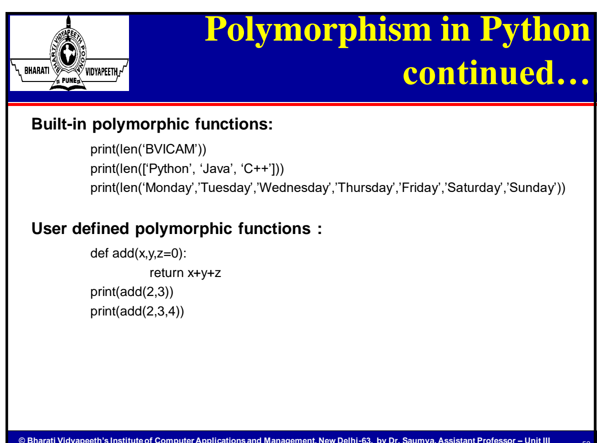
BHARATI VIDYAPEETH PUNE
Polymorphism in Python continued…
Built-in polymorphic functions:
print(len('BVICAM'))
print(len(['Python', 'Java', 'C++']))
print(len('Monday','Tuesday','Wednesday','Thursday','Friday','Saturday','Sunday'))
User defined polymorphic functions :
def add(x,y,z=0):
return x+y+z
print(add(2,3))
print(add(2,3,4))
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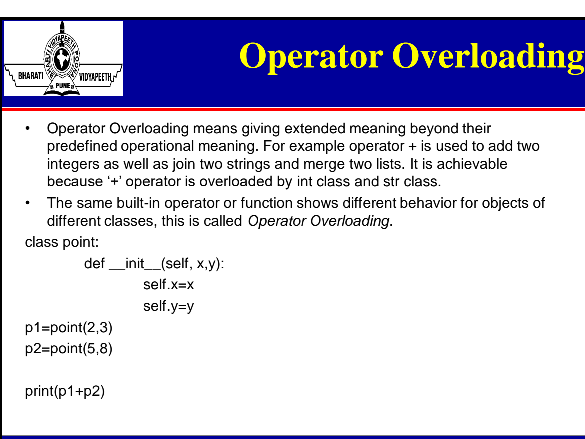
BHARATI VIDYAPEETH PUNE
Operator Overloading
Operator Overloading means giving extended meaning beyond their predefined operational meaning. For example operator + is used to add two integers as well as join two strings and merge two lists. It is achievable because '+' operator is overloaded by int class and str class.
The same built-in operator or function shows different behavior for objects of different classes, this is called Operator Overloading.
class point:
def __init__(self, x,y):
self.x=x
self.y=y
p1=point(2,3)
p2=point(5,8)
print(p1+p2)
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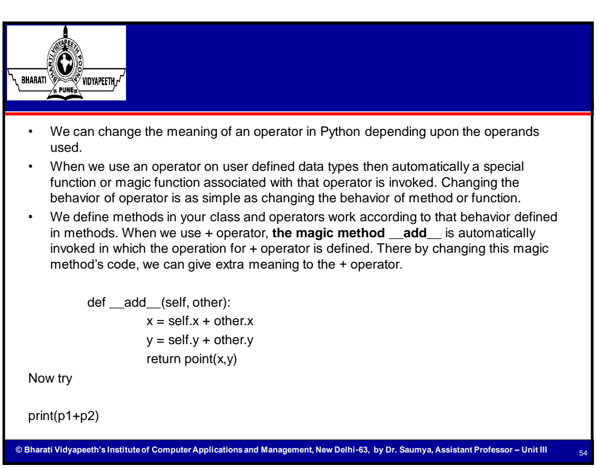
BHARATI VIDYAPEETH PUNE
We can change the meaning of an operator in Python depending upon the operands used.
When we use an operator on user defined data types then automatically a special function or magic function associated with that operator is invoked. Changing the behavior of operator is as simple as changing the behavior of method or function.
We define methods in your class and operators work according to that behavior defined in methods. When we use + operator, the magic method __add__ is automatically invoked in which the operation for + operator is defined. There by changing this magic method's code, we can give extra meaning to the + operator.
def __add__(self, other):
x = self.x + other.x
y = self.y + other.y
return point(x,y)
Now try
print(p1+p2)
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Magic Functions for Operator Overloading

Binary Operators:

Operator	Magic Function
+	__add__(self, other)
–	__sub__(self, other)
*	__mul__(self, other)
/	__truediv__(self, other)
//	__floordiv__(self, other)
%	__mod__(self, other)
**	__pow__(self, other)
>>	__rshift__(self, other)
<<	__lshift__(self, other)
&	__and__(self, other)
|	__or__(self, other)
^	__xor__(self, other)

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Magic Functions for Operator Overloading

Comparison Operators :

Operator	Magic Function
<	__lt__(self, other)
>	__gt__(self, other)
<=	__le__(self, other)
>=	__ge__(self, other)
==	__eq__(self, other)
!=	__ne__(self, other)

