Classes and Object-Oriented Programming

Chapter 11

Classes

- Classes allow the joining of related functions and data variables

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- Different objects, or instances, of a class has its own copy of the data members

Classes

- A function in a class is generally called
  - member function
  - method

Classes

- Every member function has access to the ‘this’ pointer.

Classes: The ‘this’ Pointer

- The ‘this’ pointer
  - an implicit parameter that points at the object through which the function is called

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- The ‘this’ pointer
  - an implicit parameter that points at the object through which the function is called
    - Since it is part of the object, it has access to everything public, private, and protected

Classes: The ‘this’ Pointer

```
class MyClass {
        public:
                int getData() {
                        return m_data;
                }

                void setData(int data) {
                        m_data = data;
                }
        private:
        int m_data;
};
```

Classes: The ‘this’ Pointer

- getData has no parameters and setData has one

```
int getData() {
	return m_data;
}
void setData(int data) {
	m_data = data;
}
```

Classes: The ‘this’ Pointer

- getData has no parameters and setData has one
  - In reality, they both have the hidden ‘this’ parameter

```
int getData() {
	return m_data;
}
void setData(int data) {
	m_data = data;
}
```

Classes: The ‘this’ Pointer

- Since the ‘this’ pointer is a pointer to the class instance, it can be used like any other pointer

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```
this->m_data = 7;
```

Classes: The ‘this’ Pointer

- For example:

```
int getData() {
        return this->m_data;
}
void setData(int data) {
        (*this).m_data = data;
}
```

Constant Member Functions

- In classes, it is often useful to declare a constant function

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- A constant function means that the function will make no changes to the class object

Constant Member Functions

- Constant functions are often used for accessors

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- **Constant functions are often used for accessors**

```
class MyClass {
        public:
                int getData() const {
                        return m_data;
                }
        ...
};
```

Constant Member Functions

- **Constant functions are often used for accessors**

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class MyClass {
        public:
                int getData() const {
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                }
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};
```

Constant functions have the word ‘const’ placed after the parameters

Classes: Static Members

- Sometimes it is necessary that multiple objects of the same class share data and functions

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- This can be done through static members

Classes: Static Members

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- Static members are shared by all objects of the same class
  - They are created by placing the keyword ‘static’ in front of functions or variables

Classes: Static Members

- Lets create a class with a static member variable

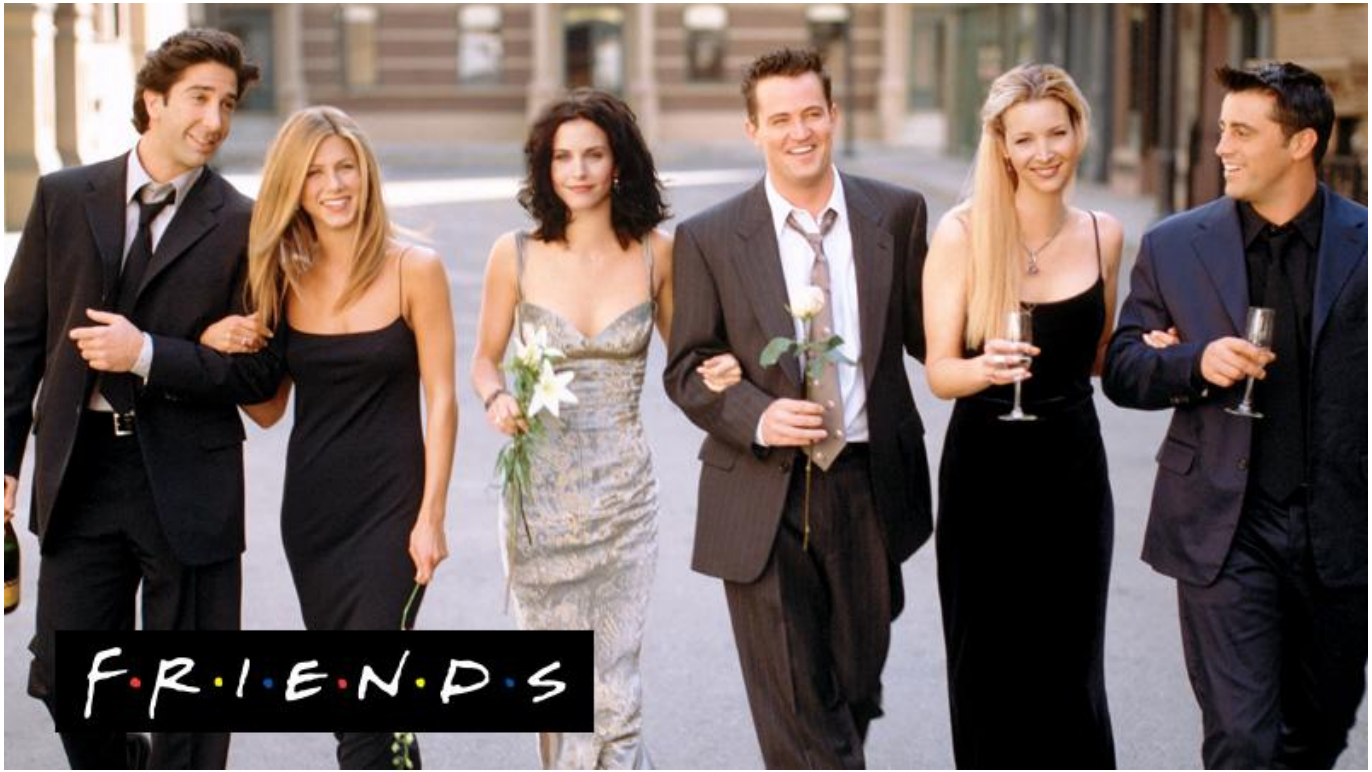
Classes: Static Members

- Lets create a class with a static member variable

- Add a static function

Class: Friends

Class: Friends



Class: Friends

- A friend is a non member function that can access private members

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```
class MyClass{
	public:
		friend void MyClass2::modifyMyClassData();
	private:
		int m_data;
};
class MyClass2{
	public:
		void modifyMyClassData();
};
```

Memberwise Assignment

- Primitive types have the ability to be assigned to one another at any point

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Memberwise Assignment

