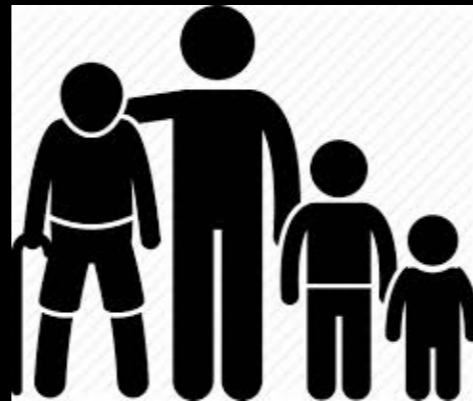


Inheritance



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Announcements

- No IDE integration in GitHub: must have **local environment** — code, debug and test locally
- Check that you are connected to the wifi and login to Gradescope so you will be ready when we take attendance.

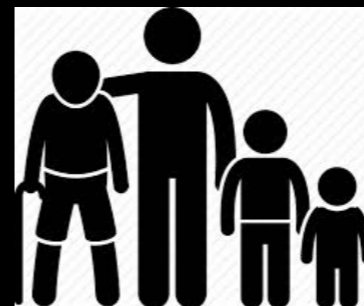
Today's Plan



Recap

Useful C++ / OOP

Inheritance



Recap

OOP

Abstraction

Encapsulation

Information Hiding

Classes

Public Interface

Private Implementation

Constructors / Destructors

Interface

SomeClass.hpp
(same as **SomeClass.h**)

Include Guards:

Implementation

Tells linker "include only if it has not been included already by some other module"

```
#ifndef SOME_CLASS_H
#define SOME_CLASS_H

#include <somelibrary>
#include "AnotherClass.h"

class SomeClass
{
public:
    SomeClass(); //Constructor
    int methodOne();
    bool methodTwo();
    bool methodThree(int
                       someParameter);

private:
    int data_member_one_;
    bool data_member_two_;
}; //end SomeClass

#endif
```

```
#include "SomeClass.hpp"

SomeClass::SomeClass()
{
    //implementation here
}

int SomeClass::methodOne()
{
    //implementation here
}

bool SomeClass::methodTwo()
{
    //implementation here
}

bool SomeClass::methodThree(int
someParameter)
{
    //implementation here
}
```

Interface as Operation Contract

Documents use and limitations of a class and its methods

Function Prototype and Comments **MUST** specify:

- Data flow
 - Input => parameters
 - Output => return
- Pre and Post Conditions

Operation Contract

```
/** sorts an array into ascending order
// @pre 1 <= number_of_elements <= MAX_ARRAY_SIZE
// @post an_array[0] <= an_array[1] <= ...
//      <= an_array[number_of_elements-1];
//      number_of_elements is unchanged
// @param an_array of values to be sorted
// @param number_of_elements contained in an_array
// @return true if an_array is sorted, false otherwise
*/
bool sort(const int& an_array[], int number_of_elements);
```

Function prototype

Naming Conventions

<https://google.github.io/styleguide/cppguide.html>

<http://isocpp.github.io/CppCoreGuidelines/CppCoreGuidelines#R1-comments>

```
string my_variable;
```

or

```
string myVariable;
```

Classes ALWAYS

start with capital

```
MyClass
```

In this course I will strive for:

```
class MyClass
```

```
MyClass class_instance;
```

```
string my_variable;
```

```
string my_member_variable_;
```

```
void myMethod();
```

```
int MY_CONSTANT;
```

Be consistent!!!

Some (Perhaps Review) Useful Concepts

Default Arguments

```
void point(int x = 3, int y = 4);  
  
point(1,2); // calls point(1,2)  
point(1);   // calls point(1,4)  
point();    // calls point(3,4)
```

Order Matters!
Parameters without default arguments must go first.

Default Arguments

```
void point(int x = 3, int y = 4);  
  
point(1,2); // calls point(1,2)  
point(1);   // calls point(1,4)  
point();    // calls point(3,4)
```

Order Matters!
Parameters without default arguments must go first.

