C++ Constructor Insanity CSE 333 Fall 2022

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Administrivia

- Next exercise released today, due Monday morning
 - Write a substantive class in C++ (but no dynamic allocation yet)
 - Look at Complex.h/Complex.cc (this lecture) for ideas
 - We now have a C/C++ style checker (cpplint) that works on the current linux systems! See the web Resources page for links
 - Questions, reports of unusual results, etc. to ed discussion board please
- Homework 2 due next Thursday (10/27)
 - How's it going? Any surprises, questions, problems?
- Please submit regrade requests for assignments promptly
 - Will be shutting down regrades about a week after feedback returned so we can copy grades to final canvas gradebook

- * Constructors
- Copy Constructors
- Assignment
- Destructors
- An extended example

Constructors

- * A constructor (ctor) initializes a newly-instantiated object
 - A class can have multiple constructors that differ in parameters
 - Which one is invoked depends on *how* the object is instantiated
- Written with the class name as the method name:

Point(const int x, const int y);

- C++ will automatically create a synthesized default constructor if you have no user-defined constructors
 - Takes no arguments and calls the default ctor on all non-"plain old data" (non-POD) member variables
 - Synthesized default ctor will fail if you have non-initialized const or reference data members

Synthesized Default Constructor

```
class SimplePoint {
 public:
  // no constructors declared!
  int get_x() const { return x ; } // inline member function
  int get_y() const { return y ; } // inline member function
  double Distance(const SimplePoint& p) const;
 void SetLocation(const int x, const int y);
 private:
  int x ; // data member
  int y ; // data member
}; // class SimplePoint
                                                     SimplePoint.h
#include "SimplePoint.h"
                                                     SimplePoint.cc
... // definitions for Distance() and SetLocation()
int main(int argc, char** argv) {
  SimplePoint x; // invokes synthesized default constructor
  return 0;
}
```

Synthesized Default Constructor

 If you define any constructors, C++ assumes you have defined all the ones you intend to be available and will not add any others

Multiple Constructors (overloading)

```
#include "SimplePoint.h"
// default constructor
SimplePoint::SimplePoint() {
  x = 0;
  y = 0;
}
// constructor with two arguments
SimplePoint::SimplePoint(const int x, const int y) {
  X = X;
  y = y;
}
void foo() {
  SimplePoint x; // invokes the default constructor
  SimplePoint a[3]; // invokes the default ctor 3 times
                      // (fails if no default ctor)
  SimplePoint y(1, 2); // invokes the 2-int-arguments ctor
}
```

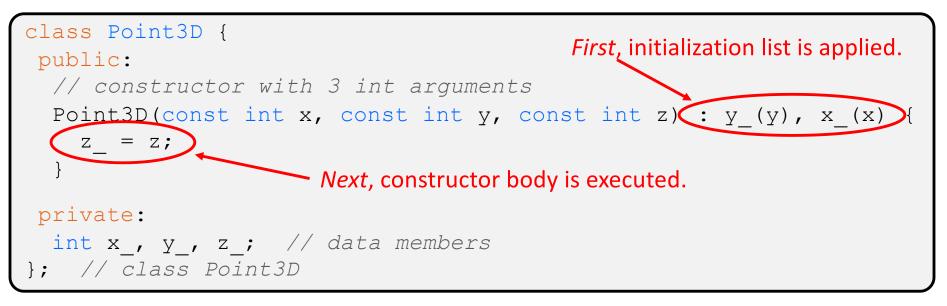
Initialization Lists

- C++ lets you optionally declare an initialization list as part of a constructor definition
 - Initializes fields according to parameters in the list
 - The following two are (nearly) identical:

```
Point::Point(const int x, const int y) {
    x_ = x;
    y_ = y;
    std::cout << "Point constructed: (" << x_ << ",";
    std::cout << y_<< ")" << std::endl;
}</pre>
```

```
// constructor with an initialization list
Point::Point(const int x, const int y) : x_(x), y_(y) {
   std::cout << "Point constructed: (" << x_ << ",";
   std::cout << y_<< ")" << std::endl;
}</pre>
```

Initialization vs. Construction



- Data members in initializer list are initialized in the order they are defined in the class, not by the initialization list ordering (!)
 - Data members that don't appear in the initialization list are *default initialized/constructed* before body is executed
- Initialization preferred to assignment to avoid extra steps of default initialization (construction) followed by assignment
- (and no, real code should never mix the two styles this way ⁽ⁱ⁾)

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Copy Constructors

- C++ has the notion of a copy constructor (cctor)
 - Used to create a new object as a copy of an existing object

```
Point::Point(const int x, const int y) : x_(x), y_(y) { }
// copy constructor
Point::Point(const Point& copyme) {
    x_ = copyme.x_;
    y_ = copyme.y_;
}
void foo() {
    Point x(1, 2); // invokes the 2-int-arguments constructor
    Point y(x); // invokes the copy constructor
    // could also be written as "Point y = x;"
}
```

Initializer lists can also be used in copy constructors (preferred)

When Do Copies Happen?

