Year	Subject Title	Sem	Sub Code
2018 -19 Onwards	**Core: COMPUTER FUNDAMENTALS AND C PROGRAMMING**	**I**	**18BIT13C**

UNITIII: Decision Making and Branching: Introduction – If, If….Else, nesting of If …Else statements- Else If ladder – The Switch statement, The?: Operator – The Go to Statement. Decision Making and Looping: Introduction- the While statement- the do statement – the for statement-jumps in loops. Arrays - Character Arrays and Strings.

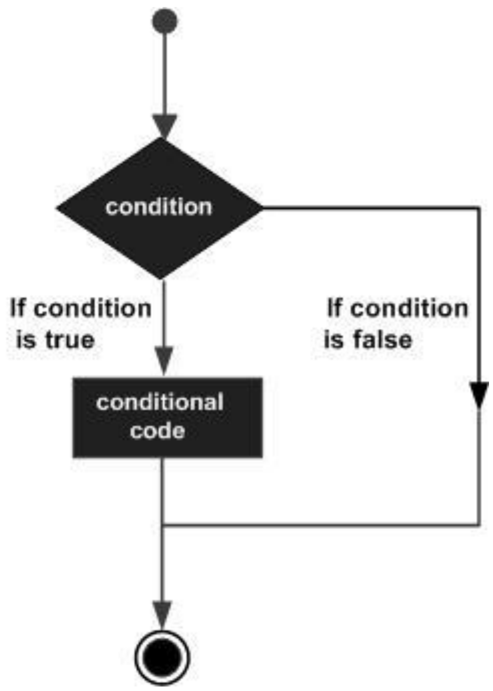
TEXT BOOK

E Balagurusamy," Computing Fundamentals & C Programming" – Tata McGraw-Hill, Second Reprint 2008, ISBN 978-0-07-066909-3.
Prepared by P.Sundari.

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.

Show 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.

Sr.No.	Statement & Description
1	if statement An **if statement** consists of a boolean expression followed by one or more statements.
2	if...else statement An **if statement** can be followed by an optional **else statement**, which executes when the Boolean expression is false.
3	nested if statements You can use one **if** or **else if** statement inside another **if** or **else if** statement(s).
4	switch statement

	A **switch** statement allows a variable to be tested for equality against a list of values.
5	nested switch statements You can use one **switch** statement inside another **switch** statement(s).

if statement

An **if** statement consists of a Boolean expression followed by one or more statements.

Syntax

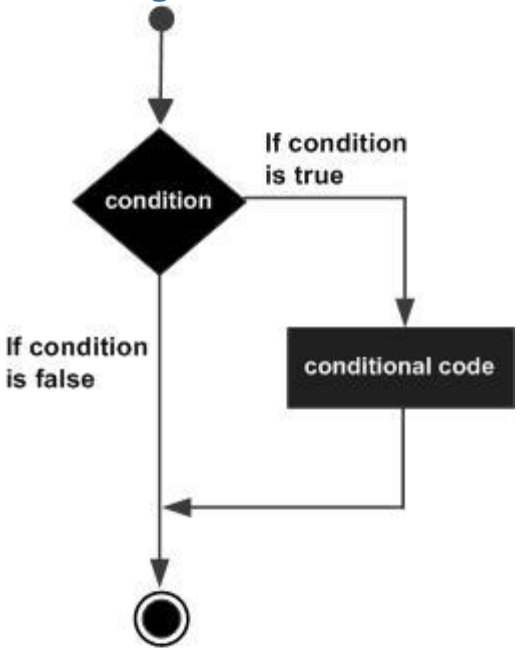
The syntax of an 'if' statement in C programming language is −

```
if(boolean_expression)
        {
          /* statement(s) will execute if the boolean expression is true */
        }
```

If the Boolean expression evaluates to **true**, then the block of code inside the 'if' statement will be executed. If the Boolean expression evaluates to **false**, then the first set of code after the end of the 'if' statement (after the closing curly brace) will be executed.

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.

Flow Diagram



Example

```
#include <stdio.h>

int main ()
{
   /* local variable definition */
   int a = 10;
   /* check the boolean condition using if statement */
   if( a < 20 )
              {
      /* if condition is true then print the following */
      printf("a is 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 less than 20;
value of a is : 10
```

if...else statement

An **if** statement can be followed by an optional **else** statement, which executes when the Boolean expression is false.

Syntax

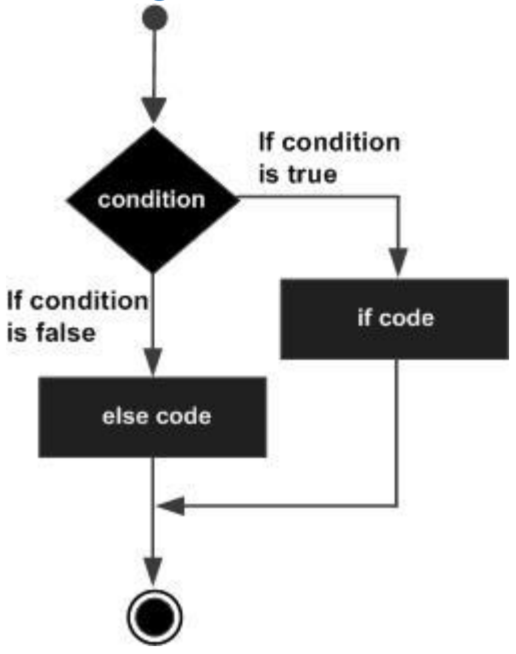
The syntax of an **if...else** statement in C programming language is −

```
if(boolean_expression)
            {
              /* statement(s) will execute if the boolean expression is true */
             }
else
            {
              /* statement(s) will execute if the boolean expression is false */
            }
```

If the Boolean expression evaluates to **true**, then the **if block** will be executed, otherwise, the **else block** will be executed.

