2023

CYBERTRON

C-PROGRAMMING

(SECOND PART)

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Index:

1. Overflow in 2's complement addition

$$-8 \leq x[4] \leq +7$$

$$-128 \leq x[8] \leq +127$$

$$-32768 \leq x[16] \leq +32767$$

$$-2147483648 \leq x[32] \leq +2147483647$$

What if the result overflows the representation?

If the result of an arithmetic operation is to too large (positive or negative) to fit into the resultant bit-group, then arithmetic overflow occurs. It is normally left to the programmer to decide how to deal with this situation.

Overflow Rule for addition:

If 2 Two's Complement numbers are added, and they both have the same sign (both positive or both negative), then overflow occurs if and only if the result has the opposite sign. Overflow never occurs when adding operands with different signs.

i.e. Adding two positive numbers must give a positive result

Adding two negative numbers must give a negative result
Overflow occurs if

- (+A) + (+B) = −C
- (−A) + (−B) = +C

Example: Using 4-bit Two's Complement numbers (−8 ≤ x ≤ +7)

(−7) 1001
+(−6) 1010

(−13) 1 0011 = 3 : Overflow (largest −ve number is −8)

Overflow Rule for Subtraction:

If 2 Two's Complement numbers are subtracted, and their signs are different, then overflow occurs if and only if the result has the same sign as the subtrahend.

Overflow occurs if

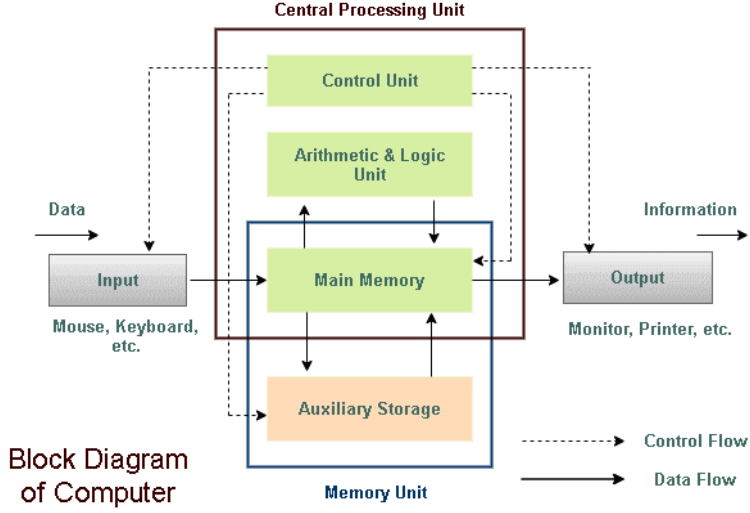
(+A) − (−B) = −C
(−A) − (+B) = +C
Example: Using 4-bit Two's Complement numbers (−8 ≤ x ≤ +7)

Subtract −6 from +7

```
 (+7) 0111              0111
−(−6) 1010 -> Negate -> +0110
----------             -----
  13                    1101 = −8 + 5 = −3 : Overflow
```

2. computer memory

A memory is just like a human brain. It is used to store data and instructions. Computer memory is the storage space in the computer, where data is to be processed and instructions required for processing are stored. The memory is divided into large number of small parts called cells. Each location or cell has a unique address, which varies from zero to memory size minus one. For example, if the computer has 64k words, then this memory unit has 64 * 1024 = 65536 memory locations. The address of these locations varies from 0 to 65535.



Memory is primarily of three types −

- Cache Memory,
- Primary Memory/Main Memory,
- Secondary Memory.

- If there are n number of bit then we can keep 2^n individual number of 0 or 1 in a memory location.
- It means if we have 2,3 and 4 number of bits then we can keep 4,8 and 16 individual number of 0 or 1.

- **What will be the output of the program given bellow:**

```
#include <stdio.h>
int main()
{
   int i;
   for(i=33;i<=126;i++){
      printf("ASCII code for %c is %d\n",i,i);
   }
   return 0;
}
```

Here,
Remember one thing that if we want to print characters which ASCII value is above 126 can't be possible because from 127 to 255 ASCII value of characters are non-printable.

- **What will be the output of the program given bellow:**

```
#include <stdio.h>
int main()
{
   char small_letter,capital_letter;
   printf("Please enter a small letter : ");
   small_letter = getchar();
   capital_letter = small_letter - 32;
   printf("The capital letter is : %c\n",capital_letter);
   return 0;
}
```

Here,
The output will be :
Please enter a small letter : a
The capital letter is : A

Now think about why it happened.

- **Write a function that will take a character type variable as a parameter and if the character is a digit then it will return 1 or if it is not then it will return 0.**

```
#include <stdio.h>

int sum(char a)
{
   if (a >= 48 && a <= 57)
   {
      return 1;
   }
   else
   {
      return 0;
   }
}

int main()
{
   char c;
   printf("Please enter a character : ");
   c = getchar();
   printf("Return value : %d\n", sum(c));
   return 0;
}
```

- **Address of variable :**

Byte is the smallest unit of computer. One after one many bytes are arranged in memory. Every single bytes have a specific address. when we declare a character variable it takes a byte in memory. Again if we declare a integer type variable it will take four byte one after one in memory. But which memory address they will take we can not say it. On the other hand if we declare any array then all the elements of the array will take place in memory one after one.

- **What will be the output of the program given bellow:**

```
#include <stdio.h>
int main()
{
   char ch1 = 'A', ch2 = 'B';
   int n1 = 100, n2 = 100000;

   printf("Value of ch1=%c,\t", ch1);
   printf("Address of ch1=%p\n", &ch1);

   printf("Value of ch2=%c,\t", ch2);
   printf("Address of ch2=%p\n", &ch2);

   printf("Value of n1=%c,\t", n1);
   printf("Address of n1=%p\n", &n1);
```

```
printf("Value of n2=%c,\t", n2);
   printf("Address of n2=%p\n", &n2);
   return 0;
}
```

Here,
The output will be:
Value of ch1=A, Address of ch1=0061FF1F
Value of ch2=B, Address of ch2=0061FF1E
Value of n1=d, Address of n1=0061FF18
Value of n2=á, Address of n2=0061FF14

%p is used for print the variable address in hexadecimal.

- If n is a variable then the address of it is &n. That's why when we use scanf function we use & before the variables name.

- **What will be the output of the program given bellow:**

```
#include <stdio.h>
int main()
{
   int ara[5] = {50, 60, 70, 80, 90};

   printf("Value of Array: %d, %d, %d, %d, %d,\n",
ara[0], ara[1], ara[2], ara[3], ara[4]);
   printf("Address of ara is %d\n", ara);
   printf("Address of ara[0] is %d\n", &ara[0]);
```

```
    printf("Address of ara[1] is %d\n", &ara[1]);
    printf("Address of ara[2] is %d\n", &ara[2]);
    printf("Address of ara[3] is %d\n", &ara[3]);
    printf("Address of ara[4] is %d\n", &ara[4]);

    return 0;
}
```

Here,
The output will be:
Value of Array: 50, 60, 70, 80, 90,
Address of ara is 6422284
Address of ara[0] is 6422284
Address of ara[1] is 6422288
Address of ara[2] is 6422292
Address of ara[3] is 6422296
Address of ara[4] is 6422300

Here we can see that at first the program will print all the arrays elements in the first line. In the second line it will print the starting address of the array, it means the address of memory storage from where the array started. The third line will print as well as the second line do because the starting address of array and the first elements address of array are same. In the fourth line it will print the second elements address of array which is large 4 byte than the first element because the array is an integer data type and we know that every integer data type variable takes 4 byte of memory storage.

- The size of variables of varies data type depends on computer architecture.
- There are a operator in C language called sizeof which can find out the variable size in byte.

- **What will be the output of the program given bellow:**

```
#include <stdio.h>
int main()
{
   int x = 10;

   printf("Value of x is %d\n", x);
   printf("Address of x is %p\n", &x);
   printf("Address of x is %X\n", &x);
   printf("Address of x is %x\n", &x);
   printf("Address of x is %d\n", &x);

   return 0;
}
```

Here,
The output will be:
Value of x is 10
Address of x is 0061FF1C
Address of x is 61FF1C
Address of x is 61ff1c
Address of x is 6422300

- **Write a program that will print size of int, char, double and float data type variables in byte.**

```
#include <stdio.h>
int main()
{
  int num;
  char ch;
  double d_num;
  float f_num;

  printf("%lu\n",sizeof(int));
  printf("Size of int in byte: %d\n",sizeof(num));
  printf("Size of char in byte: %d\n",sizeof(ch));
  printf("Size of double in byte: %d\n",sizeof(d_num));
  printf("Size of float in byte: %d\n",sizeof(f_num));

  return 0;
}
```

- If we want we can declare variable to keep in register in C language. As a example:

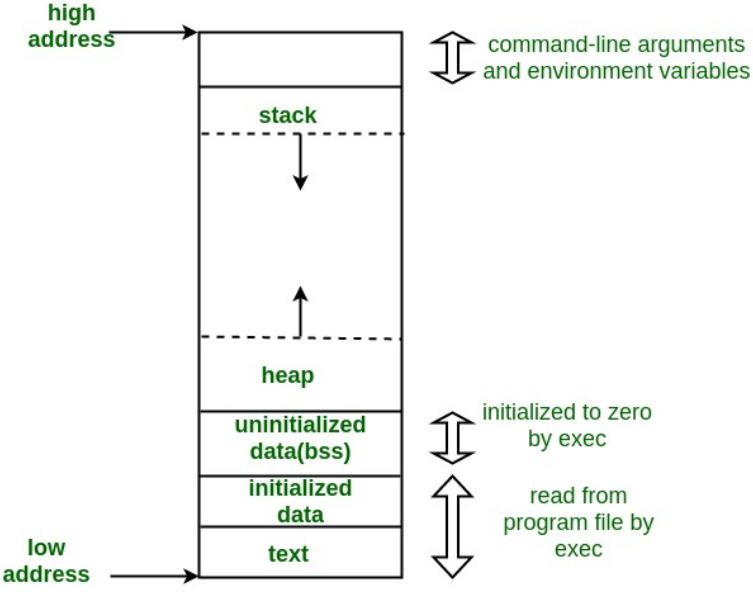
  register int number;

- Register is the fastest storage of all. It is situated in the computer processor and after this cash memory is attached with it. Cash memory is slower than register. On the other hand RAM is attached with the motherboard. RAM is also slower than RAM. There are also a storage called virtual memory. It is more slower than RAM.
- When the storage of RAM isn't enough for processing then computer operating system gives a part of hard disk to use as memory. Of course it is more slower than RAM.

Memory Layout of C Programs:

A typical memory representation of a C program consists of the following sections.

1. Text segment (i.e. instructions)
2. Initialized data segment
3. Uninitialized data segment (bss)
4. Heap
5. Stack



A typical memory layout of a running process

1. Text Segment: A text segment, also known as a code segment or simply as text, is one of the sections of a program in an object file or in memory, which contains executable instructions.

As a memory region, a text segment may be placed below the heap or stack in order to prevent heaps and stack overflows from overwriting it.
Usually, the text segment is sharable so that only a single copy needs to be in memory for frequently executed programs, such as text editors, the C compiler, the shells, and so on. Also, the text segment is often read-only, to prevent a program from accidentally modifying its instructions.

2. Initialized Data Segment: Initialized data segment, usually called simply the Data Segment. A data segment is a portion of the virtual address space of a program, which contains the global variables and static variables that are initialized by the programmer.
Note that, the data segment is not read-only, since the values of the variables can be altered at run time.
This segment can be further classified into the initialized read-only area and the initialized read-write area.
For instance, the global string defined by char s[] = “hello world” in C and a C statement like int debug=1 outside the main (i.e. global) would be stored in the initialized read-write area. And a global C statement like const char* string = “hello world” makes the string literal “hello world” to be

stored in the initialized read-only area and the character pointer variable string in the initialized read-write area.
Ex: static int i = 10 will be stored in the data segment and global int i = 10 will also be stored in data segment

3. Uninitialized Data Segment: Uninitialized data segment often called the “bss” segment, named after an ancient assembler operator that stood for “block started by symbol.” Data in this segment is initialized by the kernel to arithmetic 0 before the program starts executing uninitialized data starts at the end of the data segment and contains all global variables and static variables that are initialized to zero or do not have explicit initialization in source code.
For instance, a variable declared static int i; would be contained in the BSS segment.
For instance, a global variable declared int j; would be contained in the BSS segment.

4. Stack: The stack area traditionally adjoined the heap area and grew in the opposite direction; when the stack pointer met the heap pointer, free memory was exhausted. (With modern large address spaces and virtual memory techniques they may be placed almost anywhere, but they still typically grow in opposite directions.)
The stack area contains the program stack, a LIFO structure, typically located in the higher

parts of memory. On the standard PC x86 computer architecture, it grows toward address zero; on some other architectures, it grows in the opposite direction. A “stack pointer” register tracks the top of the stack; it is adjusted each time a value is “pushed” onto the stack. The set of values pushed for one function call is termed a “stack frame”; A stack frame consists at minimum of a return address.
Stack, where automatic variables are stored, along with information that is saved each time a function is called. Each time a function is called, the address of where to return to and certain information about the caller’s environment, such as some of the machine registers, are saved on the stack. The newly called function then allocates room on the stack for its automatic variables. This is how recursive functions in C can work. Each time a recursive function calls itself, a new stack frame is used, so one set of variables doesn’t interfere with the variables from another instance of the function.

5. Heap: Heap is the segment where dynamic memory allocation usually takes place.
The heap area begins at the end of the BSS segment and grows to larger addresses from there. The Heap area is managed by malloc, realloc, and free, which may use the brk and sbrk system calls to adjust its size (note that the use of brk/sbrk and a single “heap area” is not

required to fulfill the contract of malloc/realloc/free; they may also be implemented using mmap to reserve potentially non-contiguous regions of virtual memory into the process' virtual address space). The Heap area is shared by all shared libraries and dynamically loaded modules in a process.

Examples:

The size(1) command reports the sizes (in bytes) of the text, data, and bss segments. (for more details please refer man page of size(1))

1. Check the following simple C program

```
#include <stdio.h>

int main(void)
{
   return 0;
}
```

```
[narendra@CentOS]$ gcc memory-layout.c -o memory-layout
[narendra@CentOS]$ size memory-layout
text       data        bss        dec        hex    filename
960        248         8       1216        4c0    memory-layout
```

2. Let us add one global variable in the program, now check the size of bss (highlighted in red color).

```
#include <stdio.h>

int global; /* Uninitialized variable stored in bss*/

int main(void)
{
   return 0;
}
```

```
[narendra@CentOS]$ gcc memory-layout.c -o memory-layout
[narendra@CentOS]$ size memory-layout
text       data        bss        dec        hex    filename
 960        248         12       1220        4c4    memory-layout
```

3. Let us add one static variable which is also stored in bss.

```
#include <stdio.h>

int global; /* Uninitialized variable stored in bss*/

int main(void)
{
   static int i; /* Uninitialized static variable
stored in bss */
   return 0;
}
```

```
[narendra@CentOS]$ gcc memory-layout.c -o memory-
layout
[narendra@CentOS]$ size memory-layout
text       data        bss        dec        hex    filename
 960        248         16       1224        4c8    memory-layout
```

4. Let us initialize the static variable which will then be stored in the Data Segment (DS)

```
#include <stdio.h>

int global; /* Uninitialized variable stored in bss*/

int main(void)
{
   static int i = 100; /* Initialized static variable stored in
DS*/
   return 0;
}
```

```
[narendra@CentOS]$ gcc memory-layout.c -o memory-
layout
[narendra@CentOS]$ size memory-layout
text       data        bss        dec        hex    filename
960         252         12       1224        4c8    memory-layout
```

5. Let us initialize the global variable which will then be stored in the Data Segment (DS)

```
#include <stdio.h>

int global = 10; /* initialized global variable stored in DS*/

int main(void)
{
   static int i = 100; /* Initialized static variable stored in DS*/
   return 0;
}
```

```
[narendra@CentOS]$ gcc memory-layout.c -o memory-layout
[narendra@CentOS]$ size memory-layout
text      data      bss      dec      hex    filename
960        256        8     1224      4c8    memory-layout
```

3.function

A function is a group of statements that together perform a task. Every C program has at least one function, which is main(), and all the most trivial programs can define additional functions.

You can divide up your code into separate functions. How you divide up your code among different functions is up to you, but logically the division is such that each function performs a specific task.
A function declaration tells the compiler about a function's name, return type, and parameters. A function definition provides the actual body of the function.
The C standard library provides numerous built-in functions that your program can call. For example, strcat() to concatenate two strings, memcpy() to copy one memory location to another location, and many more functions.
A function can also be referred as a method or a sub-routine or a procedure, etc.

Defining a Function :
The general form of a function definition in C programming language is as follows −

```
return_type function_name( parameter list ) {
   body of the function
}
```

A function definition in C programming consists of a function header and a function body. Here are all the parts of a function −

Return Type − A function may return a value. The return_type is the data type of the value the function returns. Some functions perform the desired operations without returning a value. In this case, the return_type is the keyword void.

Function Name − This is the actual name of the function. The function name and the parameter list together constitute the function signature.

Parameters/arguments − A parameter is like a placeholder. When a function is invoked, you pass a value to the parameter. This value is referred to as actual parameter or argument. The parameter list refers to the type, order, and number of the parameters of a function. Parameters are optional; that is, a function may contain no parameters.

