Object-oriented Programming in C++

Fundamental Computer Programming- C++ Lab (II)

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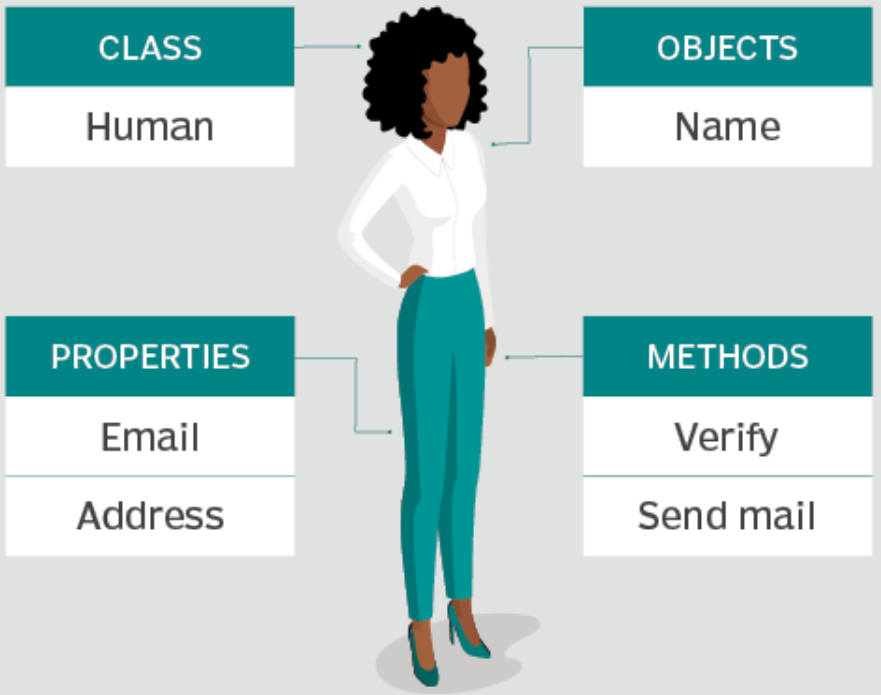
Outline

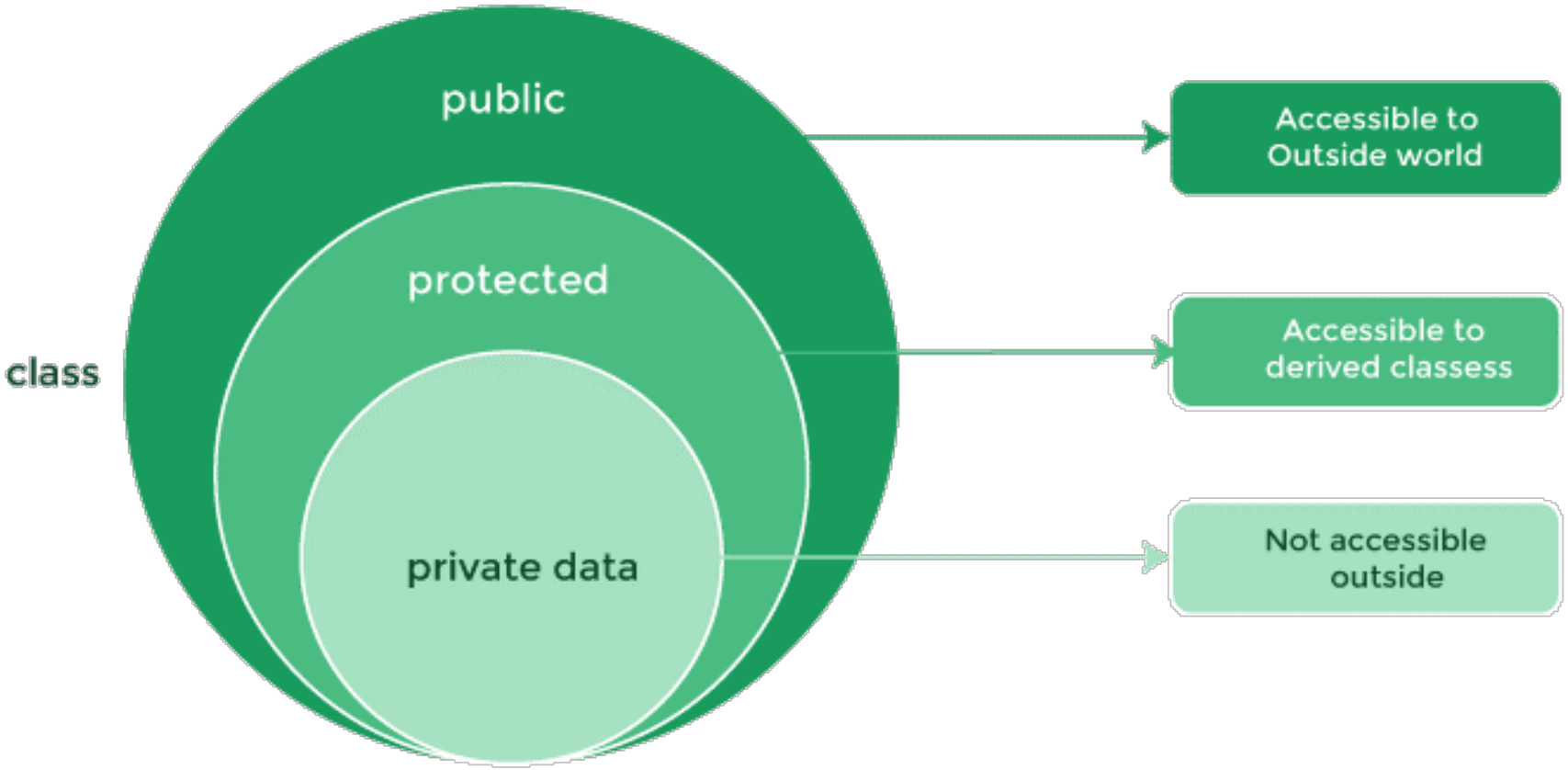
- Object-Oriented Design
- Classes and Object in C++
- Exercises

