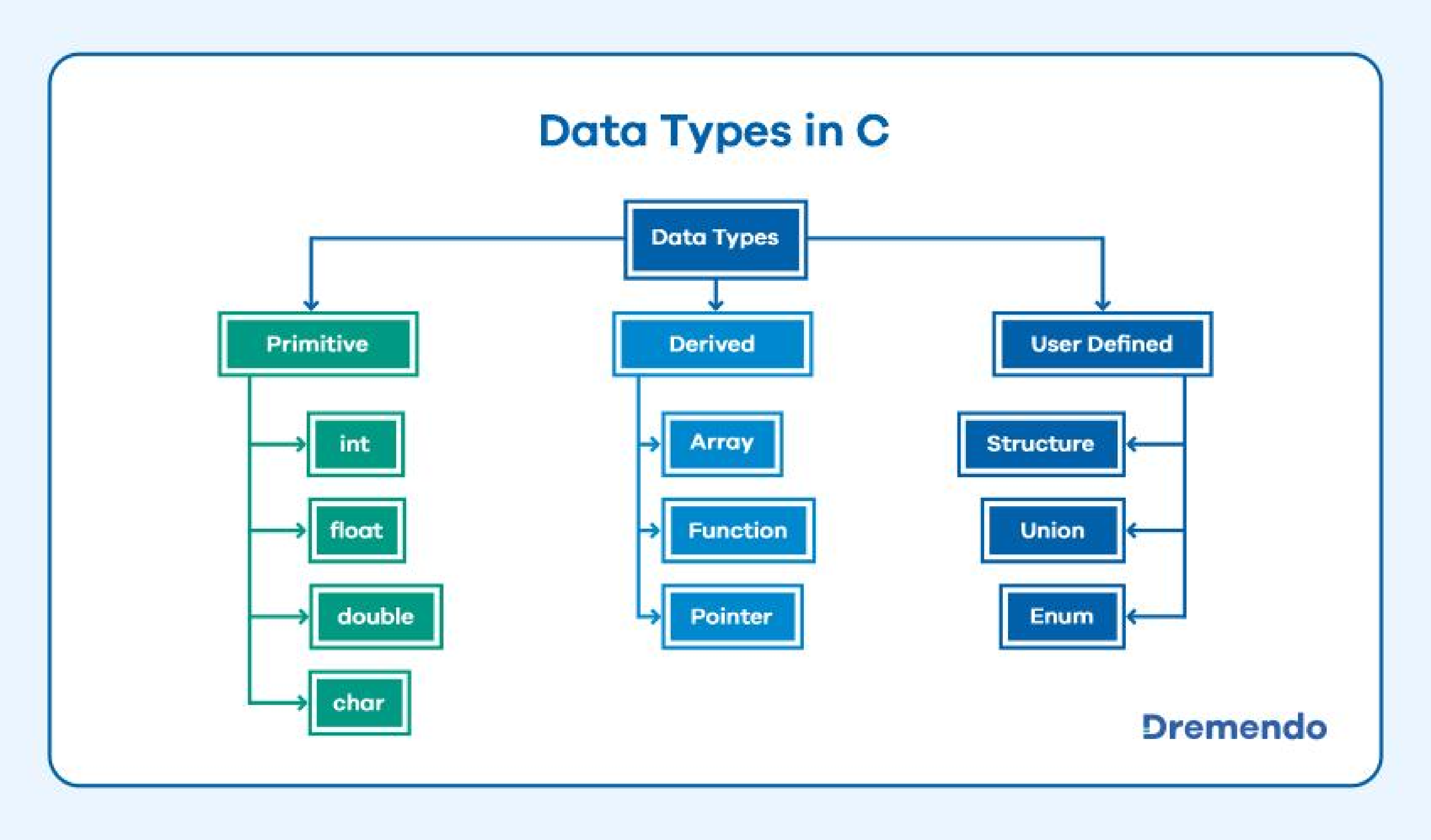
Unit 6:

Data Structures

- Struct
- Union
- Bit Field
- DMA
- Linked List



Data Types in C

User Defined Data types- **typedef, enum**

- “type definition” allows user to define variable of existing data type.
- Example.
  - typedef float marks ;
  - marks m1,m2,m3;

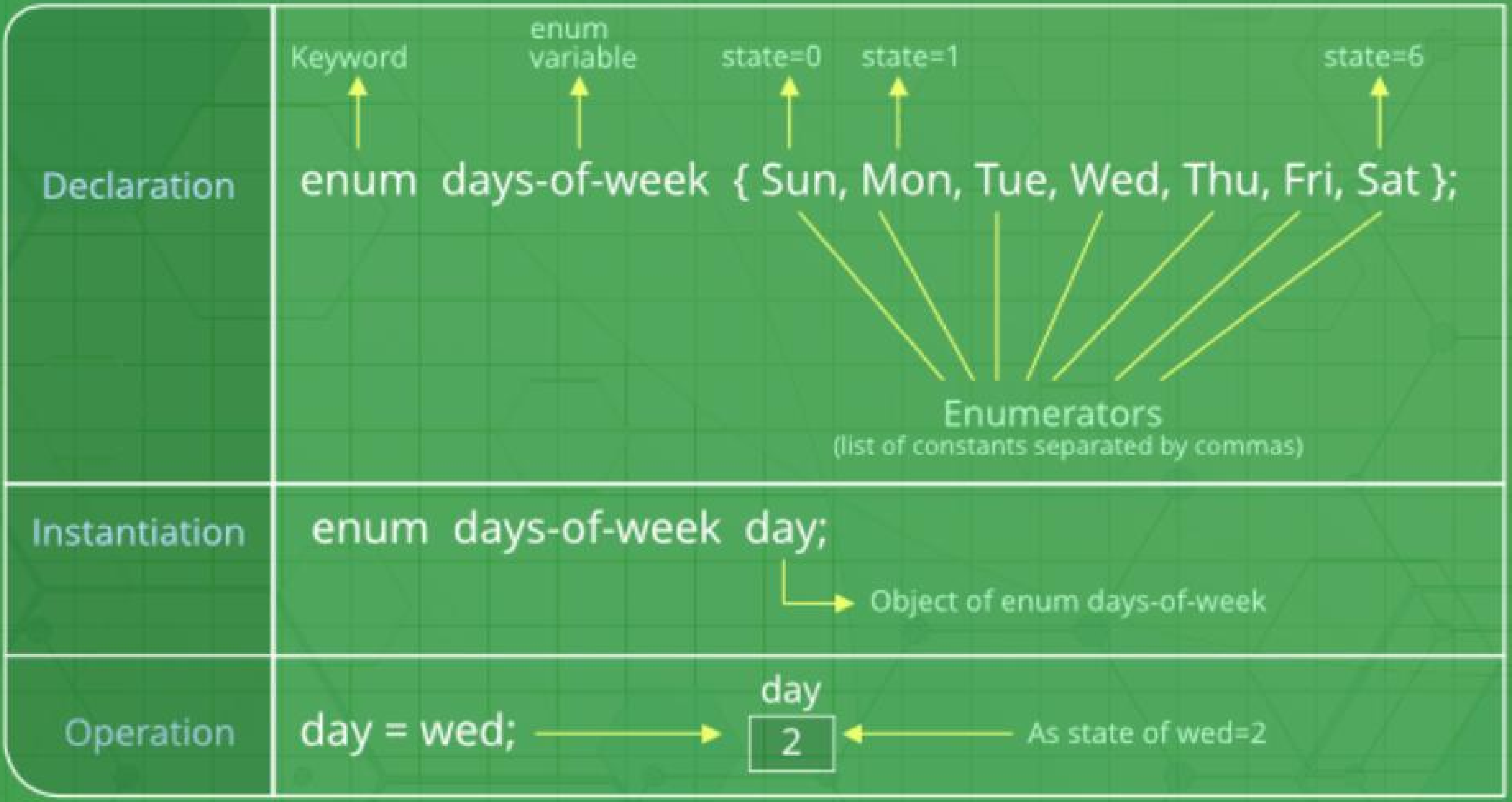
  (in above example marks is used as float data type)

Enumerated data type:

It is mainly used to assign names to integral constants, the names make a program easy to read and maintain.

