Session: 7

Inheritance and Polymorphism

Objectives

- Define and describe inheritance
- Explain method overriding
- Define and describe sealed classes
- Explain polymorphism

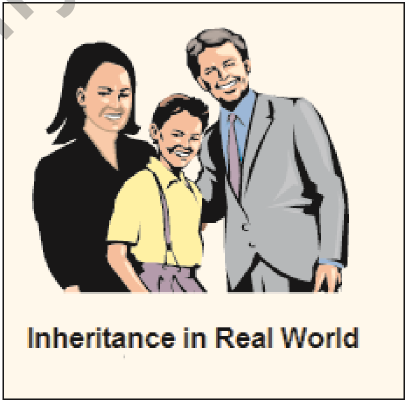
Definition of Inheritance 1-2

- The similarity in physical features of a child to that of its parents is due to the child having inherited these features from its parents.

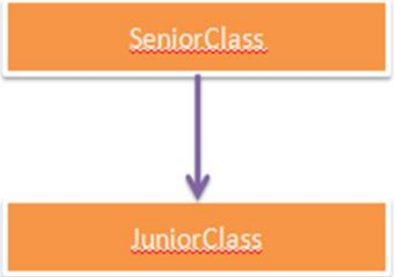
- Similarly, in C#, inheritance allows you to create a class by deriving the common attributes and methods of an existing class.

- The class from which the new class is created is known as the base class and the created class is known as the derived class.

- The process of creating a new class by extending some features of an existing class is known as inheritance.



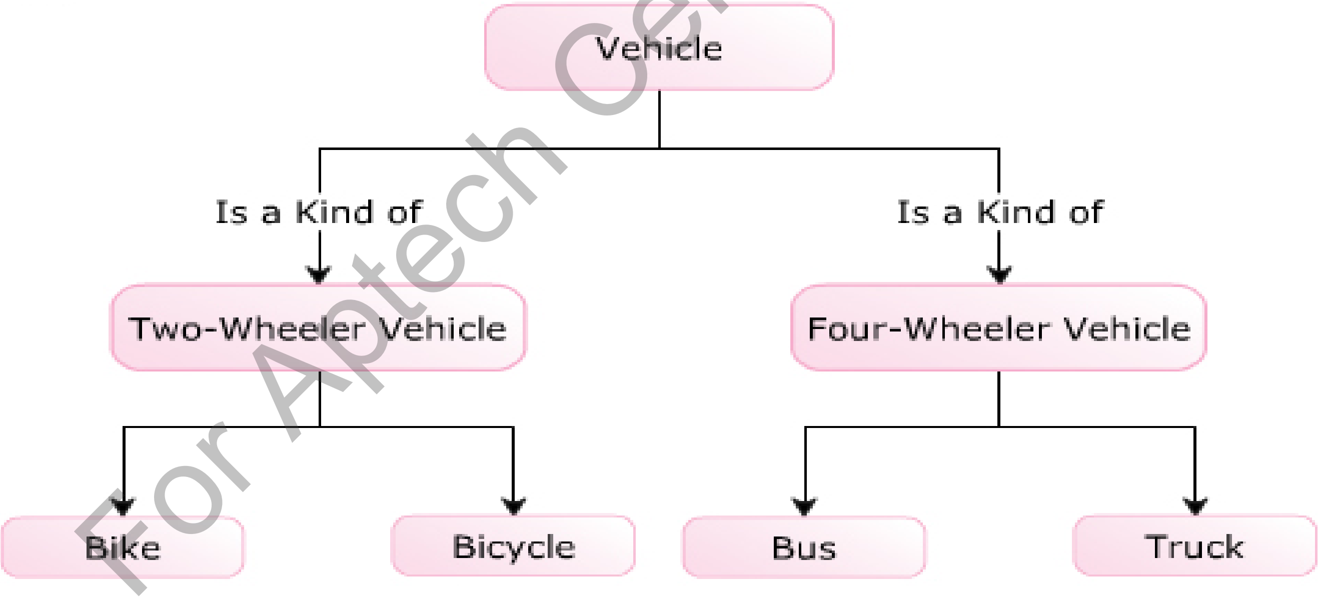
Inheritance in Real World



Definition of Inheritance 2-2

Example

- Consider a class called **`Vehicle`** that consists of a variable called **`color`** and a method called **`Speed()`**.
- These data members of the **`Vehicle`** class can be inherited by the **`TwoWheelerVehicle`** and **`FourWheelerVehicle`** classes.
- The following figure illustrates an example of inheritance:

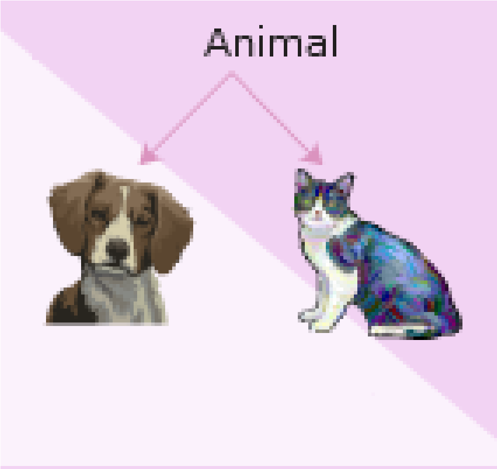


Purpose 1-3

- The purpose of inheritance is to reuse common methods and attributes among classes without recreating them.
- Reusability of a code enables you to use the same code in different applications with little or no changes.

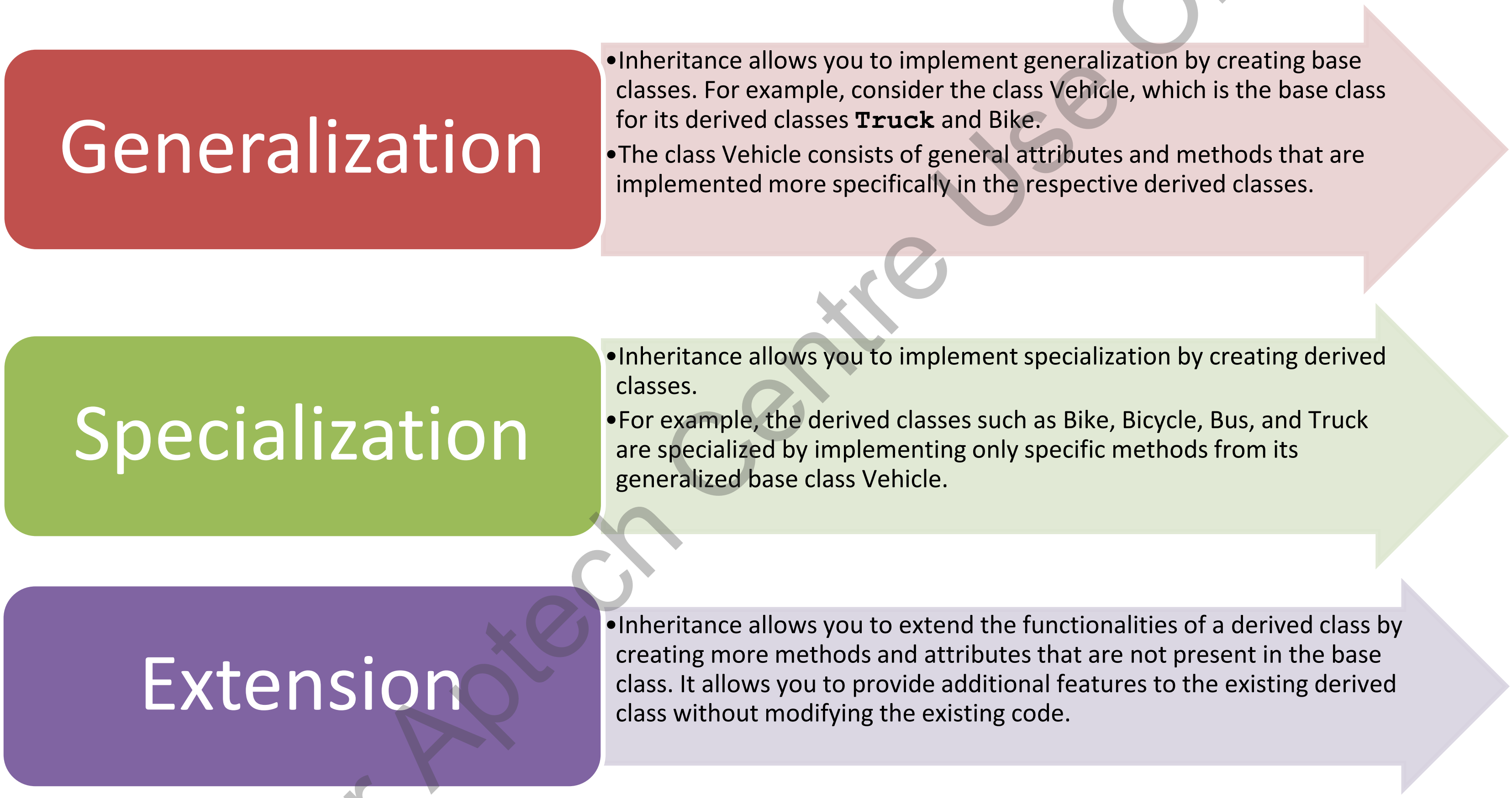
Example

- Consider a class named **`Animal`** which defines attributes and behavior for animals.
- If a new class named **`Cat`** has to be created, it can be done based on **`Animal`** because a cat is also an animal.
- Thus, you can reuse the code from the previously-defined class.



