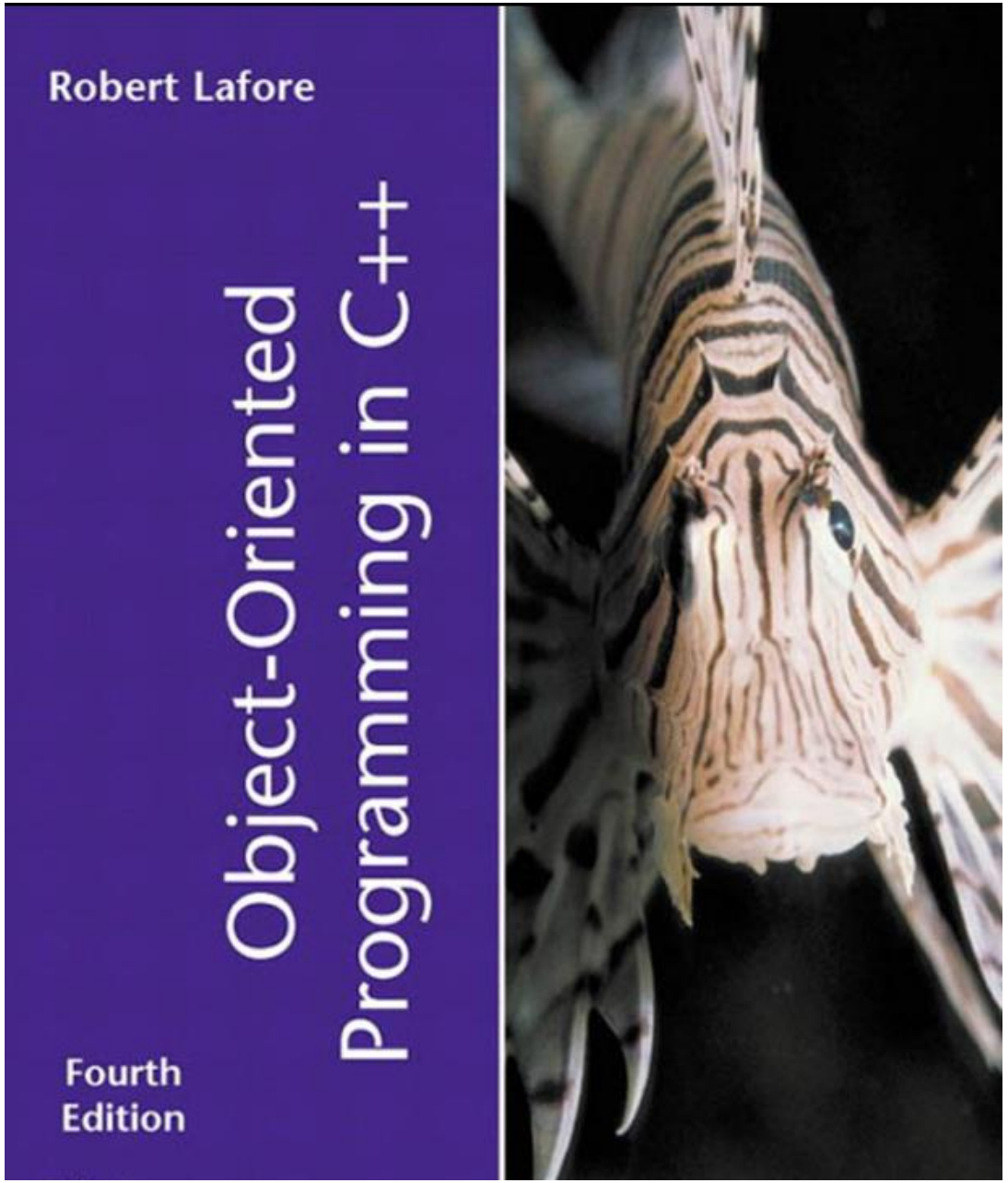
Object Oriented Programming with C++

WELCOME TO THE COURSE



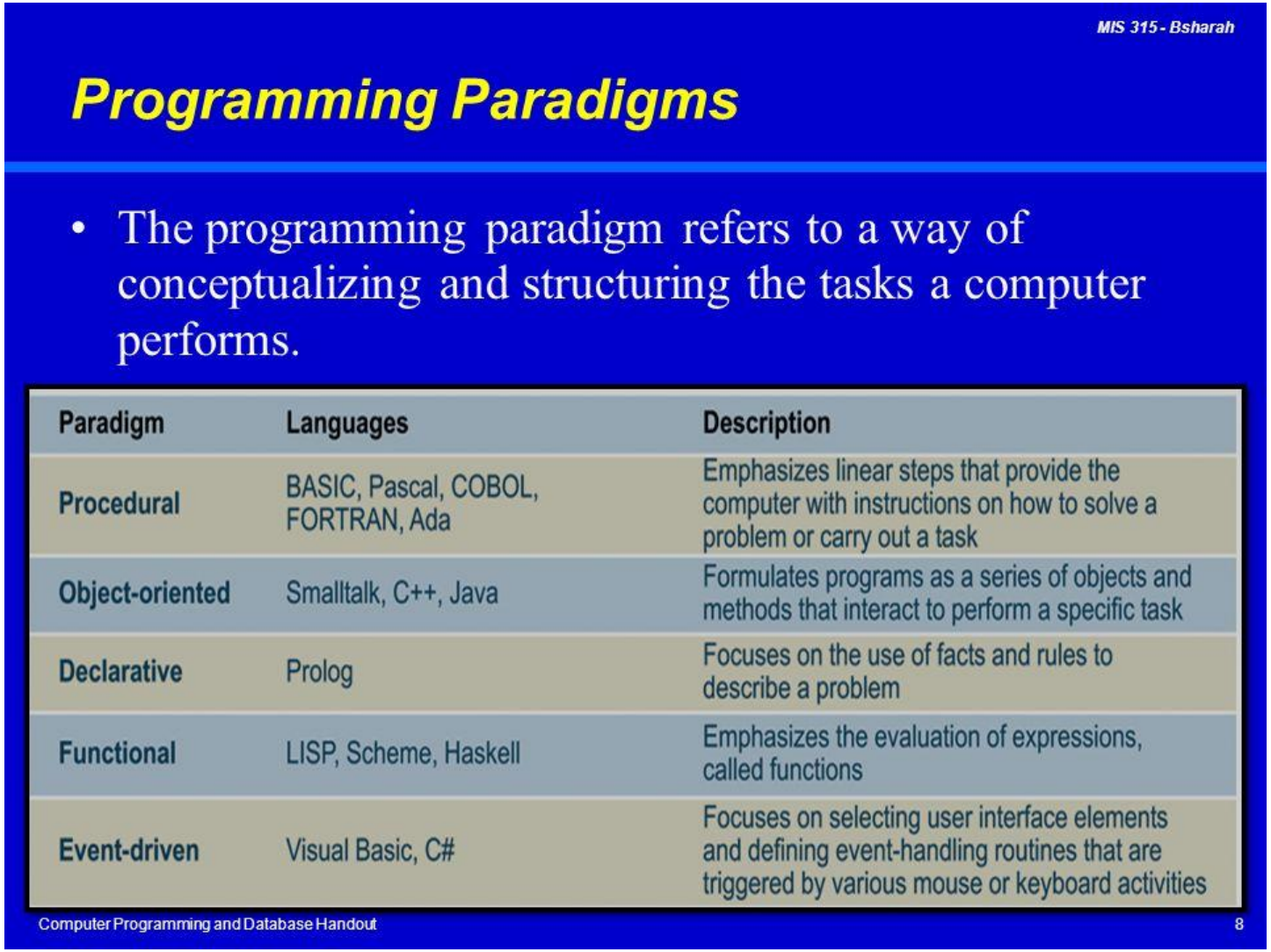
Object-Oriented Programming in C++ (4th Edition)
4th Edition

By Robert Lafore

What IS Object Oriented Programming ?

- **Object-oriented programming** (**OOP**) is a programming paradigm based on the concept of "objects"
- **A** programming paradigm **:** is a style of programming, a way of thinking about software construction.
- A programming paradigm does not refer to a specific language but rather to a way to build a program or a methodology to apply.
- Some languages make it easy to write in some paradigms but not others.
- Some Programming Languages allow the programmer to apply more than one Paradigm.

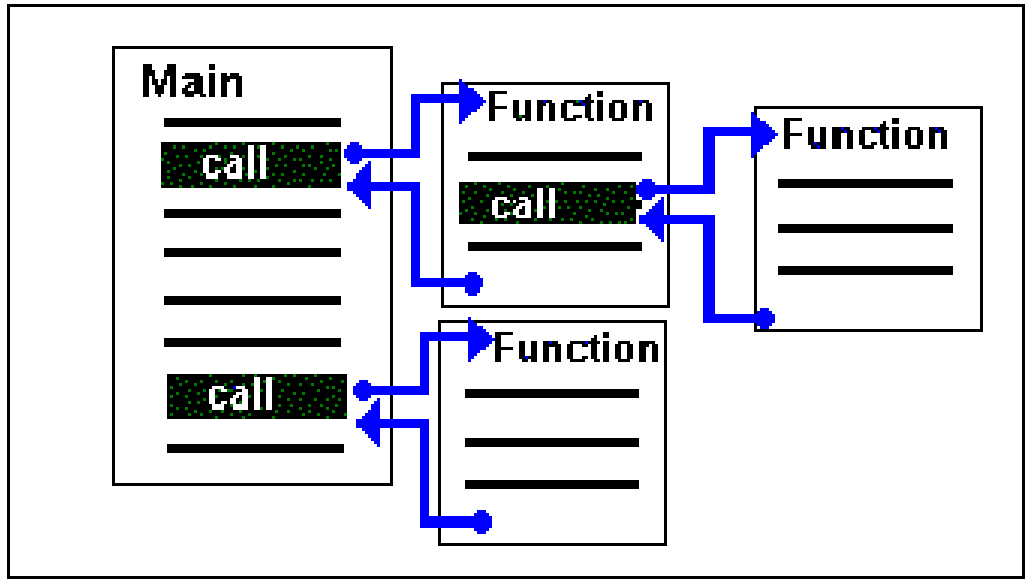
Example of Programming Paradigms



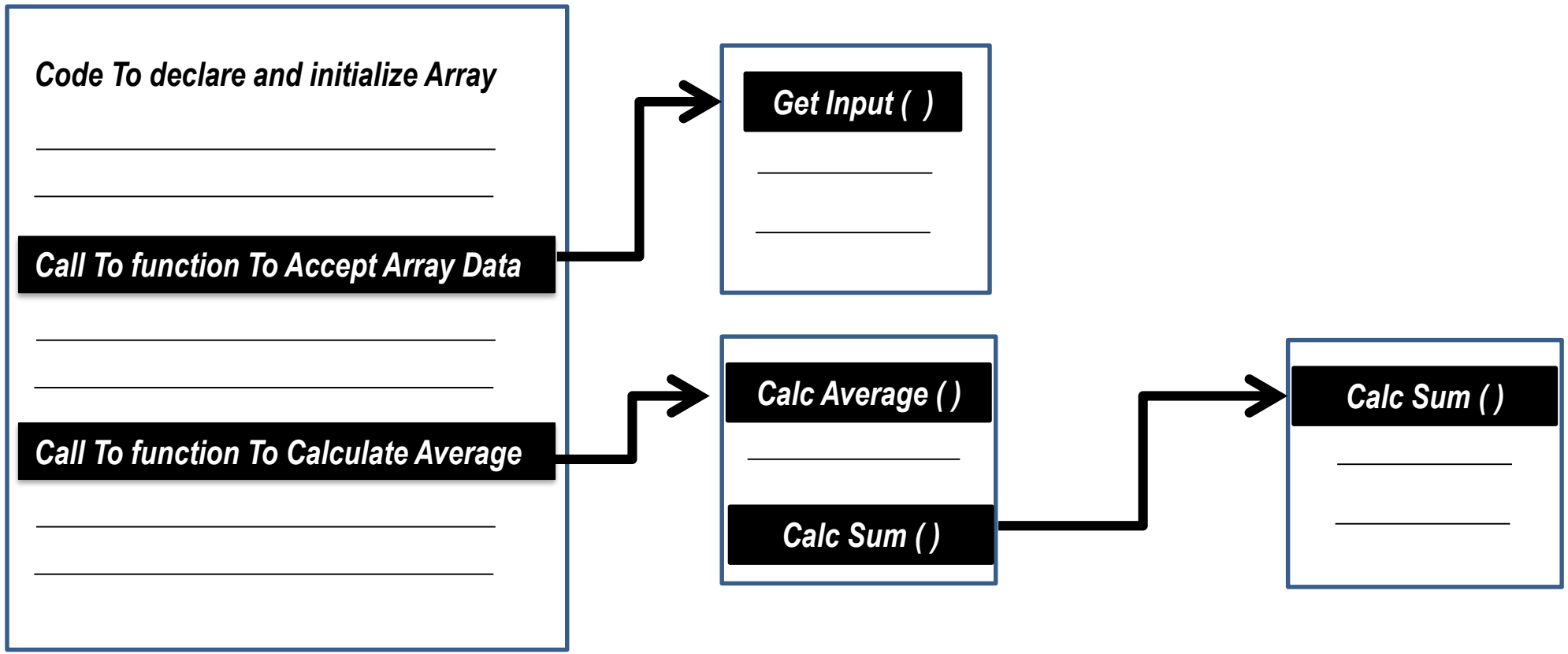
Example of Previous Programming Paradigm

Procedural Programming

Procedural programming (PP), also known as inline programming takes a top-down approach. It is about writing a list of instructions to tell the computer what to do step by step. It relies on procedures or routines.



Procedural Programming Example : Program to Calculate Average of Array Items



- **Object-oriented programming** (**OOP**) is a programming paradigm based on the concept of "objects"

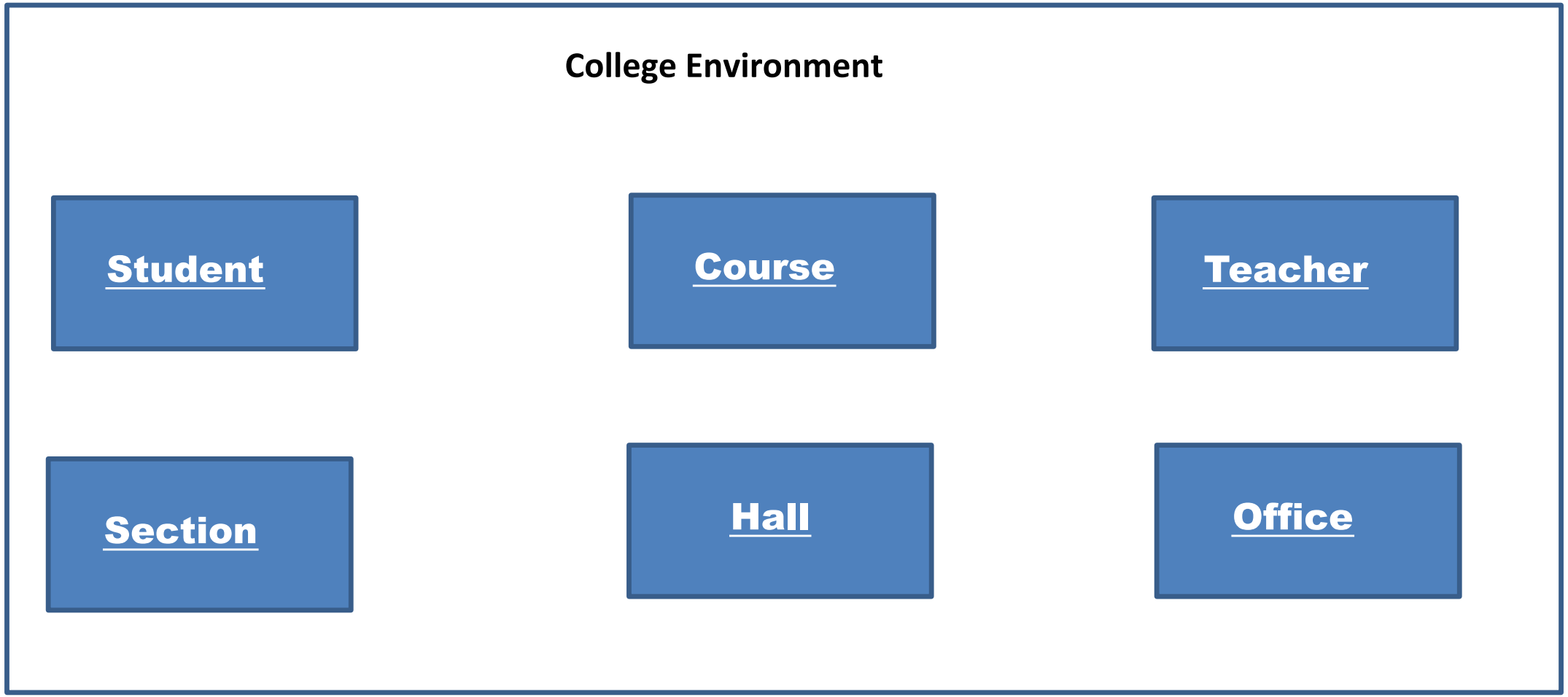
Object : is a thing (Tangible – Intangible)



