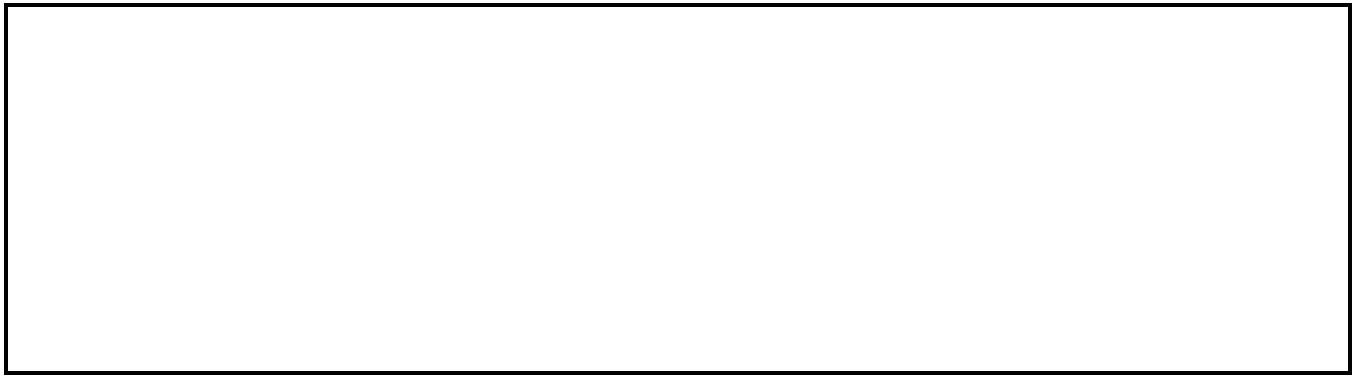
Lecture 08: Control Statements



Control Statements and Their Types

- A control statement is a statement that causes a group of C statements to execute in a manner that doesn't relate to the order it appears in the source code
- Types of control statements
  - **Selection**: also known as branching created using `if – else`, `switch`
  - **Repetition**: also known as looping created using `while`, `do - while`, `for`
  - **Jump**: created using `goto`, `break`, `continue`
  - **Label**: created using `case`, `default`, ***named label***

Selection

- A selection statement is a one in which one group of statement is selected from several available groups, depending on the outcome of a logical test
- C supports two selection statements: **`if`** and **`switch`**
  - In addition, the **`?:`** operator is an alternative to if in certain circumstances
- If condition ***true***, print statement executed and program goes on to next statement
  - If ***false***, print statement is ignored and the program goes onto the next statement

The `if` statement

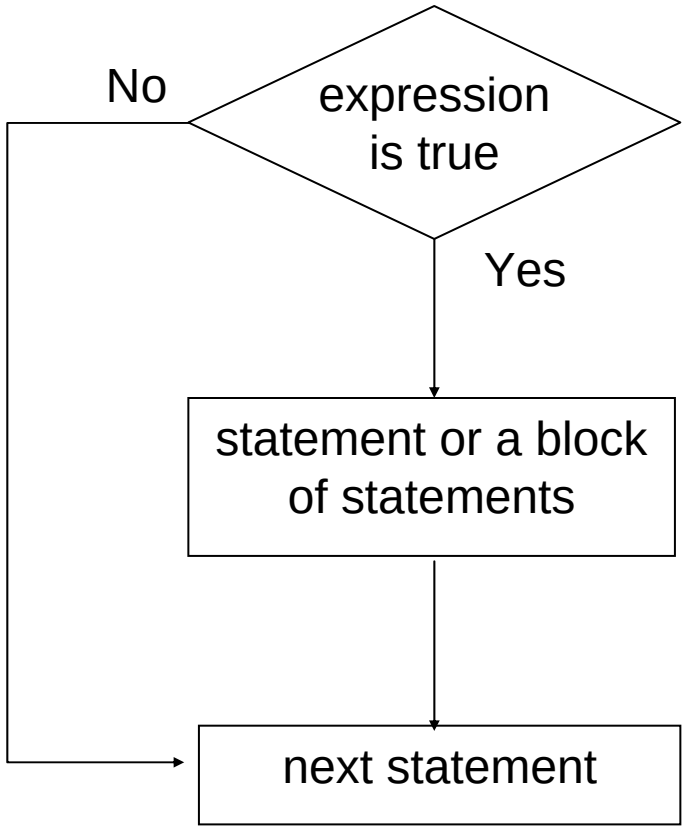
- Allows your program to execute a single statement, or a block of statements enclosed between braces, if a given condition is ***true***
- `if (`***`expression`***`)`
  `statement`
- If ***`expression`*** evaluates to true (any non-zero value), ***`statement`*** is executed. If ***`expression`*** evaluates to false (0), ***`statement`*** is not executed
  - In either case, execution then passes to whatever code follows the `if` statement
- ***`expression`*** can be any valid C expression that produces a scalar value and ***`statement`*** can be simple or compound or even another control statement