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.

Flow Diagram



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.
- Once an else if succeeds, none of the remaining else if's or else's will be tested.

Syntax

The syntax of an **if...else if...else** statement in C programming language is −

```
if(boolean_expression 1)
 {
   /* Executes when the boolean expression 1 is true */
}
 else if( boolean_expression 2)
{
   /* Executes when the boolean expression 2 is true */
}
else if( boolean_expression 3)
{
   /* Executes when the boolean expression 3 is true */
}
 else
 {
   /* executes when the none of the above condition is true */
}
```

Example

```
#include <stdio.h>

int main () {

   /* local variable definition */
   int a = 100;

   /* check the boolean condition */
   if( a == 10 ) {
      /* if condition is true then print the following */
      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) {

   /* Executes when the boolean expression 1 is true */
   if(boolean_expression 2) {
      /* Executes when the boolean expression 2 is true */
   }
}
```

You can nest **else if...else** in the similar way as you have nested *if* statements.

Example

```
#include <stdio.h>

int main () {

   /* local variable definition */
   int a = 100;
   int b = 200;

   /* check the boolean condition */
   if( a == 100 ) {

      /* if condition is true then check the following */
      if( b == 200 ) {
         /* if condition is true then print the following */
         printf("Value of a is 100 and b is 200\n" );
      }
   }
```

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

  return 0;
}
```

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

```
Value of a is 100 and b is 200
Exact value of a is : 100
Exact value of b is : 200
```

switch statement

A **switch** statement allows a variable to be tested for equality against a list of values. Each value is called a case, and the variable being switched on is checked for each **switch case**.

Syntax

The syntax for a **switch** statement in C programming language is as follows −

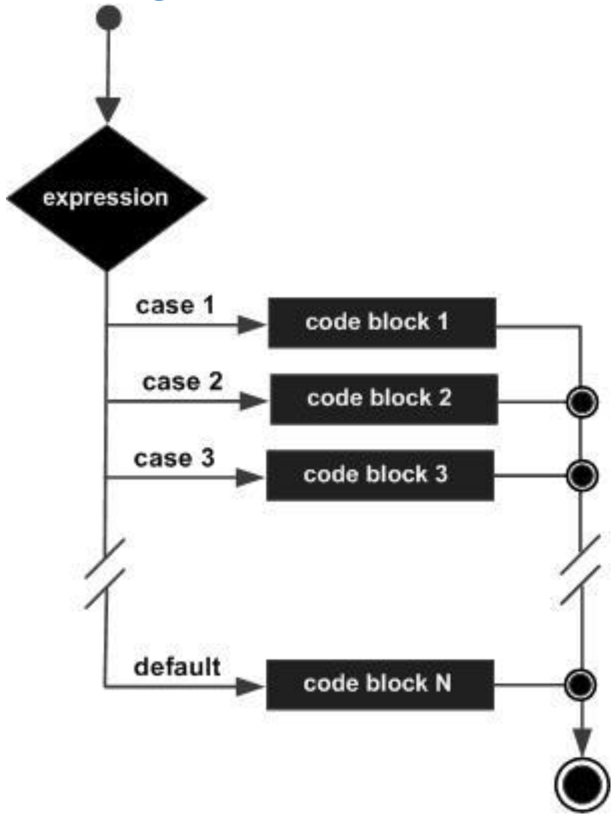
```
switch(expression) {

  case constant-expression  :
    statement(s);
    break; /* optional */

  case constant-expression  :
    statement(s);
    break; /* optional */

  /* you can have any number of case statements */
  default : /* Optional */
  statement(s);
}
```

The following rules apply to a **switch** statement −

- The **expression** used in a **switch** statement must have an integral or enumerated type, or be of a class type in which the class has a single conversion function to an integral or enumerated type.

- You can have any number of case statements within a switch. Each case is followed by the value to be compared to and a colon.
- The **constant-expression** for a case must be the same data type as the variable in the switch, and it must be a constant or a literal.
- When the variable being switched on is equal to a case, the statements following that case will execute until a **break** statement is reached.
- When a **break** statement is reached, the switch terminates, and the flow of control jumps to the next line following the switch statement.
- 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' :
         printf("Excellent!\n" );
         break;
      case 'B' :
      case 'C' :
         printf("Well done\n" );
         break;
      case 'D' :
         printf("You passed\n" );
         break;
      case 'F' :
         printf("Better try again\n" );
         break;
      default :
         printf("Invalid grade\n" );
   }

   printf("Your grade is  %c\n", grade );

   return 0;
}
```

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

```
Well done
Your grade is B
```

The ? : Operator

We have covered **conditional operator ? :** in the previous chapter which can be used to replace **if...else** statements. It has the following general form −

```
Exp1 ? Exp2 : Exp3;
```

Where Exp1, Exp2, and Exp3 are expressions. Notice the use and placement of the colon.

The value of a ? expression is determined like this −

- Exp1 is evaluated. If it is true, then Exp2 is evaluated and becomes the value of the entire ? expression.
- If Exp1 is false, then Exp3 is evaluated and its value becomes the value of the expression.