Similarly:

```
Person(int id, string first = "", string last = "");  
  
Person(143); // calls Person(143,"", "")  
Person(143, "Gina"); // calls Person("143","Gina", "")  
Person(423, "Nina", "Moreno"); // calls Person(423,"Nina","Moreno")
```

Default Arguments

```
void point(int x = 3, int y = 4);  
  
point(1,2); // calls point(1,2)  
point(1);   // calls point(1,4)  
point();    // calls point(3,4)
```

Order Matters!
Parameters without default arguments must go first.

```
Animal(std::string name = "", bool domestic = false, bool predator = false);
```

IS DIFFERENT FROM

```
Animal(std::string name, bool domestic = false, bool predator = false);
```

Overloading Functions

Same name, different parameter list (different function prototype)

```
int someFunction()  
{  
  
//implementation here  
  
} // end someFunction
```

```
int someFunction(string  
some_parameter )  
{  
    //implementation here  
  
} // end someFunction
```

Overloading Functions

Same name, different parameter list (different function prototype)

```
int someFunction()  
{  
    //implementation here  
}  
// end someFunction
```

```
int someFunction(string  
some_parameter )  
{  
    //implementation here  
}  
// end someFunction
```

```
int main()  
{  
    int x = someFunction();  
    int y = someFunction(my_string);  
    //more code here  
}  
// end main
```

Friend Functions

Functions that are **not members** of the class but **CAN access private members** of the class

Friend Functions

Functions that are **not members** of the class but **CAN** access **private members** of the class

Violates Information Hiding!!!

Yes, so don't do it unless appropriate and controlled



Friend Functions

DECLARATION:

```
class SomeClass
{
    public:
        // public member functions go here
        friend returnType someFriendFunction( parameter list);
    private:
        int some_data_member_;
}; // end SomeClass
```

IMPLEMENTATION (SomeClass.cpp):

Not a member function

```
returnType someFriendFunction( parameter list)
{
    // implementation here
    some_data_member_ = 35; //has access to private data
}
```

Operator Overloading

Desirable operator (=, +, -, == ...) behavior may not be well defined on objects


```
class SomeClass
{
    public:
        // public data members and member functions go here
        friend bool operator==(const SomeClass& object1,
                               const SomeClass& object2);

    private:
        // private members go here
}; // end SomeClass
```

Operator Overloading

IMPLEMENTATION (SomeClass.cpp):

Not a member function



```
bool operator==(const SomeClass& object1,  
               const SomeClass& object2)  
{  
    return ( (object1.memberA_ == object2.memberA_) &&  
            (object1.memberB_ == object2.memberB_) && ... );  
}
```

Enum

A user defined datatype that consist of integral constants

Why? Readability

```
enum season {SPRING, SUMMER, AUTUMN, WINTER };
```

```
enum animal_type {MAMMAL, FISH, BIRD};
```

Enum

A user defined datatype that consist of integral constants

Type name (like `int`)

Possible values:
like 0,1, 2, ...

Why? Readability

```
enum season {SPRING, SUMMER, AUTUMN, WINTER};
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enum animal_type {MAMMAL, FISH, BIRD};
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Enum

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Why? Readability

```
enum season {SPRING, SUMMER, AUTUMN, WINTER };
```

```
enum animal_type {MAMMAL, FISH, BIRD};
```

By default = 0, 1, 2, ...

To change default:

```
enum ta_role {MAMMAL = 5, FISH = 10, BIRD = 20};
```

Inheritance



From General to Specific

What if we could *inherit* functionality from one class to another?

We can!!!

Inherit **public** members of another class

Basic Inheritance

```
class Printer
{
public:
    //Constructor, destructor

    void setPaperSize(const int size);
    void setOrientation(const string& orientation);
    void printDocument(const string& document);
private:
    // stuff here
}; //end Printer
```

Basic Inheritance

```
class Printer
{
public:
    //Constructor, destructor

    void setPaperSize(const int size);
    void setOrientation(const string& orientation);
    void printDocument(const string& document);
private:
    // stuff here
}; //end Printer
```

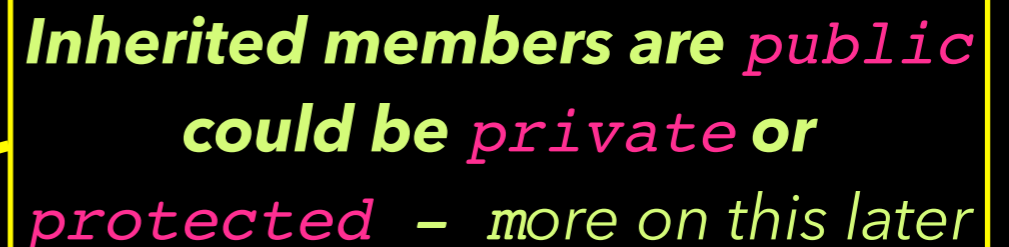
```
class BatchPrinter
{
public:
    //Constructor, destructor
    void addDocument(const string& document);
    void printAllDocuments();
private:
    vector<string> documents;
}; //end BatchPrinter
```

Basic Inheritance