```
class MyClass{...};

MyClass A;
MyClass B;

A = B;
```

or

```
MyClass A;
MyClass B = A;
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Memberwise Assignment

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This does not work for all classes!

Memberwise Assignment

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class MyClass{...};

MyClass A;
MyClass B;

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This does not work for all classes!

or

```
MyClass A;
MyClass B = A;
```

What is actually happening here?

Memberwise Assignment

- What about this?

```
class MyClass{...};


MyClass A;
...
MyClass B(A);
```

Copy Constructors

- A copy constructor is called whenever a new object is created and initialized with data from another object of the same class

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```
MyClass A;
MyClass B(A);
```

Object B is initialized with the data from A

Copy Constructors

- A default copy constructor is automatically created if the programmer does not specify one

```
MyClass A;
MyClass B(A);
```

OR

```
MyClass A;
MyClass B = A;
```

Copy Constructors

- A default copy constructor is automatically created if the programmer does not specify one

```
MyClass A;
MyClass B(A);
```

OR

```
MyClass A;
MyClass B = A;
```

The compiler smart enough to use the copy constructor instead of the normal constructor followed by an assignment

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    - Pointers
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What does a default copy constructor do if we have those data members?

Copy Constructors

- To prevent issues like that, the programmer can create his/her own copy constructor

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```
MyClass::MyClass(MyClass& rObj)
{
        ...
}
```

Copy Constructors

- To prevent issues like that, the programmer can create his/her own copy constructor

```
MyClass::MyClass(MyClass& rObj)
{
        ...
}
```

Now, the programmer has the power to do whatever is deemed correct for any special members

Copy Constructors

- As part of a copy constructor, the constructor has access all data members of the passed in object

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```
MyClass::MyClass(MyClass& rObj)
{
        m_x = rObj.m_x;
        ...
}
```

Copy Constructors

- As part of a copy constructor, the constructor has access all data members of the passed in object

```
MyClass::MyClass(MyClass& rObj)
{
        m_x = rObj.m_x;
        ...
}
```

What about initialization lists?

Copy Constructors

- How could we handle pointers and dynamic arrays in a class copy constructor?

Copy Constructors

- Const can, and possibly should, be used in copy constructors

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```
MyClass::MyClass(const MyClass& rObj)
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```

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        ...
}
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What does this tell us about the input parameter?

Copy Constructors

- Const can, and possibly should, be used in copy constructors

```
MyClass::MyClass(const MyClass& rObj)
{
        ...
}
```

What does this tell us about the input parameter?

Can we make the copy constructor a const function? ie MyClass(const MyClass& rObj) const

Operator Overloading

- Not only can we overload the copy constructor, but we can overload other functions as well

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- Not only can we overload the copy constructor, but we can overload other functions as well
  - = operator
  - < operator
  - > operator
  - == operator
  - ...

Assignment Operator

- What if we modify our example a bit

```
MyClass A;
MyClass B = A;  // The copy constructor
MyClass C;


C = A;          // What function does this call?
```

Assignment Operator

- Overloading the assignment operator gives us similar control to the copy constructor

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```
void MyClass::operator=(const MyClass& rRight)
{
    ...
}
```

Assignment Operator

- For overloading most operators there is a pattern

Return type | Function name | Parameter for object ont he right side of the operator

```
void MyClass::operator=(const MyClass& rRight)
{
    ...
}
```

Assignment Operator

- For overloading most operators there is a pattern

Return type — Function name — Parameter for object ont he right side of the operator

```
void MyClass::operator=(const MyClass& rRight)
{
    ...
}
```

How might we fill this out for a class with pointers or dynamic memory?

Assignment Operator

- For primitives, the assignment operator supports chaining, what about ours?

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```
int a = 1;
int b = 2;
int c = 3;

a = b = c;
```

Assignment Operator

- For primitives, the assignment operator supports chaining, what about ours?

```
int a = 1;
int b = 2;
int c = 3;


a = b = c;
```

How would we need to modify our assignment operator to support chaining?

Assignment Operator

- We need to modify the return type

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```
MyClass MyClass::operator=(const MyClass& rRight)
{
    …
        return *this;
}
```

Assignment Operator

- We need to modify the return type

```
MyClass MyClass::operator=(const MyClass& rRight)
{
    …
        return *this;
}
```

How many times might the Class object be constructed when chaining a = b = c?

Assignment Operator

- We need to modify the return type

```
MyClass MyClass::operator=(const MyClass& rRight)
{
    …
        return *this;
}
```

How many times might the Class object be constructed when chaining a = b = c?

Can we improve this?