Go to statement

A **goto** statement in C programming provides an unconditional jump from the 'goto' to a labeled statement in the same function.

NOTE − Use of **goto** statement is highly discouraged in any programming language because it makes difficult to trace the control flow of a program, making the program hard to understand and hard to modify. Any program that uses a goto can be rewritten to avoid them.

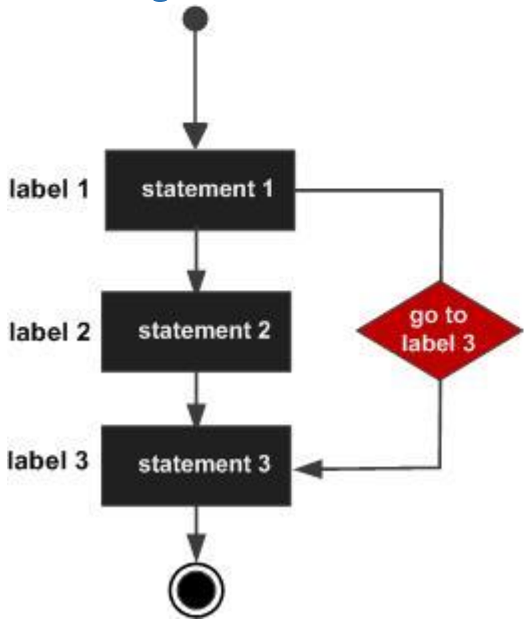
Syntax

The syntax for a **goto** statement in C is as follows −

```
goto label;
..
.
label: statement;
```

Here **label** can be any plain text except C keyword and it can be set anywhere in the C program above or below to **goto** statement.

Flow Diagram



Example

```
#include <stdio.h>

int main () {

   /* local variable definition */
   int a = 10;

   /* do loop execution */
   LOOP:do {

      if( a == 15) {
         /* skip the iteration */
         a = a + 1;
         goto LOOP;
      }

      printf("value of a: %d\n", a);
      a++;

   }while( a < 20 );

   return 0;
}
```

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

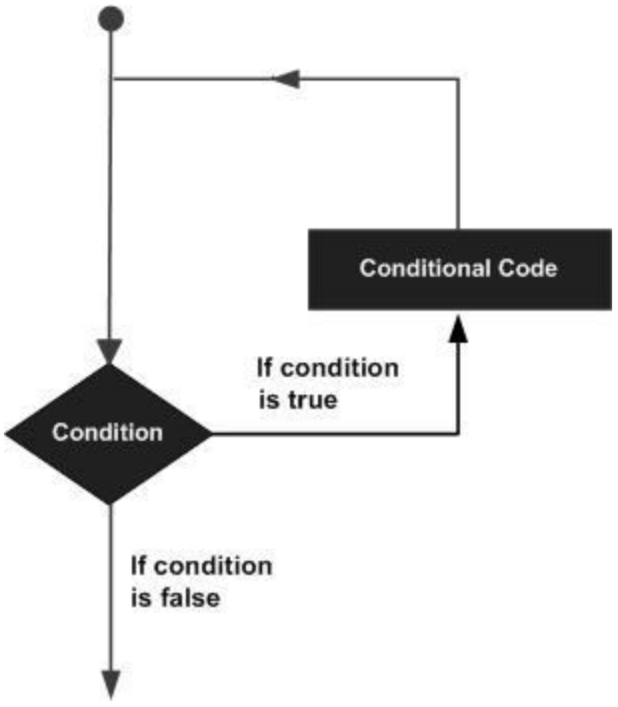
```
value of a: 10
value of a: 11
value of a: 12
value of a: 13
value of a: 14
value of a: 16
value of a: 17
value of a: 18
value of a: 19
```

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.

Sr.No.	Loop Type & Description
1	while loop Repeats a statement or group of statements while a given condition is true. It tests the condition before executing the loop body.
2	for loop

	Executes a sequence of statements multiple times and abbreviates the code that manages the loop variable.
3	do...while loop It is more like a while statement, except that it tests the condition at the end of the loop body.
4	nested loops You can use one or more loops inside any other while, for, or do..while loop.

while loop

A **while** loop in C programming repeatedly executes a target statement as long as a given condition is true.

Syntax

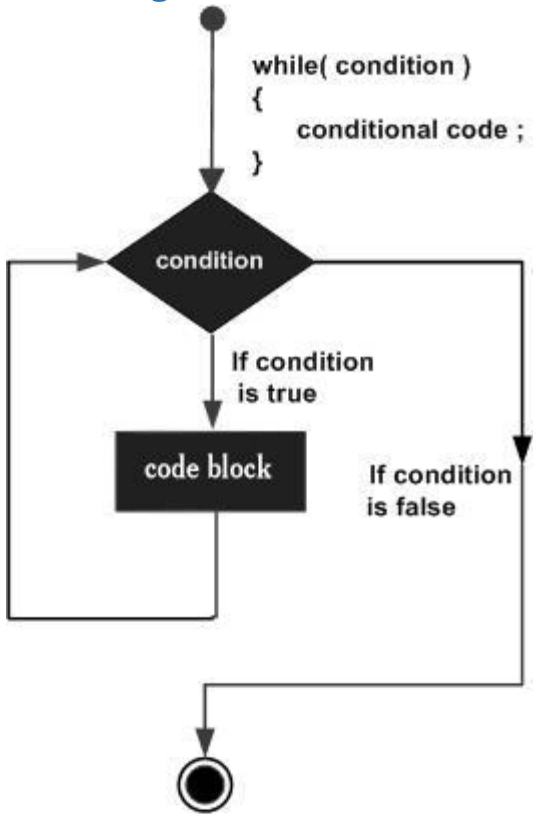
The syntax of a **while** loop in C programming language is −

```
while(condition) {
  statement(s);
}
```

Here, **statement(s)** may be a single statement or a block of statements. The **condition** may be any expression, and true is any nonzero value. The loop iterates while the condition is true.

