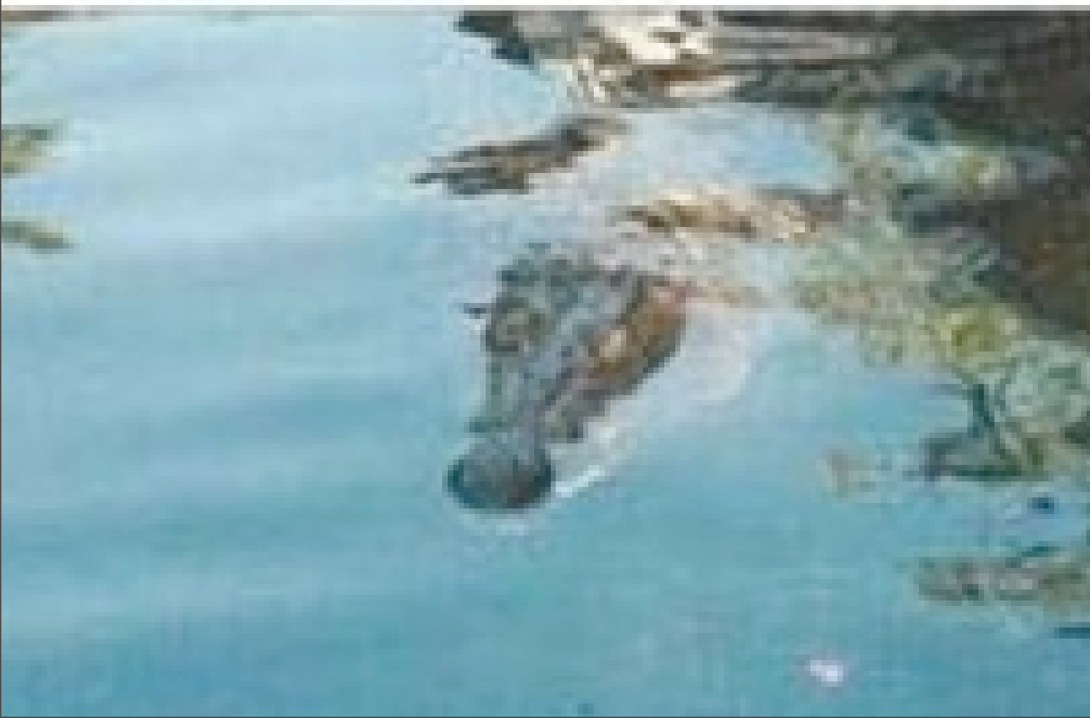
THOSE WHO
THROW OBJECTS
AT THE CROCODILES,
WILL BE ASKED TO
RETRIEVE THEM



MULTIPLE INHERITANCE & IOSTREAMS

```
class base
{
   public:
      base( int p );
      void funcOne();
      int a;
   protected:
      int b;
      void funcTwo();
   private:
      void funcThree();
      int c;
};
```

```
class derived : public base
{
   public:
      derived();
      void testFunc();
};

void derived::testFunc()
{
   a++;
   b++;
   c++;
}
```

- Let's look at some of this...
- What would the constructor look like?

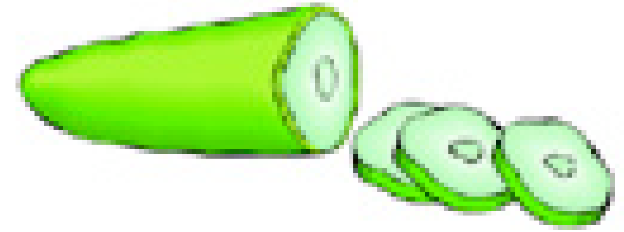
```
derived bob( 42 );
derived ted;

ted.funcOne();
ted.funcTwo();
ted.funcThree();
```

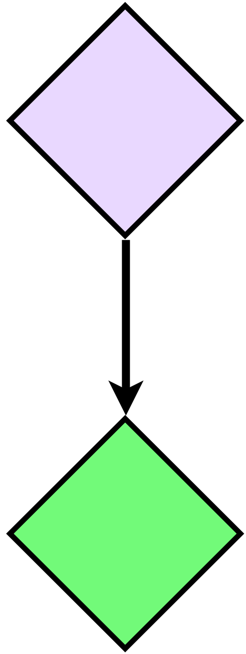
Review

```
class base
{
   public:
      void print();
};

class derived
{
   public:
      void print();

      void test()
      {
          print();
      }
};
```

- What is **polymorphism**?
- What are virtual functions and what problem do they solve?
- What does it mean to **override** a function?
- Why do destructors (sometimes) need to be virtual?
- How do we call the base class version of print() in derived::test()?
- What's an abstract/pure virtual function and what is it good for?

An Issue





FarmAnimal
int weight;

MooCow
void chewCud();
bool hungry;

- We can transparently treat MooCow as a FarmAnimal (this is what polymorphism means!)
- So we can pass MooCow into a function that accepts FarmAnimal.

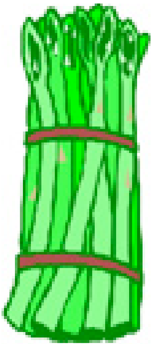
```
void printWeight( FarmAnimal animal )
{
    cout << animal.weight;
}

int main()
{
    MooCow cow;
    printWeight( cow );
}
```

let's talk about this...

- How is cow being passed?
- What type is cow?
- What type does printWeight accept?