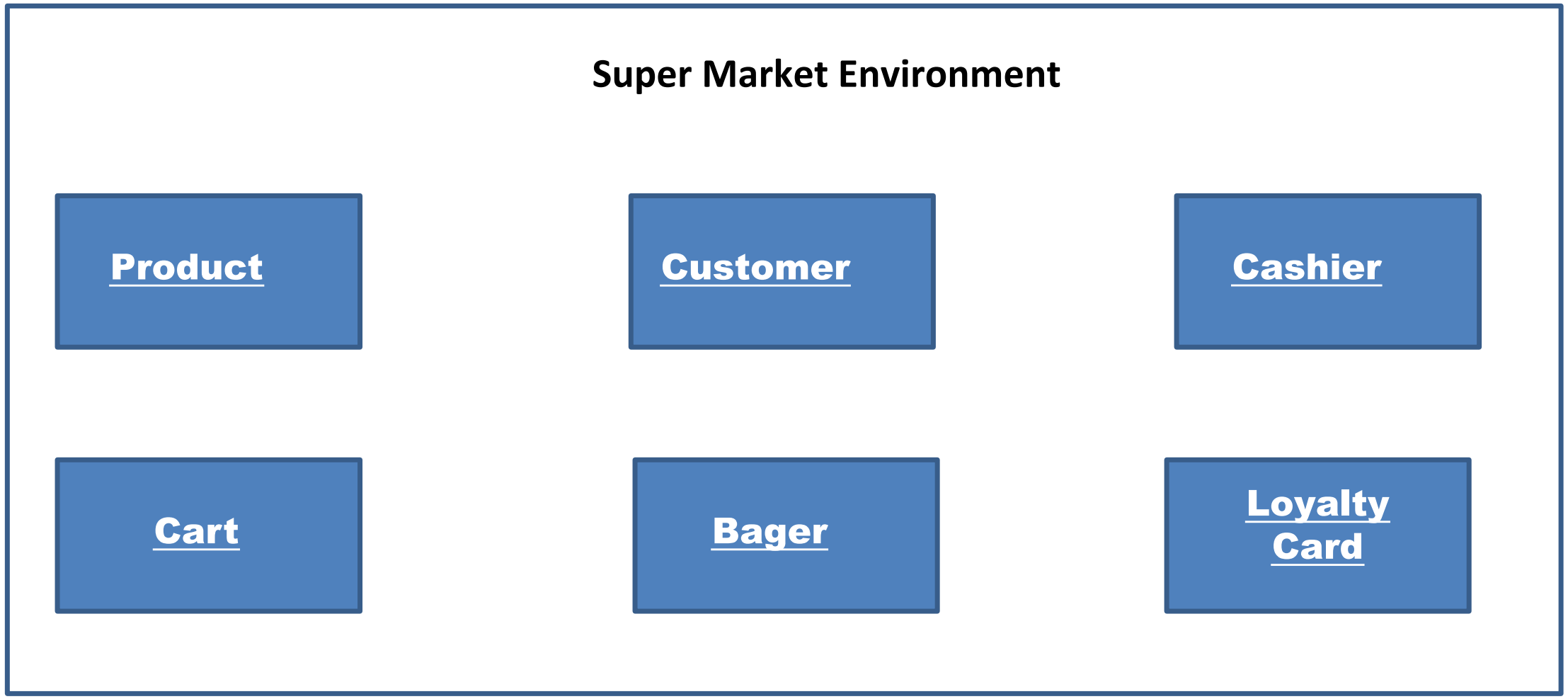




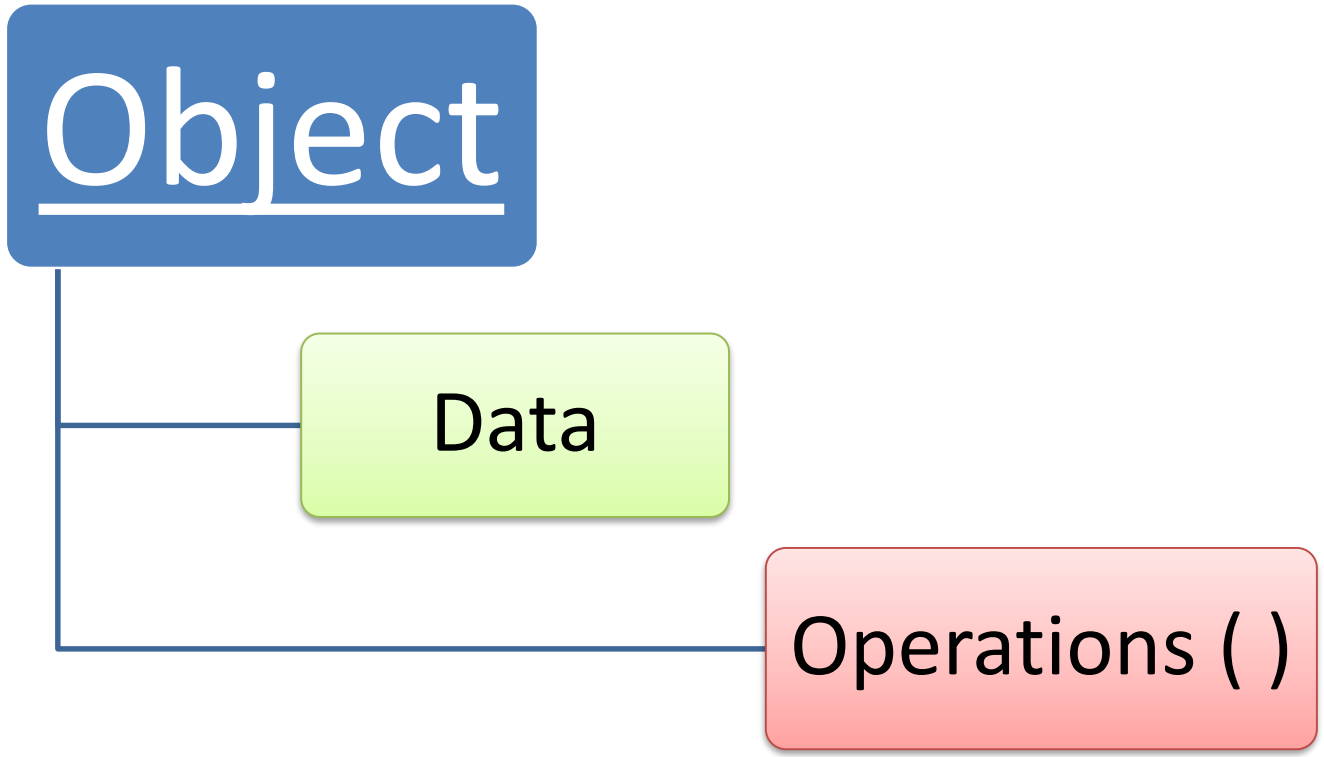
Objects in College Management Program



Objects in Super market Program



Object Is comprised Of ?



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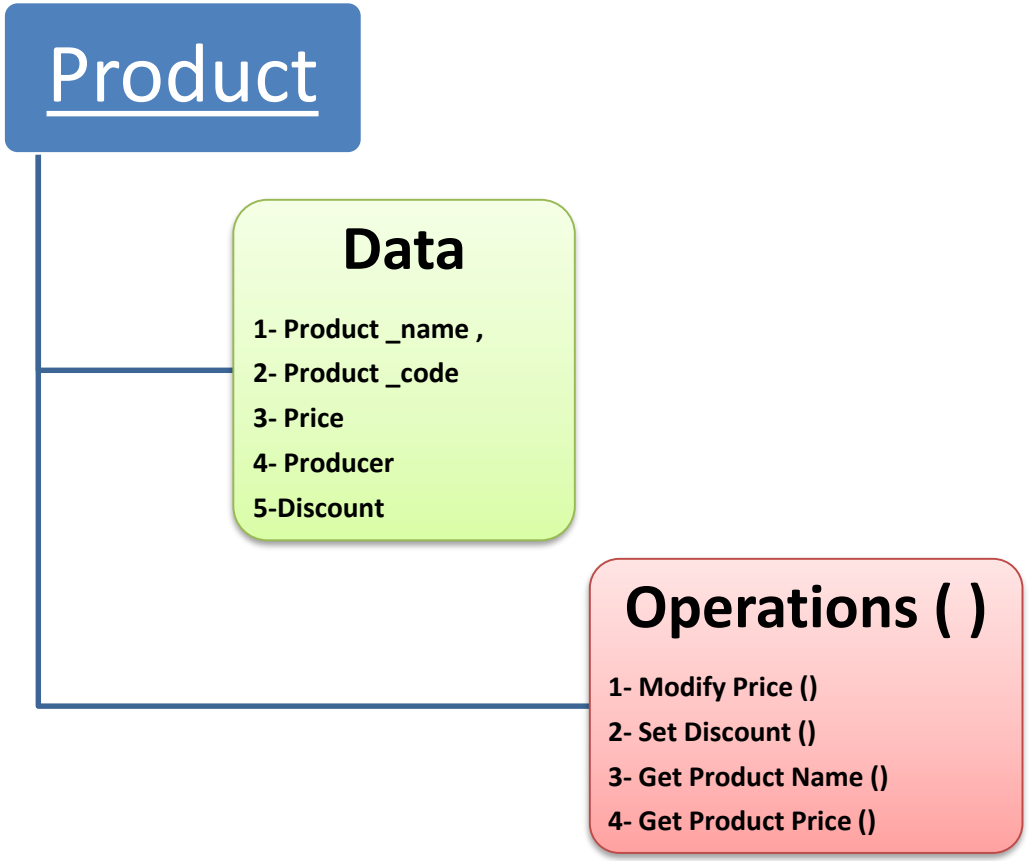

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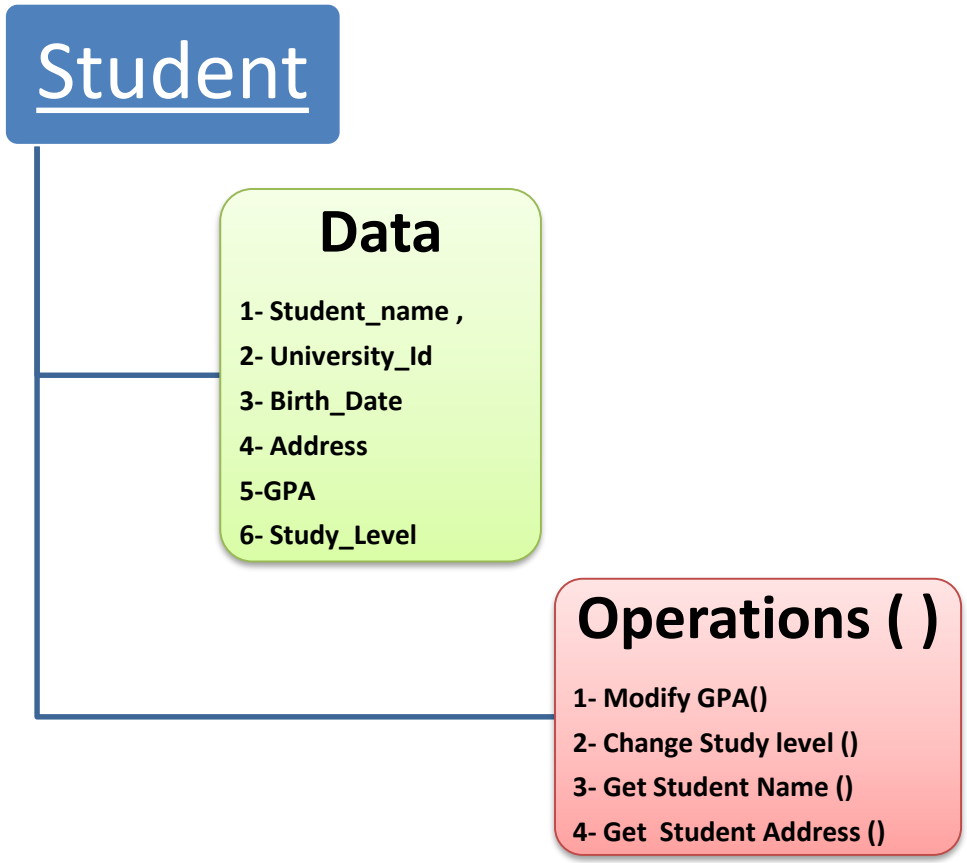
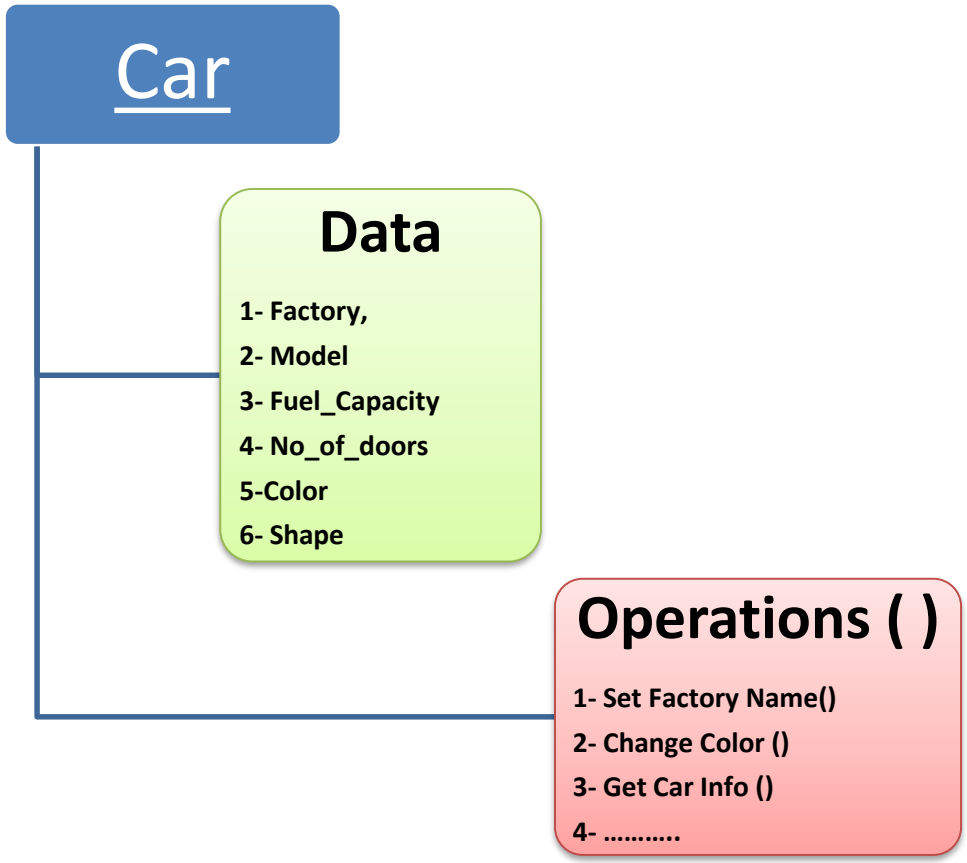


Object Is comprised Of ?



What is Class ? Why we need It ?

Student 1

Data:

1- Student_name ,
2- University_Id
3- Birth_Date
4- Address
5-GPA
6- Study_Level

Operations ( )

1- Modify GPA()
2- Change Study level ()
3- Get Student Name ()
4- Get Student Address ()

Student 2

Data:

1- Student_name ,
2- University_Id
3- Birth_Date
4- Address
6- Study_Level

GPA not included

Operations ( )

1- Modify GPA()
2- Change Study level ()
4- Get Student Address ()

Student 3

Data:

1- Student_name ,
2- University_Id
5-GPA
6- Study_Level

Birt_date adress not included

Operations ( )

1- Modify GPA()
2- Change Study level ()
3- Get Student Name ()
4- Get Student Address ()

Class is the BluePrint, Standerd for attributes and methodes

What is Class ? Why we need It ?

all Same

Class Student

Data:

1- Student_name ,
2- University_Id
3- Birth_Date
4- Address
5-GPA
6- Study_Level

Operations ( )

1- Modify GPA()
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What is Class ? Why we need It ?

