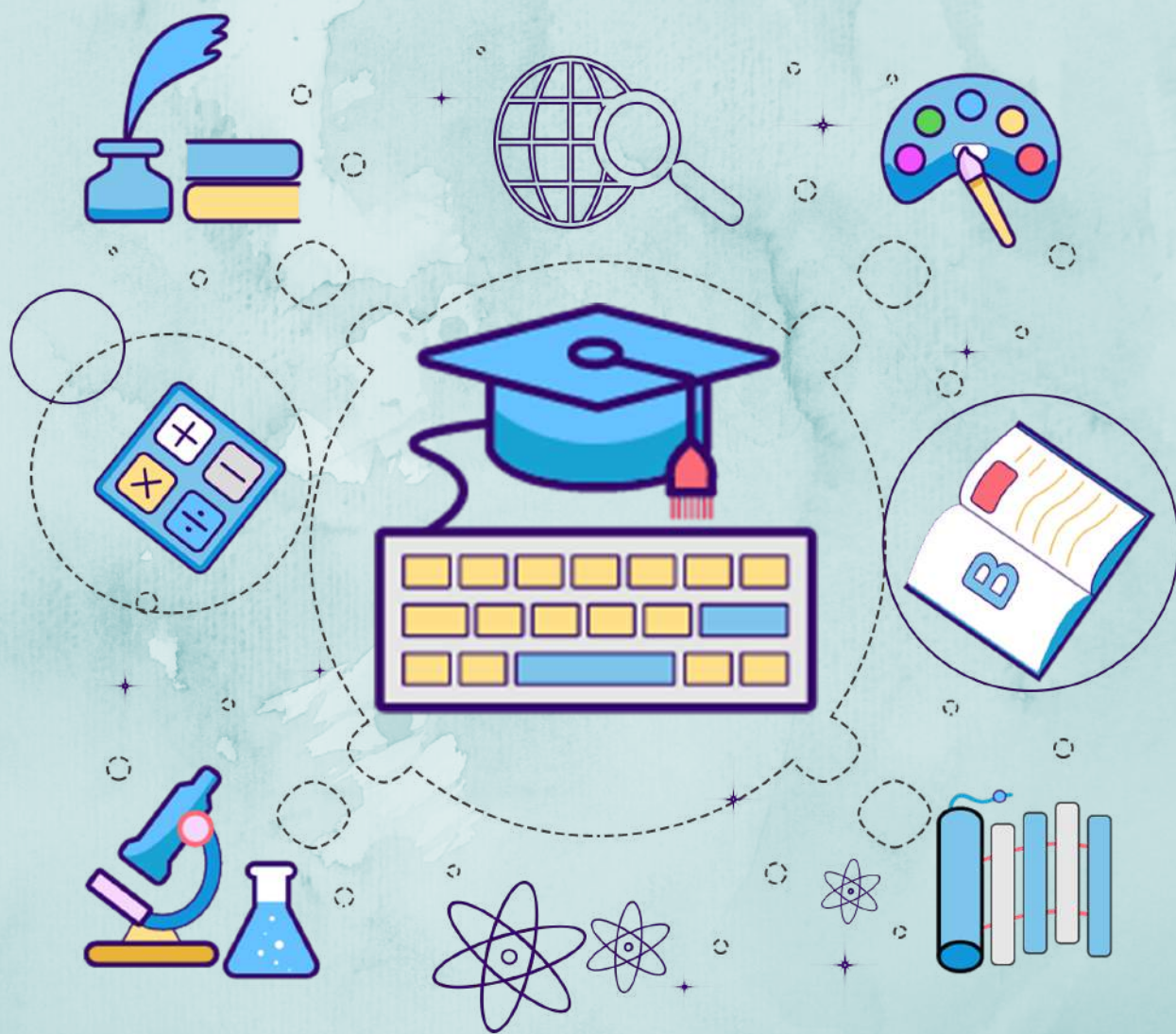


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MODULE IV

Design with classes - Objects and Classes, Methods, Instance variables, Constructor, Accessor and Mutator, Data-Modeling Examples, Structuring classes with inheritance and polymorphism. Abstract classes, Interfaces, Exceptions - Handle a single exception, handle multiple exceptions.

