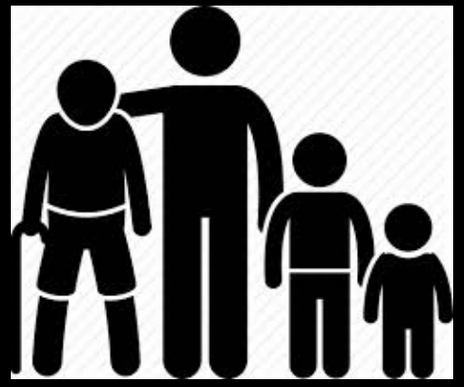
Inheritance



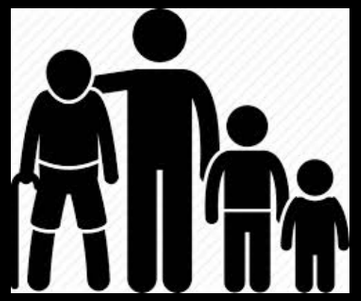
Tiziana Ligorio
Hunter College of The City University of New York

Today's Plan

Recap

Useful C++ / OOP

Inheritance



Recap

OOP

- Abstraction
- Encapsulation
- Information Hiding

Classes

- Public Interface
- Private Implementation
- Constructors / Destructors

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

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```
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)
```

Similarly:

```
Person(int id, string first = "", string last = "");

Person p1(143); // calls Person(143,"", "")
Person p2(143, "Gina");   // calls Person("143","Gina", "")
Person p3(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

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

enum animal_type {MAMMAL, FISH, BIRD};
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Enum

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Type name (like `int`)

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Why? Readability

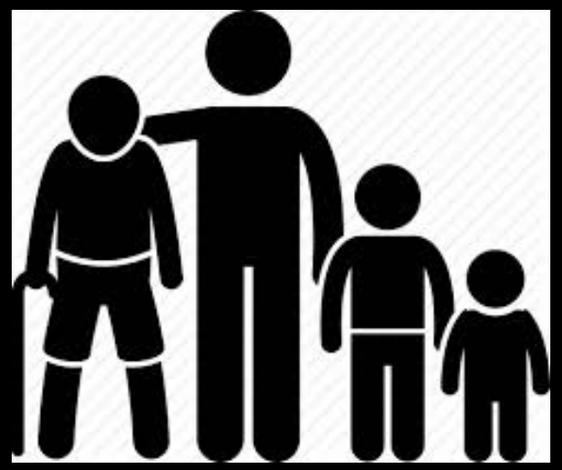
```
enum season {SPRING, SUMMER, AUTUMN, WINTER };

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

By default = 0, 1, 2, …

To change default:

```
enum animal_type {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
```

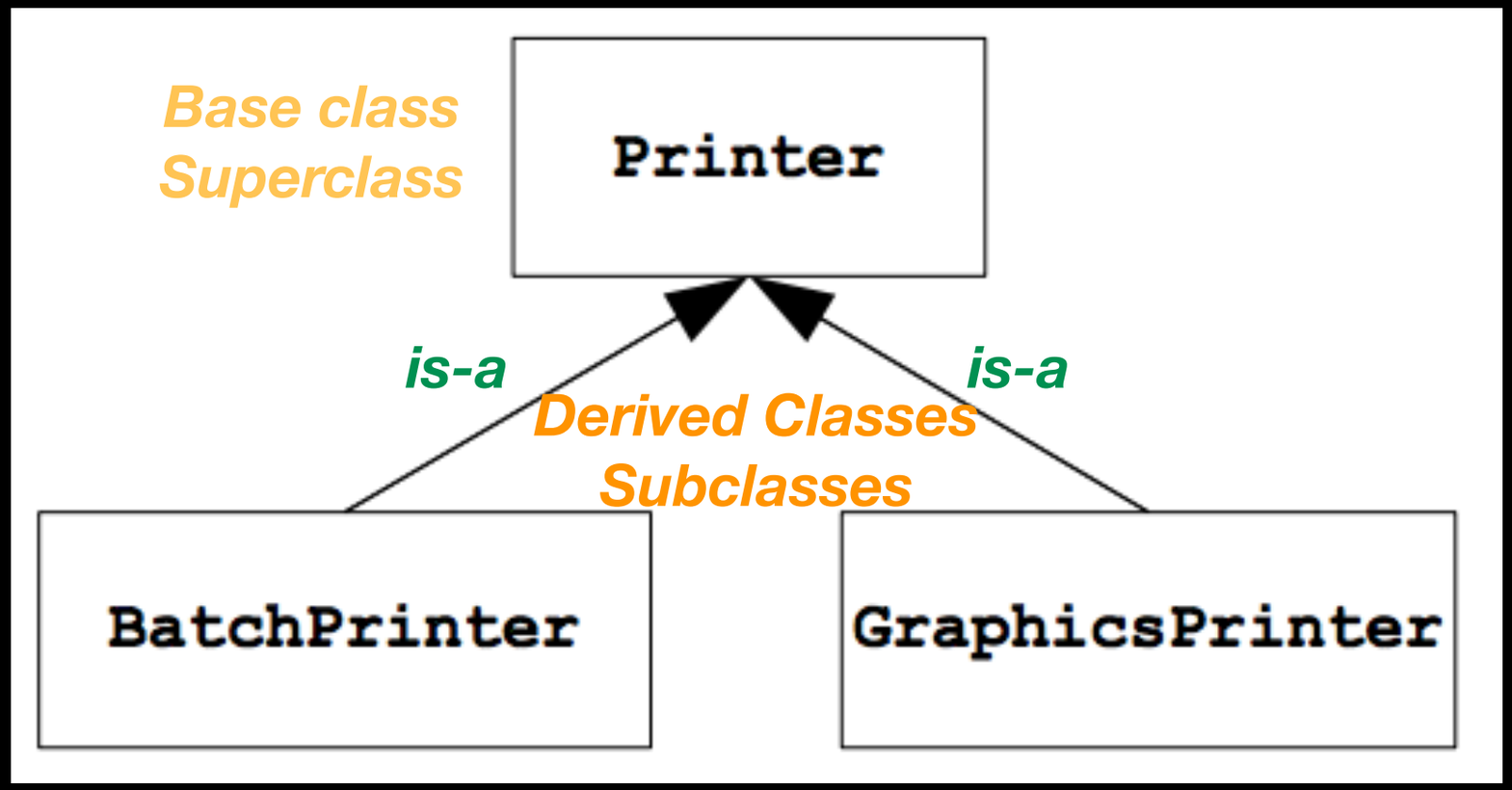
Basic Inheritance

