

Structures

Kevin Schmidt, Susan Lindsey, Charlie Dey

Spring 2019

Structures

Bundling information

Sometimes a number of variables belong logically together. For instance two doubles can be the x, y components of a vector.

This can be captured in the struct construct.

```
struct vector {  
    double x; double y; int label;  
};
```

(This can go in the main program or before it.)

The elements of a structure are usually called *members*.

How to use structures

1. Declare what is in your structure;
2. Make some structures;
3. Use them.

```
// definition of the struct
struct AStructName { int num; double val; }
int main() {
    // declaration of struct variables
    AStructName mystruct1, mystruct2;
    .... code that uses your structures ....
}
```

Using structures

Once you have defined a structure, you can make variables of that type. Setting and initializing them takes a new syntax:

Code:

```
int main() {  
  
    struct vector v1,v2;  
  
    v1.x = 1.; v1.y = 2.; v1.label = 5;  
    v2 = {3.,4.,5};  
  
    v2 = v1;  
    cout << "v2: "  
        << v2.x << ", " << v2.y  
        << endl;
```

Output

[struct] point:

```
./point  
v2: 1,2
```

Period syntax: 'apostrophe-s'.

Review quiz 1

True or false?

- All members of a struct have to have the same type.
- Writing

```
struct numbered { int n; double x; };
```

creates an object with an integer and a double as members.

- With the above definition and `struct numbered xn;`,

```
cout << xn << endl;
```

is correct C++.

- Same,

```
xn.x = xn.n+1;
```

Struct initialization

You assign a whole struct, or set defaults in the definition.

```
struct vector_a { double x; double y; } ;  
// needs compiler option: -std=c++11  
struct vector_b { double x=0; double y=0; } ;  
  
int main() {  
  
    // initialization when you create the variable:  
    struct vector_a x_a = {1.5,2.6};  
    // initialization done in the structure definition:  
    struct vector_b x_b;  
    // ILLEGAL:  
    // x_b = {3.7, 4.8};  
    x_b.x = 3.7; x_b.y = 4.8;  
}
```

Functions on structures

You can pass a structure to a function:

Code:

```
double distance
( struct vector v1,
  struct vector v2 )
{
    double
        d1 = v1.x-v2.x, d2 = v1.y-v2.y;
    return sqrt( d1*d1 + d2*d2 );
}

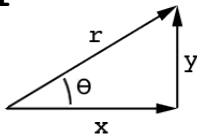
/* ... */
struct vector v1 = { 1.,1. };
cout << "Displacement x,y?";
double dx,dy; cin >> dx >> dy; cout
    << endl;
cout << "dx=" << dx << ", dy=" << dy
    << endl;
struct vector v2 = { v1.x+dx,v1.y+dy
    };
cout << "Distance: " << distance(v1,
    v2) << endl;
```

Output

[struct] pointfun:

Displacement x,y?
dx=5, dy=12
Distance: 13

Exercise 1



Write a function that, given a vector as defined above, returns the angle with the x -axis. (Hint: the `atan` function is in `cmath`)

Code:

```
struct vector a = {1.,1.};  
double  
    alpha = angle(a),  
    pifrac = (4.*atan(1.0)) / alpha;  
cout << "Angle of ("  
    << a.x << ", " << a.y  
    << ") is " << angle(a)  
    << ", or pi/" << pifrac  
    << endl;
```

Output

[struct] pointangle:

Angle of (1,1) is 0.785398, or pi/4
Angle of (0.866025,0.5) is 0.523599

Exercise 2

Write a void function that has a struct vector parameter, and exchanges its coordinates:

$$\begin{pmatrix} 2.5 \\ 3.5 \end{pmatrix} \rightarrow \begin{pmatrix} 3.5 \\ 2.5 \end{pmatrix}$$

Code:

```
struct vector a = {3.,2.};  
cout << "Flip of ("  
    << a.x << ", " << a.y << ")";  
flip(a);  
cout << " is ("  
    << a.x << ", " << a.y  
    << ")" << endl;
```

Output

[struct] pointflip:

Flip of (3,2) is (2,3)

Returning structures

You can return a structure from a function:

Code:

```
struct vector vector_add
( struct vector v1,
  struct vector v2 ) {
    struct vector p_add =
      {v1.x+v2.x, v1.y+v2.y};
    return p_add;
};

/* ... */
v3 = vector_add(v1, v2);
cout << "Added: " <<
    v3.x << ", " << v3.y << endl;
```

Output

[struct] pointadd:

Added: 5,6

(In case you're wondering about scopes and lifetimes here: the explanation is that the returned value is copied.)

Exercise 3

Write a function $y = f(x, a)$ that takes a struct vector and double parameter as input, and returns a vector that is the input multiplied by the scalar.

$$\begin{pmatrix} 2.5 \\ 3.5 \end{pmatrix}, 3 \rightarrow \begin{pmatrix} 7.5 \\ 10.5 \end{pmatrix}$$

Denotations

You can use initializer lists as struct *denotations*:

Code:

```
cout << "Distance: "  
      << distance( {1.,2.}, {6.,14.} )  
      << endl;
```

Output

[struct] pointdenote:

Displacement x,y?
dx=5, dy=12
Distance: 13

Exercise 4

Write a function `inner_product` that takes two vector structures and computes the inner product.

Exercise 5

Write a 2×2 matrix class (that is, a structure storing 4 real numbers), and write a function `multiply` that multiplies a matrix times a vector.

Can you make a matrix structure that is based on the vector structure, for instance using vectors to store the matrix rows, and then using the inner product method to multiply matrices?

Project Exercise 6

Rewrite the exercise that found a predetermined number of primes, putting the `number_of_primes_found` and `last_number_tested` variables in a structure. Your main program should now look like:

```
cin >> nprimes;
struct primesequence sequence;
while (sequence.number_of_primes_found < nprimes) {
    int number = nextprime(sequence);
    cout << "Number " << number << " is prime" << endl;
}
```

Hint: the variable `last_number_tested` does not appear in the main program. Where does it get updated? Also, there is no update of `number_of_primes_found` in the main program. Where do you think it would happen?

Turn it in!

- If you have compiled your program, do:
`sdsteststruct yourprogram.cc`
where 'yourprogram.cc' stands for the name of your source file.
- Is it reporting that your program is correct? If so, do:
`sdsteststruct -s yourprogram.cc`
where the -s flag stands for 'submit'.
- If you don't manage to get your code working correctly, you can submit as incomplete with
`sdsteststruct -i yourprogram.cc`