Assignment Operator

- We need to modify the return type again

```
MyClass& MyClass::operator=(const MyClass& rRight)
{
    …
        return *this;
}
```

Other Overloadable Operators

- There are many other overloadable operators

Other Overloadable Operators

+	-	*	/	%	^	&
|	~	!	=	<	>	+=
-=	*=	/=	%=	^=	&=	|=
<<	>>	>>=	<<=	==	!=	<=
>=	&&	||	++	--	->*	,
->	[]	()	new	delete		

Arithmetic And Relational Operators

- The arithmetic and relational operators can also be overloaded

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  - operator+
  - operator-
  - operator<
  - operator==

Arithmetic And Relational Operators

- The arithmetic and relational operators can also be overloaded
  - SomeClass operator+(SomeClass left, SomeClass right);
  - SomeClass operator-(SomeClass left, SomeClass right)
  - bool operator<(SomeClass left, SomeClass right);
  - bool operator==(SomeClass left, SomeClass right);

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  - How might we do that?

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  - How might we do that?

```
friend bool operator==(SomeClass left, SomeClass right)
{
    ...
}
```

Arithmetic And Relational Operators

- The usage of overloaded operators can be used automatically or manually

```
friend bool operator==(SomeClass left, SomeClass right) {
    … }
```

Arithmetic And Relational Operators

- The usage of overloaded operators can be used automatically or manually

```
friend bool operator==(SomeClass left, SomeClass right) {
    … }
SomeClass A, B;

if (A == B) …

if (operator==(A,B)) ...
```

Arithmetic And Relational Operators

- How might we use the operator== in a Student class?

Arithmetic And Relational Operators

- How might we use the operator== in a Student class?

- What about the operator<?

Other Operators

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  - What if we created a list, array, or other container or objects?

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SomeClass& operator[](int) const;

Other Operators

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  - What if we created a list, array, or other container or objects?

SomeClass& operator[](int) const;

Lets create a University class that contains many Student objects.

Type Conversion Operators

- Sometimes it is useful to convert a class into a different type

Type Conversion Operators

- Sometimes it is useful to convert a class into a different type
  - For example
    - We have a non trivial object that we want to convert to a const char*

Type Conversion Operators

- What other type conversions could we make?

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  - double
  - int
  - ...

Type Conversion Operators

- What other type conversions could we make?
  - double
  - int
  - …

```
operator double() const;
operator int() const;
...
```

Type Conversion Operators

- What other type conversions could we make?
  - double
  - int
  - …

What is the difference between type conversion operators and functions like ‘getAsDouble()’?

```
operator double() const;
operator int() const;
...
```

Type Conversion Operators

- Could we convert one class to another?

Convert Constructors

- We can also go the opposite direction
  - converting something else into a class

Convert Constructors

- Convert Constructors
  - provide a means for the compiler to create objects using different types/objects

Convert Constructors

- A simple example

```
class MyString{
        public:
                MyString(std::string input){
                        …
                }


        private:
        UInt8* m_pArray;
};
```

Convert Constructors

- A simple example

```
class MyString{
        public:
                MyString(std::string input){
                        …
                }


        private:
        UInt8* m_pArray;
};
```

The argument is of a different type than the class. Here we convert a standard string into a MyString class.

Convert Constructors

- A convert constructor can be called automatically

Convert Constructors

- A convert constructor can be called automatically

```
class Foo{
public:
        Foo(int value)
          : m_value(value)
        {}
        int m_value;
};

Foo obj = 4;
```

Aggregation and Composition

- In some instances, it is important that a class of one type contains a class of another type

Aggregation and Composition

- If a class owns the class of another type, then this is called Class Aggregation

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Aggregation and Composition

- A good example that shows the difference is as follows

Aggregation and Composition

```
class Date{ ...};

class Student {
        Student(Date birthday){...}

        Date getBirthday() {...}
        void setCurrentAddress(Address& rAddress){...}
        void removeCurrentAddress() {...}

        Date m_birthdate;
        Address* m_pCurrentAddress;
};
```

Aggregation and Composition

```
class Date{ ...};

class Student {
        Student(Date birthday){...}

        Date getBirthday() {...}
        void setCurrentAddress(Address& rAddress){...}
        void removeCurrentAddress() {...}

        Date m_birthdate;
        Address* m_pCurrentAddress;
};
```

The m_pCurrentAddress is added and removed during the lifetime of the student. Aggregation

Aggregation and Composition

```
class Date{ ...};

class Student {
        Student(Date birthday){...}

        Date getBirthday() {...}
        void setCurrentAddress(Address& rAddress){...}
        void removeCurrentAddress() {...}

        Date m_birthdate;
        Address* m_pCurrentAddress;
};
```

The m_birthdate object will be created when a student is created, and destroyed when the student is destroyed...Composition

Inheritance

- As in the real world, inheritance plays a big role

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  - Inheritance deals with specialized versions of things

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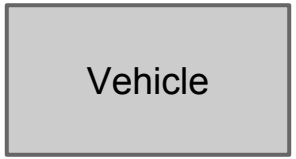
Inheritance

What type of vehicles are there?