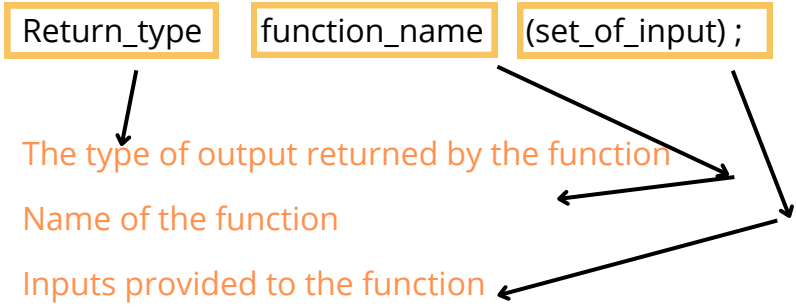
Function Body − The function body contains a collection of statements that define what the function does.

Basic of Function:

Definition:

Function is basically a set of statements that takes inputs, perform some computation and products output.

Syntax:



Why Functions ?

There are two important reasons of why we are using function:

1. Reusability:
Once the function is defined, it can be reused over and over again.
2. abstraction:
If you are just using the function in your program then you don't have to worry about how it works inside!

example: scanf function

- **What is the output of the following C program fragment:**

```
#include <stdio.h>

int areaOfRect(int length, int breadth)
{
  int area;
  area = length * breadth;
  return area;
}
int main()
{
  int l=10, b=5;
  int area = areaOfRect(l, b);
  printf("%d\n",area);
  return 0;
}
```

Output:
50

- **What is the output of the following C program fragment:**

```
#include <stdio.h>

int areaOfRect(int length, int breadth)
{
   int area;
   area = length * breadth;
   return area;
}
int main()
{
   int l=10, b=5;
   int area = areaOfRect(l, b);
   printf("%d\n",area);

   l=50, b=20;
   area = areaOfRect(l, b);
   printf("%d\n",area);
}
```

Output:
50
1000

Function Declaration:

As we already know , when we declared a variable, we declare its properties to the compiler.

For example: int var;
properties:

1. Name of variable: var
2. Type of variable: int

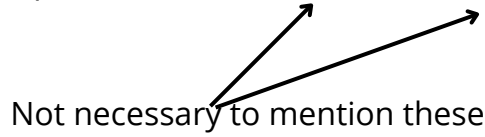
Similarly, function declaration (also called function prototype) means declaring the properties of a function to the compiler.

For example: int fun(int, char);
Properties:

1. Name of function: fun
2. Return type of function: int
3. Number of parameters: 2
4. Type of parameter 1: int
5. Type of parameter 2: char

It is not necessary to put the name of the parameters in function.

For example: int fun (int var1, char var2);



- **What is the output of the following C program fragment:**

```
#include<stdio.h>
char fun();  // Function prototype
int main()
{
  char c = fun();
  printf("Character is : %c",c);
}
char fun()
{
  return 'a';
}
```

Output:
Character is : a

Here,
Declare the function before using it is not necessary but it is preferred to declare before using it.

or,

```
#include<stdio.h>
char fun()
{
  return 'a';
}
```

```
int main()
{
  char c = fun();
  printf("Character is : %c",c);
}
```

- **What is the output of the following C program fragment:**

```
#include<stdio.h>
int main()
{
  char c = fun();
  printf("Character is : %c",c);
}
char fun()
{
  return 'a';
}
```

Output:

```
warning: implicit declaration of function 'fun' [-
Wimplicit-function-declaration]
   char c = fun();
            ^~~
At top level:
 error: conflicting types for 'fun'
 char fun()
      ^~~
note: previous implicit declaration of 'fun' was here
   char c = fun();
            ^~~
```

Function definition:

Function definition consists of block of code which is capable of performing some specific task.

For example:

```
int add(int a, int b)
{     int sum;
      sum = a+b;
      return sum;
}
```

Here,

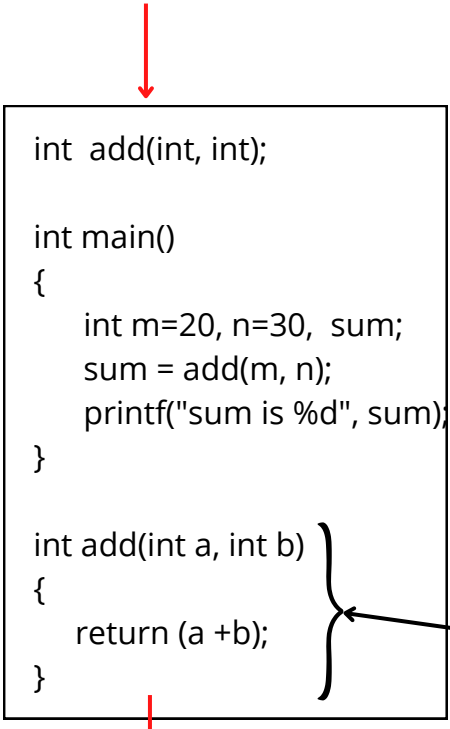
```
int  add(int, int);

int main()
{
     int m=20, n=30,  sum;
     sum = add(m, n);
     printf("sum is %d", sum);
}

int add(int a, int b)
{
    return (a +b);
}
```

This is the way you call a function.

Note: while calling a function, you should not mention the return type of the function.
Also you should not mention the data types of the arguments.

```
int  add(int, int);

int main()
{
      int m=20, n=30,  sum;
      sum = add(m, n);
      printf("sum is %d",
sum);
}

int add(int a, int b)
{
    return (a +b);
}
```

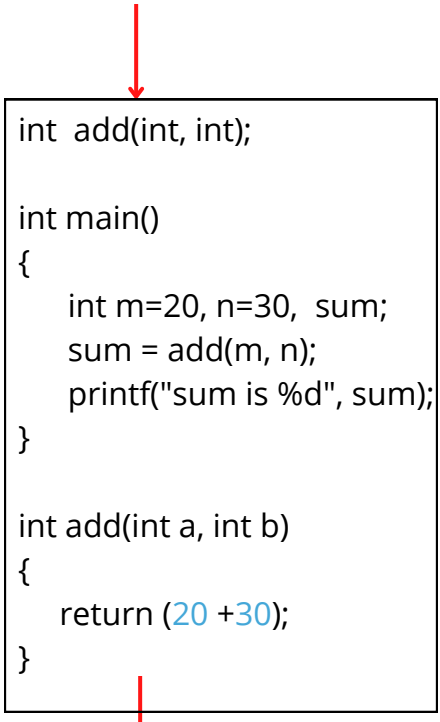
```
int  add(int, int);

int main()
{
      int m=20, n=30,  sum;
      sum = add(m, n);
      printf("sum is %d", sum);
}

int add(int a, int b)
{
    return (a +b);
}
```

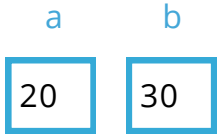


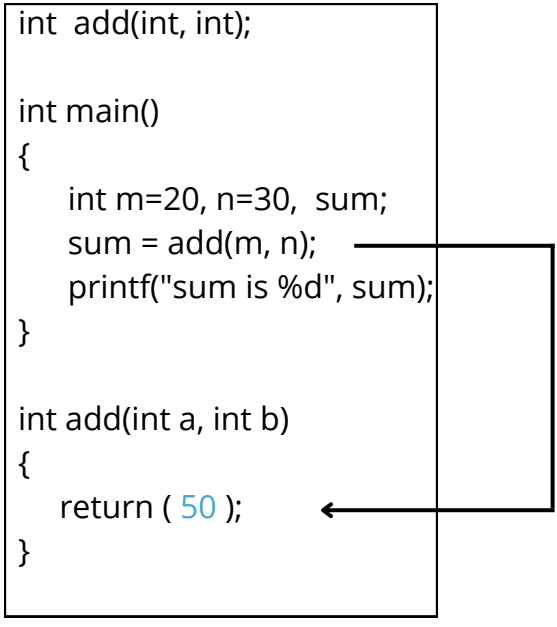
This is the way how you define a function.
Note: it is important to mention both data type and name of parameters.

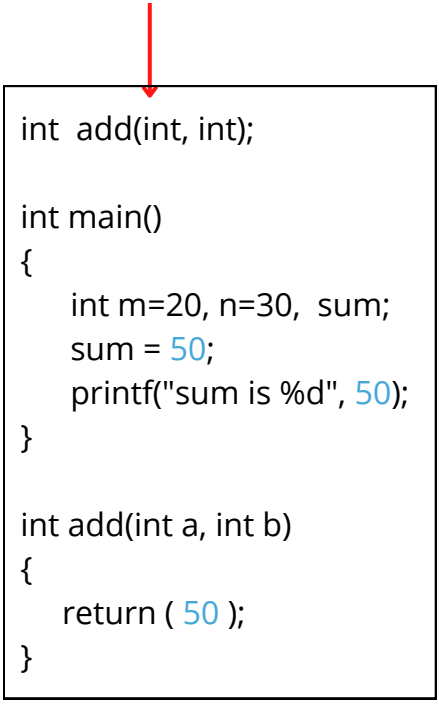
```
int  add(int, int);

int main()
{
     int m=20, n=30,  sum;
     sum = add(m, n);
     printf("sum is %d", sum);
}

int add(int a, int b)
{
    return (a +b);
}
```

a	b
20	30


int add(int, int);
int main()
{
int m=20, n=30, sum;
sum = add(m, n);
printf("sum is %d", sum);
}
int add(int a, int b)
{
return (20 +30);
}


a
b
20
30


int add(int, int);
int main()
{
int m=20, n=30, sum;
sum = add(m, n);
printf("sum is %d", sum);
}
int add(int a, int b)
{
return (50);
}



```
int  add(int, int);

int main()
{
      int m=20, n=30,  sum;
      sum = 50;
      printf("sum is %d", 50);
}

int add(int a, int b)
{
     return ( 50 );
}
```

or,

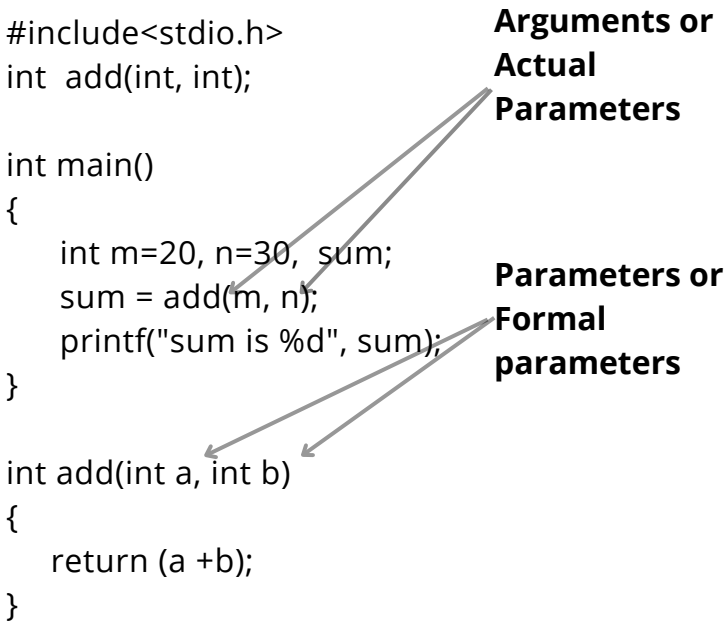
```
#include<stdio.h>
int  add(int, int);

int main()
{
      int m=20, n=30,  sum;
      sum = add(m, n);
      printf("sum is %d", sum);
}

int add(int a, int b)
{
     return (a +b);
}
```

Output;
sum is 50

Difference between an Argument and Parameter:

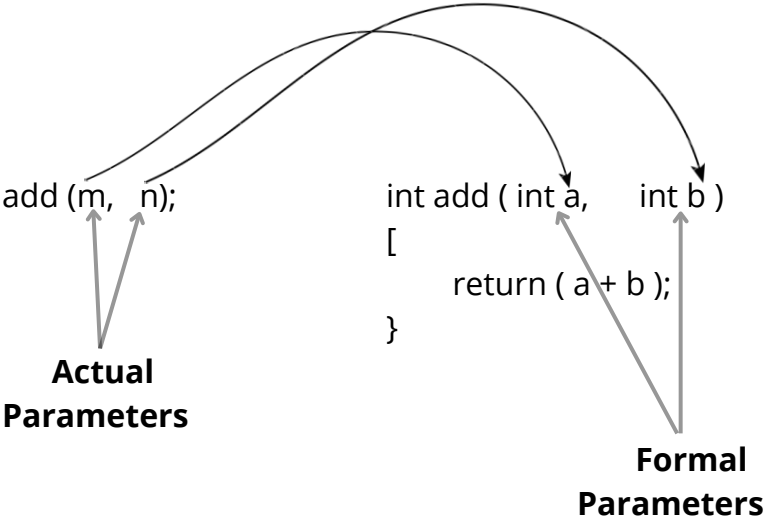
Parameter: is a variable in the declaration of the function.
Argument: is the actual value of the parameter that gets passed to the function.

Note: Parameter is also called as Formal Parameter and Argument is also called as Actual parameter.



Recall:

Actual Parameters: The parameters passed to a function.
Formal Parameters: the parameters received by a function.



Type of Function call

While calling a function, there are two ways that arguments can be passed to a function:

Call Type	Description
Call by value	This method copies the actual value of an argument into the formal parameter of the function. In this case, changes made to the parameter inside the function have no effect on the argument.
Call by reference	This method copies the address of an argument into the formal parameter. Inside the function, the address is used to access the actual argument used in the call. This means that changes made to the parameter affect the argument.

Call by Value:

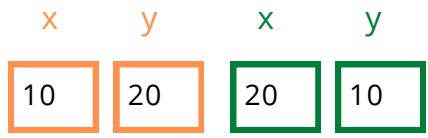
Here values of actual parameters will be copied to formal parameters and these two different parameters store values in different locations.

- In this case, changes made to the parameter inside the function have no effect on the argument.
- By default, C programming language uses call by value method to pass arguments. In general, this means that code within a function cannot alter the arguments used to call the function. Consider the function swap() definition as follows.

```
int x = 10, y = 20;
fun(x, y);
printf("x = %d, y = %d,x,y);
```

```
int fun(int x, int y)
{
   x=20;
   y=10;
}
```

Output:
x=10, y=20



- **What is the output of the following C program fragment:**

```
#include<stdio.h>
/* function definition to swap the value */
void swap(int x, int y){
  int temp;
  temp = x; /* save the value of x */
  x = y; /* put y into x */
  y = temp; /* put temp into y */
}

void main()
{
  /* local variable definition */
  int a = 100;
  int b = 200;

  printf("Before swap, value of a : %d\n",a);
  printf("Before swap, value of b : %d\n",b);

  /* calling a function to swap the value */
  swap(a, b);
```

```
  printf("After swap, value of a : %d\n", a);
  printf("After swap, value of a : %d\n", b);

}
```

Output::

```
Before swap, value of a : 100
Before swap, value of b : 200
After swap, value of a : 100
After swap, value of a : 200
```

Here,
The output shows that there is no change in the values though they had been changed inside the function.

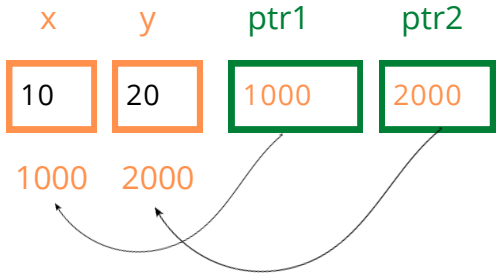
Call by Reference:

The call by reference method of passing arguments to a function copies the address of an argument into the formal parameter.

- Inside the function, the address is used to access the actual argument used in the call. This means that changes made to the parameter affect the passed argument.
- To pass the value by call by reference, argument pointers are passed to the functions.
- To pass the value by reference, argument pointers are passed to the functions just like any other value.

```
int x = 10, y = 20;
fun(&x, &y);
printf("x = %d, y = %d,x,y);

Output:
x=20, y=10
```

```
int fun (int *ptr1, int *ptr2)
{
   *ptr1=20;
   *ptr2=10;
}
```



- **What is the output of the following C program fragment:**

```
#include<stdio.h>
/* function definition to swap the value */
void swap(int *x, int *y){
  int temp;
  temp = *x; /* save the value of x */
  *x = *y; /* put y into x */
  *y = temp; /* put temp into y */
}

void main()
{
  /* local variable definition */
  int a = 100;
  int b = 200;
```

```
  printf("Before swap, value of a : %d\n",a);
  printf("Before swap, value of b : %d\n",b);

  /* calling a function to swap the value
     &a indicates pointer to a ie. address of
     variable a and &b indicates pointer b ie.
     address of variable b */
  swap(&a, &b);

  printf("After swap, value of a : %d\n", a);
  printf("After swap, value of a : %d\n", b);

}
```

- **What is the output of the following C program fragment:**

Consider the function func shown below:

```
int func(int num)
{
    int count = 0;
    while(num)
    {
        count++;
        num >>= 1;
    }
    return(count);
}
```

num = 435, count = 9

435 = 110110011

011011001 Iter 1

001101100 Iter 2

.

.

000000000 Iter 9

The value returned by func(435) is 9

[GATE 2014]

- **What is the output of the following C program fragment:**

The output of the following C program is:

```
void f1(int a, int b)
{
    int c;
    c = a; a = b; b = c;
}
void f2(int *a, int *b)
{
    int c;
    c = *a; *a = *b; *b = c;
}
int main()
{
    int a=4, b=5, c=6;
    f1(a, b);
    f2(&b, &c);
    printf("%d",   -5 );
    return 0;
}
```

Output: -5

- **What is the output of the following C program fragment:**

Consider the following C program:

```
int fun()
{
  static int num = 16;
  return num--;
}

int main()
{
  for(fun(); fun(); fun())
  printf("%d ", fun());
  return 0;
}
```

What is the output of the C program available in the LHS?