Flow Chart of `if`

```
if (expression)
        Statement;
next statement;

        Or

if (expression)
{
        Statement;
        …
}
next statement;
```



Examples of `if`

```
if (x > y)
  y = x;
```

assigns the value of **x** to **y** only if **x** is greater than **y**. If **x** is not greater than **y**, no assignment takes place.

```
if (letter == 'A')
 printf("The first capital\n");
printf("After if\n");
```

if the value of ***letter*** is **'A'**, the text **The first capital** is printed otherwise not. The last statement **After if** always gets printed

The `else` clause in an `if` statement

- An `if` statement can optionally include an `else` clause
- ```
  if (expression)
      statement1
  else
      statement2
  ```
- If *`expression`* evaluates to true, *`statement1`* is executed. If *`expression`* evaluates to false, *`statement2`* is executed. Both *`statement1`* and *`statement2`* can be compound statements or blocks
- Using if-else, you can specify an action to be performed both when the condition is ***true*** and when it is ***false***
  ```

Flow Chart of `if-else`

Example of `if` with `else` clause

```
if (age >= 18)
  printf("You can vote\n");
else
  printf("You can't vote\n");
```

```
if  (status == 'S')
  tax = 0.20 * pay;
else
  tax = 0.14 * pay;
printf("Tax: %f\n", tax);
```

```
if (pastdue > 0)
{
   printf("account no. %d is overdue", actno);
   credit = 0;
}
else
  credit = 1000.0;
```

More `if-else` example

```
if (circle)
{
  scanf("%f", &radius);
  area = 3.14159 * radius * radius;
  printf("Area of circle = %f", area);
}
else
{
  scanf("%f %f", &length, &width);
  area = length * width;
  print("Area of rectangle = %f", area);
}
```

If ***circle*** is assigned a nonzero value, the ***radius*** of circle is read into the computer; the ***area*** is calculated and then displayed. If the value of ***circle*** is zero, however, then the ***length*** and ***width*** of rectangle are read into the computer, the ***area*** is calculated and then displayed

Nested-`if`s

- A nested **`if`** is an **`if`** that is target of another **`if`** or **`else`**
- In a nested **`if`**, an **`else`** statement always refers to the nearest **`if`** statement that is within the same block as the **`else`** and that is not already associated with an **`else`**

```
if (exp1)
   if (exp2)
      statement1
   else
      statement2
else
   statement3
```

this if

is associated with this else

this else is associated with the first if
i.e., if (exp1)

Example

```
if(age >= 21 && (income>=80000 || balance>=200000))
   if(2*income < balance/2)
      loan = 2 * income;
   else
      loan = balance/2;
else
   loan = 0.0;
```

```
if (x > y)
   if (x > z)
      printf("x is greater");
   else
      printf("z is greater");
else
   if (y > z)
      printf("y is greater");
   else
      printf("z is greater");
```

if-else-if ladder

- A common programming construct is the **`if-else-if`** ladder because of its appearance

```
if (expression)
     statement;
else
     if (expression)
          statement;
     else
          if (expression)
               statement;
          .
          else
               statement;
```

The conditions are evaluated from the top downward. As soon as a true condition is found, the statement associated with it is executed and the rest of the ladder is bypassed. If none of the conditions are true, the final else is executed. If the final else is not present, no actions take place if all other conditions are false.

if-else-if example

