Structures

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Structures

Bundling information

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

This can be captured in the `struct` construct.

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

(This is a declaration; it can go in the main program or before it.)

The elements of a structure are usually called members.

How to use structures

1. Define the structure: what members are in it.
2. Declare some structure variables;
3. Use these variables.

```
// definition of the struct
struct StructName { int num; double val; }
int main() {
  // declaration of struct variables
  StructName 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 Point p1,p2;

  p1.x = 1.; p1.y = 2.; p1.label = 5;
  p2 = {3.,4.,5};

  p2 = p1;
  cout << "p2: "
       << p2.x << "," << p2.y
       << endl;
```

Output

[struct] point:

```
./point
p2: 1,2
```

Period syntax: compare to possessive 'apostrophe-s' in English.

Review quiz 1

True or false?

- All members of a struct have to be of the same type.
  `/poll struct members all the same type`
- Writing

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

  creates a structure with an integer and a double as members.
  `/poll 'struct numbered  int n; double x; ;' creates struct with int and double`
- All members of a struct have to be of different types.
  `/poll All struct members have to be different types`
- With the above definition and `struct numbered xn;`,

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

  Is this correct C++?
  `/poll 'cout << xn << endl;' legal?`
- With the same definitions, is this correct C++?

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

  `/poll 'xn.x = xn.n+1;' legal?`

Struct initialization

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

```
struct Point_a { double x; double y; } ;

// initialization when you create the variable:
struct Point_a x_a = {1.5,2.6};
```

Functions on structures

You can pass a structure to a function:

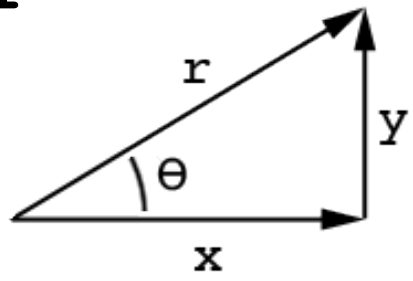
Code:

```
double distance
  ( struct point p1,
    struct point p2 )
{
  double
    d1 = p1.x-p2.x, d2 = p1.y-p2.y;
  return sqrt( d1*d1 + d2*d2 );
}
  /* ... */
  cout << "dx=" << dx
       << ", dy=" << dy << endl;
  struct point p2 = { p1.x+dx,p1.y+dy
    };
  cout << "Distance: "
       << distance(p1,p2) << endl;
```

Output
[struct] pointfun:

```
dx=5, dy=12
Distance: 13
```

Exercise 1



Write a point structure, and a function that, given such a point, returns the angle with the x-axis. (Hint: the *atan* function is in *cmath*)

Code:

```
struct point a = {1.,1.};
double
  alpha = angle(a),
  pifrac = (4.*atan(1.0)) / alpha;
cout << "Angle of ("
     << a.x << "," << a.y
     << ") is:\n " << 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, or pi/6
```

Exercise 2

Write a `void` function that has a `struct` *Point* parameter, and exchanges its coordinates:

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

Code:

```
struct point 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 point point_add
       ( struct point p1,
         struct point p2 ) {
    struct point p_add =
      {p1.x+p2.x,p1.y+p2.y};
    return p_add;
};
  /* ... */
  v3 = point_add(p1,p2);
  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 Point` and `double` parameter as input, and returns a point 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* (with the *distance* function previous defined):

Code:

```
struct point p1{1.,2.}, p2{6.,14.};
cout << "Distance: "
     << distance( p1,p2 )
     << endl;
cout << "Distance: "
     << distance( {1.,2.}, {6.,14.} )
     << endl;
```

Output
[struct] pointdenote:

```
Distance: 13
Distance: 13
```

Exercise 4

Write a function *inner_product* that takes two *Point* structures and computes the inner product. Test your code on some points where you know the answer.

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 (essentially the same as a *`Point`* struct), 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:

  `coe_struct yourprogram.cc`

  where '`yourprogram.cc`' stands for the name of your source file.
- Is it reporting that your program is correct? If so, do:

  `coe_struct -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

  `coe_struct -i yourprogram.cc`