Unary Operators :

Operator	Magic Function
–	__neg__(self)
+	__pos__(self)
~	__invert__(self)

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Magic Functions for Operator Overloading

Assignment Operators :

Operator	Magic Function
-=	__isub__(self, other)
+=	__iadd__(self, other)
*=	__imul__(self, other)
/=	__idiv__(self, other)
//=	__ifloordiv__(self, other)
%=	__imod__(self, other)
**=	__ipow__(self, other)
>>=	__irshift__(self, other)
<<=	__ilshift__(self, other)
&=	__iand__(self, other)
|=	__ior__(self, other)
^=	__ixor__(self, other)

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Abstract Classes

- **A class is called an Abstract class if it contains one or more abstract methods**. An abstract method is a method that is declared, but contains no implementation. Abstract classes may not be instantiated, and its abstract methods must be implemented by its subclasses.
- An abstract class can be considered as a blueprint for other classes.
- While we are designing large functional units we use an abstract class. When we want to provide a common interface for different implementations of a component, we use an abstract class.

How Abstract Base classes work

By default, Python does not provide abstract classes. Python comes with a module that provides the base for defining Abstract Base classes(ABC) and that module name is abc. ***abc*** works by decorating methods of the base class as abstract and then registering concrete classes as implementations of the abstract base. A method becomes abstract when decorated with the keyword @abstractmethod. For Example –

```
Import abc
Class polygon(abc.ABC)
     @abc.abstractmethod
     def noofsides(self):
          pass
```

You may also provide class methods and static methods in abstract base class by decorators @abstractclassmethod and @abstractstatic method decorators respectively.

Abstact Class continued…

```
class Triangle(polygon):
     def noofsides(self):
          print("I have 3 sides")

class Pentagon(polygon):
     def noofsides(self):
          print("I have 5 sides")

class Hexagon(polygon):
     def noofsides(self):
          print("I have 6 sides")

R = Triangle()
R.noofsides()
```

Threads in Python

Thread

In computing, a **process** is an instance of a computer program that is being executed. Any process has 3 basic components:

- An executable program.
- The associated data needed by the program (variables, work space, buffers, etc.)
- The execution context of the program (State of process)

A **thread** is an entity within a process that can be scheduled for execution. Also, it is the smallest unit of processing that can be performed in an OS (Operating System).

In simple words, a **thread** is a sequence of such instructions within a program that can be executed independently of other code. For simplicity, you can assume that a thread is simply a subset of a process!

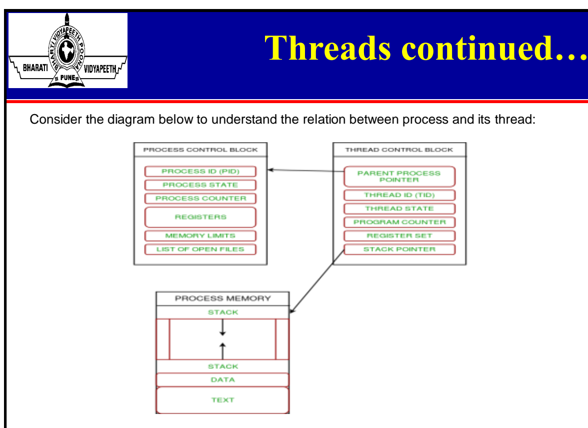
Threads continued…

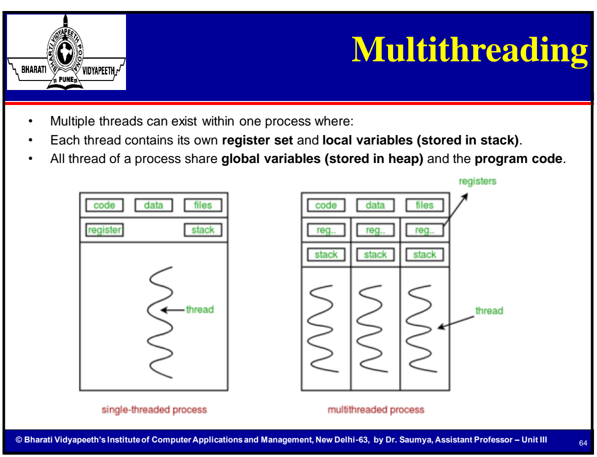
A thread contains all this information in a **Thread Control Block (TCB)**:

- **Thread Identifier:** Unique id (TID) is assigned to every new thread
- **Stack pointer:** Points to thread's stack in the process. Stack contains the local variables under thread's scope.
- **Program counter:** a register which stores the address of the instruction currently being executed by thread.
- **Thread state:** can be running, ready, waiting, start or done.
- **Thread's register set:** registers assigned to thread for computations.
- **Parent process Pointer:** A pointer to the Process control block (PCB) of the process that the thread lives on.