Purpose 2-3

- Apart from reusability, inheritance is widely used for:



Generalization

- Inheritance allows you to implement generalization by creating base classes. For example, consider the class Vehicle, which is the base class for its derived classes **Truck** and Bike.
- The class Vehicle consists of general attributes and methods that are implemented more specifically in the respective derived classes.

Specialization

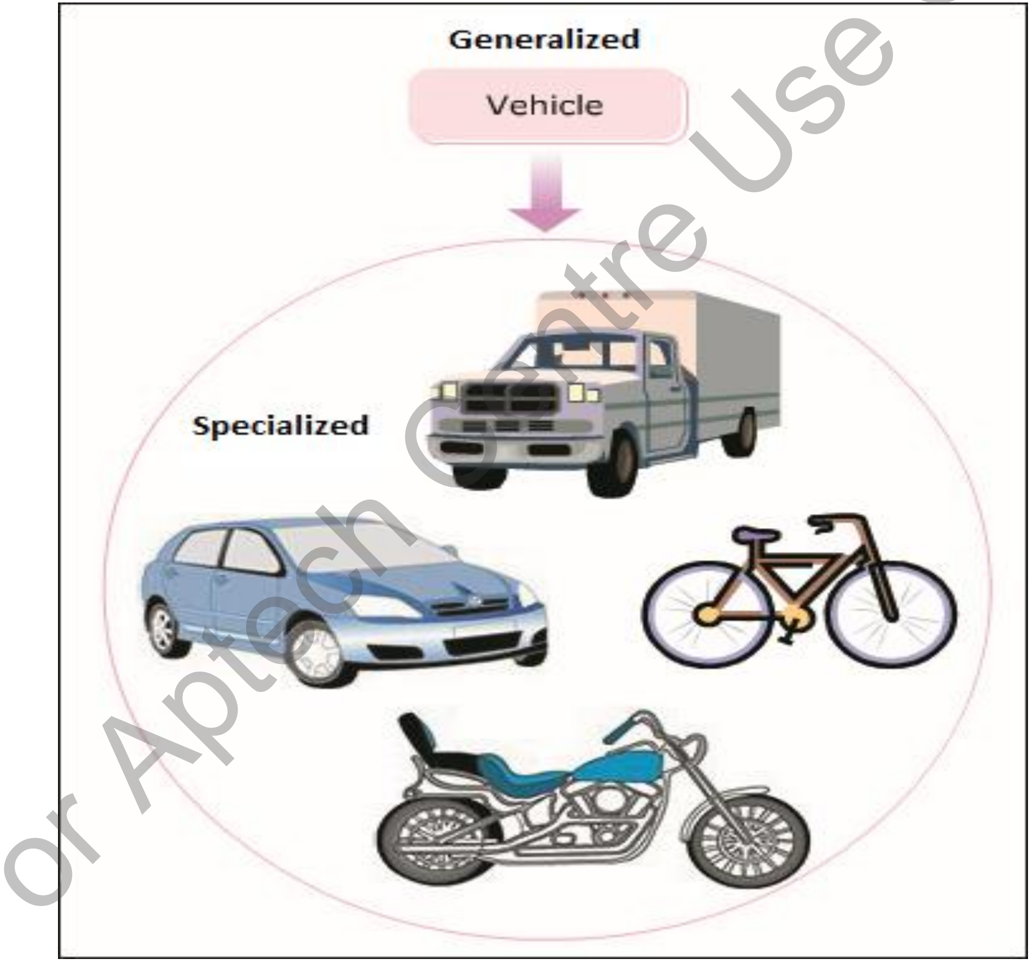
- Inheritance allows you to implement specialization by creating derived classes.
- For example, the derived classes such as Bike, Bicycle, Bus, and Truck are specialized by implementing only specific methods from its generalized base class Vehicle.

Extension

- Inheritance allows you to extend the functionalities of a derived class by creating more methods and attributes that are not present in the base class. It allows you to provide additional features to the existing derived class without modifying the existing code.

Purpose 3-3

- The following figure displays a real-world example demonstrating the purpose of inheritance:

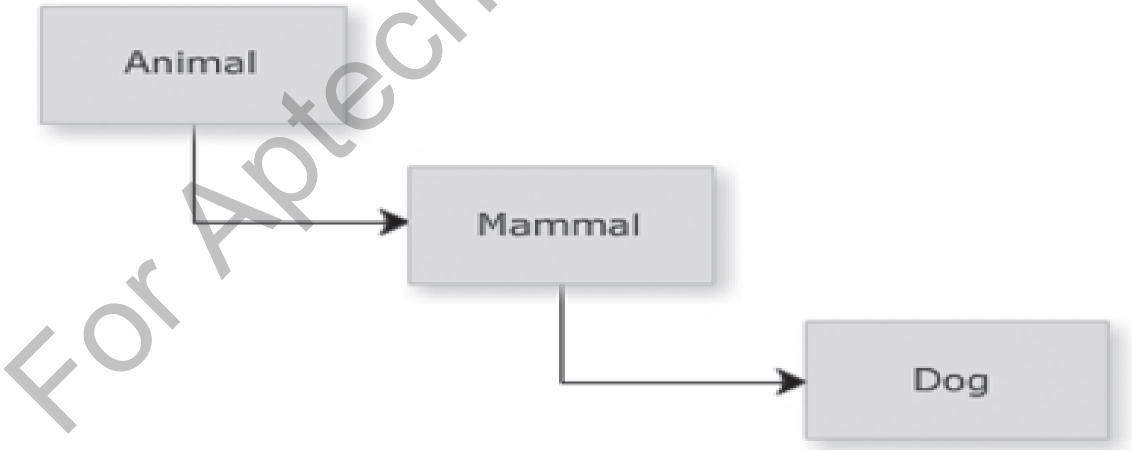


Multi-level Hierarchy 1-3

- Inheritance allows the programmer to build hierarchies that can contain multiple levels of inheritance.

Example

- Consider three classes **`Mammal`**, **`Animal`**, and **`Dog`**. The class **`Mammal`** is inherited from the base class **`Animal`**, which inherits all the attributes of the **`Animal`** class.
- The class **`Dog`** is inherited from the class `Mammal` and inherits all the attributes of both the **`Animal`** and **`Mammal`** classes.
- The following figure depicts multi-level hierarchy of related classes:



Multi-level Hierarchy 2-3

- The following code demonstrates multiple levels of inheritance:

Snippet

```
using System;
class Animal
{
      public void Eat()
      {
            Console.WriteLine(“Every animal eats something.”);
      }
}
class Mammal : Animal
{
      public void Feature()
      {
      Console.WriteLine(“Mammals give birth to young ones.”);
      }
}

class Dog : Mammal
{
            public void Noise()
            {
               Console.WriteLine(“Dog Barks.”);
            }
            static void Main(string[] args)
            {
            Dog objDog = new Dog();
            objDog.Eat();
            objDog.Feature();
            objDog.Noise();
            }
}
```

Multi-level Hierarchy 3-3

- In the code, the `Main()` method of the class **Dog** invokes the methods of the class **Animal**, **Mammal**, and **Dog**.