Let's say we wanna add one more attribute to the class.
For example it's Email.
We would have to add it to the class, so it can be a stander for all the objects

Class Student

Data:

1- Student_name ,
2- University_Id
3- Birth_Date
4- Address
5-GPA
6- Study_Level

7- Email

Operations ( )

1- Modify GPA()
2- Change Study level ()
3- Get Student Name ()
4- Get_Student Address ()

5- Print Student Info ()

Student 1

Data:

1- Student_name
2- University_Id
3- Birth_Date
4- Address
5-GPA
6- Study_Level

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Operations ( )

1- Modify GPA()
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3- Birth_Date
4- Address
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7- Email

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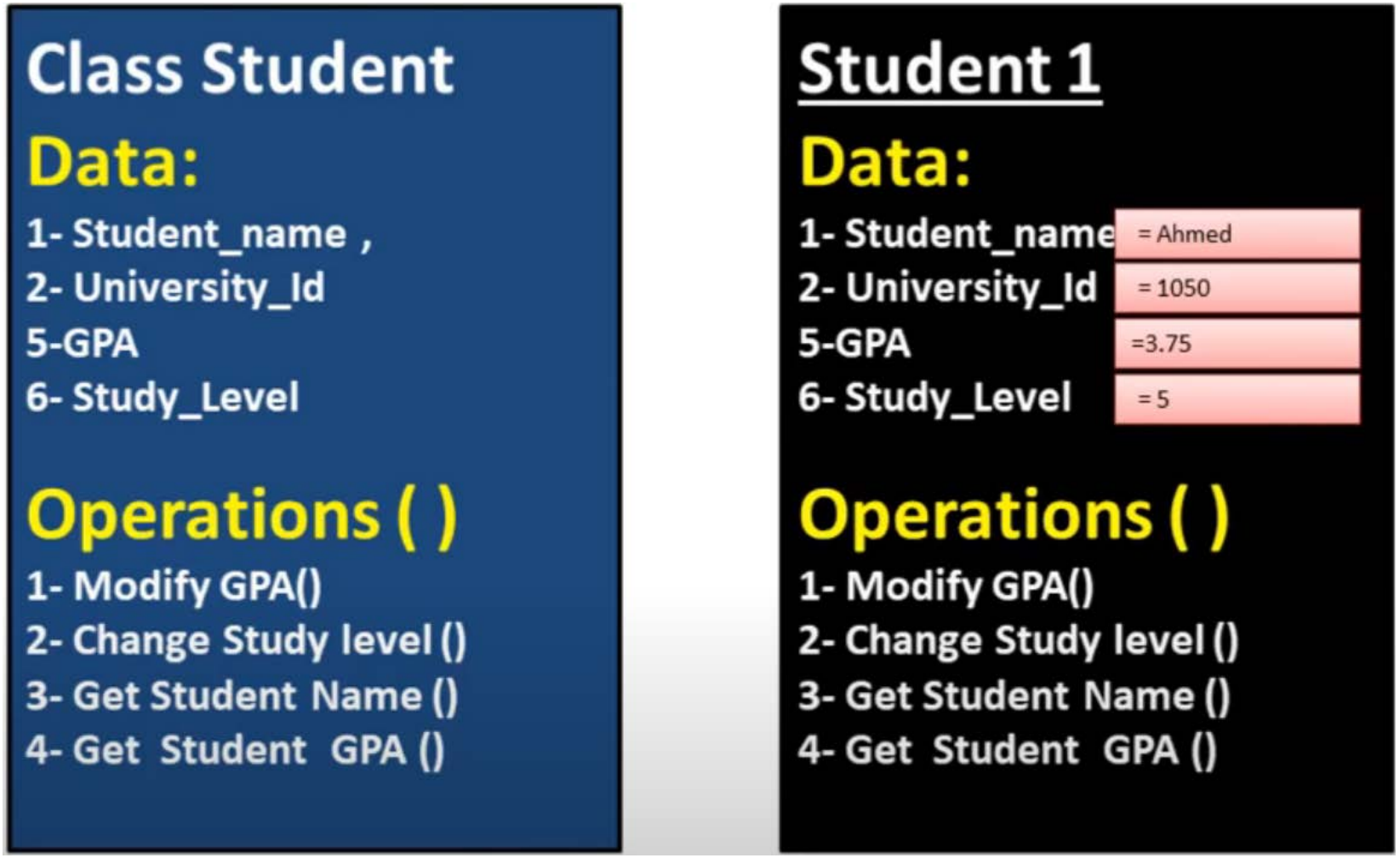
What is Class ? Why we need It ?



Objects and Classes

- Classes: Where Objects Come From
  - A *class* is code that describes a particular type of object. It specifies the data that an object can hold (the object's attributes), and the actions that an object can perform (the object's methods).
  - You can think of a class as a code "blueprint" that can be used to create a particular type of object.

"Fields", "class variables", and "attributes" are more-or-less the same

Objects and Classes

- When a program is running, it can use the class to create, in memory, as many objects of a specific type as needed.

- Each object that is created from a class is called an *instance* of the class.

Classes & Objects

- A class is defined (declared) and used as follows:

```
class MyClass
{
        [private:]
            variables (data members)
            …
            functions (methods)
            …

         public:
            variables (data members)
            …
            functions (methods)
            …
};
```

```
void main()
{
// define objects of type
// class_name
MyClass MyObject1;
MyClass MyObject2;

// call a member function
MyObject1.func1(…);
// assign value to data members
MyObject1.Index = 12;
}
```

Classes & Objects

- The class CPoint represents a point in the 2D space…

```
class CPoint
{
        int  x , y;

    public:
        void Init()
        {
            x = 0;
            y = 0;
        }

        void Set (int ax, int ay)
        {
            x = ax;
            y = ay;
        }
        void Print()
        {
            cout<<"x = "<<m_x<<", y = "<<m_y<<endl;
        }
};
```

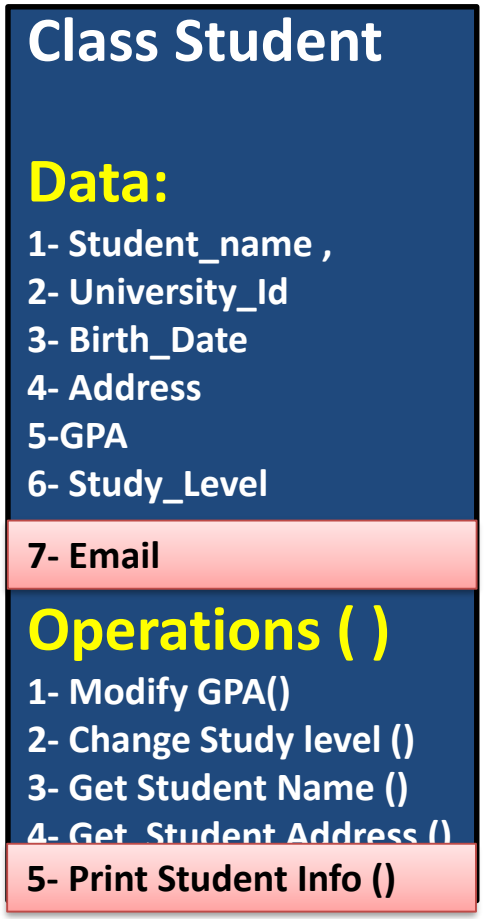
```
#include <iostream.h>

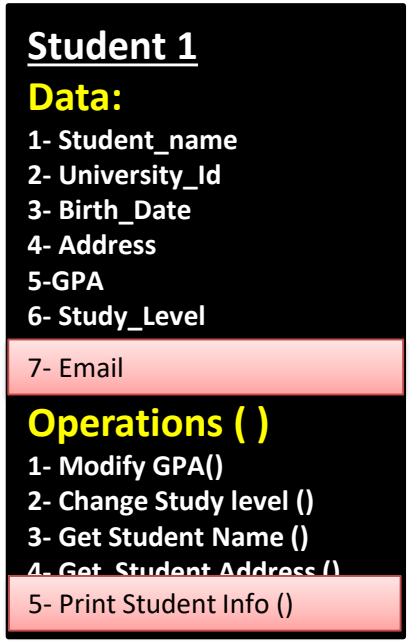
void main()
{
    CPoint p1, p2;

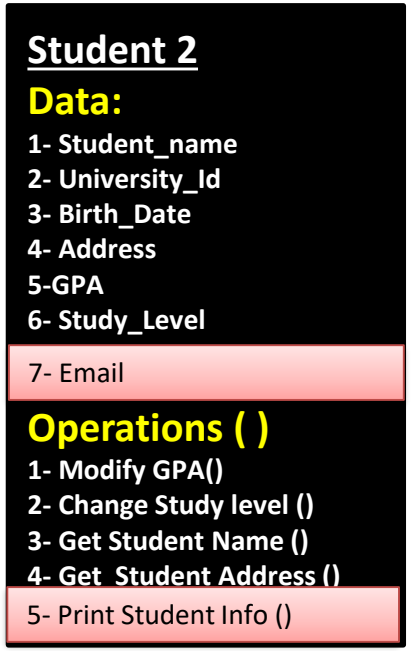
    p1.Init();
    p2.Set(4,6);

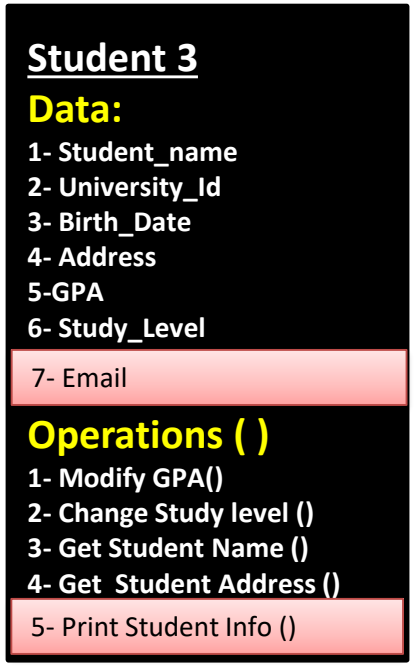
    p1.Print();
    p2.Print();
}
```

What is Class ? Why we need It ?









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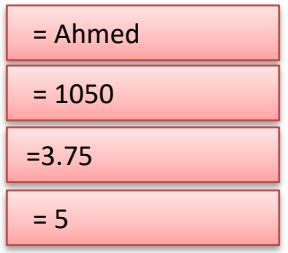
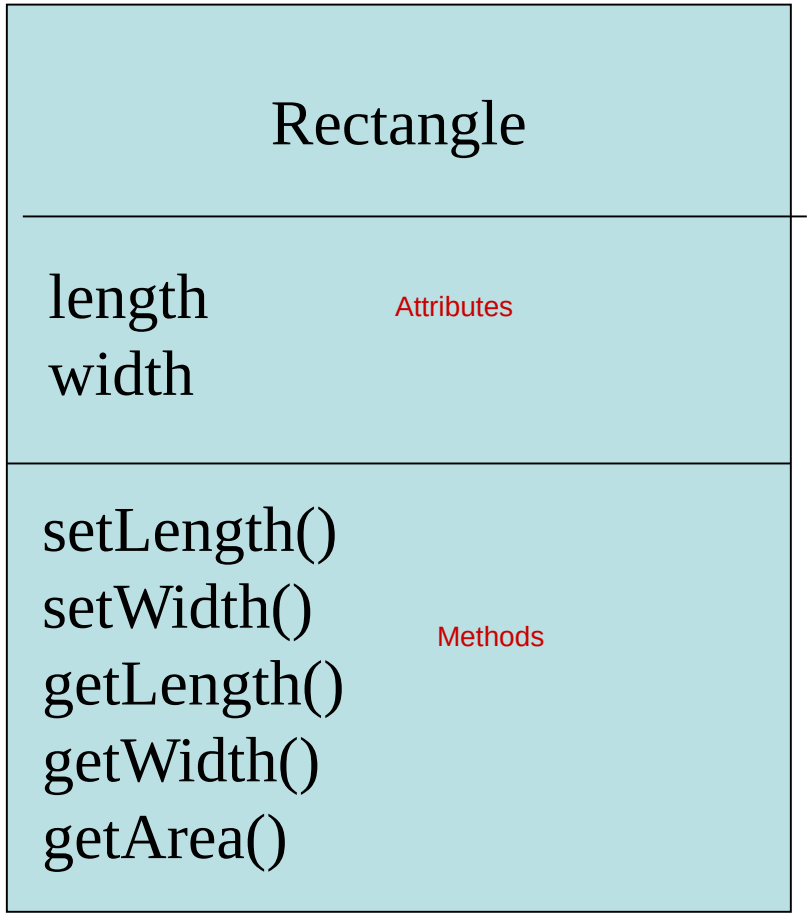


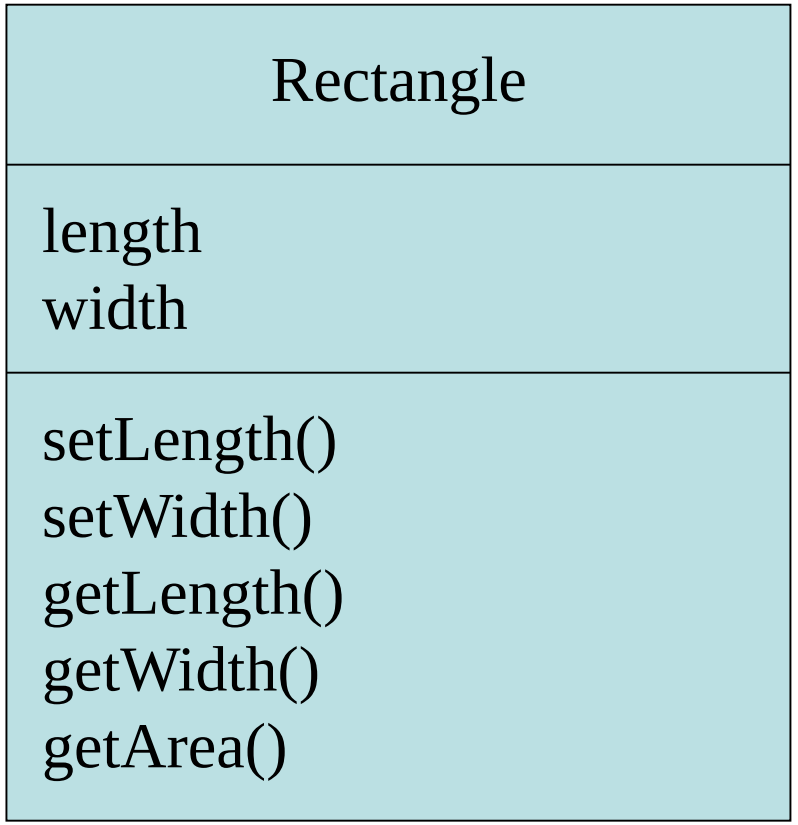
Writing a Class, Step by Step

- A `Rectangle` object will have the following fields:



Writing the Code

```
public class Rectangle
{
private:
    float length;
    float width;
}
```



Access Modifiers

- An access modifier is a C++ keyword that indicates how an attribute or method can be accessed.
- **`public`**
  - When the `public` access modifier is applied to a class member, the member can be accessed by code inside the class or outside.
- **`private`**
  - When the `private` access modifier is applied to a class member, the member cannot be accessed by code outside the class.
  - The member can be accessed only by methods that are members of the same class.

Access Specifiers in C++

Specifier	Within Same Class	In Derived Class	Outside the Class
Private	Yes	No	No
Protected	Yes	Yes	No
Public	Yes	Yes	Yes

Data Hiding

- An object hides its internal, private attributes from code that is outside the class that the object is an instance of.
- Only the class's methods may directly access and change the object’s internal data.
- Code outside the class must use the class's public methods to operate on an object's private fields.
- Data hiding is important because classes are typically used as components in large software systems, involving a team of programmers.
- Data hiding helps enforce the integrity of an object's internal data.

Access specifier

Return Type

Method Name

```
Public:
        void setLength(float len)
```

Parameter variable declaration

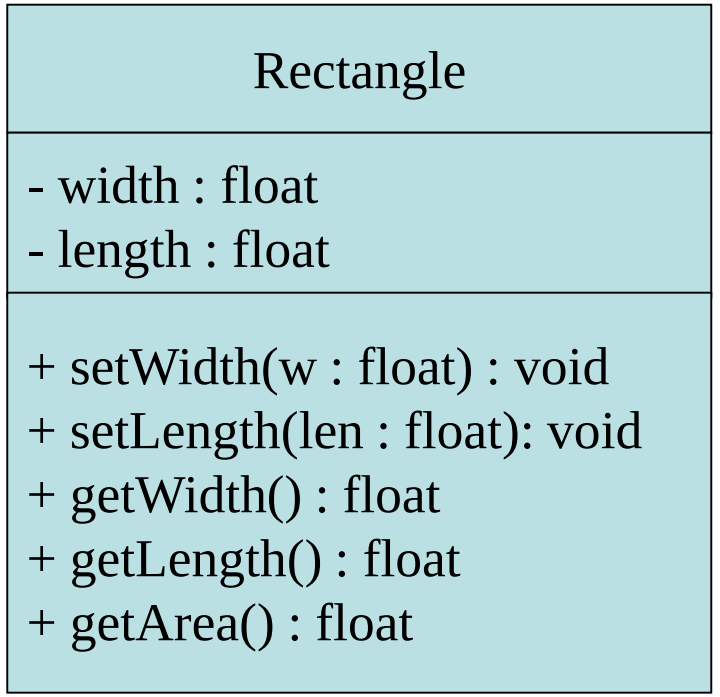
Rectangle
- width : float - length : float
+ setWidth(w : float) : void + setLength(len : float): void + getWidth() : float + getLength() : float + getArea() : float

```
public class Rectangle
{
private:
      float length;
      float width;

Public:
 void setLength(float len)
    {
If (len >=0)
 length = len;
Else cout<<"Error , Please Enter positive value";
    }
}
```

```
class Rectangle
{
private:
      float length;
      float width;

Public:
 void setLength(float len)
    {
If (len >=0)
 length = len;
Else cout <<"Error , Please Enter positive value";
    }
}
```

