

# CSC 211: Computer Programming

## Class Inheritance, Polymorphis

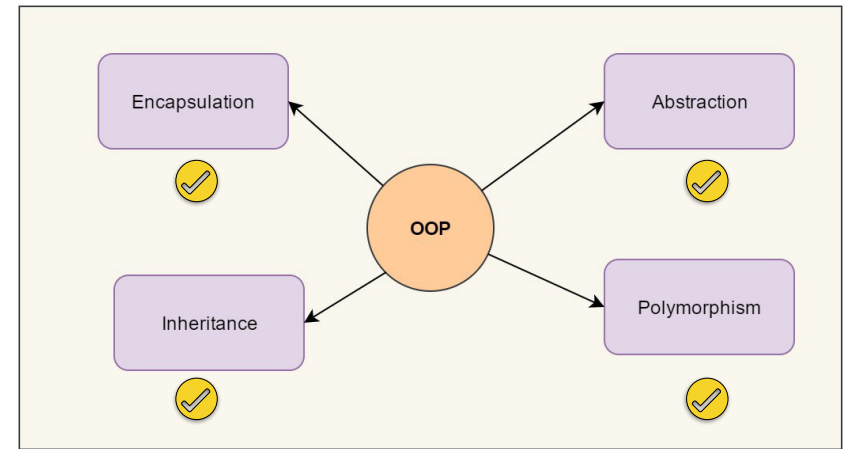
Michael Conti

Department of Computer Science and Statistics  
University of Rhode Island

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Original design and development by Dr. Marco Alvarez



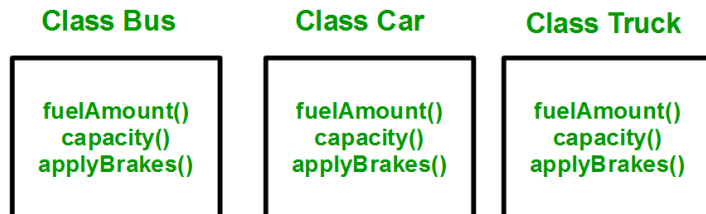
Four Pillars of Object Oriented Programming

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## Inheritance in C++

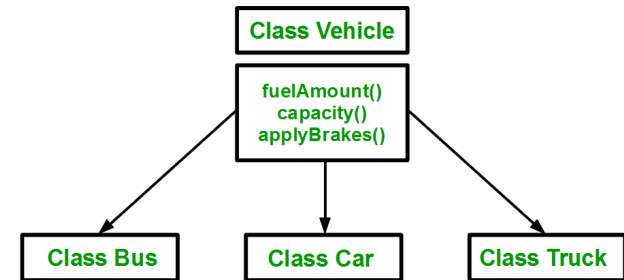
- The capability of a class to derive properties and characteristics from another class is called **Inheritance**. Inheritance is one of the most important feature of Object Oriented Programming.
- **Derived Class:** The class that inherits properties from another class is called Sub class / Derived Class / Child Class.
- **Base Class:** The class whose properties are inherited by sub class is called Base Class / Super class / Parent Class.
- Derived class is a *superset* of the base class.

Why and When  
to use Inheritance?



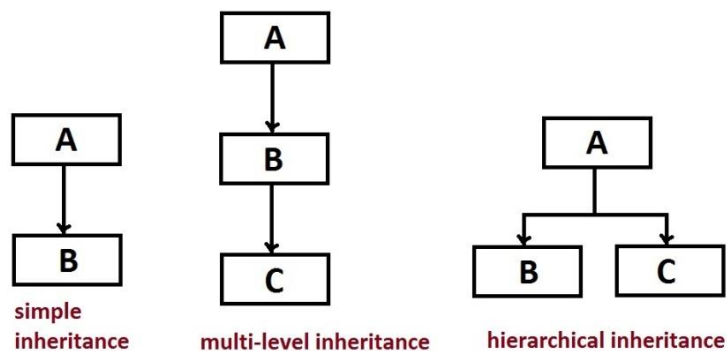
**Note:** duplication of same code 3 times

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**Note:** by using inheritance, we can avoid the duplication of data and increase re-usability of code

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# Implementing Inheritance

# Syntax

```
class subclass_name : access_mode base_class_name
{
    //body of subclass
};
```

<https://www.geeksforgeeks.org/inheritance-in-c/>

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## Modes of inheritance

## Modes of inheritance

- **Public mode:** If we derive a sub class from a public base class then the **public member of the base class** will become **public in the derived class** and **protected members of the base class** will become **protected in derived class**.
- **Protected mode:** If we derive a sub class from a Protected base class then **both public member and protected members of the base class** will become **protected in derived class**.
- **Private mode:** If we derive a sub class from a Private base class then **both public member and protected members of the base class** will become **Private in derived class**.

