Installation on Mac OS

If you use Mac OS X, the easiest way to obtain GCC is to download the Xcode development environment from Apple's web site and follow the simple installation instructions. Once you have Xcode setup, you will be able to use GNU compiler for C/C++.

Xcode is currently available at developer.apple.com/technologies/tools/.

Installation on Windows

To install GCC on Windows, you need to install MinGW. To install MinGW, go to the MinGW homepage, www.mingw.org, and follow the link to the MinGW download page. Download the latest version of the MinGW installation program, which should be named MinGW-<version>.exe.

While installing MinGW, at a minimum, you must install gcc-core, gcc-g++, binutils, and the MinGW runtime, but you may wish to install more.

Add the bin subdirectory of your MinGW installation to your **PATH** environment variable, so that you can specify these tools on the command line by their simple names.

After the installation is complete, you will be able to run gcc, g++, ar, ranlib, dlltool, and several other GNU tools from the Windows command line.

5. DATA TYPES

Data types in C refer to an extensive system used for declaring variables or functions of different types. The type of a variable determines how much space it occupies in storage and how the bit pattern stored is interpreted.

The types in C can be classified as follows:

S.N.	Types and Description
1	**Basic Types:** They are arithmetic types and are further classified into: (a) integer types and (b) floating-point types.
2	**Enumerated types:** They are again arithmetic types and they are used to define variables that can only assign certain discrete integer values throughout the program.
3	**The type void:** The type specifier *void* indicates that no value is available.
4	**Derived types:** They include (a) Pointer types, (b) Array types, (c) Structure types, (d) Union types, and (e) Function types.

The array types and structure types are referred collectively as the aggregate types. The type of a function specifies the type of the function's return value. We will see the basic types in the following section, whereas other types will be covered in the upcoming chapters.

Integer Types

The following table provides the details of standard integer types with their storage sizes and value ranges:

7. CONSTANTS AND LITERALS

Constants refer to fixed values that the program may not alter during its execution. These fixed values are also called **literals**.

Constants can be of any of the basic data types like *an integer constant, a floating constant, a character constant, or a string literal*. There are enumeration constants as well.

Constants are treated just like regular variables except that their values cannot be modified after their definition.

Integer Literals

An integer literal can be a decimal, octal, or hexadecimal constant. A prefix specifies the base or radix: 0x or 0X for hexadecimal, 0 for octal, and nothing for decimal.

An integer literal can also have a suffix that is a combination of U and L, for unsigned and long, respectively. The suffix can be uppercase or lowercase and can be in any order.

Here are some examples of integer literals:

```
212         /* Legal */
215u        /* Legal */
0xFeeL      /* Legal */
078         /* Illegal: 8 is not an octal digit */
032UU       /* Illegal: cannot repeat a suffix */
```


Following are other examples of various types of integer literals:

```
85         /* decimal */
0213       /* octal */
0x4b       /* hexadecimal */
30         /* int */
30u        /* unsigned int */
30l        /* long */
30ul       /* unsigned long */
```

	operands is non-zero, then the condition becomes true.	
!	Called Logical NOT Operator. It is used to reverse the logical state of its operand. If a condition is true, then Logical NOT operator will make it false.	!(A && B) is true.