```
char ch;
scanf("%c", &ch);
if (ch >= 'a' && ch <= 'z')
  printf("lowercase letter");
else if (ch >= 'A' && ch <= 'Z')
  printf("uppercase letter");
else if (ch >= '0' && ch <= '9')
  printf("a digit");
else if (ch==' '||ch=='\t'||ch=='\n')
  printf("whitespace character");
else
  printf("an unknown character");
```

Repetition

- Repetition is the process of executing a group of statements more than one time as long as some condition remains true
- Repetition in C can be implemented using three control statements: `while`, `do – while`, `for`
- Psuedocode:
  - ***While there are more items on my shopping list***
    Purchase next item and cross it off my list
- Also known as iteration/looping statements

Counter-controlled repetition

- Definite repetition: know how many times loop will execute
- Control variable used to count repetitions
- Counter-controlled repetition requires
  - The name of a control variable (or loop counter)
  - The initial value of the control variable
  - A condition that tests for the final value of the control variable (i.e., whether looping should continue)
  - An increment (or decrement) by which the control variable is modified each time through the loop

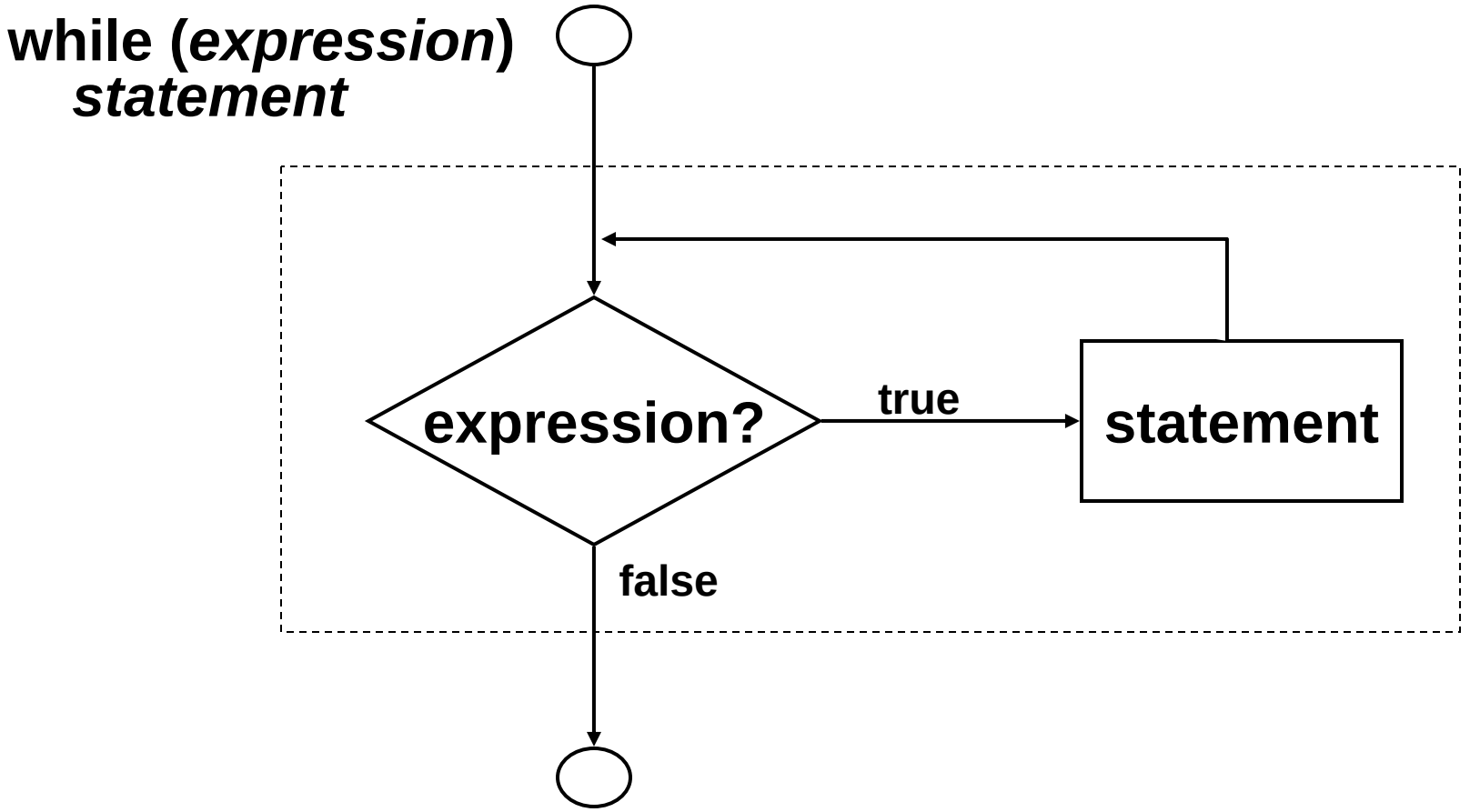
Example

- A class of ten students took a quiz. The grades (integers in the range 0 to 100) for this quiz are available to you. Determine the class average on the quiz
- Pseudocode:
  - Set total to zero
  - Set grade counter to one
  - While grade counter is less than or equal to ten
    Input the next grade
    Add the grade into the total
    Add one to the grade counter
  - Set the class average to the total divided by ten
    Print the class average

The `while` statement

- Executes a block of statements as long as a specified condition is true
- `while (`***`expression`***`)`
  `statement`
- here ***`statement`*** is executed as long as the ***`expression`*** evaluates to ***`true`***.
  - First ***`expression`*** is evaluated
  - If ***`expression`*** is nonzero (***`true`***), then ***`statement`*** is executed and control is passed back to the beginning of the **`while`** statement, otherwise control passes to next statement following the **`while`** statement

Flowchart of `while` statement



The `while` statement

- As with **`if`**, ***`expression`*** can be any valid C expression that produces a scalar value and ***`statement`*** can be simple or compound or may be a control statement
- The ***`statement`*** inside the **`while`** loop must include some feature that eventually alters the value of the ***`expression`***, thus providing a stopping condition for the loop