Output

```
Every animal eats something.
Mammals give birth to young ones.
Dog Barks.
```

Implementing Inheritance 1-3

- To derive a class from another class in C#, insert a colon after the name of the derived class followed by the name of the base class.
- The derived class can now inherit all non-private methods and attributes of the base class.
- The following syntax is used to inherit a class in C#:

Syntax

```
<DerivedClassName>:<BaseClassName>
```

where,

- `DerivedClassName`: Is the name of the newly created child class.
- `BaseClassName`: Is the name of the parent class from which the current class is inherited.

Implementing Inheritance 2-3

- The following syntax is used to invoke a method of the base class:

Syntax

```
<objectName>.<MethodName>;
```

where,

- `objectName`: Is the object of the base class.
- `MethodName`: Is the name of the method of the base class.

- The following code demonstrates how to derive a class from another existing class and inherit methods from the base class:

Snippet

```
class Animal
{
        public voidEat()
        {
        Console.WriteLine("Everyanimaleatssomething.");
        }
        publicvoidDoSomething()
        {
        Console.WriteLine("Everyanimaldoessomething.");
        }
}
class Cat:Animal
{
         static voidMain(String[]args)
         {
         Cat objCat=new Cat();
         objCat.Eat();
         objCat.DoSomething();
         }
}
```

Implementing Inheritance 3-3

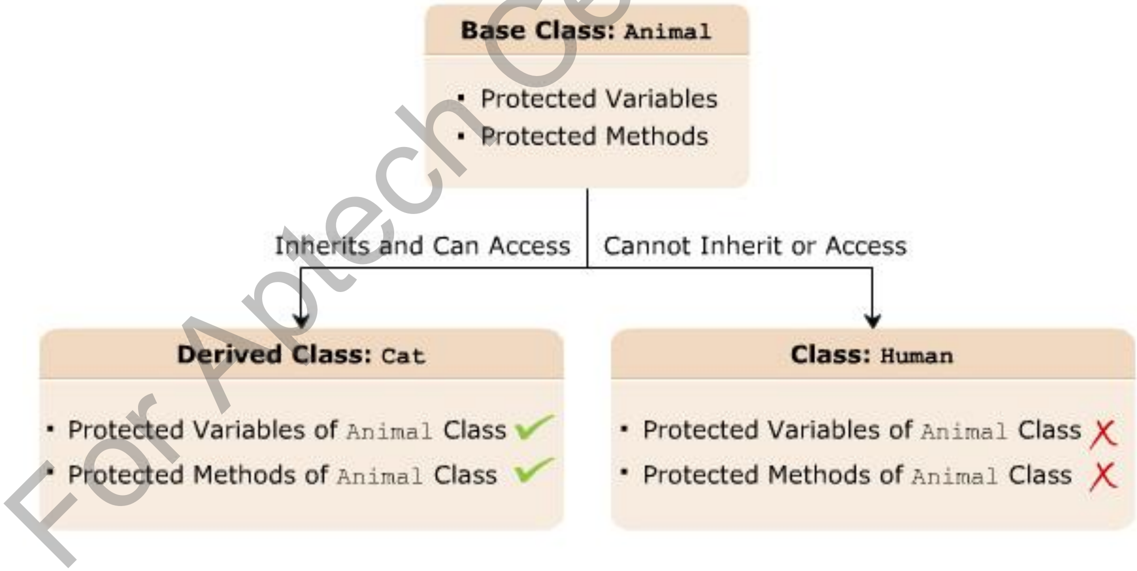
- In the code:
  - The class **Animal** consists of two methods, **Eat()** and **DoSomething()**. The class **Cat** is inherited from the class **Animal**.
  - The instance of the class **Cat** is created and it invokes the two methods defined in the class **Animal**.
  - Even though an instance of the derived class is created, it is the methods of the base class that are invoked because these methods are not implemented again in the derived class.
  - When the instance of the class **Cat** invokes the **Eat()** and **DoSomething()** methods, the statements in the **Eat()** and **DoSomething()** methods of the base class **Animal** are executed.

Output

```
Every animal eats something.
Every animal does something.
```

protected Access Modifier 1-3

- The protected access modifier protects the data members that are declared using this modifier.
- The protected access modifier is specified using the protected keyword.
- Variables or methods that are declared as protected are accessed only by the class in which they are declared or by a class that is derived from this class.
- The following figure displays an example of using the protected access modifier:


Base Class: Animal
• Protected Variables
• Protected Methods
Inherits and Can Access
Cannot Inherit or Access
Derived Class: Cat
• Protected Variables of Animal Class ✓
• Protected Methods of Animal Class ✓
Class: Human
• Protected Variables of Animal Class ✗
• Protected Methods of Animal Class ✗

protected Access Modifier 2-3

- The following syntax declares a protected variable:

Syntax

```
protected<data_type><VariableName>;
```

where,

- data_type: Is the data type of the data member.
- VariableName: Is the name of the variable.

- The following syntax declares a protected method:

Syntax

```
protected<return_type><MethodName>(argument_list);
```

where,

- return_type: Is the type of value the method will return.
- MethodName: Is the name of the method.
- argument_list: Is the list of parameters.

`protected` Access Modifier 3-3

- The following code demonstrates the use of the `protected` access modifier:

Snippet

```
class Animal
{
       protected string Food;
       protected string Activity;
}
class Cat:Animal
{
   static voidMain(String[]args)
   {
       cat objCat=newCat();
       objCat.Food="Mouse";
       objCat.Activity="lazearound";
       Console.WriteLine("The Cat loves to eat"+objCat.Food+".");
       Console.WriteLine("The Catloves to"+objCat.Activity+".");
       }
}
```

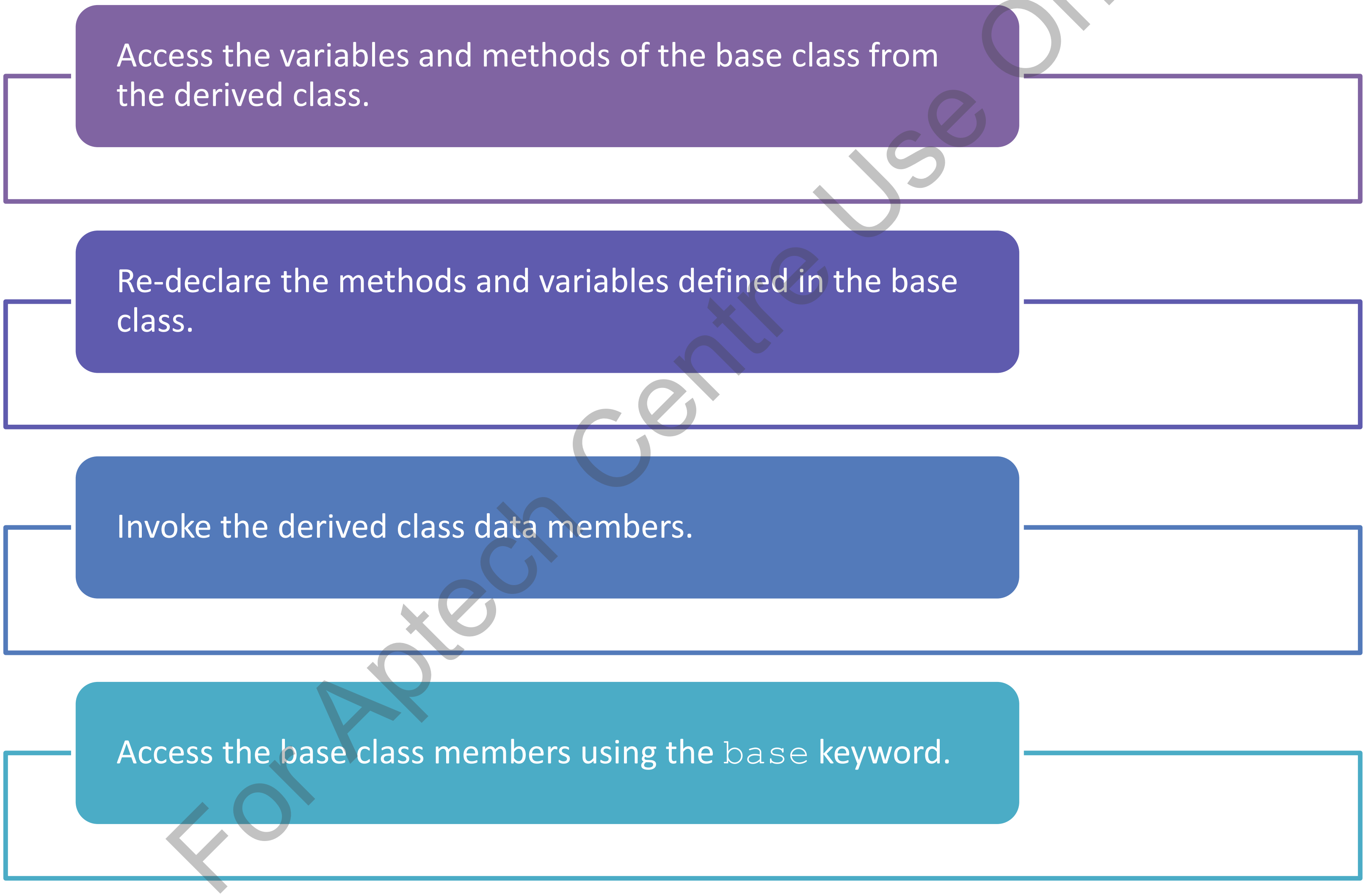
- In the code:
  - Two variables are created in the class **`Animal`** with the `protected` keyword.
  - The class **`Cat`** is inherited from the class **`Animal.`**
  - The instance of the class **`Cat`** is created that is referring the two variables defined in the class **`Animal`** using the dot (.) operator.
  - The `protected` access modifier allows the variables declared in the class **`Animal`** to be accessed by the derived class **Cat**.