Overview of OOP (Object Oriented Programming)

Python is a multi-paradigm programming language. It supports different programming approaches. One of the popular approaches to solve a programming problem is by creating objects. This is known as Object-Oriented Programming (OOP). An object has two characteristics:

- (1) attributes
- (2) behavior

Suppose a parrot is an object, as it has the following properties: name, age, color as attributes singing, dancing as behavior.

Object-oriented vs. Procedure-oriented Programming Language

| Object-oriented Programming | Procedural Programming |
|--|--|
| Object-oriented programming is the problem-solving approach and used where computation is done by using objects. | Procedural programming uses a list of instructions to do computation step by step. |
| It makes the development and maintenance easier | In procedural programming, It is not easy to maintain the codes when the project becomes lengthy. |
| It simulates the real world entity. So real-world problems can be easily solved through oops. | It doesn't simulate the real world. It works on step by step instructions divided into small parts called functions. |
| It provides data hiding. So it is more secure than procedural languages. You cannot access private data from anywhere. | Procedural language doesn't provide any proper way for data binding, so it is less secure. |
| Example of object-oriented programming languages is C++, Java, .Net, Python, C#, etc. | Example of procedural languages are: C, Fortran, Pascal. VB etc. |

Activate

Objects and Classes

- Object is an instance of a class. A class is a collection of data (variables) and methods (functions).
- A class is the basic structure of an object and is a set of attributes, which can be data members or method members. Some important terms in OOP are as follows:
 - **Class** - They are defined by the user. The class provides basic structure for an object.
 - **Data Member** - A variable defined in either a class or an object. It holds the data associated with the class or object.
 - **Instance variable** - A variable that is defined in a method; its scope is only within the object that defines it.

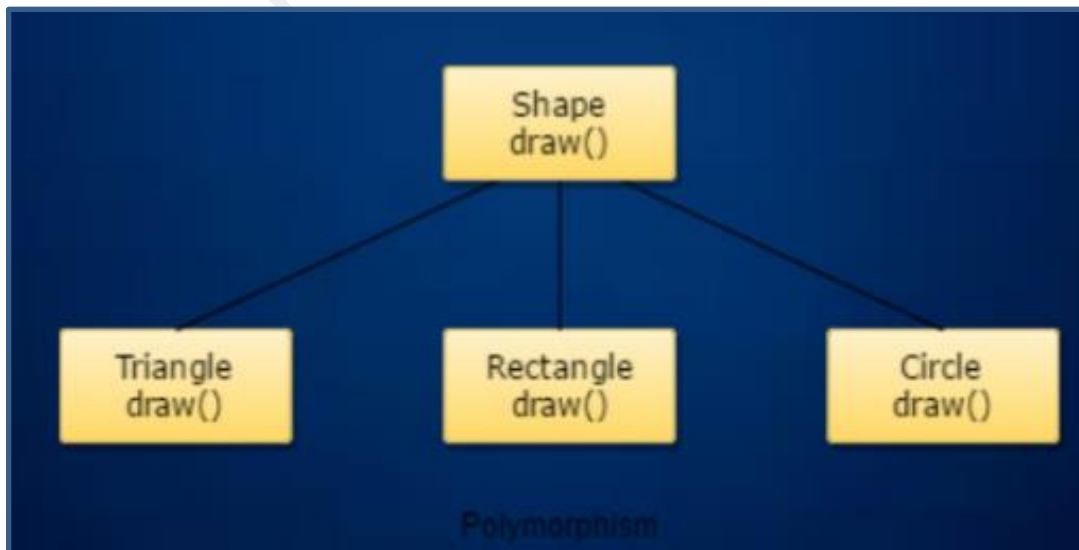
- **Class Variable** - A variable that is defined in the class and can be used by all the instances of the class.
- **Instance** - An object is an instance of the class.
- **Instantiation** - The process of creation of an object of a class.
- **Method** - Methods are the functions that are defined in the definition of class and are used by various instances of the class.
- **Function Overloading** - A function defined more than one time with different behaviors is known as function overloading. The operations performed by these functions are different.
- **Inheritance** - a class A that can use the characteristics of another class B is said to be a derived class. ie., a class inherited from B. The process is called inheritance.