```
/* Prints hello world 10 times */
counter = 1;                 /* initialization */
while (counter <= 10)        /* repetition condition */
{
   printf("Hello World\n");
   ++counter;                /* increment */
}
```

More Examples

```
/* Prints digits 0 through 9 */
int digit = 0;
while (digit <= 9)
{
  printf("%d\n", digit);
  ++digit;
}

/* Prints digits 9 through 0 */
int digit = 9;
while (digit >= 0)
{
  printf("%d\n", digit);
  --digit;
}
```

Example: Calculation of average grade

```
int grade, counter;
int total;
float average;

total = 0;
counter = 1;
while (counter <= 10)
{
     printf("Enter grade: ");
     scanf("%d", &grade);
     total += grade;
     ++counter;
}
average = (float) total / 10;
printf("The average grade is %.2f\n", average);
```

Sentinel-Controlled Repetition

- Problem :
  - ***Develop a class-averaging program that will process an arbitrary number of grades each time the program is run.***
  - Unknown number of students
  - How will the program know to end?
- Use sentinel value
  - Also called signal value, dummy value, or flag value
  - Indicates “end of data entry.”
  - Loop ends when user inputs the sentinel value
  - Sentinel value chosen so it cannot be confused with a regular input (such as -1 in this case)

Example: Calculation of average grade

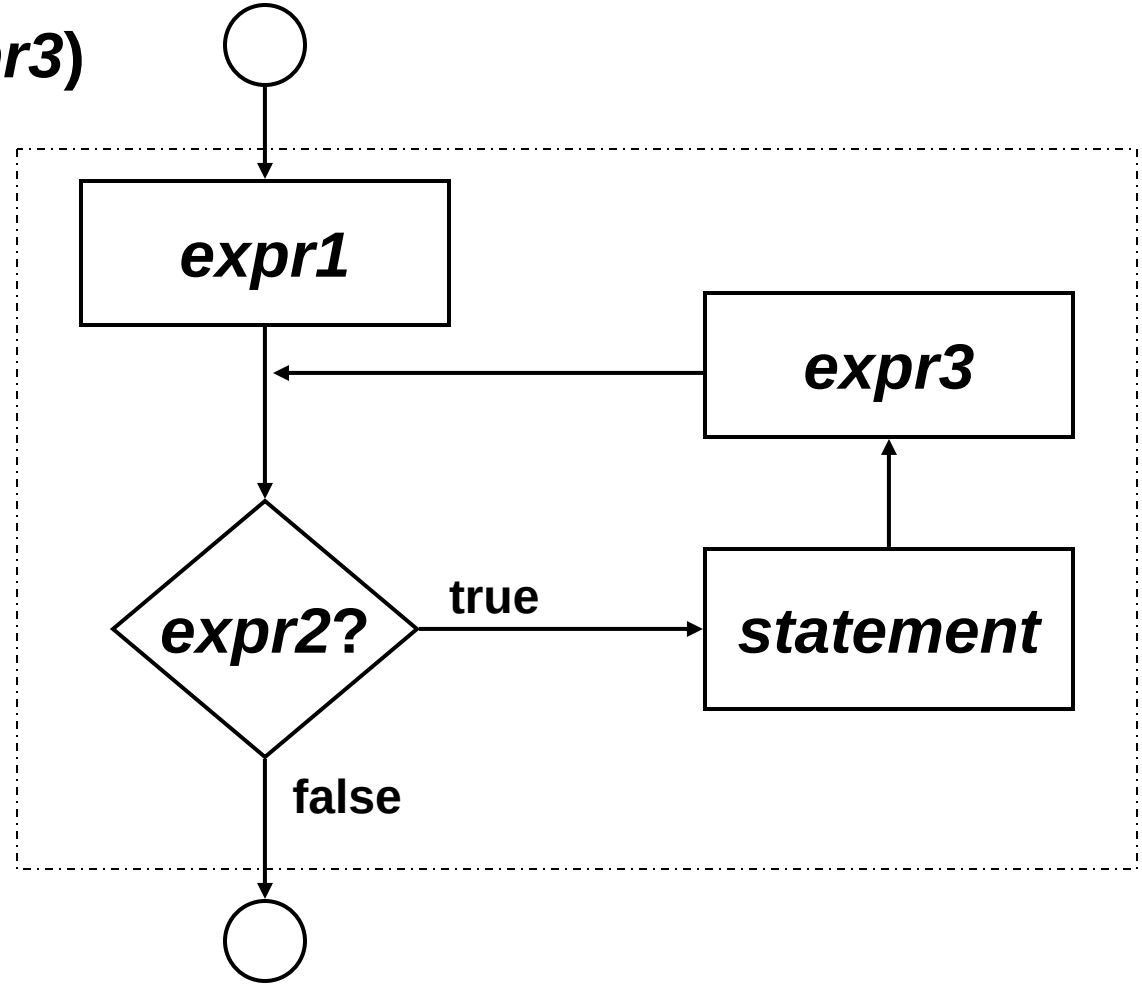
```
total = 0;
counter = 0;
printf("Enter grade (-1 to stop): ");
scanf("%d", &grade);
while (grade != -1) {
     total += grade;
