



## Module 11

Instructors: Abir  
Das and  
Sourangshu  
Bhattacharya

Objectives &  
Outline

Classes

Objects

Data Members

Complex

Rectangle

Stack

Member Func.

Complex

Rectangle

Stack

this Pointer

State

Rectangle

Stack

Module Summary

# Module 11: Programming in C++

## Classes and Objects

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Slides taken from NPTEL course on Programming in Modern C++

by **Prof. Partha Pratim Das**



# Module Objectives

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Complex

Rectangle

Stack

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Rectangle

Stack

this Pointer

State

Rectangle

Stack

Module Summary

- Understand the concept of classes and objects in C++



# Module Outline

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Outline

Classes

Objects

Data Members

Complex

Rectangle

Stack

Member Func.

Complex

Rectangle

Stack

this Pointer

State

Rectangle

Stack

Module Summary

- 1 Classes
- 2 Objects
- 3 Data Members
  - Complex
  - Rectangle
  - Stack
- 4 Member Functions
  - Complex
  - Rectangle
  - Stack
- 5 this Pointer
- 6 State of an Object
  - Rectangle
  - Stack
- 7 Module Summary



# Classes

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Objectives &  
Outline

Classes

Objects

Data Members

Complex

Rectangle

Stack

Member Func.

Complex

Rectangle

Stack

this Pointer

State

Rectangle

Stack

Module Summary

- A class is an implementation of a **type**. It is the only way to implement **User-defined Data Type (UDT)**
- A class contains *data members / attributes*
- A class has *operations / member functions / methods*
- A class defines a **namespace**
- Thus, classes offer **data abstraction / encapsulation** of **Object Oriented Programming**
- Classes are similar to structures that aggregate data logically
- A class is defined by **class** keyword
- Classes provide *access specifiers* for members to enforce **data hiding** that separates **implementation** from **interface**
  - **private** — accessible inside the definition of the class
  - **public** — accessible everywhere
- A class is a **blue print** for its instances (objects)



# Objects

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Objectives &  
Outline

Classes

Objects

Data Members

Complex

Rectangle

Stack

Member Func.

Complex

Rectangle

Stack

this Pointer

State

Rectangle

Stack

Module Summary

- An *object* of a class is an *instance* created according to its **blue print**. Objects can be automatically, statically, or dynamically created
- A object comprises *data members* that specify its *state*
- A object supports *member functions* that specify its *behavior*
- Data members of an object can be accessed by "." (dot) operator on the object
- Member functions are invoked by "." (dot) operator on the object
- An implicit **this** pointer holds the address of an object. This serves the *identity* of the object in C++
- **this** pointer is implicitly passed to methods



# Program 11.01/02: Complex Numbers: Attributes

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Objectives & Outline

Classes

Objects

Data Members

Complex

Rectangle

Stack

Member Func.

Complex

Rectangle

Stack

this Pointer

State

Rectangle

Stack

Module Summary

## C Program

```
// File Name:Complex_object.c
#include <stdio.h>

typedef struct Complex { // struct
    double re, im;      // Data members
} Complex;
int main() {
    // Variable c declared, initialized
    Complex c = { 4.2, 5.3 };
    printf("%lf %lf", c.re, c.im); // Use by dot
}
-----
4.2 5.3
```

- **struct** is a keyword in C for *data aggregation*
- **struct Complex** is defined as *composite data type* containing two **double (re, im)** data members
- Data members are accessed using **'.'** operator
- **struct** *only aggregates*

## C++ Program

```
// File Name:Complex_object_c++.cpp
#include <iostream>
using namespace std;

class Complex { public: // class
    double re, im;      // Data members
};
int main() {
    // Object c declared, initialized
    Complex c = { 4.2, 5.3 };
    cout << c.re << " " << c.im; // Use by dot
}
-----
4.2 5.3
```

- **class** is a new keyword in C+ for *data aggregation*
- **class Complex** is defined as *composite data type* containing two **double (re, im)** data members
- Data members are accessed using **'.'** operator.
- **class aggregates** and *helps build a User-defined Data Type (UDT)*



# Program 11.03/04: Points and Rectangles: Attributes

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Outline

Classes

Objects

Data Members

Complex

Rectangle

Stack

Member Func.