Data Encapsulation:

In OOP, restrictions can be imposed on the access to methods and variables. Such restrictions can be used to avoid accidental modification in the data and are known as Encapsulation.

Polymorphism

The term polymorphism means that the object of a class can have many different forms to respond in different ways to any message or action.



Class Definition

- A class is a “blueprint” for creating objects.
- It can also be defined as a group of objects that share similar attributes and relationships with each other.

eg., Fruit is a class and apple, mango and banana are its objects. The attributes of these objects can be color, taste etc.

Syntax for defining a class

In python class is created by using a keyword class. After that, the first statement can be a docstring that contains the information about the class. In the body of class, the attributes (data members or method members)

```
class <class name>(<parent class name>):
```

```
<method definition-1>
```

```
...
```

```
<method definition-n>
```

- In python, as soon as we define a class, the interpreter instantly creates an **object** that has the same name as **the class name**.
- We can create more objects of the same class. With the help of objects, we can access the attributes defined in the class.

Syntax for creating objects for a class

```
<object name> = <class name>
```

Creating class Student

```
class Student:
```

```
    "Student details"
```

```
    def fill_details (self,name,branch,year):
```

```
        self.name = name
```

```
self.branch = branch
self.year = year
print("A student detail object is created...")
def print_details(self):
    print("Name: ",self.name)
    print("Branch: ",self.branch)
    print("Year: ",self.year)
```

Creating an object of Student class

```
>>> s1 = Student()
>>> s2 = Student()
>>> s1.fill_details('Rahul','CSE','2020')
```

A student detail object is created...

```
>>> s1.print_details()
```

Name: Rahul

Branch: CSE

Year: 2020

```
>>> s2.fill_details('Akhil','ECE','2010')
```

A student detail object is created...

```
>>> s2.print_details()
```

Name: Akhil

Branch: ECE

Year: 2010

Constructors in Python

A constructor is a special type of method (function) which is used to initialize the instance members of the class.

Constructors can be of two types.

1. Parameterized Constructor
2. Non-parameterized Constructor

Creating the constructor in python

Class functions that begin with double underscore “__” are called special functions as they have special meaning. In Python, the method the `__init__()` simulates the constructor of the class. This method is called when the class is instantiated. It accepts the **self**-keyword as a first argument which allows accessing the attributes or method of the class.

Example : Display a Complex Number

```
class ComplexNumber:
```

```
    def __init__(self, r=0, i=0):
```

```
        self.real = r
```

```
        self.imag = i
```

```
    def getNumber(self):
```

```
        print(f'{self.real} + j{self.imag}')
```

```
num1 = ComplexNumber(2, 3)
```

```
num1.getNumber()
```

Output : 2+j

Example : Display Employee Details

```
class Employee:
```

```
    def __init__(self, id, name):
```

```
        self.id = id
```

```
        self.name = name
```

```
    def display(self):
```

```
        print("Id",self.id)
```

```
        print("Name",self.name)
```

```
emp1 = Employee(1, "john")
```



```
emp2 = Employee(2, "Anu")  
emp1.display()
```

Python Non-Parameterized Constructor

The non-parameterized constructor uses when we do not want to manipulate the value or the constructor that has only self as an argument.

class Student:

```
    def __init__(self):  
        print("This is non parameterized constructor")  
    def show(self, name):  
        print("Hello " , name)
```

```
s1 = Student()  
s1.show("Roshan")
```

output:

```
This is non parameterized constructor  
Hello Roshan
```

Python Parameterized Constructor

The parameterized constructor has multiple parameters along with the self.

class Student:

```
    def __init__(self, name):  
        print("This is parameterized constructor")  
        self.name = name  
    def show(self):  
        print("Hello " , self.name)
```

```
s1 = Student("Rahul")  
s1.show()
```

output:

This is parameterized constructor

Hello Rahul

Accessors and Mutators

- The Methods that allow a user to observe but not change the state of an object are called accessors.
- Methods that allow a user to modify an object's state are called mutators.