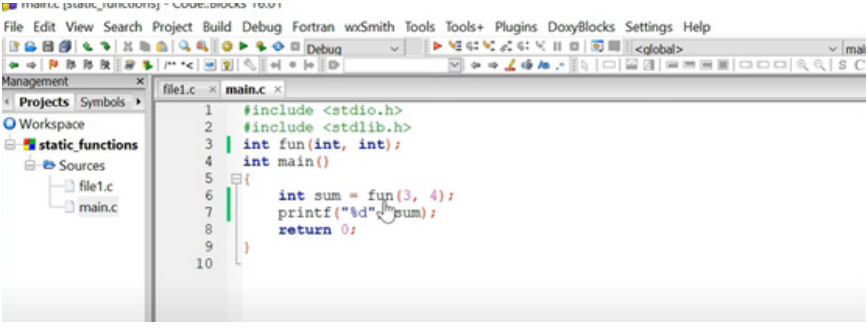
a) Infinite loop
b) 13 10 7 4 1
c) 14 11 8 5 2
d) 15 12 8 5 2

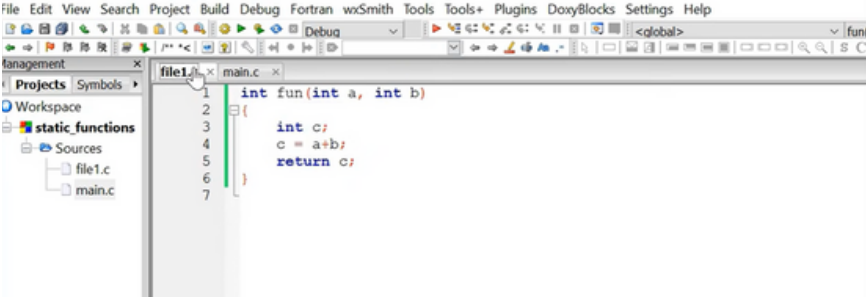
Static function in C:

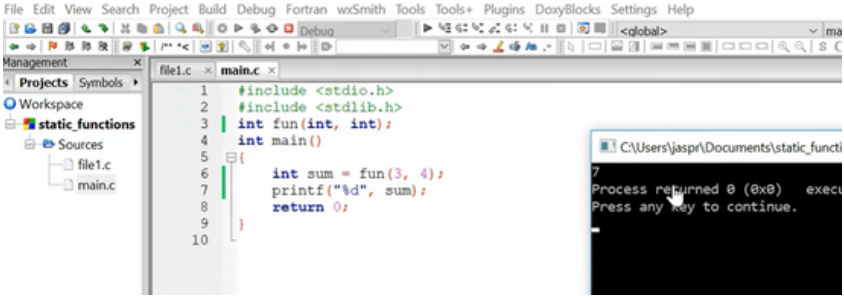
Basics:

- In C, functions are global by default.
- This means if we want to access the function outside from the file where it is declared, we can access it easily.
- now if we want to restrict this access, then we make our function static by simply putting a keyword static in front of the function.

For example:



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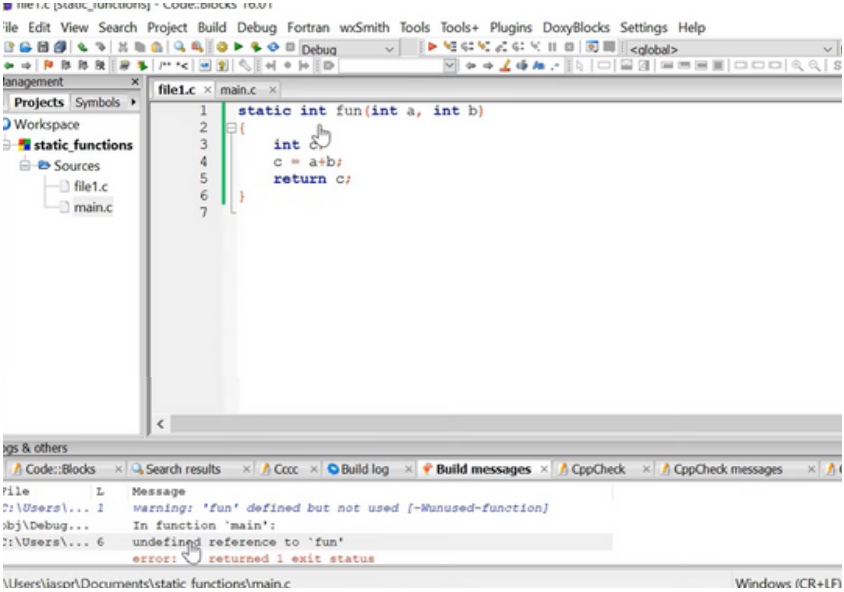
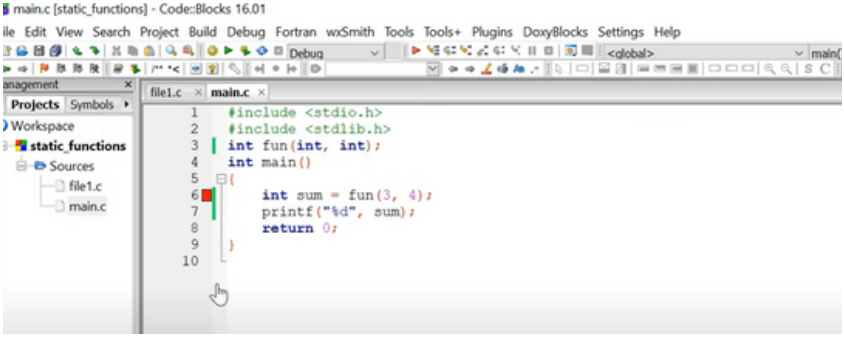
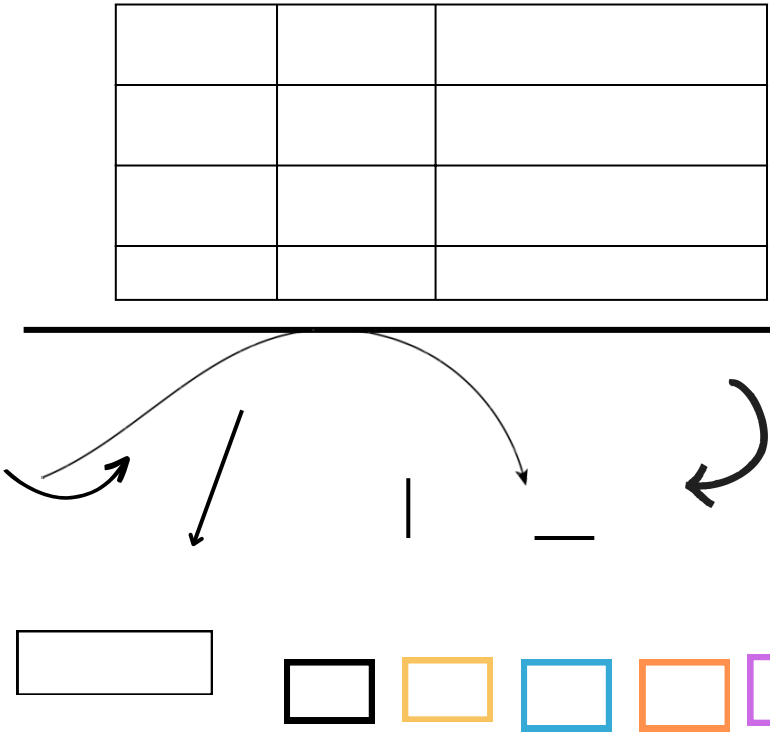
Debug
<global>
Management
Projects Symbols
Workspace
static_functions
Sources
file1.c
main.c
file1.c main.c
#include <stdio.h>
#include <stdlib.h>
int fun(int, int);
int main()
{
int sum = fun(3, 4);
printf("%d", sum);
return 0;
}
C:\Users\jaspr\Documents\static_functi
7
Process returned 0 (0x0)
Press any key to continue.


File Edit View Search Project Build Debug Fortran wxSmith Tools Tools+ Plugins DoxyBlocks Settings Help
Debug
<global>
Projects Symbols
Workspace
static_functions
Sources
file1.c
main.c
file1.c main.c
static int fun(int a, int b)
{
int c;
c = a+b;
return c;
}
Code::Blocks Search results Cccc Build log Build messages CppCheck CppCheck messages
File L Message
warning: 'fun' defined but not used [-Wunused-function]
In function 'main':
undefined reference to 'fun'
error: returned 1 exit status
Windows (CR+LF)


main.c [static_functions] - Code::Blocks 16.01
File Edit View Search Project Build Debug Fortran wxSmith Tools Tools+ Plugins DoxyBlocks Settings Help
Debug
<global>
Projects Symbols
Workspace
static_functions
Sources
file1.c
main.c
file1.c main.c
#include <stdio.h>
#include <stdlib.h>
int fun(int, int);
int main()
{
int sum = fun(3, 4);
printf("%d", sum);
return 0;
}

Operator Precedence and Associativity:



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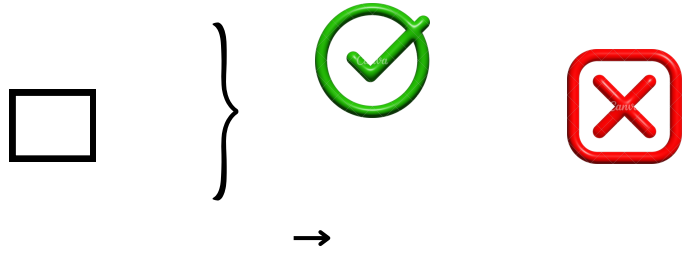


- **What is the output of the following C program fragment:**

- **Make a program that will add two numbers using function.**

```
#include<stdio.h>

int sum (int a,int b)
{
  return a+b;
}

int main()
{
  int num1,num2;
  printf("Enter two number : ");
  scanf("%d %d",&num1,&num2);

  printf("The sum is : %d\n",sum(num1,num2));
  return 0;

}
```

or,

```
#include <stdio.h>
int main()
{
  int num1, num2;
  printf("Enter two number : ");
  scanf("%d %d", &num1, &num2);

  printf("The sum is : %d\n", sum(num1, num2));
  return 0;
}

int sum(int a, int b)
{
  return a + b;
}
```

Here,
We will found an error that sum was not declared in this scope. But we don't need to warry about it because it has a solution. And the solution is we have to write the prototype of sum function before the main function. The prototype is int sum(int a, int b);

or,

```
#include <stdio.h>
int sum(int a, int b);
int main()
{
  int num1, num2;
  printf("Enter two number : ");
  scanf("%d %d", &num1, &num2);

  printf("The sum is : %d\n", sum(num1, num2));
  return 0;
}

int sum(int a, int b)
{
  return a + b;
}
```

- **What will be the output of the program given bellow.**

```
#include<stdio.h>
int test_function(int x)
{
   int y=x;
   x=2*y;
   return (x*y);
}

int main()
{
   int x=10,y=20,z=30;
   z=test_function(x);
   printf("%d %d %d\n",x,y,z);
   return 0;
}
```

Here,
The output will be 10 20 200 where we expect that the output will be 20 10 200. Why it is happening ? The reason is every functions have different variables. It is called local variable. We have print the value of x, y of main function but do not print the value of x, y of test_function. The existence of local variable of a function do not stay in other function.
If we want the existence of variable in all function then we have to declare global variable.

or,

or,

```
#include<stdio.h>

int sum(int a,int b)
{
  return a+b;
}

int main()
{
  int num1,num2;
  printf("Enter two number : ");
  scanf("%d %d",&num1,&num2);

  int result = sum(num1,num2);

  printf("The sum is : %d\n",result);
  return 0;

}
```

- **Make a program that will show sum of 1 and 2 using function.**

```
#include<stdio.h>
int sum(int a,int b)
{
  return a+b;
}

int main()
{

  int result = sum(1,2);

  printf("The sum is : %d\n",result);
  return 0;

}
```

or,

```
#include<stdio.h>
int sum(int a,int b)
{
  return a+b;
}
int main()
{
  int result;
  result = sum(1,2);
  printf("The sum is : %d\n",result);
  return 0;
}
```

- **Make a program that will show sum of 1,2 and 5,6 using function and also print 5 without function.**

```
#include <stdio.h>
int sum(int a, int b)
{
 return a + b;
}
int main()
{
 int result = sum(1, 2);
 printf("The sum is : %d\n", result);

 result = sum(5, 6);
 printf("The sum is : %d\n", result);
 printf("The sum is : %d\n", 5);
 return 0;
}
```

or,

```
#include <stdio.h>
int sum(int a, int b)
{
 return a + b;
}
int main()
{
 printf("The sum is : %d\n", sum(1, 2));
 printf("The sum is : %d\n", sum(5, 6));
 printf("The sum is : %d\n", 5);
 return 0;
}
```

- **Make a program that will show sum of 1,2,3 and 5,6,7 using function.**

```
#include<stdio.h>
int sum(int a,int b,int c)
{
  return a+b+c;
}
int main()
{
  printf("The sum is : %d\n",sum(1,2,3));
  printf("The sum is : %d\n",sum(5,6,7));
  return 0;
}
```

or,

```
#include<stdio.h>
int sum(int a,int b,int c)
{
  printf("The sum is : %d\n",a+b+c);
}
int main()
{
  sum(1,2,3);
  sum(5,6,7);
  return 0;
}
```

- **Make a program that will show sum of 1,2,3 using function.**

```
#include<stdio.h>
int sum(int a,int b,int c)
{
  printf("The sum is : %d\n",a+b+c);
}
int main()
{
  sum(1,2,3);
  return 0;
}
```

or,

```
#include<stdio.h>
void sum(int a,int b,int c)
{
  printf("The sum is : %d\n",a+b+c);
}
int main()
{
  sum(1,2,3);
  return 0;
}
```

Here,
void is used for return nothing from the function.

- **Make a program that will show sum of 1,2,3 and 5,6,7 and also subtraction of 5,4 using function.**

```
#include<stdio.h>
void sum(int a,int b,int c)
{
  printf("The sum is : %d\n",a+b+c);
}

void sub (int a,int b)
{
  printf("The subtraction is : %d\n",a-b);
}
int main()
{
  sum(1,2,3);
  sum(5,6,7);
  sub (5,4);
  return 0;
}
```

- **Make a program that will show square of any integer number using function.**

```
#include<stdio.h>
int square(int a)
{
  return a*a;
}
int main()
{
  int num;
  printf("Enter any integer number : ");
  scanf("%d",&num);
  int result=square(num);
  printf("Square is : %d\n",result);
  return 0;
}
```

or,

```
#include<stdio.h>
int square(int a)
{
  return a*a;
}
int main()
{
  int num;
  printf("Enter any integer number : ");
  scanf("%d",&num);
  printf("Square is : %d\n",square(num));
  return 0;
}
```

- **Make a program that will show area of a triangle using function.**

```
#include<stdio.h>
double area_of_traingle(double base, double height);
int main()
{
  double base, height, result;
  printf("Enter base of the traingle: ");
  scanf("%lf",&base);
  printf("Enter base of the traingle: ");
  scanf("%lf",&height);
  result = area_of_traingle(base, height);
  printf("Area of traingle is: %.2lf\n",result);
}
double area_of_traingle(double base, double height)
{
  return .5*base*height;
}
```

or,

```
#include<stdio.h>
double area_of_traingle(double base, double
height)
{
  return .5*base*height;
}
int main()
{
  double base, height, result;
  printf("Enter base of the traingle: ");
```

```
 scanf("%lf",&base);
 printf("Enter base of the traingle: ");
 scanf("%lf",&height);
 result = area_of_traingle(base, height);
 printf("Area of traingle is: %.2lf\n",result);
}
```

- **Make a program that will calculate power(base, exponent) using function.**

```
#include<stdio.h>
double power(double a, int b)
{
  double result=1, i;
  for(i=1;i<=b;i++){
    result=result*a;
  }
  return result;
}
int main()
{
  double base, Ans;
  int exponent;
  printf("Enter base in double and exponent in
integer: ");
  scanf("%lf %d",&base,&exponent);
  Ans =power(base,exponent);
  printf("Ans: %lf",Ans);
  return 0;
}
```

or,

```
#include<stdio.h>
void power(double base, double exp)
{
  double result=1,i;
  for(i=1;i<=exp;i++){
    result=result*base;
  }
  printf("%.1lf\n",result);
}
int main()
{
  power(2,3);
  return 0;
}
```

- **Make a program that will show given bellow using function.**
  2.0
  4.0
  8.0

```
#include<stdio.h>
void power(double base, double exp)
{
  double result=1,i;
  for(i=1;i<=exp;i++){
    result=result*base;
  }
  printf("%.1lf\n",result);
}
```

```
 int main()
 {
   power(2,1);
   power(2,2);
   power(2,3);
   return 0;
}
```

- **Make a program that will show Passing Array to function.**

```
#include<stdio.h>
void display(int a[])
{
   int i;
   for(i=0;i<=4;i++){
    printf("%d ",a[i]);
   }
}
int main()
{
  int num[]={10,20,30,40,50};
  display(num);
   return 0;
}
```

- **Make a program that will show maximum value from an array using function.**

```
#include <stdio.h>
int maximum(int a[5])
{
  int i;
  int max = a[0];
  {
    for (i = 1; i <= 4; i++)
    {
      if (max < a[i])
      {
        max = a[i];
      }
    }
    return max;
  }
}
int main()
{
  int num[5] = {10, 20, 30, 40, 50};
  int maximumValue = maximum(num);
  printf("Maximum value is %d\n", maximumValue);
  return 0;
}
```

or,

```
#include <stdio.h>
float maximum(float a[], int n)
{
   float max;
   for (int i = 0; i < n; i++)
   {
      if (i == 0)
      {
         max = a[0];
      }
      if (max < a[i])
      {
         max = a[i];
      }
   }
   return max;
}
int main()
{
   int n, i;
   printf("How many number do you want check:
");
   scanf("%d", &n);
   float num[n];
   for (i = 0; i < n; i++)
   {
      scanf("%f", &num[i]);
   }
   printf("maximum number =
%f\n",maximum(num,n));
}
```

- **Make a program that will show Passing String to function.**

```
#include<stdio.h>
void display(char str2[])
{
   int i=0;
   while(str2[i]!='\0'){
    printf("%c\n",str2[i]);
    i++;
   }
}
int main()
{
  char str1[]="Hamim";
  display(str1);
   return 0;
}
```

- **Make a program that can copy String using function.**

```
#include<stdio.h>
void strcpying (char *t[], char *s[])
{
    int i;
    for(i=0;s[i]!='\0';i++){
        t[i] = s[i];
    }
}
```

```
int main()
{
    char *source[1],*target[1];
    scanf(" %[^\n]",&source);
    strcpying(target,source);
    printf("%s\n",target);
    return 0;
}
```

4. pointer

- A pointer is a variable whose value is the address of another variable, i.e., direct address of the memory location. Like any variable or constant, you must declare a pointer before you can use it to store any variable address.
- The general form of a pointer variable declaration is:

```
dataType  *var_name;
```

Here,

- dataType is the pointer's base type; it must be a valid C data type(i.e., int, float, char etc).
- var_name is the name of the pointer variable.
- The asterisk * you used to declare a pointer is the same asterisk that you use for multiplication. However, in this statement the asterisk is being used to designate a variable as a pointer.