     ++counter;
     printf("Enter grade (-1 to stop): ");
     scanf("%d", &grade);
}
if (counter != 0) {
     average = (float) total / counter;
     printf("The average grade is %.2f\n", average);
}
else
     printf("No grades entered\n");
```

The `for` statement

- `for (`*`expr1`*`; `*`expr2`*`; `*`expr3`*`)`
  `statement`
- First *`expr1`* is evaluated.
- Then *`expr2`* is evaluated.
- If *`expr2`* is nonzero (***true***), then
  - *`statement`* is executed,
  - *`expr3`* is evaluated
  - control passes back to the beginning of the `for` loop again, except that evaluation of *`expr1`* is skipped.
- The process continues until *`expr2`* is zero (***false***), at which point control passes to next statement following the `for` statement

Flowchart of `for` statement

for (*expr1*; *expr2*; *expr3*)
statement



The `for` statement

- Typically:
  - ***expr1*** is used to initialize the loop control variable and is an assignment expression
  - ***expr2*** is a logical expression and represents a condition that must be true for the loop to continue
  - ***expr3*** is used to alter the value of control variable and is often an increment/decrement or assignment expression
-
```
for (counter = 1; counter <= 10; counter++)
    printf("Hello World\n");
```

Examples

```
/* Prints digits 0 through 9 */
for (digit = 0; digit <= 9; digit++)
     printf("%d\n", digit);


/* Prints digits 9 through 0 */
for (digit = 0; digit <= 9; digit--)
     printf("%d\n", digit);