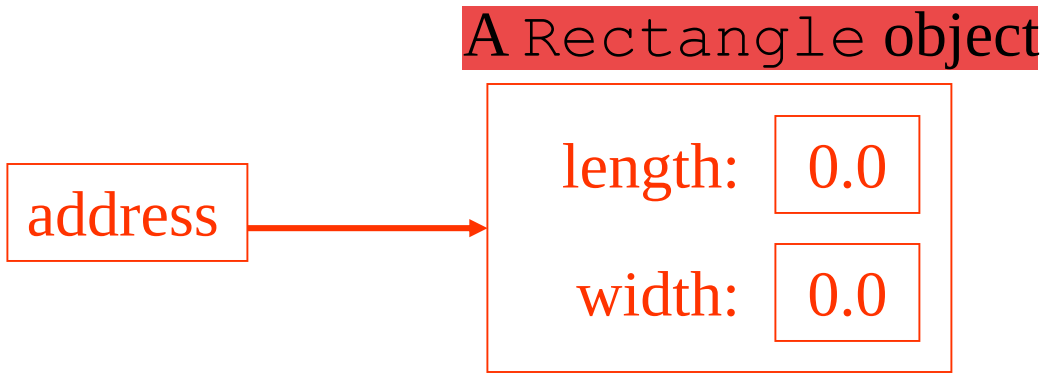


Creating a `Rectangle` object

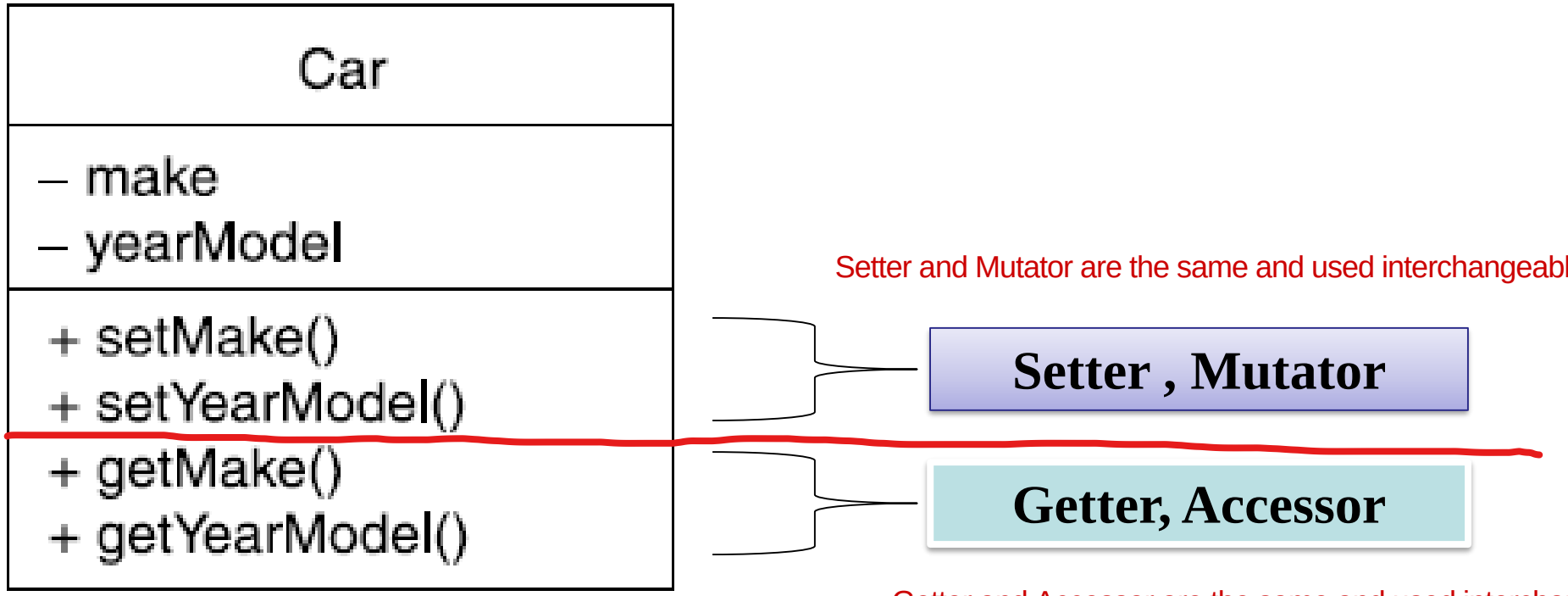
```
Rectangle box;
```

```
Int X;    String name;
```

The `box` variable holds the address of the Rectangle object.



More Examples



Separating Class Code into 2 files.

The class code can be separated into 2 files:

Not necessary but advised.

Header File - .h

- Contains the declaration of all the class members.
- Only attributes declaration and methods prototypes

Implementation File - .cpp

- Contains the implementation of the class methods.
  initialization

Client Code

- client code, is the one that includes the main function. This file should be stored by the name main.cpp

```
public class Rectangle
{
private:

 float width;
 float length;

public :
 void setWidth(float w)
     {       width = w;
     }
  void setLength(float len)
     {       length = len;
     }
 float getWidth()
     {       return width;
     }
float getLength()
     {       return length;
     }
float getArea()
          {
          return length * width;
          }
}
```

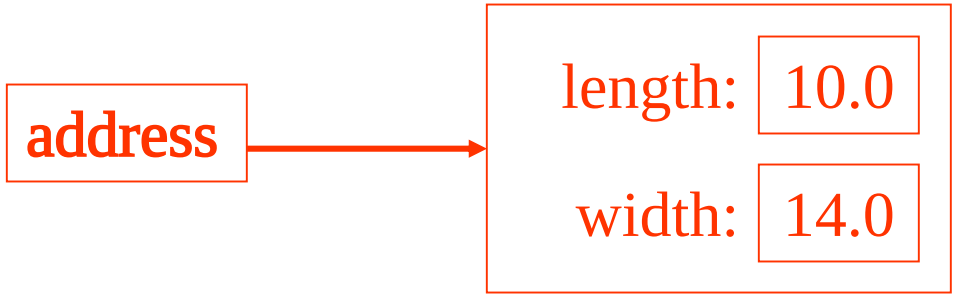
Instance attributes and Methods

- **Instance attributes and instance methods require an object to be created in order to be used.**
- **For example, every room can have different dimensions.**

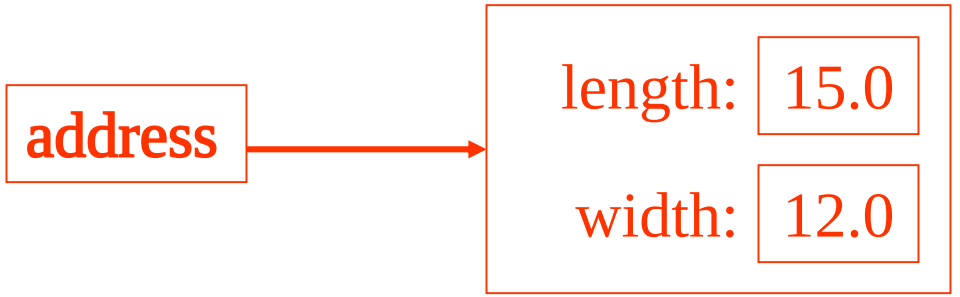
```
Rectangle   kitchen   =   new   Rectangle();
Rectangle   bedroom   =   new   Rectangle();
Rectangle den = new Rectangle();
```

States of Three Different Rectangle Objects

The `kitchen` variable holds the address of a `Rectangle` Object.



The `bedroom` variable holds the address of a `Rectangle` Object.



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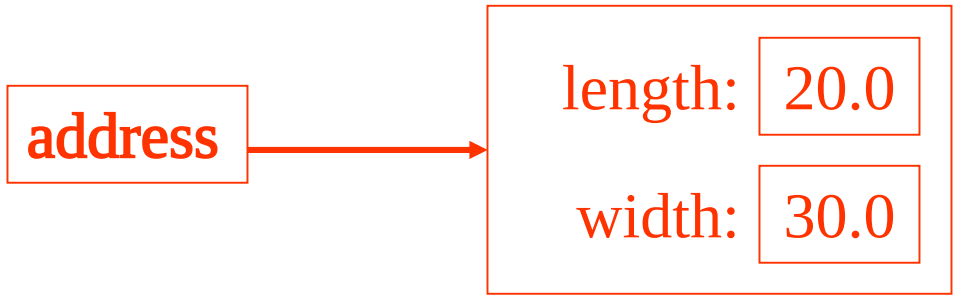


Constructors

- Classes can have special methods called *constructors*.
- A constructor is a method that is automatically called when an object is created.

Recatngle r1; -------- Car c1;

- Constructors typically initialize object attributes and perform other object initialization tasks.
- Constructors are used to perform operations at the time an object is created.

A constructor is a special method that is automatically called when an object of a class is created.

Constructors

- Constructors have a few special properties that set them apart from normal methods.
  - Constructors have the same name as the class.
  - Constructors have no return type (not even `void`).
  - Constructors may not return any values.
  - Constructors are typically public.

Constructor

```
public :
    Rectangle( )
  {
      length = 0;
      width =  0;
  }
```

Constructors – Initialization list

```
public :
      Rectangle( ): length(0), Width (0)
    {
       Cout <<"The Rectangle Length and width are initialized";
    }
```

```
  public :
  Rectangle(float len, float w)
{
      length = len;
      width = w;
}
```

```
  public :
  Rectangle(float len, float ):
  length(len),width(w)
{
}
```

Destructor

- A destructor is a special method that is automatically called when an object life time is ended.
- Like constructors, destructors do not have a return value.
- The most common use of destructors is to deallocate memory that was

allocated for the object by the constructor

```
public :
      ~Rectangle( )
    {

    }
```

Overloading Methods and Constructors

- Two or more methods in a class may have the same name as long as their signatures are different.
- Method signature (No of Args – Types of Args – Order of Args)
- When this occurs, it is called *method overloading*. This also applies to constructors.
- Method overloading is important because sometimes you need several different ways to perform the same operation.

Constructor Overloading

- Constructors can be overloaded:
  - An overloaded constructor provides multiple ways to set up a new object
  - The overloaded constructors differ by the *number* and *type* of parameters they get.
- When we construct an object, the compiler decides which constructor to invoke according to the type of the actual parameters
- A constructor with no parameters is called a *default constructor*

Constructor Overloading

In addition to overloading normal methods, you can also overload constructor methods.

Constructor overloading: Same constructor declared with different parameters in the same class.

Compiler differentiates which constructor is to be called depending upon the **number of parameters and their sequence of data types**.

Overloaded Method `add`

```
int add(int num1, int num2)
{
   int sum = num1 + num2;
   return sum;
}

int add(int num1, int num2, int num3)
{
   int sum = num1 + num2 + num3 ;
   return sum;
}


Float add(float num1, float num2)
{
      float sum = num1 + num2;
      return sum;
}
```

Constructor Overloading

```
Rectangle::Rectangle ( ):length(0),width(0)
{
}

Rectangle::Rectangle(float l , float w):length(l),width(w)
{
}
```

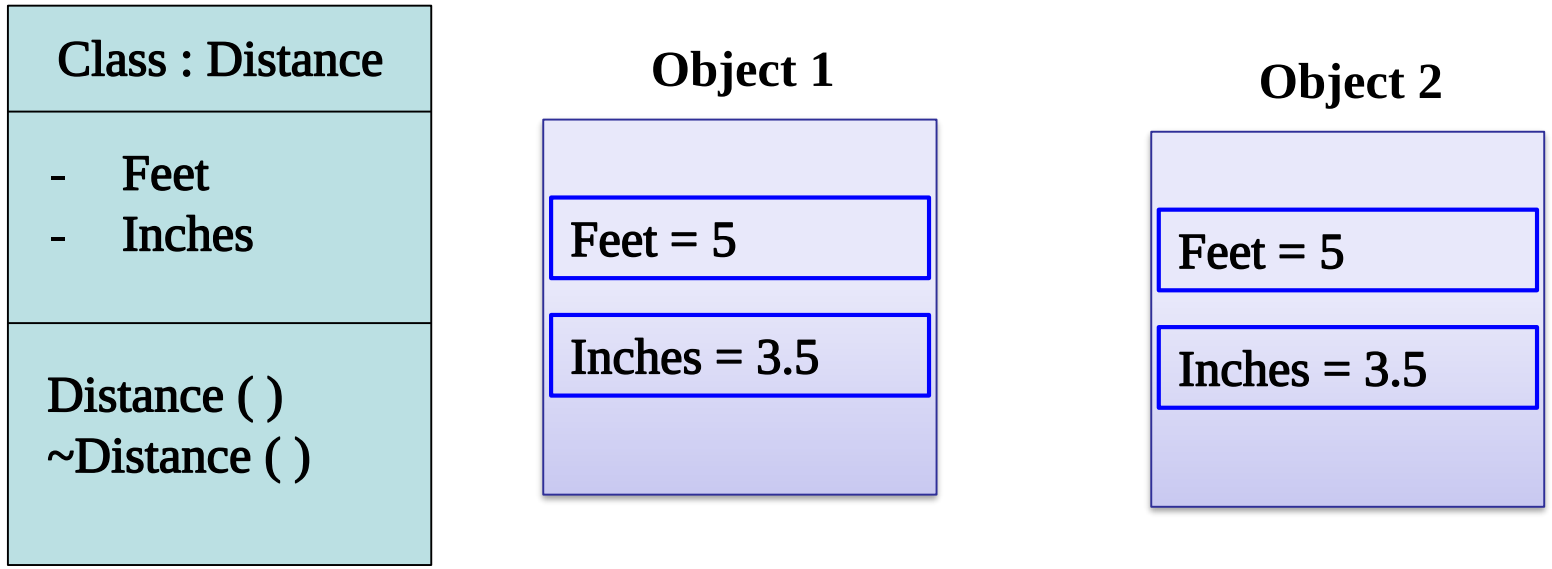
`Rectangle` Class Constructor Overload

```
Rectangle box1();

Rectangle box2(5.0, 10.0);
```

The Default Copy Constructor

- It is another way to initialize an object:
- Used to initialize an object with *another object of the same type*.
- No need to create a special constructor for this; one is already built into all classes



The Default Copy Constructor

```
class Distance { //English Distance class
private:

int feet;
float inches;

public:
Distance() : feet(0), inches(0.0)
{ }
Distance(int ft, float in) : feet(ft), inches(in){ }
}
```

```
int main() {

Distance d1;

Distance dist2 (11, 6.25);

Distance dist3 (dist2);

Distance dist4 = dist2;
```

The Default Constructor

- When an object is created, its constructor is always called.
- If you do not write a constructor, C++ provides one when the class is compiled. The constructor that C++ provides is known as the *default constructor*.

Default Constructor

- A default constructor is a constructor that is used to create an object when you don't provide initialization values.
  - `Time t1;  //calling default constructor`
- What if we do not write any constructor?
  - C++ automatically creates a **default constructor** for each class.
  - It creates an uninitialized object.
- For the Time class the default constructor looks like this:
  - `Time::Time() { }`

Important Thing about Default Constructor

- Compiler creates a default constructor only if you don't define any constructor.
- If you define any constructor, you need to define the default constructor too.
- If your class has non-default constructor but no default constructor then a declaration like this becomes an error.
  - `Time t;`

Define Default Constructor

- There are two ways to define a default constructor:
  - Define a constructor with no arguments
    - `Time();`
  - Provide default values for all arguments
    - `Time(int h=12, int m=0, int s=0);`
- There can be only one default constructor, so don't use both in a class.

The Default Constructor

- The default constructor is a constructor with no parameters, used to initialize an object in a default configuration.
- The only time that Java provides a default constructor is when you do not write any constructor for a class.
- A default constructor is not provided by Java if a constructor is already written.

Writing Your Own No-Arg Constructor

- A constructor that does not accept arguments is known as a *no-arg constructor*.
- The default constructor (provided by Java) is a no-arg constructor.
- We can write our own no-arg constructor

```
public Rectangle()
{
      length = 1.0;
      width = 1.0;
}
```

Passing Objects as Arguments

- Objects can be passed to methods as arguments.
- When an object is passed as an argument, the value of the reference variable is passed.
- The value of the reference variable is an address or reference to the object in memory.
- A *copy* of the object is *not passed*, just a pointer to the object.
- When a method receives a reference variable as an argument, it is possible for the method to modify the contents of the object referenced by the variable.

```
Class Calculator
{
Float add(float num1, float num2)
{
return num1 + num2;
}

string add(string a, string b)
{
return a + " " + b;
}
}
```

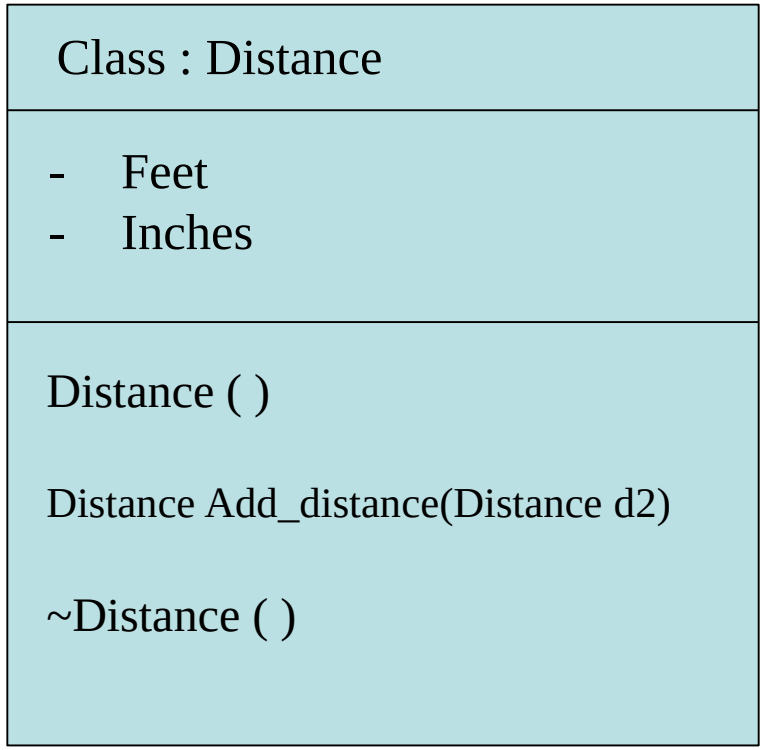
```
Main()
{
Calculator calc;
Float x  = 50.0 ;
Float Y  = 10.0;

Calc.add (x , y);

}
```

