C Keywords and Identifiers

In this tutorial, you will learn about keywords; reserved words in C programming that are part of the syntax. Also, you will learn about identifiers and how to name them.

Character set

A character set is a set of alphabets, letters and some special characters that are valid in C language.

Alphabets

Uppercase: A B C .... X Y Z
Lowercase: a b c .... x y z
C accepts both lowercase and uppercase alphabets as variables and functions.

Digits

0 1 2 3 4 5 6 7 8 9

Special Characters

,	<	>	.	_
(	)	;	$	:
%	[	]	#	?
'	&	{	}	"
^	!	*	/	|
-	\	~	+	

White space Characters
Blank space, newline, horizontal tab, carriage return and form feed.

C Keywords

Keywords are predefined, reserved words used in programming that have special meanings to the compiler. Keywords are part of the syntax and they cannot be used as an identifier. For example:
int money;
Here, int is a keyword that indicates money is a variable of type int (integer).
As C is a case sensitive language, all keywords must be written in lowercase. Here is a list of all keywords allowed in ANSI C.

auto	double	int	struct
break	else	long	switch
case	enum	register	typedef
char	extern	return	union
continue	for	signed	void
do	if	static	while
default	goto	sizeof	volatile
const	float	short	unsigned

All these keywords, their syntax, and application will be discussed in their respective topics. However, if you want a brief overview of these keywords without going further.

C Identifiers

Identifier refers to names given to entities such as variables, functions, structures etc.
Identifiers must be unique. They are created to give a unique name to an entity to identify it during the execution of the program. For example:
int money;
double accountBalance;
Here, money and accountBalance are identifiers.
Also remember, identifier names must be different from keywords. You cannot use int as an identifier because int is a keyword.

Rules for naming identifiers

1. A valid identifier can have letters (both uppercase and lowercase letters), digits and underscores.
2. The first letter of an identifier should be either a letter or an underscore.
3. You cannot use keywords like int, while etc. as identifiers.
4. There is no rule on how long an identifier can be. However, you may run into problems in some compilers if the identifier is longer than 31 characters.

You can choose any name as an identifier if you follow the above rule, however, give meaningful names to identifiers that make sense.

C Variables, Constants and Literals

In this tutorial, you will learn about variables and rules for naming a variable. You will also learn about different literals in C programming and how to create constants.

Variables

In programming, a variable is a container (storage area) to hold data.
To indicate the storage area, each variable should be given a unique name (identifier). Variable names are just the symbolic representation of a memory location. For example:

```
int playerScore = 95;
```

Here, playerScore is a variable of int type. Here, the variable is assigned an integer value 95.
The value of a variable can be changed, hence the name variable.

```
char ch = 'a';
// some code
ch = 'l';
```

Rules for naming a variable

1. A variable name can only have letters (both uppercase and lowercase letters), digits and underscore.
2. The first letter of a variable should be either a letter or an underscore.
3. There is no rule on how long a variable name (identifier) can be. However, you may run into problems in some compilers if the variable name is longer than 31 characters.

Note: You should always try to give meaningful names to variables. For example: firstName is a better variable name than fn.
C is a strongly typed language. This means that the variable type cannot be changed once it is declared. For example:

```
int number = 5;        // integer variable
number = 5.5;          // error
double number;         // error
```

Here, the type of number variable is int. You cannot assign a floating-point (decimal) value 5.5 to this variable. Also, you cannot redefine the data type of the variable to double. By the way, to store the decimal values in C, you need to declare its type to either double or float.
Visit this page to learn more about different types of data a variable can store.

Literals

Literals are data used for representing fixed values. They can be used directly in the code. For example: 1, 2.5, 'c' etc.
Here, 1, 2.5 and 'c' are literals. Why? You cannot assign different values to these terms.

---

1. Integers

An integer is a numeric literal(associated with numbers) without any fractional or exponential part. There are three types of integer literals in C programming:

- decimal (base 10)
- octal (base 8)
- hexadecimal (base 16)

For example:
Decimal: 0, -9, 22 etc
Octal: 021, 077, 033 etc
Hexadecimal: 0x7f, 0x2a, 0x521 etc
In C programming, octal starts with a 0, and hexadecimal starts with a 0x.

---

2. Floating-point Literals

A floating-point literal is a numeric literal that has either a fractional form or an exponent form. For example:
-2.0
0.0000234
-0.22E-5
Note: E-5 = 10-5

---

3. Characters

A character literal is created by enclosing a single character inside single quotation marks. For example: 'a', 'm', 'F', '2', '}' etc.

---

4. Escape Sequences

Sometimes, it is necessary to use characters that cannot be typed or have special meaning in C programming. For example: newline(enter), tab, question mark etc.
In order to use these characters, escape sequences are used.