Object Slicing

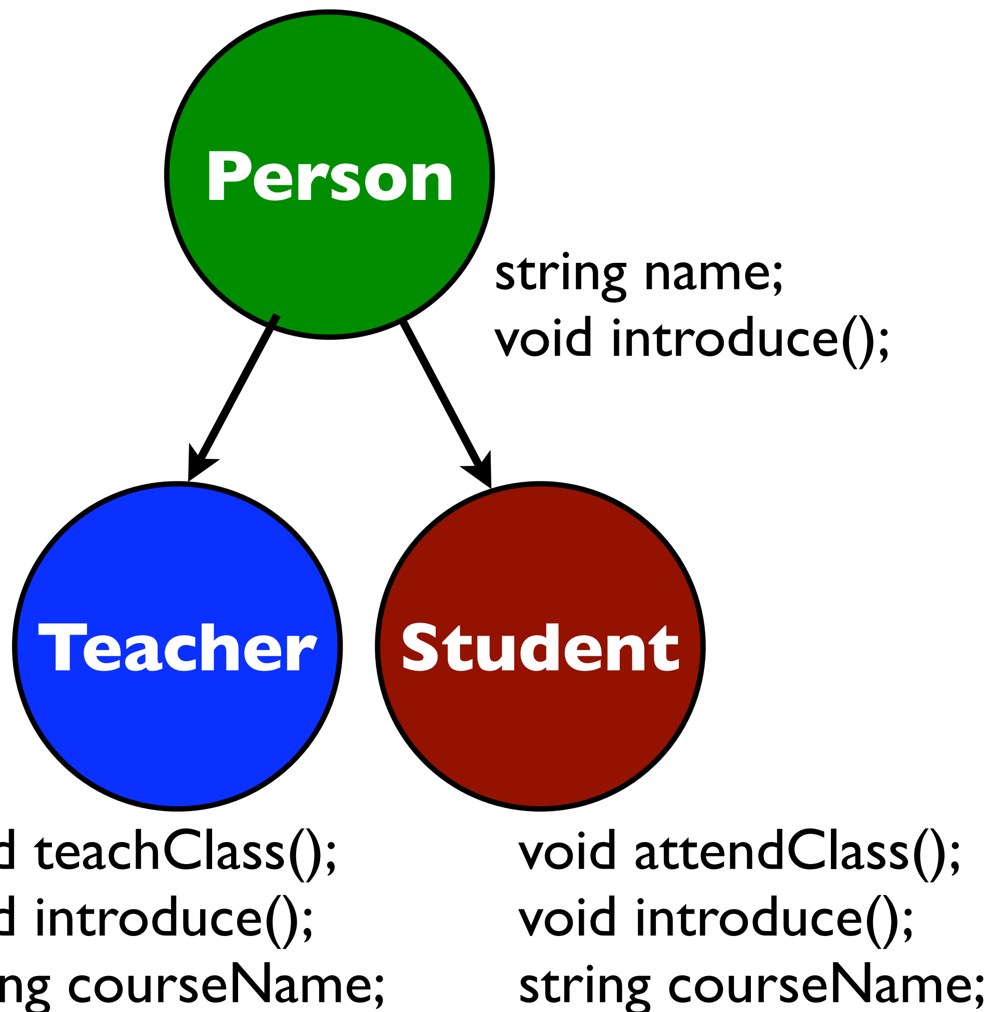
- For this to work, a MooCow must be converted to a FarmAnimal
- The compiler takes all the FarmAnimal bits and leaves behind all the MooCow bits!



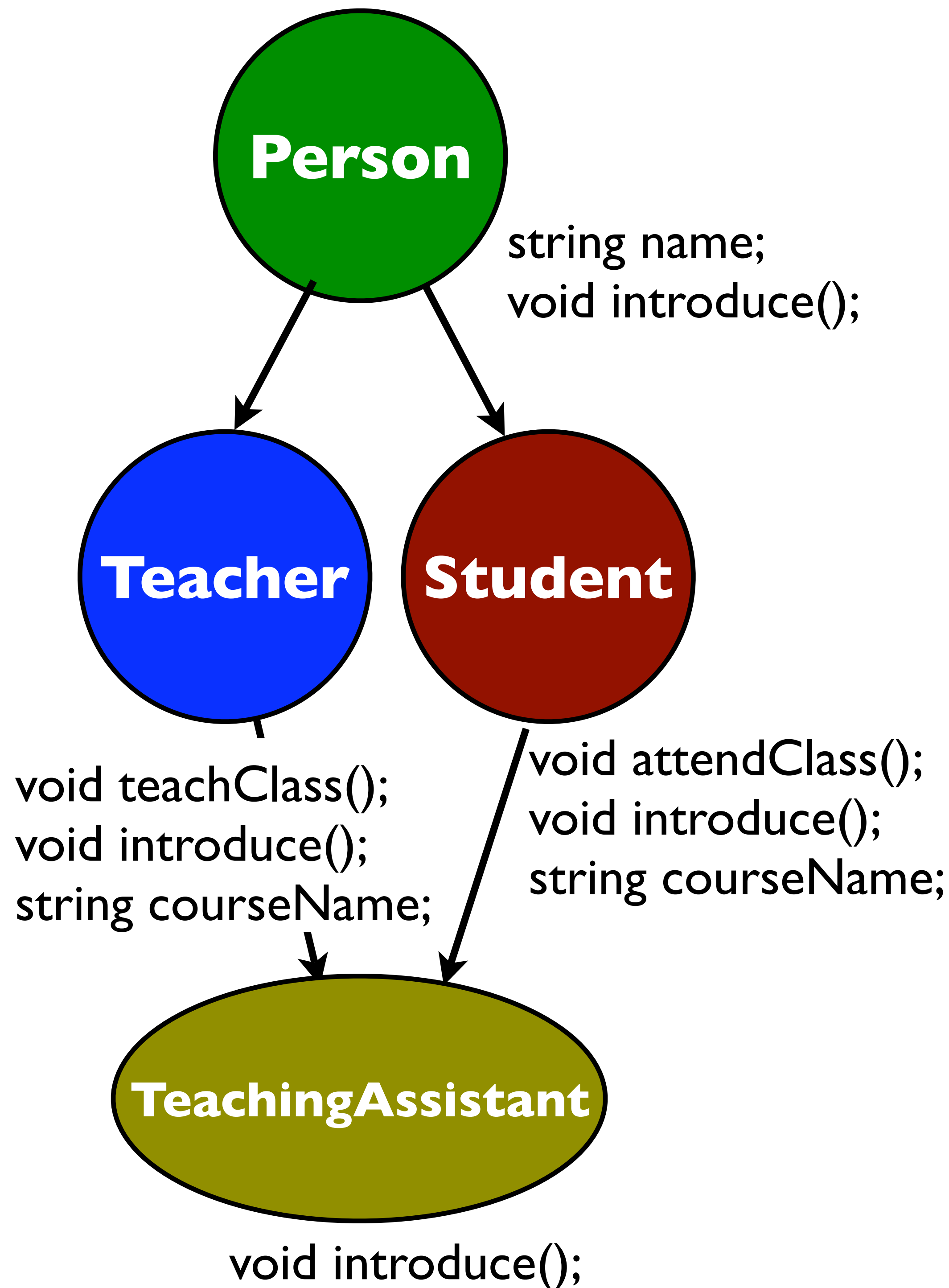
- This is called **object slicing**
- It's generally bad.
- To prevent it, use pointers or references instead!

```
void printWeight( FarmAnimal animal )
{
    cout << animal.weight;
}

int main()
{
    MooCow cow;
    printWeight( cow );
}
```