Object-Oriented Programming

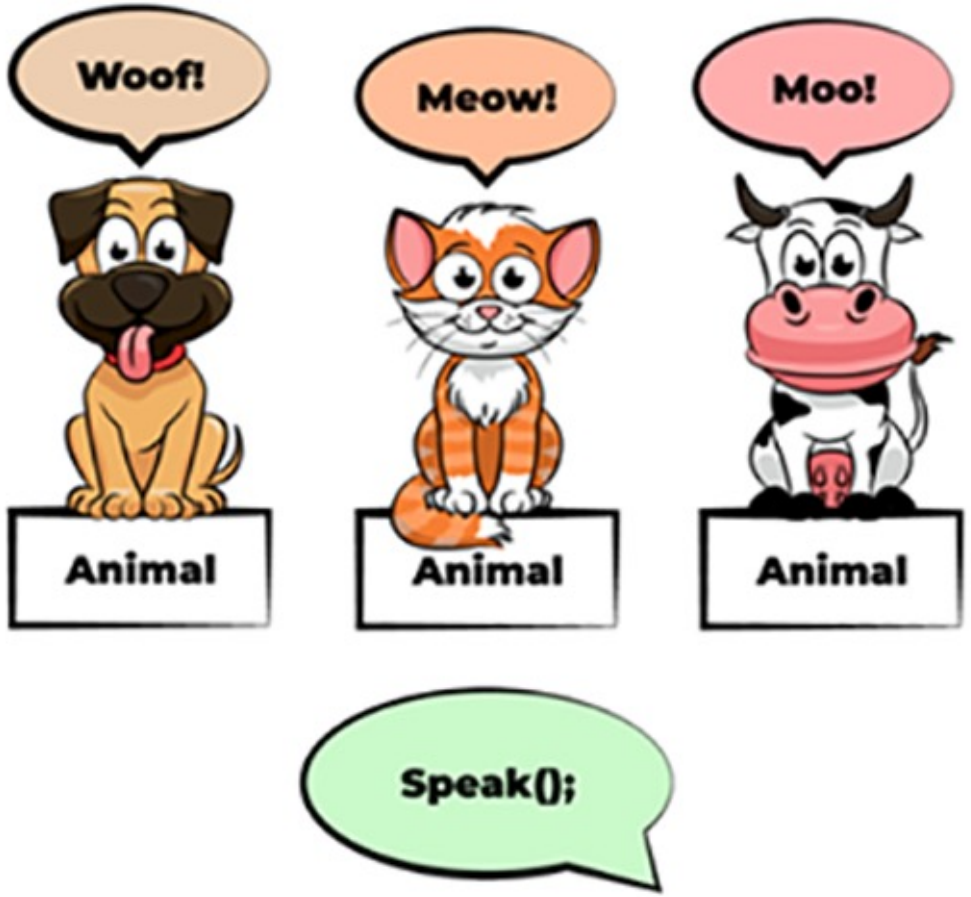
- Break the program down into objects and relationships, each with properties (*data*) and actions (*methods*).
- Helps the program easier develop and maintain.
- Concept of OOPs:
  - Encapsulation
  - Inheritance
  - Polymorphism
  - Abstraction



