Lecture 3

Classes and Objects

Topics

- Classes and Objects
- Dynamically allocated Objects
- Arrays of Objects
- Controlling Access to Member Attributes
- Friend Classes
- Friend Functions
- The this Pointer
- Function returning an object

Classes and Objects

- Real world object : Attributes and Abilities
- Programming object : Data and Functions
- **Class** is a data type which is used to define objects.
- A class serves as a blueprint (model) description.
- Class specifies what **data** and what **functions** will be included in **objects** of that class.

Classes and Objects

- A **class** is a grouping of data and functions.
- A class is very much like a **struct** type as used in C.
- Writing a class doesn't create any objects.

- An **object** is an instance of a class, which is similar to a **variable**.
- An object is what you actually use in a program.

- An **attribute** is a **member data** of a class.
- Examples: Name of a student, coordinates of a point.

- A **method (message)** is a **member function** contained within class.

Example : Point class

- Suppose a Point class is written in a graphics program.
- The Point class will have two member properties:

  x and **y** integer values as coordinates.

- The Point class will have the following member functions:

  move() function : Moves to a new (x,y) location.

  print() function : Shows the coordinates (x,y) on screen.

  is_zero() function : Checks whether the (x,y) point is on the zero point (0, 0). Returns true or false.

Point class declaration

- The Point class contains x and y member data. Their access type is private by defult.
- Class also contains member functions, which are declared as public access.

Member datas

Member functions (prototypes)

```
class Point               // Declaration of Point Class
{
  int x, y;               // Current x and y coordinates

 public:                  // public access allowed
  void move(int, int);    // A function to move to a new point
  void print();           // To print the coordinates on screen
  bool is_zero();         // Is the point on the zero point (0,0) ?
};
```

Member Functions of Point class

The **::** symbol is scope operator.
The move function is a member of the Point class.

```
// A function to move the points
void  Point :: move (int  nx,  int  ny)
{
   x = nx;   // assigns new value to x coordinate
   y = ny;   // assigns new value to y coordinate
}
```

Non-inline syntax notations are used.


```
// Print the coordinates on the screen
void  Point  ::  print ()
{
   cout  << "X = "  <<  x
         << " , Y =  "  <<  y
         << endl;
}
```

```
// Check whether the point is on the zero point(0,0)
bool  Point  ::  is_zero ()
{
   return  (x == 0) &&
           (y == 0);
   // returns true or false
}
```

Non-inline syntax notations are used.

Defining Point Objects

In main program, we can define variables (objects) by using the Point class.

```
int main()
{
   Point  P1, P2;  // Two object variables are defined.

   P1 . move (100, 50);      // P1 moves to (100, 50) location
   P1 . print();
   if  ( P1 . is_zero () )
      cout << "P1 is on zero point" << endl;
   else
      cout << "P1 is NOT on zero point" << endl;
  //--------------------------------------------------------------------
   P2 . move (0, 0);        // P2 moves to (0,  0)
   if  ( P2 . is_zero () )
      cout << "P2 is on zero point" << endl;
   else
      cout << "P2 is NOT on zero point" << endl;
}
```


Defining Methods inside a Class

- Any function (method) code written inside a class definition is considered automatically an **inline function** by the compiler.
- Example: ***is_zero*** function of Point class can be defined inside the class. The "inline" keyword is <u>not written</u>.
- Inline syntax should be preferred only for short functions.

```
class  Point  { // Declaration of Point Class
   int  x, y;     // Properties: x and y coordinates

  public:
   void  move (int, int);
   void  print ();

   bool  is_zero()   // Function is written inline
   {
      return  (x == 0)   &&  (y == 0);
   }
}
```

Inline syntax notation is used.