Output

```
Cat loves to eat Mouse.
The Cat loves to laze around.
```

base Keyword 1-3

- The `base` keyword allows you to do the following:



Access the variables and methods of the base class from the derived class.

Re-declare the methods and variables defined in the base class.

Invoke the derived class data members.

Access the base class members using the `base` keyword.

base Keyword 2-3

- The following syntax shows the use of the base keyword:

Syntax

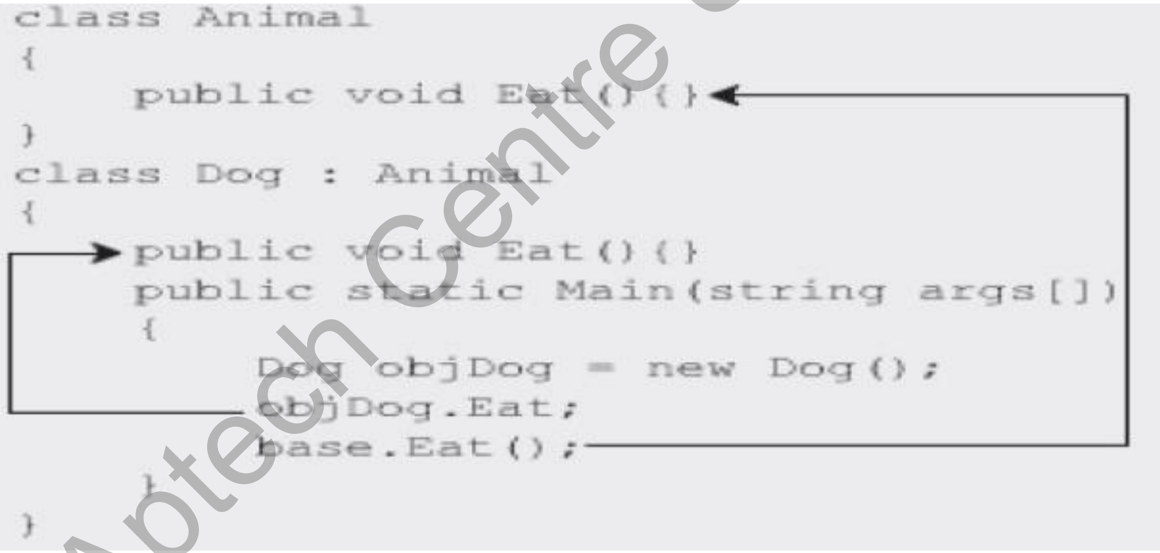
```
 class <ClassName>
{
<accessmodifier><returntype><BaseMethod>{}
}
class <ClassName1>:<ClassName>
{
base.<BaseMethod>;
}
```

where,

- <ClassName>: Is the name of the base class.
- <accessmodifier>: Specifies the scope of the class or method.
- <returntype>: Specifies the type of data the method will return.
- <BaseMethod>: Is the base class method.
- <ClassName1>: Is the name of the derived class.
- base: Is a keyword used to access the base class members.

base Keyword 3-3

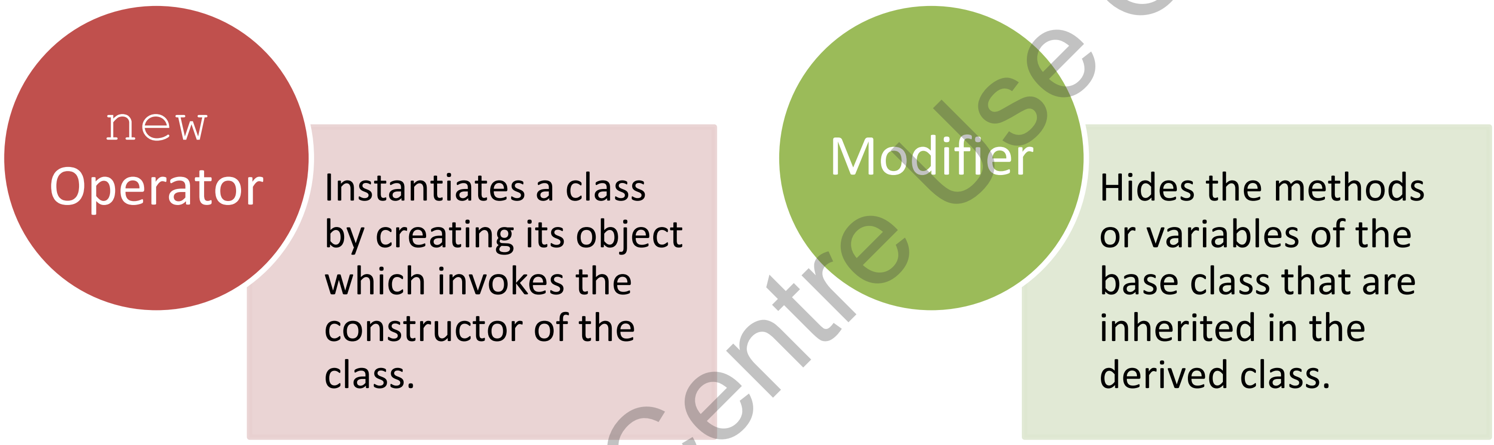
- The following figure displays an example of using the `base` keyword:



```
class Animal
{
     public void Eat(){}
}
class Dog : Animal
{
     public void Eat(){}
     public static Main(string args[])
     {
          Dog objDog = new Dog();
          objDog.Eat;
          base.Eat();
     }
}
```

new Keyword 1-2

- The new keyword can either be used as an operator or as a modifier in C#.



new Operator

Instantiates a class by creating its object which invokes the constructor of the class.

Modifier

Hides the methods or variables of the base class that are inherited in the derived class.

- This allows you to redefine the inherited methods or variables in the derived class.
- Since redefining the base class members in the derived class results in base class members being hidden, the only way you can access these is by using the base keyword.

new Keyword 2-2

- The following syntax shows the use of the new modifier:

Syntax

```
 <access modifier>class<ClassName>
{
<access modifier><returntype><BaseMethod>{}
}
<access modifier>class<ClassName1>:<ClassName>
{
new<access modifier>void<BaseMethod>{}
     }
```

where,

- <accessmodifier>: Specifies the scope of the class or method.
- <returntype>: Specifies the type of data the method will return.
- <ClassName>: Is the name of the base class.
- <ClassName1>: Is the name of the derived class.
- new: Is a keyword used to hide the base class method.