Inheritance

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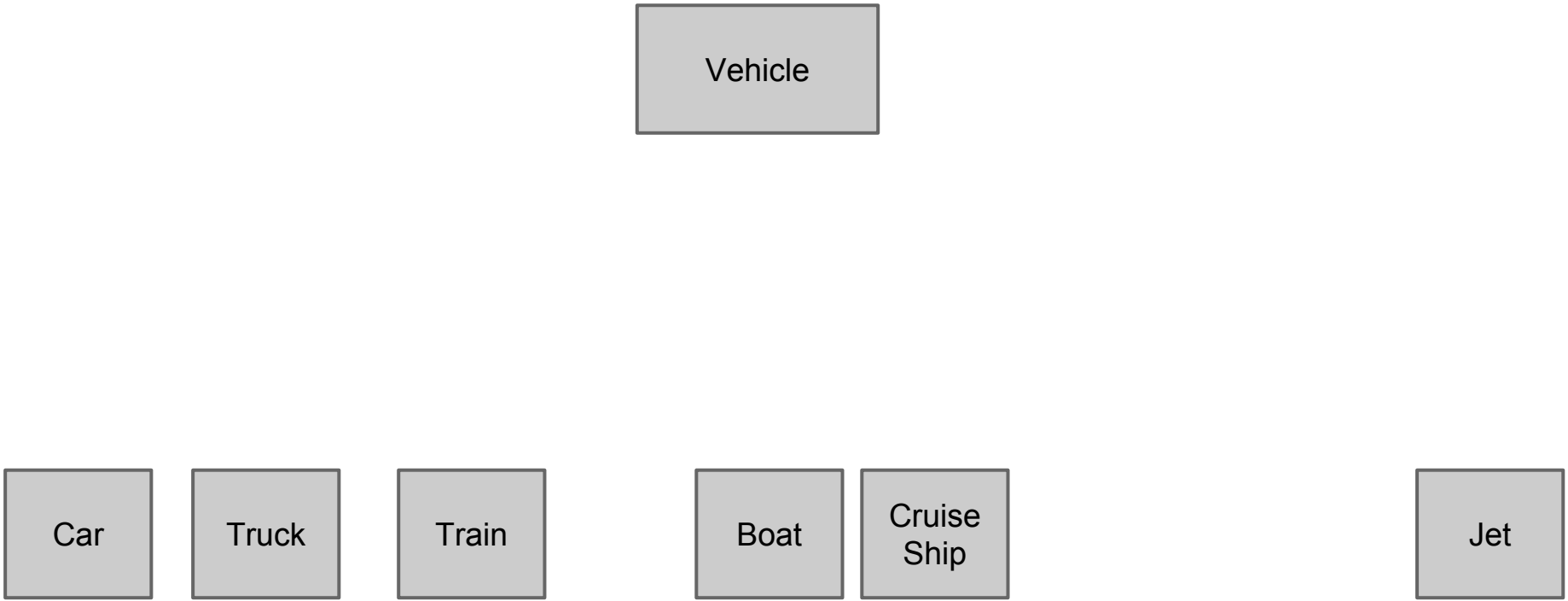
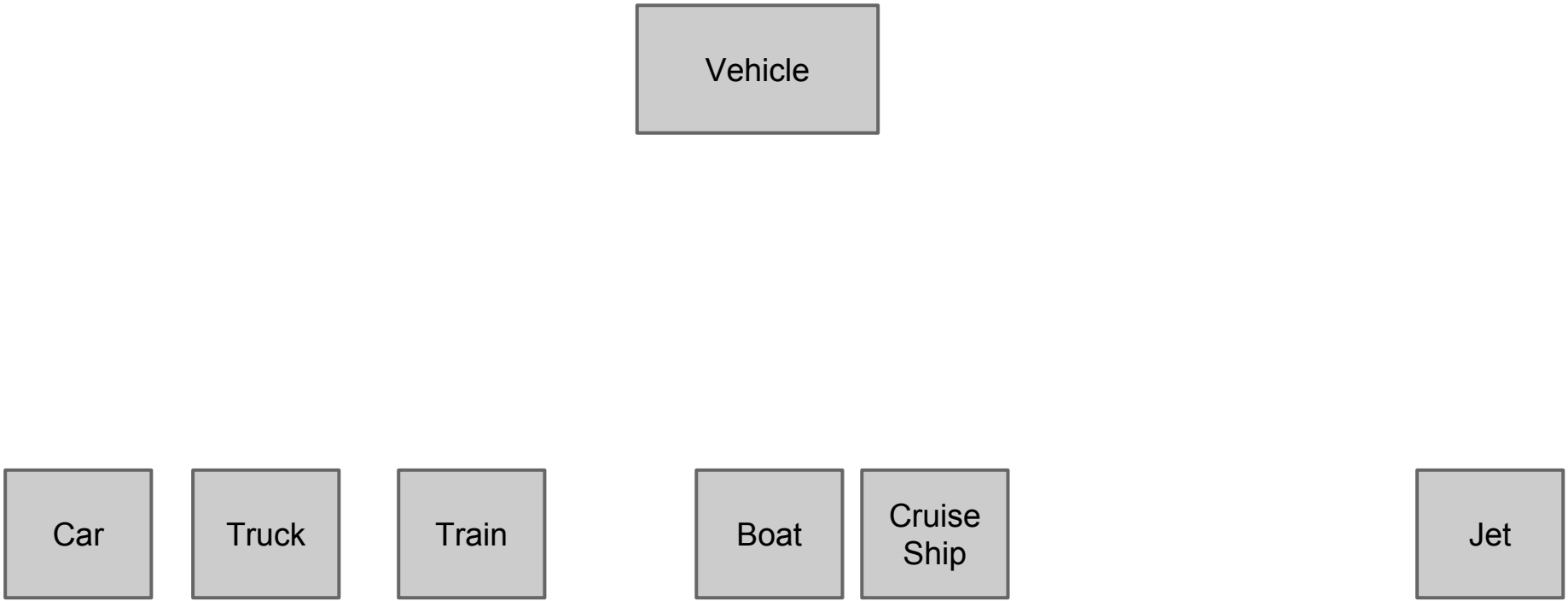