- enum day(Mon , Tue ,wed ,Thu ,Fri ,Sat , Sun)
- enum day today;
- today=Thu

Enum in C



Declaration

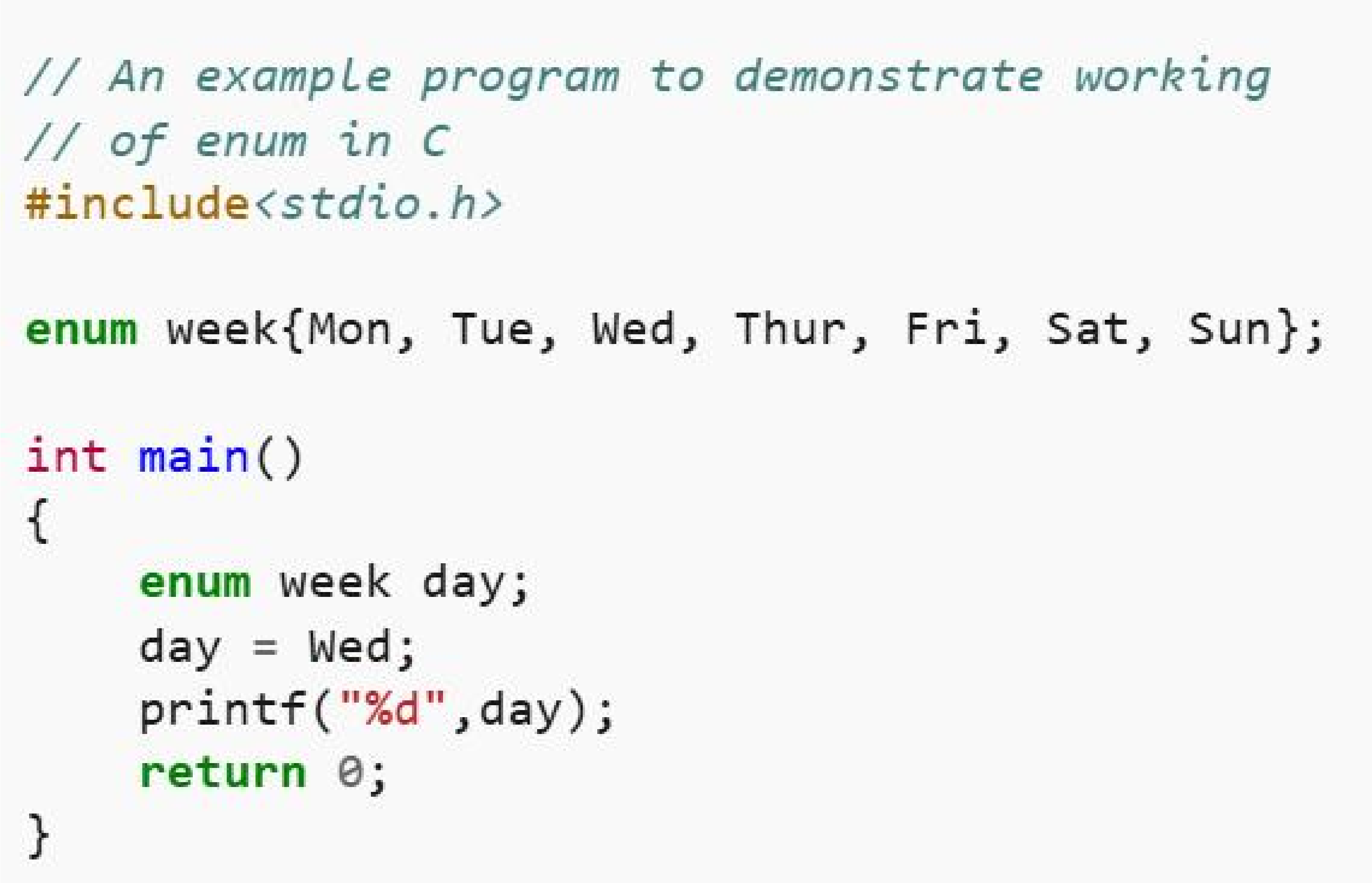
```
enum  days-of-week  { Sun, Mon, Tue, Wed, Thu, Fri, Sat };
```

Instantiation

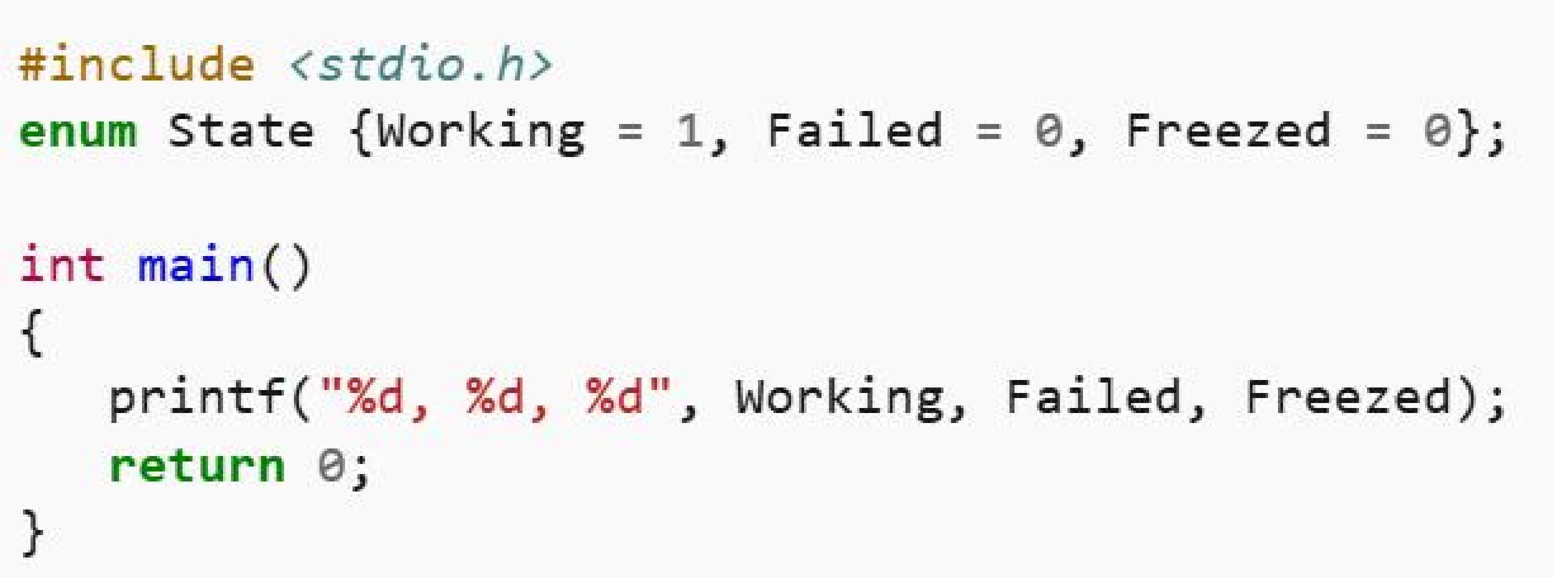
```
enum  days-of-week  day;
```

Operation

```
day = wed;
```



```c
// An example program to demonstrate working
// of enum in C
#include<stdio.h>

enum week{Mon, Tue, Wed, Thur, Fri, Sat, Sun};

int main()
{
    enum week day;
    day = Wed;
    printf("%d",day);
    return 0;
}
```



```
#include <stdio.h>
enum State {Working = 1, Failed = 0, Freezed = 0};

int main()
{
   printf("%d, %d, %d", Working, Failed, Freezed);
   return 0;
}
```

- Two enum names can have same value.
- If we do not explicitly assign values to enum names, the compiler by default assigns values starting from 0.
- Values can be assigned in any order.

Derived data types- **Array**

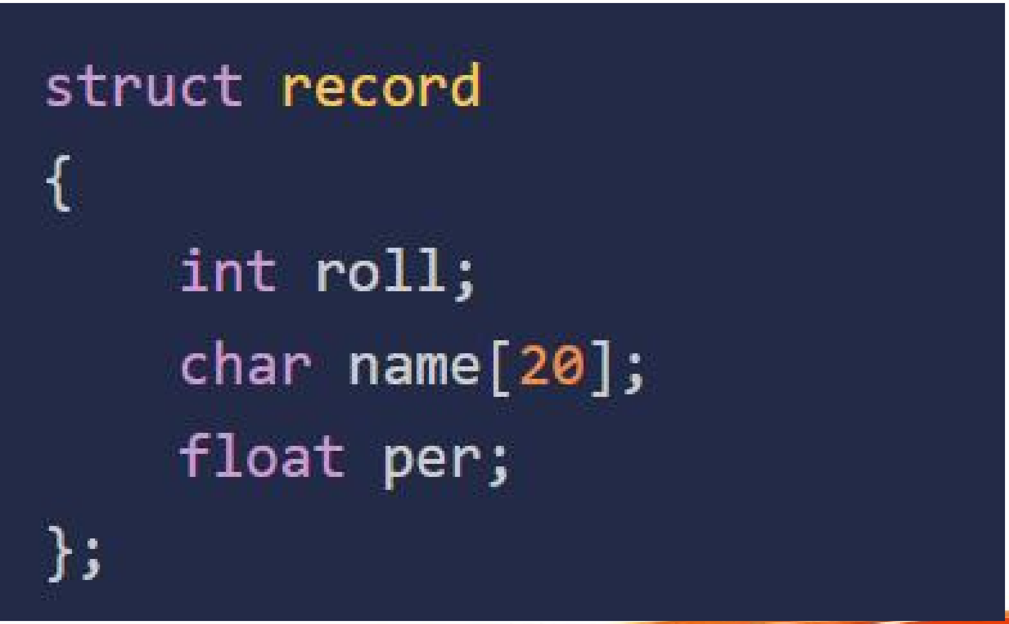
- Array:
  - It is collection of homogeneous data type elements stored in contiguous memory locations.
  - E.g.
    - int a[5];
    - Element of array is accessed with a[i] where "**a**" is the array and "i" is the index .

a[0]	**a[1]**	**a[2]**	**a[3]**	**a[4]**

Structure (Struct) in C

- created to store different types of values under a single variable.

Defining a Structure



```
struct record
{
    int roll;
    char name[20];
    float per;
};
```

Syntax:

```
struct  structure_name {
    data_type member_name1;
    data_type member_name1;
    ....
    ....
};
```

Creating Structure Variable

- After structure definition, we have to create variable of that structure to use it. It is similar to the any other type of variable declaration:

```
    struct strcuture_name var;
```

- We can also declare structure variables with structure definition.

```
struct structure_name {
  …
}var1, var2….;
```

- Structures—sometimes referred to as aggregates—are collections of related variables under one name.