Threads continued…

Consider the diagram below to understand the relation between process and its thread:




BHARATI VIDYAPEETH PUNE
Multithreading
• Multiple threads can exist within one process where:
• Each thread contains its own register set and local variables (stored in stack).
• All thread of a process share global variables (stored in heap) and the program code.
code
data
files
register
stack
thread
single-threaded process
registers
code
data
files
reg..
reg..
reg..
stack
stack
stack
thread
multithreaded process
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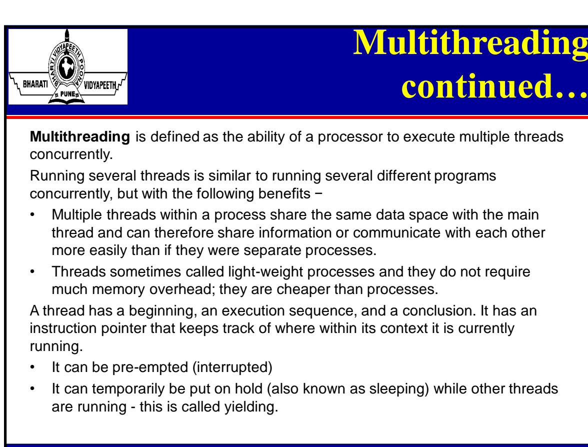
BHARATI VIDYAPEETH PUNE
Multithreading continued…
Multithreading is defined as the ability of a processor to execute multiple threads concurrently.
Running several threads is similar to running several different programs concurrently, but with the following benefits −
• Multiple threads within a process share the same data space with the main thread and can therefore share information or communicate with each other more easily than if they were separate processes.
• Threads sometimes called light-weight processes and they do not require much memory overhead; they are cheaper than processes.
A thread has a beginning, an execution sequence, and a conclusion. It has an instruction pointer that keeps track of where within its context it is currently running.
• It can be pre-empted (interrupted)
• It can temporarily be put on hold (also known as sleeping) while other threads are running - this is called yielding.
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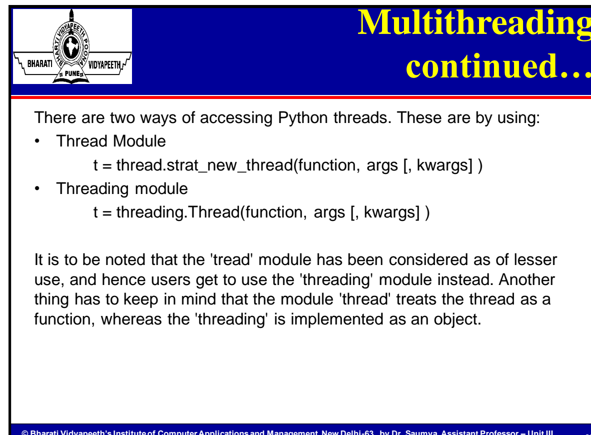
BHARATI VIDYAPEETH PUNE
Multithreading continued…
There are two ways of accessing Python threads. These are by using:
• Thread Module
t = thread.strat_new_thread(function, args [, kwargs])
• Threading module
t = threading.Thread(function, args [, kwargs])
It is to be noted that the 'tread' module has been considered as of lesser use, and hence users get to use the 'threading' module instead. Another thing has to keep in mind that the module 'thread' treats the thread as a function, whereas the 'threading' is implemented as an object.
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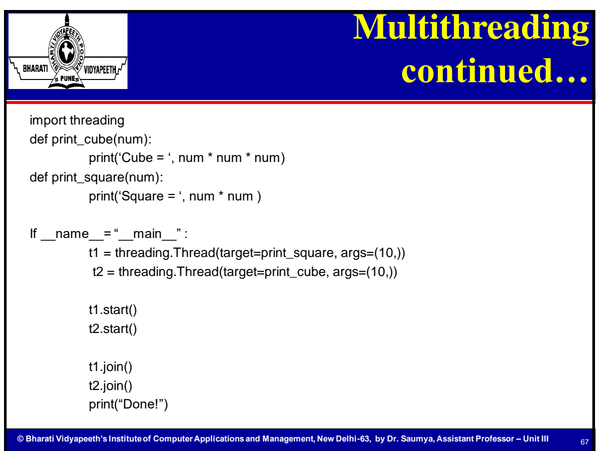