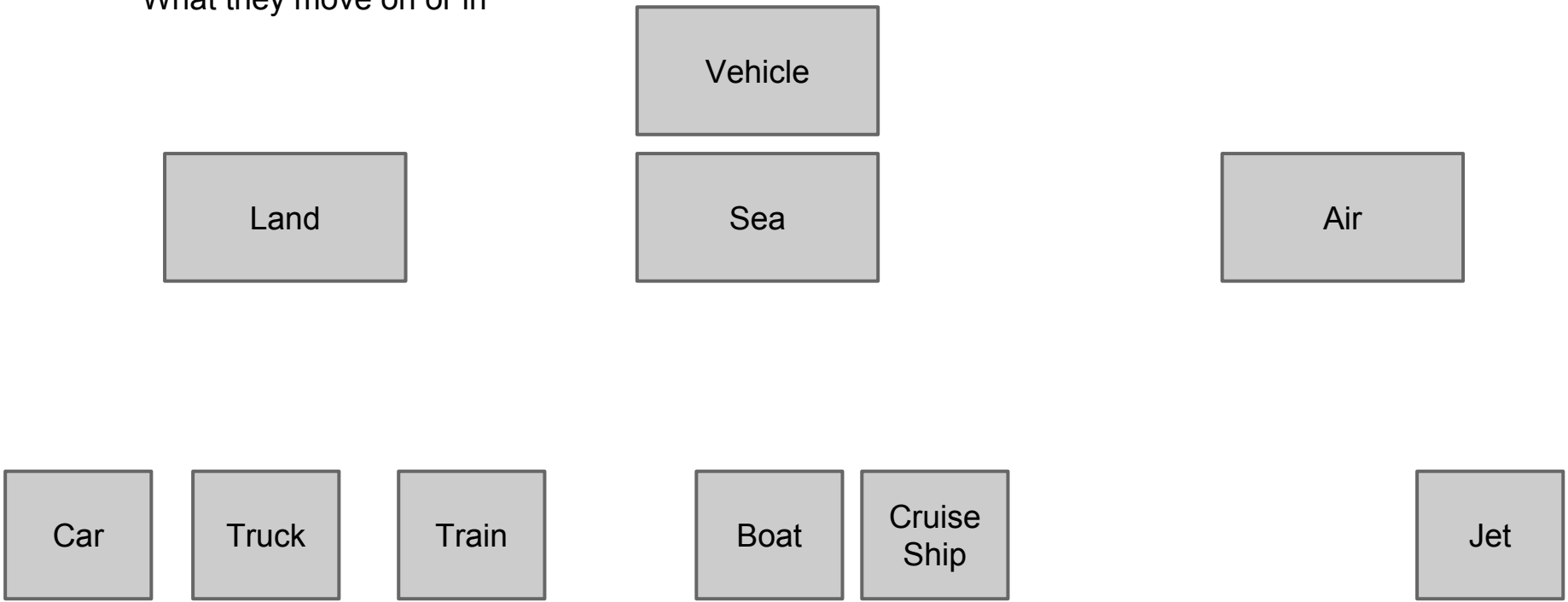
Inheritance

How could we characterize these?