- The following code creates an object using the new operator:

Snippet

```
EmployeesobjEmp=newEmployees();
```

- Here, the code creates an instance called **objEmp** of the class **Employees** and invokes its constructor.

protected Access Modifier 1-2

The following code demonstrates the use of the new modifier to redefine the inherited methods in the base class:

Snippet

```
class Employees
{
     int_empId=1;
     string_empName="JamesAnderson";
     int_age=25;
     publicvoidDisplay()
     {
         Console.WriteLine("EmployeeID:"+_empId);
         Console.WriteLine("EmployeeName:"+_empName);
     }
}
classDepartment:Employees
{
      int_deptId=501;
      string_deptName="Sales";
      newvoidDisplay()
      {
              base.Display();
              Console.WriteLine("DepartmentID:"+_deptId);
              Console.WriteLine("DepartmentName:"+_deptName);
      }
      static voidMain(string[]args)
      {
           Department objDepartment=new Department();
           objDepartment.Display();
       }
}
```

`protected` Access Modifier 2-2

- In the code:
  - The class **`Employees`** declares a method called **`Display()`**.
  - This method is inherited in the derived class **`Department`** and is preceded by the `new` keyword.
  - The `new` keyword hides the inherited method **`Display()`** that was defined in the base class, thereby executing the **`Display()`** method of the derived class when a call is made to it.
  - However, the `base` keyword allows you to access the base class members.
  - Therefore, the statements in the **`Display()`** method of the derived class and the base class are executed, and, finally, the employee ID, employee name, department ID, and department name are displayed in the console window.

Output

```
Employee ID: 1
Employee Name: James Anderson
Department ID: 501
Department Name: Sales
```

Constructor Inheritance 1-3

- In C#, you can:

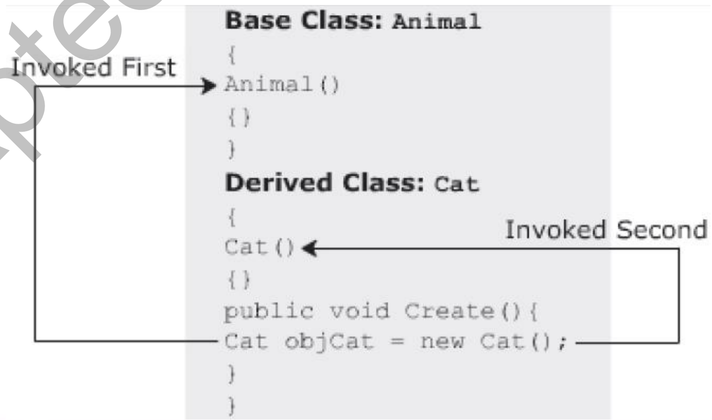
Invoke the base class constructor by either instantiating the derived class or the base class.

Invoke the constructor of the base class followed by the constructor of the derived class.

Invoke the base class constructor by using the base keyword in the derived class constructor declaration.

Pass parameters to the constructor.

- However, C# cannot inherit constructors similar to how you inherit methods.
- The following figure displays an example of constructor inheritance:



```
Base Class: Animal
{
Animal()
{}
}
Derived Class: Cat
{
Cat()
{}
public void Create(){
Cat objCat = new Cat();
}
}
```

Constructor Inheritance 2-3

- The following code explicitly invokes the base class constructor using the `base` keyword:

Snippet

```
class Animal
{
     public Animal()
     {
        Console.WriteLine("Animal constructor without parameters");
     }
     public Animal(Stringname)
     {
        Console.WriteLine("Animal constructor with a string parameter");
     }
     }
     class Canine:Animal
     {
       //base()takes a string value called“Lion”
       public Canine():base("Lion")
       {
          Console.WriteLine("DerivedCanine");
       }
     }
     class Details
     {
       static voidMain(String[]args)
       {
       Canine objCanine=new Canine();
       }
}
```

Constructor Inheritance 3-3

- In the code:
  - The class **Animal** consists of two constructors, one without a parameter and the other with a string parameter.
  - The class **Canine** is inherited from the class **Animal**.
  - The derived class **Canine** consists of a constructor that invokes the constructor of the base class Animal by using the base keyword.
  - If the base keyword does not take a string in the parenthesis, the constructor of the class **Animal** that does not contain parameters is invoked.
  - In the class **Details**, when the derived class constructor is invoked, it will in turn invoke the parameterized constructor of the base class.

Output

```
Animal constructor with a string parameter
Derived Canine
```

Invoking Parameterized Base Class Constructors 1-3

- The derived class constructor can explicitly invoke the base class constructor by using the `base` keyword.
- If a base class constructor has a parameter, the `base` keyword is followed by the value of the type specified in the constructor declaration.
- If there are no parameters, the `base` keyword is followed by a pair of parentheses.

Invoking Parameterized Base Class Constructors 2-3

- The following code demonstrates how parameterized constructors are invoked in a multi-level hierarchy:

Snippet

```
using System;
class Metals
{
    string_metalType;
    public Metals(stringtype)
    {
        _metalType=type;
        Console.WriteLine("Metal:\t\t"+_metalType);
    }
    }
    class SteelCompany : Metals
    {
         string_grade;
         public SteelCompany(stringgrade):base("Steel")
         {
         _grade=grade;
         Console.WriteLine("Grade:\t\t"+_grade);
         }
    }
    class Automobiles:SteelCompany
    {
        string_part;
        public Automobiles(stringpart):base("CastIron")
        {
        _part=part;
        Console.WriteLine("Part:\t\t"+_part);
        }
        static voidMain(string[]args)
        {
        Automobiles objAutomobiles=new Automobiles("Chassies");
        }
}
```

Invoking Parameterized Base Class Constructors 3-3

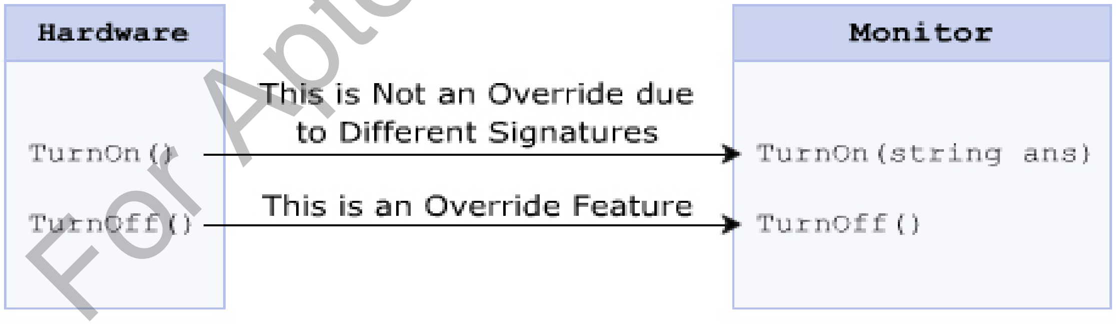
- In the code:
  - The **`Automobiles`** class inherits the **`SteelCompany`** class.
  - The **`SteelCompany`** class inherits the **`Metals`** class.
  - In the `Main()` method, when an instance of the **`Automobiles`** class is created, it invokes the constructor of the **`Metals`** class, followed by the constructor of the **`SteelCompany`** class.
  - Finally, the constructor of the **`Automobiles`** class is invoked.

Output

```
Metal: Steel
Grade: CastIron
Part: Chassies
```

Method Overriding

- Method overriding:
  - Is a feature that allows the derived class to override or redefine the methods of the base class which changes the body of the method that was declared in the base class.
  - Allows the same method with the same name and signature declared in the base class to be reused in the derived class to define a new behavior.
  - Ensures reusability while inheriting classes.
  - Is implemented in the derived class from the base class is known as the Overridden Base Method.
- The following figure depicts method overriding:



Hardware
TurnOn()
TurnOff()
This is Not an Override due to Different Signatures
This is an Override Feature
Monitor
TurnOn(string ans)
TurnOff()

virtual and override Keywords 1-5

- You can override a base class method in the derived class using appropriate C# keywords such as:

To override a particular method of the base class in the derived class, you need to declare the method in the base class using the virtual keyword.

A method declared using the virtual keyword is referred to as a virtual method.

In the derived class, you need to declare the inherited virtual method using the override keyword.

In the derived class, you need to declare the inherited virtual method using the override keyword which is mandatory for any virtual method that is inherited in the derived class.