When the condition becomes false, the program control passes to the line immediately following the loop.

Flow Diagram



Here, the key point to note is that a while loop might not execute at all. When the condition is tested and the result is false, the loop body will be skipped and the first statement after the while loop will be executed.

Example

```
#include <stdio.h>

int main () {

   /* local variable definition */
   int a = 10;

   /* while loop execution */
   while( a < 20 ) {
      printf("value of a: %d\n", a);
      a++;
   }

   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 in C

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 −

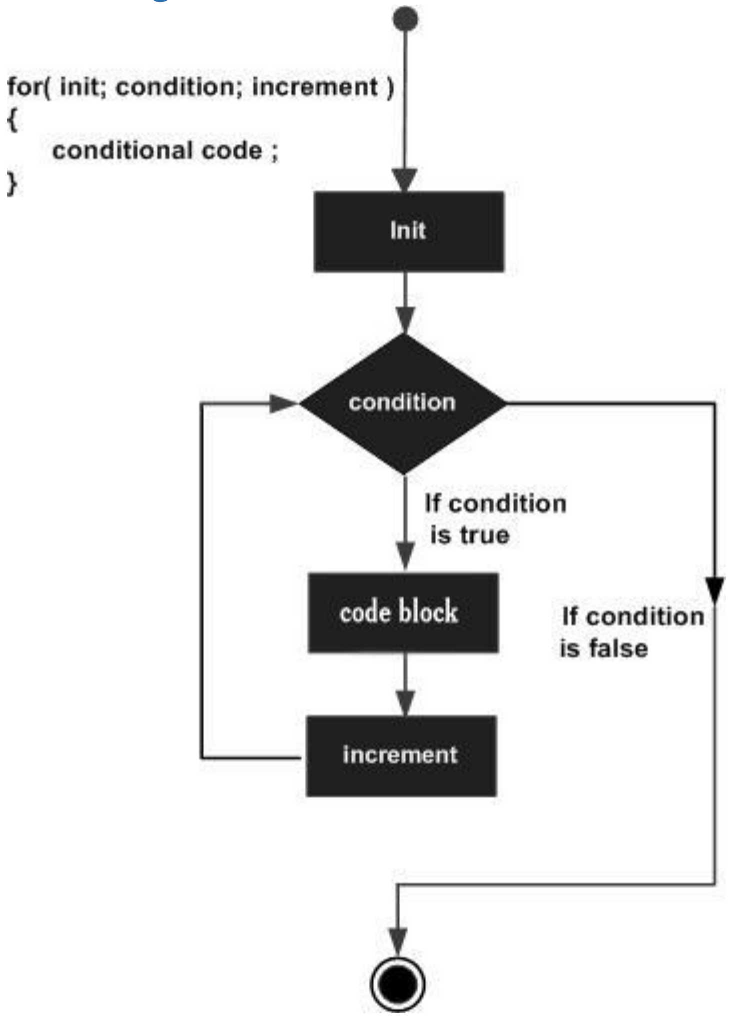
```
for ( init; condition; increment ) {
   statement(s);
}
```

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

- 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.
- 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.
- 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.

- The condition is now evaluated again. If it is true, the loop executes and the process repeats itself (body of loop, then increment step, and then again condition). After the condition becomes false, the 'for' loop terminates.

Flow Diagram



Example

```
#include <stdio.h>

int main () {

   int a;

   /* for loop execution */
   for( a = 10; a < 20; a = a + 1 ){
      printf("value of a: %d\n", a);
   }
   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
```

do...while loop in C

Unlike **for** and **while** loops, which test the loop condition at the top of the loop, the **do...while** loop in C programming checks its condition at the bottom of the loop.

A **do...while** loop is similar to a while loop, except the fact that it is guaranteed to execute at least one time.

Syntax

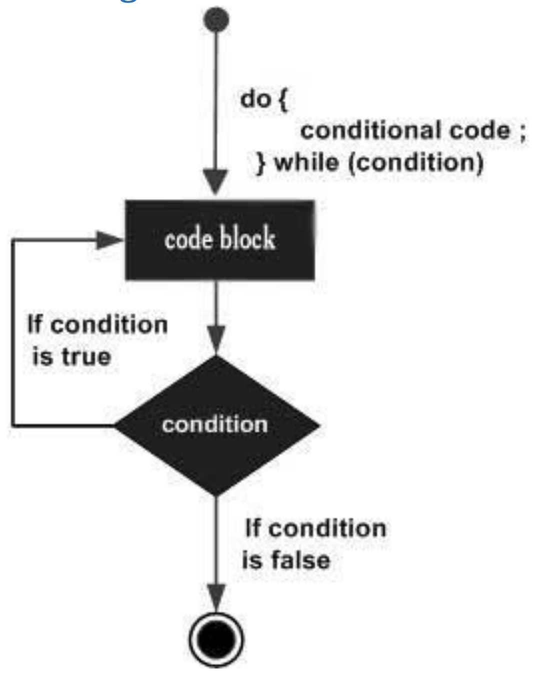
The syntax of a **do...while** loop in C programming language is −