Multiple Inheritance



- Sometimes inheriting from a single class isn't enough!
- Say we've got the simple class hierarchy to the left:
- What do we do when we want to define a **TeachingAssistant** class?
  - A TeachingAssistant both teaches *and* attends classes
  - No one base class is enough!



- We have to make **TeachingAssistant** inherit from *both* Teacher and Student!
- So: our new TA class will inherit *all* the stuff from both base classes!
- How would we write an introduce method that explains what course the TA teaches, *and* what course he/she studies?

Person

string name;
void introduce();

Teacher

void teachClass();
void introduce();
string courseName;

Student

void attendClass();
void introduce();
string courseName;

TeachingAssistant

void introduce();

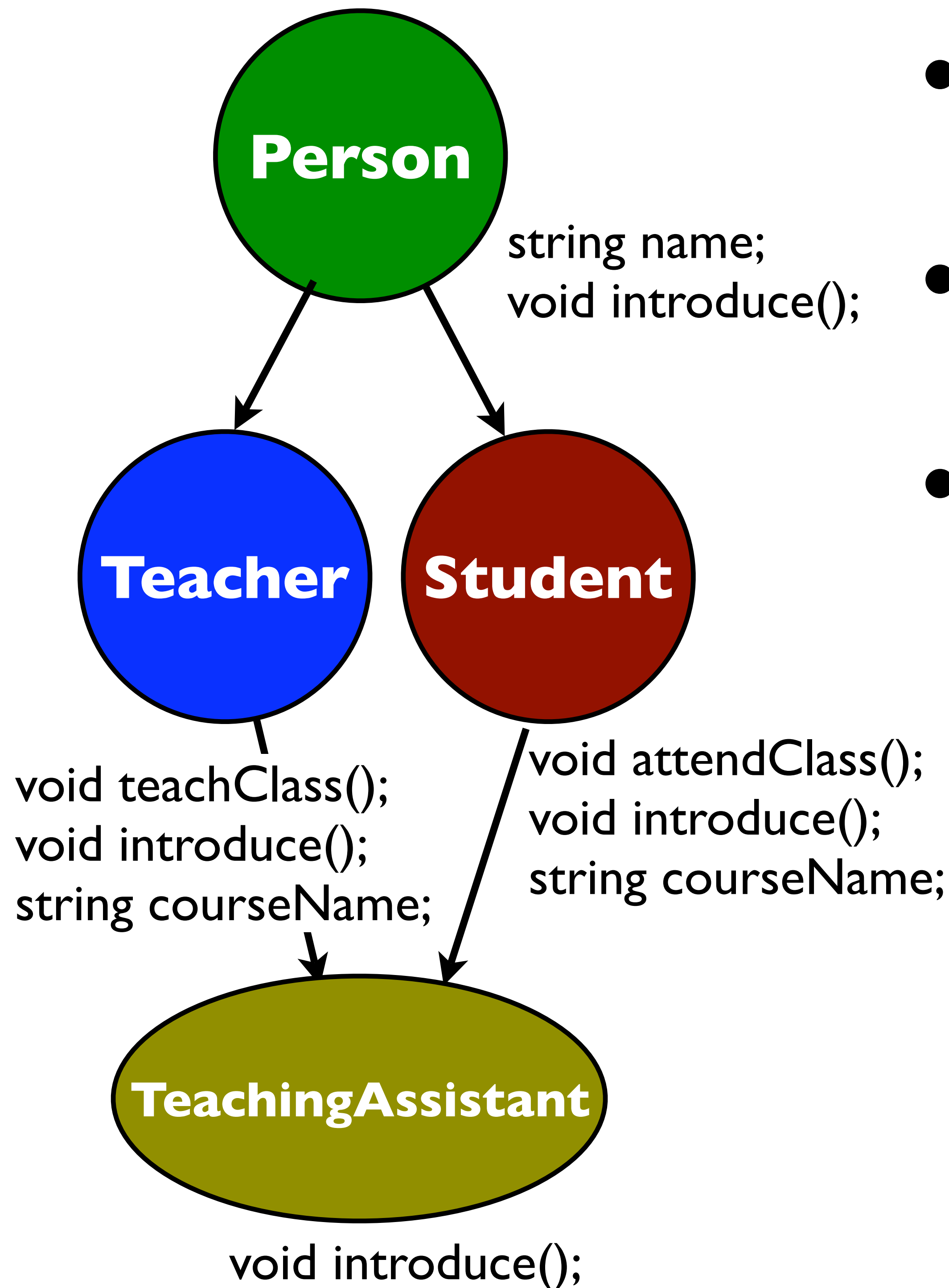
- How many courseName variables are there in TeachingAssistant?
- How do we print out the right version at the right time?

```
void TA::introduce()
{
   cout << “I teach: ”;
   cout <<  (?)
   cout << “I study: “;
   cout <<  (?)
}
```

Multiple Inheritance

```
class Teacher : public Person
{   // declaration mostly omitted
  public:
    Teacher( string name );
};

class Student : public Person
{   // declaration mostly omitted
 public:
    Student( string name );
};

class TA :
      public Teacher, public Student
{
  public:
    TA() :
      Student(name), Teacher(name)
    {}
};
```

- Doing this is pretty simple:
- Just add to the list of classes your class inherits from
- You may need to add to the constructor init list too!