Escape Sequences	Character
\b	Backspace
\f	Form feed
\n	Newline
\r	Return

\t	Horizontal tab
\v	Vertical tab
\\	Backslash
\'	Single quotation mark
\"	Double quotation mark
\?	Question mark
\0	Null character

5. String Literals

A string literal is a sequence of characters enclosed in double-quote marks. For example:

```
"good"                  // string constant
""                      // null string constant
"      "                // string constant of six white space
"x"                     // string constant having a single character.
"Earth is round\n"      // prints string with a newline
```

Constants

If you want to define a variable whose value cannot be changed, you can use the const keyword. This will create a constant. For example,

```
        const double PI = 3.14;
```

Notice, we have added keyword const.

Here, PI is a symbolic constant; its value cannot be changed.

```
        const double PI = 3.14;
        PI = 2.9; //Error
```

C Data Types

In this tutorial, you will learn about basic data types such as int, float, char etc. in C programming.
In C programming, data types are declarations for variables. This determines the type and size of data associated with variables. For example,
int myVar;
Here, myVar is a variable of int (integer) type. The size of int is 4 bytes.

Basic types

Here's a table containing commonly used types in C programming for quick access.

Type	Size (bytes)	Format Specifier
int	at least 2, usually 4	%d, %i
char	1	%c
float	4	%f
double	8	%lf
short int	2 usually	%hd
unsigned int	at least 2, usually 4	%u
long int	at least 4, usually 8	%ld, %li
long long int	at least 8	%lld, %lli
unsigned long int	at least 4	%lu
unsigned long long int	at least 8	%llu
signed char	1	%c
unsigned char	1	%c
long double	at least 10, usually 12 or 16	%Lf

int

Integers are whole numbers that can have both zero, positive and negative values but no decimal values. For example, 0, -5, 10

We can use int for declaring an integer variable.

int id;

Here, id is a variable of type integer.

You can declare multiple variables at once in C programming. For example,

int id, age;

The size of int is usually 4 bytes (32 bits). And, it can take 232 distinct states from -2147483648 to 2147483647.

---

float and double

float and double are used to hold real numbers.

float salary;

double price;

In C, floating-point numbers can also be represented in exponential. For example,

float normalizationFactor = 22.442e2;

What's the difference between float and double?

The size of float (single precision float data type) is 4 bytes. And the size of double (double precision float data type) is 8 bytes.

---

char

Keyword char is used for declaring character type variables. For example,

char test = 'h';

The size of the character variable is 1 byte.

---

void

void is an incomplete type. It means "nothing" or "no type". You can think of void as absent.

For example, if a function is not returning anything, its return type should be void.

Note that, you cannot create variables of void type.

---

short and long

If you need to use a large number, you can use a type specifier long. Here's how:

```
long a;
long long b;
long double c;
```

Here variables a and b can store integer values. And, c can store a floating-point number.

If you are sure, only a small integer ([−32,767, +32,767] range) will be used, you can use short.

```
short d;
```

You can always check the size of a variable using the sizeof() operator.

```
#include <stdio.h>
int main() {
  short a;
  long b;
  long long c;
  long double d;

  printf("size of short = %d bytes\n", sizeof(a));
  printf("size of long = %d bytes\n", sizeof(b));
  printf("size of long long = %d bytes\n", sizeof(c));
  printf("size of long double= %d bytes\n", sizeof(d));
  return 0;
}
```

signed and unsigned

In C, signed and unsigned are type modifiers. You can alter the data storage of a data type by using them. For example,

```
unsigned int x;
int y;
```

Here, the variable x can hold only zero and positive values because we have used the unsigned modifier.

Considering the size of int is 4 bytes, variable y can hold values from -231 to 231-1, whereas variable x can hold values from 0 to 232-1.

Other data types defined in C programming are:

- bool Type
- Enumerated type
- Complex types

Derived Data Types

Data types that are derived from fundamental data types are derived types. For example: arrays, pointers, function types, structures, etc.

We will learn about these derived data types in later tutorials.

C Input Output (I/O)

In this tutorial, you will learn to use scanf() function to take input from the user, and printf() function to display output to the user.

C Output

In C programming, printf() is one of the main output function. The function sends formatted output to the screen. For example,

Example 1: C Output

```
#include <stdio.h>
int main()
{
   // Displays the string inside quotations
   printf("C Programming");
   return 0;
}
```

Output :

```
C Programming
```

How does this program work?

- All valid C programs must contain the main() function. The code execution begins from the start of the main() function.
- The printf() is a library function to send formatted output to the screen. The function prints the string inside quotations.
- To use printf() in our program, we need to include stdio.h header file using the #include <stdio.h> statement.
- The return 0; statement inside the main() function is the "Exit status" of the program. It's optional.