- Structures may contain variables of ***many different data types***—
  - in contrast to arrays, which contain *only* elements of the same data type.

- To access or modify members of a structure, we use the (.) dot operator.

  structure_name . member1;

strcuture_name . member2;

E.g.

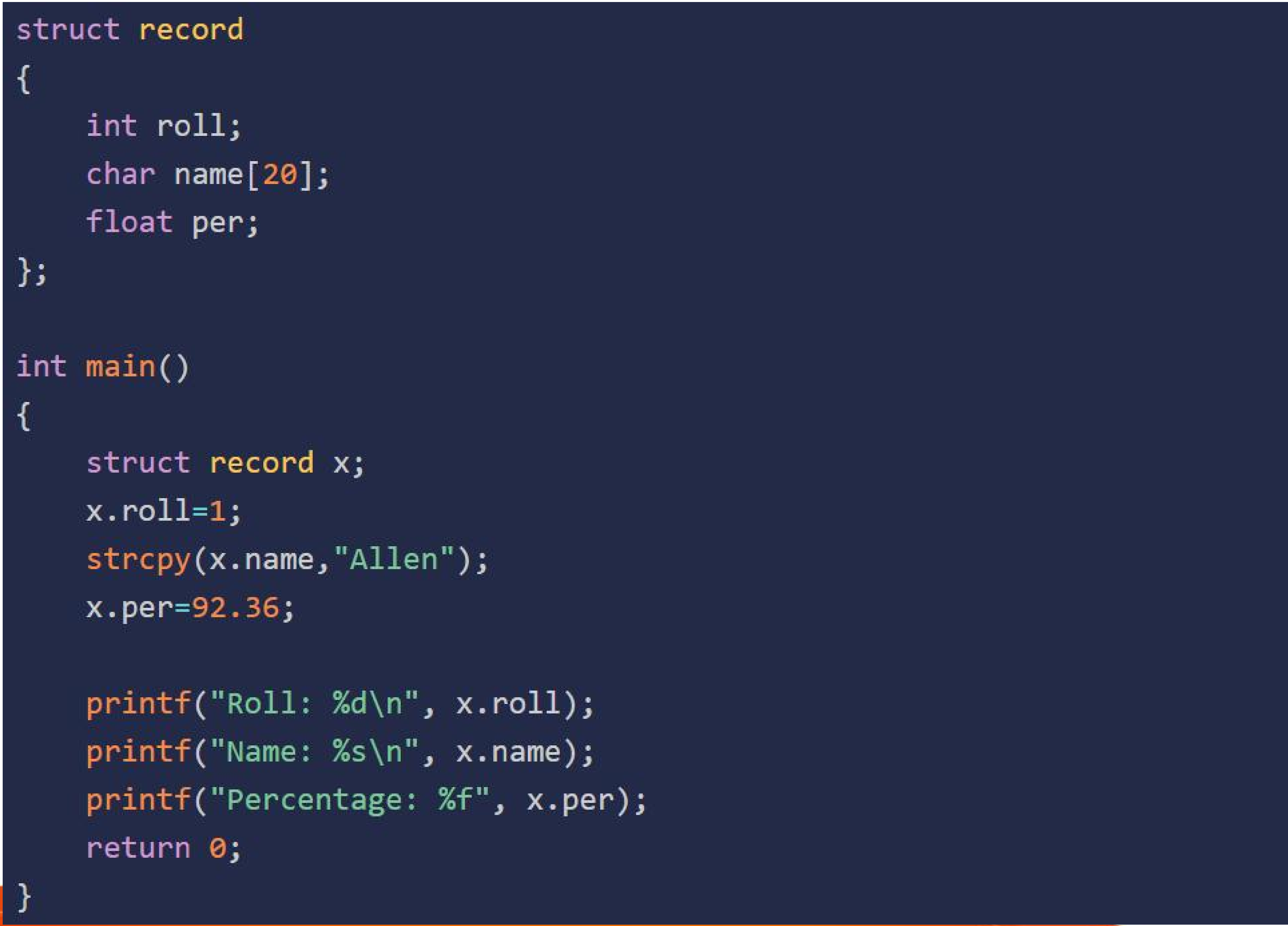
```
struct stud
        {
                int char name[35];
                int roll_no;
                char addr[50]
        }s;
```

s.Name //access the name field

- In the case where we have a pointer to the structure, we can also use the arrow operator to access the members.

