6.096 Lecture 5 – Object-Oriented C++
Abstraction, Inheritance, STL

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Outline

1. Assignment 2
2. Crash course in the STL
3. Inheritance
4. Pitfalls
Assignment 2

Linked list library (list)
- Writing linked list code that other programs can use
- No memory leaks!

Minimum spanning tree (mst)
- Using the STL
- Implementing an algorithm
- Writing fast C++

Rational numbers library (rational)
- Overloading arithmetic functions
- Edge cases
- Exceptions
Crash course in the STL

<vector>

Remember the Array class we were writing last time? A better version already exists in C++, so we don’t need to write it ourselves!

```cpp
#include <vector>

// In our code:
std::vector<int> intArray;
while (/* getting data */ ) {
    intArray.push_back(data);
}
int tenthItem = intArray[9]; // like an array
// Automatically destroys data when done
```

The angle brackets < and > let us specialize this type: we can replace T with any other type T, like `std::vector<T>`. 
Crash course in the STL

STL? What’s that?

STL stands for Standard Template Library. Containers and algorithms to use on those containers, all with a common interface. Another vector:

```cpp
#include <vector>
#include <string>

// In our code:
std::vector<std::string> stringList;
stringList.push_back( "C99" );
stringList.push_back( "C++03" );
stringList.push_back( "C++11" );
for( auto str : stringList ) { // "range-for"
    std::cout << str << "\n";
}
```
Some (BAD!) code that needs to be refactored

We’ve got a struct to hold some shape data for different ShapeTypes.

```cpp
#include <iostream>

enum ShapeType { CIRCLE = 0, SQUARE = 1, RECTANGLE = 2, TRIANGLE = 3 };

struct Shape {
  ShapeType type;
  double a, b, c, d;
};
```

And we want a function to compute the area, given a shape.
Some (BAD!) code that needs to be refactored

Without some good object-oriented practices, code like this can become a tangled mess of switch or if/else statements.

```cpp
// BAD CODE!
double area( const Shape &shape ) {
    switch( shape.type ) {
        case CIRCLE: return M_PI * shape.a * shape.a;
        case SQUARE: return shape.a * shape.a;
        case RECTANGLE: return shape.a * shape.b;
        case TRIANGLE: return 0.5 * shape.a * shape.b;
        default: std::cerr << "Error, invalid shape!\n";
    }
    return 0.0;
}
```
What’s so bad?

Any time we want to make a function that works differently on different types of shapes, we need this same switch statement.

Lots of code repetition.

The member variable names do not describe their purpose.

Not extensible: when we add a new shape, we have to modify every one of these functions.
Our refactoring: an abstract class

- Let's create an abstract class Shape. We do this by giving the class some virtual functions; these are functions which child classes can override.
- Could have member variables or not (in this case, we won’t)
- Pure virtual functions (the = 0).
- Notice the destructor is virtual.

```cpp
class Shape {
public:
    virtual double area() const = 0; // pure virtual
    virtual ~Shape() {}
};
```
Inheritance

class Shape {
public:
    virtual double area() const = 0; //pure virtual
    virtual ~Shape() {};
};
class Circle : public Shape {
    double _radius;
public:
    Circle(double theRadius) : _radius{theRadius} {}
    ~Circle() {};
    inline double radius() const { return _radius; }
    double area() const {
        return _radius * _radius * M_PI;
    }
};
Inheritance

Closer look at the child class...

- Syntax is `class Derived : public Base`

```cpp
class Circle : public Shape {
    double _radius;

public:
    Circle( double theRadius ) : _radius{theRadius} {}
    ~Circle() {}
    inline double radius() const { return _radius; }
    double area() const { return _radius * _radius * M_PI; }
};
```
Know the functions C++ automatically creates!

Looks like a pretty empty class, right?

```cpp
class Empty{};
```
Pitfalls

Know the functions \texttt{C++} automatically creates!

Looks like a pretty empty class, right? **Wrong!**

```cpp
class Empty{
public:
    Empty() { /*...*/ } // constructor
    // copy constructor
    Empty( const Empty &rhs ) { /*...*/ } // copy assignment
    Empty& operator=( const Empty& rhs ) { /*...*/ }
    ~Empty() { /*...*/ } // destructor
};
```

If we don’t want these functions, have to disallow by making them private and indicating = \texttt{delete}!
Some other tips from Scott Meyers:

- Item 7: Declare destructors virtual in polymorphic classes.
- Item 10: Have assignment operators return a reference to *this.
- Item 12: Copy all parts of an object.
- Item 22: Declare data members private
- Item 32: Make sure public inheritance models “is-a”.

Read his book, Effective C++!
Let’s see some examples...
Wrap-up & Wednesday

**Monday** is a holiday!

Second assignment due Weds. at midnight

Class on Weds.

- Design patterns and anti-patterns

Questions?

- Office hours Mon, Tues in 26-142
6.S096 Effective Programming in C and C++

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