- The copy constructor is invoked if:
 - You *initialize* an object from another object of the same type:
 - You pass a non-reference object as a value parameter to a function:

Point	х;	// default ctor
Point	y(x);	// copy ctor
Point	z = y;	// copy ctor

void foo (Poi	nt x) { }
Point y;	// default ctor
foo (y);	// copy ctor

 You return a non-reference object value from a function:

<pre>Point foo()</pre>	{	
Point y;		// default ctor
return y;		// copy ctor
}		

Compiler Optimization

- The compiler sometimes uses a "return by value optimization" or "move semantics" to eliminate unnecessary copies
 - Sometimes you might not see a constructor get invoked when you might expect it

```
Point foo() {
   Point y;   // default ctor
   return y;   // copy ctor? optimized?
}
Point x(1, 2);  // two-ints-argument ctor
Point y = x;   // copy ctor
Point z = foo();  // copy ctor? optimized?
```

Synthesized Copy Constructor

- If you don't define your own copy constructor, C++ will synthesize one for you
 - It will do a *shallow* copy of all of the fields (*i.e.* member variables) of your class
 - Sometimes the right thing; sometimes the wrong thing

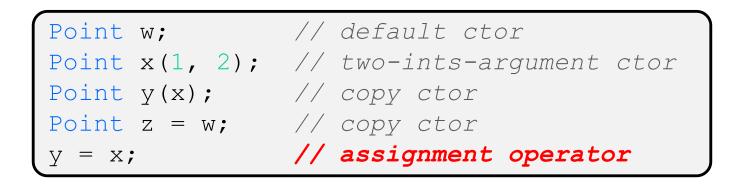
```
#include "SimplePoint.h"
... // definitions for Distance() and SetLocation()
int main(int argc, char** argv) {
   SimplePoint x;
   SimplePoint y(x); // invokes synthesized copy constructor
   ...
   return 0;
}
```

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Assignment != Construction

* "=" is the assignment operator

Assigns values to an *existing, already constructed* object



Overloading the "=" Operator

- You can choose to define the "=" operator
 - But there are some rules you should follow:

```
Point& Point::operator=(const Point& rhs) {
    if (this != &rhs) { // (1) always check against this
        x_ = rhs.x_;
        y_ = rhs.y_;
    }
    return *this; // (2) always return *this from op=
}
Point a; // default constructor
a = b = c; // works because = return *this
a = (b = c); // equiv. to above (= is right-associative)
(a = b) = c; // "works" because = returns a non-const
```

Synthesized Assignment Operator

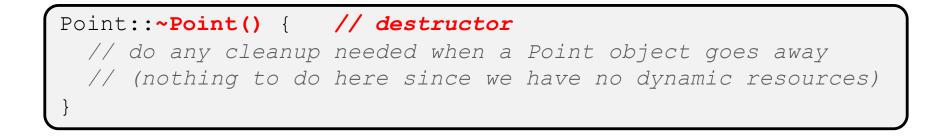
- If you don't define the assignment operator, C++ will synthesize one for you
 - It will do a *shallow* copy of all of the fields (*i.e.* member variables) of your class
 - Sometimes the right thing; sometimes the wrong thing

```
#include "SimplePoint.h"
... // definitions for Distance() and SetLocation()
int main(int argc, char** argv) {
   SimplePoint x;
   SimplePoint y(x);
   y = x; // invokes synthesized assignment operator
   return 0;
}
```

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Destructors

- C++ has the notion of a destructor (dtor)
 - Invoked automatically when a class instance is deleted, goes out of scope, etc. (even via exceptions or other causes!)
 - Place to put your cleanup code free any dynamic storage or other resources owned by the object
 - Standard C++ idiom for managing dynamic resources
 - Slogan: "Resource Acquisition Is Initialization" (RAII)



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Complex Example Walkthrough

See: Complex.h Complex.cc testcomplex.cc

 (Some details like friend functions and namespaces are explained in more detail next lecture, but ideas should make sense from looking at the code and explanations in *C++ Primer*. Use similar ideas for the new exercise.)

Extra Exercise #1

- Modify your Point3D class from Lec 10 Extra #1
 - Disable the copy constructor and assignment operator
 - Attempt to use copy & assignment in code and see what error the compiler generates
 - Write a CopyFrom() member function and try using it instead
 - (See details about CopyFrom () in next lecture)

Extra Exercise #2

- Write a C++ class that:
 - Is given the name of a file as a constructor argument
 - Has a GetNextWord() method that returns the next whitespace- or newline-separated word from the file as a copy of a string object, or an empty string once you hit EOF
 - Has a destructor that cleans up anything that needs cleaning up