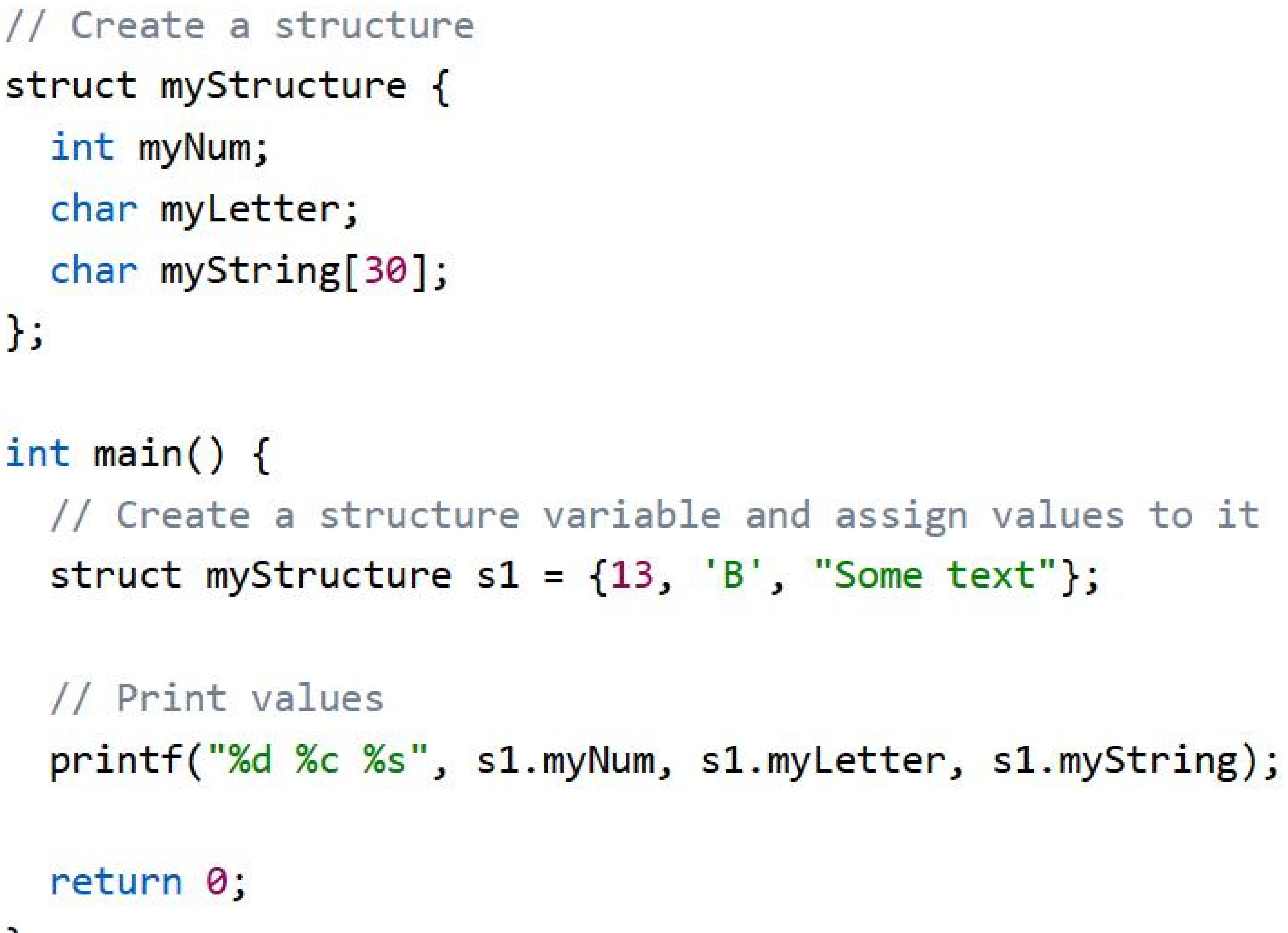
  structure_ptr -> member1

  structure_ptr -> member2



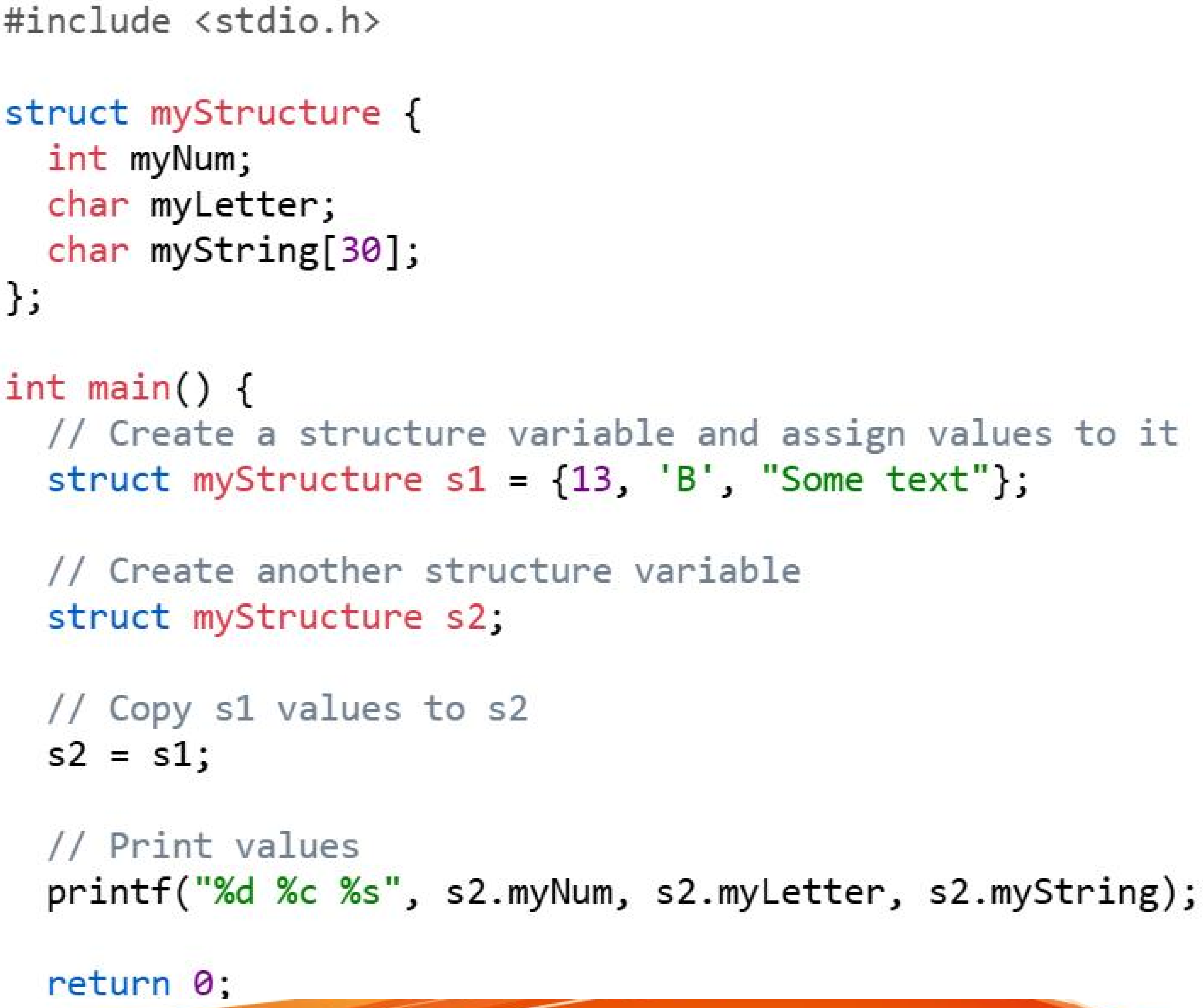
```
struct record
{
    int roll;
    char name[20];
    float per;
};

int main()
{
    struct record x;
    x.roll=1;
    strcpy(x.name,"Allen");
    x.per=92.36;

    printf("Roll: %d\n", x.roll);
    printf("Name: %s\n", x.name);
    printf("Percentage: %f", x.per);
    return 0;
}
```

Example:



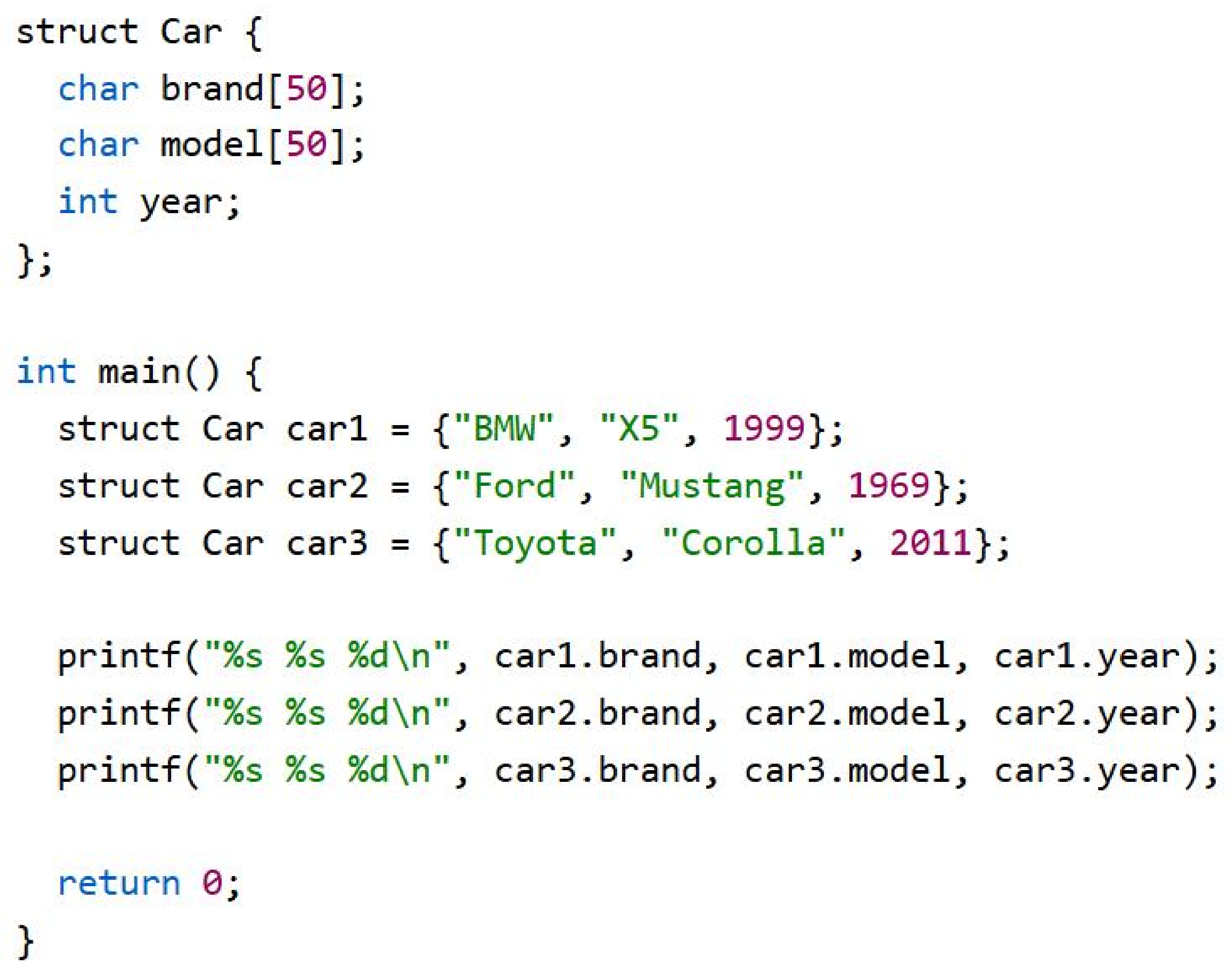
```c
// Create a structure
struct myStructure {
  int myNum;
  char myLetter;
  char myString[30];
};

int main() {
  // Create a structure variable and assign values to it
  struct myStructure s1 = {13, 'B', "Some text"};

  // Print values
  printf("%d %c %s", s1.myNum, s1.myLetter, s1.myString);

  return 0;
}
```