Distance Add_distances (Distance d1 , Distance d2)
{
}

Rectangle Merge (Rectangle r1 , Rectangle r2)
{
}



d1

Feet = 5

Inches = 3.5

Result.feet = d1.feet + d2.feet

Result.inches = d1.inches + d2.inches

d2

Feet = 3

Inches = 4.25

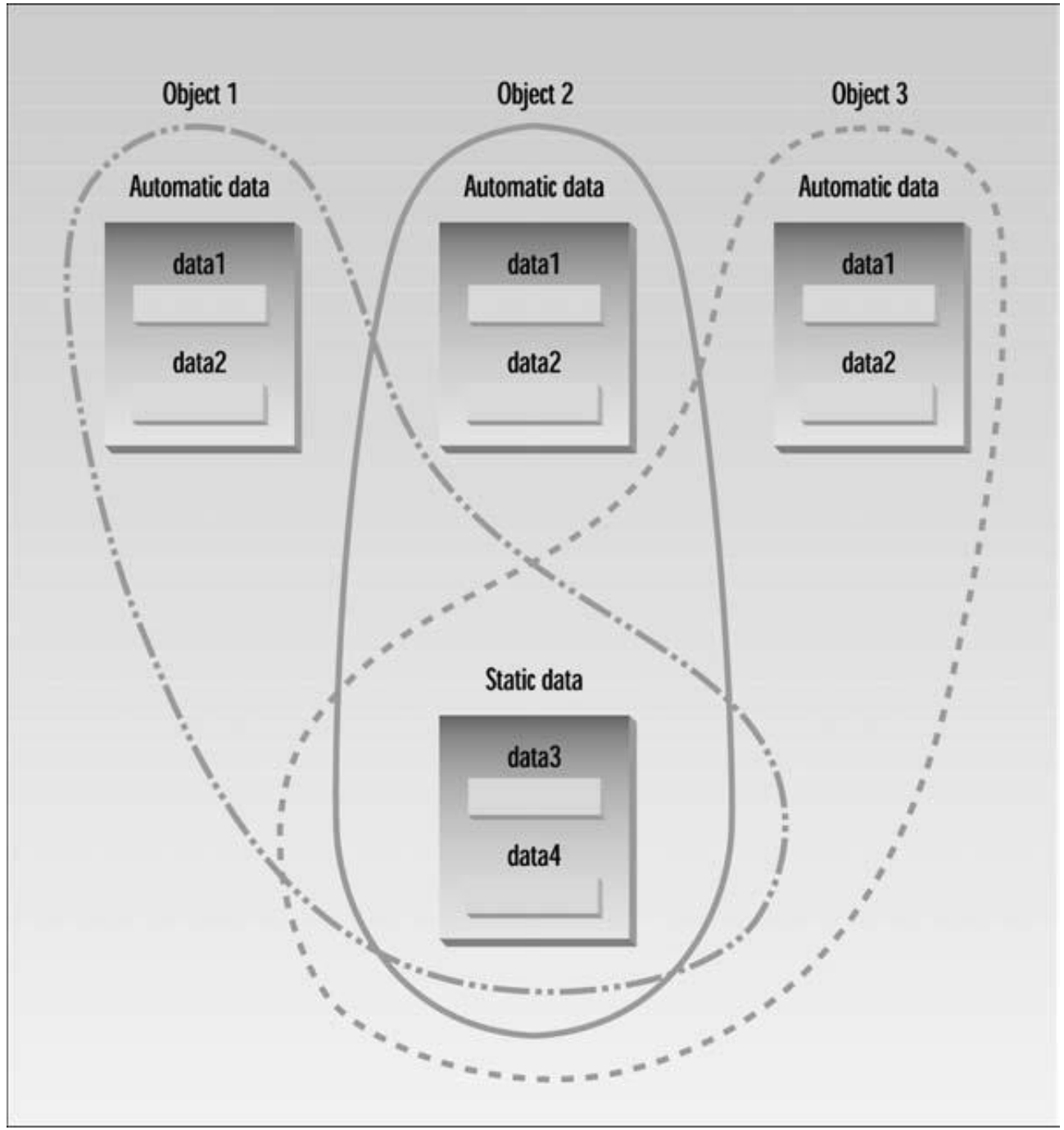
Feet = **8**

Inches = **7.75**

Result

Static Class Members

- *Static fields* and *static methods* do not belong to a single instance of a class.
- A static data item is useful when all objects of the same class must share a common item of information.
- Its lifetime is the entire program. It continues to exist even if there are no objects of the class.
- To invoke a static method or a static field, use the class name, rather than the instance name.


Object 1
Automatic data
data1
data2
Object 2
Automatic data
data1
data2
Object 3
Automatic data
data1
data2
Static data
data3
data4

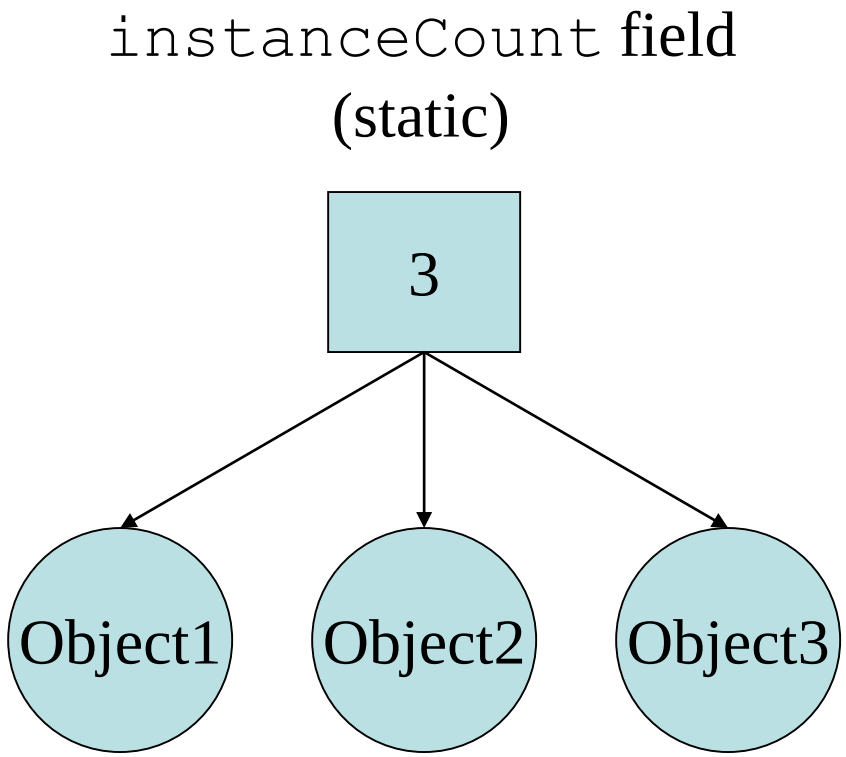
```
class Car
{

string Maker ;
int model ;
static int count;
public:
Car( ) //increments count when object created
{ count++; }
int getcount( ) //returns count
{ return count; }
};
```

```
int Car::count = 0;

int main()
{
Car c1, c2, c3; //create three objects
cout << “count is “ << c1.getcount() << endl;
cout << “count is “ << c2.getcount() << endl;
cout << “count is “ << c3.getcount() << endl;
return 0;
}
```

Static Fields



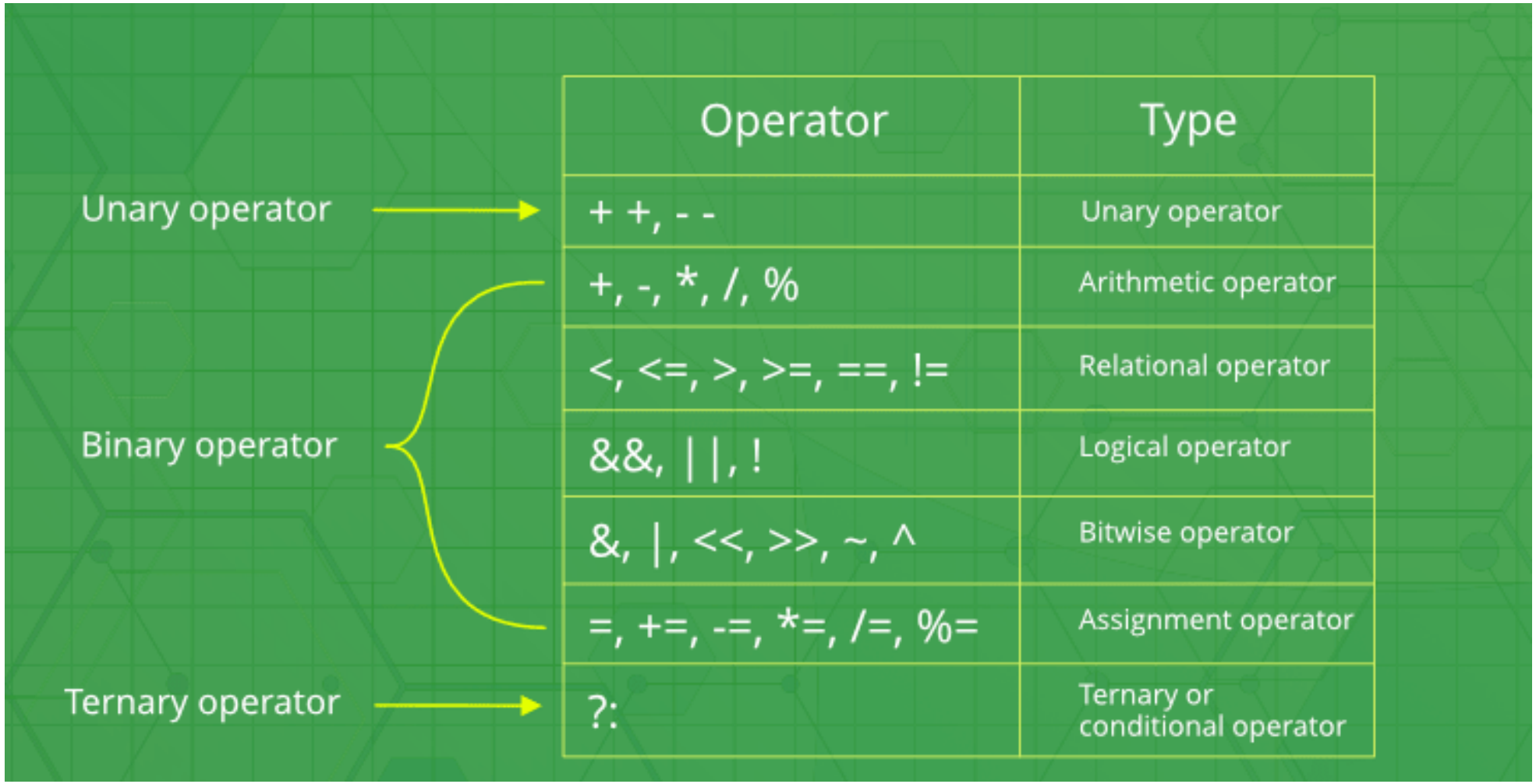
Static Methods

- Static methods are convenient because they may be called at the class level.
- They are typically used to create utility classes.
- Static methods may not communicate with instance fields, only static fields.

```
Class Calc
{
Public:

Static int add(int num1 , int num2)
{
 return num1 + num2;
}
Static int multiply (int num1 , int num2)
{
 return num1 * num2;
}
}
```

Operators in C++



Operator	Type
+ +, - -	Unary operator
+, -, *, /, %	Arithmetic operator
<, <=, >, >=, ==, !=	Relational operator
&&, ||, !	Logical operator
&, |, <<, >>, ~, ^	Bitwise operator
=, +=, -=, *=, /=, %=	Assignment operator
?:	Ternary or conditional operator

Operator overloading

- The term *operator overloading* refers to giving the normal C++ operators, such as +, *, <=, and +=, additional meanings when they are applied to user-defined data types.
- Operator overloading is one of the most exciting features of object-oriented programming.
- It can transform complex program listings into easy ones.

```
int a , b, c;
c= a + b ;
Counter c1, c2 , c3;
c3 = c1+ c2;
```

The operator Keyword is used to overload operators

Overloading Unary Operators

```
class Counter
   {
   private:
      unsigned int count;
   public:
      Counter() : count(0)
         {  }
      Counter(int c) : count(c)
         {  }
      unsigned int get_count()
         { return count; }
      Counter operator ++ ()
         {
         ++count;
         return Counter(count);
         }
   };
```

```
int main()
{
Counter c1, c2;
cout << c1.get_count();
cout << c2.get_count();

//Operator Overloading
++c1;              //increment c1
++c2;              //increment c2
++c2;              //increment c2

cout << c1.get_count();
cout << c2.get_count();
```

```
class Counter
   {
   private:
      unsigned int count;
   public:
      Counter() : count(0)
         {  }
      unsigned int get_count()
         { return count; }
      Counter operator ++ ()
         {
         ++count;
         Counter temp;
         temp.count = count;
         return temp;
         }
   };
```

```
class Counter
   {
   private:
      unsigned int count;
   public:
      Counter() : count(0)
         {  }
      Counter(int c) : count(c)
         {  }
      unsigned int get_count()
         { return count; }
      Counter operator ++ ()
         {
         ++count;
         return Counter(count);
         }
   };
```

Overloading Unary Operators – PostFix Notation

```
class Counter
   {
   private:
      unsigned int count;          //count
   public:
      Counter() : count(0)         //constructor  no args
         {  }
      Counter(int c) : count(c)    //constructor, one arg
         {  }
      unsigned int get_count() const //return count
         { return count; }

      Counter operator ++ ()       //increment count (prefix)
         {                         //increment count, then return
         return Counter(++count); //an unnamed temporary object
         }                         //initialized to this count

      Counter operator ++ (int)    //increment count (postfix)
         {                         //return an unnamed temporary
         return Counter(count++); //object initialized to this
         }                         //count, then increment count
   };
```

```
int main()
   {
   Counter c1, c2;

   cout << "\nc1=" << c1.get_count();
   cout << "\nc2=" << c2.get_count();

   ++c1;
   c2 = ++c1;

   cout << "\nc1=" << c1.get_count();
   cout << "\nc2=" << c2.get_count();

   c2 = c1++;
```

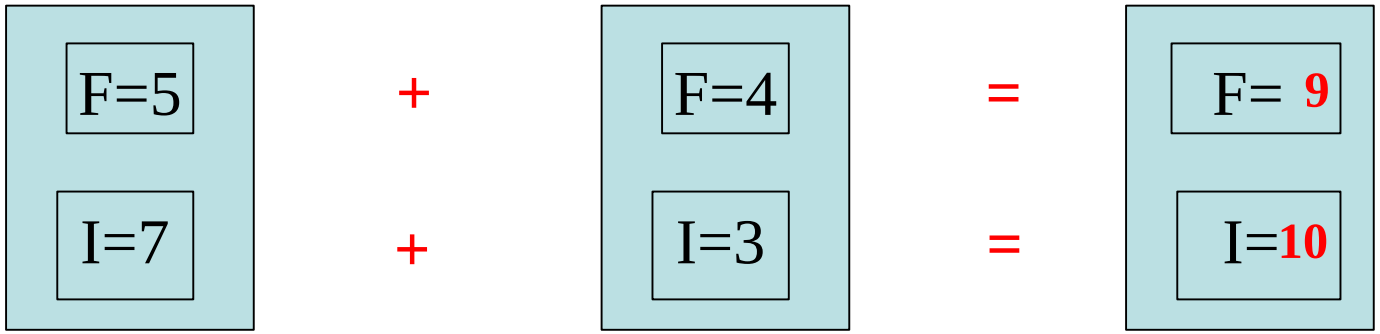
Overloading Binary Operators

Distance d1 , d2, d3;
d3= d1 + d2

Counter c1 , c2, c3;
c3= c1 + c2

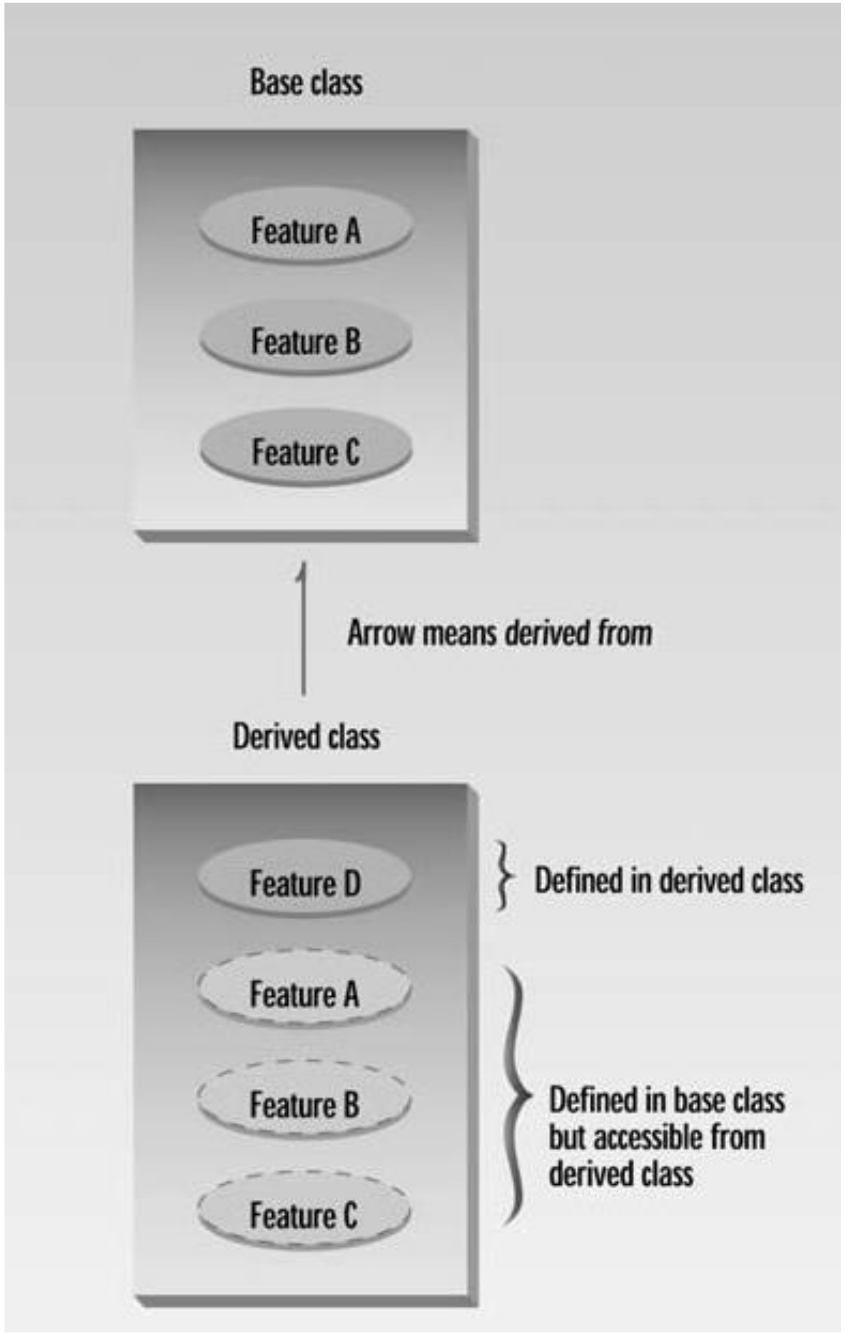
Overloading Binary Operators

```
Distance Distance::operator + (Distance d2) const  //return sum
   {
   int f = feet + d2.feet;          //add the feet
   float i = inches + d2.inches;    //add the inches
   if(i >= 12.0)                    //if total exceeds 12.0,
      {                             //then decrease inches
      i -= 12.0;                    //by 12.0 and
      f++;                          //increase feet by 1
      }                             //return a temporary Distance
   return Distance(f,i);            //initialized to sum
   }
```



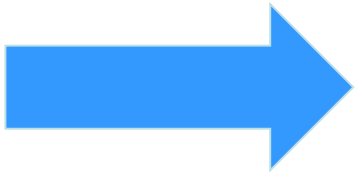
What is Inheritance?