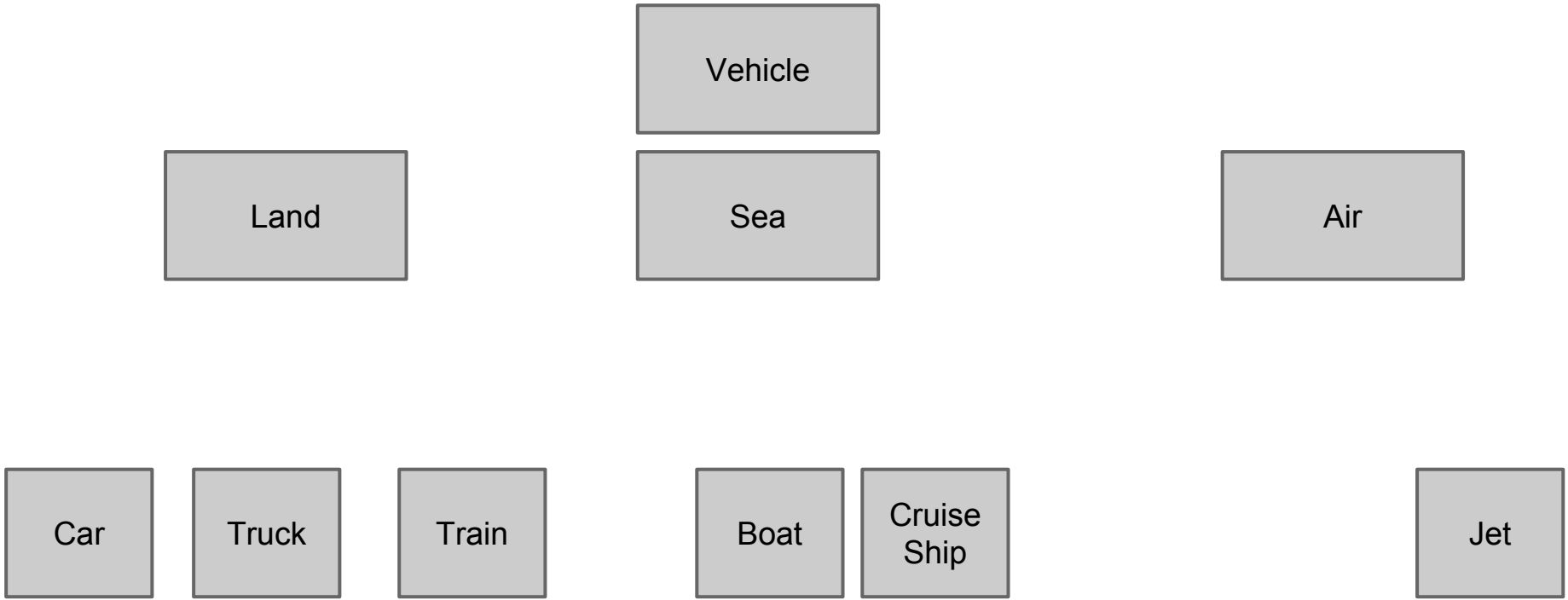
Inheritance

How could we characterize these?
What they move on or in



Inheritance

Could we get more specific?



Inheritance

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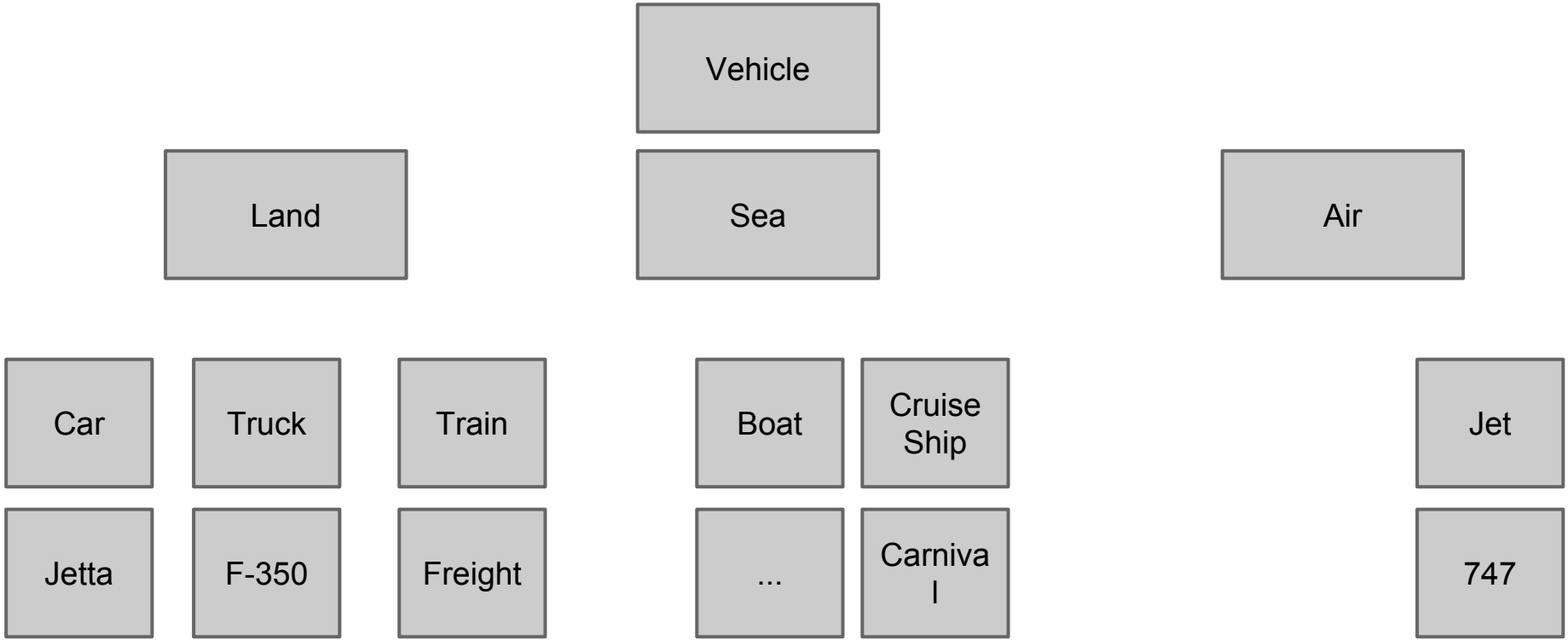
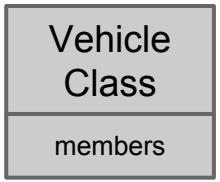


Inheritance

- Often times, inheritance follows an ‘is-a’ relationship
  - A Jetta is a Volkswagen
  - A rectangle is a shape
  - ...

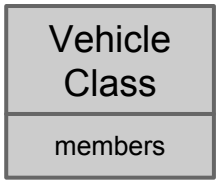
Inheritance

- To implement inheritance in C++ we create what is called a ‘base class’



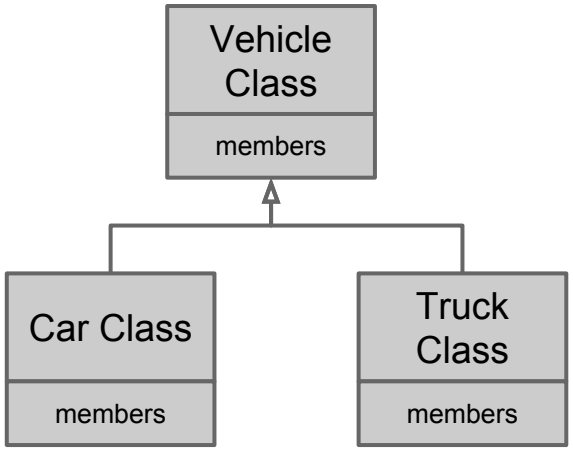
Inheritance

- To implement inheritance in C++ we create what is called a ‘base class’
  - The base class acts as a parent