Example 2: Integer Output

```
#include <stdio.h>
int main()
{
   int testInteger = 5;
   printf("Number = %d", testInteger);
   return 0;
}
```

Output:

```
Number = 5
```

We use %d format specifier to print int types. Here, the %d inside the quotations will be replaced by the value of testInteger.

Example 3: float and double Output

```
#include <stdio.h>
int main()
{
    float number1 = 13.5;
    double number2 = 12.4;

    printf("number1 = %f\n", number1);
    printf("number2 = %lf", number2);
    return 0;
}
```

Output

```
number1 = 13.500000
number2 = 12.400000
```

To print float, we use %f format specifier. Similarly, we use %lf to print double values.

Example 4: Print Characters

```
#include <stdio.h>
int main()
{
    char chr = 'a';
    printf("character = %c", chr);
    return 0;
}
```

Output

```
character = a
```

To print char, we use %c format specifier.

C Input

In C programming, scanf() is one of the commonly used function to take input from the user. The scanf() function reads formatted input from the standard input such as keyboards.

Example 5: Integer Input/Output

```
#include <stdio.h>
int main()
{
   int testInteger;
   printf("Enter an integer: ");
   scanf("%d", &testInteger);
   printf("Number = %d",testInteger);
   return 0;
}
```

Output

```
Enter an integer: 4
Number = 4
```

Here, we have used %d format specifier inside the scanf() function to take int input from the user. When the user enters an integer, it is stored in the testInteger variable.

Notice, that we have used &testInteger inside scanf(). It is because &testInteger gets the address of testInteger, and the value entered by the user is stored in that address.

Example 6: Float and Double Input/Output

```
#include <stdio.h>
int main()
{
   float num1;
   double num2;
   printf("Enter a number: ");
   scanf("%f", &num1);
   printf("Enter another number: ");
   scanf("%lf", &num2);
   printf("num1 = %f\n", num1);
   printf("num2 = %lf", num2);
   return 0;
}
```

Output

```
Enter a number: 12.523
Enter another number: 10.2
num1 = 12.523000
num2 = 10.200000
```

We use %f and %lf format specifiers for float and double respectively.

Example 7: C Character I/O

```
#include <stdio.h>
int main()
{
   char chr;
   printf("Enter a character: ");
   scanf("%c",&chr);
   printf("You entered %c.", chr);
   return 0;
}
```

Output

```
Enter a character: g
You entered g
```

When a character is entered by the user in the above program, the character itself is not stored. Instead, an integer value (ASCII value) is stored.
And when we display that value using %c text format, the entered character is displayed. If we use %d to display the character, it's ASCII value is printed.

Example 8: ASCII Value

```
#include <stdio.h>
int main()
{
   char chr;
   printf("Enter a character: ");
   scanf("%c", &chr);

   // When %c is used, a character is displayed
   printf("You entered %c.\n",chr);

   // When %d is used, ASCII value is displayed
   printf("ASCII value is %d.", chr);
   return 0;
}
```

Output

```
Enter a character: g
You entered g.
ASCII value is 103.
```

I/O Multiple Values :

Here's how you can take multiple inputs from the user and display them.

```
#include <stdio.h>
int main()
{
    int a;
    float b;

    printf("Enter integer and then a float: ");

    // Taking multiple inputs
    scanf("%d%f", &a, &b);

    printf("You entered %d and %f", a, b);
    return 0;
}
```

Output

```
Enter integer and then a float: -3
3.4
You entered -3 and 3.400000
```

Format Specifiers for I/O

As you can see from the above examples, we use

- %d for int
- %f for float
- %lf for double
- %c for char

Here's a list of commonly used C data types and their format specifiers.

Data Type	Format Specifier
int	%d
char	%c
float	%f
double	%lf
short int	%hd
unsigned int	%u
long int	%li
long long int	%lli
unsigned long int	%lu
unsigned long long int	%llu
signed char	%c
unsigned char	%c
long double	%Lf

C Programming Operators

In this tutorial, you will learn about different operators in C programming with the help of examples.
An operator is a symbol that operates on a value or a variable. For example: + is an operator to perform addition.
C has a wide range of operators to perform various operations.

C Arithmetic Operators

An arithmetic operator performs mathematical operations such as addition, subtraction, multiplication, division etc on numerical values (constants and variables).