- Inheritance is probably the most powerful feature of object-oriented programming, after classes themselves.
- Inheritance is the process of creating new classes, called *derived classes*, from existing or *base classes*
- The derived class inherits all the capabilities of the base class but can add its own features. And the base class is unchanged by this process.



- Inheritance permits code *reusability*.
- Reusing existing code saves time and money and increases a program's reliability.

```
class Counter //base class
{
protected: //NOTE: not private
int count;
public:
Counter() : count(0)
{ }
Counter(int c) : count(c)
{ }
int get_count()
{ return count; }
Counter operator ++ ()
{
 return Counter(++count);
}
};
```

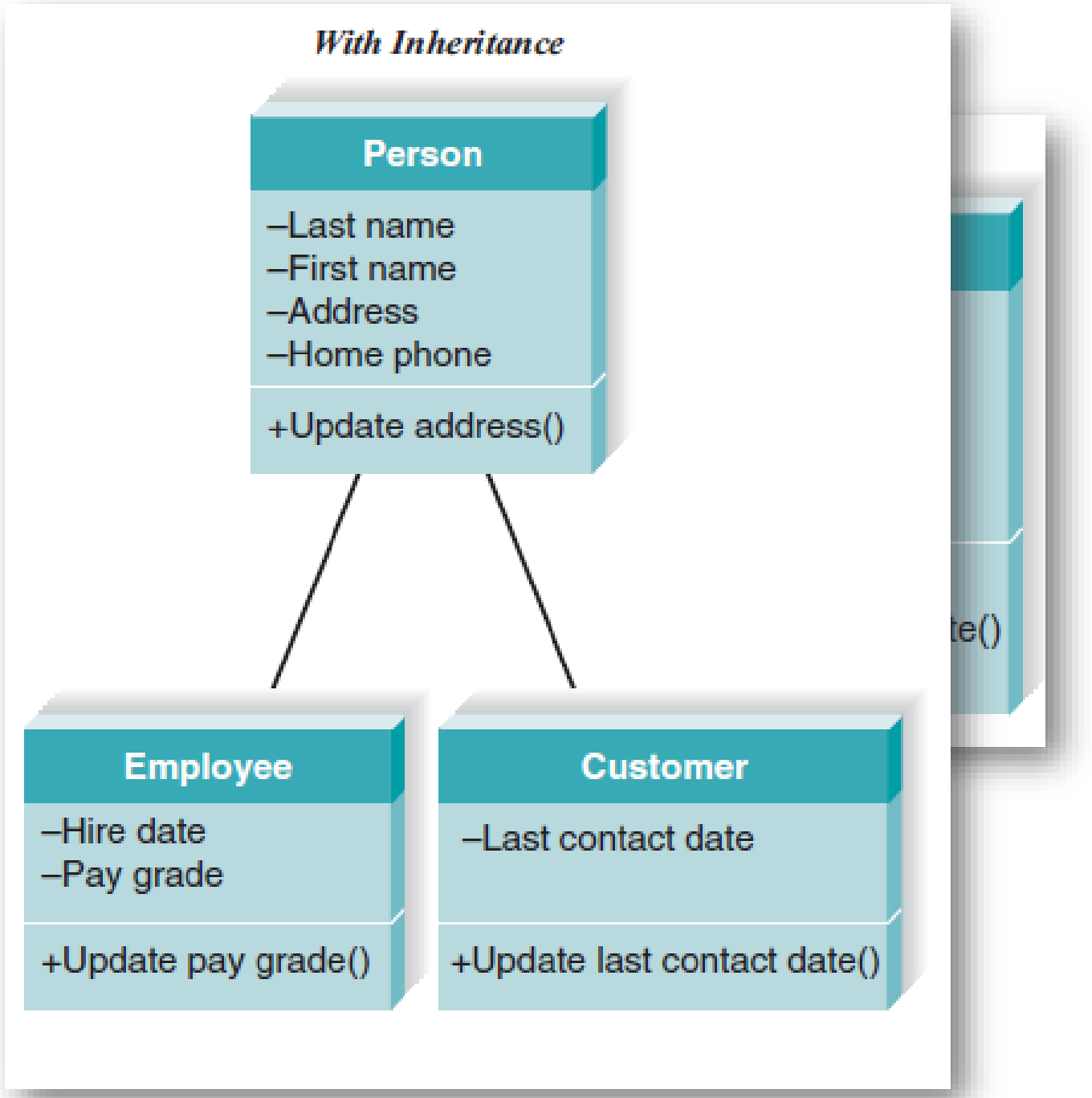


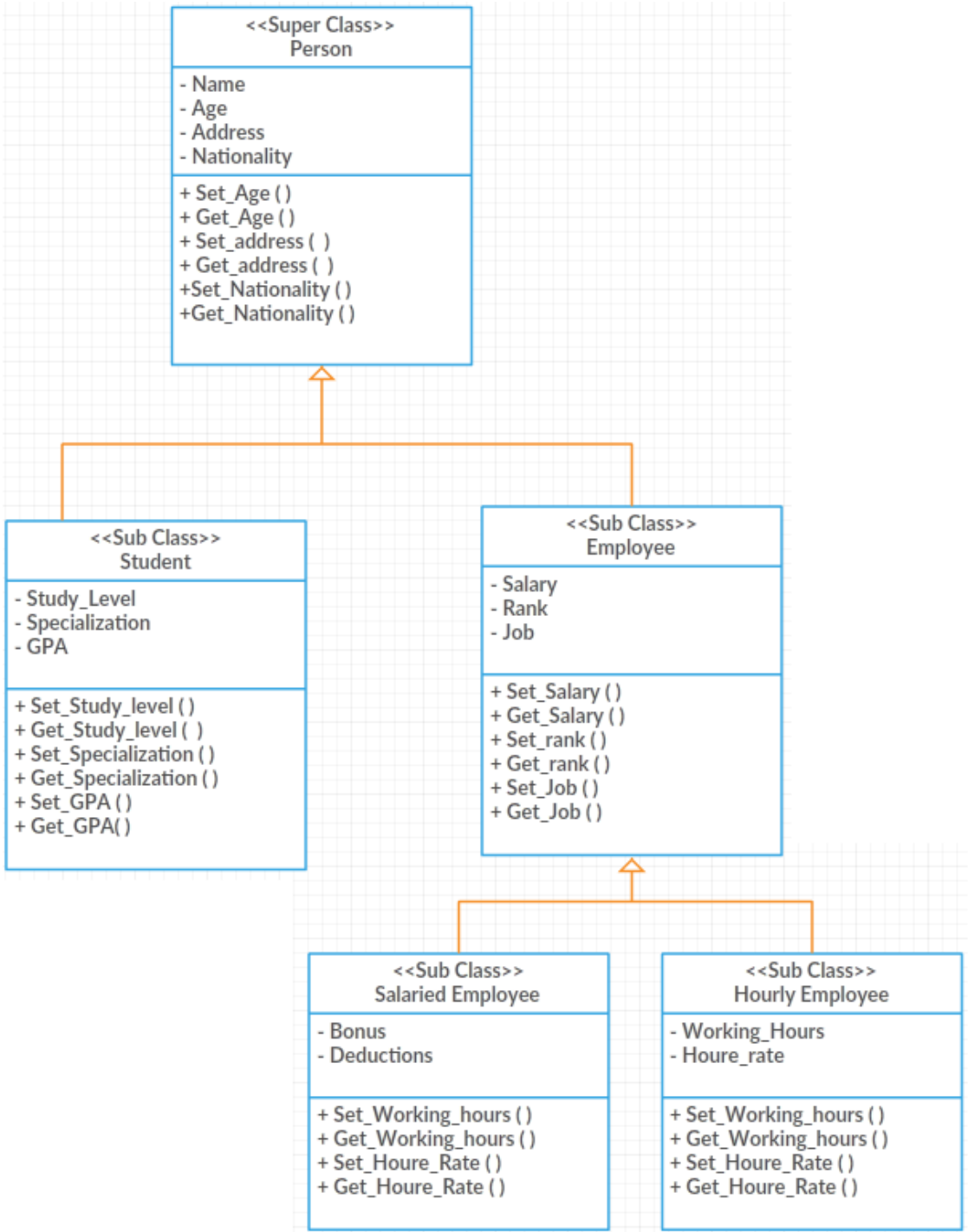
```
class CountDn : public Counter //derived class
{
public:
Counter operator -- ()
{
return Counter(--count);
}
};
```

```
int main()
{
CountDn c1; //c1 of class CountDn

++c1; ++c1; ++c1; //increment c1, 3 times

--c1; --c1; //decrement c1, twice
}
```


With Inheritance
Person
–Last name
–First name
–Address
–Home phone
+Update address()
Employee
–Hire date
–Pay grade
+Update pay grade()
Customer
–Last contact date
+Update last contact date()


<<Super Class>>
Person
- Name
- Age
- Address
- Nationality
+ Set_Age ( )
+ Get_Age ( )
+ Set_address ( )
+ Get_address ( )
+Set_Nationality ( )
+Get_Nationality ( )
<<Sub Class>>
Student
- Study_Level
- Specialization
- GPA
+ Set_Study_level ( )
+ Get_Study_level ( )
+ Set_Specialization ( )
+ Get_Specialization ( )
+ Set_GPA ( )
+ Get_GPA( )
<<Sub Class>>
Employee
- Salary
- Rank
- Job
+ Set_Salary ( )
+ Get_Salary ( )
+ Set_rank ( )
+ Get_rank ( )
+ Set_Job ( )
+ Get_Job ( )
<<Sub Class>>
Salaried Employee
- Bonus
- Deductions
+ Set_Working_hours ( )
+ Get_Working_hours ( )
+ Set_Houre_Rate ( )
+ Get_Houre_Rate ( )
<<Sub Class>>
Hourly Employee
- Working_Hours
- Houre_rate
+ Set_Working_hours ( )
+ Get_Working_hours ( )
+ Set_Houre_Rate ( )
+ Get_Houre_Rate ( )

The “is a” Relationship

- The relationship between a Base Class and an derived class is called an “is a” relationship.
  - A post graduate student “is a” Student.
  - An Employee “is a” Person.
  - Salaried Employee “is a” Employee.
  - A car “is a” vehicle.
- A specialized object has:
  - all of the characteristics of the general object, plus
  - additional characteristics that make it special.
- In object-oriented programming, *inheritance* is used to create an “is a” relationship among classes.

```
class Person
{
private:
    string name;
    string gender;
    float age;

public:
    Person() { ... }
    Person(string n, string g, long s, float a)
    void set_age(float a) { ... }
    float get_age() { ... }
    void set_name(string n) { ... }
    string get_name() { ... }
    void set_gender(string g) { ... }
    string get_gender() { ... }
    void display() { ... }
};
```

```
class Student : public Person
{
};
```

#Modes of inheritance

#Public mode

If we derive a child class from a public parent class. Then the public member of the parent class becomes a public member for the child class and protected members of parent class becomes protected members of the child class.

#Protected mode

If we derive child class from a protected base class, then the public, as well as a protected member of the parent class, becomes the protected members of the child class.

#Private mode

If we derive a child class from a private base class, then the public, as well as protected members, become private for the derived class.

Private members of a base class cannot be directly accessed in the derived class in any circumstance.

Order of Constructor Call with Inheritance in C++

- Whether derived class's default constructor is called or parameterized is called, base class's default constructor is always called inside them.

- To call base class's parameterized constructor inside derived class's parameterized constructor, we must mention it explicitly while declaring derived class's parameterized constructor.

Function Overriding

- It is the redefinition of base class function in its derived class with same signature.

```
Class a
{
public:
      virtual void display(){ cout << "hello"; }
}

Class b:public a
{
public:
       void display(){ cout << "bye";};
}
```

Function Overloading

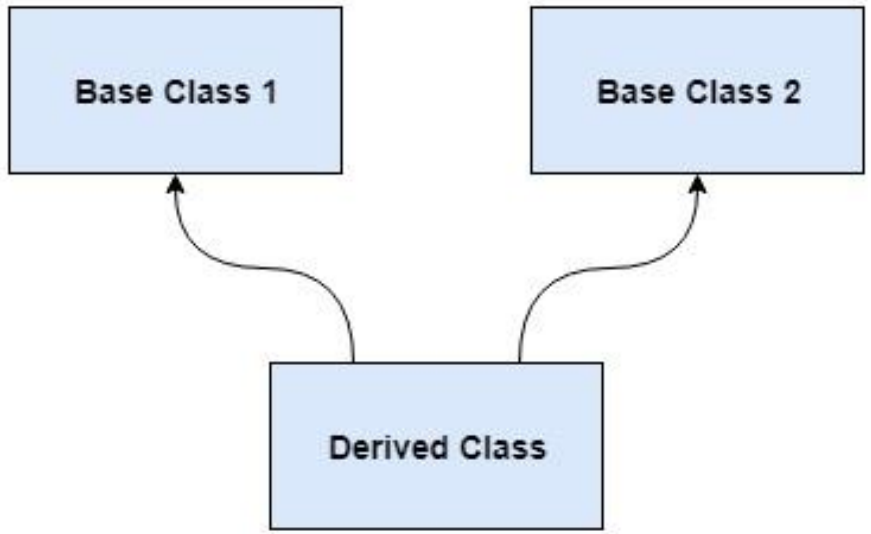
- It provides multiple definitions of the function by changing signature i.e changing number of parameters, change datatype of parameters.
- It can be done in base as well as derived class.
- **Example:**

```
void area(int a);
void area(int a, int b);
```

Multiple Inheritance in C++

- Multiple inheritance occurs when a class inherits from more than one base class. So the class can inherit features from multiple base classes in the same time.

- Unlike other object oriented programming languages, C++ allow this important features to programmers.