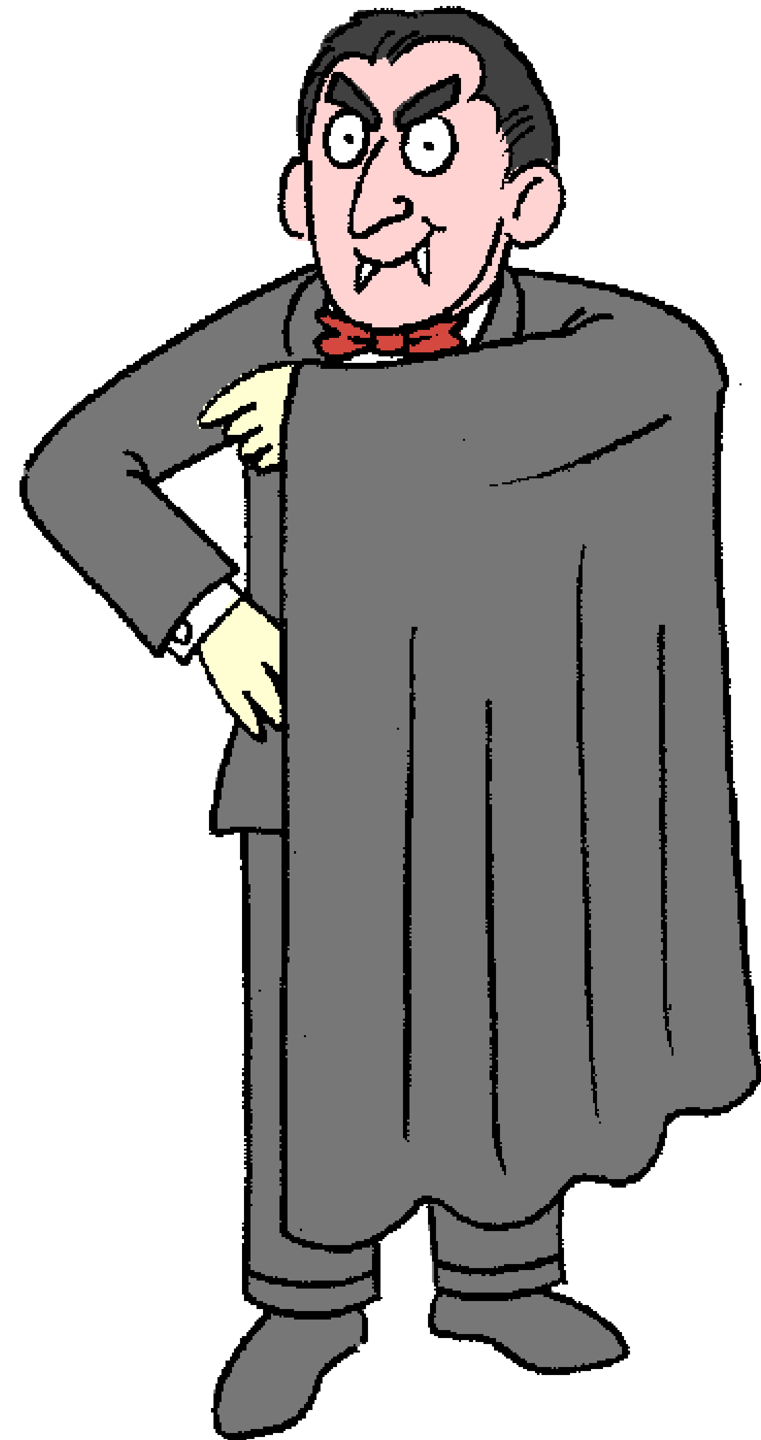
- One problem you may have noticed:
- How many copies of **name** does TeachingAssistant have?
- Which one do we use? Does it matter?