```
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 propose 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
```

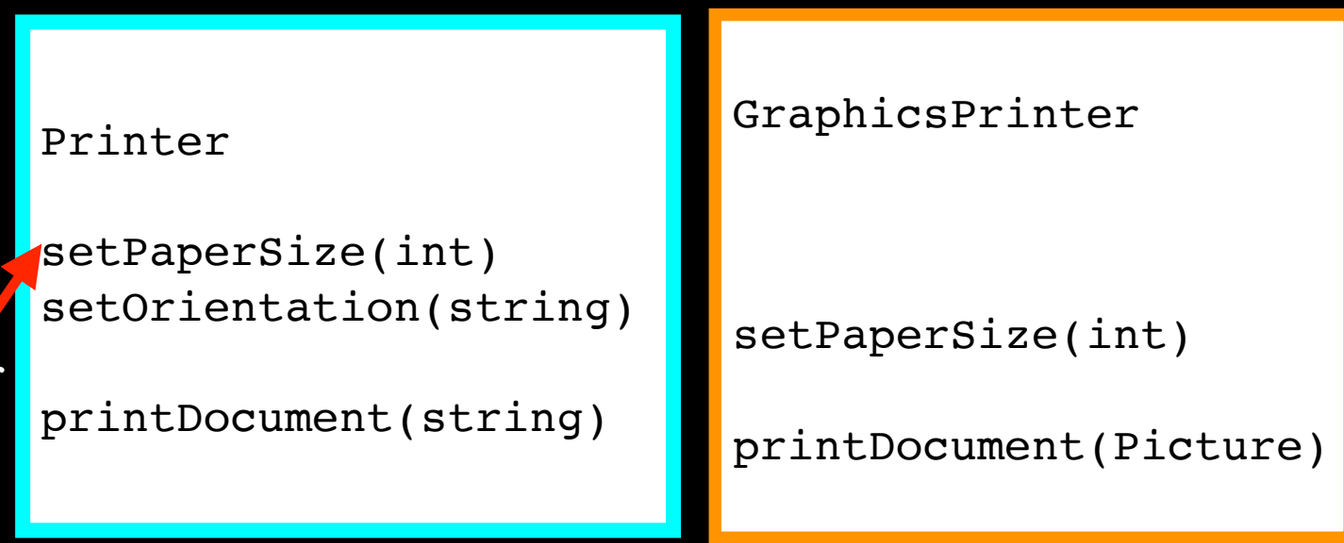
```
class GraphicsPrinter: public Printer   // inherit from printer
{
public:
    //Constructor, destructor
    void setPaperSize(const int size);
    void printDocument(const Picture& picture);//some Picture object


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

Overrides `setPaperSize()`

Overloads `printDocument()`

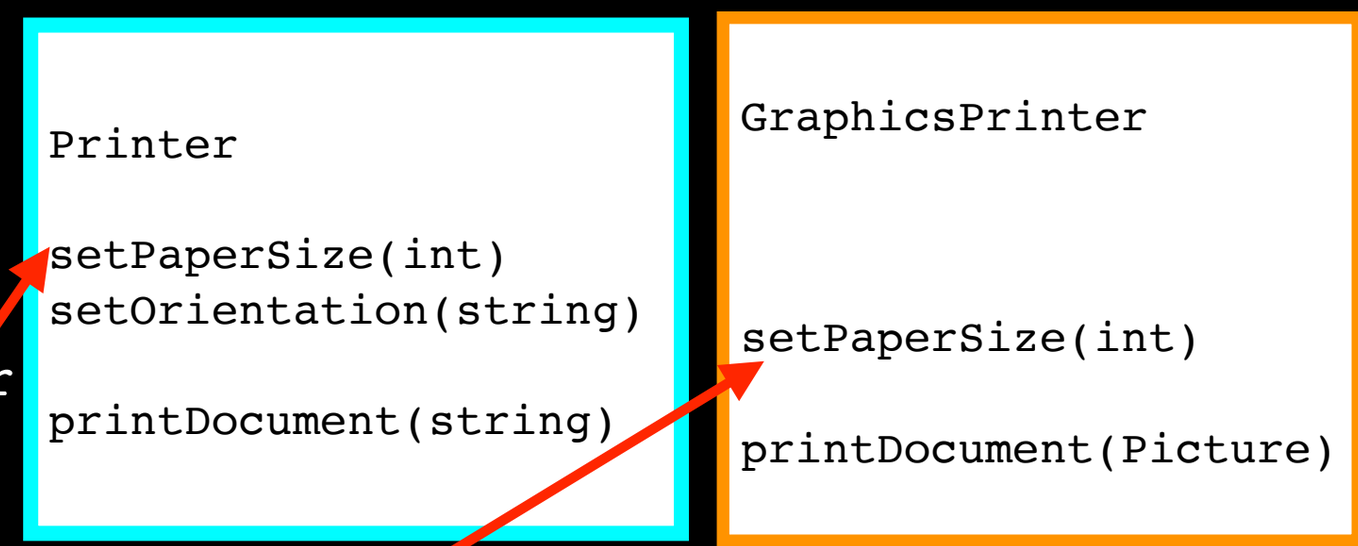
main()