The override keyword overrides the base class method in the derived class.

virtual and override Keywords 2-5

- The following is the syntax for declaring a virtual method using the virtual keyword:

Syntax

```
<access_modifier>virtual<return_type><MethodNa
me>(<parameter-list>);
```

where,

- access_modifier: Is the access modifier of the method, which can be private, public, protected, or internal.
- virtual: Is a keyword used to declare a method in the base class that can be overridden by the derived class.
- return_type: Is the type of value the method will return.
- MethodName: Is the name of the virtual method.
- parameter-list: Is the parameter list of the method; it is optional.

virtual and override Keywords 3-5

- The following is the syntax for overriding a method using the override keyword:

Syntax

```
<accessmodifier>override<returntype><MethodName>
(<parameters-list>)
```

where,

- override: Is the keyword used to override a method in the derived class.

virtual and override Keywords 4-5

- The following code demonstrates the application of the virtual and override keywords in the base and derived classes respectively:

Snippet

```
class Animal
{
      public virtual void Eat()
      {
      Console.WriteLine("Every animal eats something");
      }
      protected void DoSomething()
      {
      Console.WriteLine("Every animal does something");
      }
}
class Cat:Animal
{
      //Class Cat overrides Eat()method of class Animal
      public override void Eat()
      {
      Console.WriteLine("Cat loves to eat the mouse");
      }
      static void Main(String[]args)
      {
      Cat objCat = newCat();
      objCat.Eat();
      }
}
```

virtual and override Keywords 5-5

- In the code:
  - The class **Animal** consists of two methods, the **Eat()** method with the virtual keyword and the **DoSomething()** method with the protected keyword. The class **Cat** is inherited from the class **Animal**.
  - An instance of the class **Cat** is created and the dot (.) operator is used to invoke the **Eat()** and the **DoSomething()** methods.
  - The virtual method **Eat()** is overridden in the derived class using the override keyword.
  - This enables the C# compiler to execute the code within the **Eat()** method of the derived class.

Output

```
Cat loves to eat the mouse
```

Calling the Base Class Method 1-3

- Method overriding allows the derived class to redefine the methods of the base class.
- It allow the base class methods to access the new method but not the original base class method.
- To execute the base class method as well as the derived class method, you can create an instance of the base class.
- It allows you to access the base class method, and an instance of the derived class, to access the derived class method.

Calling the Base Class Method 2-3

- The following code demonstrates how to access a base class method:

Snippet

```
class Student
{
     string _studentName = “James”;
     string _address = “California”;
     public virtual void PrintDetails()
     {

        Console.WriteLine(“Student Name: “ + _studentName);
        Console.WriteLine(“Address: “ + _address);
     }
}
class Grade : Student
{
     string _class = “Four”;
     float _percent = 71.25F;
     public override void PrintDetails()
     {
       Console.WriteLine(“Class: “ + _class);
       Console.WriteLine(“Percentage: “ + _percent);
     }
     static void Main(string[] args)
     {
        Student objStudent = new Student();
        Grade objGrade = new Grade();
        objStudent.PrintDetails();
        objGrade.PrintDetails();
     }
}
```

Calling the Base Class Method 3-3

- In the code:
  - The class **Student** consists of a virtual method called **PrintDetails()**.
  - The class **Grade** inherits the class **Student** and overrides the base class method **PrintDetails()**.
  - The Main() method creates an instance of the base class **Student** and the derived class **Grade**.
  - The instance of the base class **Student** uses the dot (.) operator to invoke the base class method **PrintDetails()**.
  - The instance of the derived class **Grade** uses the dot (.) operator to invoke the derived class method **PrintDetails()**.

Output

```
Student Name: James
Address: California
Class: Four
Percentage: 71.25
```

Sealed Classes 1-3

- A sealed class is a class that prevents inheritance. The features of a sealed class are as follows:

A sealed class can be declared by preceding the class keyword with the `sealed` keyword.

The `sealed` keyword prevents a class from being inherited by any other class.

The sealed class cannot be a base class as it cannot be inherited by any other class. If a class tries to derive a sealed class, the C# compiler generates an error.

- The following syntax is used to declare a sealed class:

Syntax

```
sealed class<ClassName>
{
//body of the class
}
```

where,

- `sealed`: Is a keyword used to prevent a class from being inherited.
- `ClassName`: Is the name of the class that needs to be sealed.

Sealed Classes 2-3

- The following code demonstrates the use of a sealed class in C# which will generate a compiler error:

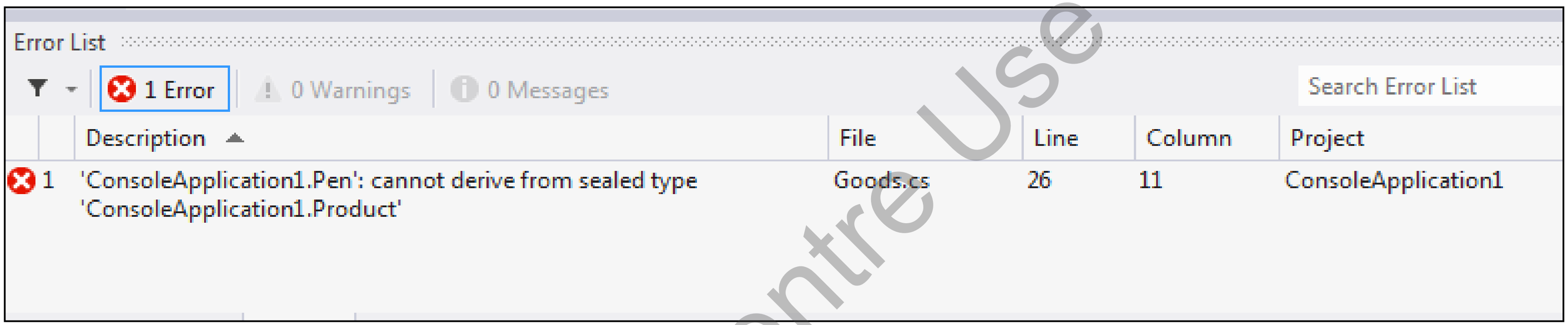
Snippet

```
sealed class Product
{
   public int Quantity;
   public int Cost;
}
class Goods
{
     static void Main(string [] args)
     {
          Product objProduct = new Product();
          objProduct.Quantity = 50;
          objProduct.Cost = 75;
          Console.WriteLine(“Quantity of the Product: ‟ + objProduct. Quantity);
          Console.WriteLine(“Cost of the Product: ‟ + objProduct.Cost);
     }
}
class Pen : Product
{
}
```

- In the code:
  - The class **Product** is declared as `sealed` and it consists of two variables.
  - The class **Goods** contains the code to create an instance of **Product** and uses the dot (.) operator to invoke variables declared in **Product**.

Sealed Classes 3-3

- The class **`Pen`** tries to inherit the sealed class **`Product`**, the C# compiler generates an error, as shown in the following figure:



	Description	File	Line	Column	Project
✖ 1	'ConsoleApplication1.Pen': cannot derive from sealed type 'ConsoleApplication1.Product'	Goods.cs	26	11	ConsoleApplication1

Purpose of Sealed Classes

- Consider a class named **`SystemInformation`** that consists of critical methods that affect the working of the operating system.

- You might not want any third party to inherit the class **`SystemInformation`** and override its methods, thus, causing security and copyright issues.

- Here, you can declare the **`SystemInformation`** class as sealed to prevent any change in its variables and methods.

Guidelines

- Sealed classes are restricted classes that cannot be inherited where the list depicts the conditions in which a class can be marked as sealed:
  - If overriding the methods of a class might result in unexpected functioning of the class.
  - When you want to prevent any third party from modifying your class.

Sealed Methods 1-3

- A sealed class cannot be inherited by any other class.

In C#, a method cannot be declared as sealed.

When the derived class overrides a base class method, variable, property or event, then the new method, variable, property, or event can be declared as sealed.

Sealing the new method prevents the method from further overriding.

An overridden method can be sealed by preceding the override keyword with the sealed keyword.

- The following syntax is used to declare an overridden method as sealed:

Syntax

```
sealed override <return_type> <MethodName>{}
```

where,

- `return_type`: Specifies the data type of value returned by the method.
- `MethodName`: Specifies the name of the overridden method.