Complex

Rectangle

Stack

this Pointer

State

Rectangle

Stack

Module Summary

## C Program

```
// File Name:Rectangle_object.c
#include <stdio.h>

typedef struct { // struct Point
    int x; int y;
} Point;
typedef struct { // Rect uses Point
    Point TL; // Top-Left. Member of UDT
    Point BR; // Bottom-Right. Member of UDT
} Rect;
int main() { Rect r = { { 0, 2 }, { 5, 7 } };
    // r.TL <-- { 0, 2 }; r.BR <-- { 5, 7 }
    // r.TL.x <-- 0; r.TL.y <-- 2
    // Members of Structure r accessed
    printf("[(%d %d) (%d %d)]",
        r.TL.x, r.TL.y, r.BR.x, r.BR.y);
}
-----
[(0 2) (5 7)]
```

## C++ Program

```
// File Name:Rectangle_object_c++.cpp
#include <iostream>
using namespace std;

class Point { public: // class Point
    int x; int y; // Data members
};
class Rect { public: // Rect uses Point
    Point TL; // Top-Left. Member of UDT
    Point BR; // Bottom-Right. Member of UDT
};
int main() { Rect r = { { 0, 2 }, { 5, 7 } };
    // r.TL <-- { 0, 2 }; r.BR <-- { 5, 7 }
    // r.TL.x <-- 0; r.TL.y <-- 2
    // Rectangle Object r accessed
    cout << "[" << r.TL.x << " " << r.TL.y <<
        "]" (" << r.BR.x << " " << r.BR.y << ")";
}
-----
[(0 2) (5 7)]
```

- Data members are of user-defined data types



# Program 11.05/06: Stacks: Attributes

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Outline

Classes

Objects

Data Members

Complex

Rectangle

Stack

Member Func.

Complex

Rectangle

Stack

this Pointer

State

Rectangle

Stack

Module Summary

### C Program

```
// File Name:Stack_object.c
#include <stdio.h>

typedef struct Stack { // struct Stack
    char data[100]; // Container for elements
    int top;        // Top of stack marker
} Stack;

// Codes for push(), pop(), top(), empty()

int main() {
    // Variable s declared
    Stack s;
    s.top = -1;

    // Using stack for solving problems
}
```

### C++ Program

```
// File Name:Stack_object_c++.cpp
#include <iostream>
using namespace std;

class Stack { public: // class Stack
    char data[100]; // Container for elements
    int top;        // Top of stack marker
};

// Codes for push(), pop(), top(), empty()

int main() {
    // Object s declared
    Stack s;
    s.top = -1;

    // Using stack for solving problems
}
```

- Data members of mixed data types





# Program 11.07/08: Complex Numbers: Member Functions

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Outline

Classes

Objects

Data Members

Complex

Rectangle

Stack

Member Func.

Complex

Rectangle

Stack

this Pointer

State

Rectangle

Stack

Module Summary

## C Program

```
// File Name:Complex_func.c
#include <stdio.h>
#include <math.h>

// Type as alias
typedef struct Complex { double re, im; } Complex;
// Norm of Complex Number - global fn.
double norm(Complex c) { // Parameter explicit
    return sqrt(c.re*c.re + c.im*c.im); }
// Print number with Norm - global fn.
void print(Complex c) { // Parameter explicit
    printf("|%lf+j%lf| = ", c.re, c.im);
    printf("%lf", norm(c)); // Call global
}

int main() { Complex c = { 4.2, 5.3 };
    print(c); // Call global fn. with c as param
}
-----
|4.200000+j5.300000| = 6.762396
```

- Access functions are *global*

## C++ Program

```
// File Name:Complex_func_c++.cpp
#include <iostream>
#include <cmath>
using namespace std;
// Type as UDT
class Complex { public: double re, im;
    // Norm of Complex Number - method
    double norm() { // Parameter implicit
        return sqrt(re*re + im*im); }
    // Print number with Norm - method
    void print() { // Parameter implicit
        cout << "|" << re << "+j" << im << "| = ";
        cout << norm(); // Call method
    }
}; // End of class Complex
int main() { Complex c = { 4.2, 5.3 };
    c.print(); // Invoke method print of c
}
-----
|4.2+j5.3| = 6.7624
```

- Access functions are *members*



# Program 11.09/10: Rectangles: Member Functions

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Objectives &  
Outline

Classes

Objects

Data Members

Complex

Rectangle

Stack

Member Func.