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

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



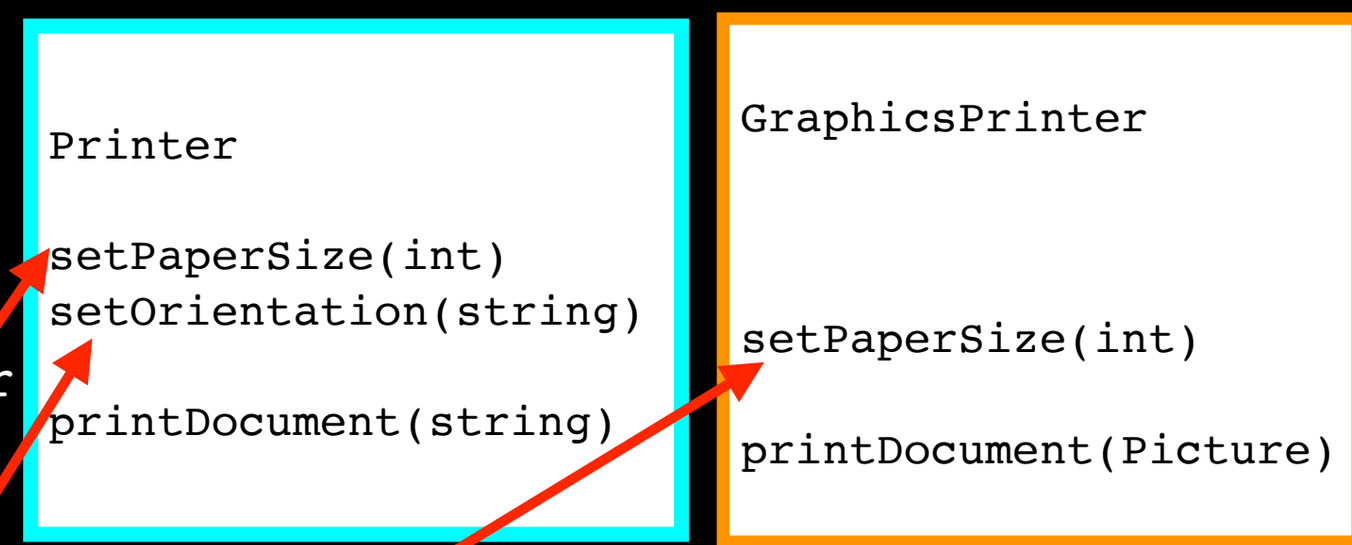
main()

```
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!!!
```



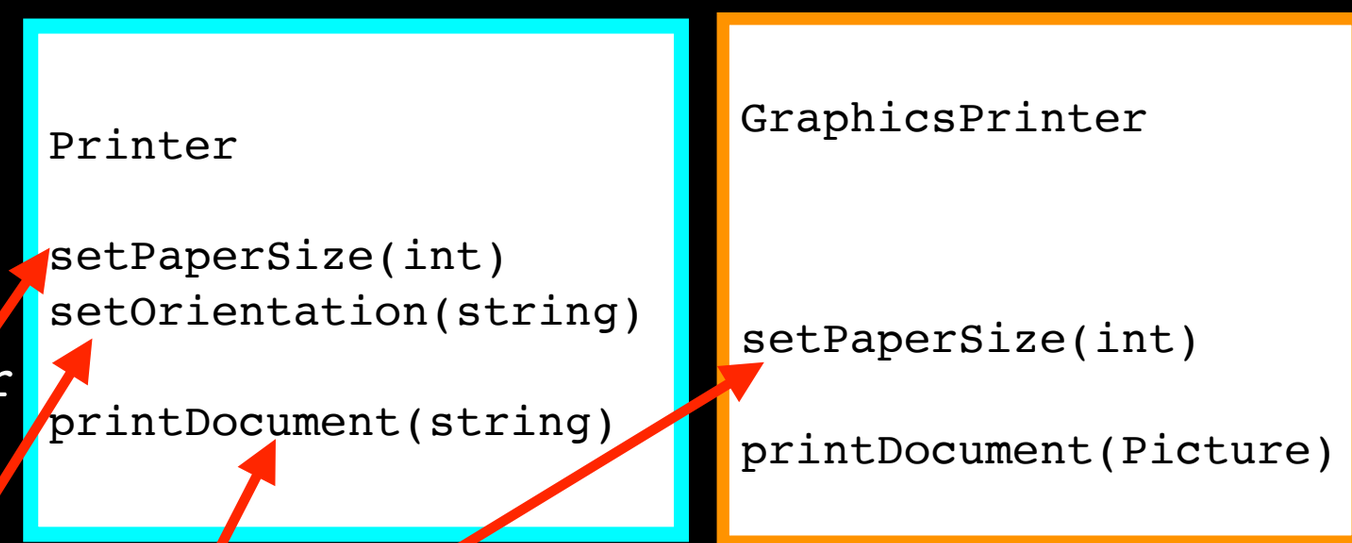
main()

```
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
```