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Defining Dynamically Allocated Objects

Two pointers (ptr1 and ptr2) to Point objects are defined and dynamically allocated.

```
int main() {
    // Allocating memory for two Point objects
    Point *  p1  =  new  Point;
    Point *  p2  =  new  Point;

    p1 -> move (50, 50);
    p1 -> print ();

    p2 -> move (100, 150);
    if ( p2 -> is_zero () )
      cout << " Object is on zero." << endl;
    else
      cout << " Object is NOT on zero." << endl;

    // Releasing the memory
    delete  p1;
    delete  p2;
}
```

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Defining Array of Objects

An array is defined with 10 elements of type Point.

```
int main()
{
   // Define an array with 10 objects
   Point   array [10];


   // Call move function of first element (index 0)
   array [0] . move (15, 40);


  // Call move function of second element (index 1)
   array [1] . move (75, 35);


   // Call print function of each element in array
   for (int i = 0;   i < 10;   i++)
       array [i] . print ();
}
```

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Controlling Access to Members

- The access specifiers are used to control access to member data and functions of a class.
- The followings are access specifier keywords :
  private (default), public, protected.

- Each access specifier applies until the next access specifier,
  or until the end of class declaration.

- **Public** members may be accessed from any place in the program.

- **Private** members can be accessed only by member functions of that class.
  It is the **default** access mode.
- Private data are hidden, and can not be used by main program or by other classes.

- **Protected** is similar to private, and related to inheritance.
  It allows derived class to access member data and functions of base class.

Example: Controlling Access to Members

- Only the **public** members (data and function) of the class A can be accessed from outside of class such as in main program.
- The f1, f2, f3 functions can access to all member data (x, y, z).

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

class A
{
  // Member data
  private      :  int  x;
  protected    :  int  y;
  public       :  int  z;

 // Member functions
  private      :  void  f1 () { }
  protected    :  void  f2 () { }
  public       :  void  f3 () { }
};
```

```
int main()
{
  A   a;     // Object definition (variable)

  a.x = 10;  // Compiler error , x is private
  a.y = 20;  // Compiler error , y is protected
  a.z = 30;  // z is public

  a.f1();  // Compiler error , f1 is private
  a.f2();  // Compiler error , f2 is protected
  a.f3();  // f3 is public
}
```


Class diagram for Point class

- The purpose of public members is to present a view of the *services (functions)* the class provides.
- This set of services forms the *public interface* of the class.
- The private members are not accessible to the clients of a class.

Point	
- x : int - y : int	Member data (- symbol indicates private access)
+ move (int, int) : void + print () : void + is_zero () : bool	Member functions (+ symbol indicates public access)

Name of class: Point

Example: The bool as Function return type

In the following version of Point class, the return type of the **move** function is changed from **void** to **bool**.

```
class Point
{
 private:
   int x, y;  // private members

  public:    // public members
   bool  move (int, int);
   void  print ();
   bool  is_zero ();
};
```


Suppose that clients (main program or other classes) of the Point class are not allowed to move a point object outside a graphics window with a size of 500x300 pixels.

```
// A function to move the points

bool  Point  ::  move (int  nx,   int  ny)
{
  if ( nx  >  0   &&   nx  <  500   &&
       ny  >  0   &&   ny  < 300)
  {
    // assign new values
     x  =  nx;
     y  =  ny;
     return  true;  // input values are accepted
  }

  return  false;     // input values are not accepted
}
```

The **move** function returns a boolean value to inform whether the input values are accepted or not.

```
int main()
{
    Point  p1;    // p1 object is defined
    int x, y;
    // Two variables to read coordinate values from keyboard

    cout << " Give x and y coordinates ";
    cin >> x >> y;          // Read two values from keyboard

    if ( p1 . move (x, y) )  // Call move function and check the result
       p1 . print();            // If result is true, print coordinates on screen
    else
      cout << endl << "Input values are not accepted";
}
```


Example : Private data members

- If the access specifier is not written for a member data or function, then they are **private by default**.
- In Point class, x and y data members are **private** by default.
- It is not possible to assign a value to x or y directly outside the class.
- Also, displaying them directly is not allowed.