```
class Printer
{
public:
    //Constructor, destructor

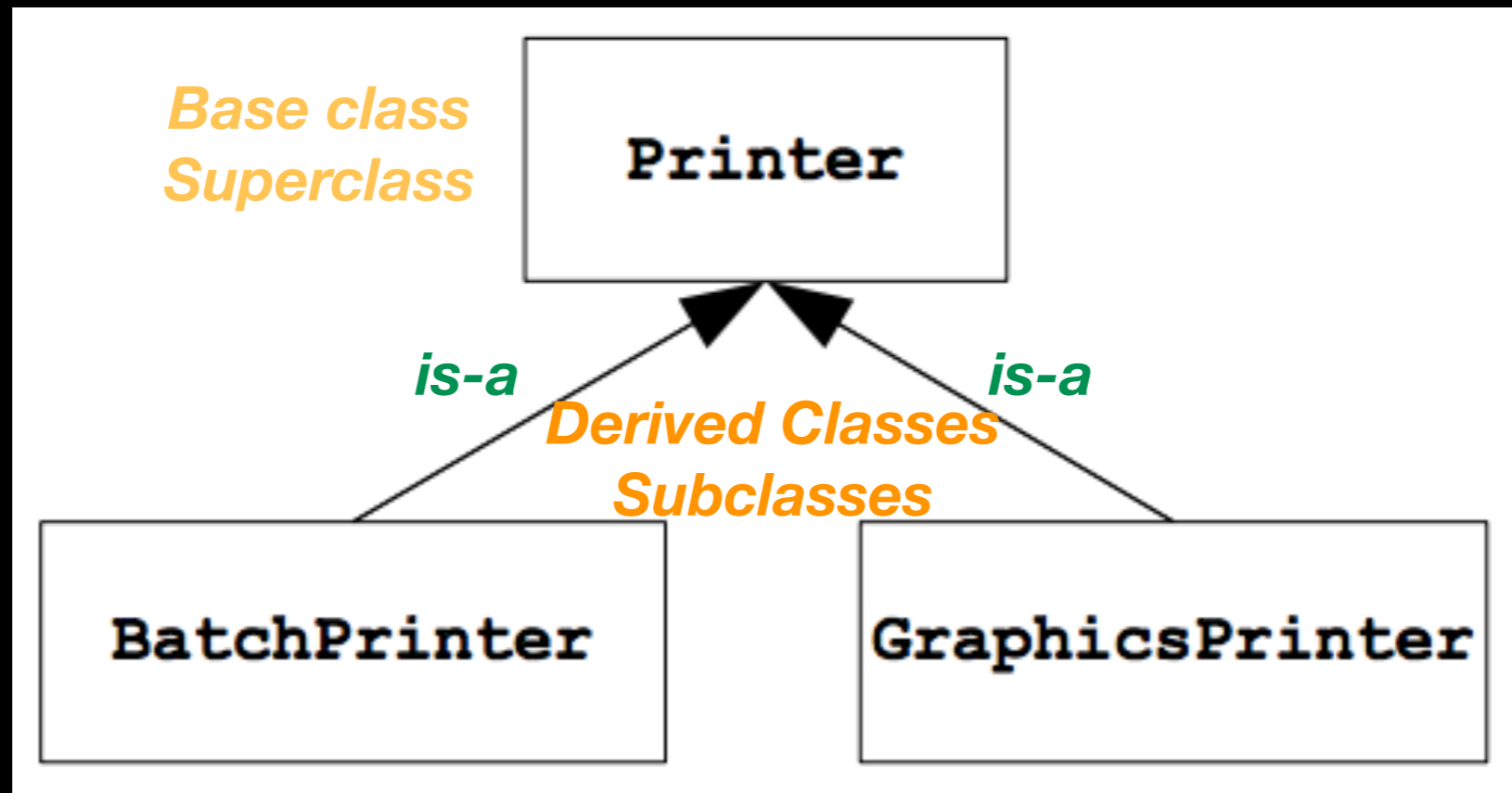
    void setPaperSize(const int size);
    void setOrientation(const string& orientation);
    void printDocument(const string& document);
private:
    // stuff here
}; //end Printer
```

Inherited members are *public* could be *private* or *protected* - more on this later