Inheritance

- Next, we create one or many classes that inherit from the base class



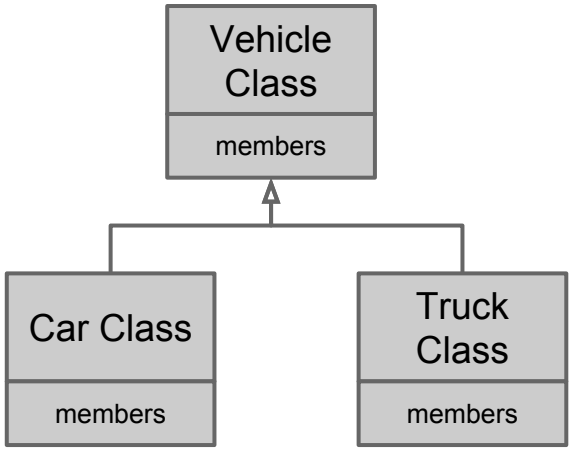
Inheritance

- Next, we create one or many classes that inherit from the base class

Derived Class

Base Class

```
class Car : public Vehicle
{
        ...
};
```



Inheritance

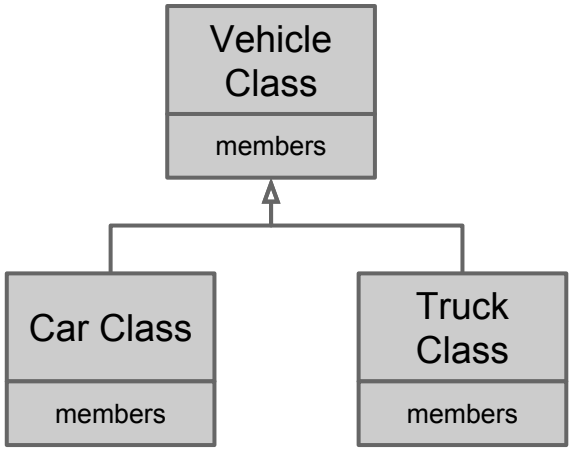
- Next, we create one or many classes that inherit from the base class

Derived Class

Base Class

```
class Car : public Vehicle
{
        ...
};
```

When the Car inherits from Vehicle, it gets all of Vehicles public and protect members and functions. Privates still exist but are not accessible from the derived class.



Inheritance

- Lets create an inheritance example

Protected Members & Class Access

- Class access is important
  - Any data members or functions that should be protected must not be accessible by anything that might modify them

Protected Members & Class Access

- Class access
  - Public
    - Anything/anyone can call, access, or modify

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    - Only the owning class (or friends) can call, access, or modify

Protected Members & Class Access

- Class access
  - Public
    - Anything/anyone can call, access, or modify
  - Private
    - Only the owning class (or friends) can call, access, or modify
  - Protected
    - The owning AND derived classes can call, access, or modify

Protected Members & Class Access

- Protected and private base class access specifications can also be used

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- Protected and private base class access specifications can also be used

Class A : protected Letter {}

Class B : private Letter{}

Protected Members & Class Access

- Base class access is a little different than the normal access restrictions

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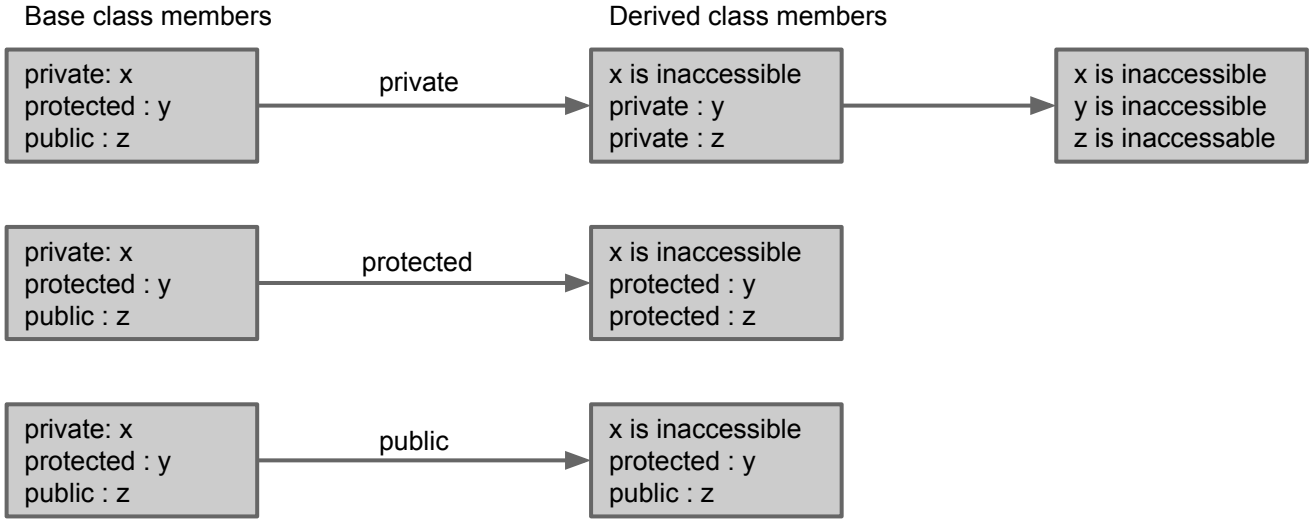