- Pointers are powerful features of C and C++ programming that differentiates it from other popular programming languages like : Java and Python.
- Using pointer makes the software more efficient cause it works with memory management.
- But excessive usage may make the application less understandable.
- If you want to be proficient in the writing of code in the C programming language, you must have a thorough working knowledge of how to use pointers.
- Some C programming tasks are performed more easily without pointers, and other tasks, such as dynamic memory allocation, cannot be performed without using pointers. So it becomes necessary to learn pointers to become a perfect C programmer.
- As you know, every variable is a memory location and every memory location has its address defined which can be accessed using ampersand (&) operator, which denotes an address in memory. Consider the following example:

Following are the valid pointer declaration:

```
int    *ip;    /* pointer to an integer */
double *dp;    /* pointer to a double */
float  *fp;    /* pointer to a float */
char   *ch     /* pointer to a character */
```

- The actual data type of the value of all pointers, whether integer, float, character, or otherwise, is the same, a long hexadecimal number that represents a memory address.
- The only difference between pointers of different data types is the data type of the variable or constant that the pointer points to.

Use of pointers :

- There are few important operations, which we will do with the help of pointers very frequently.
    1. we define a pointer variable
    2. assign the address of a variable to a pointer and
    3. finally access the value at the address available in the pointer variable by dereferencing.
- Dereferencing is done by using unary operator * that returns the value of the variable located at the address specified by its operand.

- Dereferencing a pointer means getting the value stored in the memory at the address which the pointer “points” to.
- The * is the value-at-address operator, also called the indirection operator. It is used both when declaring a pointer and when dereferencing a pointer.

- **Following example makes use of these operations:**

```
#include<stdio.h>
int main()
{
   int var = 20; /* actual variable declaration */
   int *ip;    /* pointer variable declaration */
   ip = &var; /* store address of var in pointer
                 variable */

   printf("Address of var variable: %x\n",&var);

   /* address stored in pointer variable */
   printf("Address stored in ip variable: %x\n",ip);

   /* access the value using the pointer */
   printf("Value of *ip variable: %x\n",*ip);
   return 0;
}
```

Here,
The output is :
Address of var variable: 61ff18
Address stored in ip variable: 61ff18
Value of *ip variable: 14

- the & is the address-of operator and is used to reference the memory address of a variable.
- By using the & operator in front of a variable name we can retrieve the memory address-of that variable. It is best to read this operator as address-of operator.
- Following code shows some common notations for the value-at-address (*) and adress-of (&) operators.

```
// declare an variable ptr which holds the value-at-address of an int type
int *ptr;
// declare assign an int the literal value of 1
int val = 1;
// assign to ptr the address-of the val variable
ptr = &val;
// dereference and get the value-at-address stored in ptr
int deref = *ptr;
printf("%d\n", deref);
```

- **What will be the output of the program given bellow:**

```
#include <stdio.h>
int main()
{
   int x = 10;

   printf("Value of x is %d\n", x);
   printf("Address of x is %p\n", &x);
   return 0;
}
```

Here,
The output will be:
Value of x is 10
Address of x is 0061FF1C

- **What will be the output of the program given bellow:**

```
#include<stdio.h>
int main()
{
   int x=10;
   int *p;
   p=&x;
   printf("*p=%d\n",*p);
   printf("Value of p is %d\n",p);
   return 0;
}
```

Here,
The output will be:
*p=10
Value of p is 6422296

int *p is called " integer pointer p" and *p is called "content of p".

- **What will be the output of the program given bellow:**

```
#include<stdio.h>
int main()
{
  int x=10;
  int *p;
  p=&x;
  printf("Value of x: %d\n",x);
  *p=20;
  printf("Value of x: %d\n",x);
  printf("Value of p: %d\n",*p);
  printf("Address of x: %d\n",&x);
  printf("Value of p: %d\n",p);
  return 0;
}
```

Here,
The output will be:
Value of x: 10
Value of x: 20
Value of p: 20
Address of x: 6422296
Value of p: 6422296

- **What will be the output of the program given bellow:**

```
#include<stdio.h>
int main()
{
   int x=10;
   int *p;
   printf("Value of x: %d\n",x);
   p=&x;
   *p=20;
   printf("Value of x: %d\n",x);
   x=15;
   printf("Value of x: %d\n",x);
   printf("Value stored at location %p is
%d\n",p,*p);
   printf("Address of x: %p\n",&x);
   printf("Value of p: %p\n",p);
   return 0;
}
```

Here,
The output will be:
Value of x: 10
Value of x: 20
Value of x: 15
Value stored at location 0061FF18 is 15
Address of x: 0061FF18
Value of p: 0061FF18

- **What will be the output of the program given bellow:**

```
#include<stdio.h>
int main()
{
   int x=10;
   int y;
   int *p;
   printf("Value of x: %d\n",x);
   p=&x;
   y=*p;
   *p=15;
   printf("Value of x: %d\n",x);
   printf("Value of y: %d\n",y);
   printf("Value of *p:%d\n",*p);
   printf("Address of x: %p\n",&x);
   printf("Address of x: %p\n",&y);
   printf("Value of p: %p\n",p);
   return 0;
}
```

Here,
The output will be:
Value of x: 10
Value of x: 15
Value of y: 10
Value of *p:15
Address of x: 0061FF18
Address of x: 0061FF14
Value of p: 0061FF18

- **What will be the output of the program given bellow:**

```
#include<stdio.h>
int main()
{
   int x=10,y;
   int *p,*q;
   p=&x;
   q=&y;
   y=*p;
   *p=15;
   *q=20;
   printf("Value of x: %d\n",x);
   printf("Value of y: %d\n",y);
   printf("Value of *p: %d\n",*p);
   printf("Value of *q: %d\n",*q);
   return 0;
}
```

Here,
The output will be:
Value of x: 15
Value of y: 20
Value of *p: 15
Value of *q: 20

- **What will be the output of the program given bellow:**

```
#include<stdio.h>
int main()
{
   int x=10,y;
   int *p,*q;
   p=&x;
   y=*p;
   *p=15;
   *q=20;
   printf("Value of x: %d\n",x);
   printf("Value of y: %d\n",y);
   printf("Value of *p: %d\n",*p);
   printf("Value of *q: %d\n",*q);
   return 0;
}
```

Here,
The output will be error because we do not indicate q to point y. So, if we want to do content exes of any pointer we must assign a variable address in this pointer first.

- **What will be the output of the program given bellow:**

```
#include<stdio.h>
int main()
{
   int x=10,y;
   int *p,*q;
   p=&x;
   q=&y;
   y=*p;
   *p=15;
   *q=20;
   printf("Value of x: %d\n",x);
   printf("Value of y: %d\n",y);
   printf("Value of *p: %d\n",*p);
   printf("Value of *q: %d\n",*q);
   return 0;
}
```

Here,
The output will be:
Value of x: 15
Value of y: 20
Value of *p: 15
Value of *q: 20

- **Make a program which will print the address of the variables defined in hexadecimal.**

```
#include<stdio.h>
int main()
{
  int var1;
  char var2[10];
  printf("Address of var1 variable: %x\n",&var1);
  printf("Address of var2 variable: %x\n",&var2);
  printf("Address of var2[0] variable:
%x\n",&var2[0]);
  return 0;
}
```

Here,
The output is :
Address of var1 variable: 61ff1c
Address of var2 variable: 61ff12
Address of var2[0] variable: 61ff12

- **Make a program which will print the address of the variables defined in decimal/integer.**

```
#include<stdio.h>
int main()
{
  int var1;
  char var2[10];
  printf("Address of var1 variable: %d\n",&var1);
  printf("Address of var2 variable: %d\n",&var2);
  printf("Address of var2[0] variable:
%d\n",&var2[0]);
  return 0;
}
```

Here,
The output will be :
Address of var1 variable: 6422300
Address of var2 variable: 6422290
Address of var2[0] variable: 6422290

or,

```
#include<stdio.h>
int main()
{
   int a,b=7;
   int *ptr1,*ptr2;

   ptr1=&a;
   ptr2=&b;

      printf("Address of a variable : %d\n",ptr1);
      printf("Address of b variable : %d\n",ptr2);
}
```

- **Make a program which will show a variable address and print the variable using pointer and also show the pointer variable address.**

```
#include<stdio.h>
int main()
{
   int x=5;
   int *ptr;
   ptr = &x;

   printf("Value of x = %d\n",x);
   printf("Memory address of x = %d\n",&x);
   printf("Memory address of ptr = x = %d\n",ptr);
   printf("Value of x using pointer = %d\n",*ptr);
   printf("Memory address of ptr = %d\n",&ptr);
   return 0;
}
```

Here,
The output will be :
Value of x = 5
Memory address of x = 6422300
Memory address of ptr = x = 6422300
Value of x using pointer = 5
Memory address of ptr = 6422296

- **Make a program that will show pointer pointing to different variable.**

```
#include<stdio.h>
int main()
{
   int x=10,y=20,z=30;
   int *ptr;

   ptr = &x;
   printf("Value of x = %d\n",*ptr);

   ptr = &y;
   printf("Value of x = %d\n",*ptr);

   ptr = &z;
   printf("Value of x = %d\n",*ptr);

   return 0;
}
```

or,

```
#include<stdio.h>
int main()
{
   int x=10,y=20,z=30;
   int *ptr1=&x,*ptr2=&y,*ptr3=&z;

   printf("Value of x = %d\nValue of y =
%d\nValue of z = %d",*ptr1,*ptr2,*ptr3);
   return 0;
}
```

- **Make a program that will add two numbers using pointer.**

```
#include<stdio.h>
int main()
{
   int x=10,y=20,sum;
   int *ptr1,*ptr2;
   ptr1 = &x;
   ptr2 = &y;

   sum = *ptr1 + *ptr2;
   printf("Sum = %d\n",sum);
   return 0;
}
```

or,

```
#include<stdio.h>
int main()
{
   int x=10,y=20,sum;
   int *ptr1=&x,*ptr2=&y;

   sum = *ptr1 + *ptr2;
   printf("Sum = %d\n",sum);
   return 0;
}
```

- **swapping two numbers using pointer.**

```
#include<stdio.h>
int main()
{
   int x=10,y=20,temp;
   int *ptr1,*ptr2;

   ptr1 = &x;
   ptr2 = &y;

   // swapping
   temp = *ptr1;
   *ptr1 = *ptr2;
   *ptr2 = temp;
   printf("x = %d\n",x);
   printf("y = %d\n",y);
   return 0;
}
```

- **swapping two numbers using pointer and function.**

```
#include<stdio.h>
void swapping(int *ptr1, int *ptr2)
{
   int temp;
   temp=*ptr1;
   *ptr1=*ptr2;
   *ptr2=temp;
}
int main()
{
   int x=10,y=20;
   printf("Before swapping : x=%d, y=%d\n",x,y);
   swapping(&x,&y);
   printf("After swapping : x=%d, y=%d\n",x,y);
   return 0;
}
```

- **Access array elements using pointer.**

```
#include<stdio.h>
int main()
{
   int a[5]={10,20,30,40,5000000};
   int *ptr;
   int i;

   ptr=&a[0];

   for(i=0;i<5;i++)
   {
      printf("%d\n",*ptr);
      ptr++;
   }
}
```

or,

```
#include<stdio.h>
int main()
{
   int a[5]={10,20,30,40,5000000};
   int *ptr;
   int i;
   for(i=0;i<5;i++)
   {
      ptr=&a[i];
      printf("%d\n",*ptr);
   }
}
```

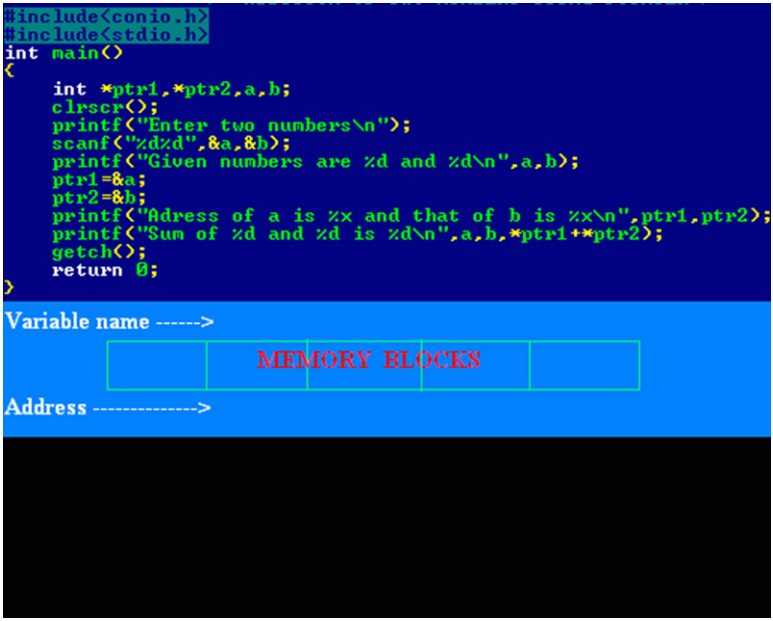
NULL Pointers in C :

- It is always a good practice to assign a NULL value to a pointer variable in case you do not have exact address to be assigned. This is done at the time of variable declaration. A pointer that is assigned NULL is called a null pointer.
- The NULL pointer is a constant with a value of zero defined in several standard libraries. **Consider the following program:**

```
#include<stdio.h>
int main()
{
  int *ptr = NULL;
  printf("The value of ptr is : %x\n",ptr);
  return 0;
}
```

Here,
The output is :
The value of ptr is : 0

- **When the above code is compiled and executed, it produces the following result:**



- On most of the operating systems, programs are not permitted to access memory at address 0 because that memory is reserved by the operating system. However, the memory address 0 has special significance; it signals that the pointer is not intended to point to an accessible memory location. But by convention, if a pointer contains the null (zero) value, it is assumed to point to nothing.
- To check for a null pointer you can use an if statement as follows:

```
if(ptr)     /* succeeds if p is not null */
if(!ptr)    /* succeeds if p is null */
```

```
#include<stdio.h>
int main()
{
  int *ptr=NULL;
  printf("The value of ptr is %d\n",ptr);
  if(ptr){
    printf("I am going to die\n");
  }
  else if(!ptr){
    printf("I am not going to die\n");
  }
  return 0;
}
```

- **What will be the output of the program given bellow:**

```
#include<stdio.h>
int main()
{
   int x=100;
   int *p = NULL;
   printf("The value of x: %d\n",x);
   printf("The value of *p: %d\n",*p);
   return 0;
}
```

Here,
The output will be:
The value of x: 100
But the value of p does not printed because p isn't pointing any variable but we are trying to print *p.

- **What will be the output of the program given bellow:**

```
#include<stdio.h>
int main()
{
   int x=100;
   int *p = NULL;
   printf("The value of x: %d\n",x);
   p=&x;
   printf("The value of *p: %d\n",*p);
   return 0;
}
```

Here,
The output will be:
The value of x: 100
The value of *p: 100

- **Strings and pointer :**
- **Write a program that will print a string and address of the strings.**

```
#include<stdio.h>
int main()
{
  char s[]="Bangladesh";
  printf("Name of our country is , s = %s\n",s);
  printf("Memory Address of s: %d\n",s);
  printf("Memory Address of s: %d\n",&s[0]);
  printf("Memory Address of s: %d\n",&s[1]);
  return 0;
}
```

Here,
The output will be:
Name of our country is , s = Bangladesh
Address of s: 0061FF15
And we do not need any ampersand (&) sign before string variable because it take ampersand (&) sign automatically but when you want to watch the single character address of string you must have to give the ampersand sign infornt of s[l] (s[o]) otherwise it will show the assci value of the character of the string.