Sealed Methods 2-3

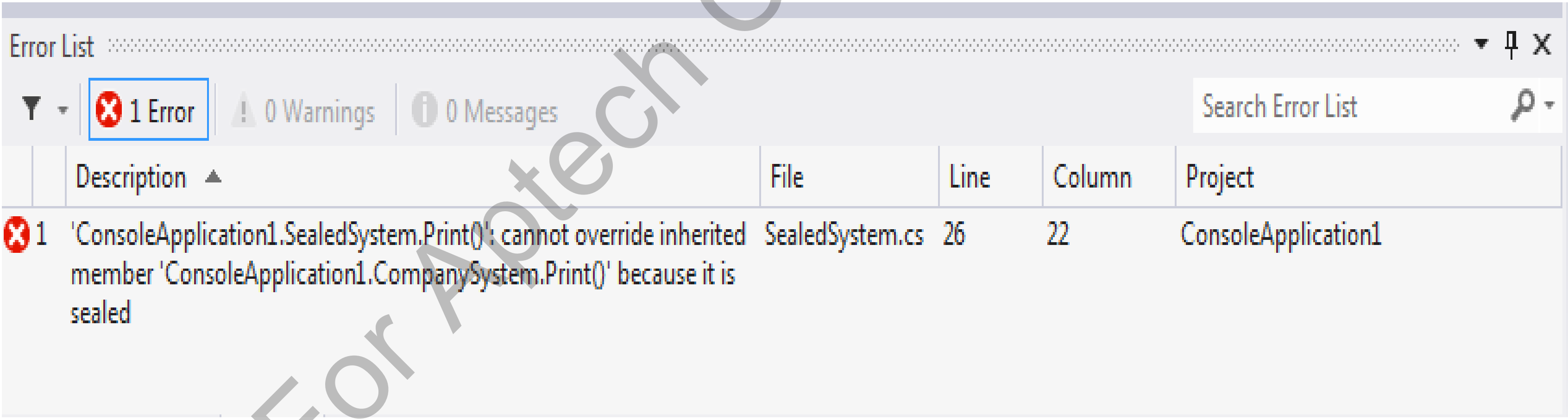
- The following code declares an overridden method `Print()` as sealed:

Snippet

```
using System;
class ITSystem
{
      public virtual void Print()
      {
      Console.WriteLine (“The system should be handled carefully”);
   }
}
class CompanySystem : ITSystem
{
      public override sealed void Print()
      {
        Console.WriteLine (“The system information is
        confidential”);
        Console.WriteLine (“This information should not be
        overridden”);
   }
}
class SealedSystem : CompanySystem
{
      public override void Print()
      {
       Console.WriteLine (“This statement won’t get
       executed”);
      }
      static void Main (string [] args)
      {
       SealedSystem objSealed = new SealedSystem();
       objSealed.Print ();
      }
}
```

Sealed Methods 3-3

- In the code:
  - The class **`ITSystem`** consists of a virtual function **`Print()`**.
  - The class **`CompanySystem`** is inherited from the class **`ITSystem`**.
  - It overrides the base class method **`Print()`**.
  - The overridden method **`Print()`** is sealed by using the `sealed` keyword, which prevents further overriding of that method.
  - The class **`SealedSystem`** is inherited from the class **`CompanySystem`**.
  - When the class **`SealedSystem`** overrides the sealed method **`Print()`**, the C# compiler generates an error as shown in the following figure:



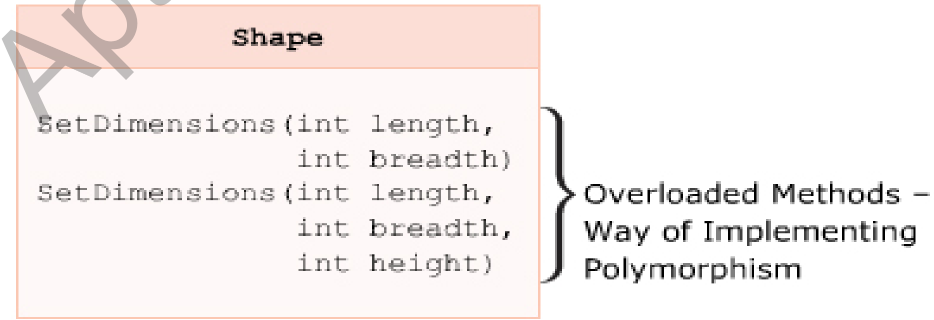
	Description	File	Line	Column	Project
1	'ConsoleApplication1.SealedSystem.Print()': cannot override inherited member 'ConsoleApplication1.CompanySystem.Print()' because it is sealed	SealedSystem.cs	26	22	ConsoleApplication1

Polymorphism

- Polymorphism is the ability of an entity to behave differently in different situations.
- Polymorphism is derived from two Greek words, namely **Poly** and **Morphos**, meaning forms. Polymorphism means existing in multiple forms.
- The following methods in a class have the same name but different signatures that perform the same basic operation but in different ways:
  - `Area(float radius)`
  - `Area(float base, float height)`
- These methods calculate the area of the circle and triangle taking different parameters and using different formulae.

Example

- Polymorphism allows methods to function differently based on the parameters and their data types. The following figure displays the polymorphism:

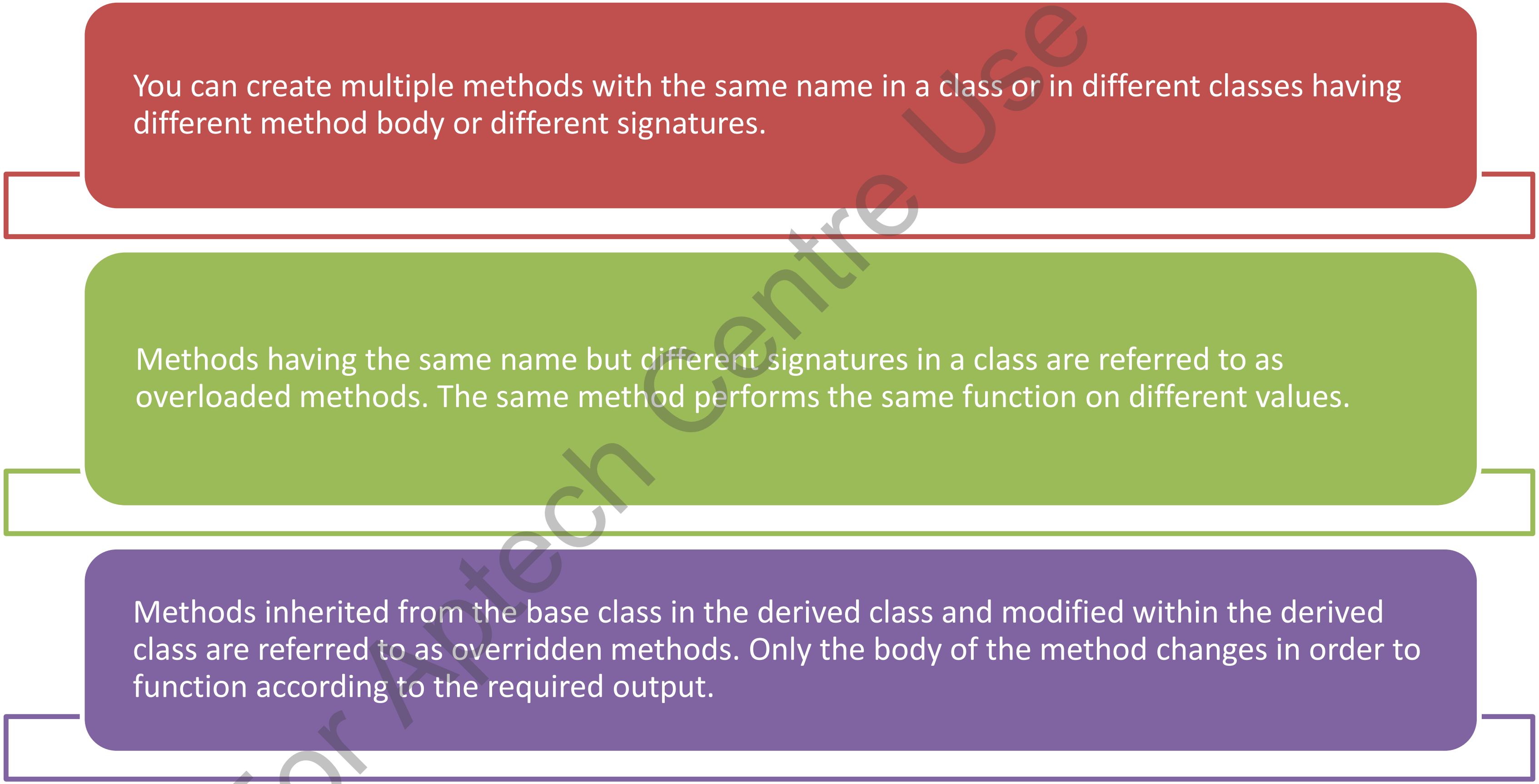


Shape

```
SetDimensions(int length,
              int breadth)
SetDimensions(int length,
              int breadth,
              int height)
```

Implementation 1-3

- Polymorphism can be implemented in C# through method overloading and method overriding.