Constructors, Destructors, and Inheritance

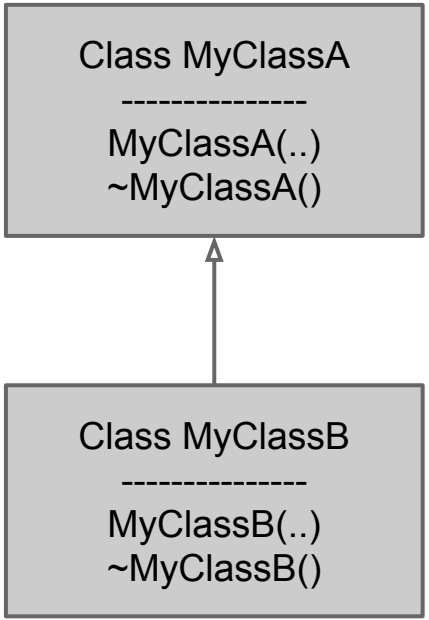
- With inheritance, the base class constructor gets called before the derived class constructor

Constructors, Destructors, and Inheritance

- With inheritance, the base class constructor gets called before the derived class constructor

- When the object is destructed, the derived destructor is called before the base class

Constructors, Destructors, and Inheritance



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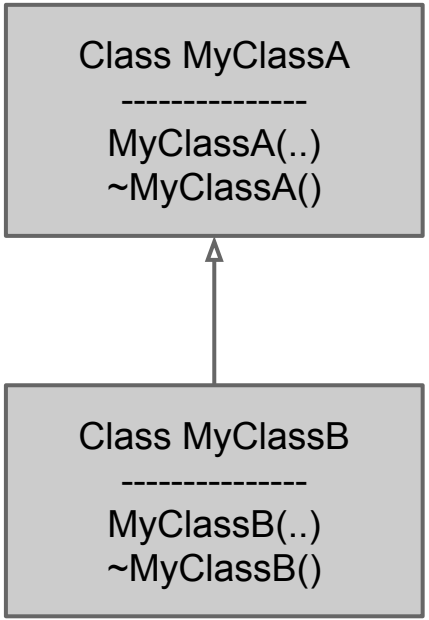

On construction:

MyClassA();
MyClassB();

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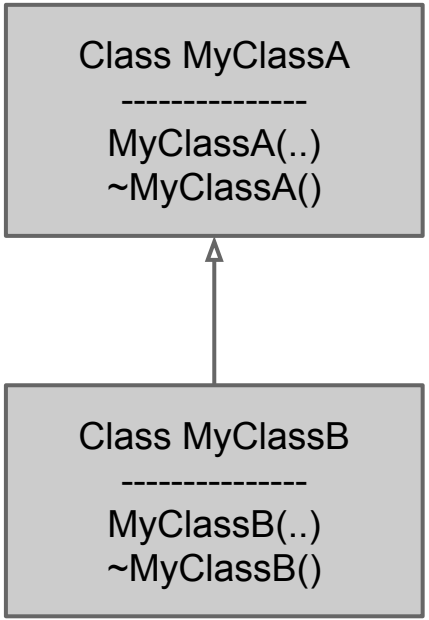


On construction:

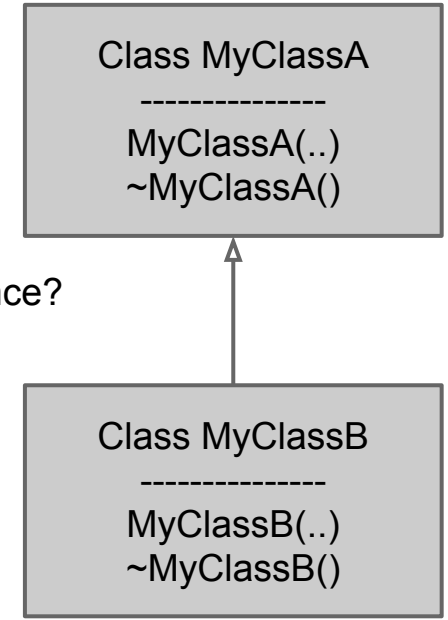
MyClassA();
MyClassB();

On destruction:

~MyClassB();
~MyClassA();

Constructors, Destructors, and Inheritance

What happens with multiple inheritance?



On construction:

MyClassA();
MyClassB();

On destruction:

~MyClassB();
~MyClassA();

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```
MyClassB()
  : MyClassA(TYPE_B)
{
   ...
}
```

Overriding Base Class Functions

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  - Unfortunately, it is sometimes necessary for a derived class to change, or override, a base class function

Overriding Base Class Functions

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```
Class A{
        int myFunction();
}

Class B : public A{
        int myFunction();
}
```

Overriding Base Class Functions

- Override base class functions is as easy as redefining the same function in the derived class

```
Class A{
        int myFunction();
}

Class B : public A{
        int myFunction();
}
```

The function name, return type, and parameter list should match!

Overriding Base Class Functions

- When overriding base class function, funny things happen when a base class pointer points to a derived class

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MyClassA::myFunction();
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This is very useful for overloaded equality operators!

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- Overriding
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  - redefines something that was already defined
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- Overriding
  - Can only be done via inheritance
  - redefines something that was already defined
- Overloading
  - Defining different functions within the same class with the same name and different parameters
  - Can be global