- **What will be the output of the program given bellow:**

```
#include<stdio.h>
int main()
{
  char s[]="Bangladesh";
  char *p;
  p=s;
  printf("Name of our country : %s\n",p);
  printf("Memory address of s : %d\n",p);
  printf("Memory address of s : %d\n",s);
  return 0;
}
```

Here,
The output will be:
Name of our country : Bangladesh
Memory address of s : 6422289
Memory address of s : 6422289
And we do not need any ampersand (&) sign before string variable for assigning the address of s in p because string variable take ampersand (&) sign automatically. Here we also do not need to give '*' sign before p to print the string. If we use '*' sign before p then there will be no output.

- **What will be the output of the program given bellow:**

```
#include<stdio.h>
int main()
{
   char c1='A',c2='B',c3='C';
   char *p1,*p2,*p3;
   p1=&c1;
   p2=&c2;
   p3=&c3;
   printf("%c,%c,%c\n",*p1,*p2,*p3);
   return 0;
}
```

Here,
The output will be:
A,B,C

- **What will be the output of the program given bellow:**

```
#include<stdio.h>
int main()
{
   char *ptr="Bangladesh";
   printf("Name of our country is , ptr = %s\n",ptr);
   printf("Memory Address of ptr: %p\n",ptr);
   return 0;
}
```

Here,
The output will be:
Name of our country is , ptr = Bangladesh
Memory Address of ptr: 00405064

- **What will be the output of the program given bellow:**

```
#include<stdio.h>
int main()
{
   char *ptr[2];
   printf("Enter your name: ");
   scanf(" %[^\n]",&ptr);
   printf("Your name is = %s\n",ptr);
   printf("Memory Address of ptr: %p\n",ptr);
   return 0;
}
```

Output:
Enter your name: Hamim Talukder
Your name is = Hamim Talukder
Memory Address of ptr: 0061FF18

- **Pointer's pointer :**

- **Write a program that will print a variable address and a pointer address which containing the address of the variable.**

```
#include<stdio.h>
int main()
{
   char c='A';
   char *p;
   p=&c;
   printf("Address of c : %p\n",p);
   printf("Address of p : %p\n",&p);
   return 0;
}
```

Here,
The output will be:
Address of c : 0061FF1F
Address of p : 0061FF18

- **Write a program that will print a character type variable's value using Pinter's pointer.**

```
#include<stdio.h>
int main()
{
   char c='A';
   char *p,**q;
   p=&c;
   q=&p;
   printf("Value of c : %c\n",c);
   printf("Value of c : %c\n",*p);
   printf("Value of c : %c\n",**q);
   return 0;
}
```

Here,
The output will be:
Value of c : A
Value of c : A
Value of c : A

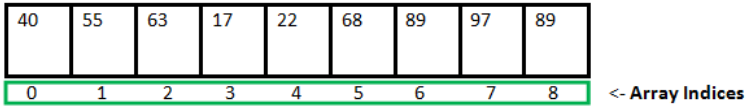
- **What will be the output of the program given bellow:**

```
#include<stdio.h>
int main()
{
   char c='A';
   char *p,**q;
   p=&c;
   q=&p;
   **q='B';
   printf("Value of c : %c\n",c);
   printf("Value of c : %c\n",*p);
   printf("Value of c : %c\n",**q);
   return 0;
}
```

Here,
The output will be:
Value of c : B
Value of c : B
Value of c : B

Dynamic Memory Allocation in C using malloc(), calloc(), free() and realloc() :

Since C is a structured language, it has some fixed rules for programming. One of them includes changing the size of an array. An array is a collection of items stored at contiguous memory locations.



Array Length = 9
First Index = 0
Last Index = 8

As it can be seen that the length (size) of the array above made is 9. But what if there is a requirement to change this length (size). For Example,

If there is a situation where only 5 elements are needed to be entered in this array. In this case, the remaining 4 indices are just wasting memory in this array. So there is a requirement to lessen the length (size) of the array from 9 to 5.
Take another situation. In this, there is an array of 9 elements with all 9 indices filled. But there is a need to enter 3 more elements in this array. In this case, 3 indices more are required. So the length (size) of the array needs to be changed from 9 to 12.

This procedure is referred to as Dynamic Memory Allocation in C.
Therefore, C Dynamic Memory Allocation can be defined as a procedure in which the size of a data structure (like Array) is changed during the runtime.
C provides some functions to achieve these tasks. There are 4 library functions provided by C defined under <stdlib.h> header file to facilitate dynamic memory allocation in C programming. They are:

- malloc()
- calloc()
- free()
- realloc()

C malloc() method:

The “malloc” or “memory allocation” method in C is used to dynamically allocate a single large block of memory with the specified size. It returns a pointer of type void which can be cast into a pointer of any form. It doesn’t Initialize memory at execution time so that it has initialized each block with the default garbage value initially.

Syntax:

ptr = (cast-type*) malloc(byte-size)
For Example:
ptr = (int*) malloc(100 * sizeof(int));
Since the size of int is 4 bytes, this statement will allocate 400 bytes of memory. And, the pointer

ptr holds the address of the first byte in the allocated memory.

malloc function:

prototype:
void * malloc (size_t size)
Input :
size_t size : It takes the memory space in bytes as input.
Return value :
void * : After doing memory allocation it returns void pointer of that address.
Action/work :
size takes bytes equivalent space from memory and returns a void pointer in that address.

- **Write a program that can take the marks of each student of a class and show them using pointer.**

```
#include<stdio.h>
#include<stdlib.h>
int main()
{
   int *marks;
   int i, n;
   printf("Please enter the number of students: ");
   scanf("%d",&n);
   // now allocate memory
   marks = (int *) malloc(sizeof(int) * n);
   printf("Enter the marks for each student: \n");
   for(i=0;i<n;i++){
      scanf("%d", &marks[i]);
   }
```

```
   printf("Now here you can see the values:\n");
    // now print the marks array
    for(i=0;i<n;i++){
        printf("%d\n",marks[i]);
    }
    return 0;
}
```

Here,
The malloc function will return a pointer and gives us the starting memory address from the allocated memory address. But if there anything goes wrong doing the memory allocation then it will return NULL. If memory allocation is done in this way then it will take place in the heap segment of memory.
Here we use (int*) before malloc for doing type cast and convert the type of allocated memory address into integer form.

C calloc() method:

“calloc” or “contiguous allocation” method in C is used to dynamically allocate the specified number of blocks of memory of the specified type. it is very much similar to malloc() but has two different points and these are:

1. It initializes each block with a default value ‘0’.
2. It has two parameters or arguments as compare to malloc().

Syntax:

ptr = (cast-type*)calloc(n, element-size);
here, n is the no. of elements and element-size is the size of each element.
For Example:
ptr = (float*) calloc(25, sizeof(float));
This statement allocates contiguous space in memory for 25 elements each with the size of the float.

- **Write a program that can take the marks of each student of a class and show them using pointer.**

```
#include<stdio.h>
#include<stdlib.h>
int main()
{
   int *marks;
   int i, n;
   printf("Please enter the number of students: ");
   scanf("%d",&n);
   // now allocate memory
   marks = (int *) calloc(n,sizeof(int));
   printf("Enter the marks for each student: \n");
   for(i=0;i<n;i++){
      scanf("%d", &marks[i]);
   }
   printf("Now here you can see the values:\n");
```

```
  // now print the marks array
   for(i=0;i<n;i++){
       printf("%d\n",marks[i]);
   }
   return 0;
}
```

C free() method:

“free” method in C is used to dynamically de-allocate the memory. The memory allocated using functions malloc() and calloc() is not de-allocated on their own. Hence the free() method is used, whenever the dynamic memory allocation takes place. It helps to reduce wastage of memory by freeing it.

Syntax:

```
free(ptr);
```

Prototype:

void free (void * ptr)
Input:
void * ptr : It takes the address of allocated memory using malloc, calloc function.
return value:
void ; it returns no value .
action:
ptr free up the allocated space of memory location (deallocation).

- **Write a program that can take the marks of each student of a class and show them using pointer after then free up the allocated memory space.**

```
#include<stdio.h>
#include<stdlib.h>
int main()
{
   int *marks;
   int i, n;
   printf("Please enter the number of students: ");
   scanf("%d",&n);
   // now allocate memory
   marks = (int *) malloc(sizeof(int) * n);
   printf("Enter the marks for each student: \n");
   for(i=0;i<n;i++){
      scanf("%d", &marks[i]);
   }
   printf("Now here you can see the values:\n");
   // now print the marks array
   for(i=0;i<n;i++){
      printf("%d\n",marks[i]);
   }
   // now free up the memory
   free (marks);
   return 0;
}
```

C realloc() method

“realloc” or “re-allocation” method in C is used to dynamically change the memory allocation of a previously allocated memory. In other words, if the memory previously allocated with the help of malloc or calloc is insufficient, realloc can be used to dynamically re-allocate memory. re-allocation of memory maintains the already present value and new blocks will be initialized with the default garbage value.

Syntax:
ptr = realloc(ptr, newSize);
where ptr is reallocated with new size 'newSize'.
f space is insufficient, allocation fails and returns a NULL pointer.

Example:

```
#include <stdio.h>
#include <stdlib.h>
int main()
{
 // This pointer will hold the
 // base address of the block created
 int* ptr;
 int n, i;
 // Get the number of elements for the array
 n = 5;
 printf("Enter number of elements: %d\n", n);
 // Dynamically allocate memory using calloc()
 ptr = (int*)calloc(n, sizeof(int));
```

```
 // Check if the memory has been successfully
 // allocated by malloc or not
 if (ptr == NULL) {
  printf("Memory not allocated.\n");
  exit(0);
 }
 else {

  // Memory has been successfully allocated
  printf("Memory successfully allocated using
calloc.\n");

  // Get the elements of the array
  for (i = 0; i < n; ++i) {
   ptr[i] = i + 1;
  }

  // Print the elements of the array
  printf("The elements of the array are: ");
  for (i = 0; i < n; ++i) {
   printf("%d, ", ptr[i]);
  }

  // Get the new size for the array
  n = 10;
  printf("\n\nEnter the new size of the array:
%d\n", n);

  // Dynamically re-allocate memory using
realloc()
  ptr = realloc(ptr, n * sizeof(int));
```

```
 // Memory has been successfully allocated
  printf("Memory successfully re-allocated using
realloc.\n");

  // Get the new elements of the array
  for (i = 5; i < n; ++i) {
   ptr[i] = i + 1;
  }

  // Print the elements of the array
  printf("The elements of the array are: ");
  for (i = 0; i < n; ++i) {
   printf("%d, ", ptr[i]);
  }

  free(ptr);
 }

 return 0;
}
```

- **Write a program that can take the marks of each student of class one to five and show them using pointer.**

```
#include<stdio.h>
#include<stdlib.h>
int main()
{
  int *ara[5], num[5];
  int i, j, n;
  for(i=0;i<5;i++){
    printf("Enter the number of stdunts for class
%d : ",i+1);
    scanf("%d",&n);
    num[i] = n;
    ara[i] = (int *) malloc(sizeof(int) * n);
    if(ara[i] == NULL){
      printf("Memory allocation failed\n");
      return 1;
    }
    for(j=0;j<n;j++){
      printf("Enter marks for student %d: ",j+1);
      scanf("%d", &ara[i][j]);
    }
  }
  // now print the results
   printf("Output:\n");
   for(i=0;i<5;i++){
    printf("Class %d : ",i+1);
    for(j=0;j<num[i];j++){
      printf("%4d",ara[i][j]);
    }
```

```
 printf("\n");
 }
 return 0;
}
```

- **Write a program that can take the marks of each student of any classes and show them using pointer.**

```
#include<stdio.h>
#include<stdlib.h>
int main()
{
   int **ara, num[12];
   int i, j, total_classes, n;
   printf("Enter the total number of classes : ");
   scanf("%d",&total_classes);
   ara = (int **)malloc(sizeof(int*)*total_classes);
   if(ara == NULL){
      printf("Memory allocation failled\n");
      return 1;
   }
   for(i=0;i<total_classes;i++){
      printf("Enter the number of students for
class %d : ",i+1);
      scanf("%d",&n);
      num[i] = n;
      ara[i] = (int *) malloc (sizeof(int) * n);
      if(ara[i] == NULL){
         printf("Memory allocation failed\n");
         return 1;
      }
```

```
        for(j=0;j<n;j++){
            printf("Enter marks for student %d: ",j+1);
            scanf("%d",&ara[i][j]);
        }
    }
    // now print the results
    printf("Output:\n");
    for(i=0;i<total_classes;i++){
        printf("Class %d : ",i+1);
        for(j=0;j<num[i];j++){
            printf("%4d",ara[i][j]);
        }
        printf("\n");
    }
    return 0;
}
```

- **What will be the output of the program given bellow.**

```
#include<stdio.h>
int main()
{
   int ara[] = {100,300,500,700.900};
   int *p;
   p = ara;
   printf("*p : %d\n",*p);
   printf("*p + 1 : %d\n",*p+1);
   printf("*(p+1) : %d\n",*(p+1));
   printf("*p+2 : %d\n",*p+2);
   printf("*(p+2) : %d\n",*(p+2));
   return 0;
}
```

- **What will be the output of the program given bellow.**

```
#include<stdio.h>
int main()
{
   char *str = "Bangladesh";
   printf("%c,%c,%c,%c\n",*str,*(str+1),*(str+2),*
(str+3));

printf("%c,%c,%c,%c\n",*str,*str+1,*str+2,*str+3);
   return 0;
}
```

- **What will be the output of the program given bellow.**

```
#include<stdio.h>
int main()
{
   char *p, a=10;
   int *q, b = 'F';
   double *r, c=302.64;
   p=&a;
   q=&b;
   r=&c;
   printf("Size of char: %d byte\n",sizeof(char));
   printf("p  : %p\n",p);
   printf("p+1: %p\n",p+1);
   printf("p+2: %p\n",p+2);

   printf("Size of int: %d byte\n",sizeof(int));
   printf("q  : %p\n",q);
   printf("q+1: %p\n",q+1);
   printf("q+2: %p\n",q+2);

   printf("Size of double: %d
byte\n",sizeof(double));
   printf("r  : %p\n",r);
   printf("r+1: %p\n",r+1);
   printf("r+2: %p\n",r+2);
   return 0;
}
```

- **Void pointer:**

A void pointer is a pointer that has no associated data type with it. A void pointer can hold address of any type and can be typecasted to any type.

void pointer declaration: void *ptr;

In void pointer to dereference/print the value which we pointed by pointer, we have do type cast the pointer variable, otherwise, it can not be possible to print.

Pointer type cast system: *((int*) ptr)

- **What will be the output of the program given bellow.**

```
# include<stdio.h>
int main()
{
   void *vp;
   int n=10;
   vp=&n;
   printf("Address of n: %p\n",&n);
   printf("Value of vp: %p\n",vp);
   printf("Content of vp: %d\n",*((int*)vp));

   return 0;
}
```

- **Function pointer:**

In C, like normal data pointers (int *, char *, etc), we can have pointers to functions.

Function pointer: int (*fnc) (int, int);

- **What will be the output of the program given bellow.**

```
#include<stdio.h>
int add(int n1, int n2)
{
   return n1 + n2;
}

int sub(int n1, int n2)
{
   return n1 - n2;
}

int main()
{
   int (*fnc)(int, int);
   int n1=10, n2=5;
   fnc=&add;
   printf("Result : %d\n", fnc(n1,n2));
   fnc=&sub;
   printf("Result : %d\n", fnc(n1,n2));
   return 0;
}
```

Here,
The main advantage of a function pointer is that we can use any function as the parameter of other function.

- **What will be the output of the program given bellow.**

```
#include<stdio.h>
int add(int n1, int n2)
{
   return n1 + n2;
}

int sub(int n1, int n2)
{
   return n1 - n2;
}

int operate (int (*op) (int, int), int a, int b)
{
   return op(a, b);
}

int main()
{
   int n1 = 10, n2 = 5;
   printf("Result : %d\n", operate(&add, n1, n2));
   printf("Result : %d\n", operate(&sub, n1, n2));
   return 0;
}
```

or,

```
#include<stdio.h>
int add(int n1, int n2)
{
   return n1 + n2;
}

int sub(int n1, int n2)
{
   return n1 - n2;
}

int operate (int (*op) (int, int), int a, int b)
{
   return op(a, b);
}

int main()
{
   int n1 = 10, n2 = 5;
   printf("Result : %d\n", operate(add, n1, n2));
   printf("Result : %d\n", operate(sub, n1, n2));
   return 0;
}
```

- **qsort and bsearch:**

You all must know that if we have multiple data, then we can sort them in a particular order. This sort of work is called sorting. There are many different algorithms for sorting, one of the most popular being QuickSort. When you read Algorithms, you will surely learn QuickSort Algorithm and be impressed by its beauty. Until then, you can use the function called qsort in the stdlib.h header file. The prototype of the function looks like this:

void qsort (void* base, size_t items, size_t size, int (*compar) (const void*, const void*));

The function name is qsort, the return type is void (ie the function will not return anything). Now let's look at the parameters of the function.

The first parameter is a void pointer called base. That's the array we want to sort

So, the pointer to its first element is this base. But the qsort function doesn't know any

array of types to be sorted. So here the void pointer is being used as if it were an integer

We can sort any array like array, float array, structure array etc.

The second parameter is nitems , which indicates the total number of elements in the array. The third parameter is size, the number of bytes an element occupies in the array to be sorted must be stored in size.

The fourth parameter is a pointer to a function. The function is to compare two objects. will be used. The function will take two const void* as parameters and return an integer. The reason for using void* is that we don't know what type of object to compare, so we can pass any type of variable. And putting const before it means that the values we send will not be changed.
Now let's write a program to see how to use qsort.