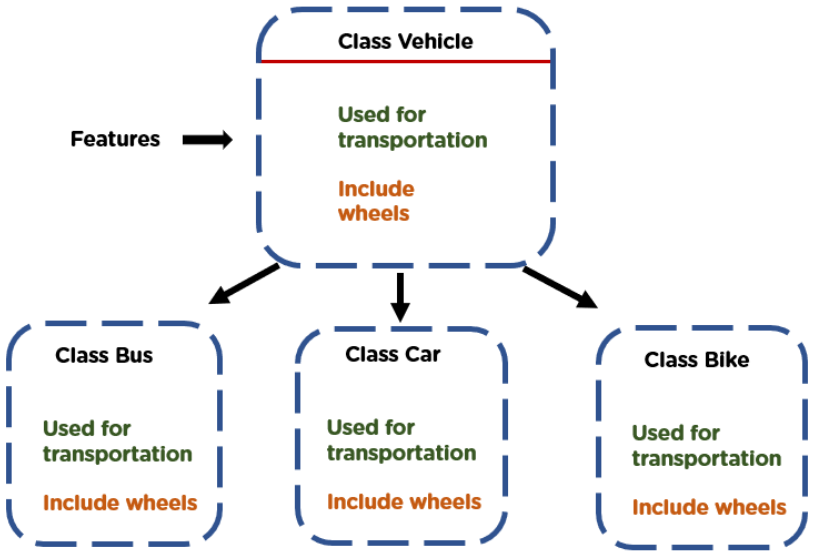
Encapsulation

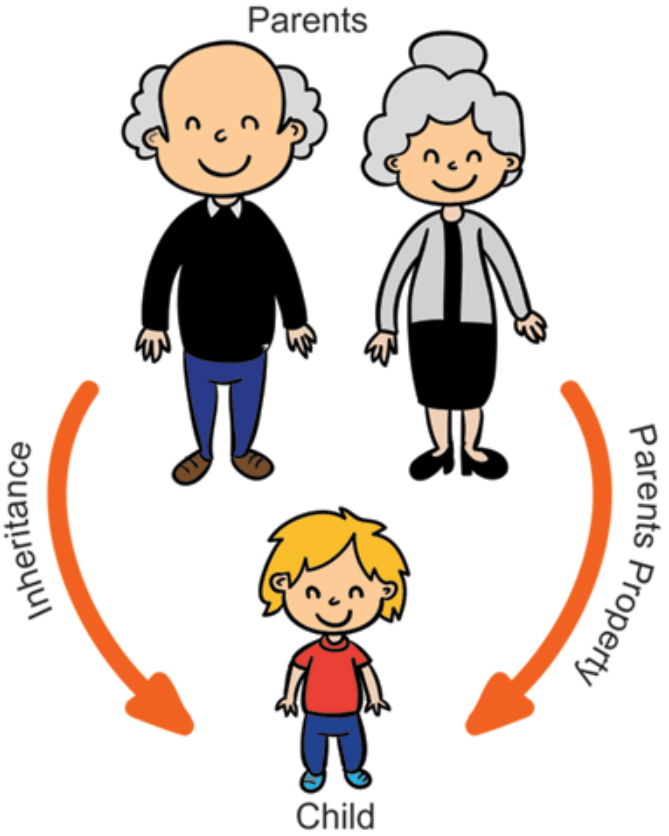


Polymorphism

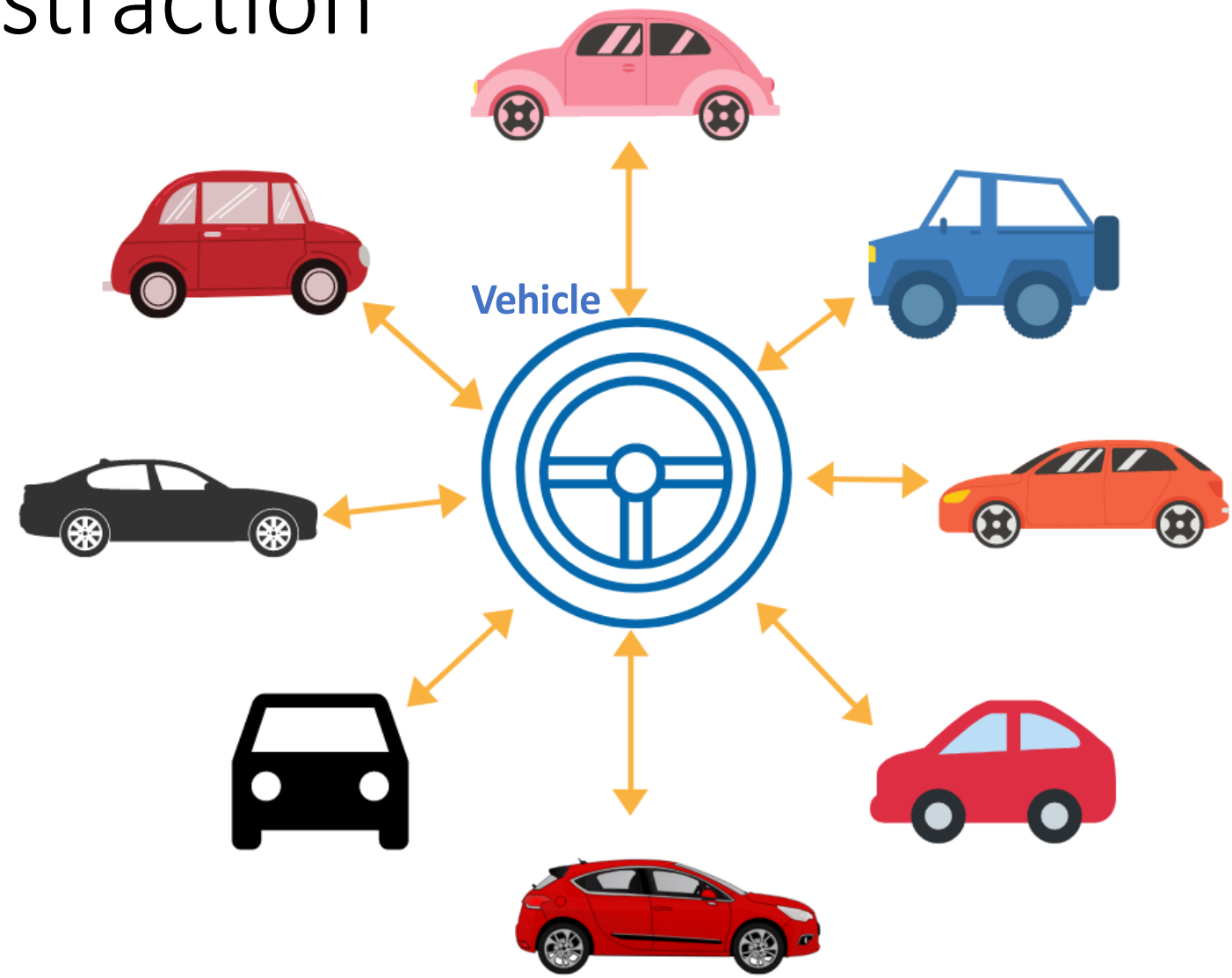


Inheritance





Abstraction



Classes and Object in C++

- Define Class
- Declare Class Object
- Constructor & Destructor
- Copy Constructor
- Friend Functions
- Keyword `this`
- Pointer to C++ Classes
- Static Member of a Class