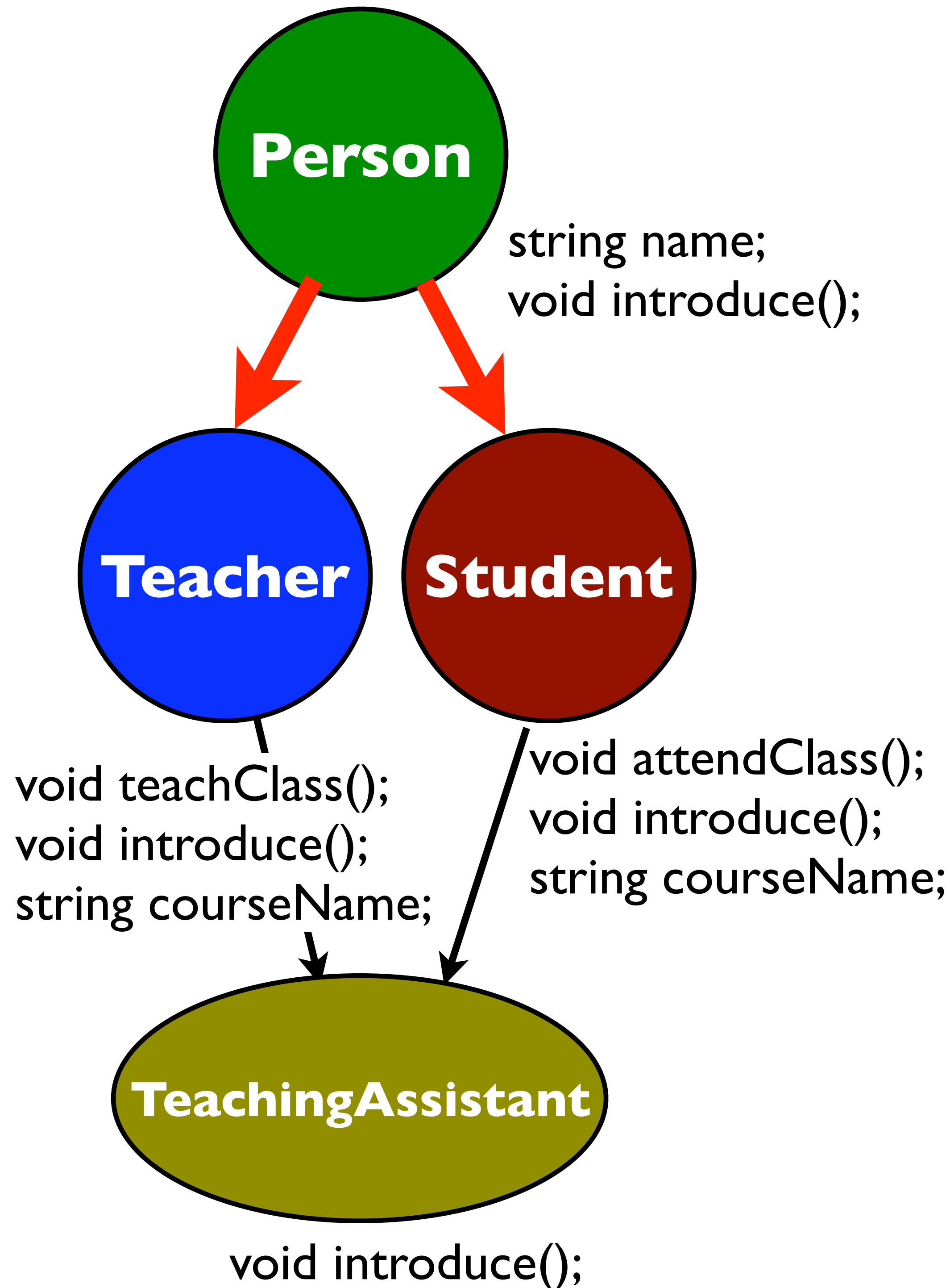
```
void TA::introduce()
{
    cout << “My name is:”;
    cout <<  (?)
    cout << “I teach: ”;
    cout <<  (?)
    cout << “I study: “;
    cout <<  (?)
}
```

- **TeachingAssistant** is derived from both **Student** and **Teacher**
- Both Student and Teacher inherited a **name** attribute from **Person**
- Therefore, TeachingAssistant has **two** copies of **name**!
- This might be OK but it might not: could each copy of name have a different value?

Virtual Inheritance

- The way to solve this: **virtual inheritance**
- If you inherit "virtually" from a base class, you tell the compiler:
  - there must be one instance of that base class if someone inherits from the current class
- This is weird, and ugly, but it solves the problem neatly





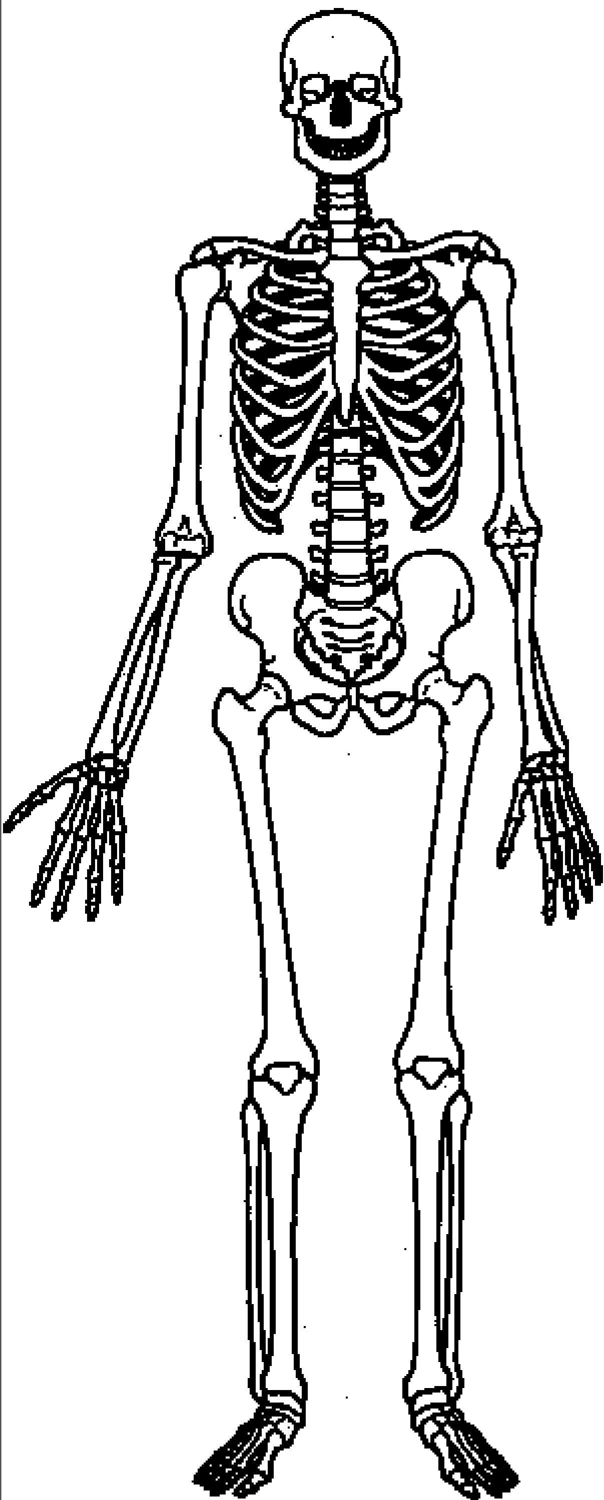
how this works:

- Before we had **two** copies of name in TeachingAssistant
- Now, Teacher and Student are inheriting *virtually* from Person (red arrows)
- So there will be only *one* copy of Person in any class inherited from Teacher and Student
- ... aka TeachingAssistant, only has a single copy of Person - (therefore, name)

Virtual Inheritance

```
// declarations mostly omitted...
class Person
{
  public:
    string name;
};

class Teacher : virtual public Person
{
  public:
    Teacher( string name );
};

class Student : virtual public Person
{
 public:
    Student( string name );
};

class TA :
      public Teacher, public Student
{
  public:
    TA(string name) :
      Student(name), Teacher(name)
    {}
};
```

- To inherit virtually, just stick the keyword **virtual** right before the **public**
- This has nothing to do with virtual functions!
- Why do *both* Student and Teacher use virtual inheritance? Is this necessary?