- **What will be the output of the program given bellow.**

```
#include <stdio.h>
#include <stdlib.h>

int comparefunc (const void * a, const void * b)
{
   return (*(int*) a - *(int*)b);
}

int main(){
int i, n=5;
int values[] = { 65, 6, 100, 1, 250 };
qsort(values, 5, sizeof(int), comparefunc);
```

```
for (i=0; i < n; i++) {
    printf("%d ", values[i]);
}
printf("\n");
return 0;
}
```

If you run the program you will see the output: 1 6 65 100 250 .

One thing to note is that inside the comparefunc we are on an integer pointer converted because we now know that our array is an array of integers.

If we wanted to sort in ascending to descending order, we would write b - a instead of a - b inside comparefunc (of course the pointer must be cast).

Another such function is bsearch, which performs a binary search. Binary search is discussed in detail in my book Computer Programming Volume 1, if you forget that book you can check from it. The prototype of the function looks like this:

void bsearch(const void *key, const void *base, size_t nitems, size_t size, int (*compar) (const void *, const void *));

Also see void pointer and function pointer used here. The return type of the function is void pointer. Because the function will return the data type of the variable we are searching for, and since there is no way to know in advance what type of variable will be returned, void pointers are used.

The first parameter of the function is a void pointer (key) that we will search for in the array. And the next things are same as above qsort function. Here also we need to write a comparer function. Let's see a complete example.

- **What will be the output of the program given bellow.**

```
#include <stdio.h>
#include <stdlib.h>

int comparefunc (const void * a, const void * b)
{
   return (*(int*) a - *(int*)b);
}
int main()
{
   int key, *item, n=5;
   int values[]={1, 2, 5, 8, 10};

   while (1) {
```

```
    printf("Enter the value of the key (0 to exit): ");
    scanf("%d", &key);
    if (key == 0) {
    break;
    }
    item = (int *) bsearch (&key, values, n,
sizeof(int), comparefunc);

    if (item != NULL)
    {
       printf("Item found: %d\n", *item);
    }

    else {

       printf("Item not found in array\n");
     }
     }
    return 0;
}
```

Here,
If you take a good look at the program, the array in which we need to find something, but that array must be sorted beforehand. Otherwise binary search cannot be performed. Now your task with writing a program that first sorts an array using qsort, then searches the array using bsearch. And in the examples I've shown, I've used integer arrays. But you can use any type of array, even an array of structures.

C Pointers in Detail :

Concept	Description
C - Pointer arithmetic	There are four arithmetic operators that can be used on pointers: ++, --, +, -
C - Array of pointers	You can define arrays to hold a number of pointers.
C - Pointer to pointer	C allows you to have pointer on a pointer and so on.
Passing pointers to functions in C	Passing an argument by reference or by address both enable the passed argument to be changed in the calling function by the called function.
Return pointer from functions in C	C allows a function to return a pointer to local variable, static variable and dynamically allocated memory as well.

C - Pointer arithmetic :

- C pointer is an address, which is a numeric value. Therefore, you can perform arithmetic operations on a pointer just as you can a numeric value.
- There are four arithmetic operators that can be used on pointers: ++, --, +, and -
- To understand pointer arithmetic, let us consider that ptr is an integer pointer which points to the address 1000. Assuming 32-bit integers, let us perform the following arithmetic operation on the pointer:

  ++ptr
- Now, after the above operation, the ptr will point to the location 1004 because each time ptr is incremented, it will point to the next integer location which is 4 bytes next to the current location.
- If ptr points to a character whose address is 1000, then above operation will point to the location 1001 because next character will be available at 1001.

Incrementing a Pointer :

- We prefer using a pointer in our program instead of an array because the variable pointer can be incremented, unlike the array name which cannot be incremented because it is a constant pointer.

- **Make a program that will increments the variable pointer to access each succeeding element of the array (see next slide).**

```
#include<stdio.h>
const int MAX = 3;
int main()
{
   int var[]={10,100,200};
   int i, *ptr;
   /* let us have array address in pointer */
   ptr = var;
   for(i=0;i<MAX;i++)
   {
      printf("Address of var[%d] = %x\n",i,ptr);
      printf("Value of var[%d] = %d\n",i,*ptr);

      /* move to the next location */
      ptr++;
   }
   return 0;
}
```

Here,
The output is :

```
Address of var[0] = 61ff0c
Value of var[0] = 10
Address of var[1] = 61ff10
Value of var[1] = 100
Address of var[2] = 61ff14
Value of var[2] = 200
```

Decrementing a Pointer :

- **Make a program which will decreases its value by the number of bytes of its data.**

```
#include<stdio.h>
const int MAX = 3;
int main()
{
   int var[]={10,100,200};
   int i, *ptr;
   /* let us have array address in pointer */
   ptr = &var[MAX-1];
   for(i=MAX;i>0;i--)
   {
      printf("Address of var[%d] = %x\n",i,ptr);
      printf("Value of var[%d] = %d\n",i,*ptr);

      /* move to the next location */
      ptr--;
   }
   return 0;
}
```

Here,
The output will be :

```
Address of var[3] = 61ff14
Value of var[3] = 200
Address of var[2] = 61ff10
Value of var[2] = 100
Address of var[1] = 61ff0c
Value of var[1] = 10
```

Pointer * and ++ :

Expression	*Meaning*
`*p++` or `*(p++)`	Value of expression is `*p` before increment; increment `p` later
`(*p)++`	Value of expression is `*p` before increment; increment `*p` later
`*++p` or `*(++p)`	Increment `p` first; value of expression is `*p` after increment
`++*p` or `++(*p)`	Increment `*p` first; value of expression is `*p` after increment

Pointer Comparisons :

- Pointers may be compared by using relational operators, such as ==, <, and >.
- If p1 and p2 point to variables that are related to each other, such as elements of the same array, then p1 and p2 can be meaningfully compared.

- **Make a program that will modifies the previous example one by incrementing the variable pointer as long as the address to which it points is either less than or equal to the address of the last element of the array, which is &var[MAX - 1].**

```
#include<stdio.h>
const int MAX = 3;
int main()
{
   int var[]={10,100,200};
   int i, *ptr;
   /* let us have address of the first element in
pointer */
   ptr = var;
   i=0;
```

```
 while(ptr <= &var[MAX -1])
   {
      printf("Address of var[%d] = %x\n",i,ptr);
      printf("Value of var[%d] = %d\n",i,*ptr);

      /* point to the previous location */
      ptr++;
      i++;
   }
   return 0;
}
```

Here,
The output will be :
Address of var[0] = 61ff0c
Value of var[0] = 10
Address of var[1] = 61ff10
Value of var[1] = 100
Address of var[2] = 61ff14
Value of var[2] = 200

Array of pointers :

- **Before we understand the concept of arrays of pointers, let us consider the following example, which makes use of an array of 3 integers:**

```
#include<stdio.h>
const int MAX = 3;
int main()
{
   int var[]={10,100,200};
   int i;
   for(i=0;i<MAX;i++)
   {
      printf("Value of var[%d] = %d\n",i,var[i]);
   }
   return 0;
}
```

Here,
The output will be :
Value of var[0] = 10
Value of var[1] = 100
Value of var[2] = 200

- There may be a situation when we want to maintain an array, which can store pointers to an int or char or any other data type available. Following is the declaration of an array of pointers to an integer:

```
int *ptr[ ];
```

- This declares ptr as an array of integer pointers. Thus, each element in ptr, now holds a pointer to an int value. Following example makes use of three integers, which will be stored in an array of pointers as follows:

- **Make a program that will show use of three integers, which will be stored in an array of pointers.**

```
#include<stdio.h>
const int MAX = 3;
int main()
{
   int var[]={10,100,200};
   int i,*ptr[MAX];

    for(i=0;i<MAX;i++)
   {
      ptr[i] = &var[i]; /* assign the address of
      integer. */
   }
   for(i=0;i<MAX;i++)
   {
      printf("Value of var[%d] = %d\n",i,*ptr[i]);
   }
   return 0;
}
```

Here,
The output will be :
Value of var[0] = 10
Value of var[1] = 100
Value of var[2] = 200

- **Make a program that will store a list of strings using an array of pointers to character.**

```
#include<stdio.h>
const int MAX = 4;
int main()
{
   char *names[]={
      "Hamim Ali",
      "Hameam Ali",
      "Haameem Ali",
      "Hameem Ali",

   };
   for(int i=0;i<MAX;i++)
   {
      printf("Value of var[%d] = %s\n",i,names[i]);
   }
   return 0;
}
```

Here,
The output will be :
Value of var[0] = Hamim Ali
Value of var[1] = Hameam Ali
Value of var[2] = Haameem Ali
Value of var[3] = Hameem Ali

Pointer to Pointer :

- A pointer to a pointer is a form of multiple indirection, or a chain of pointers. Normally, a pointer contains the address of a variable. When we define a pointer to a pointer, the first pointer contains the address of the second pointer, which points to the location that contains the actual value as shown below.

- A variable that is a pointer to a pointer must be declared as such. This is done by placing an additional asterisk in front of its name. For example, following is the declaration to declare a pointer to a pointer of type int:

```
int **var;
```

- **When a target value is indirectly pointed to by a pointer to a pointer, accessing that value requires that the asterisk operator be applied twice, as is shown below in the example:**

```
#include<stdio.h>
const int MAX = 4;
int main()
{
   int var;
   int *ptr;
   int **pptr;
   var = 3000;

   /* take the address of var */
   ptr = &var;

   /* take the address of ptr using address
   of operator & */
   pptr = &ptr;

   /* take the value using pptr */
   printf("Value of var = %d\n",var);
   printf("Value available at *ptr = %d\n",*ptr);
   printf("Value available at **pptr = %d\n",**pptr);
   return 0;
}
```

Here,
The output will be :
Value of var = 3000
Value available at *ptr = 3000
Value available at **pptr = 3000

Passing pointers to functions :

- C programming language allows you to pass a pointer to a function. To do so, simply declare the function parameter as a pointer type.
- **Following is a simple example where we pass an unsigned long pointer to a function and change the value inside the function which reflects back in the calling function:**

```
#include<stdio.h>
#include<time.h>

void getSeconds(unsigned long *par);
int main()
{
   unsigned long sec;
   getSeconds(&sec);

   /* print the actual value */
   printf("Number of seconds: %ld\n",sec);
   return 0;
}

void getSeconds(unsigned long *par)
{
   /* get the current number of seconds */
   *par = time (NULL);
   return;
}
```

Here,
The output will be :
Number of seconds: 1662029220

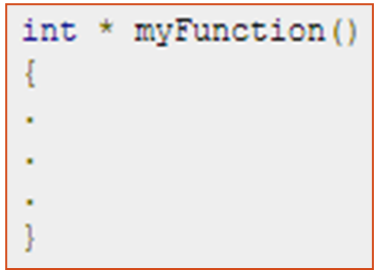
- **The function, which can accept a pointer, can also accept an array as shown in the following example:**

```
#include<stdio.h>
/* function declaration */
double getAverage(int *arr, int size);
int main()
{
   /* an int array with 5 elements */
   int balance[5]={1000,2,3,17,50};
   double avg;

   /* pass pointer t0 the array as an argument */
   avg = getAverage(balance,5);

   /* output the return value */
   printf("Average value is :%f\n",avg);

   return 0;
}
double getAverage(int *arr,int size)
{
   int i,sum = 0;
   double avg;
```

```
 for(i = 0; i<size; ++i){
       sum += arr[i];
    }
    avg = (double)sum/size;
    return avg;
}
```

Return pointer from functions :

- C allows us to return a pointer from a function. To do so, you would have to declare a function returning a pointer as in the following example:



- Second point to remember is that, it is not good idea to return the address of a local variable to outside of the function so you would have to define the local variable as static variable.

- **Consider the following function which will generate 10 random numbers and return them using an array name which represents a pointer i.e., address of first array element.**

```
#include <stdio.h>
#include <time.h>

/* function to generate and return random
numbers. */
int *getRandom()
{
   static int r[10];
   int i;

   /* set the seet */
   srand((unsigned)time(NULL));
   for (i = 0; i < 10; ++i)
   {
      r[i] = rand();
      printf("%d\n", r[i]);
   }
   return r;
}

/* main function to call above defined function */
int main()
{
   /* &a pointer to an int */
```

```
 int *p;
    int i;
    p = getRandom();
    for (i = 0; i < 10; i++){
        printf("*(p+[%d]) : %d\n", i, *(p + i));
    }
    return 0;
}
```

Here,
The output is :

```
20989
3705
2994
20654
3506
11499
7648
10965
16750
28264
*(p+[0]) : 20989
*(p+[1]) : 3705
*(p+[2]) : 2994
*(p+[3]) : 20654
*(p+[4]) : 3506
*(p+[5]) : 11499
*(p+[6]) : 7648
*(p+[7]) : 10965
*(p+[8]) : 16750
*(p+[9]) : 28264
```

5. Recursion

Local & Global variable:

Local variable:

A variable that is declared and used inside the function or block is called a local variable. It is scope is limited to function or block. It cannot be used outside the block. Local variables need to be initialized before use.

Global variable:

A variable that is declared outside the function or block is called a global variable. It is declared at the start of the program. It is available for all functions.

- **What will be the output of the program bellowed?**

```
#include <stdio.h>
int x; //global variable
int main()
{
   int y; // local variable
   printf("x = %d, y = %d\n",x,y);
   return 0;
}
```

Output;
x = 0, y = 4194432
Here,
x is a global variable and y is a local variable.
at the time of declaring global variable if we do not assign any value, it will automatically assign 0.
But the local variable can't do this. That's why local variable assign garbage value.

- **What will be the output of the program bellowed?**

```
#include <stdio.h>
int x = 1; //global variable
void myfnc(int y){
    y=y*2;
    x=x+10;
    printf("myfnc, x = %d, y = %d\n",x,y);
}
int main()
{
    int y = 5; // local variable
    x = 10;
    myfnc(y);
    printf("main, x = %d, y = %d\n",x,y);
    return 0;
}
```

Output;
myfnc, x = 20, y = 10
main, x = 20, y = 5
Here,
If any program has a global variable and a function of a local variable that is the same as the global variable then the function will evaluate the local variable.

- **What will be the output of the program bellowed?**

```
#include <stdio.h>
int x = 1; //global variable
int y = 5; //glocal variable
void myfnc(){
   y=y*2;
   x=x+10;
   printf("myfnc, x = %d, y = %d\n",x,y);
}
int main()
{
   myfnc();
   printf("main, x = %d, y = %d\n",x,y);
   return 0;
}
```

Output:
myfnc, x = 11, y = 10
main, x = 11, y = 10

Static variable:

Static variables have a property of preserving their value even after they are out of their scope! Hence, static variables preserve their previous value in their previous scope and are not initialized again in the new scope.
We can write static variable in two ways :
In global scope(out of function) and function scope(into the function).

- **What will be the output of the program bellowed?**

```
#include <stdio.h>
int a;
static int b;
void func()
{
   a=a+1;
   b=b+1;
}
int main()
{
   func();
   printf("a=%d\n",a);
   printf("b=%d\n",b);
   return 0;
}
```

Here,
a=1
b=1

- **What will be the output of the program bellowed?**

```
#include<stdio.h>
void func()
{
   int a=10;
   static int s=10;
   a=a+2;
   s=s+2;
   printf("a = %d, s = %d\n",a,s);
}
int main()
{
   func();
   func();
   func();
   return 0;
}
```

Output:
a = 12, s = 12
a = 12, s = 14
a = 12, s = 16
Here,
Note that we declared two integers a and s in the func function. One is an ordinary integer variable, the other is a static integer variable. I assigned the value 10 to both. Then I added 2 to the two variables and printed it. Now call func

function three times from main function. a variable did 12 leaps every time but variable s printed 12, 14 and 16 respectively. This is the property of static variables. The first time the function (the function in which the static variable is declared) is crawled, the value assigned to that variable is not deleted after the function is exited. It remains in memory as long as the program is running.

The interesting thing is that since the variable is declared inside a function, it cannot be accessed in any other function outside of that function, it can only be accessed if that function is called again. So the second time we call the func function, the value of the s variable remains 12 and adds 2 to it, printing 14.

Recursion :

Recursion is the process of repeating items in a self-similar way. Same applies in programming languages as well where if a programming allows you to call a function inside the same function that is called recursive call of the function as follows.

```
void recursion()
{
   recursion(); /* function calls itself */
}

int main()
{
   recursion();
}
```

- The C programming language supports recursion, i.e., a function to call itself.
- But while using recursion, programmers need to be careful to define an exit condition (base condition) from the function, otherwise it will go in infinite loop.
- Recursive function are very useful to solve many mathematical problems like to calculate factorial of a number, generating Fibonacci series, etc.