Complex

Rectangle

Stack

this Pointer

State

Rectangle

Stack

Module Summary

## Using struct

```
#include <iostream>
#include <cmath>
using namespace std;
typedef struct { int x; int y; } Point;
typedef struct {
    Point TL; // Top-Left
    Point BR; // Bottom-Right
} Rect;
// Global function
void computeArea(Rect r) { // Parameter explicit
    cout << abs(r.TL.x - r.BR.x) *
           abs(r.BR.y - r.TL.y);
}

int main() { Rect r = { { 0, 2 }, { 5, 7 } };

    computeArea(r); // Global fn. call
}
-----
25
```

- Access functions are *global*

## Using class

```
#include <iostream>
#include <cmath>
using namespace std;
class Point { public: int x; int y; };
class Rect { public:
    Point TL; // Top-Left
    Point BR; // Bottom-Right

    // Method
    void computeArea() { // Parameter implicit
        cout << abs(TL.x - BR.x) *
               abs(BR.y - TL.y);
    }
};

int main() { Rect r = { { 0, 2 }, { 5, 7 } };

    r.computeArea(); // Method invocation
}
-----
25
```

- Access functions are *members*



# Program 11.11/12: Stacks: Member Functions

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Objectives &  
Outline

Classes

Objects

Data Members

Complex

Rectangle

Stack

Member Func.

Complex

Rectangle

Stack

this Pointer

State

Rectangle

Stack

Module Summary

## Using struct

```
#include <iostream>
using namespace std;
typedef struct Stack { char data_[100]; int top_;
} Stack;
// Global functions
bool empty(const Stack& s) { return (s.top_ == -1); }
char top(const Stack& s) { return s.data_[s.top_]; }
void push(Stack& s, char x) { s.data_[++(s.top_)] = x; }
void pop(Stack& s) { --(s.top_); }

int main() { Stack s; s.top_ = -1;
char str[10] = "ABCDE"; int i;
for (i = 0; i < 5; ++i) push(s, str[i]);
cout << "Reversed String: ";
while (!empty(s)) {
    cout << top(s); pop(s);
}
}
-----
Reversed String: EDCBA
```

- Access functions are *global*

## Using class

```
#include <iostream>
using namespace std;
class Stack { public:
    char data_[100]; int top_;
    // Member functions
    bool empty() { return (top_ == -1); }
    char top() { return data_[top_]; }
    void push(char x) { data_[++top_] = x; }
    void pop() { --top_; }
};
int main() { Stack s; s.top_ = -1;
char str[10] = "ABCDE"; int i;
for (i = 0; i < 5; ++i) s.push(str[i]);
cout << "Reversed String: ";
while (!s.empty()) {
    cout << s.top(); s.pop();
}
}
-----
Reversed String: EDCBA
```

- Access functions are *members*



# Program 11.13: this Pointer

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Outline

Classes

Objects

Data Members

Complex

Rectangle

Stack

Member Func.

Complex

Rectangle

Stack

this Pointer

State

Rectangle

Stack

Module Summary

- An *implicit this* pointer holds the address of an object
- *this* pointer serves as the *identity* of the object in C++
- Type of *this* pointer for a *class X* object: *X \* const this*;
- *this* pointer is accessible *only in member functions*

```
#include <iostream>
using namespace std;
class X { public: int m1, m2;
    void f(int k1, int k2) {           // Sample member function
        m1 = k1;                       // Implicit access without this pointer
        this->m2 = k2;                 // Explicit access with this pointer
        cout << "Id   = " << this << endl; // Identity (address) of the object
    }
};
int main() { X a;
    a.f(2, 3);
    cout << "Addr = " << &a << endl;      // Address (identity) of the object
    cout << "a.m1 = " << a.m1 << "   a.m2 = " << a.m2 << endl;
    return 0;
}
-----
Id   = 0024F918
Addr = 0024F918
a.m1 = 2   a.m2 = 3
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```



# this Pointer

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Objectives & Outline

Classes

Objects

Data Members

Complex

Rectangle

Stack

Member Func.

Complex

Rectangle

Stack

this Pointer

State

Rectangle

Stack

Module Summary

- **this** pointer is implicitly passed to methods

In Source Code	In Binary Code
<ul style="list-style-type: none"> <li>• <code>class X { void f(int, int); ... }</code></li> <li>• <code>X a; a.f(2, 3);</code></li> </ul>	<ul style="list-style-type: none"> <li>• <code>void X::f(X * const this, int, int);</code></li> <li>• <code>X::f(&amp;a, 2, 3); // &amp;a = this</code></li> </ul>

- Use of **this** pointer

- Distinguish member from non-member