Multithreading continued…
import threading
def print_cube(num):
print('Cube = ', num * num * num)
def print_square(num):
print('Square = ', num * num)
If __name__ = "__main__" :
t1 = threading.Thread(target=print_square, args=(10,))
t2 = threading.Thread(target=print_cube, args=(10,))
t1.start()
t2.start()
t1.join()
t2.join()
print("Done!")
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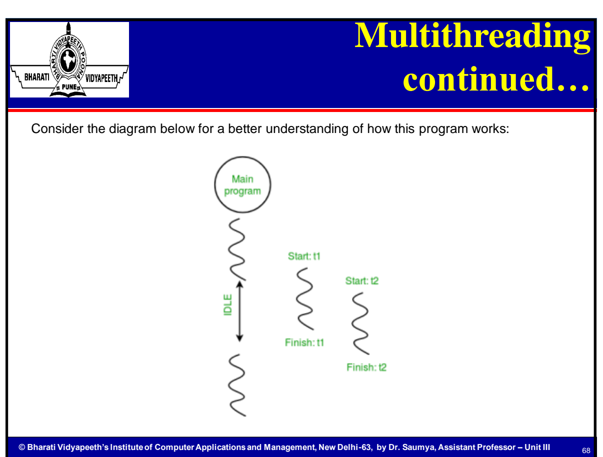

Multithreading continued…
Consider the diagram below for a better understanding of how this program works:
Main program
Start: t1
Start: t2
IDLE
Finish: t1
Finish: t2
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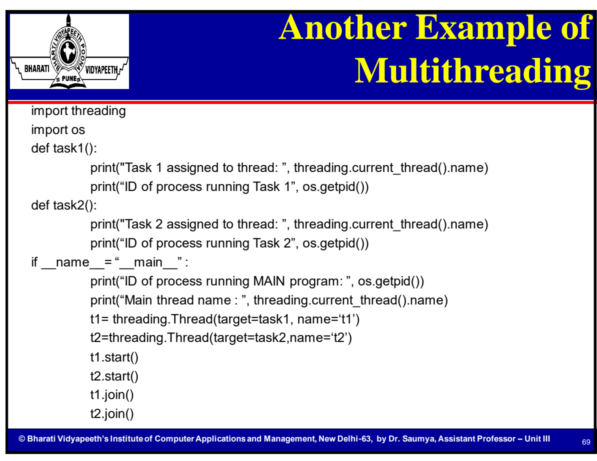

Another Example of Multithreading
import threading
import os
def task1():
print("Task 1 assigned to thread: ", threading.current_thread().name)
print("ID of process running Task 1", os.getpid())
def task2():
print("Task 2 assigned to thread: ", threading.current_thread().name)
print("ID of process running Task 2", os.getpid())
if __name__ = "__main__" :
print("ID of process running MAIN program: ", os.getpid())
print("Main thread name : ", threading.current_thread().name)
t1= threading.Thread(target=task1, name='t1')
t2=threading.Thread(target=task2,name='t2')
t1.start()
t2.start()
t1.join()
t2.join()
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Python Program for Various Thread States

- There are five thread states - **new, runnable, running, waiting and dead**.
- Among these five Of these five, we will majorly focus on three states - running, waiting and dead.
- A thread gets its resources in the running state, waits for the resources in the waiting state; the final release of the resource, if executing and acquired is in the dead state.
- The following Python program with the help of start(), sleep() and join() methods will show how a thread entered in running, waiting and dead state respectively.

Step 1 − Import the necessary modules, for example : <threading> and <time>

Step 2 − Define a function, which will be called while creating a thread.

Step 3 − We are using the sleep() method of time module to make our thread waiting for say 2 seconds.

Step 4 − Now, we are creating a thread (e.g T1), which takes the argument of the function defined above.

Step 5 − Now, with the help of the start() function we can start our thread. It will produce the message, which has been set by us while defining the function.

Step 6 − Now, at last we can kill the thread with the join() method after it finishes its execution.

Daemon Thread in Python

- A **daemon thread** is a thread that dies whenever the main thread dies, it is also called a non-blocking thread.
- Usually, the main thread should wait for other threads to finish in order to quit the program, but if you set the daemon flag, you can let the thread do its work and forget about it, and when the program quits, it will be killed automatically.
- For example, you may want to make a thread that watches for log files in your program, and alert you when a critical error is occurred.
- Usually our main program implicitly waits until all other threads have completed their work.
- The default setting for a thread is non-daemon. To designate a thread as a daemon, we call its **setDaemon()** method with a boolean argument.

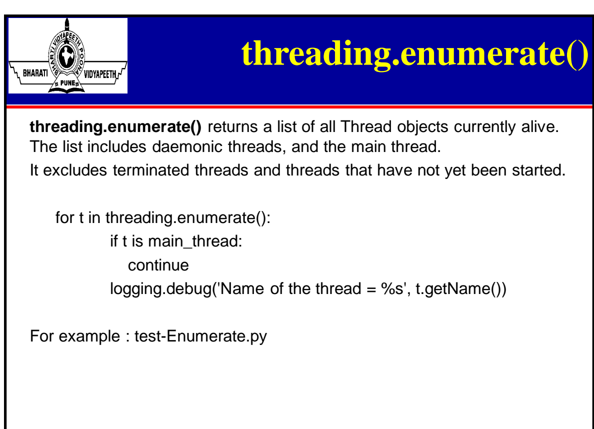
Example: test-Daemon.py

Join() method in Python

On invoking the **join()** method, the calling thread gets blocked until the thread object (on which the thread is called) gets terminated. The thread objects can terminate under any one of the following conditions:

- Either normally.
- Through an ill-handled exception.
- Till the optional timeout occurs.