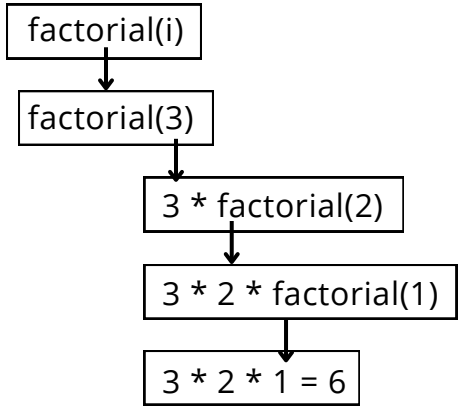
- **Make a program which will calculates factorial for a given number using a recursive function.**

```
#include<stdio.h>

int factorial(unsigned int i){
  if (i<=1){
    return 1;
  }
  return i*factorial(i-1);
}
int main()
{
  int i = 3;
  printf("Factorial of %d is %d\n", i, factorial(i));
  return 0;
}
```

Output:

Factorial of 3 is 6

Here,



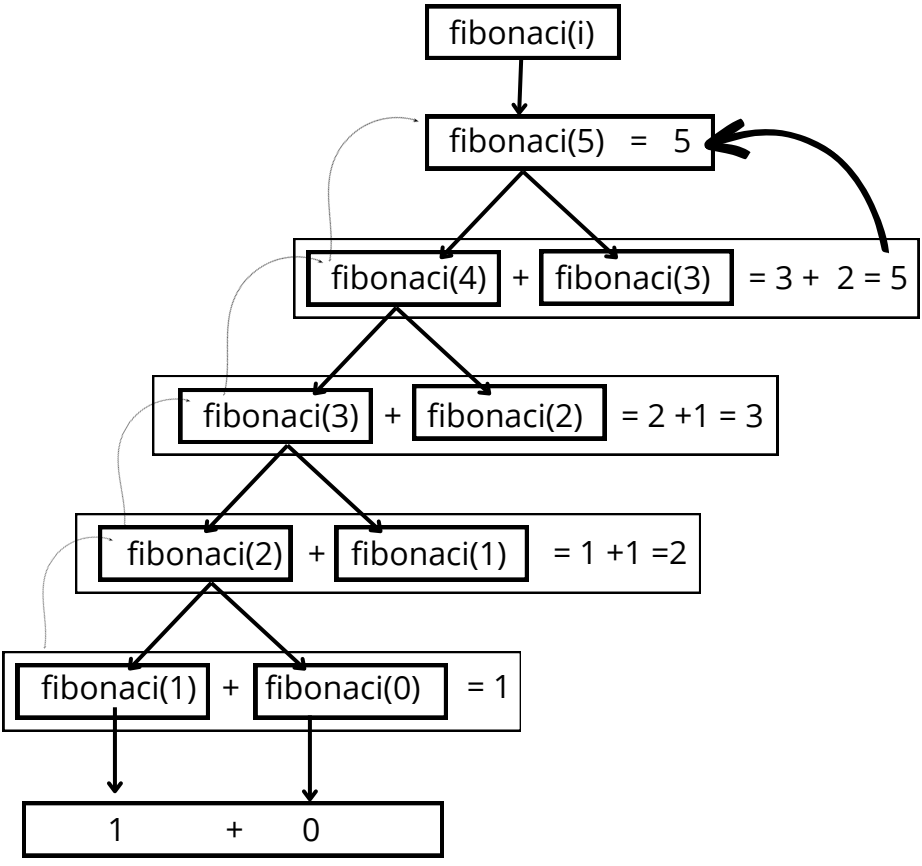
- **Make a program which will generates Fibonacci series for a given number using a recursive function**

```
#include<stdio.h>

int fibonaci(int i)
{
  if(i==0){
    return 0;
  }
  if(i==1){
    return 1;
  }
  return fibonaci(i-1) + fibonaci(i-2);
}
 int main()
 {
  int i;
  for(i = 0; i<10; i++)
  {
    printf("%d\t%n",fibonaci(i));
  }
  return 0;
 }
```

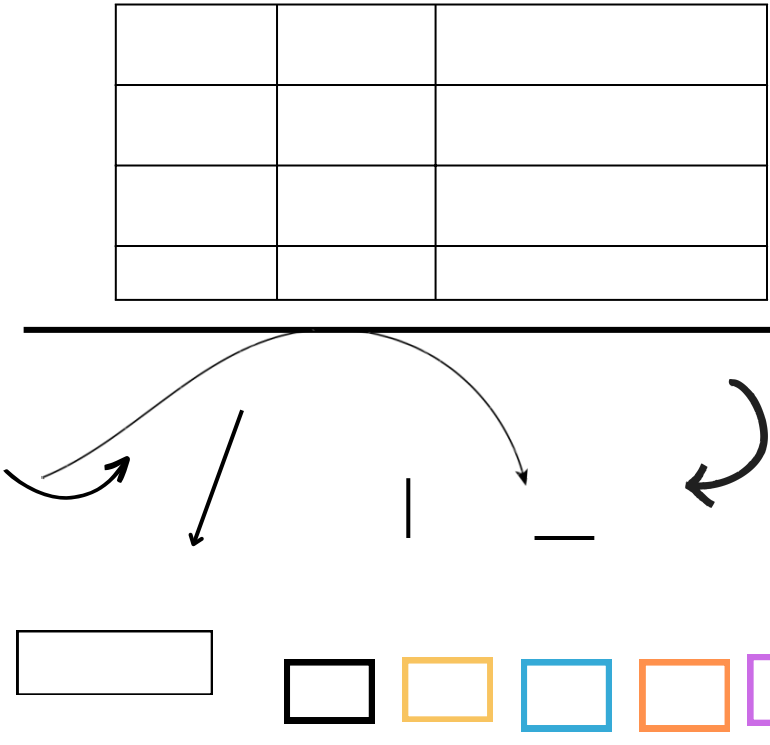
Output:

0 1 1 2 3 5 8 13 21 34

Here,

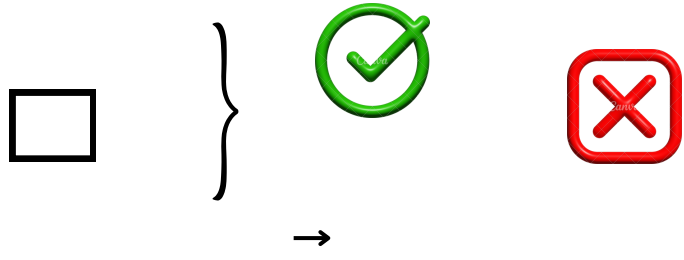

fibonaci(i)
fibonaci(5) = 5
fibonaci(4) + fibonaci(3) = 3 + 2 = 5
fibonaci(3) + fibonaci(2) = 2 +1 = 3
fibonaci(2) + fibonaci(1) = 1 +1 =2
fibonaci(1) + fibonaci(0) = 1
1 + 0

Operator Precedence and Associativity:



Hamim

Jim

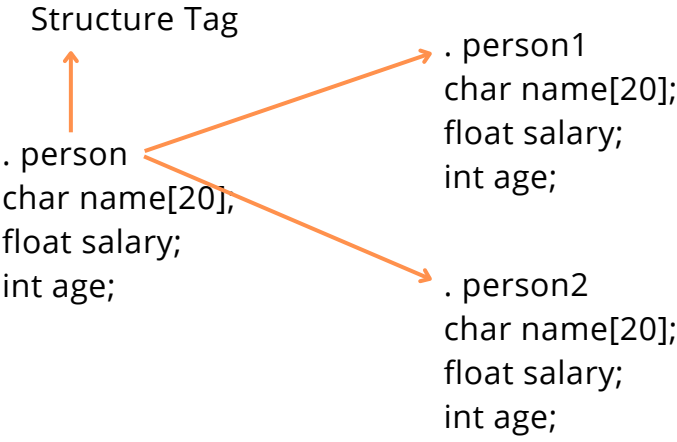


- **What is the output of the following C program fragment:**

7. structure

Structure is a collection of variables of different types under a single type.
A structure is a user defined data type in C/C++.

Structure is a collection of different types under a single name.



- **What will be the output of the program bellowed?**

```
#include<stdio.h>
// global structre
struct Person
{
  int age;
  float salary;
};

int main()
{
    struct Person man1, man2; // local variable
    man1.age=22;
    man1.salary=12300.12;

    printf("man1 :\n");
    printf("Age = %d\n",man1.age);
    printf("Salary = %.2f\n",man1.salary);

    printf("\n");

    man2.age=25;
    man2.salary=23500.12;

    printf("man2 :\n");
    printf("Age = %d\n",man2.age);
    printf("Salary = %.2f\n",man2.salary);
    return 0;
}
```

Here,
Person is a structure tag.

or,

```
#include<stdio.h>
int main()
{
    // local structre
   struct Person
   {
     int age;
     float salary;
   };
   struct Person man1, man2;  // local variable
   man1.age=22;
   man1.salary=12300.12;

   printf("man1 :\n");
   printf("Age = %d\n",man1.age);
   printf("Salary = %.2f\n",man1.salary);

   printf("\n");

   man2.age=25;
   man2.salary=23500.12;

   printf("man2 :\n");
   printf("Age = %d\n",man2.age);
   printf("Salary = %.2f\n",man2.salary);
   return 0;
}
```

or,

```
#include<stdio.h>
// global structre
struct Person
{
  int age;
  float salary;
};

struct Person man1, man2; // global variable

int main()
{
    man1.age=22;
    man1.salary=12300.12;

    printf("man1 :\n");
    printf("Age = %d\n",man1.age);
    printf("Salary = %.2f\n",man1.salary);

    printf("\n");

    man2.age=25;
    man2.salary=23500.12;

    printf("man2 :\n");
    printf("Age = %d\n",man2.age);
    printf("Salary = %.2f\n",man2.salary);
    return 0;
}
```

Output:
man1 :
Age = 22
Salary = 12300.12

man2 :
Age = 25
Salary = 23500.12

- **Make a program that will show given bellow using structure.**

Enter information for man1:
Enter Age: 23
Enter salary: 65600

man1 :
Age = 23
Salary = 65600.00

Enter information for man2:
Enter Age: 45
Enter salary: 65000.889

man2 :
Age = 45
Salary = 65000.89

```
#include<stdio.h>
// global structre
struct Person
{
  int age;
  float salary;
};

int main()
{
    struct Person man1, man2; // local variable

    printf("Enter information for man1:\n");
    printf("Enter Age: ");
    scanf("%d",&man1.age);
    printf("Enter salary: ");
    scanf("%f",&man1.salary);

    printf("\nman1 :\n");
    printf("Age = %d\n",man1.age);
    printf("Salary = %.2f\n",man1.salary);
    printf("\n");
    printf("Enter information for man2:\n");
    printf("Enter Age: ");
    scanf("%d",&man2.age);
    printf("Enter salary: ");
    scanf("%f",&man2.salary);

    printf("\nman2 :\n");
    printf("Age = %d\n",man2.age);
    printf("Salary = %.2f\n",man2.salary);
    return 0;
}
```

- **What will be the output of the program bellowed?**

```
#include<stdio.h>

struct employee
{
  char *name;
  int age;
  int salary;
};

int manager()
{
  struct employee manager;
  manager.age = 27;
  if(manager.age>30)
     manager.salary = 65000;
  else
     manager.salary = 55000;
  return manager.salary;
}

int main()
{
  struct employee emp1;
  struct employee emp2;
  printf("Enter the salary of employee1: ");
  scanf("%d", &emp1.salary);
  printf("Enter the salary of employee2: ");
  scanf("%d", &emp2.salary);
```

```
 printf("Employee 1 salary is: %d\n",emp1.salary);
  printf("Employee 2 salary is: %d\n",emp2.salary);
  printf("Manager's salary is %d", manager());
}

or,
#include<stdio.h>

struct
{
  char *name;
  int age;
  int salary;
} emp1, emp2;

int manager()
{
  struct
{
  char *name;
  int age;
  int salary;
} manager;

  manager.age = 27;
  if(manager.age>30)
      manager.salary = 65000;
  else
      manager.salary = 55000;
  return manager.salary;
}
```

```
int main()
{
  printf("Enter the salary of employee1: ");
  scanf("%d", &emp1.salary);
  printf("Enter the salary of employee2: ");
  scanf("%d", &emp2.salary);
  printf("Employee 1 salary is: %d\n",emp1.salary);
  printf("Employee 2 salary is: %d\n",emp2.salary);
  printf("Manager's salary is %d", manager());
}

or,
#include<stdio.h>

struct employee
{
  char *name;
  int age;
  int salary;
}emp1;

int manager()
{
  struct employee manager;
  manager.age = 27;
  if(manager.age>30)
      manager.salary = 65000;
  else
      manager.salary = 55000;
  return manager.salary;
}
```

```
int main()
{
  struct employee emp2;
  printf("Enter the salary of employee1: ");
  scanf("%d", &emp1.salary);
  printf("Enter the salary of employee2: ");
  scanf("%d", &emp2.salary);
  printf("Employee 1 salary is: %d\n",emp1.salary);
  printf("Employee 2 salary is: %d\n",emp2.salary);
  printf("Manager's salary is %d", manager());
}
```

Output:

```
Enter the salary of employee1: 12000
Enter the salary of employee2: 13000
Employee 1 salary is: 12000
Employee 2 salary is: 13000
Manager's salary is 55000
```

typedef keyword:

typedef gives freedom to the user by allowing them to creat their own types.

Syntax: typedef existing_data_type new_data_type

- **What will be the output of the program bellowed?**

```
#include<stdio.h>
typedef int integer;

int main()
{
  integer var1 = 100;
  int var2 = 200;
  printf("var1 = %d\n",var1);
  printf("var2 = %d\n",var2);
  return 0;
}
```

Output:

```
var1 = 100
var2 = 200
```

- **What will be the output of the program given bellow.**

```
#include<stdio.h>

typedef struct car {
  char engine[50];
  char fuel_type[10];
  int fuel_tank_cap;
  int seating_cap;
  float city_milage;
}car;

int main()
{
  car c1, c2;
  printf("Enter c1 car engine name: ");
  fflush(stdin);
  gets(c1.engine);
  printf("Enter c2 car engine name: ");
  scanf("%[^\n]",&c2.engine);
  printf("c1 car engine name: %s\n",c1.engine);
  printf("c2 car engine name: %s\n",c2.engine);
  return 0;
}
```

Output:

```
Enter c1 car engine name: VIVIT_14
Enter c2 car engine name: VIVIT_15
c1 car engine name: VIVIT_14
c2 car engine name: VIVIT_15
```

- **What will be the output of the program bellowed?**

```
#include<stdio.h>
// global structre
struct Person
{
  int age;
  float salary;
};

int main()
{
    struct Person man1 = {27,25550.256}; // local
variable
    struct Person man2, man3;

    // element wise assignment
    man2.age = 25;
    man2.salary = 27896.78;

    // structure variable assignment
    man3 = man2;

    printf("\nman1 :\n");
    printf("Age = %d\n",man1.age);
    printf("Salary = %.2f\n",man1.salary);

    printf("\n");

    printf("man2 :\n");
```

```
   printf("Age = %d\n",man2.age);
    printf("Salary = %.2f\n",man2.salary);
    printf("\n");

    printf("man3 :\n");
    printf("Age = %d\n",man3.age);
    printf("Salary = %.2f\n",man3.salary);
    return 0;
}
```

Output:

```
man1 :
Age = 27
Salary = 25550.26

man2 :
Age = 25
Salary = 27896.78

man3 :
Age = 25
Salary = 27896.78
```

- **What will be the output of the program bellowed?**

```
#include<stdio.h>

struct car {
  char engine[50];
  char fuel_type[10];
  int fuel_tank_cap;
  int seating_cap;
  float city_milage;
}car;

int main()
{
  struct car c1={"DDis 190 Engine","Diesel", 37, 5,
19.74};
  struct car c2={"Kappa 200 Engine","Petrol", 22,
8, 14.74};
  printf("car c1 data:\n");
  printf("Engine: %s\n",c1.engine);
  printf("Fuel type: %s\n",c1.fuel_type);
  printf("Fuel tank capacity:
%d\n",c1.fuel_tank_cap);
  printf("Seating capacity: %d\n",c1.seating_cap);
  printf("City milage: %.2f\n",c1.city_milage);
  printf("\n");
  printf("car c2 data:\n");
  printf("Engine: %s\n",c2.engine);
  printf("Fuel type: %s\n",c2.fuel_type);
  printf("Fuel tank capacity:
%d\n",c2.fuel_tank_cap);
```

```
printf("Seating capacity: %d\n",c2.seating_cap);
  printf("City milage: %.2f\n",c2.city_milage);
  return 0;
}


or,
#include<stdio.h>

struct car {
  char engine[50];
  char fuel_type[10];
  int fuel_tank_cap;
  int seating_cap;
  float city_milage;
}car;

int main()
{
  struct car c1={ .engine = "DDis 190 Engine",
.fuel_type = "Diesel", .fuel_tank_cap = 37,
.seating_cap = 5, .city_milage = 19.74};
  struct car c2={ .engine = "Kappa 200 Engine",
.fuel_type = "Petrol", .fuel_tank_cap = 22,
.seating_cap = 8, .city_milage = 14.74};
  printf("car c1 data:\n");
  printf("Engine: %s\n",c1.engine);
  printf("Fuel type: %s\n",c1.fuel_type);
  printf("Fuel tank capacity:
%d\n",c1.fuel_tank_cap);
  printf("Seating capacity: %d\n",c1.seating_cap);
```

```
printf("City milage: %.2f\n",c1.city_milage);
  printf("\n");
  printf("car c2 data:\n");
  printf("Engine: %s\n",c2.engine);
  printf("Fuel type: %s\n",c2.fuel_type);
  printf("Fuel tank capacity: %d\n",c2.fuel_tank_cap);
  printf("Seating capacity: %d\n",c2.seating_cap);
  printf("City milage: %.2f\n",c2.city_milage);
  return 0;
}
```

Output:

```
car c1 data:
Engine: DDis 190 Engine
Fuel type: Diesel
Fuel tank capacity: 37
Seating capacity: 5
City milage: 19.74

car c2 data:
Engine: Kappa 200 Engine
Fuel type: Petrol
Fuel tank capacity: 22
Seating capacity: 8
City milage: 14.74
```

- **Make a program that will show whether the structural elements of different structure variables are equal or not.**

```
#include<stdio.h>
// global structre
struct Person
{
  int age;
  float salary;
};

int main()
{
    struct Person man1 = {27,25550.256}; // local
variable
    struct Person man2;

    // element wise assignment
    man2.age = 27;
    man2.salary = 25550.256;

    if(man1.age == man2.age && man1.salary ==
man2.salary){
        printf("man1 equal to man2");
    }
    else
        printf("man1 not equal to man2");
    return 0;
}
```