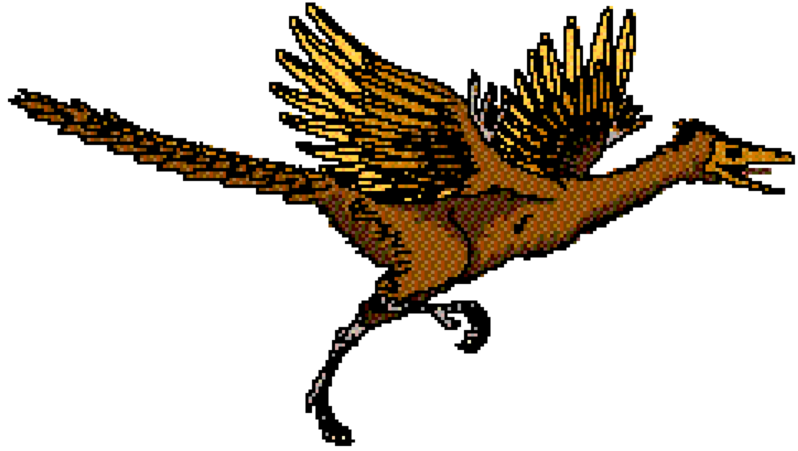


Multiple Inheritance

- Many people disagree on the usefulness of Multiple Inheritance
  - Many newer languages don't support MI at all, or only a small subset of it
- If you find yourself needing to use MI a lot, consider redesigning your classes so you don't!
- Not used nearly as widely as regular inheritance

One Method...

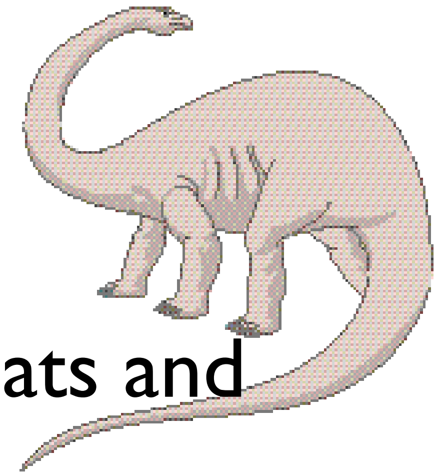
- One reasonable way to use Multiple Inheritance:
- Make all or most of the base classes be interface classes
  - What does this mean?
  - What problem does it solve?



The Basics

- I/O is a big part of nearly every program
- We've been doing simple I/O for most of the semester, using **cin** and **cout**
- **cin** and **cout** are just two examples of a more general C++ feature called **iostreams**

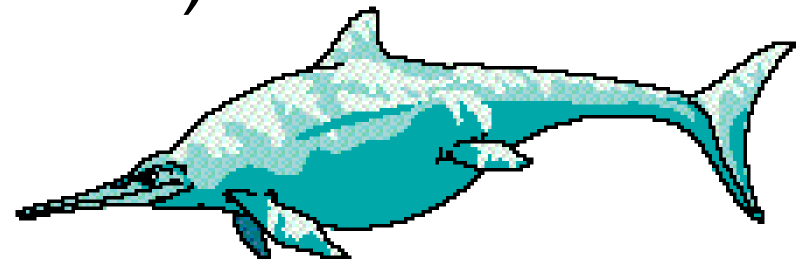
Streams



- A **stream** is a C++ object that formats and holds bytes of data
- There can be input streams (an **istream**) or an output stream (an **ostream**)
  - cin is an istream, cout is an ostream; these give you access to **stdin** and **stdout**
- Streams don't only do I/O: they also buffer the data to make I/O more efficient

iostream properties

- Streams are designed to be source independent: a stream should be used the same way regardless of where the data is coming or going
- The same interface can work on:
  - keyboard/screen I/O (cout/cin)
  - file I/O
  - network I/O
  - a string
- Thanks to the magic of... ?

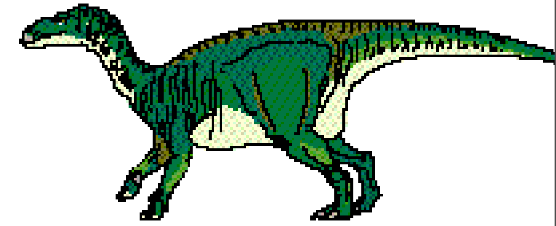


- We've been doing stuff like this all semester:

```
int input;

cin >> input;
cout << “this is some output” << endl;
```

- Let's look at what this stuff actually *is:*
  - **>>** is an *extraction* operator
  - **<<** is an *insertion* operator
  - **endl** is a *manipulator*
  - **cout** is an *ostream*; **cin** is an *istream*

Manipulators



- A *manipulator* is an object that acts on the stream itself
- **endl** is an example: when we try and "print" an endl:
  - it inserts a newline into the stream
  - it flushes the stream
- There's a bunch of other manipulators that we can use too

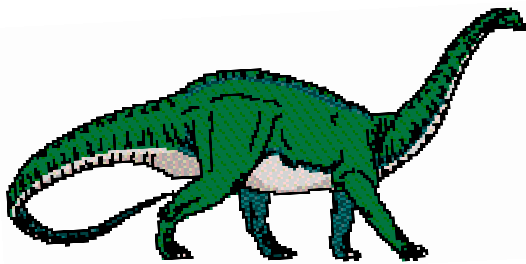
More Manipulators

- We can just flush the stream, *without* printing a newline first:

```
cout << flush;
```