Example

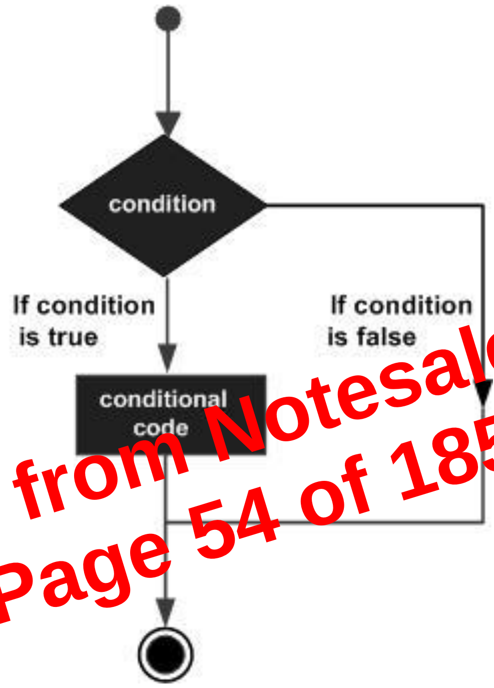
Try the following example to understand all the logical operators available in C:

```
#include <stdio.h>


main()
{
   int a = 5;
   int b = 20;
   int c ;

   if ( a && b )
   {
      printf("Line 1 - Condition is true\n" );
   }
   if ( a || b )
   {
      printf("Line 2 - Condition is true\n" );
   }
   /* lets change the value of  a and b */
   a = 0;
   b = 10;
   if ( a && b )
   {
      printf("Line 3 - Condition is true\n" );
   }
```

10. DECISION MAKING

Decision-making structures require that the programmer specifies one or more conditions to be evaluated or tested by the program, along with a statement or statements to be executed if the condition is determined to be true, and optionally, other statements to be executed if the condition is determined to be false.

Shown below is the general form of a typical decision-making structure found in most of the programming languages:



C programming language assumes any **non-zero** and **non-null** values as **true**, and if it is either **zero** or **null**, then it is assumed as **false** value.

C programming language provides the following types of decision-making statements.

Statement	**Description**
if statement	An **if statement** consists of a boolean expression followed by one or more statements.
if...else statement	An **if statement** can be followed by an optional **else statement**, which executes when

Example

```
#include <stdio.h>

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

   /* check the boolean condition */
   if( a < 20 )
   {
       /* if condition is true then print the following */
       printf("a is less than 20\n" );
   }
   else
   {
       /* if condition is false then print the following */
       printf("a is not less than 20\n" );
   }
   printf("value of a is : %d\n", a);

   return 0;
}
```


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

```
a is not less than 20;
value of a is : 100
```

if...else if...else Statement

An **if** statement can be followed by an optional **else if...else** statement, which is very useful to test various conditions using single if...else if statement.

When using if…else if…else statements, there are few points to keep in mind:

- An if can have zero or one else's and it must come after any else if's.
- An if can have zero to many else if's and they must come before the else.

```
        printf("Value of a is 10\n" );
    }
    else if( a == 20 )
    {
        /* if else if condition is true */
        printf("Value of a is 20\n" );
    }
    else if( a == 30 )
    {
        /* if else if condition is true  */
        printf("Value of a is 30\n" );
    }
    else
    {
        /* if none of the conditions is true */
        printf("None of the values is matching\n" );
    }
    printf("Exact value of a is: %d\n", a );

    return 0;
}
```


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

```
None of the values is matching
Exact value of a is: 100
```

Nested if Statements

It is always legal in C programming to **nest** if-else statements, which means you can use one if or else if statement inside another if or else if statement(s).

