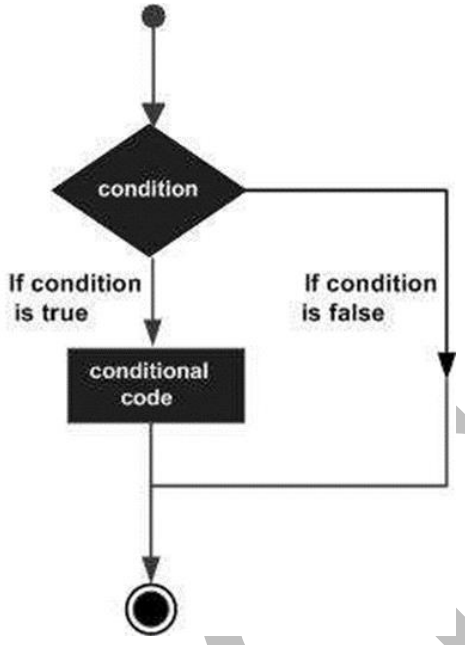
UNIT II: Branching and Loop Statements

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
nested if statements	the Boolean expression is false. You can use one **if** or **else if** statement inside another **if** or **else if** statement(s).
switch statement	A **switch** statement allows a variable to be tested for equality against a list of values.
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

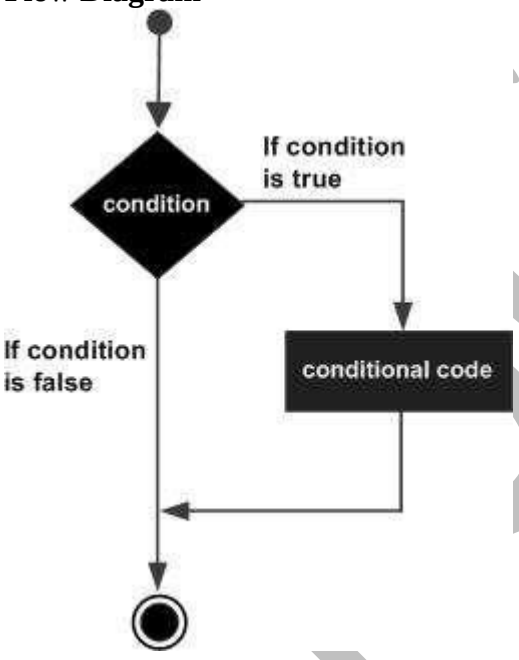
The syntax of an 'if' statement in C programming language is:

```
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);
```

}

Output:
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

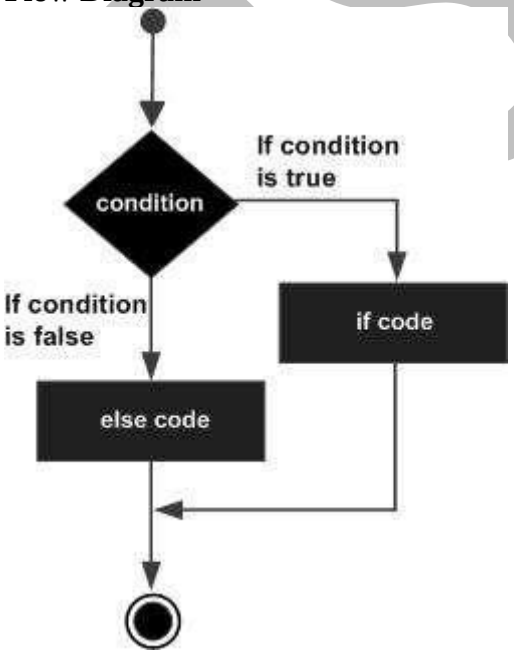
The syntax of an **if...else** statement in C programming language is:

```
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;
}
```

Output:
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:

1. An if can have zero or one else's and it must come after any else if's.
2. An if can have zero to many else if's and they must come before the else.
3. 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;
}
```

Output :

```
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;
}
```

Output:

```
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:

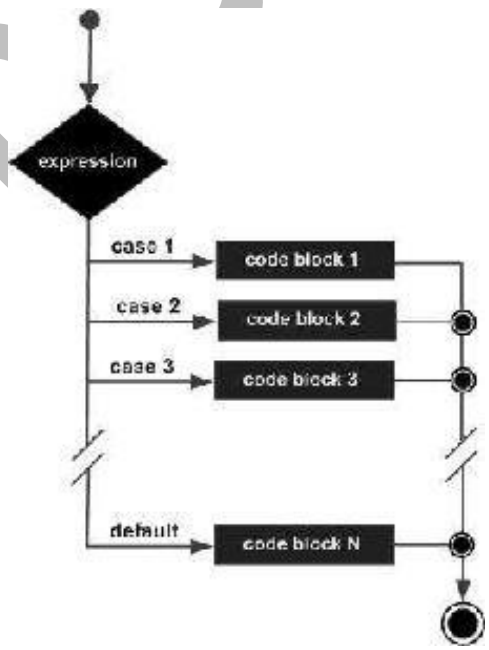
```
switch(expression){

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;
}
```

Output:
Well done
Your grade is B

Nested switch Statements

It is possible to have a switch as a part of the statement sequence of an outer switch. Even if the case constants of the inner and outer switch contain common values, no conflicts will arise.