Define Class in C++

- A class in C++ is defined using the keyword class followed by class name.

```
class Student
{
     public: // Access modifier
          // Data members
          int ID;
          string Name;
          int Age;
          // Member functions
          void getDetails()
          {
               cout << “Student Details\nID:” << ID << endl;
               cout << “Name :” << Name << endl;
               cout << “Age :” << Age << endl;
          }
};
```

Define Class in C++

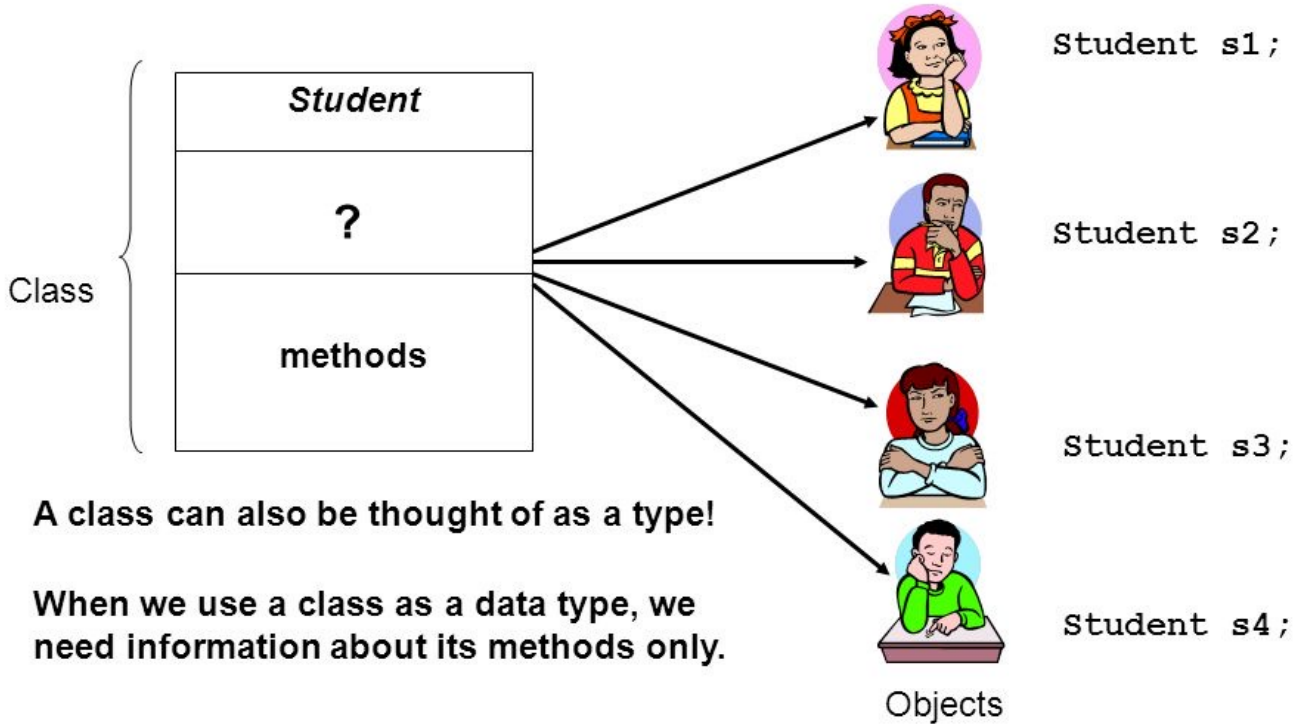
- Example of member function definition outside the class

```
class Student
{
     public:
          int RollNo;
          string Name;
          int Age;
          void getDetails();
};

void Student::getDetails() {
     cout<< “Student Details\nRoll No.:” << RollNo << endl;
     cout<< “Name:” << Name << endl;
     cout<< “Age:” << Age << endl;
}
```

Objects in C++

A **class** is the blueprint from which **objects** are generated;



A class can also be thought of as a type!

When we use a class as a data type, we need information about its methods only.