```
do {
   statement(s);
} while( condition );
```

Notice that the conditional expression appears at the end of the loop, so the statement(s) in the loop executes once before the condition is tested.

If the condition is true, the flow of control jumps back up to do, and the statement(s) in the loop executes again. This process repeats until the given condition becomes false.

Flow Diagram



Example

```
#include <stdio.h>

int main () {

   /* local variable definition */
   int a = 10;

   /* do loop execution */
   do {
      printf("value of a: %d\n", a);
      a = a + 1;
   }while( a < 20 );

   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
```

<u>**nested loops in C**</u>

C programming allows to use one loop inside another loop. The following section shows a few examples to illustrate the concept.

Syntax

The syntax for a **nested for loop** statement in C is as follows −

```
for ( init; condition; increment ) {

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

The syntax for a **nested while loop** statement in C programming language is as follows −

```
while(condition) {

  while(condition) {
    statement(s);
  }
  statement(s);
}
```

The syntax for a **nested do...while loop** statement in C programming language is as follows −

```
do {
  statement(s);

  do {
    statement(s);
```

```
   }while( condition );

}while( condition );
```

A final note on loop nesting is that you can put any type of loop inside any other type of loop. For example, a 'for' loop can be inside a 'while' loop or vice versa.

Example

The following program uses a nested for loop to find the prime numbers from 2 to 100 −

```
#include <stdio.h>

int main () {

   /* local variable definition */
   int i, j;

   for(i = 2; i<100; i++) {

      for(j = 2; j <= (i/j); j++)
      if(!(i%j)) break; // if factor found, not prime
      if(j > (i/j)) printf("%d is prime\n", i);
   }

   return 0;
}
```

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

```
2 is prime
3 is prime
5 is prime
7 is prime
11 is prime
13 is prime
17 is prime
19 is prime
23 is prime
29 is prime
31 is prime
37 is prime
```

```
41 is prime
43 is prime
47 is prime
53 is prime
59 is prime
61 is prime
67 is prime
71 is prime
73 is prime
79 is prime
83 is prime
89 is prime
97 is prime
```

Loop Control Statements

Loop control statements change execution from its normal sequence. When execution leaves a scope, all automatic objects that were created in that scope are destroyed.

C supports the following control statements.

Sr.No.	Control Statement & Description
1	break statement Terminates the **loop** or **switch** statement and transfers execution to the statement immediately following the loop or switch.
2	continue statement Causes the loop to skip the remainder of its body and immediately retest its condition prior to reiterating.
3	goto statement Transfers control to the labeled statement.

break statement in C

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).

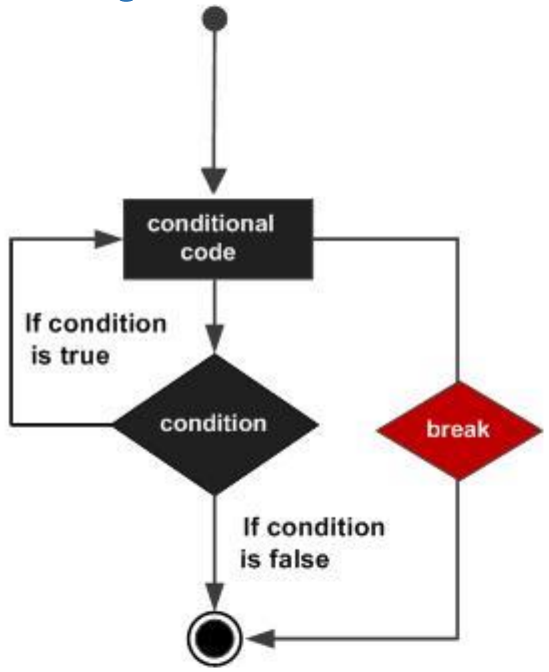
If you are using nested loops, the break statement will stop the execution of the innermost loop and start executing the next line of code after the block.

Syntax

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

```
break;
```

Flow Diagram



Example

```
#include <stdio.h>

int main () {

   /* local variable definition */
   int a = 10;
```

```
  /* while loop execution */
  while( a < 20 ) {

     printf("value of a: %d\n", a);
     a++;

     if( a > 15) {
        /* terminate the loop using break statement */
        break;
     }
  }

  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
```

continue statement in C

The **continue** statement in C programming works somewhat like the **break** statement. Instead of forcing termination, it forces the next iteration of the loop to take place, skipping any code in between.

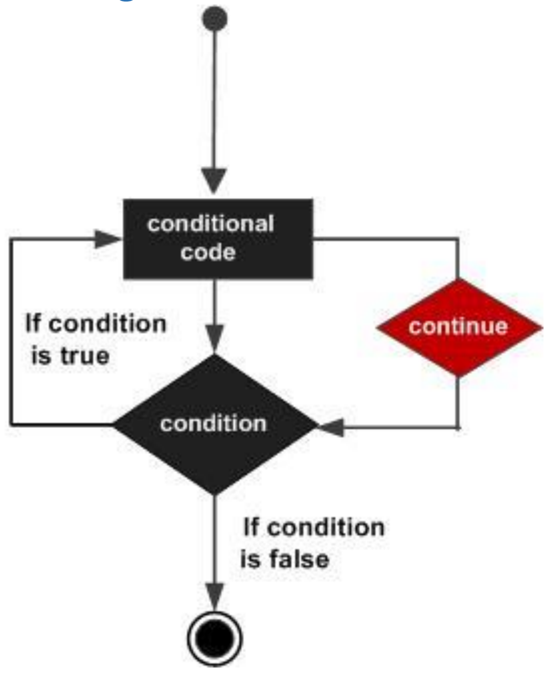
For the **for** loop, **continue** statement causes the conditional test and increment portions of the loop to execute. For the **while** and **do...while** loops, **continue** statement causes the program control to pass to the conditional tests.