Hence the join() method indicates wait till the thread terminates. We can also specify a timeout value to the join() method. In such a situation the calling thread may ask the thread to stop by sending a signal through an event object. The join() method can be called multiple times.



threading.enumerate()

threading.enumerate() returns a list of all Thread objects currently alive. The list includes daemonic threads, and the main thread.
It excludes terminated threads and threads that have not yet been started.

```
for t in threading.enumerate():
    if t is main_thread:
        continue
    logging.debug('Name of the thread = %s', t.getName())
```

For example : test-Enumerate.py

Thread Synchronization in Python

Thread synchronization is defined as a mechanism which ensures that two or more concurrent threads do not simultaneously execute some particular program segment known as **critical section**.

Following issues may arise while implementing concurrent programming or applying synchronizing primitives:
1. Dead Lock
2. Race condition

In Python, we can implement synchronization by using the following concepts
- **Lock**
- **RLock**
- **Semaphore**

Synchronization By using Locks in python:

Locks are the most fundamental synchronization mechanism provided by the threading module. We can create Lock object as follows,

l=Lock()

The Lock object can be held by only one thread at a time. If any other thread wants the same lock then it will have to wait until the other one releases it. It's similar to waiting in line to book a train ticket, public telephone booth etc.
- **acquire() method:** A Thread can acquire the lock by using acquire() method
  l.acquire()
- **release() method:** A Thread can release the lock by using release() method.
  l.release()

Examples : Test-Lock.py and Test-Lock1.py

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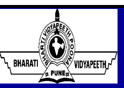
Problem with Simple Lock in Python:

- The standard lock object does not care which thread is currently holding that lock. If the lock is being held by one thread, and if any other thread tries to accquire the lock, then it will be blocked, even if it's the same thread that is already holding the lock.
- So, if the Thread calls recursive functions or nested access to resources, then the thread may try to acquire the same lock again and again, which may result in blocking of our thread. Hence Traditional Locking mechanism won't work for executing recursive functions.

Synchronization By using RLock concept in Python:

- To overcome the above problem of Simple Lock, we should go for RLock(Reentrant Lock). Reentrant means the thread can acquire the same lock again and again. This will block the thread only if the lock is held by any other thread. Reentrant facility is available only for owner thread but not for other threads.
- This RLock keeps track of recursion level and hence for every acquire() there should be a release() call available.
- The number of acquire() calls and release() calls should be matched then for the lock to be released i.e if there are two accquire calls then there should be two release calls for the lock to be released. If there is only one release call for two accquire calls then the lock wont be released.

Example : test-Rlock()



Difference between Lock and RLock in Python:

Lock	RLock
A Lock object can be acquired by only one thread at a time. Even the owner thread also cannot acquire multiple times.	A RLock object can be acquired by only one thread at a time, but the owner thread can acquire the same lock object multiple times.
Not suitable to execute recursive functions and nested access calls	Best suitable to execute recursive functions and nested access calls
In this case the Lock object will only see whether its Locked or unlocked and it will never hold or take care of owner thread and recursion level.	In this case RLock object will see whether its Locked or unlocked and also about owner thread information and recursion level.

Synchronization by using Semaphore in Python:

- Semaphore provides threads with synchronized access to a limited number of resources.
- A semaphore is just a variable. The variable reflects the number of currently available resources. For example, a parking lot with a display of number of available slots on a specific level of a shopping mall is a semaphore.
- The value of semaphore cannot go less than zero and greater then the total number of the available resources.
- The semaphore is associated with two operations – **acquire** and **release**.
- When one of the resources synchronized by a semaphore is "**acquired**" by a thread, the value of the semaphore is decremented.
- When one of the resources synchronized by a semaphore is "**released**" by a thread the value of the semaphore is incremented.

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Semaphores in Python:

- The Semaphore class of the Python threading module implements the concept of semaphore.
- It has a constructor and two methods acquire() and release().
- The acquire() method decreases the semaphore count if the count is greater than zero. Else it blocks till the count is greater than zero.
- The release() method increases the semaphore count and wakes up one of the threads waiting on the semaphore.

Way to create an object of Semaphore :

1. object_name.Semaphore()
   In this case, by default value of the count variable is 1 due to which only one thread is allowed to access. It is exactly the same as the **Lock** concept.
2. object_name.Semaphore(n)
   In this case, a Semaphore object can be accessed by n Threads at a time. The remaining Threads have to wait until releasing the semaphore.

