
COMP 2012H Honors Object-Oriented Programming and Data Structures

**Topic 7: Structure — a Collection of Heterogeneous Objects**

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# Part I

## C++ Structure

| Name | Age | Score |
|---|---|---|
| Adam | 20 | 55.6 |
| Bob | 18 | 90.3 |
| Calvin | 19 | 88.0 |
| Desmond | 18 | 99.9 |
| Eddie | 30 | 76.8 |
| Fred | 25 | 47.1 |

record

array



## What is a structure?

- A structure is, in general, a collection of heterogeneous objects — different kinds of objects. (c.f. array which is a collection of homogeneous objects.)
- It is equivalent to record in Pascal.
- Examples:
  student record : name, ID, gender, department, etc.
  address book : name, address, phone numbers, etc.
  human body : head, body, arms, hands, legs, etc.
- C++ allows you to define a new user-defined data type using the keyword "struct".



## C++ struct

**Syntax: struct Definition**

```
struct <structure identifier>
{
        <data-type> <identifier for the 1st member> ;
        <data-type> <identifier for the 2nd member> ;
        ⋮
} ;
```

- Each object in a struct is called its member.
- The data types of various members of a struct can be the same or different.
- The member types can be basic data type, user-defined data type, or a pointer to the new struct currently being defined!
- The struct definition just defines a new user-defined data type, not an object. It is usually defined globally.

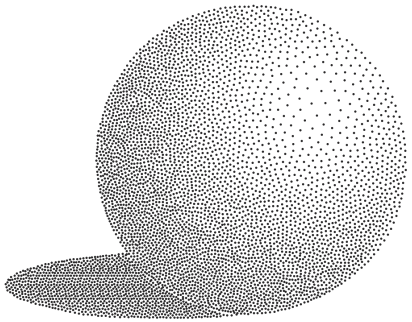
**Syntax: Define/Declare a struct Variable**

```
<structure identifier> <variable> ;
```

## Example: 2D Points — point.h

```
/* File: point.h */

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





## Access struct Members by the . Operator

**Syntax: . Operator to Access a struct Member**

<struct-variable>.<member-variable>

**Examples**

```
Point a, b; // a, b contain garbage

// Initialize a Point struct by memberwise assignments
a.x = 24.5;
a.y = 123.0;

// Input/output of a Point struct one member at a time
cin >> a.x >> a.y;
cout << '(' << b.x << ", " << b.y << ')';
```



## struct-struct Assignment: Memberwise Copy

- struct-struct assignment is like memberwise copy: each member of the struct on the RHS is copied to the corresponding member of the same kind of struct on the LHS.
- Even a member array can be copied!

**Example**

```
struct Example
{
    int x;
    float y[5];
};

// Memberwise copy between 2 structs (copy bit-by-bit)
Example a, b;
b = a;

// Similar to but different from memberwise assignments
b.x = a.x;
b.y = a.y; // Error: arrays can't be assigned to each other!!!
```



## Initialization of a struct Variable

- Just like an array variable, a struct variable can be initialized when it is defined using the initializer list with braces.

```
Point a = { 24.5, 123.0 };
```

- If it is not initialized during its definition, later its members can only be modified using separate memberwise assignments or struct-struct assignment (memberwise copy).

```
b.x = 24.5;     // Separate memberwise assignments
b.y = 123.0;    // if no similar object to copy from

// struct-struct assignment to copy a's members to b's
b = a;
```

- For relatively big structures, write a function to do that.

```
void init_point(Point& p, float x, float y)
{
    p.x = x; p.y = y; // Memberwise initialization
}
```

## Example: Euclidean Distance — point-test.cpp

```
#include <iostream>     /* File: point-test.cpp */
#include "point.h"
using namespace std;

// To compute and print the Euclidean distance between 2 points
void print_distance(const Point&, const Point&);

int main()       /* To find the length of the sides of a triangle */
{
    Point a, b, c;
    cout << "Enter the co-ordinates of point A: "; cin >> a.x >> a.y;
    cout << "Enter the co-ordinates of point B: "; cin >> b.x >> b.y;
    cout << "Enter the co-ordinates of point C: "; cin >> c.x >> c.y;

    cout << endl << "Results: " << endl;
    print_distance(a, b);
    print_distance(b, c);
    print_distance(c, a);
    return 0;
}
```



## Example: Euclidean Distance — point-distance.cpp

```
#include <iostream>     /* File: point-distance.cpp */
#include <cmath>
#include "point.h"
using namespace std;

/* To find the 2D Euclidean distance between 2 points */
double euclidean_distance(const Point& p1, const Point& p2)
{
    double x_diff = p1.x - p2.x;
    double y_diff = p1.y - p2.y;
    return sqrt(x_diff*x_diff + y_diff*y_diff);
}

void print_point(const Point& p)
{ cout << '(' << p.x << ", " << p.y << ')'; }

void print_distance(const Point& p1, const Point& p2)
{
    cout << "Distance between "; print_point(p1);
    cout << " and "; print_point(p2);
    cout << " is " << euclidean_distance(p1, p2) << endl;
}
```



## Example: Student Record — student-record.h

```
enum Dept { CSE, ECE, MATH }; /* File: student-record.h */

struct Date
{
    unsigned int year;
    unsigned int month;
    unsigned int day;
};

struct Student_Record
{
    char name[32];
    unsigned int id;
    char gender;
    Dept dept;
    Date entry;
};

// Global constants for department names
const char dept_name[ ][30]
  = {"Computer Science", "Electrical Engineering", "Mathematics"};
```



## Access Members of the Student Record struct

```
#include <cstring> // Load the lib header file for strcpy

Student_Record x;  // x contains garbage
strcpy(x.name, "Adam");
x.id = 12345;
x.gender = 'M';
x.dept = CSE;

// Notice how members of nested structures can be assigned
// values through successive use of the dot operator
x.entry.year = 2006;
x.entry.month = 9;
x.entry.day = 1;
```

## Initialization of a Variable of Student Record struct

- Initialize using the braces while it is defined.