- **Make a program that will show given bellow using structure.**

Enter information for Person1
Enter age : 20
Enter salary : 12500.678
Enter information for Person2
Enter age : 22
Enter salary : 14500
Enter information for Person3
Enter age : 23
Enter salary : 45900.89
Enter information for Person4
Enter age : 40
Enter salary : 67000.67

Information for Person1
Age : 20
Salary : 12500.68

Information for Person2
Age : 22
Salary : 14500.00

Information for Person3
Age : 23
Salary : 45900.89

Information for Person4
Age : 40
Salary : 67000.67

```
#include<stdio.h>
// global structre
struct Person
{
  int age;
  float salary;
};

int main()
{
    struct Person person[4];
    int i;

    for(i=0;i<4;i++){
        printf("Enter information for
Person%d\n",i+1);
        printf("Enter age : ");
        scanf("%d",&person[i].age);
        printf("Enter salary : ");
        scanf("%f",&person[i].salary);
    }
    for(i=0;i<4;i++){
        printf("\n\nInformation for
Person%d\n",i+1);
        printf("Age : %d\n",person[i].age);
        printf("Salary : %.2f\n",person[i].salary);
    }
    return 0;
}
```

- **Make a program that will show given bellow using structure.**

Enter information for Person1
Enter Name : Hamim Talukder
Enter age : 22
Enter salary : 34000.3535

Enter information for Person2
Enter Name : Safin
Enter age : 24
Enter salary : 23787.89

Enter information for Person3
Enter Name : Atik
Enter age : 45
Enter salary : 34000

Enter information for Person4
Enter Name : Munmun
Enter age : 23
Enter salary : 25678.896

Information for Person1
Name : Hamim Talukder
Age : 22
Salary : 34000.35

Information for Person2
Name : Safin
Age : 24
Salary : 23787.89

Information for Person3
Name : Atik
Age : 45
Salary : 34000.00

Information for Person4
Name : Munmun
Age : 23
Salary : 25678.90

```
#include<stdio.h>
// global structre
struct Person
{
   char name[50];
   int age;
   float salary;
};

int main()
{
   struct Person person[4];
   int i;

   for(i=0;i<4;i++){
      printf("Enter information for Person%d\n",i+1);
      printf("Enter Name : ");
      fflush(stdin);
      gets(person[i].name);
      printf("Enter age : ");
      scanf("%d",&person[i].age);
```

```
        printf("Enter salary : ");
        scanf("%f",&person[i].salary);
        printf("\n");
    }
    for(i=0;i<4;i++){
        printf("\n\nInformation for Person%d\n",i+1);
        printf("Name : %s\n",person[i].name);
        printf("Age : %d\n",person[i].age);
        printf("Salary : %.2f\n",person[i].salary);
    }
    return 0;
}
```

Here,
fflush(stdin) is a library function that is used to solve the string assigning problem.

- **Passing structure variable to function:**

- **What will be the output of the program bellowed?**

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

// global structre
struct Person
{
   char name[50];
   int age;
   float salary;
};

void display(struct Person p)
{
   printf("Name : %s\n",p.name);
   printf("Age : %d\n",p.age);
   printf("Salary : %.2f\n",p.salary);
}

int main()
{
   struct Person person1,person2;
   strcpy(person1.name,"Hamim Talukder");
   person1.age = 27;
   person1.salary = 12250.50;
   display(person1);
   return 0;
}
```

Output:
Name : Hamim Talukder
Age : 27
Salary : 12250.50

- **What will be the output of the program bellowed?**

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

// global structre
struct Person
{
   char name[50];
   int age;
   float salary;
};

void display(struct Person p)
{
   printf("Name : %s\n",p.name);
   printf("Age : %d\n",p.age);
   printf("Salary : %.2f\n",p.salary);
}

int main()
{
   struct Person person1,person2;
   strcpy(person1.name,"Hamim Talukder");
   person1.age = 22;
   person1.salary = 92250.50;
   display(person1);
```

```
    strcpy(person2.name,"Hridi");
    person2.age = 23;
    person2.salary = 81250.50;
    display(person2);
    return 0;
}


or,
#include<stdio.h>
#include<string.h>

// global structre
struct Person
{
    char name[50];
    int age;
    float salary;
};

void display(struct Person p)
{
    printf("Name : %s\n",p.name);
    printf("Age : %d\n",p.age);
    printf("Salary : %.2f\n",p.salary);
}

int main()
{
    struct Person person1;
    strcpy(person1.name,"Hamim Talukder");
    person1.age = 22;
```

```
    person1.salary = 92250.50;
    display(person1);

    strcpy(person1.name,"Hridi");
    person1.age = 23;
    person1.salary = 81250.50;
    display(person1);
    return 0;
}
```

Output:

```
Name : Hamim Talukder
Age : 22
Salary : 92250.50
Name : Hridi
Age : 23
Salary : 81250.50
```

- **What will be the output of the program bellowed?**

```
#include<stdio.h>
struct abc{
  int x;
  int y;
};
int main()
{
  struct abc a = {0, 1};
  struct abc *ptr = &a;

  printf("%d %d",(*ptr).x, (*ptr).y);
}
```

or,

```
#include<stdio.h>
struct abc{
  int x;
  int y;
};
int main()
{
  struct abc a = {0, 1};
  struct abc *ptr = &a;

  printf("%d %d",ptr->x, ptr->y);
}
```

or,

```
#include<stdio.h>
struct abc{
  int x;
  int y;
};
int main()
{
  struct abc a = {0, 1};
  struct abc *ptr = &a;

  printf("%d %d",(*&a).x, (*&a).y);
}
```

or,

```
#include<stdio.h>
struct abc{
  int x;
  int y;
};
int main()
{
  struct abc a = {0, 1};
  struct abc *ptr = &a;

  printf("%d %d",a.x, a.y);
}
```

Output:

0 1

- **Predict the output of the following C program.**

```
#include<stdio.h>
struct Point
{
  int x, y, z;
};
int main()
{
  struct Point p1 = {.y = 0, .z = 1, .x = 2};
  printf("%d %d %d\n",p1.x, p1.y, p1.z);
  return 0;
}
```

Output:

2 0 1

- **Predict the output of the following C program.**

```
#include<stdio.h>
struct Ournode
{
  char x, y, z;
};
int main()
{
  struct Ournode p = {'1', '0', 'a'+2};
  struct Ournode *q = &p;
  printf("%c, %c", *((char*)q+1), *((char*)q+2));
  return 0;
}
```

Output:

0, c

- **Predict the output of the following C program.**

```
#include<stdio.h>
int main()
{
 struct student {
  int id;
  char *name;
 };
 struct student one;
 one.id = 1;
 one.name = "Hamim Talukder";
 printf("ID: %d\nName: %s\n",one.id,one.name);
 return 0;
}
```

or,

```
#include<stdio.h>
#include<string.h>
int main()
{
  struct student {
    int id;
    char name[50];
  };
  struct student one;
  one.id = 1;
  strcpy(one.name,"Hamim Talukder");
  printf("ID: %d\nName: %s\n",one.id,one.name);
  return 0;
}
```

Output:
ID: 1
Name: Hamim Talukder

- **Make a program that will show given bellow using structure.**

Enter your ID: 5369
Enter your Name: Hamim Talukder
ID: 5369
Name: Hamim Talukder

```
#include<stdio.h>
int main()
{
 struct student {
  int id;
  char name[ 50];
 };
 struct student one;
 printf("Enter  your ID: ");
 scanf("%d",&one.id);
 printf("Enter  your Name: ");
 scanf(" %[^\n]",&one.name);
 printf("ID: %d\nName: %s\n",one.id,one.name);
 return 0;
}
```

- **Predict the output of the following C program.**

```
#include<stdio.h>
#include<string.h>
struct nametype{
   char first[20];
   char last[20];
};
struct student{
   int id;
   struct nametype name;
};
int main()
{
   struct student one;
   printf("Enter ID: ");
   scanf("%d",&one.id);
   printf("Enter your first name: ");
   scanf("%s",one.name.first);
   printf("Enter your last name: ");
   scanf("%s",&one.name.last);
   printf("ID: %d\n",one.id);
   printf("Name: %s %s\n",one.name.first,
one.name.last);
   return 0;
}
```

Output:

```
Enter ID: 221
Enter your first name: Hamim
Enter your last name: Talukder
ID: 221
Name: Hamim Talukder
```

- **Predict the output of the following C program.**

```
#include<stdio.h>
#include<string.h>
struct nametype{
   char first[20];
   char last[20];
};
struct student{
   int id;
   struct nametype name;
};
int main()
{
   struct student one;
   printf("Enter ID: ");
   scanf("%d",&one.id);
   printf("Enter your first and last name: ");
   scanf("%s%s",&one.name.first, &one.name.last);
   printf("ID: %d\n",one.id);
   printf("Name: %s %s\n",one.name.first,
one.name.last);
   return 0;
}
```

or,

```
#include<stdio.h>
#include<string.h>
struct nametype{
   char first[20];
   char last[20];
};
struct student{
   int id;
   struct nametype name;
};
int main()
{
   struct student one;
   printf("Enter ID: ");
   scanf("%d",&one.id);
   printf("Enter your first and last name: ");
   scanf("%s%s",one.name.first, one.name.last);
   printf("ID: %d\n",one.id);
   printf("Name: %s %s\n",one.name.first,
one.name.last);
   return 0;
}
```

Output:

```
Enter ID: 221
Enter your first and last name: Hamim Talukder
ID: 221
Name: Hamim Talukder
```

- **Predict the output of the following C program.**

```
#include<stdio.h>
#include<string.h>
struct nametype{
   char first[20];
   char last[20];
};
struct student_type{
   int id;
   struct nametype name;
};
int main()
{
   printf("Enter student number: ");
   int i, n;
   scanf("%d",&n);
   struct student_type student[n];
   for(i=0;i<n;i++){
      printf("%d no. student\n",i+1);
      printf("Enter ID: ");
      scanf("%d",&student[i].id);
      printf("Enter your first and last name: ");
      scanf("%s%s",student[i].name.first,
student[i].name.last);
   }
   printf("Output:\n\n");
   for(i=0;i<n;i++){
      printf("%d no. student\n",i+1);
```

```
      printf("ID: %d\n",student[i].id);
       printf("Name: %s %s\n",student[i].name.first,
student[i].name.last);
   }
   return 0;
}
```

- **What will be the output of the program given bellow.**

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

typedef struct
{
  char first[20];
  char last[20];
} nametype;

typedef struct
{
  int id;
  nametype name;
  char grade[3];
} studenttype;

void calculate_grade(studenttype *s, int mark)
{
  if (mark >= 80)
  {
    strcpy(s->grade, "A+");
  }
```

```
else if (mark >= 70)
  {
    strcpy(s->grade, "A");
  }
  else if (mark >= 60)
  {
    strcpy(s->grade, "A-");
  }
  else if (mark >= 50)
  {
    strcpy(s->grade, "B");
  }
  else if (mark >= 40)
  {
    strcpy(s->grade, "C");
  }
  else
  {
    strcpy(s->grade, "F");
  }
}

int main()
{
  studenttype student[5];
  int i, n = 5;
  int marks[] = {72, 82, 60, 20, 50};

  for (i = 0; i < n; i++)
  {
```

```
    printf("Enter the ID for student %d: ", i + 1);
    scanf("%d", &student[i].id);
    printf("Enter the first name for student %d: ", i
+ 1);
    scanf("%s", student[i].name.first);
    printf("Enter the last name for student %d: ", i
+ 1);
    scanf("%s", student[i].name.last);
    strcpy(student[i].grade, "");
    printf("\n");
  }

  for (i = 0; i < n; i++)
  {
    calculate_grade(&student[i], marks[i]);
  }

  printf("Output: \n\n");

  for (i = 0; i < n; i++)
  {
    printf("ID: %d\n", student[i].id);
    printf("Name: %s %s\n", student[i].name.first,
student[i].name.last);
    printf("Grade: %s\n", student[i].grade);
  }

  return 0;
}
```

Output:
Enter the ID for student 1: 1
Enter the first name for student 1: Hamim
Enter the last name for student 1: Talukder

Enter the ID for student 2: 2
Enter the first name for student 2: Jim
Enter the last name for student 2: islam

Enter the ID for student 3: 3
Enter the first name for student 3: Hridi
Enter the last name for student 3: Chowdhuri

Enter the ID for student 4: 4
Enter the first name for student 4: Mim
Enter the last name for student 4: Islam

Enter the ID for student 5: 5
Enter the first name for student 5: Shuruvi
Enter the last name for student 5: Khatun

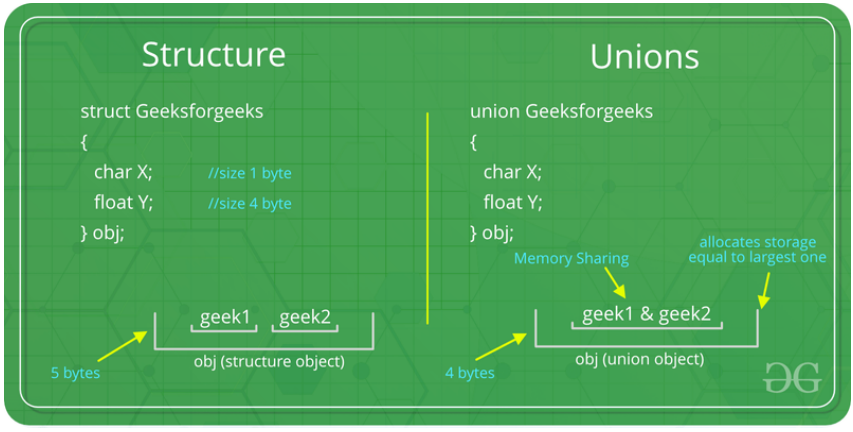
Output:

ID: 1
Name: Hamim Talukder
Grade: A
ID: 2
Grade: A+
ID: 3
Name: Hridi Chowdhuri
Grade: A-

ID: 4
Name: Mim Islam
Grade: F
ID: 5
Name: Shuruvi Khatun
Grade: B

Unions:

Union is a user defined data type but unlike structures, union members share same memory location.



For example in the following C program, both x and y share the same location. If we change x, we can see the changes being reflected in y:

```
#include <stdio.h>

// Declaration of union is same as structures
union test {
 int x, y;
};

int main()
{
 // A union variable t
 union test t;
```

```
t.x = 2; // t.y also gets value 2
 printf("After making x = 2:\n x = %d, y = %d\n\n",
  t.x, t.y);

 t.y = 10; // t.x is also updated to 10
 printf("After making y = 10:\n x = %d, y =
%d\n\n",
  t.x, t.y);
 return 0;
}
```

Output:

```
After making x = 2:
 x = 2, y = 2

After making y = 10:
 x = 10, y = 10
```

How is the size of union decided by compiler?

Size of a union is taken according the size of largest member in union.

```
#include <stdio.h>
union test1 {
 int x;
 int y;
} Test1;

union test2 {
 int x;
 char y;
} Test2;
```

```
union test3 {
 int arr[10];
 char y;
} Test3;

int main()
{
 printf("sizeof(test1) = %lu, sizeof(test2) = %lu, "
  "sizeof(test3) = %lu",
  sizeof(Test1),
  sizeof(Test2), sizeof(Test3));
 return 0;
}
```

Output:

```
sizeof(test1) = 4, sizeof(test2) = 4, sizeof(test3) = 40
```

Pointers to unions?

Like structures, we can have pointers to unions and can access members using the arrow operator (->). The following example demonstrates the same.

```
#include <stdio.h>
union test {
 int x;
 char y;
};
int main()
{
 union test p1;
 p1.x = 65;
```

```
 // p2 is a pointer to union p1
 union test* p2 = &p1;

 // Accessing union members using pointer
 printf("%d %c", p2->x, p2->y);
 return 0;
}
```

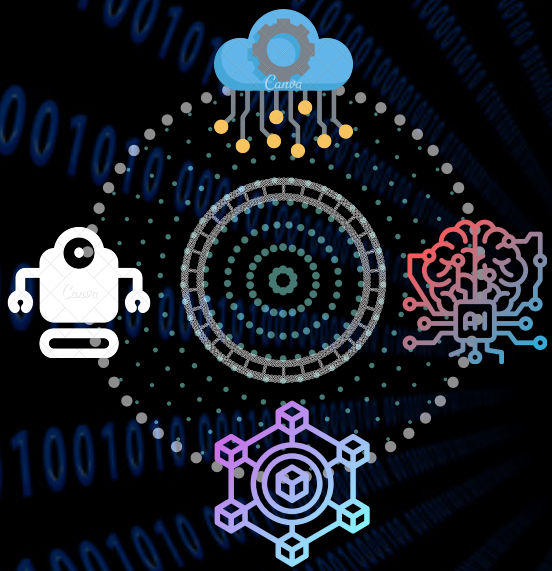
Output:
65 A

What are applications of union?
Unions can be useful in many situations where we want to use the same memory for two or more members. For example, suppose we want to implement a binary tree data structure where each leaf node has a double data value, while each internal node has pointers to two children, but no data. If we declare this as:

```
struct NODE {
 struct NODE* left;
 struct NODE* right;
 double data;
};
```

then every node requires 16 bytes, with half the bytes wasted for each type of node. On the other hand, if we declare a node as following, then we can save space.

```
struct NODE {
 bool is_leaf;
 union {
  struct
  {
   struct NODE* left;
   struct NODE* right;
  } internal;
  double data;
 } info;
};
```



C-PROGRAMMING (FIRST PART)

T.I.M. HA-MEAM

ABC PROKASHONI