Accessor Method: This method is used to access the state of the object i.e, the data hidden in the object can be accessed from this method. However, this method cannot change the state of the object, it can only access the data hidden. We can name these methods with the word **get**.

Mutator Method: This method is used to mutate/modify the state of an object i.e, it alters the hidden value of the data variable. It can set the value of a variable instantly to a new value. This method is also called as **update method**. Moreover, we can name these methods with the word **set**.

Example : Accessors and Mutators

class Fruit:

```
    def __init__(self, name):
```

```
        self.name = name
```

```
    def setFruitName(self, name):
```

```
        self.name = name
```

```
    def getFruitName(self):
```

```
        return self.name
```

```
f1 = Fruit("Apple")
```

```
print("First fruit name: ", f1.getFruitName())
```

```
f1.setFruitName("Grape")
```

```
print("Second fruit name: ", f1.getFruitName())
```

Output:

First fruit name: Apple

Second fruit name: Grape

Inheritance in Python

- Inheritance is an important aspect of the object-oriented paradigm. Inheritance provides code reusability to the program because we can use an existing class to create a new class instead of creating it from scratch.
- 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.

Syntax:

class derived class name(base class):

<class-suite>

Types of Inheritance

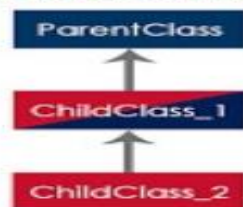
Simple Inheritance



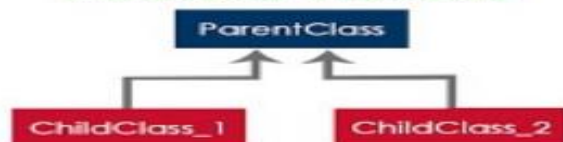
Multiple Inheritance



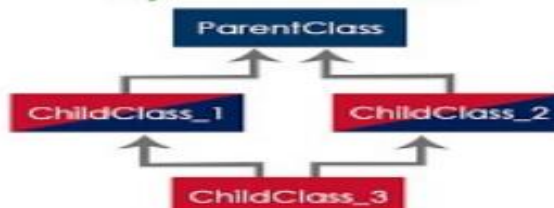
Multi Level Inheritance



Hierarchical Inheritance



Hybrid Inheritance



Single Inheritance

- When a child class inherits from only one parent class, it is called single inheritance.

class derive-class(<base class >):

<class - suite>

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

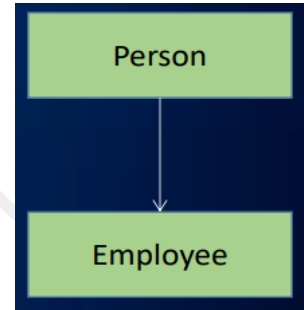
    def getName(self):
        return self.name

    def isEmployee(self):
        return False

class Employee(Person):
    def isEmployee(self):
        return True

p = Person("Anu")
print(p.getName(),
      p.isEmployee())