/* Sum of first n natural numbers */
scanf("%d", &n);
sum = 0;
for (counter = 1; counter <= n; counter++)
   sum += counter;
printf("The sum of first %d numbers is %d", n, sum);
```

for and while loop

- Every `for` statement can be written in terms of `while` statement and vice versa

```
for (expr1; expr2; expr3)
        statement
```

```
expr1;
while (expr2)
{
    statement
    expr3;
}
```

The `do-while` statement

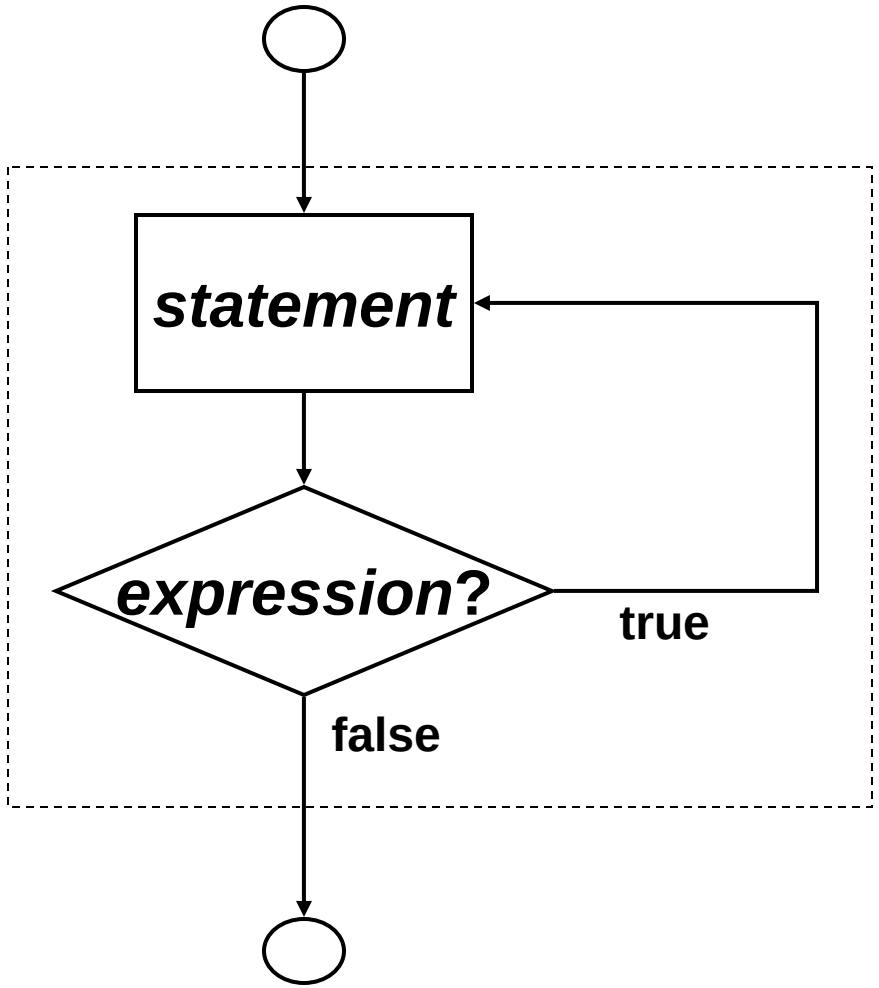
- Similar to the **`while`** statement but condition for repetition tested after the body of the loop is performed
- `do`
  `statement`
  `while (`*`expr`*`);`
  - First ***`statement`*** is executed, and ***`expr`*** is evaluated
  - If the value of ***`expr`*** is nonzero (***true***), then control passes back to the beginning of the do statement and process repeats itself
  - When ***`expr`*** is zero (***false***), control passes to next statement following the **`do-while`** statement

Flowchart of `do-while` statement

```
do
   statement
while (expr);
```

Note that a semicolon is present after the closing parenthesis of the expression

Note that statement will always be executed at least once, since the test for repetition does not occur until the end of the first pass through the loop



The `do-while` statement

- As with **`while`**, ***`expr`*** can be any valid C expression that produces a scalar value and ***`statement`*** can be simple or compound or may be a control statement

```
counter = 1;
do {
   printf("Hello World\n");
   counter++;
} while (counter <= 10);

digit = 0;
do {
   printf("%d\n", digit);
   digit++;
} while (digit <= 9);
```

More Examples

- The **`do-while`** statement is most appropriate when the loop body must be executed at least once