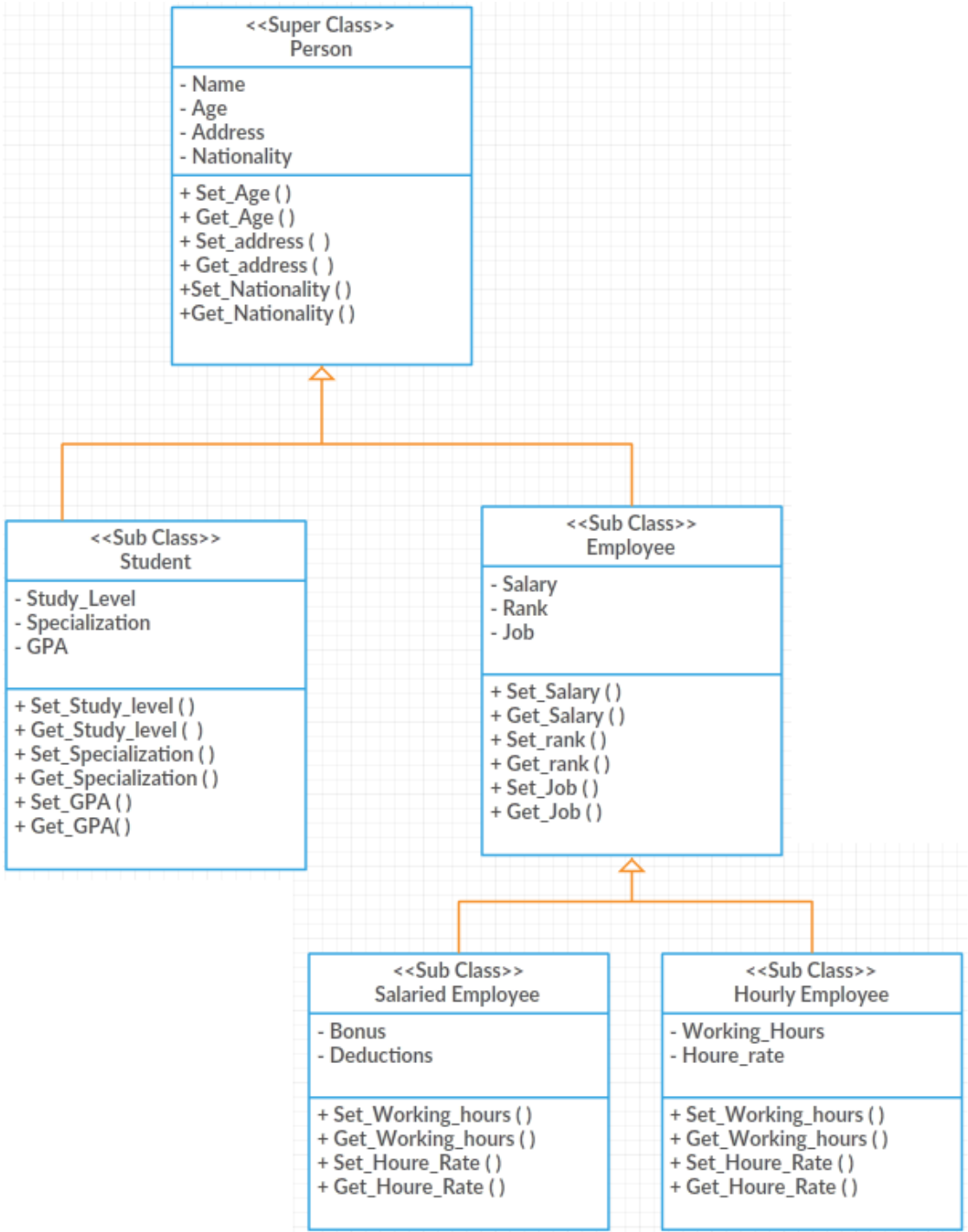
Multiple Inheritance

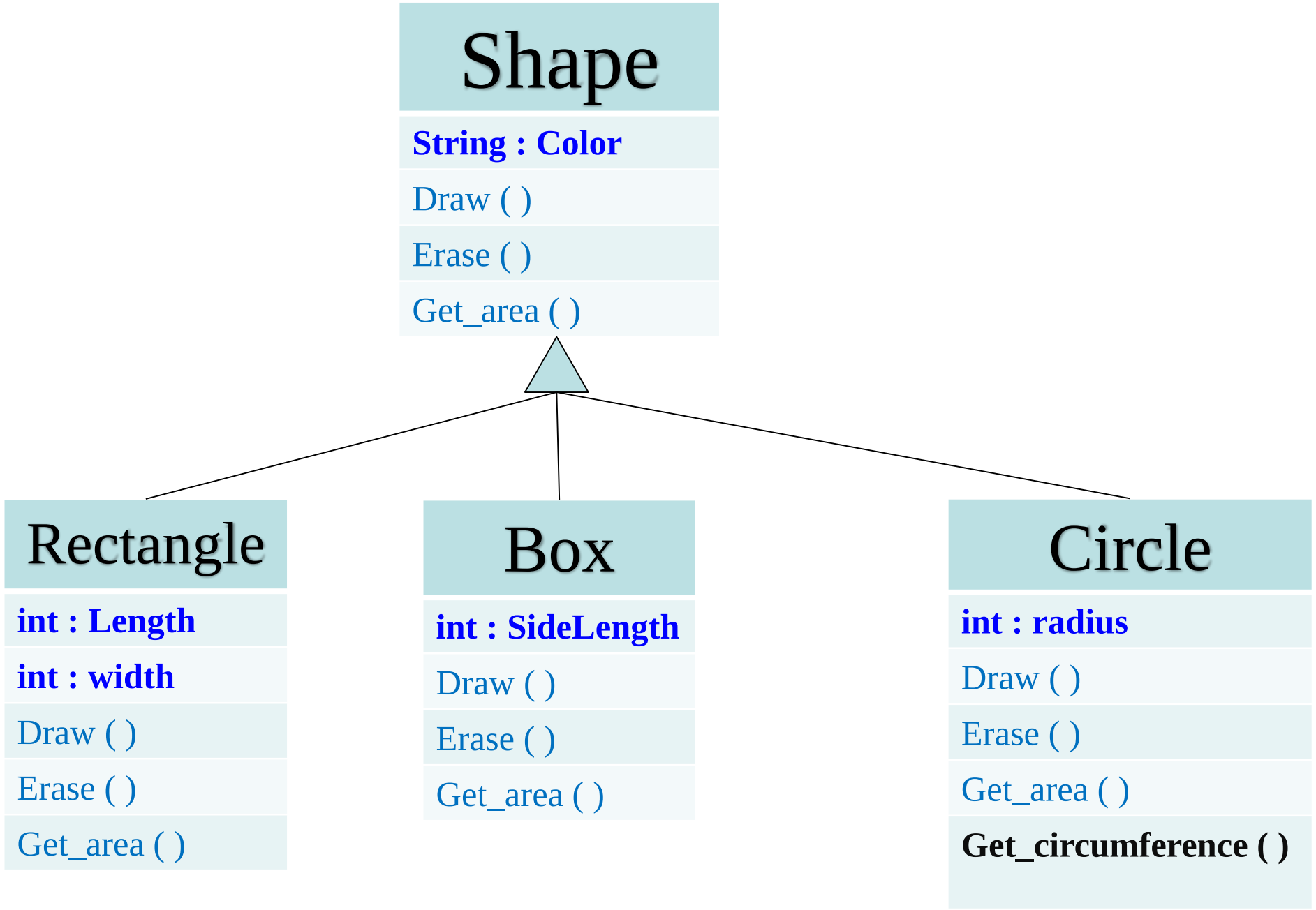
```
class A {
   public:
   int a = 5;
   A() {
      cout << "Constructor for class A" << endl;
   }
};
class B {
   public:
   int b = 10;
   B() {
      cout << "Constructor for class B" < endl;
   }
};
```

```
class C: public A, public B {
   public:
   int c = 20;
   C() {
      cout << "Constructor for class C" << endl;
      cout<<"Class C inherits from class A and class B" << endl;
   }
};
```

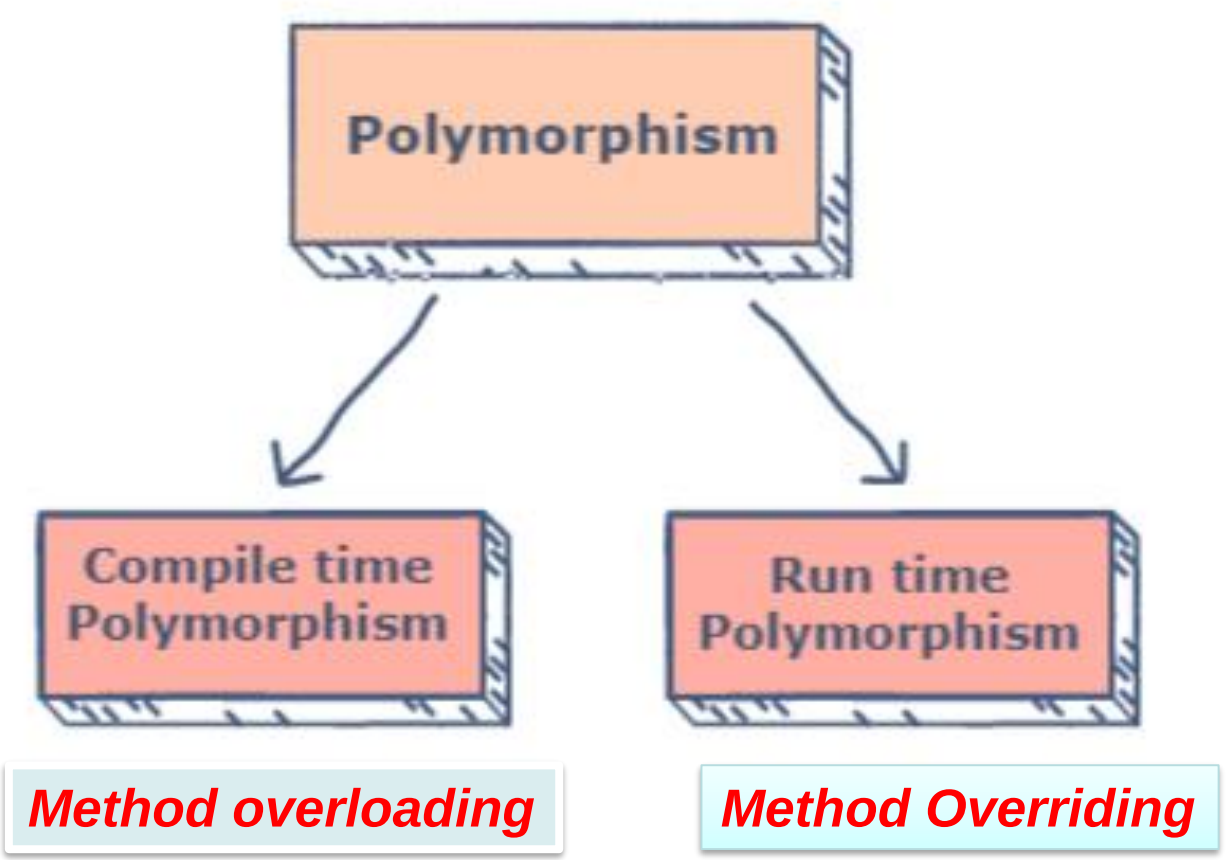
What is Polymorphism ?

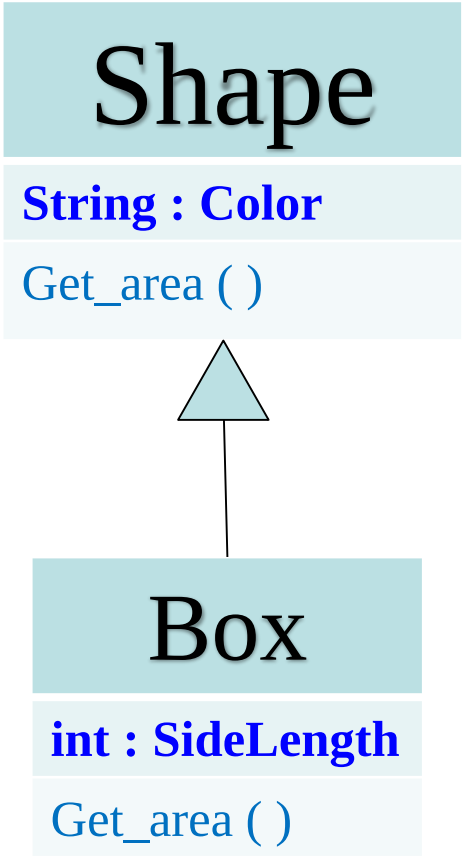
- **Polymorphism** is an object-oriented programming concept that refers to the ability of a *variable*, *function* or *object* to take on *multiple* forms.
- with **polymorphism**, class objects belonging to the same hierarchical tree (inherited from a common **parent** *class*) may have functions with the same name, but with different behaviors.


<<Super Class>>
Person
- Name
- Age
- Address
- Nationality
+ Set_Age ( )
+ Get_Age ( )
+ Set_address ( )
+ Get_address ( )
+Set_Nationality ( )
+Get_Nationality ( )
<<Sub Class>>
Student
- Study_Level
- Specialization
- GPA
+ Set_Study_level ( )
+ Get_Study_level ( )
+ Set_Specialization ( )
+ Get_Specialization ( )
+ Set_GPA ( )
+ Get_GPA( )
<<Sub Class>>
Employee
- Salary
- Rank
- Job
+ Set_Salary ( )
+ Get_Salary ( )
+ Set_rank ( )
+ Get_rank ( )
+ Set_Job ( )
+ Get_Job ( )
<<Sub Class>>
Salaried Employee
- Bonus
- Deductions
+ Set_Working_hours ( )
+ Get_Working_hours ( )
+ Set_Houre_Rate ( )
+ Get_Houre_Rate ( )
<<Sub Class>>
Hourly Employee
- Working_Hours
- Houre_rate
+ Set_Working_hours ( )
+ Get_Working_hours ( )
+ Set_Houre_Rate ( )
+ Get_Houre_Rate ( )


Shape
String : Color
Draw ( )
Erase ( )
Get_area ( )
Rectangle
int : Length
int : width
Draw ( )
Erase ( )
Get_area ( )
Box
int : SideLength
Draw ( )
Erase ( )
Get_area ( )
Circle
int : radius
Draw ( )
Erase ( )
Get_area ( )
Get_circumference ( )

Types of Polymorphism





int Add(int x , int y);
double Add (double x, double y);

Box b;
b.Get_area ( );

Functions Overriding using Virtual Functions

- A virtual function a member function which is declared within a base class and is re-defined(Overriden) by a derived class. When you refer to a derived class object using a pointer to the base class, you can call a virtual function for that object and execute the derived class's version of the function.

- Virtual functions ensure that the correct function is called for an object, regardless of the type of reference (or pointer) used for function call.

```
class Shape {
   protected:
      int width, height;

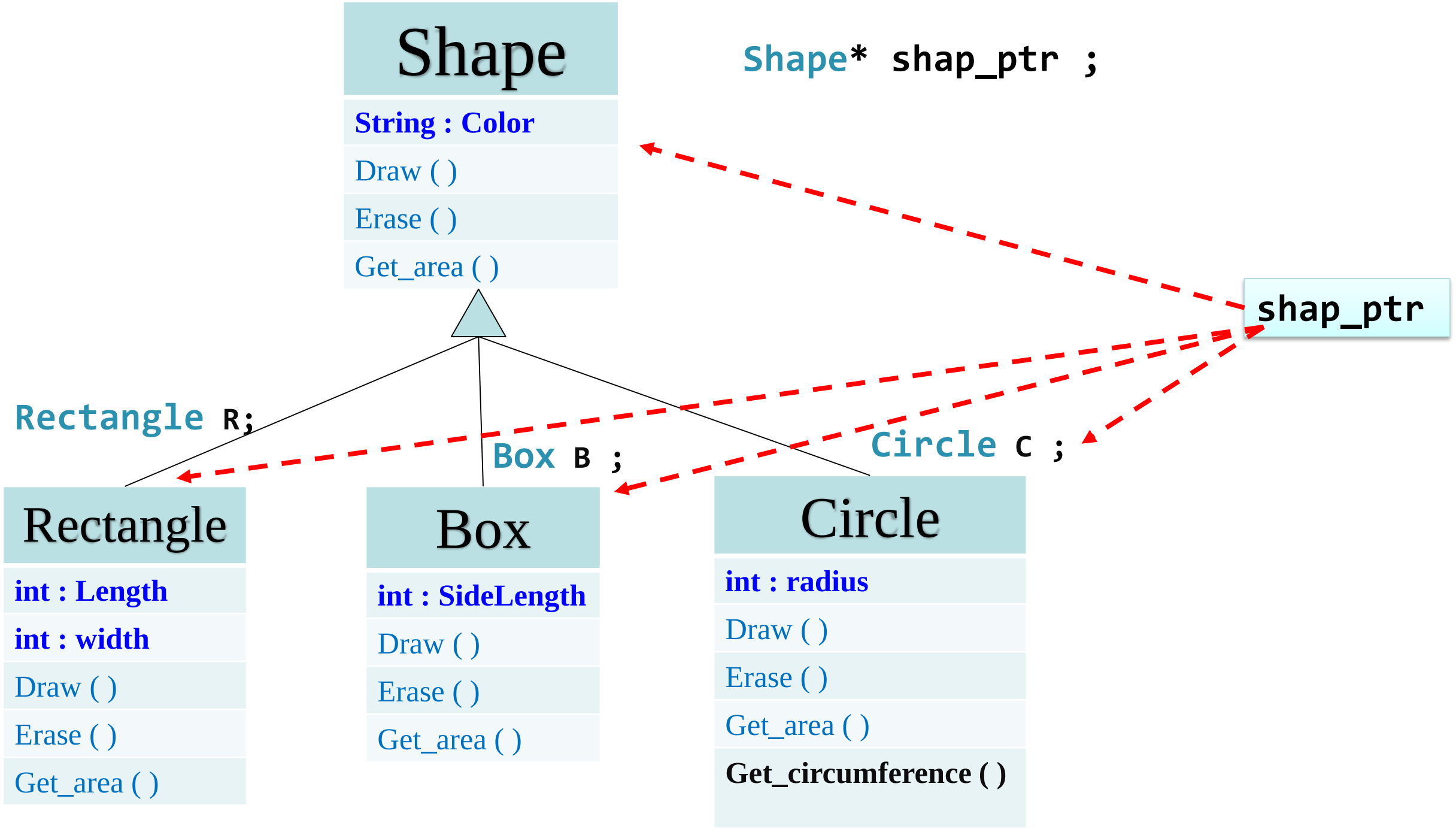
   public:
      Shape( int a = 0, int b = 0) {
         width = a;
         height = b;
      }
      virtual int area() {
         cout << "Parent class area :" <<endl;
         return 0;
      }
};
```

```
class Rectangle: public Shape {
   public:
      Rectangle( int a = 0, int b = 0):Shape(a, b) { }

      int area () {
         cout << "Rectangle class area :" <<endl;
         return (width * height);
      }
};

class Triangle: public Shape {
   public:
      Triangle( int a = 0, int b = 0):Shape(a, b) { }

      int area () {
         cout << "Triangle class area :" <<endl;
         return (width * height / 2);
      }
};
```