Syntax

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

```
switch(ch1)
{
        case 'A': printf("This A is part of outer switch" );
                switch(ch2) {
                                case 'A': printf("This A is part of inner switch" );
                                        break;

                                case 'B': /* case code */
                                }
                break;
case 'B': /* case code */
}
```

Example

```
#include <stdio.h>
int main ()
{
/* local variable definition */
int a = 100;
int b = 200;
switch(a)
          {
        case 100:  printf("This is part of outer switch\n", a );
                   switch(b)
                    {
                        case 200: printf("This is part of inner switch\n", a );
                    }
}
printf("Exact value of a is : %d\n", a );
printf("Exact value of b is : %d\n", b );
return 0;
}
```

Output:
This is part of outer switch
This is part of inner switch
Exact value of a is : 100
Exact value of b is : 200

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:

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

Summary:

Statement	**Syntax**
If statement	if(condition) Statement;
If-else statement	If (condition) {

	Statement 1;
	Statement 2;
	}
	else
	{
	Statement 3;
	Statement 4;
	}

Nested if-else statement	If (condition)
	{
	Statement1;
	Statement2;
	}
	Else if (condition)
	{
	Statement3;
	Statement4;
	}
	Else
	{
	Statement5;
	Statement6;
	}

Break statement	Break;
Continue statement	Continue;
Goto statement	goto label;

Switch() statement	Switch (variable or expression)
	{
	Case constantA: Statement; Break;
	Case constantB: Statement; Break;
	Default: Statement;
	}

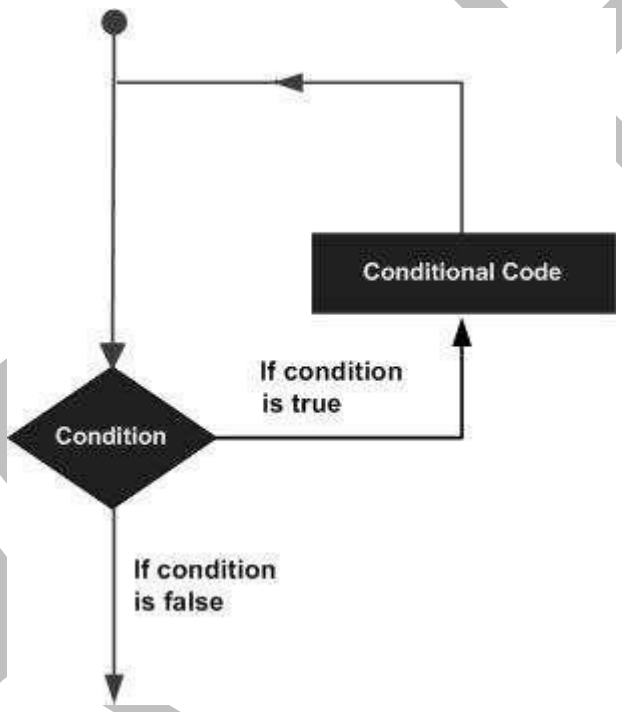
LOOPS

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.
do...while loop	It is more like a while statement, except that it tests the condition at the end of the loop body.
nested loops	You can use one or more loops inside any other while, for, or do..while loop.

while Loop

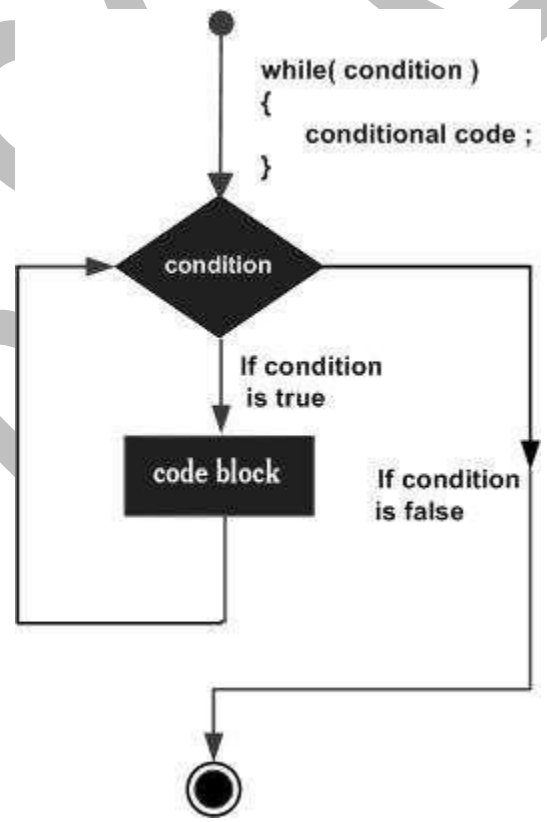
A **while** loop in C programming repeatedly executes a target statement as long as a given condition is true.