```
class Point {
   int  x, y;  // private member data by default
public:
   bool  move (int, int);
   void  print ();
};
int main() {
   Point   p1;
   p1 . move (100, 50);
   p1 . print();
   p1.x = 70;                 // Compiler error
   p1.y = 130;                // Compiler error
   cout << p1.x << endl;   // Compiler error
   cout << p1.y << endl;   // Compiler error
}
```

Example : Public data members

When x and y data members are defined as **public**, there will be no access restrictions.

```
class Point {
public:
    int  x, y;
    bool  move (int, int);
    void  print ();
};

int main() {
   Point   p1;
   p1 . move (100, 50);
   p1 . print();
   p1.x = 70;                  // Allowed
   p1.y = 130;                 // Allowed
   cout << p1.x << endl;  // Allowed
   cout << p1.y << endl;  // Allowed
}
```


Example: Private function members

Private member functions are not allowed to be called directly, such as from main.

```
class Point {
    // The move function is private by default
    bool  move (int, int);

public:
    int x, y;
    void print();
};

int main() {
   Point   p1;
   p1 . move (100, 50);     // Compiler error
   p1 . print();
   p1.x = 70;
   p1.y = 130;
   cout << p1.x << endl;
   cout << p1.y << endl;
}
```

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Friend Classes

- An entire class may be declared to be a friend of another class.
- A *friend* of a class has the right to access all member data and functions (private, protected or public) of the given class.

```
class  A
{
  friend  class  B;

  private:  // private members of A
     int i;

  public:   // public members of A
     void  func1 ();
};
```

- Class B is friend of class A.
- Class B can access members of class A.
- But class A can not access members of class B.

Class B can access private members (data ad functions) of class A.

```
class  B
{
   int  j;

  public:
   void  func2 (A   x)
   //Takes an object of class A, as argument
   {
      cout << j << endl;
      cout << x . i;   // i is member of class A
      x . func1 ();    // func1 is member of class A
   }
};
```

The object **a** is passed to member function of the object **b**.

```
int main() {
   A   a;
   B   b;
   b . func2 ( a );
}
```


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Friend Functions

- A non-member function may be declared to be a friend of a class.
- **A friend function** is **not a member** of any class.
- A *friend* function has the right to access all members (private, protected or public) of the specified class.
- If a member (data or function) of a class is already defined as public, then it is not necessary to declare any other class or function as friend.

```
class Point
{
   // Define a friend function of the Point class
   friend  void  set_to_zero (Point  &);  // Not a member of Point class

    int  x, y;    // private members: x and y coordinates

  public:    // public members
    bool  move (int, int);
    void  print ();
    bool  is_zero ();
};
```


The **set_to_zero** friend function can access private members of the Point class.

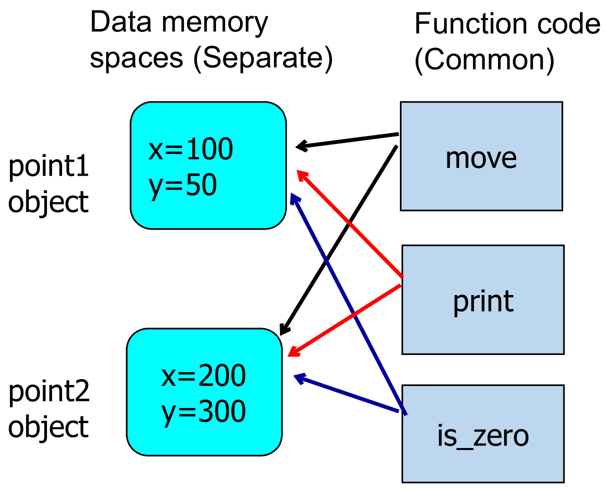
```
// Nonmember function
// (Not a member of any class)

void  set_to_zero (Point   &p)
{
   p . x  =  0;
   p . y  =  0;
}
```

The object p1 is passed to the **set_to_zero** friend function.