- We can change the number base to oct (octal) or dec (decimal) or hex (hexadecimal) to any subsequent integers will be output in that base:

```
cout << hex << "0x" << i << endl;
```



Input

```
int i;
cin >> i;

float f;
cin >> f;

char c;
cin >> c;

char buf[100];
cin >> buf;
```

- Input tends to be fragile
- Users have to input the right data types, in the right order
- If the input isn't what the program expects, it can choke
- This is true with iostreams too:

What does this code do with this input?

```
12 1.4 c this is a test
```

The Problem

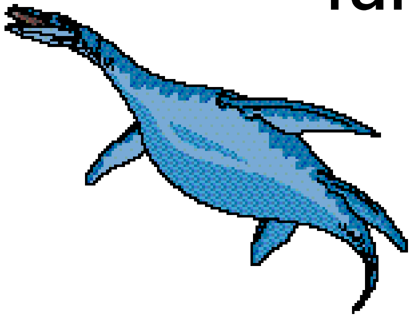
- By default, istreams are *space delimited* (as you may have seen in some of the projects)
- So when we attempt to do something like this:

```
char buf[100];
cin >> buf;
```

- with the input “this is a test”, buf will contain the word “this”
- The rest of the input stays buffered

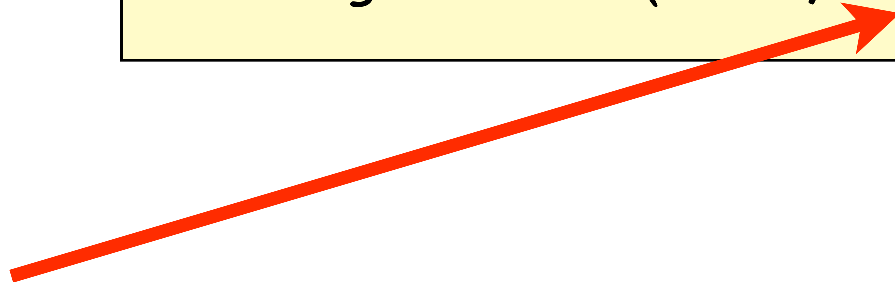
reading in a whole line

- Often you'll need to read in entire lines (until there's a newline character in the input stream)
- You do this using the **getline** member function:



```
char buf[100];
cin.getline(buf, 100);
```

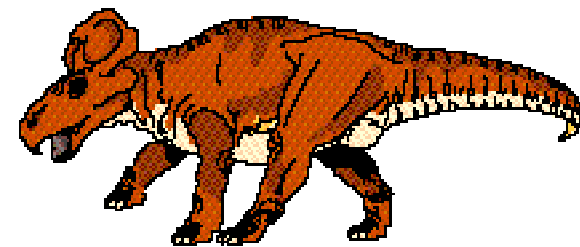
Note that we have to give cin a size, too! (why?)



Getting a character

- Another way to do things:
- Sometimes you want to get input character by character (*including* the whitespace!)
- You can do that with another cin member function:

```
cin.get();
```

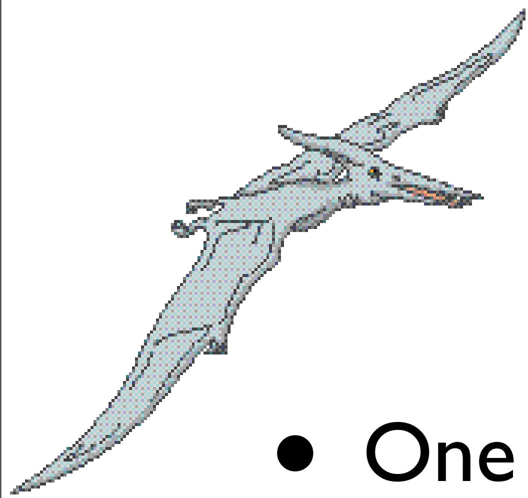


- get() reads the *next single character* from the stream (or EOF if the stream is at its end)

Streams Weirdness

- Input streaming doesn't always work the way you think it does
- How does this chunk of code act?

```
char answer;
cout << "Exit Program? [Y/N] ";
cin  >> answer;
cout << "Press Enter\n";
cin.get();
```

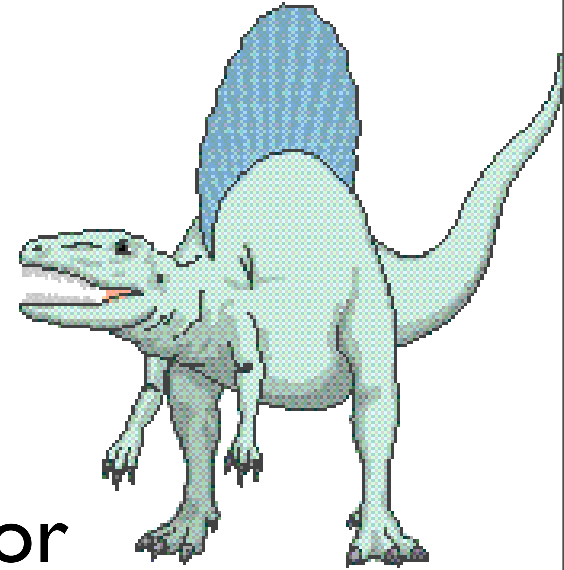


Discarding Input

- One solution: get rid of stuff in the stream buffer that we aren't going to want to deal with
- We can do this with the ignore() function:

```
cin.ignore();    // ignores a single character
cin.ignore(3);   // ignores 3 characters

// ignores 10 characters, or the “stop character”,
// whichever comes first
cin.ignore(10, ‘\n’);
```

File I/O



- So far we've used iostreams solely for console input/output
- A more important use is for file I/O
- This works largely the same way, although there's a bit more work required
- For file I/O, we must **#include<fstream>**

