

Objects and classes

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Fall 2018

Classes

Classes look a bit like structures

Code:

```
class Vector {  
public:  
    double x,y;  
};  
  
int main() {  
    Vector p1;  
    p1.x = 1.; p1.y = 2.; // This Is Not A Good Idea. See later.  
    cout << "sum of components: " << p1.x+p1.y << endl;
```

Output:

sum of components: 3

We'll get to that 'public' in a minute.

Class initialization and use

Use a *constructor*: function with same name as the class.

```
class Vector {  
private: // recommended!  
    double vx,vy;  
public:  
    Vector( double x,double y ) {  
        vx = x; vy = y;  
    };  
  
}; // end of class definition  
  
int main() {  
    Vector p1(1.,2.);  
}
```

Example of accessor functions

Getting and setting of members values is done through accessor functions:

```
class Vector {  
private: // recommended!  
    double vx,vy;  
public:  
    Vector( double x,double y ) {  
        vx = x; vy = y;  
    };  
};
```

```
double x() { return vx; };  
double y() { return vy; };  
void setx( double newx ) {  
    vx = newx; };  
void sety( double newy ) {  
    vy = newy; };  
};
```

```
}; // end of class definition
```

```
int main() {  
    Vector p1(1.,2.);  
};
```

Usage:

```
p1.setx(3.12);  
/* ILLEGAL: p1.x() = 5; */  
cout << "P1's x=" << p1.x() << endl;
```

Interface versus implementation

- Implementation: data members, keep private,
- Interface: public functions to get/set data.
- Protect yourself against inadvertant changes of object data.
- Possible to change implementation without rewriting calling code.

Private access gone wrong

We make a class with two members that sum to one.
You don't want to be able to change just one of them!

```
class SumIsOne {
public:
    float x,y;
    SumIsOne( double xx ) { x = xx; y = 1-x; };
}
int main() {
    SumIsOne pointfive(.5);
    pointfive.y = .6;
}
```

In general: enforce predicates on the members.

Member default values

Class members can have default values, just like ordinary variables:

```
class Point {  
private:  
    float x=3., y=.14;  
private:  
    // et cetera  
}
```

Each object will have its members initialized to these values.

Member initialization

Other syntax for initialization:

```
class Vector {
private:
    double x,y;
public:
    Vector( double userx,double usery ) : x(userx),y(usery) {
    }
```

Even:

Code:

Output:

p1 = 1,2

Initializer lists can be used as denotations.

```
Point(float ux,float uy) {
/* ... */
Rectangle(Point bl,Point tr) {
/* ... */
    lieLow( {0,0}, {5,2} );
```

Methods

Functions on objects

Code:

```
class Vector {
private:
    double vx,vy;
public:
    Vector( double x,double y ) {
        vx = x; vy = y;
    };
    double length() { return sqrt(vx*vx + vy*vy); };
    double angle() { return 0.; /* something trig */; };
};

int main() {
    Vector p1(1.,2.);
    cout << "p1 has length " << p1.length() << endl;
```

Output:

p1 has length 2.23607

We call such internal functions 'methods'.
Data members, even private, are global to the methods.

Methods that alter the object

Code:

```
class Vector {  
    /* ... */  
    void scaleby( double a ) {  
        vx *= a; vy *= a; };  
    /* ... */  
};  
/* ... */  
Vector p1(1.,2.);  
cout << "p1 has length " << p1.length() << endl;  
p1.scaleby(2.);  
cout << "p1 has length " << p1.length() << endl;
```

Output:

```
p1 has length 2.23607  
p1 has length 4.47214
```

Methods that create a new object

Code:

```
class Vector {  
    /* ... */  
    Vector scale( double a ) {  
        return Vector( vx*a, vy*a ); };  
    /* ... */  
};  
/* ... */  
cout << "p1 has length " << p1.length() << endl;  
Vector p2 = p1.scale(2.);  
cout << "p2 has length " << p2.length() << endl;
```

Output:

```
p1 has length 2.23607  
p2 has length 4.47214
```

Default constructor

```
Vector p1(1.,2.), p2;  
cout << "p1 has length " << p1.length() << endl;  
p2 = p1.scale(2.);  
cout << "p2 has length " << p2.length() << endl;
```

gives (g++; different for intel):

```
pointdefault.cxx: In function 'int main()':  
pointdefault.cxx:32:21: error: no matching function for call to  
      'Vector::Vector()'  
      Vector p1(1.,2.), p2;
```

The problem is with p2. How is it created? We need to define two constructors:

```
Vector() {};  
Vector( double x,double y ) {  
    vx = x; vy = y;  
};
```

Exercise 1

```
class Point {  
private:  
    float x,y;  
public:  
    Point(float ux,float uy) { x = ux; y = uy; };  
    float distance(Point other) {  
        float xd = x-other.x, yd = y-other.y;  
        return sqrt( xd*xd + yd*yd );  
    };  
};
```

Access to internals

Class initialization and use

Use a *constructor*: function with same name as the class.

```
class Vector {  
private: // recommended!  
    double vx,vy;  
public:  
    Vector( double x,double y ) {  
        vx = x; vy = y;  
    };  
  
}; // end of class definition  
  
int main() {  
    Vector p1(1.,2.);  
}
```

Accessor for setting private data

Class methods:

```
double x() { return vx; };  
double y() { return vy; };  
void setx( double newx ) {  
    vx = newx; };  
void sety( double newy ) {  
    vy = newy; };
```

Use accessor functions!

```
class PositiveNumber { /* ... */ }  
class Point {  
private:  
    // data members  
public:  
    Point( float x,float y ) { /* ... */ };  
    Point( PositiveNumber r,float theta ) { /* ... */ };  
    float get_x() { /* ... */ };  
    float get_y() { /* ... */ };  
    float get_r() { /* ... */ };  
    float get_theta() { /* ... */ };  
};
```

Functionality is independent of implementation.