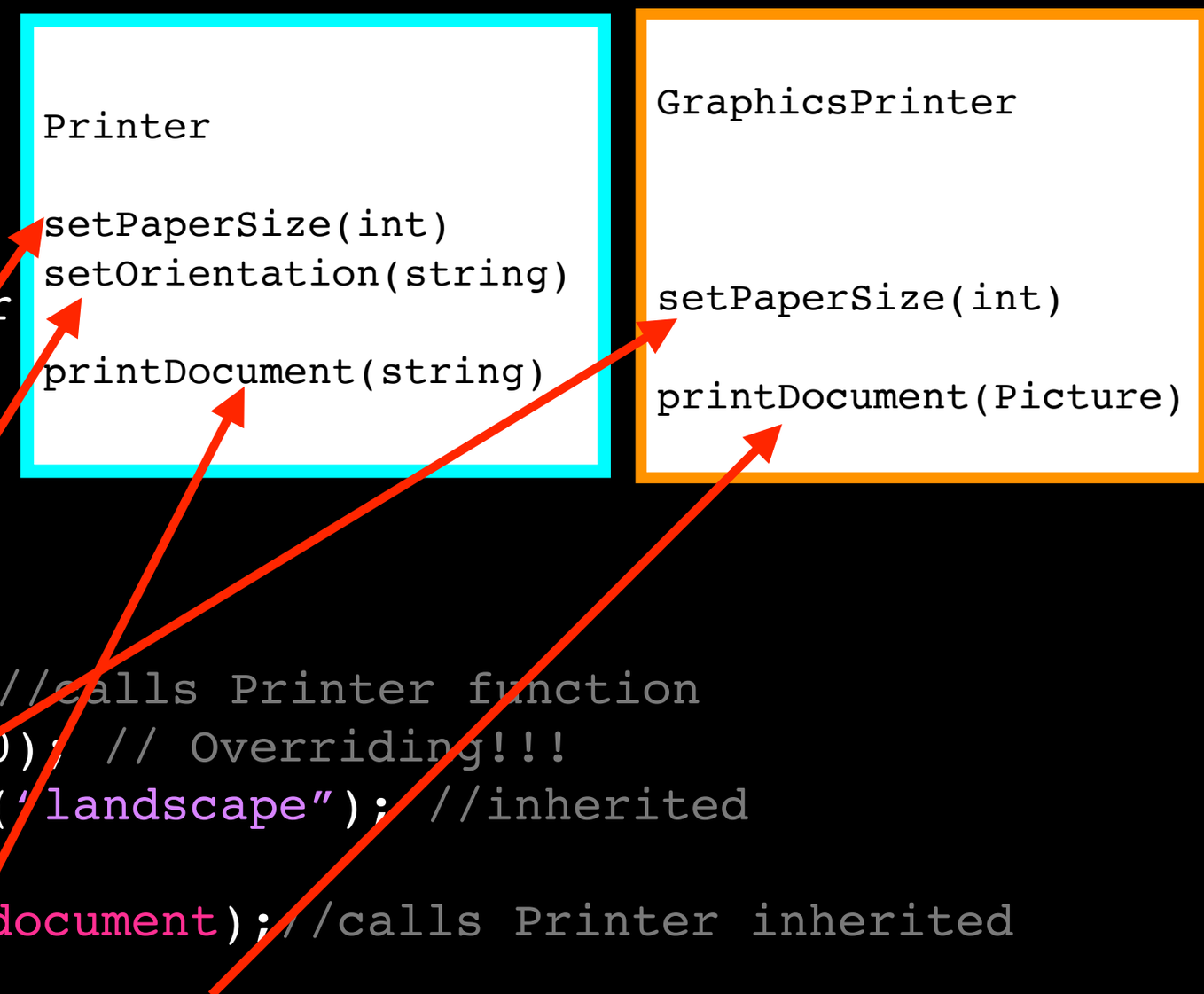
main()

```
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
```