Operator	Meaning of Operator
+	addition or unary plus
-	subtraction or unary minus
*	multiplication
/	division
%	remainder after division (modulo division)

Example 1: Arithmetic Operators

```
// Working of arithmetic operators
#include <stdio.h>
int main()
{
   int a = 9,b = 4, c;

   c = a+b;
   printf("a+b = %d \n",c);
   c = a-b;
   printf("a-b = %d \n",c);
   c = a*b;
   printf("a*b = %d \n",c);
   c = a/b;
   printf("a/b = %d \n",c);
   c = a%b;
   printf("Remainder when a divided by b = %d \n",c);
   return 0;
}
```

Output

```
a+b = 13
a-b = 5
a*b = 36
a/b = 2
Remainder when a divided by b=1
```

The operators +, - and * computes addition, subtraction, and multiplication respectively as you might have expected.

In normal calculation, 9/4 = 2.25. However, the output is 2 in the program.

It is because both the variables a and b are integers. Hence, the output is also an integer. The compiler neglects the term after the decimal point and shows answer 2 instead of 2.25.

The modulo operator % computes the remainder. When a=9 is divided by b=4, the remainder is 1. The % operator can only be used with integers.

Suppose a = 5.0, b = 2.0, c = 5 and d = 2. Then in C programming,

```
// Either one of the operands is a floating-point number
a/b = 2.5
a/d = 2.5
c/b = 2.5

// Both operands are integers
c/d = 2
```

C Increment and Decrement Operators

C programming has two operators increment ++ and decrement -- to change the value of an operand (constant or variable) by 1.

Increment ++ increases the value by 1 whereas decrement -- decreases the value by 1. These two operators are unary operators, meaning they only operate on a single operand.

Example 2: Increment and Decrement Operators

```
// Working of increment and decrement operators
#include <stdio.h>
int main()
{
   int a = 10, b = 100;
   float c = 10.5, d = 100.5;

   printf("++a = %d \n", ++a);
   printf("--b = %d \n", --b);
   printf("++c = %f \n", ++c);
   printf("--d = %f \n", --d);

   return 0;
}
```

```
Output :        ++a = 11
                --b = 99
                ++c = 11.500000
                --d = 99.500000
```

Here, the operators ++ and -- are used as prefixes. These two operators can also be used as postfixes like a++ and a--.

C Assignment Operators

An assignment operator is used for assigning a value to a variable.

Operator	Example	Same as
=	a = b	a = b
+=	a += b	a = a+b
-=	a -= b	a = a-b
*=	a *= b	a = a*b
/=	a /= b	a = a/b
%=	a %= b	a = a%b

Example 3: Assignment Operators

```
// Working of assignment operators
#include <stdio.h>
int main()
{
   int a = 5, c;
   c = a;      // c is 5
   printf("c = %d\n", c);
   c += a;     // c is 10
   printf("c = %d\n", c);
   c -= a;     // c is 5
   printf("c = %d\n", c);
   c *= a;     // c is 25
   printf("c = %d\n", c);
   c /= a;     // c is 5
   printf("c = %d\n", c);
   c %= a;     // c = 0
   printf("c = %d\n", c);
 return 0;
}
```

Output

```
c = 5
c = 10
c = 5
c = 25
c = 5
c = 0
```

C Relational Operators

A relational operator checks the relationship between two operands. If the relation is true, it returns 1; if the relation is false, it returns value 0.
Relational operators are used in decision making and loops.

Operator	Meaning of Operator	Example
==	Equal to	5 == 3 is evaluated to 0
>	Greater than	5 > 3 is evaluated to 1
<	Less than	5 < 3 is evaluated to 0
!=	Not equal to	5 != 3 is evaluated to 1
>=	Greater than or equal to	5 >= 3 is evaluated to 1
<=	Less than or equal to	5 <= 3 is evaluated to 0

Example 4: Relational Operators

```
// Working of relational operators
#include <stdio.h>
int main()
{
   int a = 5, b = 5, c = 10;

   printf("%d == %d is %d \n", a, b, a == b);
   printf("%d == %d is %d \n", a, c, a == c);
   printf("%d > %d is %d \n", a, b, a > b);
   printf("%d > %d is %d \n", a, c, a > c);
   printf("%d < %d is %d \n", a, b, a < b);
   printf("%d < %d is %d \n", a, c, a < c);
   printf("%d != %d is %d \n", a, b, a != b);
   printf("%d != %d is %d \n", a, c, a != c);
   printf("%d >= %d is %d \n", a, b, a >= b);
   printf("%d >= %d is %d \n", a, c, a >= c);
   printf("%d <= %d is %d \n", a, b, a <= b);
   printf("%d <= %d is %d \n", a, c, a <= c);

   return 0;
}
```

Output

```
5 == 5 is 1
5 == 10 is 0
5 > 5 is 0
5 > 10 is 0
5 < 5 is 0
5 < 10 is 1
5 != 5 is 0
5 != 10 is 1
5 >= 5 is 1
5 >= 10 is 0
5 <= 5 is 1
5 <= 10 is 1
```

C Logical Operators

An expression containing logical operator returns either 0 or 1 depending upon whether expression results true or false. Logical operators are commonly used in decision making in C programming.