Example : test-Semaphores.py

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Bounded Semaphore in Python:

Try this :

```
from threading import *
s=Semaphore(2)
s.acquire()
s.acquire()
s.release()
s.release()
s.release()
s.release()
print("End")
```

In **Normal Semaphore**, discussed above, the release method can be called any number of times to increase the counter, irrespective of the acquire method. Sometimes, the number of release() calls can exceed

It is valid because in normal semaphore we can call release() any number of times. This may result in programming errors or may raise confusions. So, it is always recommended to use **Bounded Semaphore** which raises an error if the number of release() calls exceeds the number of acquire() calls. the number of acquire() calls also.

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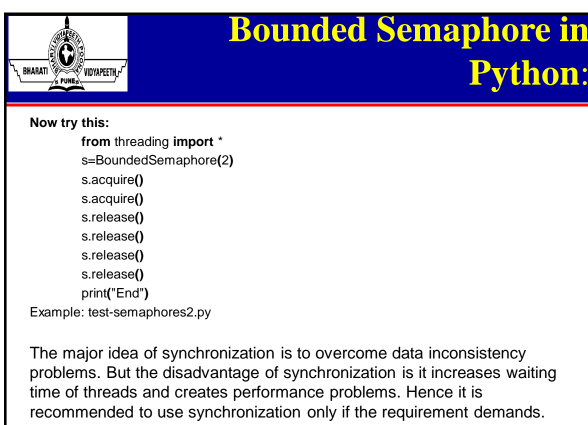

Thread Synchronization using Event Object

The Event class object provides a simple mechanism which is used for communication between threads where one thread signals an event while the other threads wait for it.

So, when one thread which is intended to produce the signal produces it, then the waiting thread gets activated.

An internal flag is used by the event object known as the **event flag** which can be set as true using the set() method and it can be reset to false using the clear() method

The wait() method blocks a thread until the event flag for which it is waiting is set true by any other thread.

There are few useful functions used along with an event object:

1. isSet()
2. set()
3. clear()
4. wait([Timeout])

Thread Synchronization using Event Object

isSet Method:

This method returns true if and only if the internal flag is true.

set() Method:

When this method is called for any event object then the internal flag is set to true. And as soon as set() methos is called for any event all threads waiting for it are awakened.

clear() Method:

This method resets the internal flag to false. Subsequently, threads calling wait() on the event for which clear() is called, it will block until the internal flag is not true again.

wait([Timeout]) Method:

- When we have to make any thread wait for an event, we can do so by calling this method on that event which has the internal flag set to false, doing so blocks the thread until the internal flag is true for the event.
- If the internal flag is true on entry, then the thread will never get blocked. Otherwise, it is blocked until another thread calls set() to set the flag to true, or until the optional timeout occurs. The timeout argument specifies a timeout for the operation in seconds.

Example : test-event.py

Exception Handling

Error in Python can be of two types i.e. Syntax errors and Exceptions. Errors are the problems in a program due to which the program will stop the execution. On the other hand, exceptions are raised when some internal events occur which changes the normal flow of the program.

Exceptions: Exceptions are raised when the program is syntactically correct but the code resulted in an error. This error does not stop the execution of the program, however, it changes the normal flow of the program.

```
marks =1000
a=marks / 0
print(a)
```

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Exception Handling

Python provides two very important features to handle any unexpected error in your Python programs and to add debugging capabilities in them −

- **Exception Handling**
- **Assertions**

Python provides a way to handle the exception so that the code can be executed without any interruption. If we do not handle the exception, the interpreter doesn't execute all the code that exists after the exception.

Python has many **built-in exceptions** that enable our program to run without interruption and give the output.

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Exception Handling

Common Exceptions

Python provides the number of built-in exceptions, but here we are describing the common standard exceptions. A list of common exceptions that can be thrown from a standard Python program is given below.

- **ZeroDivisionError:** Occurs when a number is divided by zero.
- **NameError:** It occurs when a name is not found. It may be local or global.
- **IndentationError:** If incorrect indentation is given.
- **IOError:** It occurs when Input Output operation fails.
- **EOFError:** It occurs when the end of the file is reached, and yet operations are being performed.
- **ArithmeticError:** Base class for all errors that occur for numeric calculation.
- **OverflowError:** Raised when a calculation exceeds maximum limit for a numeric type.
- **IndexError:** Raised when an index is not found in a sequence.
- **SyntaxError**: Raised when there is an error in Python syntax.
- **ValueError:** Raised when the built-in function for a data type has the valid type of arguments, but the arguments have invalid values specified.