Copy structure



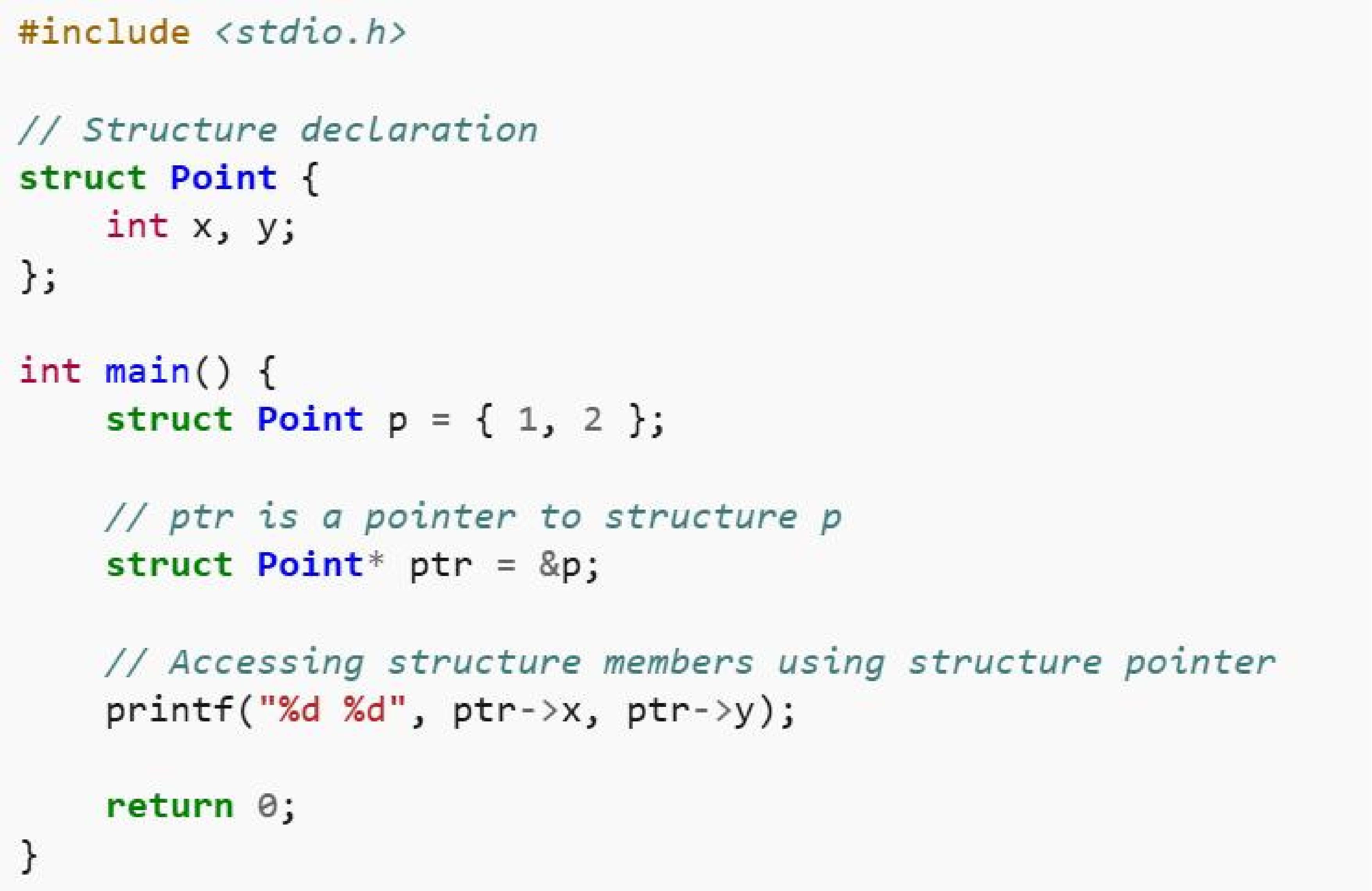
```
#include <stdio.h>

struct myStructure {
  int myNum;
  char myLetter;
  char myString[30];
};

int main() {
  // Create a structure variable and assign values to it
  struct myStructure s1 = {13, 'B', "Some text"};

  // Create another structure variable
  struct myStructure s2;

  // Copy s1 values to s2
  s2 = s1;

  // Print values
  printf("%d %c %s", s2.myNum, s2.myLetter, s2.myString);

  return 0;
```

Real-Life Example



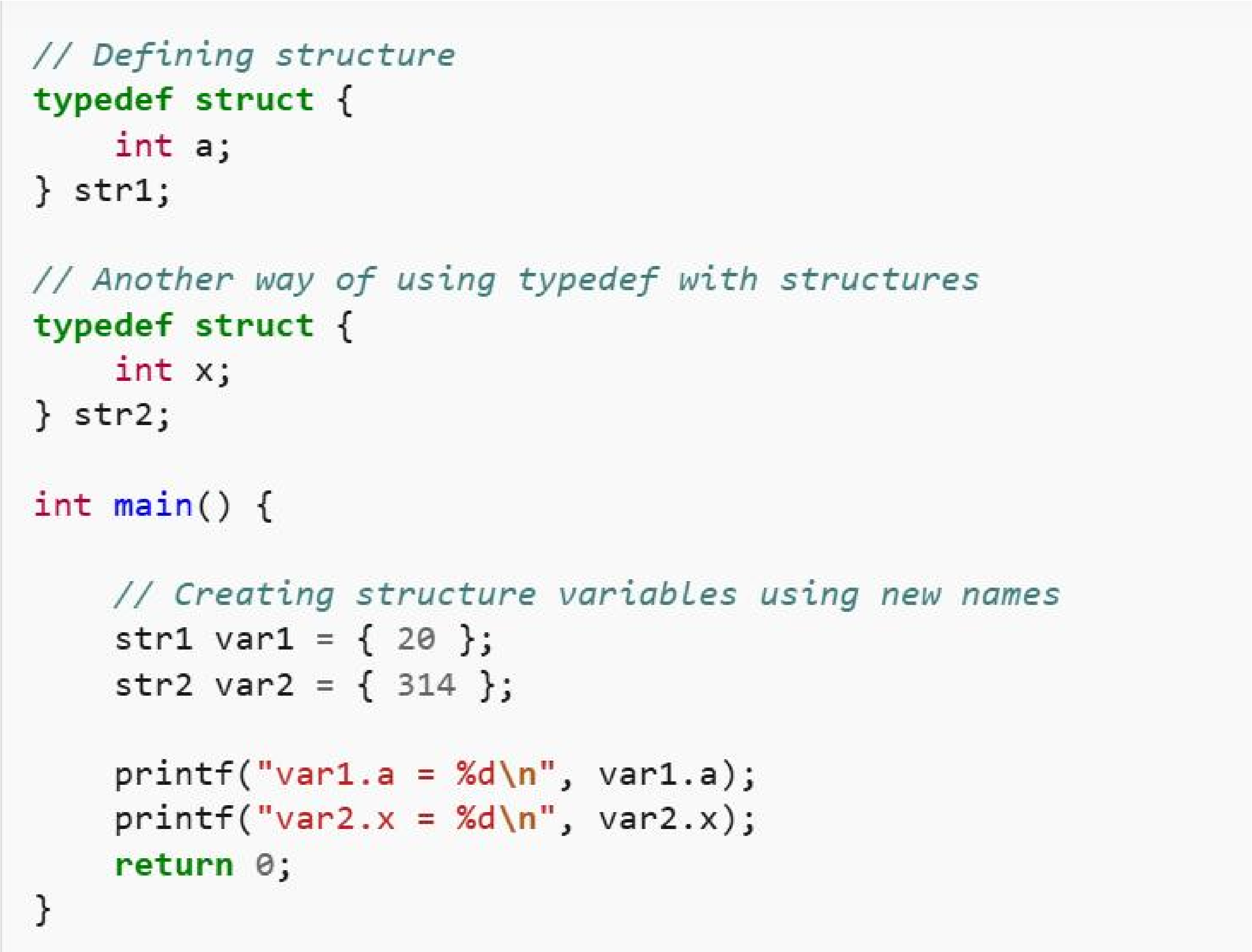
```c
struct Car {
  char brand[50];
  char model[50];
  int year;
};

int main() {
  struct Car car1 = {"BMW", "X5", 1999};
  struct Car car2 = {"Ford", "Mustang", 1969};
  struct Car car3 = {"Toyota", "Corolla", 2011};

  printf("%s %s %d\n", car1.brand, car1.model, car1.year);
  printf("%s %s %d\n", car2.brand, car2.model, car2.year);
  printf("%s %s %d\n", car3.brand, car3.model, car3.year);

  return 0;
}
```

Structure Pointer



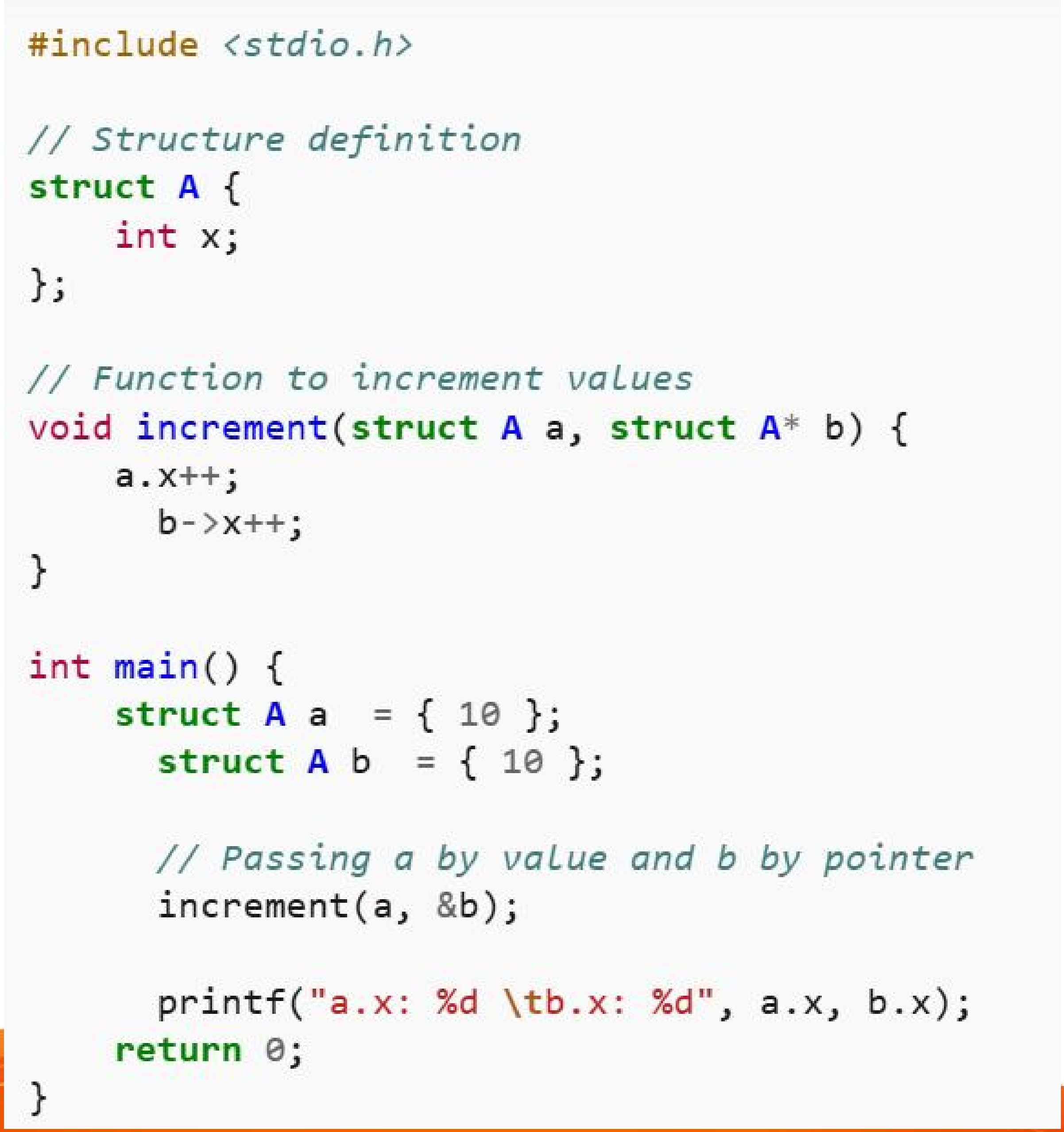
```c
#include <stdio.h>

// Structure declaration
struct Point {
    int x, y;
};

int main() {
    struct Point p = { 1, 2 };

    // ptr is a pointer to structure p
    struct Point* ptr = &p;

    // Accessing structure members using structure pointer
    printf("%d %d", ptr->x, ptr->y);

    return 0;
}
```