Operator	Meaning	Example
&&	Logical AND. True only if all operands are true	If c = 5 and d = 2 then, expression ((c==5) && (d>5)) equals to 0.
||	Logical OR. True only if either one operand is true	If c = 5 and d = 2 then, expression ((c==5) || (d>5)) equals to 1.
!	Logical NOT. True only if the operand is 0	If c = 5 then, expression !(c==5) equals to 0.

Example 5: Logical Operators

```
// Working of logical operators

#include <stdio.h>
int main()
{
   int a = 5, b = 5, c = 10, result;

   result = (a == b) && (c > b);
   printf("(a == b) && (c > b) is %d \n", result);

   result = (a == b) && (c < b);
   printf("(a == b) && (c < b) is %d \n", result);

   result = (a == b) || (c < b);
   printf("(a == b) || (c < b) is %d \n", result);

   result = (a != b) || (c < b);
   printf("(a != b) || (c < b) is %d \n", result);

   result = !(a != b);
   printf("!(a != b) is %d \n", result);

   result = !(a == b);
   printf("!(a == b) is %d \n", result);
   return 0;
}
```

Output

```
(a == b) && (c > b) is 1
(a == b) && (c < b) is 0
(a == b) || (c < b) is 1
(a != b) || (c < b) is 0
!(a != b) is 1
!(a == b) is 0
```

Explanation of logical operator program

- (a == b) && (c > 5) evaluates to 1 because both operands (a == b) and (c > b) is 1 (true).
- (a == b) && (c < b) evaluates to 0 because operand (c < b) is 0 (false).
- (a == b) || (c < b) evaluates to 1 because (a = b) is 1 (true).
- (a != b) || (c < b) evaluates to 0 because both operand (a != b) and (c < b) are 0 (false).
- !(a != b) evaluates to 1 because operand (a != b) is 0 (false). Hence, !(a != b) is 1 (true).
- !(a == b) evaluates to 0 because (a == b) is 1 (true). Hence, !(a == b) is 0 (false).

C Bitwise Operators

During computation, mathematical operations like: addition, subtraction, multiplication, division, etc are converted to bit-level which makes processing faster and saves power.
Bitwise operators are used in C programming to perform bit-level operations.

Operators	Meaning of operators
&	Bitwise AND
|	Bitwise OR
^	Bitwise exclusive OR
~	Bitwise complement
<<	Shift left
>>	Shift right

Other Operators

Comma Operator

Comma operators are used to link related expressions together. For example:

```
int a, c = 5, d;
```

The sizeof operator

The sizeof is a unary operator that returns the size of data (constants, variables, array, structure, etc).

Example 6: sizeof Operator

```
#include <stdio.h>
int main()
{
    int a;
    float b;
    double c;
    char d;
    printf("Size of int=%lu bytes\n",sizeof(a));
    printf("Size of float=%lu bytes\n",sizeof(b));
    printf("Size of double=%lu bytes\n",sizeof(c));
    printf("Size of char=%lu byte\n",sizeof(d));

    return 0;
}
```

Output

```
Size of int = 4 bytes
Size of float = 4 bytes
Size of double = 8 bytes
Size of char = 1 byte
```

Other operators such as ternary operator ?:, reference operator &, dereference operator * and member selection operator -> will be discussed in later tutorials.

C if...else Statement

In this tutorial, you will learn about the if statement (including if...else and nested if..else) in C programming with the help of examples.

C if Statement

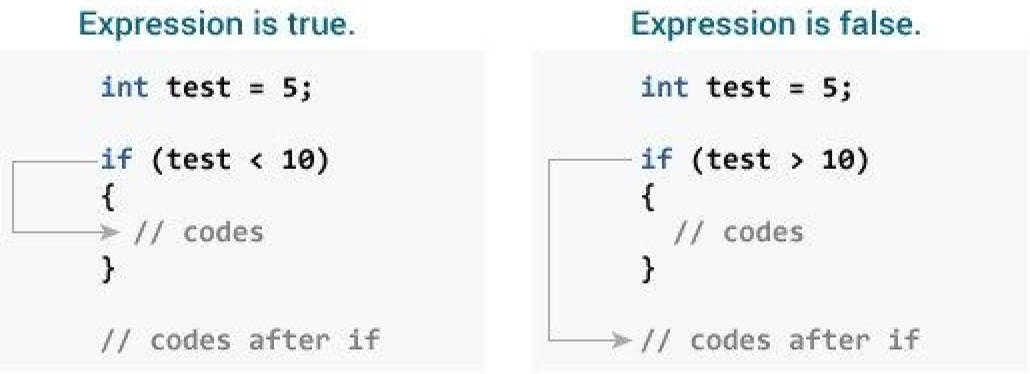
The syntax of the if statement in C programming is:

```
if (test expression)
{
  // code
}
```

How if statement works?