```
Student_Record a = { "Adam", 12345, 'M', CSE, { 2006 , 9 , 1 } };
```

- Initialize using a function:

```
void init_date(Date& x,
    unsigned int year,
    unsigned int month,
    unsigned int day)
{
    x.year = year;
    x.month = month;
    x.day = day;
}
```

```
void init_student_record(Student_Record& a,
    const char name[], unsigned int id,
    char gender, Dept dept, const Date& date)
{
    strcpy(a.name, name);

    a.id = id;
    a.gender = gender;
    a.dept = dept;
    a.entry = date; // struct-struct assignment
}
```



## Example: Student Record — student-record.cpp

```
#include <iostream>     /* File: student-record.cpp */
#include "student-record.h"
using namespace std;

void print_date(const Date& date) {
    cout << date.year << '/' << date.month << '/' << date.day << endl;
}

void print_student_record(const Student_Record& x) {
    cout.width(12); cout << "name: " << x.name << endl;
    cout.width(12); cout << "id: " << x.id << endl;
    cout.width(12); cout << "gender: " << x.gender << endl;
    cout.width(12); cout << "dept: " << dept_name[x.dept] << endl;
    cout.width(12); cout << "entry date: "; print_date(x.entry);
}

int main()
{
    Student_Record a = { "Adam", 12345, 'M', CSE, { 2006 , 9 , 1 } };
    print_student_record(a); return 0;
}
```



# Part II

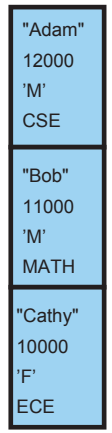
# Array of Structures



## Array of Structures

You may create an array of basic data types as well as user-defined data types, such as structures.

student_record sr[3];




(The above figure ignores the Date member of the Student Record.)

## Example: struct Array — student-record-array.cpp

```
#include <iostream>     /* File: student-record-array.cpp */
using namespace std;
#include "student-record.h"
#include "student-record-extern.h"

int main()
{
    Student_Record sr[] = {
        { "Adam", 12000, 'M', CSE, { 2006 , 1 , 10 } },
        { "Bob", 11000, 'M', MATH, { 2005 , 9 , 1 } },
        { "Cathy", 10000, 'F', ECE, { 2006 , 8 , 20 } }
    };

    for (int j = 0; j < sizeof(sr)/sizeof(Student_Record); ++j)
        print_student_record(sr[j]);

    return 0;
}

/* g++ student-record-array.cpp student-record-functions.cpp */
```



## Example: struct Array — student-record-extern.h

```
/* File: student-record-extern.h */

void print_date(const Date&);
void print_student_record(const Student_Record&);
void init_date(Date& x, unsigned int, unsigned int, unsigned int);
void init_student_record(Student_Record&, const char[],
                         unsigned int, char, Dept, const Date&);
void swap_SR(Student_Record&, Student_Record&);
void sort_3SR_by_id(Student_Record sr[]);
```



## Example: struct Array — student-record-functions.cpp I

```
#include <iostream>     /* File: student-record-functions.cpp */
#include "student-record.h"
using namespace std;

void print_date(const Date& date)
{
    cout << date.year << '/' << date.month << '/' << date.day << endl;
}

void print_student_record(const Student_Record& x)
{
    cout.width(12); cout << "name: " << x.name << endl;
    cout.width(12); cout << "id: " << x.id << endl;
    cout.width(12); cout << "gender: " << x.gender << endl;
    cout.width(12); cout << "dept: " << dept_name[x.dept] << endl;
    cout.width(12); cout << "entry date: "; print_date(x.entry);
}

void init_date(Date& x, unsigned int year, unsigned int month, unsigned int day)
{
    x.year = year; x.month = month; x.day = day;
}
```



## Example: struct Array — student-record-functions.cpp II

```
void init_student_record(Student_Record& a, const char name[], unsigned int id,
                         char gender, Dept dept, const Date& date)
{
    strcpy(a.name, name);
    a.id = id;
    a.gender = gender;
    a.dept = dept;
    a.entry = date;     // struct-struct assignment
}
```

## Example: Sort — sort-student-record.cpp

```
#include "student-record.h" /* File: sort-student-record.cpp */
#include "student-record-extern.h"

void swap_SR(Student_Record& x, Student_Record& y) {
    Student_Record temp = x; x = y; y = temp;
}

void sort_3SR_by_id(Student_Record sr[ ]) {
    if (sr[0].id > sr[1].id) swap_SR(sr[0], sr[1]);
    if (sr[0].id > sr[2].id) swap_SR(sr[0], sr[2]);
    if (sr[1].id > sr[2].id) swap_SR(sr[1], sr[2]);
}

int main()
{
    Student_Record sr[] = {
        { "Adam", 12000, 'M', CSE, { 2006 , 1 , 10 } },
        { "Bob", 11000, 'M', MATH, { 2005 , 9 , 1 } },
        { "Cathy", 10000, 'F', ECE, { 2006 , 8 , 20 } } };

    sort_3SR_by_id(sr);
    for (int j = 0; j < sizeof(sr)/sizeof(Student_Record); j++)
        print_student_record(sr[j]);
    return 0;
} /* g++ sort-student-record.cpp student-record-functions.cpp */
```



## That's all!

Any questions?