typedef for Structures



```
// Defining structure
typedef struct {
    int a;
} str1;

// Another way of using typedef with structures
typedef struct {
    int x;
} str2;

int main() {

    // Creating structure variables using new names
    str1 var1 = { 20 };
    str2 var2 = { 314 };

    printf("var1.a = %d\n", var1.a);
    printf("var2.x = %d\n", var2.x);
    return 0;
}
```

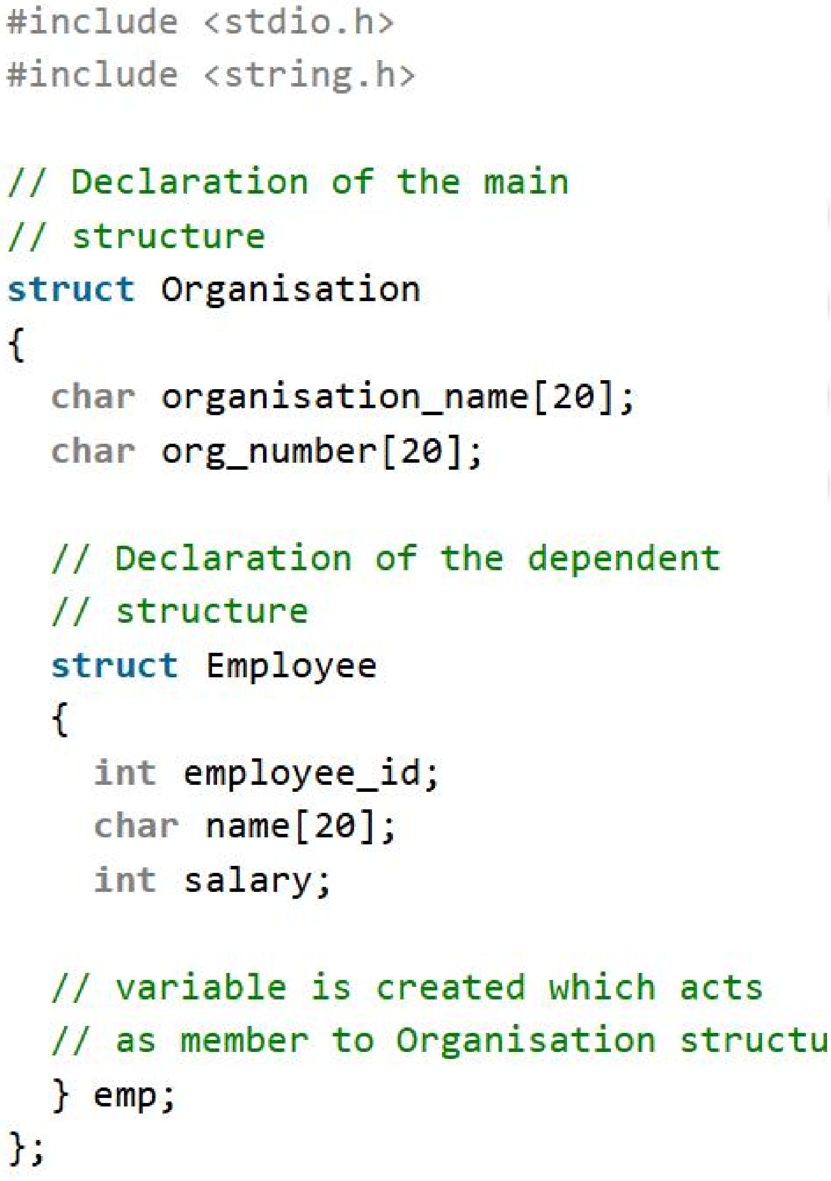
Passing Structure to Functions



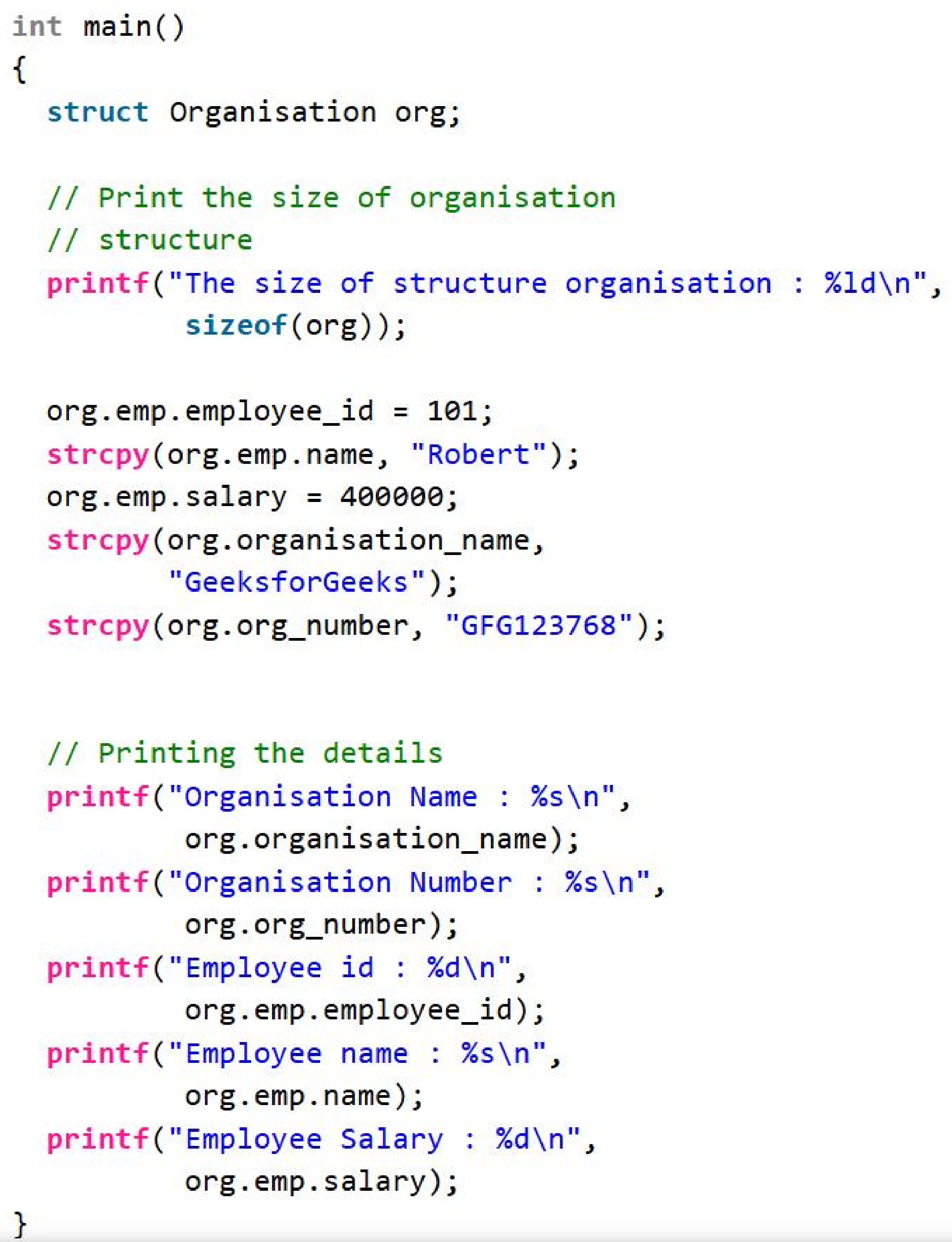
```c
#include <stdio.h>

// Structure definition
struct A {
    int x;
};

// Function to increment values
void increment(struct A a, struct A* b) {
    a.x++;
      b->x++;
}

int main() {
    struct A a  = { 10 };
      struct A b  = { 10 };

      // Passing a by value and b by pointer
      increment(a, &b);

      printf("a.x: %d \tb.x: %d", a.x, b.x);
    return 0;
}
```