```
int main()
{
   Point   p1;
   set_to_zero (p1);
}
```

Data memory spaces and Function code

- Each object has its own distinct data space in memory.
- When an object is defined, memory is allocated only for its data members.
- Each object of the same class uses the same common function code.



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The this Pointer

- For every class definition, C++ compiler maintains a special built-in pointer, called the **this** pointer.

- When a member function is called, the **this** pointer contains the **self address** of the object.

- **Example:** point1 and point2 objects have different **this** pointers.
- The member functions of Point class can access data members using the **this** pointer.

In the examples below, usage of the **this** pointer is optional (not required).

```
void  Point :: move  (int  nx,   int  ny)
{
  // assigns new values to coordinates
   this -> x   =   nx;
   this -> y   =   ny;
}
```

```
void  Point :: print ()
{
   cout <<   this -> x
          <<   " "
          <<   this -> y
          <<   endl;
}
```

Example: Member data and Argument with same name

When arguments (parameters) of a function has the same names as the data members of class, the **this** pointer is required to be used in the function.

```
class Point {
    int x, y;          // private members

  public:              // public members
    bool move (int x, int y);
          .....
};
```

```
bool  Point  ::  move (int x, int y)  // parameters has the same name as
{                                      // data members x and y
        if  ( x > 0  &&   x < 500    &&     y > 0   &&   y < 300)  {
            this -> x    =    x;     // assigns given x value to member x
            this -> y    =    y;     // assigns given y value to member y
            return  true;            // input values are accepted
        }
        return  false;               // input values are not accepted
}
```


Example: Displaying memory address of objects with the this pointer and with & operator

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

class A
{
public:
  void  display () {
       cout << "This = " << this << endl;
  }
};


int main()
{
  A  a1;
  A  a2;
  a1 . display();
  a2 . display();

  cout << "Address of a1 = " << &a1 << endl;
  cout << "Address of a2 = " << &a2 << endl;
}
```

Screen Output

```
This = 0x6cfecf
This = 0x6cfece
Address of a1 = 0x6cfecf
Address of a2 = 0x6cfece
```

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Example : Function returning an object

- The ***find_furthest_point()*** member function below takes a Point object as argument.
- It compares hypothenus distance of itself and the distance of the argument object.
- Then it returns the address of the object, which has the furthest distance from the coordinate origin.

```
Point *   Point :: find_furthest_point (Point  &   p)
{
  int  distance1, distance2;  //Distance from point p to the origin (0,0)

  distance1   =   sqrt ( ( x * x) + (y * y) );           // Hypothenus formula
  distance2   =   sqrt ( ( p.x * p.x) + (p.y * p.y) );   // Hypothenus formula

  if  (distance1  >  distance2 )
     return  this;  // Object returns its own address.
  else
     return  &p;   // Else returns the address of the p object.
}
```

Main program

```
int main()
{
  Point  P1, P2;     // Two objects defined : P1 and P2

  //P1 has bigger hypothenus distance than P2
  P1 . move (100, 50);
  P2 . move (20, 90);

  Point *  a;         // a is a pointer
  a  =  P1 . find_furthest_point (P2);

  // Alternative command (same result)
  a  =  P2 . find_furthest_point (P1);

  // Point that has the largest distance is printed on screen.
  a -> print ();     //Displays the x and y coordinates of P1 object
}
```


Alternative solution: Calling a non-member function

```
class  Point
{
public:
   int x, y;  // Data members are public
   ......
};
```

```
// Non-member function
Point *   find_furthest_point  (Point &  p1,   Point &  p2)
{
   int  distance1   =   sqrt ( ( p1.x * p1.x)  +  (p1.y * p1.y) );
   int  distance2   =   sqrt ( ( p2.x * p2.x)  +  (p2.y * p2.y) );

   if  (distance1  >  distance2 )  return  &p1;
       else  return  &p2;
}
```

```
int main()
{
  Point  P1, P2;

  //P1 has bigger hypothenus distance than P2
  P1 . move (100, 50);
  P2 . move (20, 90);

  Point *  a;
  a   =   find_furthest_point ( P1, P2 );

  cout << "Furthest point is :   ";
  a -> print ();   //Displays the x and y coordinates of P1 object
}
```

Screen
Output

```
Furthest point is :    X= 100, Y= 50
```