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



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
}
```

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

main()

```
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

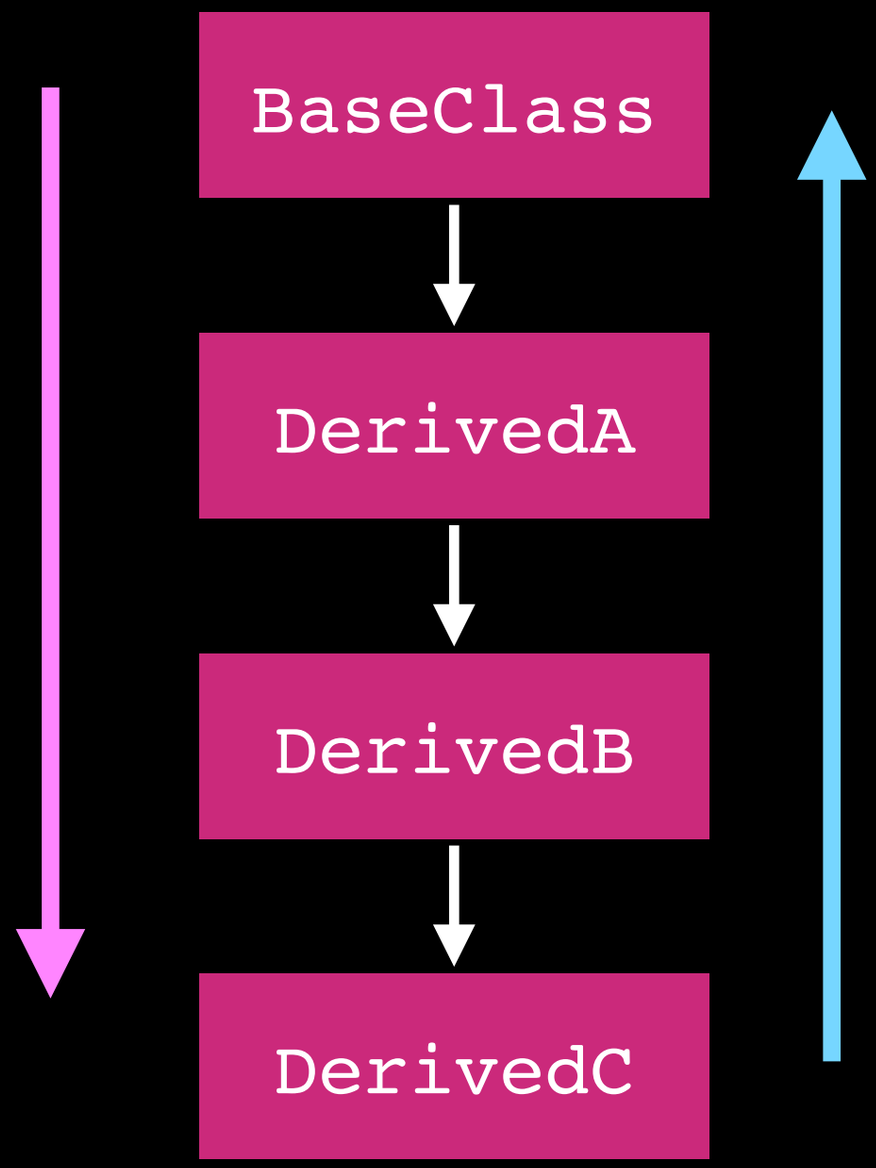
Destructor invoked if:

- 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:

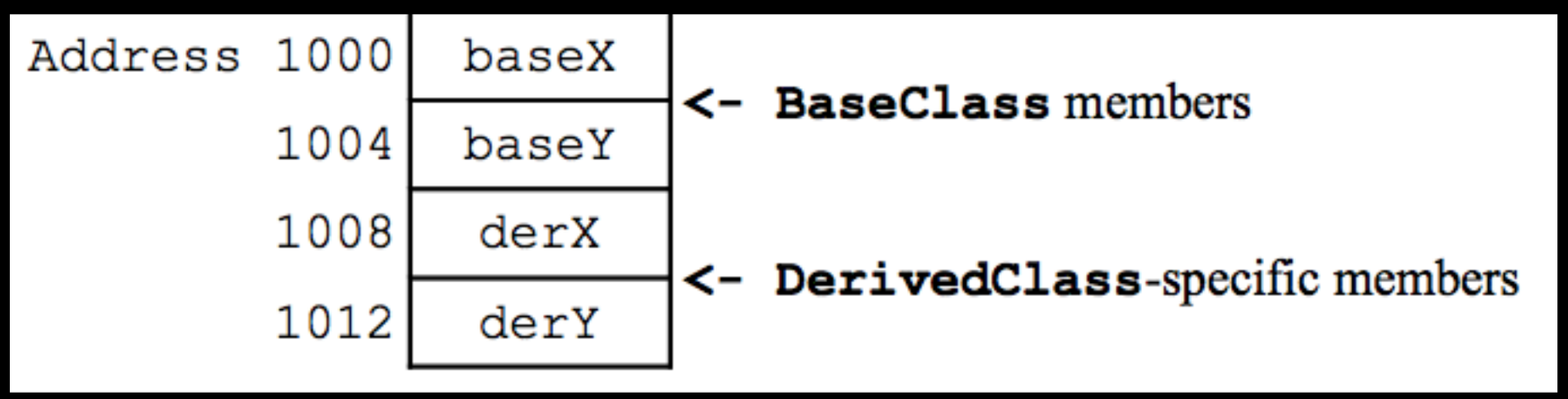
```
~DerivedC()
~DerivedB()
~DerivedA()
~BaseClass()
```

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



Recap

Recap

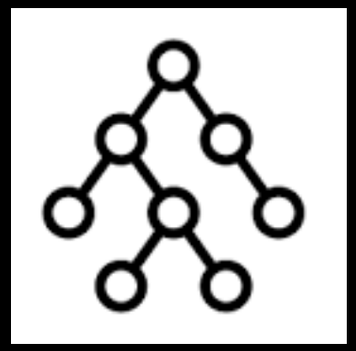
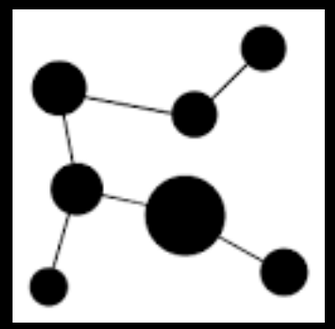
Useful C++ / OOP

Inheritance

Next Time

Abstract Data Types



Templates