The if statement evaluates the test expression inside the parenthesis ().

- If the test expression is evaluated to true, statements inside the body of if are executed.
- If the test expression is evaluated to false, statements inside the body of if are not executed.



Expression is true.

```
int test = 5;

if (test < 10)
{
  // codes
}

// codes after if
```

Expression is false.

```
int test = 5;

if (test > 10)
{
  // codes
}

// codes after if
```

To learn more about when test expression is evaluated to true (non-zero value) and false (0), check relational and logical operators.

Example 1: if statement

```
// Program to display a number if it is negative

#include <stdio.h>
int main() {
   int number;

   printf("Enter an integer: ");
   scanf("%d", &number);

   // true if number is less than 0
   if (number < 0) {
      printf("You entered %d.\n", number);
   }

   printf("The if statement is easy.");

   return 0;
}
```

Output 1

```
Enter an integer: -2
You entered -2.
The if statement is easy.
```

When the user enters -2, the test expression number<0 is evaluated to true. Hence, You entered -2 is displayed on the screen.

Output 2

```
Enter an integer: 5
The if statement is easy.
```

When the user enters 5, the test expression number<0 is evaluated to false and the statement inside the body of if is not executed

C if...else Statement

The if statement may have an optional else block. The syntax of the if..else statement is:

```
if (test expression) {
   // run code if test expression is true
}
else {
   // run code if test expression is false
}
```

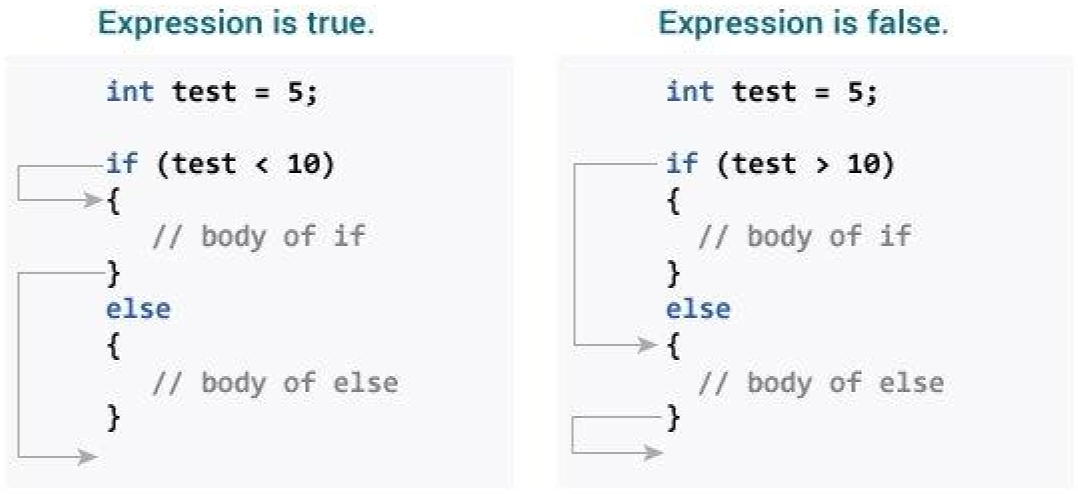
How if...else statement works?

If the test expression is evaluated to true,

- statements inside the body of if are executed.
- statements inside the body of else are skipped from execution.

If the test expression is evaluated to false,

- statements inside the body of else are executed
- statements inside the body of if are skipped from execution.



Expression is true.

```
int test = 5;

if (test < 10)
{
   // body of if
}
else
{
   // body of else
}
```

Expression is false.

```
int test = 5;

if (test > 10)
{
  // body of if
}
else
{
  // body of else
}
```

Example 2: if...else statement

```
// Check whether an integer is odd or even

#include <stdio.h>
int main() {
   int number;
   printf("Enter an integer: ");
   scanf("%d", &number);

   // True if the remainder is 0
   if  (number%2 == 0) {
      printf("%d is an even integer.",number);
   }
   else {
      printf("%d is an odd integer.",number);
   }

   return 0;
}
```

Output

```
Enter an integer: 7
7 is an odd integer.
```

When the user enters 7, the test expression number%2==0 is evaluated to false. Hence, the statement inside the body of else is executed.

C if...else Ladder

The if...else statement executes two different codes depending upon whether the test expression is true or false. Sometimes, a choice has to be made from more than 2 possibilities.
The if...else ladder allows you to check between multiple test expressions and execute different statements.