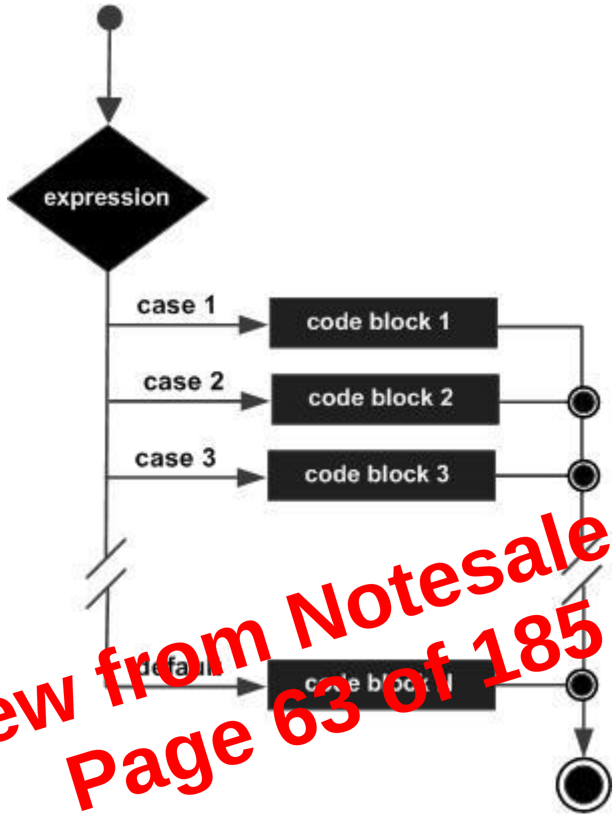
Syntax

The syntax for a **nested if** statement is as follows:

```
if( boolean_expression 1)
{
```

- Not every case needs to contain a **break**. If no **break** appears, the flow of control will *fall through* to subsequent cases until a break is reached.
- A **switch** statement can have an optional **default** case, which must appear at the end of the switch. The default case can be used for performing a task when none of the cases is true. No **break** is needed in the default case.

Flow Diagram



Example

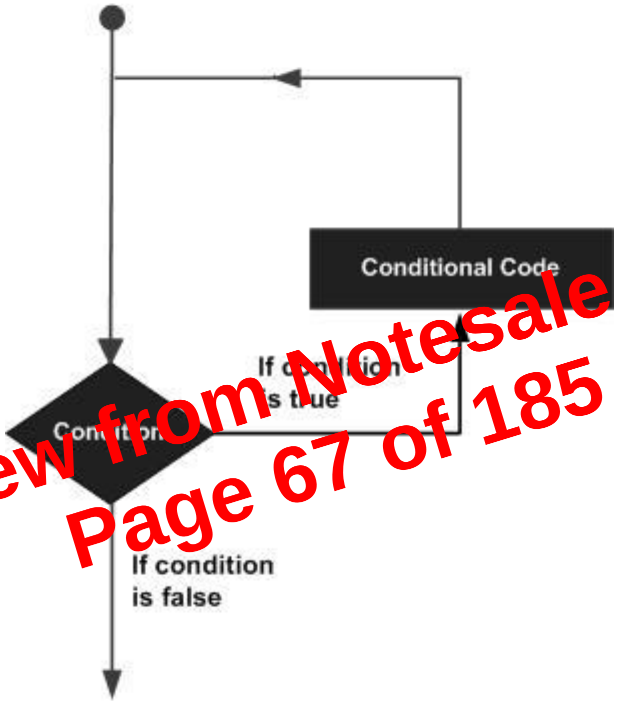
```
#include <stdio.h>


int main ()
{
   /* local variable definition */
   char grade = 'B';


   switch(grade)
   {
   case 'A' :
```

11. LOOPS

You may encounter situations when a block of code needs to be executed several number of times. In general, statements are executed sequentially: The first statement in a function is executed first, followed by the second, and so on.

Programming languages provide various control structures that allow for more complicated execution paths.

A loop statement allows us to execute a statement or group of statements multiple times. Given below is the general form of a loop statement in most of the programming languages:



C programming language provides the following types of loops to handle looping requirements.

Loop Type	**Description**
while loop	Repeats a statement or group of statements while a given condition is true. It tests the condition before executing the loop body.
for loop	Executes a sequence of statements multiple times and abbreviates the code that manages the loop variable.

```
   return 0;
}
```

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

```
value of a: 10
value of a: 11
value of a: 12
value of a: 13
value of a: 14
value of a: 15
value of a: 16
value of a: 17
value of a: 18
value of a: 19
```

for Loop

A **for** loop is a repetition control structure that allows you to efficiently write a loop that needs to execute a specific number of times.

Syntax

The syntax of a **for** loop in C programming language is:

```
for ( init; condition; increment )
{
   statement(s);
}
```

Here is the flow of control in a 'for' loop:

1. The **init** step is executed first, and only once. This step allows you to declare and initialize any loop control variables. You are not required to put a statement here, as long as a semicolon appears.
2. Next, the **condition** is evaluated. If it is true, the body of the loop is executed. If it is false, the body of the loop does not execute and the flow of control jumps to the next statement just after the 'for' loop.
3. After the body of the 'for' loop executes, the flow of control jumps back up to the **increment** statement. This statement allows you to update any loop control variables. This statement can be left blank, as long as a semicolon appears after the condition.

