

C: an introduction

Structures - basics

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User-Defined Types

- C provides facilities to define one's own types.
- These may be a composite of basic types (`int`, `double`, etc) and other user-defined types.
 - Array: homogeneous data
 - Structure: heterogeneous data
- The structure type allows to specify a group of related variables, each representing a facet, or component, of the thing being modeled.
- The most common user-defined type is a structure, defined by the keyword `struct`.

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Structures

- *A structure is a collection of one or more variables, possibly of different types, grouped together under a single name for convenient handling*
- They assist program organisation by
 - Grouping logically related data, and giving this set of variables a higher-level name and more abstract representation.
 - Enabling related variables to be manipulated as a single unit rather than as separate entities.
 - Reducing the number of parameters that need to be passed between functions.
 - Providing another means to return multiple values from a function.

Structure Syntax

- A structure is defined by the keyword **struct** followed by a set of variables enclosed in braces.
- Consider the following structure to represent a person's details.

```
struct Personnel {  
    char name[100];  
    int age;  
    double height;  
};
```
- The variables **name**, **age** and **height** are called *members* of the structure type **Personnel** (a.k.a. *tag* - acting as a template)
- **Style note / convention:** Structures (custom data types) start with Capital first letters. Distinguish them from variables and functions (lowercase first letter), and symbolic constants (all uppercase).

Structure storage

- A struct holds multiple values in consecutive memory locations, called fields
- Struct elements are stored in the order they are declared in:
 - Total size reserved for a struct variable is not necessarily the sum of the size of the elements
 - Some systems require some variables to be aligned at certain memory addresses (usually small power of 2)
 - Requires some padding between members in memory = wasted space
 - If members are reordered, it may reduce total number of padding bytes required
 - Usually rule of thumb is to place larger members at the beginning of definition, and small types (char) last

Declaring Structure Variables

There are two ways to define variables of a particular structure type.

1. Declare them at the structure definition.

```
struct Personnel {  
    char name[100];  
    int age;  
    double height;  
} p1, p2, p3; /* Define 3 variables */
```

2. Define the variables at some point *after* the structure definition.

```
struct Personnel p1, p2, p3; /* Define 3 variables */  
struct Personnel pa[3]; /* Define array of structure */
```

Typedef

- The keyword **typedef** provides a mechanism for creating new data type names (*synonyms*).
`typedef <data type definition> <data type name>;`
- It does not create new types, just new names (*synonyms*) for existing types.

```
typedef int Length;  
Length len, maxlen;  
Length lengths[50];
```

- **typedef** provides a simplification in structure declaration syntax.

```
typedef struct {  
    int x;  
    int y;  
} Coord;  
Coord p1, p2;
```

Initialising Structure Variables

- A structure may be initialised when it is defined using brace notation.

```
struct Personnel captain = {"Fred", 37, 1.83};
```

- The order of values in the initialiser list matches the order of declarations in the structure.

Accessing Members

- Members of a structure type may be accessed via the “.” member operator (dot operator).

```
struct Personnel captain;  
  
strcpy(captain.name, "Fred");  
captain.age = 37;  
captain.height = 1.83;  
  
printf("%s is %d years old.",  
captain.name, captain.age);
```

Nested Structures

- Structures may be defined inside other structures.

```
struct Payroll {  
    struct Personnel person;  
    double amount;  
};
```

- To access lower-level members, need to use member operator multiple times.

```
struct Payroll lieutenant;  
lieutenant.person.height = 2.1;  
lieutenant.amount = 75.4;
```

```

1 /*
2 struct_point_xy.c
3 */
4 #include <stdio.h>
5
6 struct point
7 {
8     int x;
9     int y;
10 };
11
12 struct point x1;
13 struct point x2 = {200, 300};
14
15 void pointinfo(struct point xx);
16
17 int main()
18 {
19     printf ("x1 without initialisation \n");
20     pointinfo (x1);
21
22     x1.x = 100;
23     x1.y = 100;
24
25     printf ("x1 after initialisation \n");
26     pointinfo (x1);
27
28     printf ("x2 after initialisation \n");
29     pointinfo (x2);
30
31     x1.x += x2.x;
32     printf ("x1 summing x-dim of x2 \n");
33     pointinfo (x1);
34
35     return 0;
36 }
37
38 void pointinfo ( struct point xx )
39 {
40     printf ("dim1 %d \t dim2 %d \n", xx.x, xx.y);
41 }

```

```

frankvp@CRD-L-08004:../Structures$ gcc struct_point_xy.c -o struct_point_xy
frankvp@CRD-L-08004:../Structures$ ./struct_point_xy
x1 without initialisation
dim1 0   dim2 0
x1 after initialisation
dim1 100   dim2 100
x2 after initialisation
dim1 200   dim2 300
x1 summing x-dim of x2
dim1 300   dim2 100
frankvp@CRD-L-08004:../Structures$

```

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```

1 /*
2 struct_manip_1.c
3 manipulate the data contained in a structure
4 */
5 #include <stdio.h>
6 #include <string.h>
7
8 typedef struct record
9 { char name[20]; int age; float reward;} Person;
10
11 void display(char *name, int age, float reward);
12 void raise(Person * a);
13
14 int main ()
15 {
16     Person p1, p2;
17
18     strcpy(p1.name, "Joe Brown");
19     p1.age = 21;
20     p1.reward = 123.4;
21     display (p1.name, p1.age, p1.reward);
22     raise(&p1);
23     display (p1.name, p1.age, p1.reward);
24
25     return 0;
26 }
27
28
29 void display(char *name, int age, float reward)
30 {
31     printf("name is %s \nage is %d \nreward is %1f \n", name, age, reward);
32 }
33
34 void raise(Person * a)
35 {
36     a->reward = a->reward * 1.15;
37 }

```

```

frankvp@CRD-L-08004:../Structures$ gcc struct_manip_1.c -o struct_manip_1
frankvp@CRD-L-08004:../Structures$ ./struct_manip_1
name is Joe Brown
age is 21
reward is 123.400002
name is Joe Brown
age is 21
reward is 141.910004
frankvp@CRD-L-08004:../Structures$

```

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Operations on Structures

- Copy, assign

```
struct Personnel p1 = {"Fred", 37, 1.83};
struct Personnel p2;

p2 = p1;          /* Valid. */

if (p1 == p2)     /* Invalid. Won't compile. */
    printf("People are equal\n");

if (strcmp(p1.name, p2.name) == 0 && /* Valid. */
    p1.age == p2.age &&
    p1.height == p2.height)
    printf("People are equal\n");
```

- Passed as an argument in a function – *manip_struct.c*
- Returned as a result from a function – *demo_swap_struct.c*
- Look up or set individual components in a struct
- Can not be compared to each other