Syntax of if...else Ladder

```
if (test expression1) {
   // statement(s)
}
else if(test expression2) {
   // statement(s)
}
else if (test expression3) {
   // statement(s)
}
.
.
else {
   // statement(s)
}
```

Example 3: C if...else Ladder

```
// Program to relate two integers using =, > or < symbol

#include <stdio.h>
int main() {
    int number1, number2;
    printf("Enter two integers: ");
    scanf("%d %d", &number1, &number2);

    //checks if the two integers are equal.
    if(number1 == number2) {
        printf("Result: %d = %d",number1,number2);
    }

    //checks if number1 is greater than number2.
    else if (number1 > number2) {
        printf("Result: %d > %d", number1, number2);
    }

    //checks if both test expressions are false
    else {
        printf("Result: %d < %d",number1, number2);
    }

    return 0;
}
```

Output

```
Enter two integers: 12
23
Result: 12 < 23
```

Nested if...else

It is possible to include an if...else statement inside the body of another if...else statement.

Example 4: Nested if...else

This program given below relates two integers using either <, > and = similar to the if...else ladder's example. However, we will use a nested if...else statement to solve this problem.

```
#include <stdio.h>
int main() {
    int number1, number2;
    printf("Enter two integers: ");
    scanf("%d %d", &number1, &number2);

    if (number1 >= number2) {
      if (number1 == number2) {
        printf("Result: %d = %d",number1,number2);
      }
      else {
        printf("Result: %d > %d", number1, number2);
      }
    }
    else {
        printf("Result: %d < %d",number1, number2);
    }

    return 0;
}
```

If the body of an if...else statement has only one statement, you do not need to use brackets {}.

For example, this code

```
if (a > b) {
    printf("Hello");
}
printf("Hi");
```

is equivalent to

```
if (a > b)
    printf("Hello");
printf("Hi");
```

C while and do...while Loop

In this tutorial, you will learn to create while and do...while loop in C programming with the help of examples.

In programming, loops are used to repeat a block of code until a specified condition is met.

C programming has three types of loops.

1. for loop
2. while loop
3. do...while loop

In the previous tutorial, we learned about for loop. In this tutorial, we will learn about while and do..while loop.

---

while loop

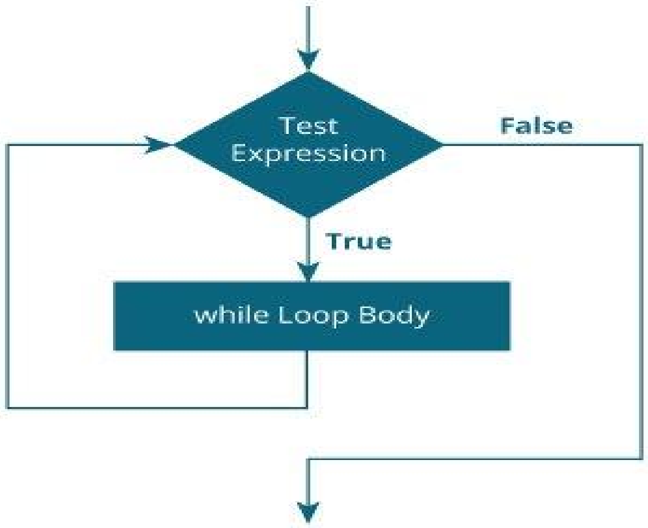
The syntax of the while loop is:

```
while (testExpression) {
  // the body of the loop
}
```

How while loop works?

- The while loop evaluates the testExpression inside the parentheses ().
- If testExpression is true, statements inside the body of while loop are executed. Then, testExpression is evaluated again.
- The process goes on until testExpression is evaluated to false.
- If testExpression is false, the loop terminates (ends).

Flowchart of while loop



Example 1: while loop

```
// Print numbers from 1 to 5
#include <stdio.h>
int main() {
  int i = 1;
  while (i <= 5) {
    printf("%d ", i);
    ++i;
  }
  return 0;
}
Output : 1 2 3 4 5
```

Here, we have initialized i to 1.

1. When i = 1, the test expression i <= 5 is true. Hence, the body of the while loop is executed. This prints 1 on the screen and the value of i is increased to 2.
2. Now, i = 2, the test expression i <= 5 is again true. The body of the while loop is executed again. This prints 2 on the screen and the value of i is increased to 3.
3. This process goes on until i becomes 6. Then, the test expression i <= 5 will be false and the loop terminates.

---

do...while loop

The do..while loop is similar to the while loop with one important difference. The body of do...while loop is executed at least once. Only then, the test expression is evaluated.