C supports the following control statements.

Control Statement	Description
break statement	Terminates the **loop** or **switch** statement and transfers execution to the statement immediately following the loop or switch.
continue statement	Causes the loop to skip the remainder of its body and immediately retest its condition prior to reiterating.
goto statement	Transfers control to the labeled statement.

break Statement

The **break** statement in C programming has the following two usages:

- When a **break** statement is encountered inside a loop, the loop is immediately terminated and the program control resumes at the next statement following the loop.
- It can be used to terminate a case in the **switch** statement (covered in the next chapter).

If you are using nested loops, the break statement will stop the execution of the innermost loop and start executing the next line of code after the block.

Syntax

The syntax for a **break** statement in C is as follows:

```
break;
```

Flow Diagram

```
   *y = temp;    /* put temp into y */

   return;
}
```

Let us now call the function **swap()** by passing values by reference as in the following example:

```
#include <stdio.h>

/* function declaration */
void swap(int *x, int *y);

int 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 values.
    * &a indicates pointer to a i.e. address of variable a and
    * &b indicates pointer to b i.e. address of variable b.
   */
   swap(&a, &b);

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

   return 0;
}
```


Let us put the above code in a single C file, compile and execute it, to produce the following result:

	array by specifying the array's name without an index.
Return array from a function	C allows a function to return an array.
Pointer to an array	You can generate a pointer to the first element of an array by simply specifying the array name, without any index.

Multidimensional Arrays

C programming language allows multidimensional arrays. Here is the general form of a multidimensional array declaration:

```
type name[size1][size2]...[sizeN];
```

For example, the following declaration creates a three-dimensional integer array:

```
int threedim[5][10][4];
```


Two-dimensional Arrays

The simplest form of multidimensional array is the two-dimensional array. A two-dimensional array is, in essence, a list of one-dimensional arrays. To declare a two-dimensional integer array of size [x][y], you would write something as follows:

```
type arrayName [ x ][ y ];
```

Where **type** can be any valid C data type and **arrayName** will be a valid C identifier. A two-dimensional array can be considered as a table which will have x number of rows and y number of columns. A two-dimensional array **a**, which contains three rows and four columns can be shown as follows:

	Column 0	Column 1	Column 2	Column 3
Row 0	a[0][0]	a[0][1]	a[0][2]	a[0][3]
Row 1	a[1][0]	a[1][1]	a[1][2]	a[1][3]
Row 2	a[2][0]	a[2][1]	a[2][2]	a[2][3]

Thus, every element in the array **a** is identified by an element name of the form **a[i][j]**, where 'a' is the name of the array, and 'i' and 'j' are the subscripts that uniquely identify each element in 'a'.

```
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;
}
```

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


```
r[0] = 313959809
r[1] = 1759055877
r[2] = 1113101911
r[3] = 2133832223
r[4] = 2073354073
r[5] = 167288147
r[6] = 1827471542
r[7] = 834791014
r[8] = 1901409888
r[9] = 1990469526
*(p + 0) : 313959809
*(p + 1) : 1759055877
*(p + 2) : 1113101911
*(p + 3) : 2133832223
*(p + 4) : 2073354073
*(p + 5) : 167288147
*(p + 6) : 1827471542
```

15. POINTERS

Pointers in C are easy and fun to learn. Some C programming tasks are performed more easily with 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. Let's start learning them in simple and easy steps.

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, which prints the address of the variables defined:

```
#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  );

   return 0;
}
```


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

```
Address of var1 variable: bff5a400
Address of var2 variable: bff5a3f6
```

What are Pointers?