Syntax

The syntax for a **continue** statement in C is as follows −

```
continue;
```

Flow Diagram



Example

```
#include <stdio.h>

int main () {

   /* local variable definition */
   int a = 10;

   /* do loop execution */
   do {

      if( a == 15) {
         /* skip the iteration */
         a = a + 1;
         continue;
      }

      printf("value of a: %d\n", a);
      a++;

   } while( a < 20 );
   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: 16
value of a: 17
value of a: 18
value of a: 19
```

goto statement in C

A **goto** statement in C programming provides an unconditional jump from the 'goto' to a labeled statement in the same function.

NOTE − Use of **goto** statement is highly discouraged in any programming language because it makes difficult to trace the control flow of a program, making the program hard to understand and hard to modify. Any program that uses a goto can be rewritten to avoid them.

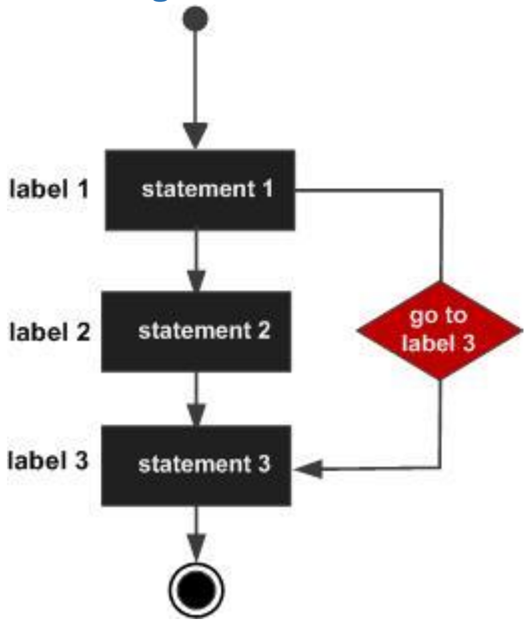
Syntax

The syntax for a **goto** statement in C is as follows −

```
goto label;
..
.
label: statement;
```

Here **label** can be any plain text except C keyword and it can be set anywhere in the C program above or below to **goto** statement.

Flow Diagram



Example

```
#include <stdio.h>

int main () {

   /* local variable definition */
   int a = 10;

   /* do loop execution */
   LOOP:do {

      if( a == 15) {
         /* skip the iteration */
         a = a + 1;
         goto LOOP;
      }

      printf("value of a: %d\n", a);
      a++;

   }while( a < 20 );

   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: 16
value of a: 17
value of a: 18
value of a: 19
```

The Infinite Loop

A loop becomes an infinite loop if a condition never becomes false. The **for** loop is traditionally used for this purpose. Since none of the three expressions that form the 'for' loop are required, you can make an endless loop by leaving the conditional expression empty.

```
#include <stdio.h>

int main () {

   for( ; ; ) {
      printf("This loop will run forever.\n");
   }

   return 0;
}
```

When the conditional expression is absent, it is assumed to be true. You may have an initialization and increment expression, but C programmers more commonly use the for(;;) construct to signify an infinite loop.

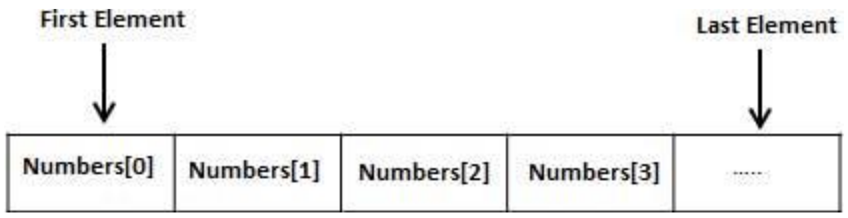
NOTE − You can terminate an infinite loop by pressing Ctrl + C keys.

Arrays

Arrays a kind of data structure that can store a fixed-size sequential collection of elements of the same type. An array is used to store a collection of data, but it is often more useful to think of an array as a collection of variables of the same type.

Instead of declaring individual variables, such as number0, number1, ..., and number99, you declare one array variable such as numbers and use numbers[0], numbers[1], and ..., numbers[99] to represent individual variables. A specific element in an array is accessed by an index.

All arrays consist of contiguous memory locations. The lowest address corresponds to the first element and the highest address to the last element.



Declaring Arrays

To declare an array in C, a programmer specifies the type of the elements and the number of elements required by an array as follows −

type arrayName [arraySize];

This is called a *single-dimensional* array. The **arraySize** must be an integer constant greater than zero and **type** can be any valid C data type. For example, to declare a 10-element array called **balance** of type double, use this statement −

double balance[10];

Here *balance* is a variable array which is sufficient to hold up to 10 double numbers.

Initializing Arrays

You can initialize an array in C either one by one or using a single statement as follows −

double balance[5] = {1000.0, 2.0, 3.4, 7.0, 50.0};

The number of values between braces { } cannot be larger than the number of elements that we declare for the array between square brackets [ ].