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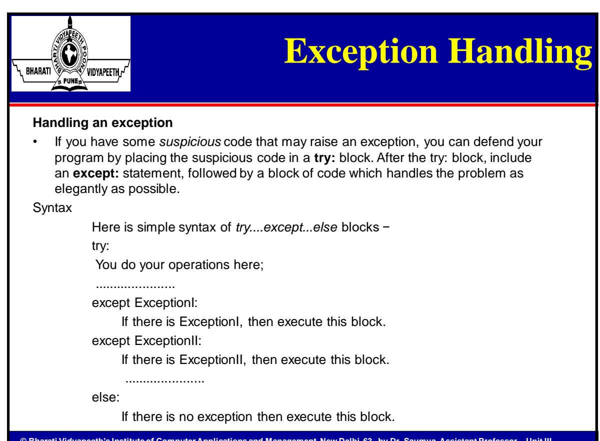


Exception Handling

Handling an exception

- If you have some *suspicious* code that may raise an exception, you can defend your program by placing the suspicious code in a **try:** block. After the try: block, include an **except:** statement, followed by a block of code which handles the problem as elegantly as possible.

Syntax

Here is simple syntax of *try....except...else* blocks –

```
try:
 You do your operations here;
 ......................
except ExceptionI:
    If there is ExceptionI, then execute this block.
except ExceptionII:
    If there is ExceptionII, then execute this block.
    ......................
else:
    If there is no exception then execute this block.
```


Exception Handling

Here are few important points about the syntax –

- A single try statement can have multiple except statements. This is useful when the try block contains statements that may throw different types of exceptions.
- You can also provide a generic except clause, which handles any exception.
- After the except clause(s), you can include an else-clause. The code in the else-block executes if the code in the try: block does not raise an exception.
- The else-block is a good place for code that does not need the try: block's protection.

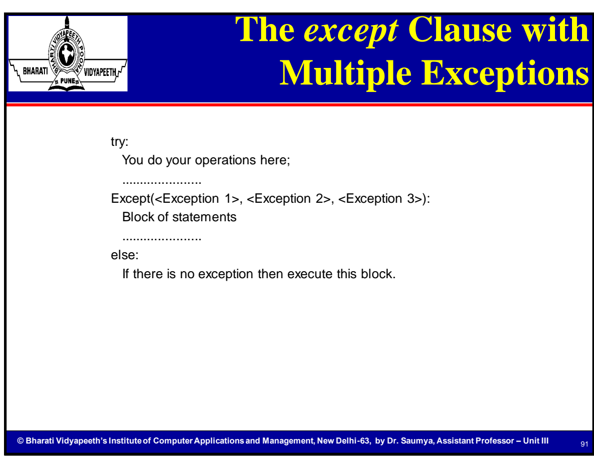
```
try:
   fh = open("testfile", "w")
   fh.write("This is my test file for exception handling!!")
except IOError:
   print "Error: can\'t find file or read data"
else:
   print "Written content in the file successfully"
   fh.close()
```


The *except* Clause with No Exceptions

You can also use the except statement with no exceptions defined as follows –

```
try:
   You do your operations here;
   ......................
except:
   If there is any exception, then execute this block.
   ......................
else:
   If there is no exception then execute this block.
```

This kind of a **try-except** statement catches all the exceptions that occur. Using this kind of try-except statement is not considered a good programming practice though, because it catches all exceptions but does not make the programmer identify the root cause of the problem that may occur.



The try-finally Clause

Python provides the optional **finally** statement, which is used with the **try** statement. It is executed no matter what exception occurs and used to release the external resource. The finally block provides a guarantee of the execution.

```
try:
    fileptr = open("file2.txt","r")
    try:
        fileptr.write("Hi I am good")
    finally:
        fileptr.close()
        print("file closed")
except:
    print("Error")
```

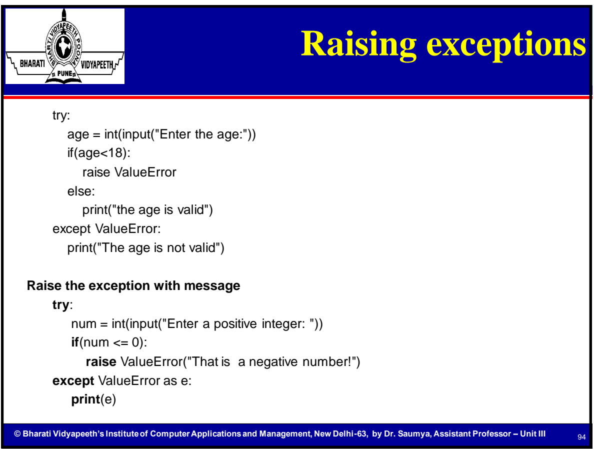

Raising exceptions

- An exception can be raised forcefully by using the **raise** clause in Python. It is useful in in that scenario where we need to raise an exception to stop the execution of the program.
- For example, there is a program that requires 2GB memory for execution, and if the program tries to occupy 2GB of memory, then we can raise an exception to stop the execution of the program.
- The syntax to use the raise statement is given below.

```
Raise Exception_class, <value>
```

Points to remember

- To raise an exception, the raise statement is used. The exception class name follows it.
- An exception can be provided with a value that can be given in the parenthesis.
- To access the value "**as**" keyword is used. "**e**" is used as a reference variable which stores the value of the exception.
- We can pass the value to an exception to specify the exception type.