e = Employee("Ammu")
print(e.getName(),
      e.isEmployee())
```



Multiple inheritance

- When a child class inherits from multiple parent classes, it is called multiple inheritance.

class derive-class(<base class1>,<base class2>,...<base class n>):

<class-suite>

Example:

class Person:

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



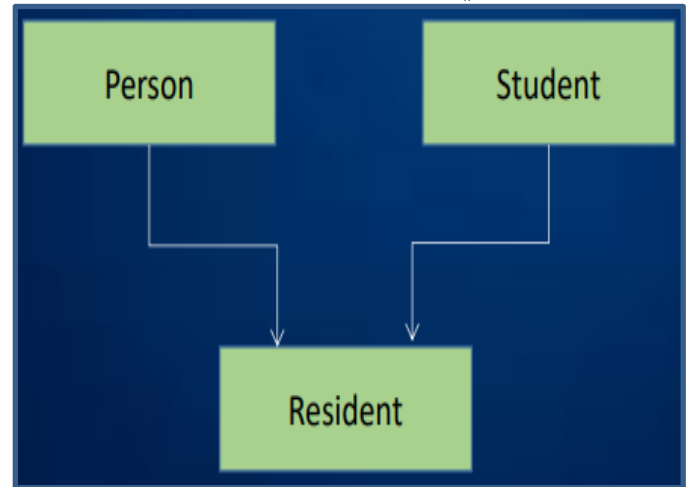
```
        self.age = age
    def showName(self):
        print(self.name)
    def showAge(self):
        print(self.age)
class Student:
    def __init__(self, rollno):
        self.rollno = rollno
    def getRollno(self):
        print(self.rollno)
class Resident(Person, Student):
    def __init__(self, name, age, rollno):
        Person.__init__(self, name, age)
        Student.__init__(self, rollno)
r = Resident("Roshan", 21, 101)
r.showName()
r.showAge()
r.getRollno()
```

Output:

Roshan

21

101



Resolving the Conflict with Python Multiple Inheritance :

class A:

```
def __init__(self):
    self.name = "John"
    self.age = 23
```

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

class B:

```
def __init__(self):
    self.name = "Richard"
    self.id = 32
```

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

class C(A, B):

```
def __init__(self):
    A.__init__(self)
    B.__init__(self)
```

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

C1 = C()

print(C1.getName())

Output:

Richard

Method Resolution Order (MRO)

MRO works in a depth first left to right way. **super()** in the **__init__** method indicates the class that is in the next hierarchy. At first the **super()** of C indicates A. Then **super** in the constructor of A searches for its superclass. If it doesn't find any, it executes the rest of the code and returns. So the order in which constructors are called here is:

C -> A -> B

Resolving the Conflict with Python Multiple Inheritance :

```
class A:
    def __init__(self):
        super().__init__()
        self.name = 'John'
        self.age = 23

    def getName(self):
        return self.name

class B:
    def __init__(self):
        super().__init__()
        self.name = 'Richard'
        self.id = '32'
```

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

```
class C(A, B):
    def __init__(self):
        super().__init__()
```

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

```
C1 = C()
print(C1.getName())
print(C.__mro__)
```

Output : John

Multilevel Inheritance

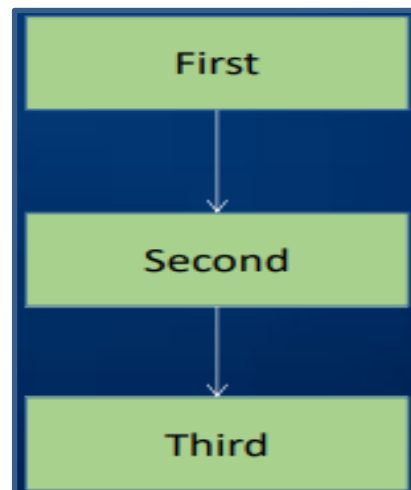
- This is achieved when a derived class inherits another derived class. There is no limit on the number of levels up to which, the multi-level inheritance is achieved in python.

Syntax

```
class class1:
    <class-suite>

class class2(class1):
    <class suite>

class class3(class2):
    <class suite>
```



Example:

```
class First:
    def first(self):
        print("I am the first class")

class Second(First):
    def second(self):
        print("I am the second class")

class Third(Second):
    def third(self):
        print("I am the third class")

t = Third()
t.first()
t.second()
t.third()
```

Output:

I am the first class
I am the second class
I am the third class

Hierarchical Inheritance

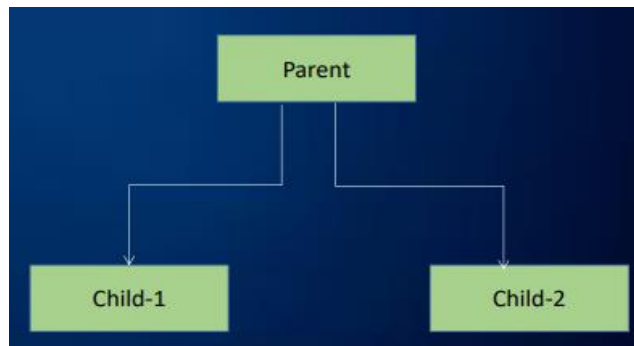
When more than one derived classes are created from a single base – it is called hierarchical inheritance.

Syntax

```
class class1:
    <class-suite>

class class2(class1):
    <class suite>

class class3(class1):
```



<class suite>

```

class Parent:
    def func1(self):
        print("This function is in
Parent")

class Child1(Parent):
    def func2(self):
        print("This function is in
child1")

class Child2(Parent):
    def func3(self):
        print("This function is in
child3")

```

c1 = Child1()
c2 = Child2()

c1.func1()
c1.func2()

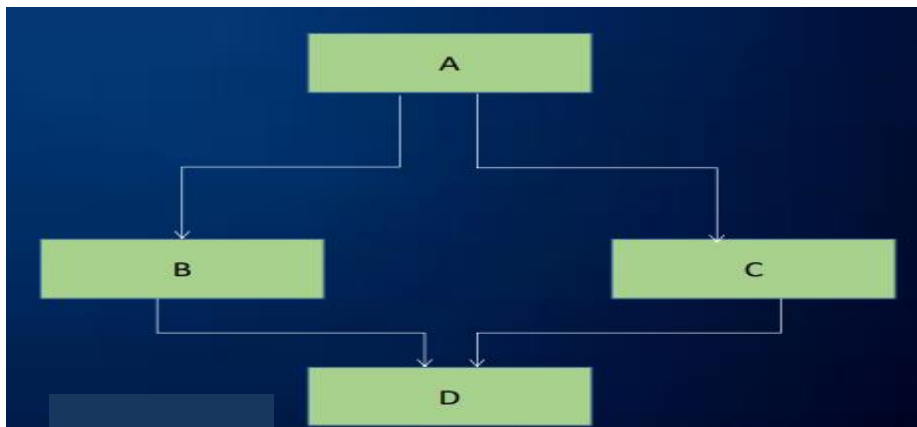
c2.func1()
c2.func3()

Output:

This function is in child1
This function is in Parent
This function is in child3

Hybrid Inheritance

The hybrid inheritance is the combination of more than one type of inheritance. We may use any combination as a single with multiple inheritances, multi-level with multiple inheritances etc.



Super() function

- Python also has a super() function that will make the child class inherit all the methods and properties from its parent:
- By using the super() function, you do not have to use the name of the parent element, it will automatically inherit the methods and properties from its parent.

class Person:

```
def __init__(self, fname, lname):  
    self.firstname = fname  
    self.lastname = lname  
  
def printname(self):  
    print(self.firstname, self.lastname)
```

class Student(Person):

```
def __init__(self, fname, lname):  
    super().__init__(fname, lname)
```

x = Student("John", "Samuel")

x.printname()

Output:

John Samuel

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.
- It 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.

Operator overloading

- Operator overloading is a kind of overloading in which an operator may be used in ways other than those stated in its predefined definition.

```
num1 = 1
num2 = 2
print(num1+num2)
```

output : 3

```
str1 = "Python"
str2 = "Programming"
print(str1+" "+str2)
```

output : Python Programming

- We can see from the above example that the addition operator is utilized in a variety of ways. In the first example, since the data given is two integer values, the operator performed a two-number addition.
- And in the second example, the values are supplied as string data and the same operator concatenates the two strings.

Another example:

```
print(2*7)
14
print("a"*3)
aaa
```

Method Overloading

- Overloading a method refers to a class that has many methods with the same name but perhaps distinct parameters.
- While Python does not natively enable method overloading, there are numerous techniques to do this.
- Consider an example in which we utilized conditional statements to invoke several functions in distinct ways.

Example:

class Area:

```
def find_area(self, a=None, b=None):  
    if a != None and b != None:  
        print("Rectangle:", (a * b))  
    elif a != None:  
        print("square:", (a * a))  
    else:  
        print("No figure assigned")  
  
obj1=Area()  
obj1.find_area()  
obj1.find_area(10)  
obj1.find_area(10,20)
```

Polymorphism with Inheritance

- Like in other programming languages, 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**.

In Python, to override a method, you have to meet certain conditions, and they are:

- You **can't override** a method within the **same class**. It means you have to do it in the child class using the Inheritance concept.
- To override the **Parent Class method**, you have to create a **method in the Child class** with the same name and the same number of parameters.

```
class Parent:  
    def __init__(self):  
        self.value = "Inside Parent"
```



```
def show(self):  
    print(self.value)  
  
class Child(Parent):  
    def __init__(self):  
        self.value = "Inside Child"  
  
    def show(self):  
        print(self.value)  
  
obj1 = Parent()  
obj2 = Child()  
obj1.show()  
obj2.show()
```

Output:

Inside Parent

Inside Child

Abstraction

Abstraction means hiding the complexity and only showing the essential features of the object. So in a way, Abstraction means hiding the real implementation and we, as a user, knowing only how to use it.

Abstract Class in Python

- An **abstract class** is a class that contains one or more abstract methods.
- An **Abstract method** is a method that generally doesn't have any implementation, it is left to the sub classes to provide implementation for the abstract methods.
- Abstract class can't be instantiated so it is not possible to create objects of an

abstract class.

- In Python abstract class is created by deriving from the meta class ABC which belongs to the abc (Abstract Base Class) module.

Syntax for creating Abstract Class

```
from abc import ABC
```

```
class MyClass(ABC):
```

Abstract Method in Python

- For defining abstract methods in an abstract class, method has to be decorated with @abstractmethod decorator.
- From abc module @abstractmethod decorator has to be imported to use that annotation.

Syntax for defining abstract method in abstract class in Python

```
from abc import ABC, abstractmethod
```

```
class MyClass(ABC):
```

```
    @abstractmethod
```

```
        def mymethod(self):
```

```
            none
```

Important points about abstract class in Python

- Abstract class can have both concrete methods as well as abstract methods.
- Abstract class works as a template for other classes.
- Abstract class can't be instantiated so it is not possible to create objects of an abstract class.
- Generally abstract methods defined in abstract class don't have anybody but it is possible to have abstract methods with implementation in abstract class.

- If any abstract method is not implemented by the derived class Python throws an error.

Example program using abstract methods and abstract class :

```
from abc import ABC, abstractmethod

class Parent(ABC):
    def common(self):
        print("I am the common of parent")
    @abstractmethod
    def vary(self):
        none

class Child1(Parent):
    def vary(self):
        print("I am vary of child1")

class Child2(Parent):
    def vary(self):
        print("I am vary method of child2")

obj1 = Child1()
obj1.common()
obj1.vary()

obj2 = Child2()
obj2.common()
obj2.vary()
```

Output:

I am the common of parent

I am vary of child1

I am the common of parent

I am vary method of child

Errors and Exceptions

Two common kinds of errors that you may have to deal with are

- Syntax errors
- Exceptions

Syntax Errors:

- It occur when you type the code incorrectly.

Exceptions:

- They are different from syntax errors. They occur during the execution of a program when something unexpected happens.

Some Common Built-in Exceptions

- **NameError:** This exception is raised when the program cannot find a local or global name. The name that could not be found is included in the error message.
- **TypeError:** This exception is raised when a function is passed an object of the inappropriate type as its argument. More details about the wrong type are provided in the error message.
- **ValueError:** This exception occurs when a function argument has the right type but an inappropriate value.
- **NotImplementedError:** This exception is raised when an object is supposed to support an operation but it has not been implemented yet. You should not use this error when the given function is not meant to support the type of input argument. In those situations, raising a `TypeError` exception is more appropriate.
- **ZeroDivisionError:** This exception is raised when you provide the second argument for a division or modulo operation as zero.

- **FileNotFoundError:** This exception is raised when the file or directory that the program requested does not exist.

Handling an Exception

```
a = True
```

```
while a:
```

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

```
    print("Dividing 50 by", x, "will give you:", 50/x)
```

You will get **Value Error** on entering decimal number or string as input.

- To handle the exception,

The first step of the process is to include the code that you think might raise an exception inside the **try** clause. The next step is to use the **except** keyword to handle the exception that occurred in the above code.