```
/* Read a number that is between 1 and 99 */
/* If not, reread the number */
int n;
do
{
     printf("Enter a number between 1 and 99: ");
     scanf("%d", &n);
} while (n < 1 || n > 99);
```

On Loop Statements

- Because of the features that are built into the **`for`** statement, it is particularly well suited for loops in which the number of passes is known in advance
- **`while`** loops should be used when the no of times the statements inside the loop to be executed is not known in advance
- Use **`do-while`** loop, when you want the loop body to execute at least once for the first time regardless of the outcome of condition

Comma Operator in `for` statement

- Comma operator can be used for multiple initialization and multiple processing of loop control variables in a `for` statement

```
/* sum of numbers from 1 to n */
for (sum = 0, i = 1; i <= n; i++)
   sum += i;


/*printing numbers from 1 to n, n to 1 */
for (i = 1, j = n; i <= n; i++, j--)
   printf("%2d %2d\n", i, j);
```

The 3 expressions in `for` statement

- You can omit, any of the three expression of the **`for`** statement
  - However, semicolons must be present
- If you omit first or third expression, nothing happens at the time of their evaluation
- If you omit second expression, it will assume the value 1 (true)

```
int digit = 0;
for ( ; digit <= 9 ; )
     printf("%d\n", digit++);
```

The `switch` Multiple-Selection Statement

- **`switch`** is a multiple branch selection statement, that successively tests the value of an expression against a list of integer or character constants
  - When a match is found, the statements associated with that constant are executed.
- Useful when a variable or expression is tested for all the values it can assume and different actions are taken

```
switch (expression)
{
  case constant1:
    statement sequence
    break;
  case constant2:
    statement sequence
    break;

   ...
  case constantn:
    statement sequence
    break;
  default:
    statement sequence
    break;
}
```

The `switch` statement

- The ***`expression`*** must evaluate to an integer type
- The value of ***`expression`*** is tested against the constants present in the **`case`** labels
- When a match is found, the ***`statement sequence`***, if present, associated with that **`case`** is executed until the **`break`** statement or the end of the **`switch`** statement is reached
- The statement sequence following **`default`** label is executed if no matches are found
  - The **`default`** label is optional, and if it is not present, no action takes place if all matches fail

Examples

```
choice = getchar();
switch (choice)
{
case 'r':
       printf("RED");
       break;
case 'w':
       printf("WHITE");
       break;
case 'b':
       printf("BLUE");
        break;
default:
       printf("Unknown");
}
```

```
scanf("%d", &n);
switch (n) {
case 1:
case 2:
   printf("1 or 2");
   break;
case 3:
case 4:
   printf(“3 or 4”);
case 5:
case 6:
   printf("5 or 6?");
   printf("or may be 3 or 4");
default:
   break;
}
```

Things to remember with `switch`

- A **`switch`** statement can only be used to test for equality of an expression
  - You cannot use relational or logical expression like in if
- **`switch`** expression must evaluate to an integral value
- No two **`case`** constants can be same
- Omission of a **`break`** statement causes execution to go to next **`case`** label
- The statement sequence after the **`default`** label is executed when no **`case`** constants matches the expression value

Nested Control Statements

- Loops, like **`while`**, **`for`** statements, can be nested, one within another
  - The inner and outer loops need not be generated by same type of control structure
  - It is essential, however, that one loop be completely embedded within the other—there can be no overlap
  - Each loop must be controlled by a different index
- Nested control statements can also involve both loops and **`if - else`** statements
  - Thus, a loop can be nested within an **`if - else`** statement, and an **`if - else`** statement can be nested within a loop

Examples (`if` nested inside loops)

```
/*Print numbers between 1 to n that are divisible by 3 or 5*/
scanf("%d", &n);
for (i = 1; i <= n; i++)
   if (i%3==0 || i%5 == 0)
      printf("%d\n",i);
```

```
/*count no of characters, excluding spaces in a line of text*/
char ch;
unsigned numchars = 0;
ch = getchar();
while (ch != '\n') {
   if (ch != ' ' || ch != '\t')
      numchars++;
   ch = getchar();
}
printf("Number of characters is %u\n", numchars);
```

Examples (`if-else` nested inside loops)