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 using it to store any variable address. The general form of a pointer variable declaration is:

```
        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;
}
```

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

```
Address of var[0] = bfdbcb20
Value of var[0] = 10
Address of var[1] = bfdbcb24
Value of var[1] = 100
Address of var[2] = bfdbcb28
Value of var[2] = 200
```


Array of Pointers

Before we understand the concept of arrays of pointers, let us consider the following example, which uses 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;
}
```

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

```
Value of var = 3000
Value available at *ptr = 3000
Value available at **pptr = 3000
```

Passing Pointers to Functions

C programming allows passing 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)
```

```
1523198053
1187214107
1108300978
430494959
1421301276
930971084
123250484
106932140
1604461820
149169022
*(p + [0]) : 1523198053
*(p + [1]) : 1187214107
*(p + [2]) : 1108300978
*(p + [3]) : 430494959
*(p + [4]) : 1421301276
*(p + [5]) : 930971084
*(p + [6]) : 123250484
*(p + [7]) : 106932140
*(p + [8]) : 1604461820
*(p + [9]) : 149169022
```

```
#include <string.h>

struct Books
{
   char  title[50];
   char  author[50];
   char  subject[100];
   int   book_id;
};

/* function declaration */
void printBook( struct Books book );
int main( )
{
   struct Books Book1;        /* Declare Book1 of type Book */
   struct Books Book2;        /* Declare Book2 of type Book */

   /* book 1 specification */
   strcpy( Book1.title, "C Programming");
   strcpy( Book1.author, "Nuha Ali");
   strcpy( Book1.subject, "C Programming Tutorial");
   Book1.book_id = 6495407;

   /* book 2 specification */
   strcpy( Book2.title, "Telecom Billing");
   strcpy( Book2.author, "Zara Ali");
   strcpy( Book2.subject, "Telecom Billing Tutorial");
   Book2.book_id = 6495700;

   /* print Book1 info */
   printBook( Book1 );

   /* Print Book2 info */
```

```
    /* print Book2 info by passing address of Book2 */
    printBook( &Book2 );

    return 0;
}
void printBook( struct Books *book )
{
    printf( "Book title : %s\n", book->title);
    printf( "Book author : %s\n", book->author);
    printf( "Book subject : %s\n", book->subject);
    printf( "Book book_id : %d\n", book->book_id);
}
```

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

```
Book title : C Programming
Book author : Nuha Ali
Book subject : C Programming Tutorial
Book book_id : 6495407
Book title : Telecom Billing
Book author : Zara Ali
Book subject : Telecom Billing Tutorial
Book book_id : 6495700
```


Bit Fields

Bit Fields allow the packing of data in a structure. This is especially useful when memory or data storage is at a premium. Typical examples include:

- Packing several objects into a machine word, e.g. 1 bit flags can be compacted.
- Reading external file formats -- non-standard file formats could be read in, e.g., 9-bit integers.

C allows us to do this in a structure definition by putting :bit length after the variable. For example:

```
struct packed_struct {
```

```
#include <string.h>

union Data
{
   int i;
   float f;
   char  str[20];
};

int main( )
{
   union Data data;

   data.i = 10;
   data.f = 220.5;
   strcpy( data.str, "C Programming");

   printf( "data.i : %d\n", data.i);
   printf( "data.f : %f\n", data.f);
   printf( "data.str : %s\n", data.str);

   return 0;
}
```


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

```
data.i : 1917853763
data.f : 4122360580327794860452759994368.000000
data.str : C Programming
```

Here, we can see that the values of **i** and **f** members of union got corrupted because the final value assigned to the variable has occupied the memory location and this is the reason that the value of **str** member is getting printed very well.