<https://www.geeksforgeeks.org/inheritance-in-c/>

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Base class member access specifier	Type of Inheritance		
	Public	Protected	Private
Public	Public	Protected	Private
Protected	Protected	Protected	Private
Private	Not accessible (Hidden)	Not accessible (Hidden)	Not accessible (Hidden)

<https://www.geeksforgeeks.org/inheritance-in-c/>

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# Example

```
// C++ Implementation to show that a derived class
// doesn't inherit access to private data members.
// However, it does inherit a full parent object
class A {
public:
    int x;
protected:
    int y;
private:
    int z;
};

class B : public A {
    // x is public
    // y is protected
    // z is not accessible from B
};

class C : protected A {
    // x is protected
    // y is protected
    // z is not accessible from C
};

class D : private A {    // 'private' is default for classes
    // x is private
    // y is private
    // z is not accessible from D
};
```

<https://www.geeksforgeeks.org/inheritance-in-c/>

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# Order of Constructor Call with Inheritance

## Order of Constructor Call

- Base class constructors are **always called** in the derived class constructors.
- Whenever you create a derived class object, **first** the base class default constructor is executed and **then** the derived class's constructor finishes execution.

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## Order of Constructor Call

```
class Base
{
public:
    int x;
    // default constructor
    Base()
    {
        std::cout << "Base default constructor\n";
    }
};

class Derived : public Base
{
public:
    int y;
    // default constructor
    Derived()
    {
        std::cout << "Derived default constructor\n";
    }
    // parameterized constructor
    Derived(int i)
    {
        std::cout << "Derived parameterized constructor\n";
    }
};
```

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# Order of Constructor Call

```
int main()
{
    Base b;
    Derived d1;
    Derived d2(10);
}
```

## OUTPUT

Base default constructor  
Base default constructor  
Derived default constructor  
Base default constructor  
Derived parameterized constructor

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# Inheritance Example

## Example

```
class Entity{
public:
    float x, y;

    void move(float xa, float ya){
        x += xa;
        y += ya;
    }

    void printLoc(){
        std::cout << "x = " << x << std::endl;
        std::cout << "y = " << y << std::endl;
    }
};
```

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## Example

```
class Player{
public:
    const char* name;
    float x, y;

    void move(float xa, float ya){
        x += xa;
        y += ya;
    }

    void printLoc(){
        std::cout << "x = " << x << std::endl;
        std::cout << "y = " << y << std::endl;
    }

    void printName(){
        std::cout << name << std::endl;
    }
};
```

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## Example

```
class Player : public Entity{  
    public:  
        const char* name;  
  
    void printName(){  
        std::cout << name << std::endl;  
    }  
};
```

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# Polymorphism

## Polymorphism

- Polymorphism in C++ means, the same entity (function or object) behaves differently in different scenarios.
- Consider this example:
- The “ + ” operator in c++ can perform two specific functions at two different scenarios

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## Example

```
int a = 6;  
int b = 6;  
int sum = a + b; // sum =12
```

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```
string firstName = "John";  
string lastName = "Doe";  
  
// name = "John Doe "  
string name = firstName + lastName;
```

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## Types of Polymorphism in C++

- Polymorphism in C++ is categorized into two types
- **Compile Time Polymorphism**
  - ✓ Function overloading
  - ✓ Operator overloading
- **Runtime (Dynamic) Polymorphism**
  - ✓ Function overriding
  - ✓ Virtual functions

## Compile Time Polymorphism

- Function overloading
  - ✓ One function can perform many tasks.
  - ✓ A single function is used to perform many tasks with the **same name** and **different types of arguments**.
  - ✓ Correct overloaded function will be called at compile time based on argument type

## Function overloading

```
class Addition {
public:
    int ADD(int X,int Y)    // Function with parameter
    {
        return X+Y;    // this function is performing addition of two int values
    }

    int ADD() {            // Function with same name but without parameter
        string a= "HELLO";
        string b="SAM";    // in this function concatenation is performed
        string c= a+b;
        cout<<c<<endl;
    }
};

int main() {
    Addition obj;    // Object is created
    cout<<obj.ADD(128, 15)<<endl; //first method is called
    obj.ADD();    // second method is called
    return 0;
}
```

## Compile Time Polymorphism

- **Operator Overloading**
  - ✓ Defining additional semantic behavior to operators
  - ✓ The purpose of operator overloading is to provide a special meaning to the user-defined data types.
  - ✓ The advantage of operator overloading is to perform different operations on the same operand.

# Function overloading

The parameter 'A a' represents the second operand in the addition (the right-hand side of the + operator).