```
class BatchPrinter: public Printer // inherit from printer
{
public:
    //Constructor, destructor
    void addDocument(const string& document);
    void printAllDocuments();
private:
    vector<string> documents;
}; //end BatchPrinter
```

Basic Inheritance



```
void initializePrinter(Printer& p)
{
    //some initialization function
}
```

```
BatchPrinter batch;
initializePrinter(batch); //legal because batch is-a printer
```

Think of argument types as specifying **minimum requirements**

More subclasses

Can you think up more Printer subclasses

Can you think of multiple levels of inheritance
(specialization of a specialization)

Overloading vs Overriding

Overloading (independent of inheritance): Define new function with same name but different parameter list (different signature or prototype)

```
int someFunction(){ }  
int someFunction(string some_string){ }
```

Overriding: Rewrite function with *same signature* in derived class

```
int BaseClass::someMethod(){ }  
int DerivedClass::someMethod(){ }
```

```
class Printer
{
public:
    //Constructor, destructor

    void setPaperSize(const int size);
    void setOrientation(const string& orientation);
    void printDocument(const string& document);
private:
    // stuff here
}; //end Printer
```

```
class GraphicsPrinter: public Printer    // inherit from printer
{
public:
    //Constructor, destructor
    void setPaperSize(const int size);
    void printDocument(const Picture& picture); //some Picture object
private:
    //stuff here
}; //end GraphicsPrinter
```

Overrides setPaperSize()

Overloads printDocument()

main()

```
Printer base_printer;  
GraphicsPrinter graphics_printer  
Picture picture;  
// initialize picture here  
string document;  
// initialize document here
```

```
base_printer.setPaperSize(11); //calls Printer function
```

Printer

setPaperSize(int)
setOrientation(string)
printDocument(string)

GraphicsPrinter

setPaperSize(int)
printDocument(Picture)

main()

```
Printer base_printer;  
GraphicsPrinter graphics_printer  
Picture picture;  
// initialize picture here  
string document;  
// initialize document here
```

```
base_printer.setPaperSize(11); //calls Printer function  
graphics_printer.setPaperSize(60); // Overriding!!!
```

Printer

```
setPaperSize(int)  
setOrientation(string)  
printDocument(string)
```

GraphicsPrinter

```
setPaperSize(int)  
printDocument(Picture)
```

main()

```
Printer base_printer;  
GraphicsPrinter graphics_printer;  
Picture picture;  
// initialize picture here  
string document;  
// initialize document here
```

```
base_printer.setPaperSize(11); //calls Printer function  
graphics_printer.setPaperSize(60); // Overriding!!!  
graphics_printer.setOrientation("landscape"); //inherited
```

Printer

```
setPaperSize(int)  
setOrientation(string)  
printDocument(string)
```

GraphicsPrinter

```
setPaperSize(int)  
printDocument(Picture)
```

main()

```
Printer base_printer;
GraphicsPrinter graphics_printer;
Picture picture;
// initialize picture here
string document;
// initialize document here

base_printer.setPaperSize(11); //calls Printer function
graphics_printer.setPaperSize(60); // Overriding!!!
graphics_printer.setOrientation("landscape"); //inherited

graphics_printer.printDocument(string); //calls Printer inherited function
```

Printer

setPaperSize(int)
setOrientation(string)
printDocument(string)

GraphicsPrinter

setPaperSize(int)
printDocument(Picture)

main()

```
Printer base_printer;
GraphicsPrinter graphics_printer;
Picture picture;
// initialize picture here
string document;
// initialize document here

base_printer.setPaperSize(11); //calls Printer function
graphics_printer.setPaperSize(60); // Overriding!!!
graphics_printer.setOrientation("landscape"); //inherited

graphics_printer.printDocument(string); //calls Printer inherited function
graphics_printer.printDocument(picture); // Overloading!!!
```

Printer

setPaperSize(int)
setOrientation(string)
printDocument(string)

GraphicsPrinter

setPaperSize(int)
printDocument(Picture)

protected access specifier

```
class SomeClass
{
    public:
        // public members available to everyone

    protected:
        // protected members available to class members
        // and derived classes

    private:
        // private members available to class members ONLY
}; // end SomeClass
```

Important Points about Inheritance

Derived class inherits all public and protected members of base class

Does not have access to base class private members

Does not inherit constructor and destructor

Does not inherit assignment operator

Does not inherit friend functions and friend classes

Constructors

A class needs user-defined constructor if must initialize data members

Base-class constructor **always** called before derived-class constructor

If base class has only parameterized constructor, derived class **must supply constructor** that calls base-class constructor explicitly

Constructors

INTERFACE