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;
}
```

Output:

```
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

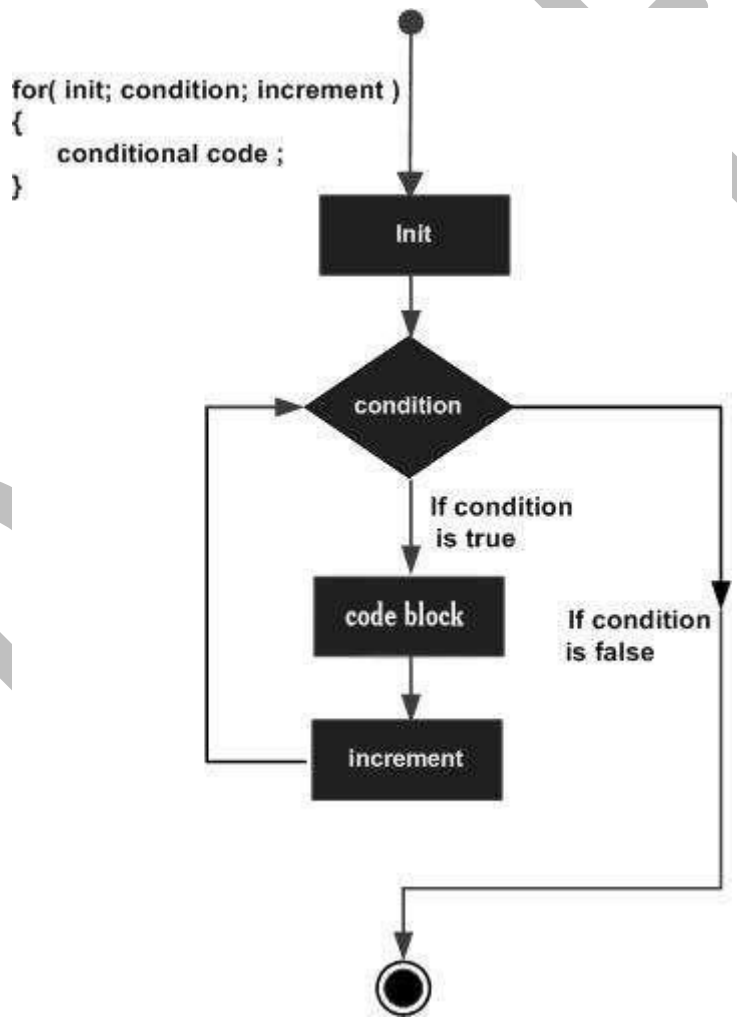
The syntax of a **for** loop in C programming language is:

```
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.
4. 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 ()
{
```

```
/* for loop execution */
for( int a = 10; a < 20; a = a + 1 )
{
printf("value of a: %d\n", a);
}
return 0;
}
```

Output:

```
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

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

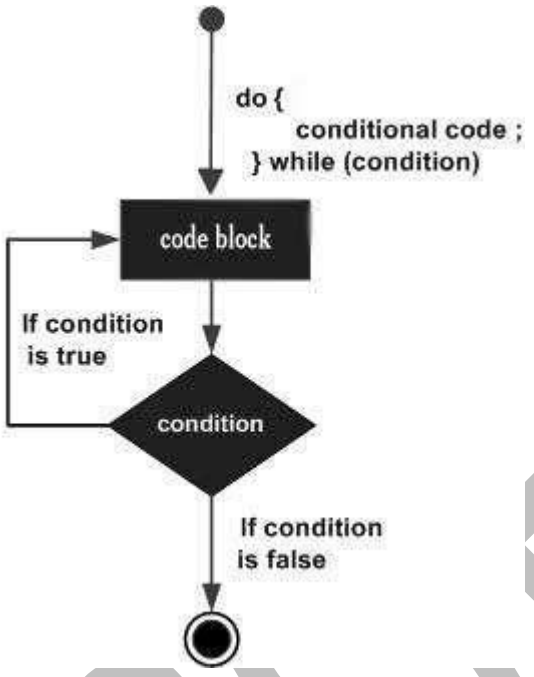
The syntax of a **do...while** loop in C programming language is:

```
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;
}
```

Output:

```
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
```

Nested Loops
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;
}
```

Output:

```
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.

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:

1. 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.

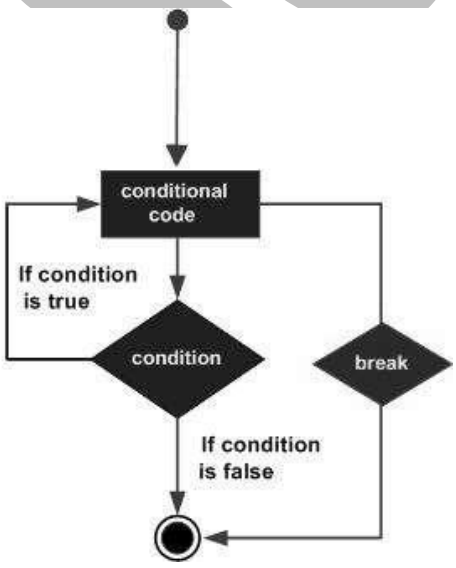
2. It can be used to terminate a case in the **switch** statement (covered in the next chapter).

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;
}
```

Output:
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

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.

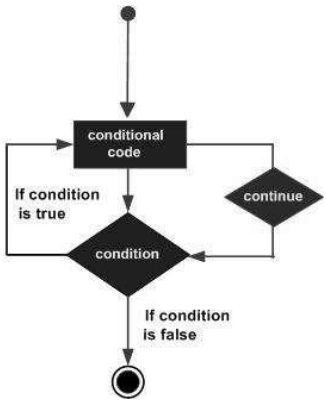
For the **for** loop, **continue** statement causes the conditional test and increment portions of the loop to execute. For the **while** and **do...while** loops, **continue** statement causes the program control to pass to the conditional tests.

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;
}
```

Output:
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

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.

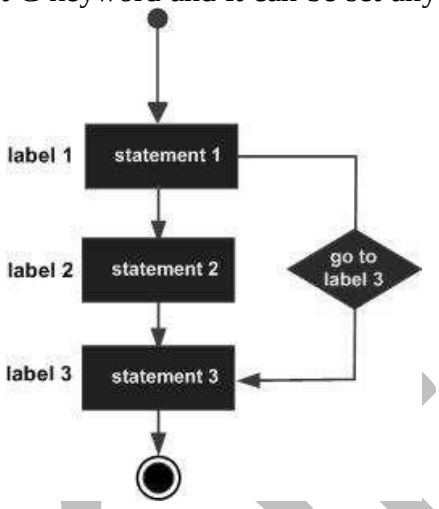
Syntax
The syntax for a **goto** statement in C is as follows:

```
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;
}
```

Output:

```
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.

Statement	**Syntax**

For loop	For(initialize counter; test condition; re-evaluation parameter)
	{
	Sta**tement;
	Statement;
	}

Nested for loop	for(initialize counter; test condition; re-evaluation parameter)
	{
	Statement;
	Statement;
	for(initialize counter; test condition; re-evaluation parameter) Statement;
	Statement;
	}
	}

While loop	While (test condition)
	{
	Body of the loop
	}

Do while loop	do
	{
	Statement;
	}
	While(condition);

Do-while with while loop	Do while(condition)
	{
	Statement;
	}
	While (condition);

Question Bank

1. What are decision control statements in C? Explain all with example.
2. Does a break is required by default case in switch statement?
3. In a switch statement, what will happen if a break statement is omitted?
4. What are all decision control statements in C?
5. Why is default statement used in switch case in C?
6. Differentiate between for loop and a while loop? What are its uses?
7. Explain the syntax for for loop
8. What is a nested loop?
9. What are all loop control statements in C?
10. What is the difference between while and do-while loops in C?
11. What is an infinite loop?
12. Write a program to find a number is even or odd.
13. Write a program to find year is leap year or not.
14. Write a program to find greatest number among three numbers using nested if else.
15. Write a program to print sum of digits of a number using modulus operator.
16. Write a program to print reverse of a number.
17. Write a program that shows concept of switch case.
18. Write a program to find percentage, total marks and status(first division/second division/third division/fail) of a student by taking five subjects with the help of nested if-else.
19. What are loop control structures? Explain for loop, while loop and do-while loop with their syntax.
20. Explain break, continue and goto+ statement with example and their use.
21. Write a program to print series of number divisible by 3 from 1 to 100 using for loop.
22. Write a program to find factorial of a number using for loop.
23. Write a program to print Fibonacci series.
24. Write a program to find a number is prime number or not.
25. Write a program to print pyramid of star using nested for loop.

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26. Write a program to print table of a number given by user.
27. Write a program to find a number is Armstrong number or not.
28. Write a program to print series of number from 1 to 100 those are divisible by 5 and 7 both.