```
#include <iostream>
using namespace std;
class A
{
public:
    string x;

    A(){}
    A(string i)
    {
        x=i;
    }
    void operator+(A);
    void display();
};

void A::operator+(A a)
{
    string m = x+a.x;
    cout<<"The result of the addition
        of two objects is : "<<m;
}

int main()
{
    A a1("Welcome");
    A a2("back");
    a1+a2;
    return 0;
}
```

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# Run Time (Dynamic) Polymorphism

## Run Time (Dynamic) Polymorphism

### Function overriding

- ✓ Give the new definition to base class function in the derived class. It can be only possible to override a function from the 'derived class'.
- ✓ Have two definitions of the same function, one in the superclass and one in the derived class. The decision about which function definition requires calling happens at runtime.
- ✓ That is the reason we call it 'Runtime polymorphism'.

<https://www.mygreatlearning.com/blog/polymorphism-in-cpp/>

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# Function overriding

```
class Animal {
public:
    void function()
    {cout<<"Eating..."<<endl;}
};

class Man: public Animal
{
public:
    void function() override //override keyword optional
    { cout<<"Walking ..."<<endl; }
};

int main() {
    Animal A;
    A.function();//parent class object

    Man m;
    m.function();// child class object

    return 0;
}
```

```
PROBLEMS  OUTPUT  DEBUG CONSOLE  TERMINAL
● michaelconti@Michaels-MacBook-Pro-2 Desktop % ./temp
Eating...
Walking ...
○ michaelconti@Michaels-MacBook-Pro-2 Desktop %
```

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# Run Time Polymorphism

## Virtual Functions

- ✓ Virtual functions ensure that the correct function is called for an object, **regardless of the type of reference (or pointer) used for function call**.
- ✓ The actual function that gets executed is based on the object the pointer or reference points to.
- ✓ Functions are declared with a virtual keyword in base class.
- ✓ The resolving of function call is done at runtime.

<https://www.mygreatlearning.com/blog/polymorphism-in-cpp/>

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# Virtual Functions

```
class base {
public:
    virtual void print()
    {
        cout << "print base class\n";
    }

    void show()
    {
        cout << "show base class\n";
    }
};

class derived : public base {
public:
    void print()
    {
        cout << "print derived class\n";
    }

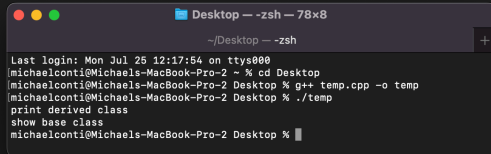
    void show()
    {
        cout << "show derived class\n";
    }
};

int main()
{
    base *basePtr;
    derived d;
    basePtr = &d;

    // Virtual function bypassed, binded at runtime
    // Object pointed to is of type 'derived'
    basePtr->print();

    // Non-virtual function, binded at compile time
    // Pointer is of type 'base'
    basePtr->show();

    return 0;
}
```



```
Desktop --zsh -- 78x8
~/Desktop --zsh
Last login: Mon Jul 25 12:17:54 on ttys000
michaelconti@Michaels-MacBook-Pro-2 ~ % cd Desktop
michaelconti@Michaels-MacBook-Pro-2 Desktop % g++ temp.cpp -o temp
michaelconti@Michaels-MacBook-Pro-2 Desktop % ./temp
print derived class
show base class
michaelconti@Michaels-MacBook-Pro-2 Desktop %
```

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## Practice

- Write a base Person class with following properties and methods
- Person (base):  
Member Variables: name, age, favorite color, birthday
- **Derive a Student from person and an Employee class**  
**derives student** with the respective additional attributes
- Student: GPA, Major, Year, StudentID  
Employee: Job Title, Salary, Years Employed
- Print for employee class

<https://www.geeksforgeeks.org/inheritance-in-c/>

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