Now let's look into the same example once again where we will use one variable at a time which is the main purpose of having unions:

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

```
  unsigned int widthValidated;
  unsigned int heightValidated;
} status1;

/* define a structure with bit fields */
struct
{
  unsigned int widthValidated : 1;
  unsigned int heightValidated : 1;
} status2;

int main( )
{
   printf( "Memory size occupied by status1 : %d\n", sizeof(status1));
   printf( "Memory size occupied by status2 : %d\n", sizeof(status2));

   return 0;
}
```

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

```
Memory size occupied by status1 : 8
Memory size occupied by status2 : 4
```


Bit Field Declaration

The declaration of a bit-field has the following form inside a structure:

```
struct
{
  type [member_name] : width ;
};
```

The following table describes the variable elements of a bit field:

Elements	Description

```
#define tokenpaster(n) printf ("token" #n " = %d", token##n)


int main(void)
{
   int token34 = 40;


   tokenpaster(34);
   return 0;
}
```

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

```
token34 = 40
```

It happened so because this example results in the following actual output from the preprocessor:

```
printf ("token34 = %d", token34);
```

This example shows the concatenation of token##n into token34 and here we have used both **stringize** and **token-pasting**.

The Defined() Operator

The preprocessor **defined** operator is used in constant expressions to determine if an identifier is defined using #define. If the specified identifier is defined, the value is true (non-zero). If the symbol is not defined, the value is false (zero). The defined operator is specified as follows:

```
#include <stdio.h>


#if !defined (MESSAGE)
   #define MESSAGE "You wish!"
#endif


int main(void)
{
   printf("Here is the message: %s\n", MESSAGE);
   return 0;
}
```

```
      fprintf(stderr, "Division by zero! Exiting...\n");
      exit(-1);
   }
   quotient = dividend / divisor;
   fprintf(stderr, "Value of quotient : %d\n", quotient );

   exit(0);
}
```

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

```
Division by zero! Exiting...
```

Program Exit Status

It is a common practice to exit with a value of EXIT_SUCCESS in case of program coming out after a successful operation. Here, EXIT_SUCCESS is a macro and it is defined as 0.

If you have an error condition in your program and you are coming out then you should exit with a status EXIT_FAILURE which is defined as -1. So let's write above program as follows:


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

main()
{
   int dividend = 20;
   int divisor = 5;
   int quotient;

   if( divisor == 0){
      fprintf(stderr, "Division by zero! Exiting...\n");
      exit(EXIT_FAILURE);
   }
   quotient = dividend / divisor;
   fprintf(stderr, "Value of quotient : %d\n", quotient );
```

27. RECURSION

Recursion is the process of repeating items in a self-similar way. In programming languages, if a program allows you to call a function inside the same function, then it is called a recursive call of the function.

```
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 from the function, otherwise it will go into an infinite loop.

Recursive functions are very useful to solve many mathematical problems, such as calculating the factorial of a number, generating Fibonacci series, etc.

Number Factorial

The following example calculates the factorial of 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);
```

5. Use a macro **va_end** to clean up the memory assigned to **va_list** variable.

Now let us follow the above steps and write down a simple function which can take the variable number of parameters and return their average:

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

double average(int num,...)
{

    va_list valist;
    double sum = 0.0;
    int i;

    /* initialize valist for num number of arguments */
    va_start(valist, num);

    /* access all the arguments assigned to valist */
    for (i = 0; i < num; i++)
    {
       sum += va_arg(valist, int);
    }
    /* clean memory reserved for valist */
    va_end(valist);

    return sum/num;
}

int main()
{
   printf("Average of 2, 3, 4, 5 = %f\n", average(4, 2,3,4,5));
   printf("Average of 5, 10, 15 = %f\n", average(3, 5,10,15));
}
```

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

int main()
{
   char name[100];
   char *description;

   strcpy(name, "Zara Ali");

   /* allocate memory dynamically */
   description = malloc( 200 * sizeof(char) );
   if( description == NULL )
   {
      fprintf(stderr, "Error - unable to allocate required memory\n");
   }
   else
   {
      strcpy( description, "Zara ali a DPS student in class 10th");
   }
   printf("Name = %s\n", name );
   printf("Description: %s\n", description );
}
```


When the above code is compiled and executed, it produces the following result.

```
Name = Zara Ali
Description: Zara ali a DPS student in class 10th
```

Same program can be written using **calloc();** only thing is you need to replace malloc with calloc as follows:

```
calloc(200, sizeof(char));
```

So you have complete control and you can pass any size value while allocating memory, unlike arrays where once the size is defined, you cannot change it.