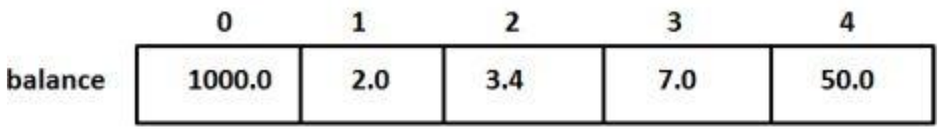
If you omit the size of the array, an array just big enough to hold the initialization is created. Therefore, if you write −

double balance[] = {1000.0, 2.0, 3.4, 7.0, 50.0};

You will create exactly the same array as you did in the previous example. Following is an example to assign a single element of the array −

balance[4] = 50.0;

The above statement assigns the 5th element in the array with a value of 50.0. All arrays have 0 as the index of their first element which is also called the base index and the last index of an array will be total size of the array minus 1. Shown below is the pictorial representation of the array we discussed above −



Accessing Array Elements

An element is accessed by indexing the array name. This is done by placing the index of the element within square brackets after the name of the array. For example −

double salary = balance[9];

The above statement will take the 10th element from the array and assign the value to salary variable. The following example Shows how to use all the three above mentioned concepts viz. declaration, assignment, and accessing arrays −

```
#include <stdio.h>

int main () {

  int n[ 10 ]; /* n is an array of 10 integers */
  int i,j;

  /* initialize elements of array n to 0 */
  for ( i = 0; i < 10; i++ ) {
    n[ i ] = i + 100; /* set element at location i to i + 100 */
  }

  /* output each array element's value */
  for (j = 0; j < 10; j++ ) {
    printf("Element[%d] = %d\n", j, n[j] );
  }

  return 0;
}
```

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

```
Element[0] = 100
Element[1] = 101
Element[2] = 102
Element[3] = 103
Element[4] = 104
Element[5] = 105
Element[6] = 106
Element[7] = 107
Element[8] = 108
Element[9] = 109
```

Arrays in Detail

Arrays are important to C and should need a lot more attention. The following important concepts related to array should be clear to a C programmer −

Sr.No.	Concept & Description
1	Multi-dimensional arrays C supports multidimensional arrays. The simplest form of the multidimensional array is the two-dimensional array.
2	Passing arrays to functions You can pass to the function a pointer to an array by specifying the array's name without an index.
3	Return array from a function C allows a function to return an array.
4	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.

<u>Multi-dimensional Arrays in C</u>

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 −

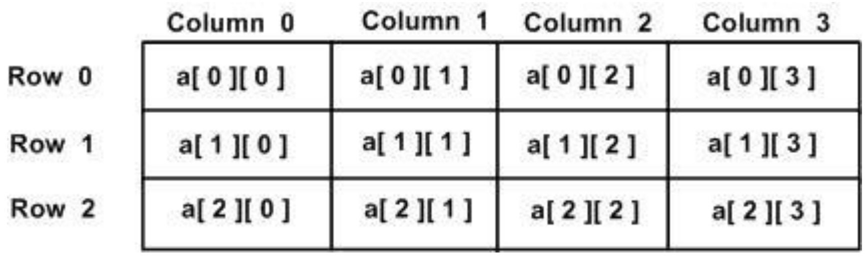
int three dim[5][10][4];

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'.

Initializing Two-Dimensional Arrays

Multidimensional arrays may be initialized by specifying bracketed values for each row. Following is an array with 3 rows and each row has 4 columns.

```
int a[3][4] = {
   {0, 1, 2, 3} ,   /*  initializers for row indexed by 0 */
   {4, 5, 6, 7} ,   /*  initializers for row indexed by 1 */
   {8, 9, 10, 11}   /*  initializers for row indexed by 2 */
};
```

The nested braces, which indicate the intended row, are optional. The following initialization is equivalent to the previous example −

```
int a[3][4] = {0,1,2,3,4,5,6,7,8,9,10,11};
```

Accessing Two-Dimensional Array Elements

An element in a two-dimensional array is accessed by using the subscripts, i.e., row index and column index of the array. For example −

```
int val = a[2][3];
```

The above statement will take the 4th element from the 3rd row of the array. You can verify it in the above figure. Let us check the following program where we have used a nested loop to handle a two-dimensional array −

```
#include <stdio.h>

int main () {

  /* an array with 5 rows and 2 columns*/
  int a[5][2] = { {0,0}, {1,2}, {2,4}, {3,6},{4,8}};
  int i, j;

  /* output each array element's value */
  for ( i = 0; i < 5; i++ ) {

    for ( j = 0; j < 2; j++ ) {
      printf("a[%d][%d] = %d\n", i,j, a[i][j] );
    }
  }

  return 0;
}
```

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

```
a[0][0]: 0
a[0][1]: 0
a[1][0]: 1
a[1][1]: 2
a[2][0]: 2
a[2][1]: 4
a[3][0]: 3
```

```
a[3][1]: 6
a[4][0]: 4
a[4][1]: 8
```

As explained above, you can have arrays with any number of dimensions, although it is likely that most of the arrays you create will be of one or two dimensions.

Passing Arrays as Function Arguments in C

If you want to pass a single-dimension array as an argument in a function, you would have to declare a formal parameter in one of following three ways and all three declaration methods produce similar results because each tells the compiler that an integer pointer is going to be received. Similarly, you can pass multi-dimensional arrays as formal parameters.