```
int numalpha, numother;
char ch;

numalpha=numother=0;

ch = getchar();

while (ch != '\n') {

  if (ch>='A' && ch<='Z‘ || ch >= 'a' && ch <= 'z')
    numalpha++;

  else
    numother++;

  ch = getchar();
}

printf("Alphabets: %d, Other: %d", numalpha, numother);
```

Nested for loops

```
/* Prints a multiplication table */

int i, j;
int size;
scanf("%d", &size);
for (i = 1; i <= size; i++) {
   for (j = 1; j <= size; j++)
      printf("%3d", i*j);
   printf("\n");
}
```

```
/* Print the first n factorials */

int i, j, n;
long int prod;
scanf("%d", &n);
for (i = 0; i <= n; i++) {
   prod = 1;
   for (j = 1; j <= i; j++)
      prod *= j;
   printf("%d ", prod);
}
```

Nested loops

```
/* average number of characters per line */

char ch;
int numchars, totalchars, numlines;
float avg;
totalchars = numlines = 0;
do {
        numchars = 0;
        ch = getchar();
        while (ch != '\n') {
                numchars++;
                ch = getchar();
        }
        totalchars += numchars;
        if (numchars > 0)
                numlines++;
} while (numchars > 0);

avg = (float) totalchars/numlines;

printf("Total lines: %d, Average: %.2f\n", numlines, avg);
```

The `break` statement

- The **`break`** statement is used to exit from a **`while`**, **`for`**, **`do-while`** or **`switch`** structure
- It can only be used inside the body of a **`for`**, **`while`**, **`do – while`**, or **`switch`** statement
- The **`break`** statement is written simply as

  ```
  break;
  ```

  without any embedded expressions or statements.
- Program execution continues with the first statement after the structure

Use of `break`

```
scanf("%f", &x);
while (x <= 100) {
  if (x < 0) {
    printf("Error – negative value for x");
    break;
  }
  /* process the nonnegative value of x */
  . . . . .
  scanf("%f", &x);
}
```

use break inside a while loop
if value of x is negative exit from loop

`break` inside nested loops

- If a **`break`** statement is used inside nested **`while`**, **`do – while`**, **`for`** or **`switch`** statements, it will cause a transfer of control out of inner enclosing structure

```
for (count = 0; count <= n; ++count)
{
     . . . . .
     while (c = getchar() != '\n')
     {
          if (c = '*') break;
          . . . . .
     }
}
```

The `continue` statement

- Skips the remaining statements in the body of a **`while`**, **`for`** or **`do-while`** structure
  - Proceeds with the next iteration of the loop
- The **`continue`** statement can be included within a **`while`**, a **`do – while`** or a **`for`** statement
- It is written simply as
  `continue;`
  without any embedded statements or expressions
- **`continue`** inside **`while`** and **`do-while`**
  - Loop-continuation test is evaluated immediately after the **`continue`** statement is executed

The `continue` statement

- `continue` inside `for`
  - increment expression is executed, then the loop-continuation test is evaluated

```
do {
     scanf("%f", &x);
     if (x < 0) {
          printf("ERROR – NEGATIVE VALUE FOR X");
          continue;
     };
     /* process the nonnegative value of x */
     . . . . .
} while (x <= 100);
```

The `goto` statement

- The **`goto`** statement is used to alter the normal sequence of program execution by transferring control to some other part of the current function
- The **`goto`** statement is written as

  `goto` ***`label`***`;`

  where ***`label`*** is an identifier that is used to label the target statement to which control will be transferred
- Control may be transferred to any other statement within the current function

The `goto` statement

- The target statement will appear as
  ***`label`*`: statement`**
- Each label statement within the current function must have a unique name
- The use of **`goto`** should be avoided
- However, **`goto`** can helpful when you want to exit from a doubly nested loop
  - This can be done with two **`if-break`** statements, though this would be awkward

Example

```
scanf("%d", &x);
while (x <= 100) {
   ...
   for (i = x - 4; i < x + 4; i++) {
     ...
     if ( (i + x) % 10 == 0)
        goto errorcheck;
     ...
   }
   ...
}
...
errorcheck:
   printf("ERROR");
...
```