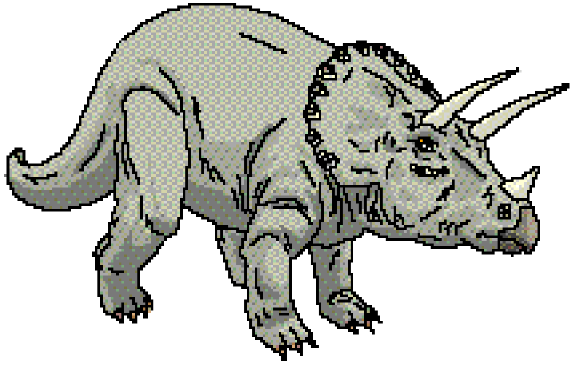
Starting Out

- To begin with, we create an object of the appropriate type: **ifstream** defaults to input, **ofstream** defaults to output
- We create the object and call good() on it to make sure it got instantiated properly:

```
ofstream output("c:\\test.txt");
if( !output.good() )
    return;
```

- At this point the object can be used much like cout or cin

Open Modes



- We can control the way a file is opened by changing an argument to the ifstream/ofstream constructor:

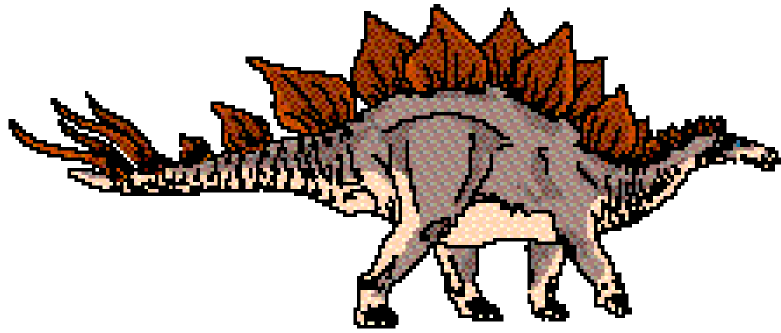
ios::in	open a file for input
ios::out	open a file for output (truncation)
ios::app	open a file for appending
ios::ate	open an existing file and seek to the end
ios::nocreate	open a file only if it *does* exist
ios::noreplace	open a file only if it does *not* exist
ios::trunc	open a file and delete the old one if it exists
ios::binary	open a file in binary mode (default is text)

Multiple Modes

- We can combine these flags by OR-ing them together with the **bitwise OR operator**: |

```
ofstream outFile(“out.txt”, ios::app | ios::nocreate );
```

- This opens “out.txt” for appending, and fails if the file doesn’t already exist
- The | operator combines the different flags together - this is pretty common



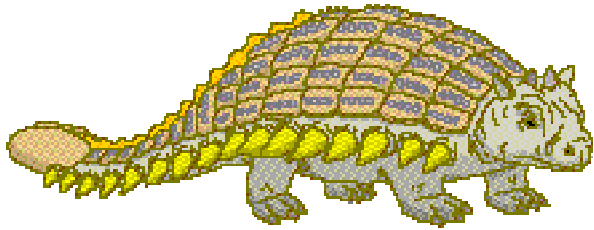
...Seeking

- Each ofstream or ifstream has a read position and a write position - we ***seek*** through the file by changing these, so the object reads from/writes to a different spot
- We do this with the **seekg** (changes the get pointer) and **seekp** (changes the put pointer) member functions
- They let us seek relative to a position: the beginning, current position, or the end

Seeking Example

- We tell the seek function to seek x number of bytes relative to the beginning (ios::beg), current position(ios::cur), or end (ios::end) of the file

```
ifstream in("test.txt");
char c;

if( !in.good() )
    return;

// seek 50 bytes from the beginning of the file
in.seekg( 50, ios::beg );
in >> c;
```



Error Handling

- We can find out whether an iostream object is OK using a few member functions:
  - **eof()** returns true if the end of the file (or input) has been reached
  - **fail()** returns true if some operation has failed - formatting issues, for example
  - **bad()** returns true if something serious went wrong - running out of memory, for example
  - **good()** returns true if none of that stuff happened and everything is groovy

Error Handling 2

- To “reset” the error status of an iostream object, you can use the **clear()** function
- We might do this if we want to keep using the object - aka “rewind” a file and read some more from it
- clear() only resets the error status - it doesn’t do anything with the buffer

Insertion/Extraction

- iostreams are a library, not built into the language
- So << and >> don't have any special I/O meaning to the compiler - these are all overloaded!
- So for every data type that can appear on the right side of a >>, there's an overloaded **operator>>** function somewhere

```
int input;
cin >> input;
```

This works because istream defines an operator>> that accepts an integer as a parameter

Insertion/Extraction

- So far we haven't learned any way to make the following code work
- The **<<** operator is not defined for MyClass and ostreams, so this is a compiler error

```
class MyClass
{
    // stuff is declared here
};

MyClass m;
cout << m << endl;
```

- We can make it work providing that definition

Operator Overloading

- When we're overloading << and >> for our classes, these overloaded operators *can't be defined* as member functions!
- They still need access to private class data, though, so they're usually defined as global functions, and declared as friends
- Once we've overloaded << and >> for a custom class, we can use that class with iostreams such as cin/cout

```
class TwoInts
{
  public:
    TwoInts()
    { one = two = 17; }

    friend ostream& operator<<( ostream&, TwoInts& );
    friend istream& operator>>( istream&, TwoInts& );

  private:
    int one, two;
};

ostream& operator<<( ostream& out, TwoInts& ti )
{
   out << ti.one << ti.two;
   return out;
}

istream& operator>>( istream& in, TwoInts& ti )
{
   in >> ti.one;
   in >> ti.two;
   return in;
}
```

Example...

- Reading in a list of information from a file using iostreams

Project 4

- The goal of Project 4 is to create a simple Account Manager using file I/O and polymorphism
- Create different classes representing several different types of accounts: credit card, savings account, checking account, all derived from a common base
- The program should save the balance of each account in a file upon exiting and reload it upon startup
- The program should be written using polymorphism wherever possible