Way-1

Formal parameters as a pointer −

```
void myFunction(int *param) {
   .
   .
   .
}
```

Way-2

Formal parameters as a sized array −

```
void myFunction(int param[10]) {
   .
   .
   .
}
```

Way-3

Formal parameters as an unsized array −

```
void myFunction(int param[]) {
   .
   .
   .
}
```

Example

Now, consider the following function, which takes an array as an argument along with another argument and based on the passed arguments, it returns the average of the numbers passed through the array as follows −

```
double getAverage(int arr[], int size) {

   int i;
   double avg;
   double sum = 0;

   for (i = 0; i < size; ++i) {
      sum += arr[i];
   }

   avg = sum / size;

   return avg;
}
```

Now, let us call the above function as follows −

```
#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 to the array as an argument */
   avg = getAverage( balance, 5 ) ;

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

   return 0;
}
```

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

```
Average value is: 214.400000
```

As you can see, the length of the array doesn't matter as far as the function is concerned because C performs no bounds checking for formal parameters.

Return array from function in C

C programming does not allow to return an entire array as an argument to a function. However, you can return a pointer to an array by specifying the array's name without an index.

If you want to return a single-dimension array from a function, you would have to declare a function returning a pointer as in the following example −

```
int * myFunction() {
   .
   .
   .
}
```

Second point to remember is that C does not advocate 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.

Now, consider the following function which will generate 10 random numbers and return them using an array and call this function as follows −

```
#include <stdio.h>

/* function to generate and return random numbers */
int * getRandom( ) {

   static int  r[10];
   int i;

   /* set the seed */
   srand( (unsigned)time( NULL ) );

```

```
  for ( i = 0; i < 10; ++i) {
    r[i] = rand();
    printf( "r[%d] = %d\n", i, 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;
}
```

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
*(p + 7) : 834791014
*(p + 8) : 1901409888
*(p + 9) : 1990469526
```

Strings

Strings are actually one-dimensional array of characters terminated by a **null** character '\0'. Thus a null-terminated string contains the characters that comprise the string followed by a **null**.

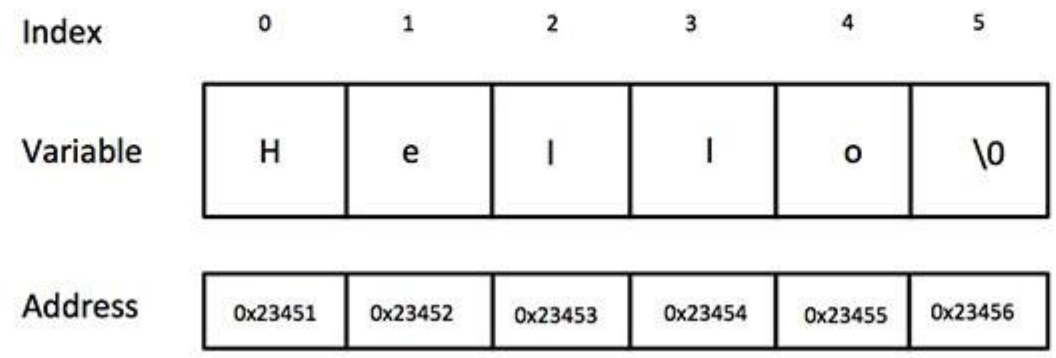
The following declaration and initialization create a string consisting of the word "Hello". To hold the null character at the end of the array, the size of the character array containing the string is one more than the number of characters in the word "Hello."

```
char greeting[6] = {'H', 'e', 'l', 'l', 'o', '\0'};
```

If you follow the rule of array initialization then you can write the above statement as follows −

```
char greeting[] = "Hello";
```

Following is the memory presentation of the above defined string in C/C++ −



Actually, you do not place the *null* character at the end of a string constant. The C compiler automatically places the '\0' at the end of the string when it initializes the array. Let us try to print the above mentioned string −

```
#include <stdio.h>

int main () {

   char greeting[6] = {'H', 'e', 'l', 'l', 'o', '\0'};
   printf("Greeting message: %s\n", greeting );
   return 0;
}
```

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

```
Greeting message: Hello
```

C supports a wide range of functions that manipulate null-terminated strings −

Sr.No.	Function & Purpose
1	**strcpy(s1, s2);** Copies string s2 into string s1.
2	**strcat(s1, s2);** Concatenates string s2 onto the end of string s1.
3	**strlen(s1);** Returns the length of string s1.
4	**strcmp(s1, s2);** Returns 0 if s1 and s2 are the same; less than 0 if s1<s2; greater than 0 if s1>s2.
5	**strchr(s1, ch);** Returns a pointer to the first occurrence of character ch in string s1.
6	**strstr(s1, s2);** Returns a pointer to the first occurrence of string s2 in string s1.

The following example uses some of the above-mentioned functions −

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

```
int main () {

   char str1[12] = "Hello";
   char str2[12] = "World";
   char str3[12];
   int  len ;

   /* copy str1 into str3 */
   strcpy(str3, str1);
   printf("strcpy( str3, str1) :  %s\n", str3 );

   /* concatenates str1 and str2 */
   strcat( str1, str2);
   printf("strcat( str1, str2):   %s\n", str1 );

   /* total lenghth of str1 after concatenation */
   len = strlen(str1);
   printf("strlen(str1) :  %d\n", len );

   return 0;
}
```

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

```
strcpy( str3, str1) :  Hello
strcat( str1, str2):   HelloWorld
strlen(str1) :  10
```