Objects in C++

- An instance of a class is called an object. When a class is defined, no memory is allocated, we only define the specifications for its object. Memory is allocated when we create an object of a class.
- Data members and member functions of a class can be used and accessed by creating objects.
- We can create multiple objects of a class.

```
ClassName ObjectName; // Syntax
Student s1, s2, s3;   // Instances of Student
```

Objects in C++

- An instance of a class is called an object.
- Data members and member functions of a class can be used and accessed by creating objects.
- We can create multiple objects of a class.

```
ClassName ObjectName; // Syntax
Student s1, s2, s3; // Instances of Student

Student.Name; //Accessing data member
Student.getDetails(); //Accessing member function
```

Access Modifiers in C++

There are three types of access specifiers in C++:

- **Public**:
  - Accessible from anywhere in the program.
- **Private**:
  - Only accessible by functions defined within the class.
  - Cannot access from outside class except friend functions and friend classes.
- **Protected**:
  - Similar to private, except these can also be accessed by derived classes.

Access Modifiers in C++

Example

```
Name:Vidvan
Age:10yrs
```

```cpp
#include <iostream>
#include <string>

using namespace std;

class Person {
    private:
    string name;
    int age;
    public:
    void insert(string n, int a) {
        name = n;
        age = a;
    }
    void display() {
        cout<<"Name:"<<name<<endl;
        cout<<"Age:"<<age<<"yrs";
    }
};

int main() {
  Person p1;
  p1.insert("Vidvan", 10);
  p1.display();
  return 0;
}
```

Constructor

- A class constructor is a special member function of a class that is executed whenever we create new objects of that class.
- A constructor will have exact same name as the class and it does not have any return type at all, not even void.
- Constructors can be very useful for setting initial values for certain member variables.

Constructor

Example

```
Object is being created
Length of line : 6
```

```cpp
#include <iostream>

using namespace std;

class Line {
   public:
      void setLength( double len );
      double getLength( void );
      Line();  // This is the constructor
   private:
      double length;
};

// Member functions definitions including constructor
Line::Line(void) {
   cout << "Object is being created" << endl;
}
void Line::setLength( double len ) {
   length = len;
}
double Line::getLength( void ) {
   return length;
}

// Main function for the program
int main() {
   Line line;

   // set line length
   line.setLength(6.0);
   cout << "Length of line : " << line.getLength() <<endl;

   return 0;
}
```

Parameterized Constructor

Example

```
Object is being created,
length = 10
Length of line : 10
Length of line : 6
```

```cpp
#include <iostream>

using namespace std;
class Line {
   public:
      void setLength( double len );
      double getLength( void );
      Line(double len);  // This is the constructor

   private:
      double length;
};

// Member functions definitions including constructor
Line::Line( double len) {
   cout << "Object is being created, length = " << len << endl;
   length = len;
}
void Line::setLength( double len ) {
   length = len;
}
double Line::getLength( void ) {
   return length;
}

// Main function for the program
int main() {
   Line line(10.0);

   // get initially set length.
   cout << "Length of line : " << line.getLength() <<endl;

   // set line length again
   line.setLength(6.0);
   cout << "Length of line : " << line.getLength() <<endl;

   return 0;
}
```

Using Initialization Lists to Initialize Fields

In case of parameterized constructor, you can use following syntax to initialize the fields

```
Line::Line( double len): length(len) {
   cout << "Object is being created, length = " << len << endl;
}
```

Above syntax is equal to the following syntax –

```
Line::Line( double len) {
   cout << "Object is being created, length = " << len << endl;
   length = len;
}
```

If for a class C, you have multiple fields X, Y, Z, etc., to be initialized, then use can use same syntax and separate the fields by comma as follows –

```
C::C( double a, double b, double c): X(a), Y(b), Z(c) {
   ....
}
```

Destructor

- A destructor is a special member function of a class that is executed whenever an object of its class goes out of scope or whenever the delete expression is applied to a pointer to the object of that class.
- A destructor will have exact same name as the class prefixed with a tilde (~) and it can neither return a value nor can it take any parameters.
- Destructor can be very useful for releasing resources before coming out of the program like closing files, releasing memories etc.