Custom Exception

The Python allows us to create our exceptions that can be raised from the program and caught using the except clause. However, we suggest you read this section after visiting the Python object and classes.

```
class ErrorInCode(Exception):
    def __init__(self, data):
        self.data = data
    def __str__(self):
        return repr(self.data)

try:
    raise ErrorInCode(2000)
except ErrorInCode as ae:
    print("Received error:", ae.data)
```

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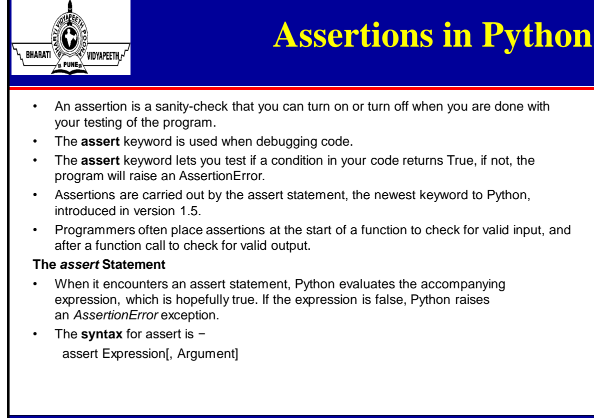

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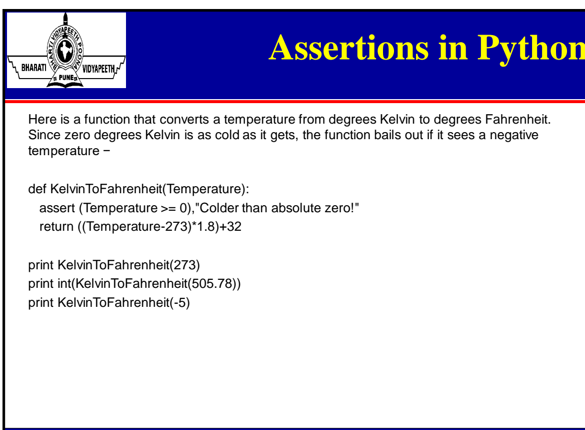

Exception Class Hierarchy in Python:

- All exception classes are derived from the BaseException class.
- The BaseException is the base class of all other exceptions. User defined classes cannot be directly derived from this class, to derive user defied class, we need to use Exception class.

Python Exception Hierarchy.docx

Composition in Python

- **Composition** is an object oriented design concept that models a **has a** relationship. In composition, a class known as **composite** contains an object of another class known to as **component**. In other words, a composite class **has a** component of another class.
- Composition allows composite classes to reuse the implementation of the components it contains. The composite class doesn't inherit the component class interface, but it can leverage its implementation.
- The composition relation between two classes is considered loosely coupled. That means that changes to the component class rarely affect the composite class, and changes to the composite class never affect the component class.
- This provides better adaptability to change and allows applications to introduce new requirements without affecting existing code.
- When looking at two competing software designs, one based on inheritance and another based on composition, the composition solution usually is the most flexible.
- Example : test-Composition.py

Iterators in Python

A process that is repeated more than one time by applying the same logic is called an Iteration. In programming languages like python, a loop is created with few conditions to perform iteration till it exceeds the limit. If the loop is executed 6 times continuously, then we could say the particular block has iterated 6 times.

```
a = [0, 5, 10, 15, 20]
for i in a:
    if i % 2 == 0:
        print(str(i)+' is an Even Number')
    else:
        print(str(i)+' is an Odd Number')
```

Iterators in Python

- An iterator is an object which contains a countable number of values and it is used to iterate over iterable objects like list, tuples, sets, etc.
- Iterators are implemented using a class and a local variable for iterating is not required here, It follows lazy evaluation where the evaluation of the expression will be on hold and stored in the memory until the item is called specifically which helps us to avoid repeated evaluation.
- As lazy evaluation is implemented, it requires only 1 memory location to process the value and when we are using a large dataset then, wastage of RAM space will be reduced the need to load the entire dataset at the same time will not be there.

How to use an iterator-

- **iter()** keyword is used to create an iterator containing an iterable object.
- **next**() keyword is used to call the next element in the iterable object.
- After the iterable object is completed, to use them again reassign them to the same object.

```
iter_list = iter(['Java', 'Python', 'C++'])
print(next(iter_list))
print(next(iter_list))
```

Generators in Python

- It is another way of creating iterators in a simple way where it uses the keyword “yield” instead of returning it in a defined function.
- Generators are implemented using a function.
- Just as iterators, generators also follow lazy evaluation.
- The yield function returns the data without affecting or exiting the function. It will return a sequence of data in an iterable format where we need to iterate over the sequence to use the data as they won't store the entire sequence in the memory.

Example : test-Generator.py