```
a = True
```

```
while a:
```

```
    try:
```

```
        x = int(input("Please enter a number: "))
```

```
        print("Dividing 50 by", x, "will give you: ", 50/x)
```

```
    except ValueError:
```

```
        print("The input was not an integer. Please try again...")
```

Output:

Please enter a number: a

The input was not an integer. Please try again...

Please enter a number: 2

Dividing 50 by 2

- If no exception was raised, the program skips the **except** clause and the rest of the code executes normally.
- If an exception is raised, the program skips the remaining code inside the **try** clause and the **type** of the exception is matched with the **name** of the exception after the **except** keyword.
- In case of a match, the code inside the **except** clause is executed first, and then the rest of the code after the **try** clause is executed normally.
- When you enter an integer as an input, the program gives you the final result of the division.
- When a non-integral value is provided, the program prints a message asking you to try and enter an integer again.
- Note that this time, the program does not abruptly quit when you provide some invalid input.
- You can also handle multiple exceptions using a single except clause by passing these exceptions to the clause as a tuple.

except (ZeroDivisionError, ValueError, TypeError):

```
print("Something has gone wrong..")
```

- One possible use of catching all exceptions is to properly print out the exception error on screen like the following code:

```
import math
```

```
import sys
```

```
try:
```

```
    result = math.factorial(2.4)
```

except:

```
print("Something Unexpected has happened.")
```

else:

```
print("The factorial is", result)
```

Using the Else Clause

- The else clause is meant to contain code that needs to be executed if the try clause did not raise any exceptions.
- If you decide to use an else clause, you should include it after all the except clauses but before the finally block.

```
a = True
```

while a:

try:

```
x = int(input("Please enter a number: "))
```

except ValueError:

```
print("The input was not a valid integer. Please try again...")
```

else:

```
print("Dividing 50 by", x, "will give you :", 50 / x)
```

Using the Finally Clause

- The code inside the finally clause is always executed irrespective of whether the try block raised an exception.

```
a = True
```

while a:

try:

```
x = int(input("Please enter a number: "))
```

except ValueError:

```
print("The input was not a valid integer. Please try again...")
```

else:

```
print("Dividing 50 by", x, "will give you :", 50/x)
```

finally:

```
print("Already did everything necessary.")
```

Output:

Please enter a number: 2

Dividing 50 by 2 will give you : 25.0

Already did everything necessary.

Please enter a number: d

The input was not a valid integer. Please try again...

Already did everything necessary.

Please enter a number:

Raising exceptions

- An exception can be raised forcefully by using the raise clause in Python. It is useful in that scenario where we need to raise an exception to stop the execution of the program.

Syntax: raise Exception_class,<value>

- 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.

EXAMPLE:

try:

```
age = int(input("Enter the age:"))
```

```
if(age<18):
```

```
    raise ValueError
```

```
else:
```

```
    print("the age is valid")
```

except ValueError:

```
    print("The age is not valid")
```

Output:

Enter the age:16

The age is not valid

User-Defined Exceptions

In Python, users can define **custom exceptions** by creating a new class. This exception class has to be derived, either directly or indirectly, from the built-in Exception class. Most of the built-in exceptions are also derived from this class.

```
class customError(Exception):
```

```
    none
```

```
raise customError
```

Here, we have created a user-defined exception called **CustomError** which inherits from the **Exception** class. This new exception, like other exceptions, can be raised using the **raise** statement with an **optional error message**.