Destructor

Example

```
Object is being created
Length of line : 6
Object is being deleted
```

```cpp
#include <iostream>

using namespace std;
class Line {
   public:
      void setLength( double len );
      double getLength( void );
      Line();   // This is the constructor declaration
      ~Line();  // This is the destructor: declaration

   private:
      double length;
};

// Member functions definitions including constructor
Line::Line(void) {
   cout << "Object is being created" << endl;
}
Line::~Line(void) {
   cout << "Object is being deleted" << endl;
}
void Line::setLength( double len ) {
   length = len;
}
double Line::getLength( void ) {
   return length;
}

// Main function for the program
int main() {
   Line line;

   // set line length
   line.setLength(6.0);
   cout << "Length of line : " << line.getLength() <<endl;

   return 0;
}
```

Copy Constructor

- The copy constructor is a constructor which creates an object by initializing it with an object of the same class
- The copy constructor is used to:
  - Initialize one object from another of the same type.
  - Copy an object to pass it as an argument to a function.
  - Copy an object to return it from a function.
- If a copy constructor is not defined in a class, the *compiler itself defines one*.
- If the class has pointer variables and has some dynamic memory allocations, then it is a must to have a copy constructor.
- The most common form of copy constructor is shown here −

```
ClassName (const ClassName &obj) { // Constructor
   // body of constructor
}
```

Copy Constructor

Example

```
p1.x = 10, p1.y = 15
p2.x = 10, p2.y = 15
```

```cpp
#include <iostream>
using namespace std;

class Point {
    private:
        int x, y;

    public:
        Point(int x1, int y1)
        {
            x = x1;
            y = y1;
        }

        // Copy constructor
        Point(const Point& p1)
        {
            x = p1.x;
            y = p1.y;
        }

        int getX() { return x; }
        int getY() { return y; }
};

int main()
{
    Point p1(10, 15); // Normal constructor is called here
    Point p2 = p1; // Copy constructor is called here

    // Let us access values assigned by constructors
    cout << "p1.x = " << p1.getX()
         << ", p1.y = " << p1.getY();
    cout << "\np2.x = " << p2.getX()
         << ", p2.y = " << p2.getY();
    return 0;
}
```

Friend Functions

- A friend function of a class is defined outside a class, but it has the right to access all private and protected members of the class.
- A friend can be a function, function template, or member function, or a class or class template, in which case the entire class and all its members are friends.

```
Width of box : 10
```

```cpp
#include <iostream>

using namespace std;

class Box {
   double width;

   public:
      friend void printWidth( Box box );
      void setWidth( double wid );
};

// Member function definition
void Box::setWidth( double wid ) {
   width = wid;
}

// Note: printWidth() is not a member function of any class.
void printWidth( Box box ) {
   /* Because printWidth() is a friend of Box, it can
   directly access any member of this class */
   cout << "Width of box : " << box.width <<endl;
}

// Main function for the program
int main() {
   Box box;

   // set box width without member function
   box.setWidth(10.0);

   // Use friend function to print the wdith.
   printWidth( box );

   return 0;
}
```

Keyword `this`

- `this` pointer is an implicit parameter to all member functions. Therefore, inside a member function, this may be used to refer to the invoking object.
- Friend functions do not have a `this` pointer, because friends are not members of a class. Only member functions have a `this` pointer.

```
Constructor called.
Constructor called.
Box2 is equal to or larger
than Box1
```

```cpp
#include <iostream>

using namespace std;

class Box {
   public:
      // Constructor definition
      Box(double l = 2.0, double b = 2.0, double h = 2.0) {
         cout <<"Constructor called." << endl;
         length = l;
         breadth = b;
         height = h;
      }
      double Volume() {
         return length * breadth * height;
      }
      int compare(Box box) {
         return this->Volume() > box.Volume();
      }

   private:
      double length;     // Length of a box
      double breadth;    // Breadth of a box
      double height;     // Height of a box
};

int main(void) {
   Box Box1(3.3, 1.2, 1.5);    // Declare box1
   Box Box2(8.5, 6.0, 2.0);    // Declare box2

   if(Box1.compare(Box2)) {
      cout << "Box2 is smaller than Box1" <<endl;
   } else {
      cout << "Box2 is equal to or larger than Box1" <<endl;
   }

   return 0;
}
```