Exercise 2

```
class LinearFunction {
private:
    Point p1,p2;
public:
    LinearFunction( Point &input_p2 ) {
        p1 = Point(0.,0.);
        p2 = input_p2;
    };
    LinearFunction( Point &input_p1,Point &input_p2 ) {
        p1 = input_p1; p2 = input_p2;
    };
    float evaluate_at( float x ) {
        float slope = (p2.y-p1.y) / (p2.x-p1.x);
        float intercept = p1.y - p1.x * slope;
        return intercept + x*slope;
    };
};
```

Exercise 3

```
class LinearFunction {
private:
    Point p1,p2;
public:
    LinearFunction( Point &input_p2 ) {
        p1 = Point(0.,0.);
        p2 = input_p2;
    };
    LinearFunction( Point &input_p1,Point &input_p2 ) {
        p1 = input_p1; p2 = input_p2;
    };
    float evaluate_at( float x ) {
        float slope = (p2.y-p1.y) / (p2.x-p1.x);
        float intercept = p1.y - p1.x * slope;
        return intercept + x*slope;
    };
};
```

Exercise 4

```
struct primesequance {
    int number_of_primes_found = 0;
    int last_number_tested = 1;
} ;

int nextprime( struct primesequance &sequence ) {
    do {
        sequence.last_number_tested++;
    } while (!isprime(sequence.last_number_tested));
    sequence.number_of_primes_found++;
    return sequence.last_number_tested;
};
```

Exercise 5

```
primes sequence;
for (int even=4; even<2000; even+=2) {
    cout << "Testing: " << even << endl;
    bool found = false;
    for ( int p = sequence.firstprime(); p<even ; p=sequence.nextprime() ) {
        int q = even-p;
        if (isprime(q)) {
            found = true;
            cout << even << "=" << p << "+" << q << endl;
        }
        if (found) break; // stop the q loop
    }
    if (!found) cout << "Stop the presses! Counter example: " << even << endl;
}
```

More about constructors

Copy constructor

- Several default copy constructors are defined
- They copy an object, recursively.
- You can redefine them as needed.

```
class has_int {  
private:  
    int mine{1};  
public:  
    has_int(int v) {  
        cout << "set: " << v << endl;  
        mine = v; };  
    has_int( has_int &h ) {  
        auto v = h.mine;  
        cout << "copy: " << v << endl;  
        mine = v; };  
    void printme() { cout  
        << "I have: " << mine << endl; };  
};
```

Code:

```
has_int an_int(5);  
has_int other_int(an_int);  
an_int.printme();  
other_int.printme();
```

Output:

```
set: 5  
copy: 5  
I have: 5  
I have: 5
```

Copying is recursive

Class with a vector:

```
class has_vector {  
private:  
    vector<int> myvector;  
public:  
    has_vector(int v) { myvector.push_back(v); };  
    void set(int v) { myvector.at(0) = v; };  
    void printme() { cout  
        << "I have: " << myvector.at(0) << endl; };  
};
```

Copying is recursive, so the copy has its own vector:

Code:

```
has_vector a_vector(5);  
has_vector other_vector(a_vector);  
a_vector.set(3);  
a_vector.printme();  
other_vector.printme();
```

Output:

```
I have: 3  
I have: 5
```

Destructor

- Every class `myclass` has a *destructor* `~myclass` defined by default.
- The default destructor does nothing:

```
~myclass() {};
```
- A destructor is called when the object goes out of scope.
Great way to prevent memory leaks: dynamic data can be released in the destructor.

Destructor example

Destructor called implicitly:

Code:

```
class SomeObject {
public:
    SomeObject() { cout <<
        "calling the constructor"
        << endl; };
    ~SomeObject() { cout <<
        "calling the destructor"
        << endl; };
};

/* ... */
cout << "Before the nested scope" << endl;
{
    SomeObject obj;
    cout << "Inside the nested scope" << endl;
}
cout << "After the nested scope" << endl;
```

Output:

Before the nested scope
calling the constructor
Inside the nested scope
calling the destructor
After the nested scope

Other object stuff

'this'

Inside an object, a *pointer* to the object is available as `this`:

```
class MyClass {  
private:  
    int myint;  
public:  
    MyClass(int myint) {  
        this->myint = myint;  
    };  
};
```

(also for calling functions inside the object that need the object as argument)

Class prototypes

Header file:

```
class something {  
public:  
    double somedo(vector);  
};
```

Implementation file:

```
double something::somedo(vector v) {  
    .... something with v ....  
};
```

Strangely, data members also go in the header file.