Nested Structures

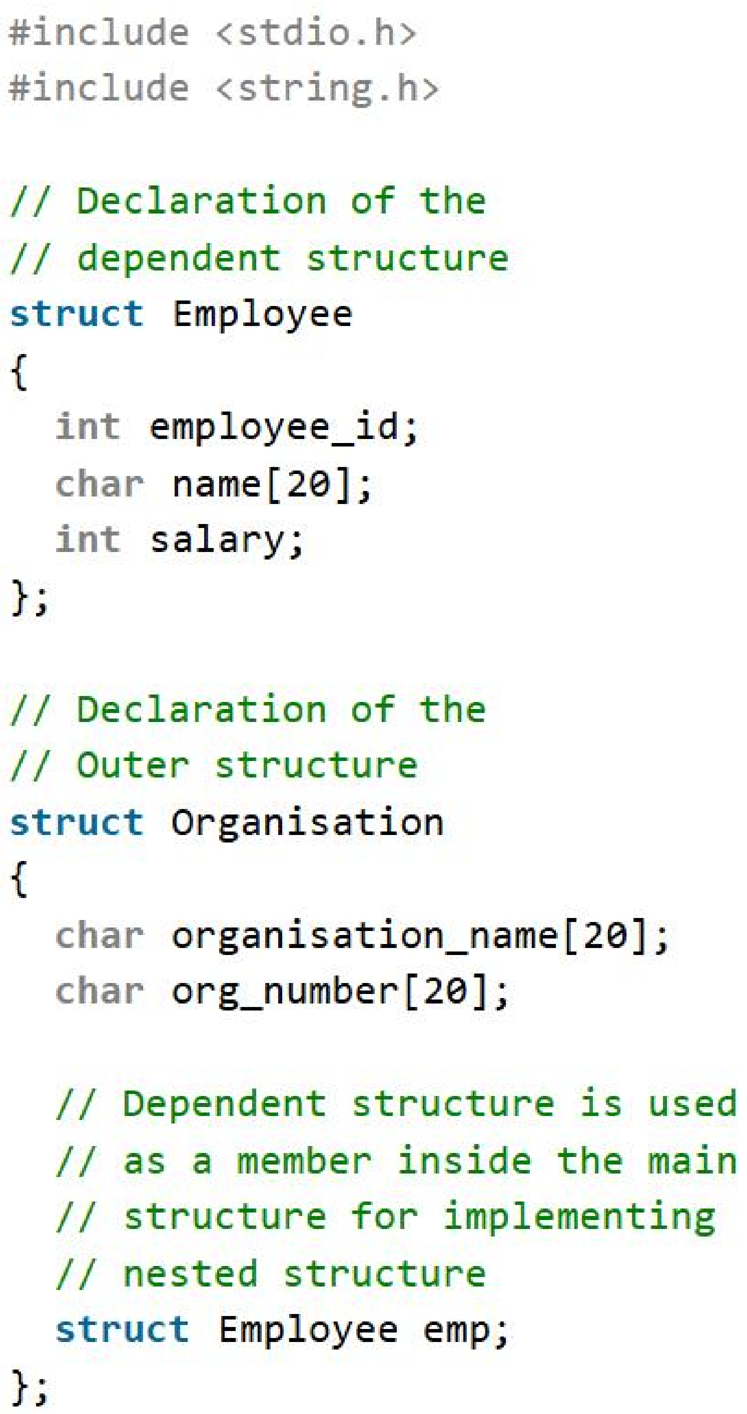
- Nested structure refers to a structure that contains another structure as one of its members.
- Two ways:
  - **Embedded Structure Nesting:** The structure being nested is also declared inside the parent structure.
  - **Separate Structure Nesting:** Two structures are declared separately and then the member structure is nested inside the parent structure.



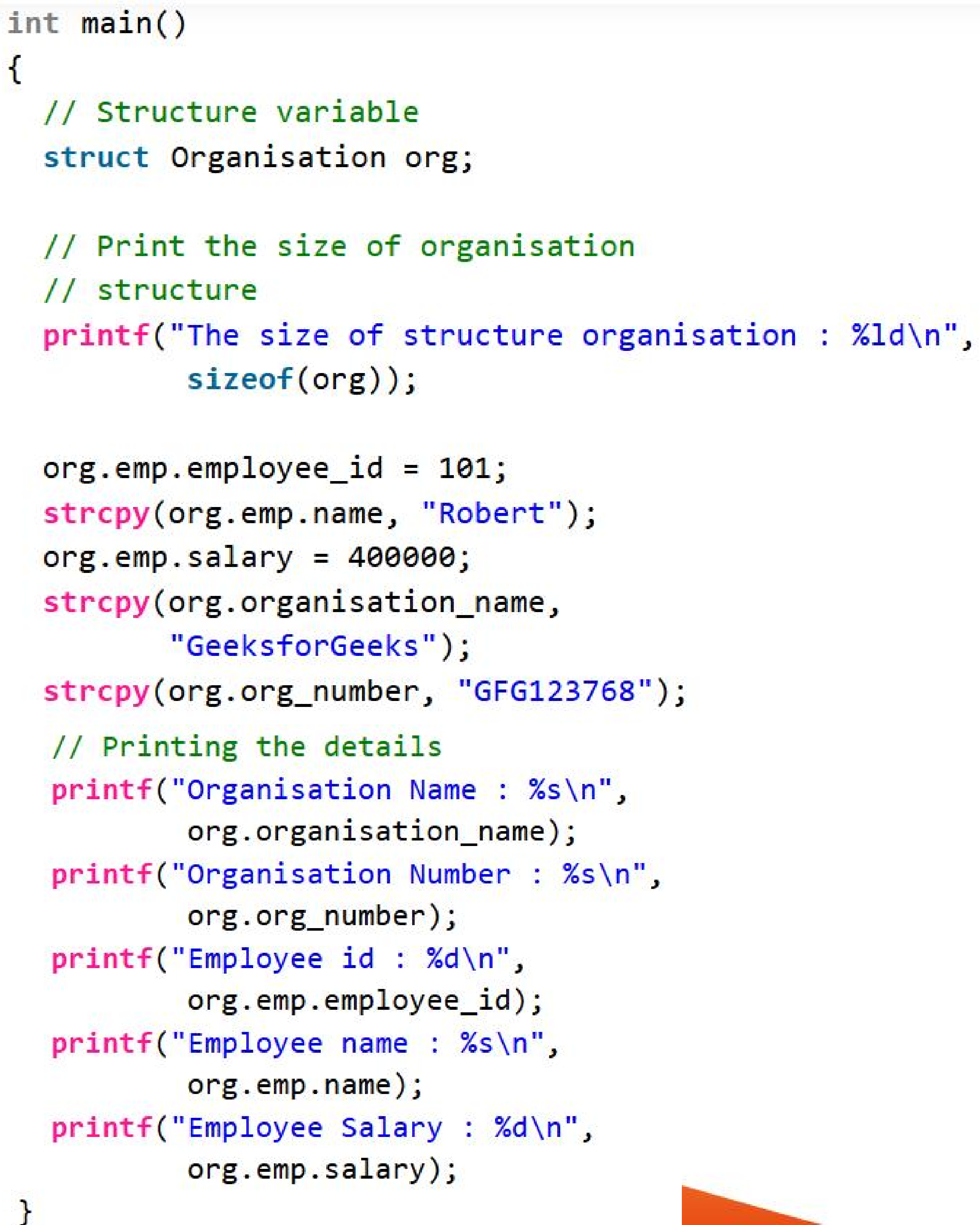
```c
#include <stdio.h>
#include <string.h>

// Declaration of the main
// structure
struct Organisation
{
  char organisation_name[20];
  char org_number[20];

  // Declaration of the dependent
  // structure
  struct Employee
  {
    int employee_id;
    char name[20];
    int salary;

  // variable is created which acts
  // as member to Organisation structu
  } emp;
};
```



```c
int main()
{
  struct Organisation org;

  // Print the size of organisation
  // structure
  printf("The size of structure organisation : %ld\n",
         sizeof(org));

  org.emp.employee_id = 101;
  strcpy(org.emp.name, "Robert");
  org.emp.salary = 400000;
  strcpy(org.organisation_name,
        "GeeksforGeeks");
  strcpy(org.org_number, "GFG123768");


  // Printing the details
  printf("Organisation Name : %s\n",
         org.organisation_name);
  printf("Organisation Number : %s\n",
         org.org_number);
  printf("Employee id : %d\n",
         org.emp.employee_id);
  printf("Employee name : %s\n",
         org.emp.name);
  printf("Employee Salary : %d\n",
         org.emp.salary);
}
```



```c
#include <stdio.h>
#include <string.h>

// Declaration of the
// dependent structure
struct Employee
{
  int employee_id;
  char name[20];
  int salary;
};

// Declaration of the
// Outer structure
struct Organisation
{
  char organisation_name[20];
  char org_number[20];

  // Dependent structure is used
  // as a member inside the main
  // structure for implementing
  // nested structure
  struct Employee emp;
};
```



```c
int main()
{
  // Structure variable
  struct Organisation org;

  // Print the size of organisation
  // structure
  printf("The size of structure organisation : %ld\n",
          sizeof(org));

  org.emp.employee_id = 101;
  strcpy(org.emp.name, "Robert");
  org.emp.salary = 400000;
  strcpy(org.organisation_name,
         "GeeksforGeeks");
  strcpy(org.org_number, "GFG123768");
  // Printing the details
  printf("Organisation Name : %s\n",
          org.organisation_name);
  printf("Organisation Number : %s\n",
          org.org_number);
  printf("Employee id : %d\n",
          org.emp.employee_id);
  printf("Employee name : %s\n",
          org.emp.name);
  printf("Employee Salary : %d\n",
          org.emp.salary);
}
```