```
class BaseClass
{
public:
    //stuff here

private:
    //stuff here
}; //end BaseClass
```

```
class DerivedClass: public BaseClass
{
public:
    DerivedClass();
    //stuff here

private:
    //stuff here
}; //end DerivedClass
```

IMPLEMENTATION

```
DerivedClass::DerivedClass()
{
    //implementation here
}
```

main()

```
DerivedClass my_derived_class;
//BaseClass compiler-supplied default constructor called
//then DerivedClass constructor called
```


Constructors

INTERFACE

```
class BaseClass
{
public:
    BaseClass();
    //may also have other
    //constructors
private:
    //stuff here
}; //end BaseClass
```

```
class DerivedClass: public BaseClass
{
public:
    DerivedClass();
    //stuff here
private:
    //stuff here
}; //end DerivedClass
```

IMPLEMENTATION

```
BaseClass::BaseClass()
{
    //implementation here
}
```

```
DerivedClass::DerivedClass()
{
    //implementation here
}
```

main()

```
DerivedClass my_derived_class;
//BaseClass default constructor called
//then DerivedClass constructor called
```

Constructors

INTERFACE

```
class BaseClass
{
public:
    BaseClass(int value);
    //stuff here

private:
    int base_member_;
}; //end BaseClass
```

```
class DerivedClass: public BaseClass
{
public:
    DerivedClass();
    //stuff here

private:
    //stuff here
}; //end DerivedClass
```

IMPLEMENTATION

```
BaseClass::
BaseClass(int value):
base_member_(value)
{
    //implementation here
}
main()
```

```
DerivedClass::DerivedClass()
{
    //implementation here
}
```

DerivedClass my_derived_class; ←

//PROBLEM!!! there is no default constructor to be called
//for BaseClass

Constructors

INTERFACE

```
class BaseClass
{
public:
    BaseClass(int value);
    //stuff here

private:
    int base_member_;
}; //end BaseClass
```

```
class DerivedClass: public BaseClass
{
public:
    DerivedClass();
    //stuff here

private:
    static const int INITIAL_VAL = 0;
}; //end DerivedClass
```

IMPLEMENTATION

```
BaseClass::
BaseClass(int value):
base_member_(value)
{
    //implementation here
}
```

```
DerivedClass::DerivedClass():
BaseClass(INITIAL_VAL)
{
    //implementation here
}
```



Fix