```
class X { public: int m1, m2;
        void f(int k1, int k2) {
            m1 = k1;          // this->m1 (member) is valid; this->k1 is invalid
            this->m2 = k2;    // m2 (member) is valid; this->k2 is invalid
        }
};
```

- Explicit Use

```
// Link the object
class DoublyLinkedListNode { public: DoublyLinkedListNode *prev, *next; int data;
                             void append(DoublyLinkedListNode *x) { next = x; x->prev = this; }
};
---
// Return the object
Complex& inc() { ++re; ++im; return *this; }
```



# State of an Object: Rectangle

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Objectives &  
Outline

Classes

Objects

Data Members

Complex

Rectangle

Stack

Member Func.

Complex

Rectangle

Stack

this Pointer

State

Rectangle

Stack

Module Summary

- The *state of an object* is determined by the *combined value of all its data members*

```
// Data members of Rect class: Point TL; Point BR; // Point class type object
// Data members of Point class: int x; int y;
```

```
Rectangle r = { { 0, 5 }, { 5, 0 } }; // Initialization
// STATE 1 of r = { { 0, 5 }, { 5, 0 } }
{ r.TL.x = 0; r.TL.y = 5; r.BR.x = 5; r.BR.y = 0 }
```

```
r.TL.y = 9;
// STATE 2 of r = { { 0, 9 }, { 5, 0 } }
```

```
r.computeArea();
// STATE 2 of r = { { 0, 9 }, { 5, 0 } } // No change in state
```

```
Point p = { 3, 4 };
r.BR = p;
// STATE 3 of r = { { 0, 9 }, { 3, 4 } }
```



# State of an Object: Stack

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Bhattacharya

Objectives &  
Outline

Classes

Objects

Data Members

Complex

Rectangle

Stack

Member Func.

Complex

Rectangle

Stack

this Pointer

State

Rectangle

Stack

Module Summary

```
// Data members of Stack class: char data[5] and int top;

Stack s;
// STATE 1 of s = {{?, ?, ?, ?, ?}, ?} // No data member is initialized

s.top_ = -1;
// STATE 2 of s = {{?, ?, ?, ?, ?}, -1}

s.push('b');
// STATE 3 of s = {{'b', ?, ?, ?, ?}, 0}

s.push('a');
// STATE 4 of s = {{'b', 'a', ?, ?, ?}, 1}

s.empty();
// STATE 4 of s = {{'b', 'a', ?, ?, ?}, 1} // No change of state

s.push('t');
// STATE 5 of s = {{'b', 'a', 't', ?, ?}, 2}

s.top();
// STATE 5 of s = {{'b', 'a', 't', ?, ?}, 2} // No change of state

s.pop();
// STATE 6 of s = {{'b', 'a', 't', ?, ?}, 1}
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```



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Objects

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Complex

Rectangle

Stack

Member Func.

Complex

Rectangle

Stack

this Pointer

State

Rectangle

Stack

Module Summary

- **Class**

```
class Complex { public:
    double re_, im_;

    double norm() { // Norm of Complex Number
        return sqrt(re_ * re_ + im_ * im_);
    }
};
```

- **Attributes**

Complex::re\_, Complex::im\_

- **Member Functions**

double Complex::norm();

- **Object**

Complex c = {2.6, 3.9};

- **Access**

```
c.re_ = 4.6;
cout << c.im_;
cout << c.norm();
```

- **this Pointer**

```
double Complex::norm() { cout << this; return ... }
```

- **State of Object**

```
Rectangle r = { { 0, 5 }, { 5, 0 } }; // STATE 1 r = { { 0, 5 }, { 5, 0 } }
r.TL.y = 9; // STATE 2 r = { { 0, 9 }, { 5, 0 } }
r.computeArea(); // STATE 2 r = { { 0, 9 }, { 5, 0 } }
Point p = { 3, 4 }; r.BR = p; // STATE 3 r = { { 0, 9 }, { 3, 4 } }
```