Union

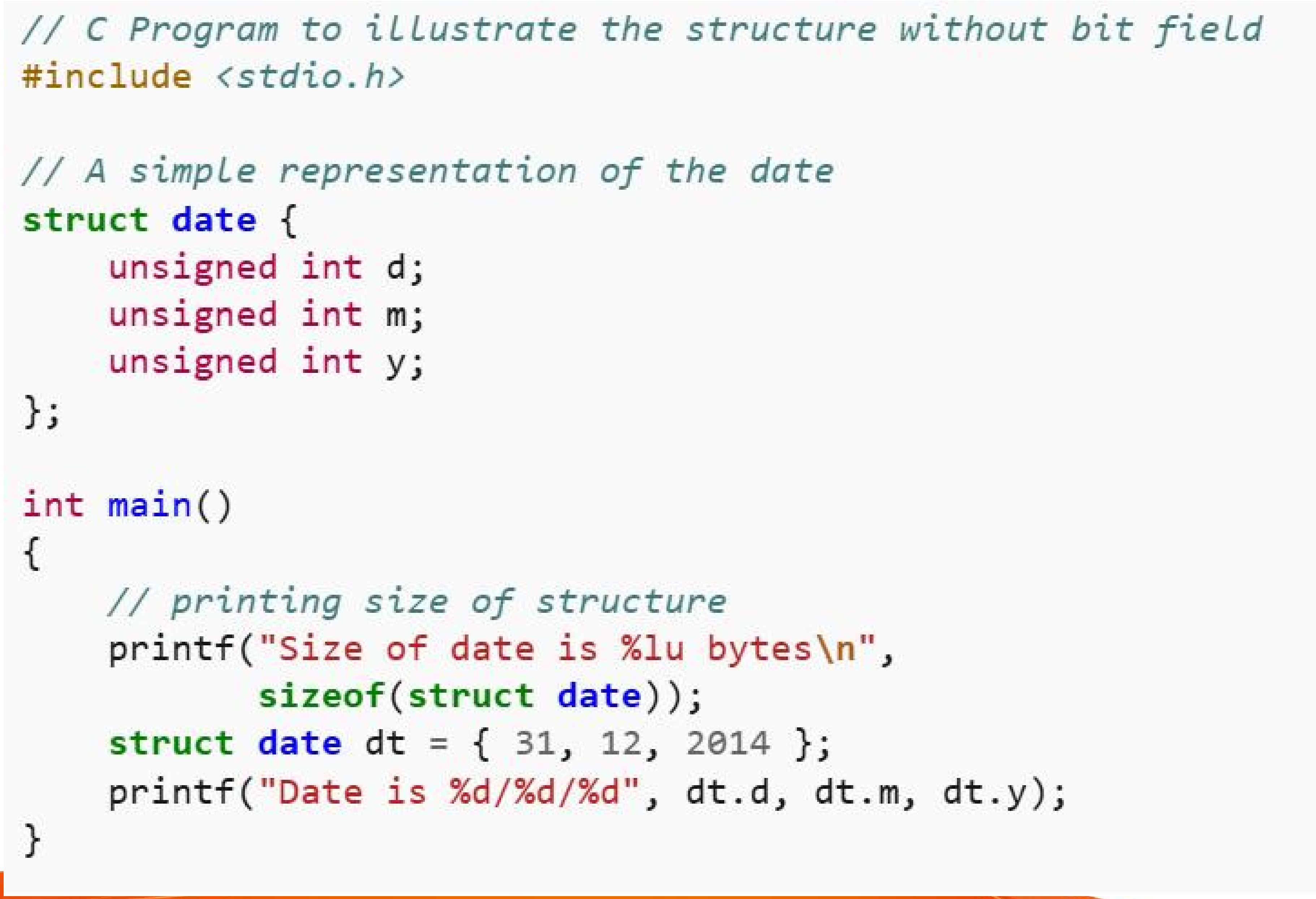
- It is similar to structure data type .
- Difference between structure and union is that in structure every data member has its own storage where members of union shares same memory locations.
- Elements of union can be accessed using dot(.) operator
- Storage for below union is 4bytes
- E.g

```
  union item
  {
     int m;    //2byte
     float z;  //4 byte
     char c;   //1 byte
  }u;
```

BIT Field

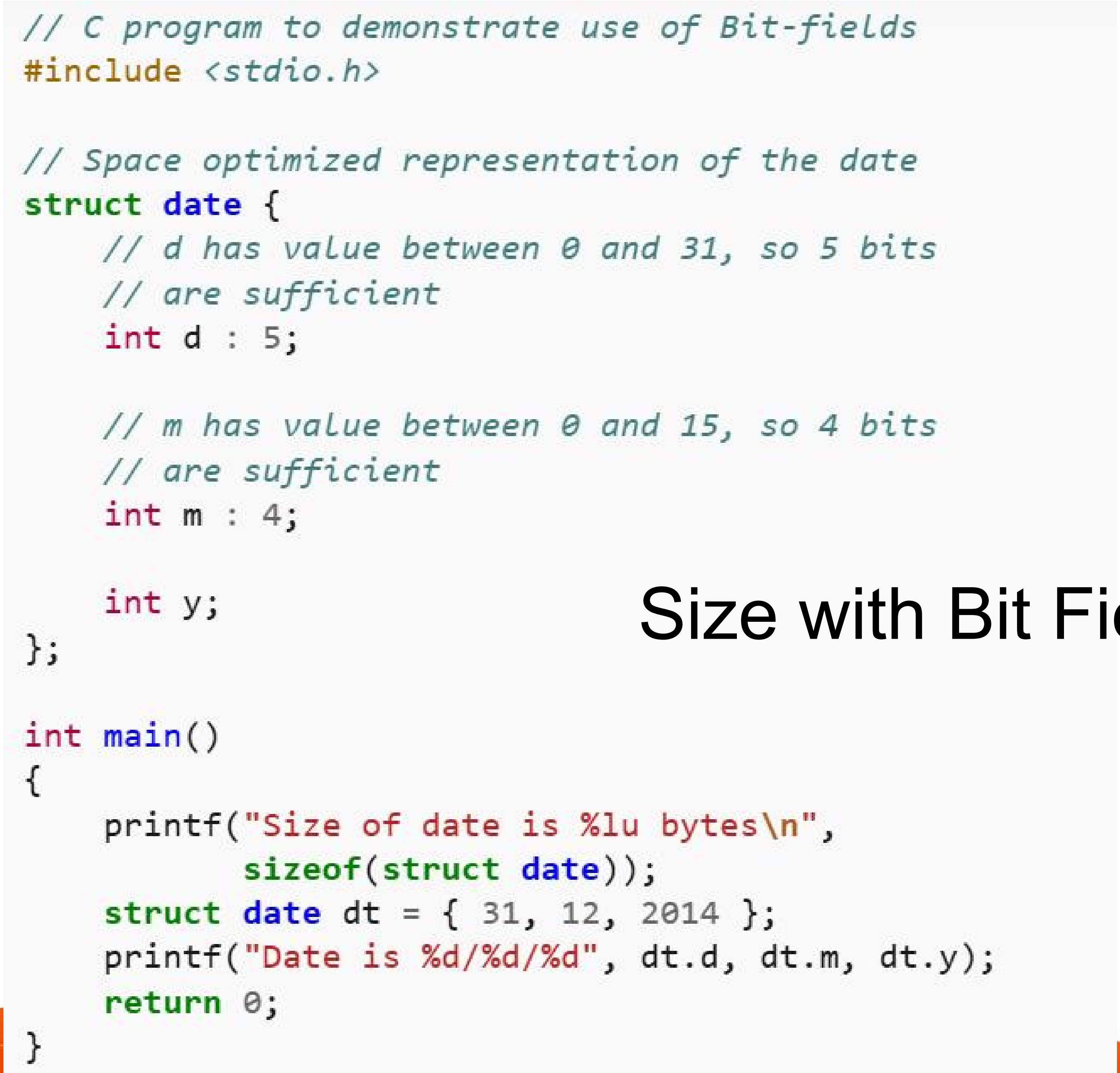
- Can specify the size (in bits) of the structure and union members.
- to use memory efficiently when we know that the value of a field or group of fields will never exceed a limit or is within a small range.
- C Bit fields are used when the storage of our program is limited.

Size without Bit Field



```c
// C Program to illustrate the structure without bit field
#include <stdio.h>

// A simple representation of the date
struct date {
    unsigned int d;
    unsigned int m;
    unsigned int y;
};

int main()
{
    // printing size of structure
    printf("Size of date is %lu bytes\n",
           sizeof(struct date));
    struct date dt = { 31, 12, 2014 };
    printf("Date is %d/%d/%d", dt.d, dt.m, dt.y);
}
```

Size with Bit Field



```c
// C program to demonstrate use of Bit-fields
#include <stdio.h>

// Space optimized representation of the date
struct date {
    // d has value between 0 and 31, so 5 bits
    // are sufficient
    int d : 5;

    // m has value between 0 and 15, so 4 bits
    // are sufficient
    int m : 4;

    int y;
};

int main()
{
    printf("Size of date is %lu bytes\n",
           sizeof(struct date));
    struct date dt = { 31, 12, 2014 };
    printf("Date is %d/%d/%d", dt.d, dt.m, dt.y);
    return 0;
}
```