Pointer to C++ Classes

- A pointer to a C++ class is done the same way as a pointer to a structure and to access members of a pointer to a class you use the member access operator -> operator.

```
Constructor called.
Constructor called.
Volume of Box1: 5.94
Volume of Box2: 102
```

```cpp
#include <iostream>

using namespace std;

class Box {
   public:
      // Constructor definition
      Box(double l = 2.0, double b = 2.0, double h = 2.0) {
         cout <<"Constructor called." << endl;
         length = l;
         breadth = b;
         height = h;
      }
      double Volume() {
         return length * breadth * height;
      }

   private:
      double length;     // Length of a box
      double breadth;    // Breadth of a box
      double height;     // Height of a box
};

int main(void) {
   Box Box1(3.3, 1.2, 1.5);    // Declare box1
   Box Box2(8.5, 6.0, 2.0);    // Declare box2
   Box *ptrBox;                // Declare pointer to a class.

   // Save the address of first object
   ptrBox = &Box1;

   // Now try to access a member using member access operator
   cout << "Volume of Box1: " << ptrBox->Volume() << endl;

   // Save the address of second object
   ptrBox = &Box2;

   // Now try to access a member using member access operator
   cout << "Volume of Box2: " << ptrBox->Volume() << endl;

   return 0;
}
```

Static member

- A static keyword is used to define those functions.
- They can be directly called by using just the class name, without creating an instance of the class.
- These are only accessible within the body of the class they are defined in, thus, implementing class-wide operations and certain security measures..

```
Inital Stage Count: 0
Constructor called.
Constructor called.
Final Stage Count: 2
```

```cpp
#include <iostream>

using namespace std;

class Box {
   public:
      static int objectCount;

      // Constructor definition
      Box(double l = 2.0, double b = 2.0, double h = 2.0) {
         cout <<"Constructor called." << endl;
         length = l;
         breadth = b;
         height = h;

         // Increase every time object is created
         objectCount++;
      }
      double Volume() {
         return length * breadth * height;
      }
      static int getCount() {
         return objectCount;
      }

   private:
      double length;     // Length of a box
      double breadth;    // Breadth of a box
      double height;     // Height of a box
};

// Initialize static member of class Box
int Box::objectCount = 0;

int main(void) {
   // Print total number of objects before creating object.
   cout << "Inital Stage Count: " << Box::getCount() << endl;

   Box Box1(3.3, 1.2, 1.5);    // Declare box1
   Box Box2(8.5, 6.0, 2.0);    // Declare box2

   // Print total number of objects after creating object.
   cout << "Final Stage Count: " << Box::getCount() << endl;

   return 0;
}
```

Exercise 1

Write a **Student** class as design.

- **Input()**: Enter info of student
- **Ouput()**: Print infor of student to the screen.

Write a **main** function to test the class.

Student
string **ID** string **Name** int **Age** double **Score**
void **Input()** void **Output()**

Exercise 2

Write a **Rectangle** class as design.

- **Input()**: Enter info of the rectangle
- **Draw()**: Output the rectable to the screen by using * symbol
- **Area()**: Calculate and return area of the rectangle.
- **Perimeter():** Calculate and return perimeter of the rectangle.

Write a **main** function to test the class.

Rectangle
`int Width` `int Length`

`void Input()`
`void Draw()`
`double Area()`
`double Perimeter()`

Formulas

Area of a rectangle = Length × Width

Perimeter of a rectangle = 2(Length + Width)

Exercise 3

Write a **Product** class as design.

- **Input()**: Enter info of that product
- **Output()**: Print info of that product in one line to the screen.

- Write a **main** function to input *n* of products. Then print all info of all products to the screen.

Product
string **ID** string **Name** double **Price** int **Quantity**
void **Input()** void **Output()**

Exercise 4

Write a **Book** class as design.

- **Input()**: Enter info of that book
- **Output()**: Print info of that book in one line to the screen.

- Write a **main** function to input *n* of books. Then print all info of all books to the screen.

Book
string **Code** string **Name** string **Publisher** int **NumPage** double **Price**
void **Input()** void **Output()**

Thank you for your attention