```
main()
```

```
DerivedClass my_derived_class;
// BaseClass constructor explicitly called by DerivedClass
//constructor
```

Destructors

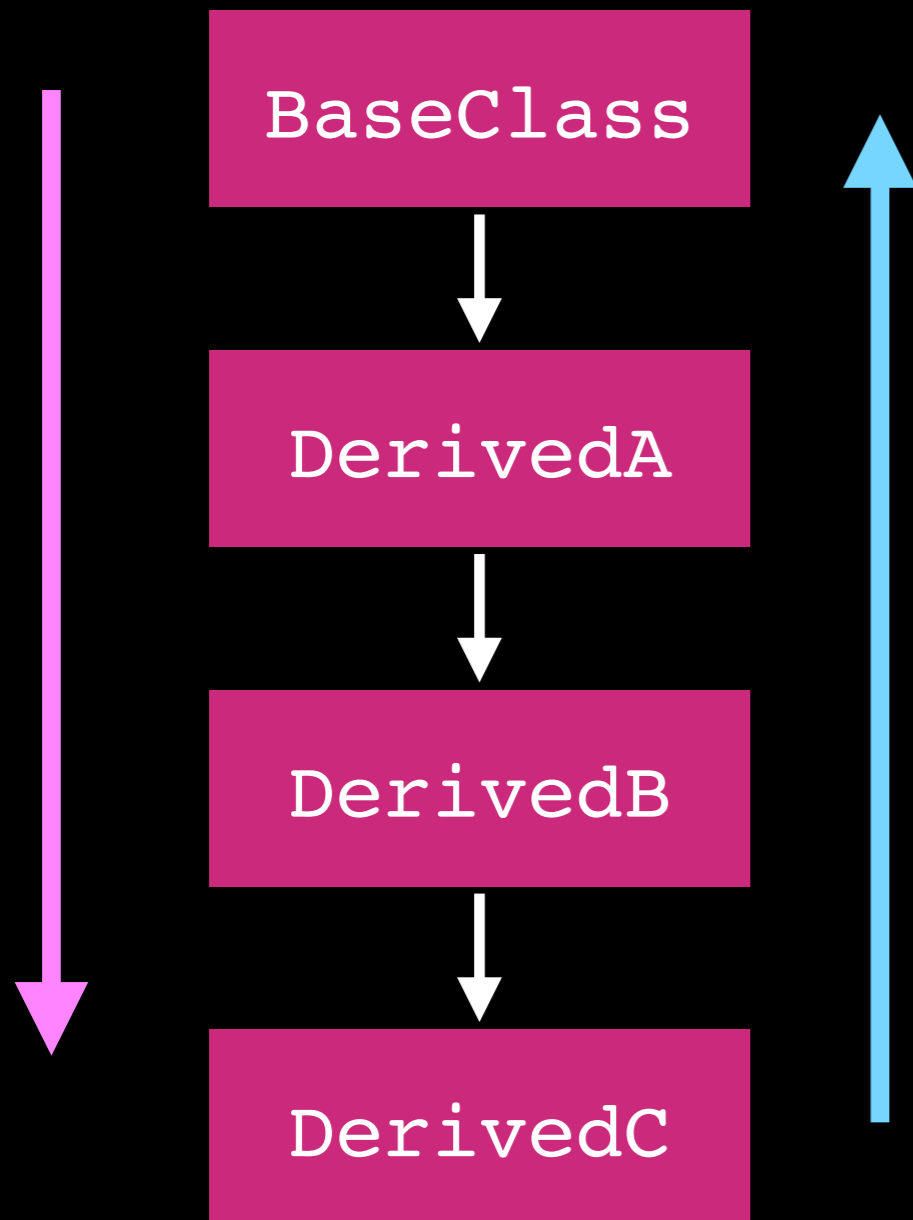
Destructor invoked if:

- program execution left scope containing object definition
- `delete` operator was called on object that was created dynamically

Destructors

Derived class destructor **always causes base class** destructor to be called implicitly

Derived class destructor is called **before base class** destructor



Order of calls to **constructors when instantiating a **DerivedC** object:**

```
BaseClass()  
DerivedA()  
DerivedB()  
DerivedC()
```

Order of calls to **destructors when instantiating a **DerivedC** object:**

```
~DerivedC()  
~DerivedB()  
~DerivedA()  
~BaseClass()
```

Basic Inheritance

No runtime cost

In memory `DerivedClass` is simply `BaseClass` with extra members tacked on the end

Basically saving to re-write `BaseClass` code

Address	1000	baseX	<- BaseClass members
	1004	baseY	
	1008	derX	<- DerivedClass -specific members
	1012	derY	

Project 2

Post subclasses (General, Promotional, Poll)

Derived class default constructor will **IMPLICITLY** call
Base class constructor

Derived class parameterized constructor **MUST**
EXPLICITLY call Base class constructor

Questions?

Recap



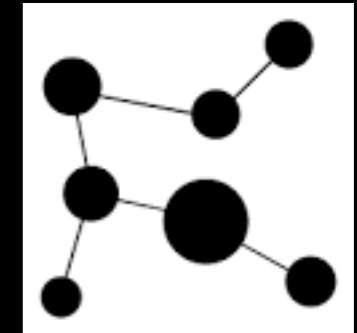
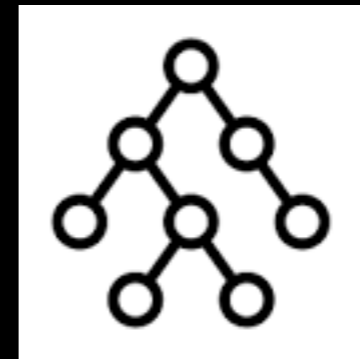
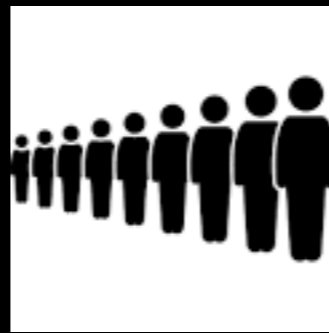
Recap

Useful C++ / OOP

Inheritance

Next Time

Abstract Data Types



Templates