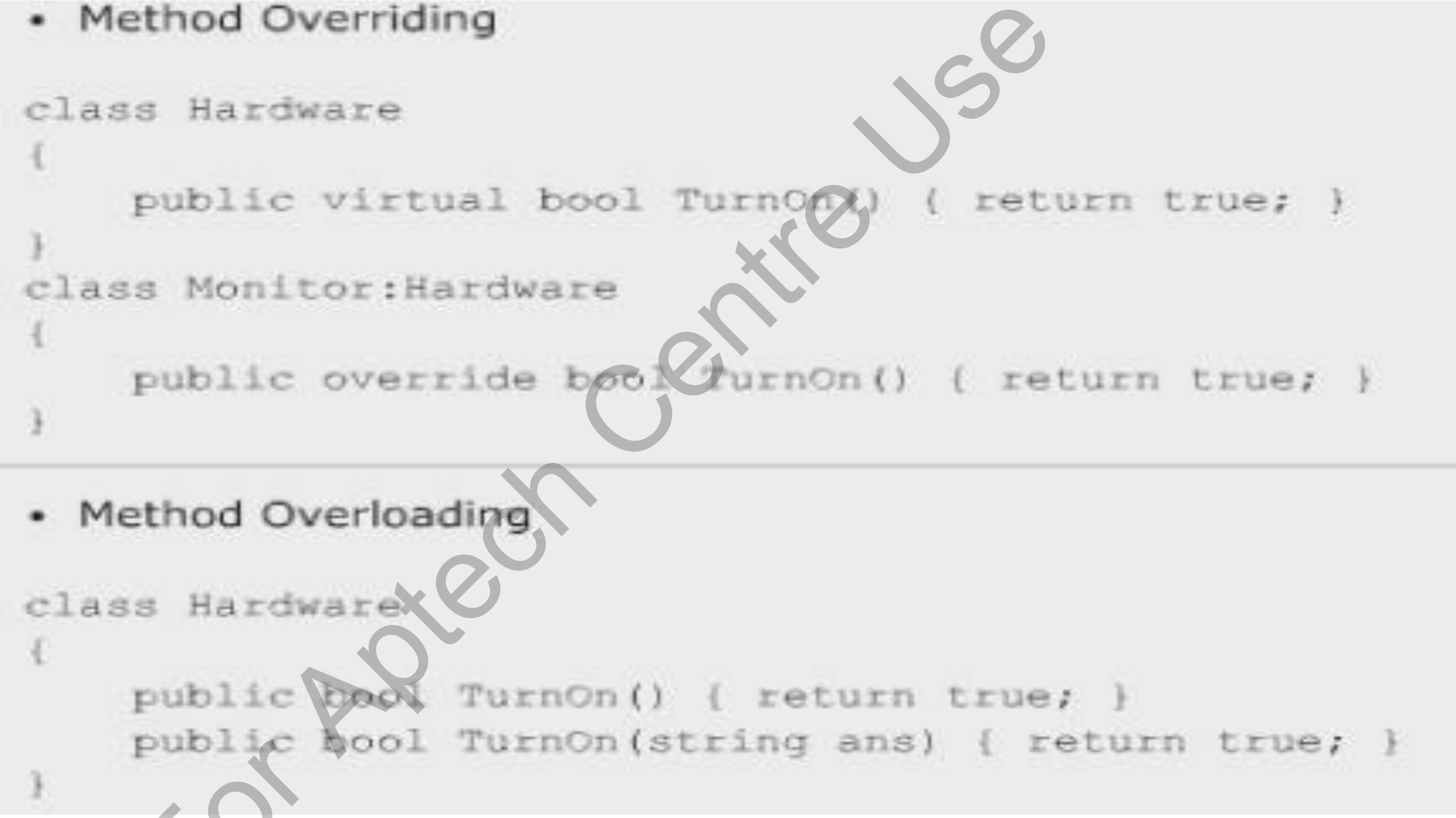


You can create multiple methods with the same name in a class or in different classes having different method body or different signatures.

Methods having the same name but different signatures in a class are referred to as overloaded methods. The same method performs the same function on different values.

Methods inherited from the base class in the derived class and modified within the derived class are referred to as overridden methods. Only the body of the method changes in order to function according to the required output.

- The following figure displays the implementation:



- Method Overriding

```
class Hardware
{
    public virtual bool TurnOn() { return true; }
}
class Monitor:Hardware
{
    public override bool TurnOn() { return true; }
}
```

- Method Overloading

```
class Hardware
{
    public bool TurnOn() { return true; }
    public bool TurnOn(string ans) { return true; }
}
```

Implementation 3-3

- The following code demonstrates the use of method overloading feature:

Snippet

```
class Area
{
      static int CalculateArea(int len, int wide)
      {
      return len * wide;
      }
      static double CalculateArea(double valOne, double valTwo)
      {
          return 0.5 * valOne * valTwo;
}
      static void Main(string[] args)
      {
        int length = 10;
        int breadth = 22;
        double tbase = 2.5;
        double theight = 1.5;
        Console.WriteLine(“Area of Rectangle: ‟ + CalculateArea(length, breadth));
        Console.WriteLine(“Area of triangle: ‟ + CalculateArea(tbase, theight));
     }
}
```

- In the code:
  - The class **`Area`** consists of two static methods of the same name, **`CalculateArea`**. However, both these methods have different return types and take different parameters.

Output

```
Area of Rectangle: 220
Area of triangle: 1.875
```

Compile-time and Run-time Polymorphism 1-3

- Polymorphism can be broadly classified into the following categories:
  - Compile-time polymorphism
  - Run-time polymorphism
- The following table differentiates between compile-time and run-time polymorphism:

Compile-time Polymorphism	Run-time Polymorphism
Is implemented through method **overloading**.	Is implemented through method **overriding**.
Is executed at the compile-time since the compiler knows which method to execute depending on the number of parameters and their data types.	Is executed at run-time since the compiler does not know the method to be executed, whether it is the base class method that will be called or the derived class method.
Is referred to as **static** polymorphism.	Is referred to as **dynamic** polymorphism.

Compile-time and Run-time Polymorphism 2-3

- The following code demonstrates the implementation of run-time polymorphism:

Snippet

```
using System;
class Circle
{
     protected const double PI = 3.14;
     protected double Radius = 14.9;
     public virtual double Area()
     {
     return PI * Radius * Radius;
     }
}
     class Cone : Circle
     {
     protected double Side = 10.2;
     public override double Area()
     {
     return PI * Radius * Side;
     }
     static void Main(string[] args)
     {
     Circle objRunOne = new Circle();
     Console.WriteLine(“Area is: “ + objRunOne.Area());
     Circle objRunTwo = new Cone();
     Console.WriteLine(“Area is: “ + objRunTwo.Area());
     }
}
```

Compile-time and Run-time Polymorphism 3-3

- In the code:
  - The class **`Circle`** initializes protected variables and contains a virtual method **`Area()`** that returns the area of the circle.
  - The class Cone is derived from the class **`Circle`**, which overrides the method **`Area()`**.
  - The **`Area()`** method returns the area of the cone by considering the length of the cone, which is initialized to the value 10.2.
  - The `Main()` method demonstrates how polymorphism can take place by first creating an object of type **`Circle`** and invoking its **`Area()`** method and later creating a reference of type **`Circle`** but instantiating it to **`Cone`** at runtime and then calling the **`Area()`** method.
  - In this case, the **`Area()`** method of **`Cone`** will be called even though the reference created was that of **`Circle`**.

Output

```
Area is: 697.1114
Area is: 477.2172
```

Summary

- Inheritance allows you to create a new class from another class, thereby inheriting its common properties and methods.
- Inheritance can be implemented by writing the derived class name followed by a colon and the name of the base class.
- Method overriding is a process of redefining the base class methods in the derived class.
- Methods can be overridden by using a combination of virtual and override keywords within the base and derived classes respectively.
- Sealed classes are classes that cannot be inherited by other classes.
- You can declare a sealed class in C# by using the sealed keyword.
- Polymorphism is the ability of an entity to exist in two forms that are compile-time polymorphism and run-time polymorphism.