Shape
String : Color
Draw ( )
Erase ( )
Get_area ( )
Shape* shap_ptr ;
shap_ptr
Rectangle R;
Box B ;
Circle C ;
Rectangle
int : Length
int : width
Draw ( )
Erase ( )
Get_area ( )
Box
int : SideLength
Draw ( )
Erase ( )
Get_area ( )
Circle
int : radius
Draw ( )
Erase ( )
Get_area ( )
Get_circumference ( )

Pure Virtual Functions

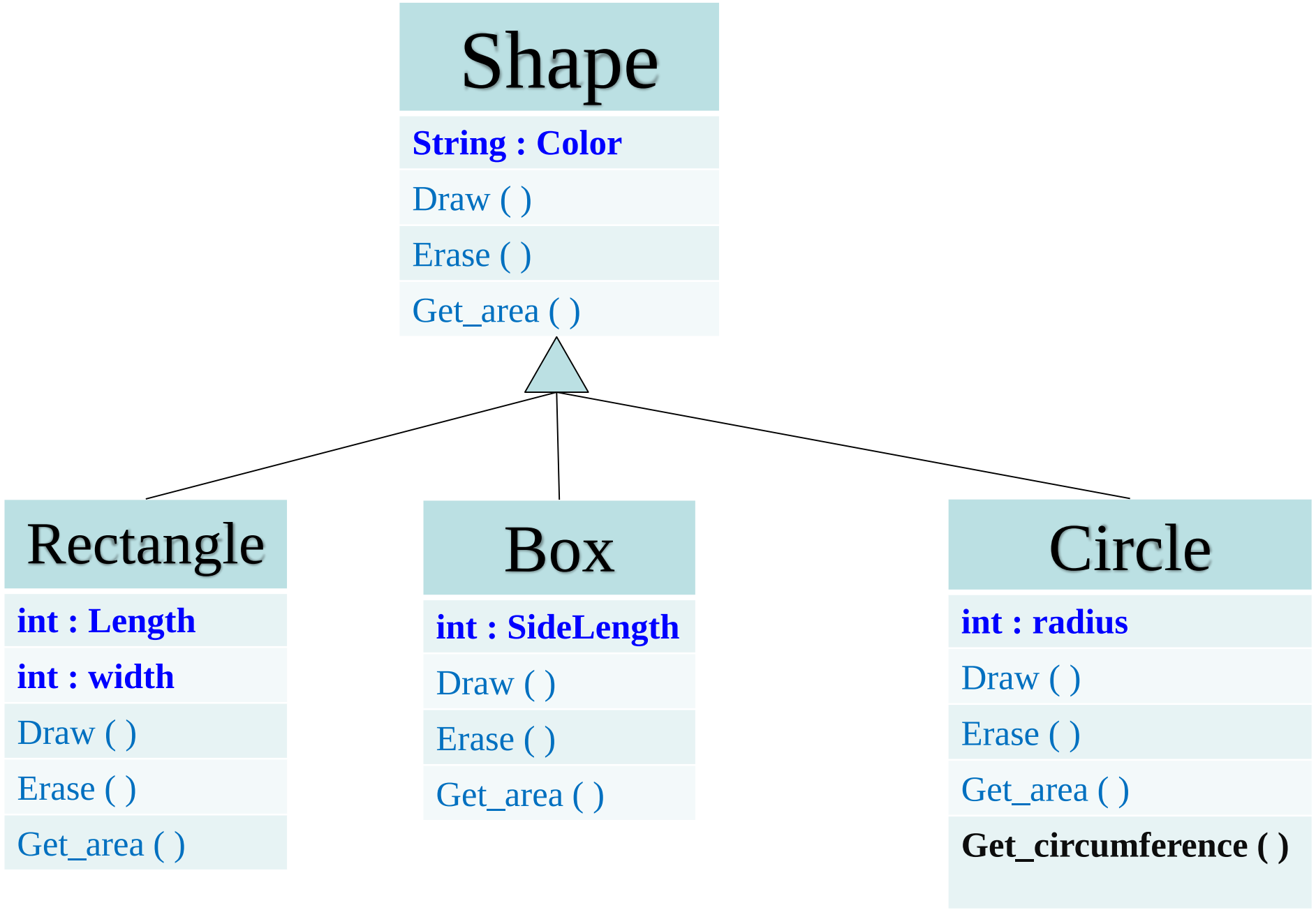
```
class Shape {
   protected:
      int width, height;

   public:
      Shape(int a = 0, int b = 0) {
         width = a;
         height = b;
      }

      // pure virtual function
      virtual int area() = 0;
};
```

Abstract Classes - Interfaces

- An interface (Abstract Class) describes the behavior or capabilities of a C++ class without committing to a particular implementation of that class.
- The purpose of an **abstract class** is to provide the Desired base class Form which will be inherited by other classes in the class hierarchy.
- Abstract classes cannot be used to instantiate objects and serves only as an **interface**.
- A class is made abstract by declaring *at least one* of its functions as pure virtual function.


Shape
String : Color
Draw ( )
Erase ( )
Get_area ( )
Rectangle
int : Length
int : width
Draw ( )
Erase ( )
Get_area ( )
Box
int : SideLength
Draw ( )
Erase ( )
Get_area ( )
Circle
int : radius
Draw ( )
Erase ( )
Get_area ( )
Get_circumference ( )

- A class is made abstract by declaring at least one of its functions as pure virtual function.

```
class Shape {
   protected:
      int width, height;

   public:
      Shape(int a = 0, int b = 0) {
         width = a;
         height = b;
      }

      // pure virtual function
      virtual int area() = 0;
};
```

Friend Function

- A friend function of a class is defined outside that class' scope but it has the right to access all private and protected members of the class.
- The prototypes for friend functions appear in the class definition.
- friends are not member functions.

```
class className{

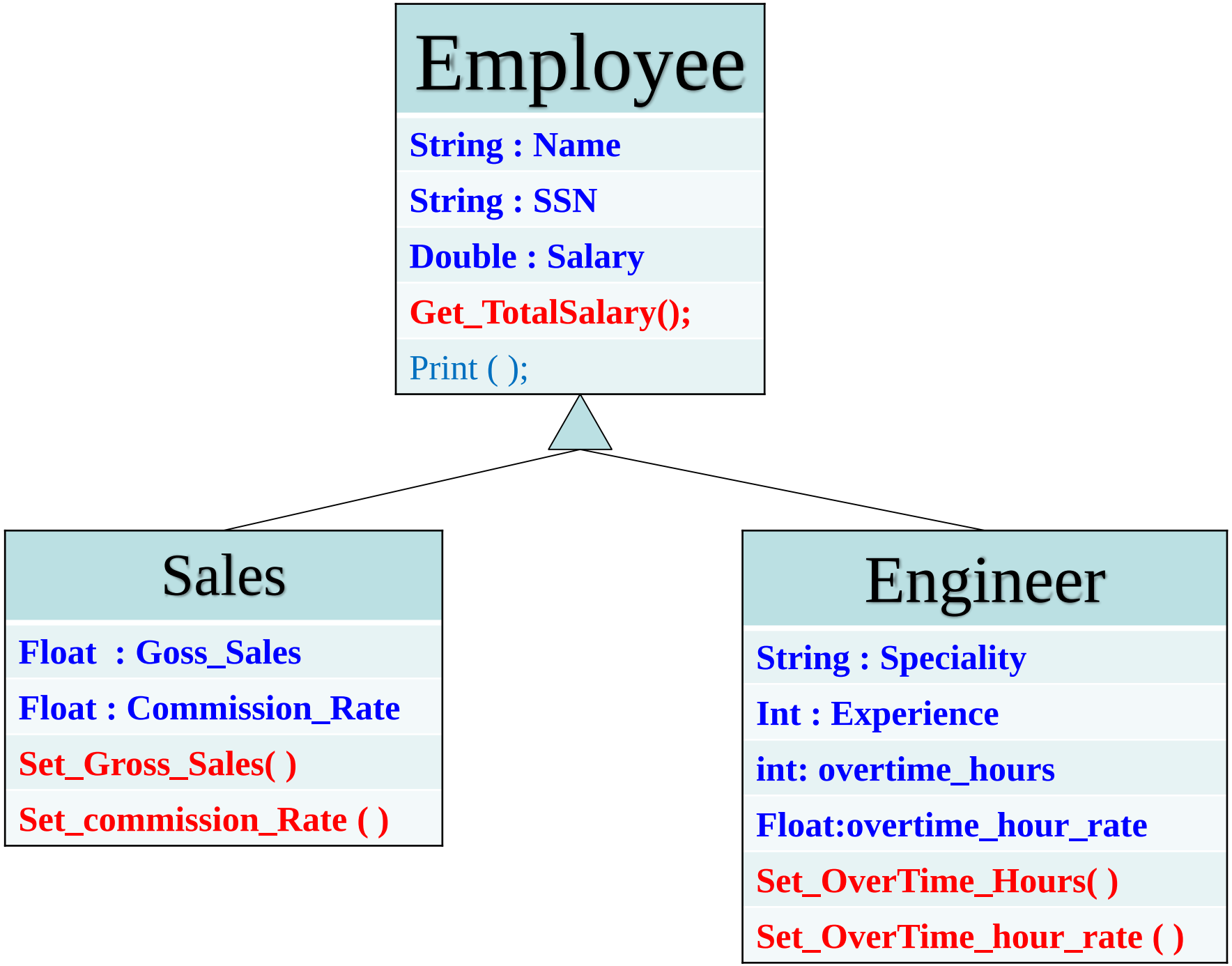
.....

friend returnType functionName(arg list);
};
```

Friend Class

- Just like friend functions, we can also have a friend class.
- Friend class can access private and protected members of the class to which it is a friend.
- Note that the friendship is not mutual unless we make it so.
- The friendship of the class is not inherited. This means that as class B is a friend of class A, it will not be a friend of the subclasses of class A.

```
class A{
.....
friend class B;
};
class B{
.........
};
```


Employee
String : Name
String : SSN
Double : Salary
Get_TotalSalary();
Print ( );
Sales
Float : Goss_Sales
Float : Commission_Rate
Set_Gross_Sales( )
Set_commission_Rate ( )
Engineer
String : Speciality
Int : Experience
int: overtime_hours
Float:overtime_hour_rate
Set_OverTime_Hours( )
Set_OverTime_hour_rate ( )

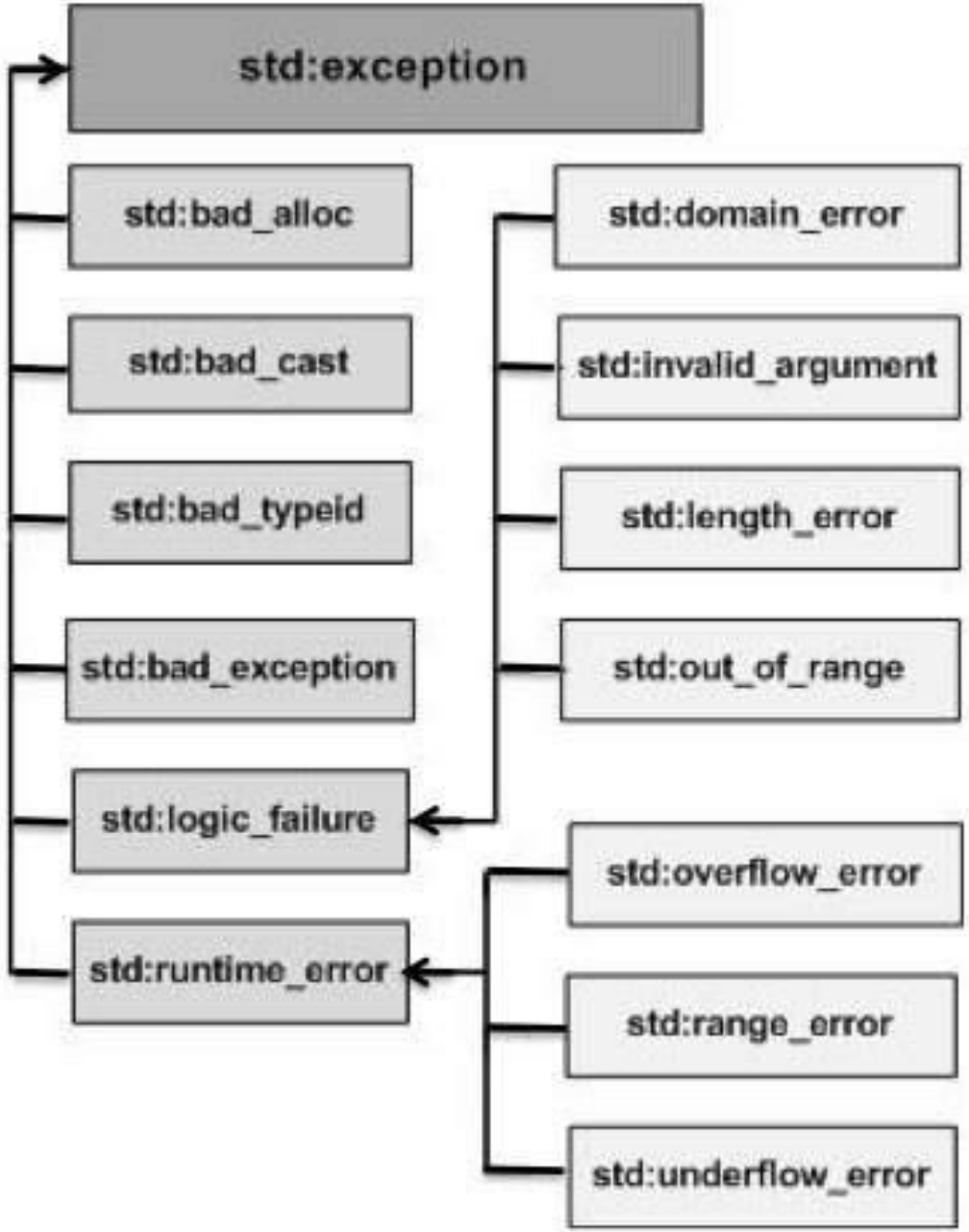
Introduction

- **Exceptions**
  - Indicate problems that occur during a program's execution
  - A C++ exception is a response to an exceptional circumstance that arises while a program is running, such as an attempt to *divide by zero*.
- **Exception handling**
  - Can resolve exceptions
    - Allow a program to continue executing or
    - Notify the user of the problem and
    - Terminate the program in a controlled manner
  - Makes programs robust and fault-tolerant

Exception Handling

- An *exception* is a class
  - Usually derived from one of the system's exception base classes
- Exception Class is the standard C++ base class for all exceptions
- Provides derived classes with virtual function **`what()`**
  - Returns the exception's stored error message

- If an exceptional or error situation occurs, program *throws* an object of that class.


std:exception
std:bad_alloc
std:bad_cast
std:bad_typeid
std:bad_exception
std:logic_failure
std:runtime_error
std:domain_error
std:invalid_argument
std:length_error
std:out_of_range
std:overflow_error
std:range_error
std:underflow_error

- Exceptions provide a way to transfer control from one part of a program to another. three keywords: **try, catch , throw are used**
- **try** – A **try** block identifies a block of code for which particular exceptions will be activated. It's followed by one or more catch blocks.
- **throw** – A program throws an exception when a problem shows up. This is done using a **throw** keyword.
- **catch** – A program catches an exception with an exception handler at the place in a program where you want to handle the problem. The **catch** keyword indicates the catching of an exception.

```
int x = 10, y = 2;
try
{
if (y == 0)
        throw  exception ( )";
else
cout << x / y << endl;
}
catch (exception e)
{
        cout << e.what ( ) <<endl;
}
cout << "The Program Continued" << endl;
```

```
int x = 10, y = 2;
try
{
if (y == 0)
        throw "division by zero Exception";
else
cout << x / y << endl;
}
catch (const char* msg)
{
        cout << msg <<endl;
       cout << "Y must be greater than 0" << endl;
}
cout << "The Program Continued" << endl;
```

```
try {
  int age = 15;
  if (age > 18) {
    cout << "Access granted - you are old enough.";
  } else {
        throw (age);
  }
}
catch (int myNum) {
  cout << "Access denied - You must be at least 18 years old.\n";
  cout << "Age is: " << myNum;
}
```

Exception Handling – General Syntax

- try {
  // Block of code to try
  throw *exception*; // Throw an exception when a problem arise
  }
  catch ( ) {
  // Block of code to handle errors
  }

Exception Handling

```
try {
  // code to try
}
catch (exceptionClass1 &name1) {
  // handle exceptions of exceptionClass1
}

catch (exceptionClass2 &name2) {
  // handle exceptions of exceptionClass2
}

catch (exceptionClass3 &name3) {
  // handle exceptions of exceptionClass3
}
...
```

`catch` clauses attempted in order; first match wins!

Handle Any Type of Exceptions (...)

```
int x = 10, y = 2;
try
{
if (y == 0)
        throw "Integer division by zero";
else
        cout << x / y << endl;
}
catch (…)
{       cout << “An exception Caught"<<endl;
}
cout << "The Program Continued" << endl;
```

Exception Specifications

- Also called **`throw`** lists
- Keyword **`throw`**
  - Comma-separated list of exception classes in parentheses
- Example
  - ```
    int someFunction( double value )
       throw ( ExceptionA, ExceptionB,
               ExceptionC )
    {
       ...
    }
    ```
  - Indicates **`someFunction`** can **`throw`** types **`ExceptionA`**, **`ExceptionB`** and **`ExceptionC`**

Optional!
    ```

Exception Specifications (continued)

- A function can **`throw`** only exceptions of types in its specification (or derived types)
  - If a function throws a non-specification exception, function **`unexpected`** is called
    - This normally terminates the program
- Absence of exception specification indicates that the function can **`throw`** any exception
- An empty exception specification, **`throw()`**, indicates the function *cannot* **`throw`** any exceptions