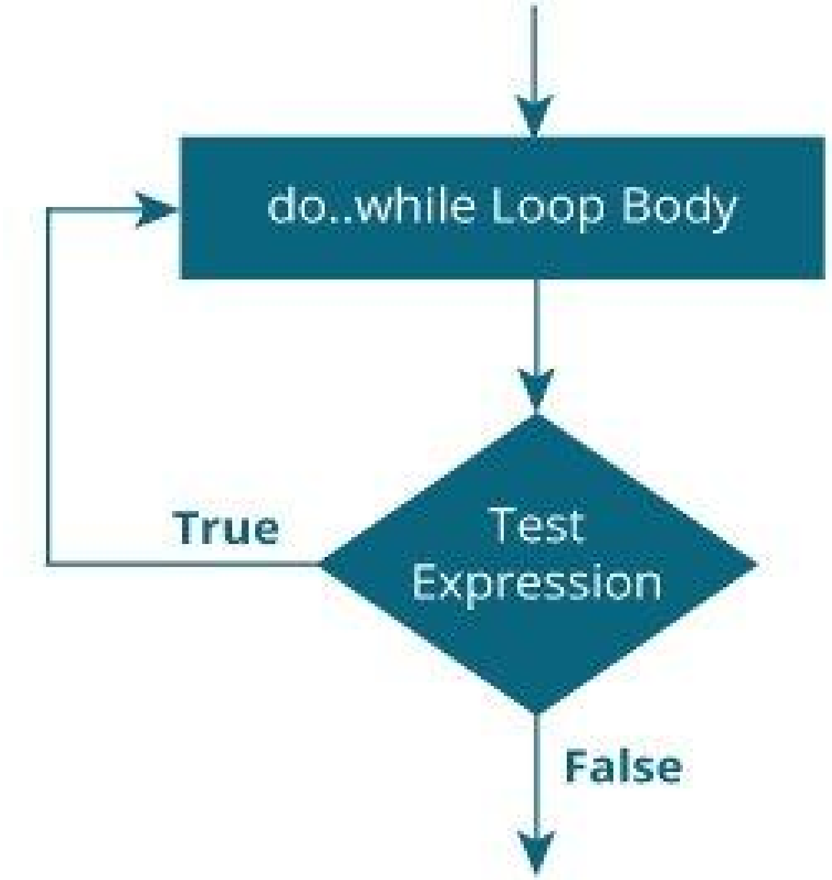
The syntax of the do...while loop is:

```
do {
  // the body of the loop
}
while (testExpression);
```

How do...while loop works?

- The body of do...while loop is executed once. Only then, the testExpression is evaluated.
- If testExpression is true, the body of the loop is executed again and testExpression is evaluated once more.
- This process goes on until testExpression becomes false.
- If testExpression is false, the loop ends.

Flowchart of do...while Loop



Example 2: do...while loop

```
// Program to add numbers until the user enters zero

#include <stdio.h>
int main() {
  double number, sum = 0;

  // the body of the loop is executed at least once
  do {
    printf("Enter a number: ");
    scanf("%lf", &number);
    sum += number;
  }
  while(number != 0.0);

  printf("Sum = %.2lf",sum);

  return 0;
}
```

Output :

```
Enter a number: 1.5
Enter a number: 2.4
Enter a number: -3.4
Enter a number: 4.2
Enter a number: 0
Sum = 4.70
```

Here, we have used a do...while loop to prompt the user to enter a number. The loop works as long as the input number is not 0.

The do...while loop executes at least once i.e. the first iteration runs without checking the condition. The condition is checked only after the first iteration has been executed.

```
do
{
  printf("Enter a number: ");
  scanf("%lf", &number);
  sum += number;
}
while(number != 0.0);
```

So, if the first input is a non-zero number, that number is added to the sum variable and the loop continues to the next iteration. This process is repeated until the user enters 0.

But if the first input is 0, there will be no second iteration of the loop and the sum becomes 0.0.

Outside the loop, we print the value of sum.

C break

The break statement ends the loop immediately when it is encountered.

Its syntax is:

```
      break;
```

The break statement is almost always used with if...else statement inside the loop.

C continue

The continue statement skips the current iteration of the loop and continues with the next iteration.

Its syntax is:

```
      continue;
```

The continue statement is almost always used with the if...else statement.

C switch Statement

In this tutorial, you will learn to create the switch statement in C programming with the help of an example.
The switch statement allows us to execute one code block among many alternatives.
You can do the same thing with the if...else..if ladder. However, the syntax of the switch statement is much easier to read and write.

Syntax of switch...case

```
switch (expression)
{
   case constant1:
     // statements
     break;

   case constant2:
     // statements
     break;
   .
   .
   .
   default:
     // default statements
}
```

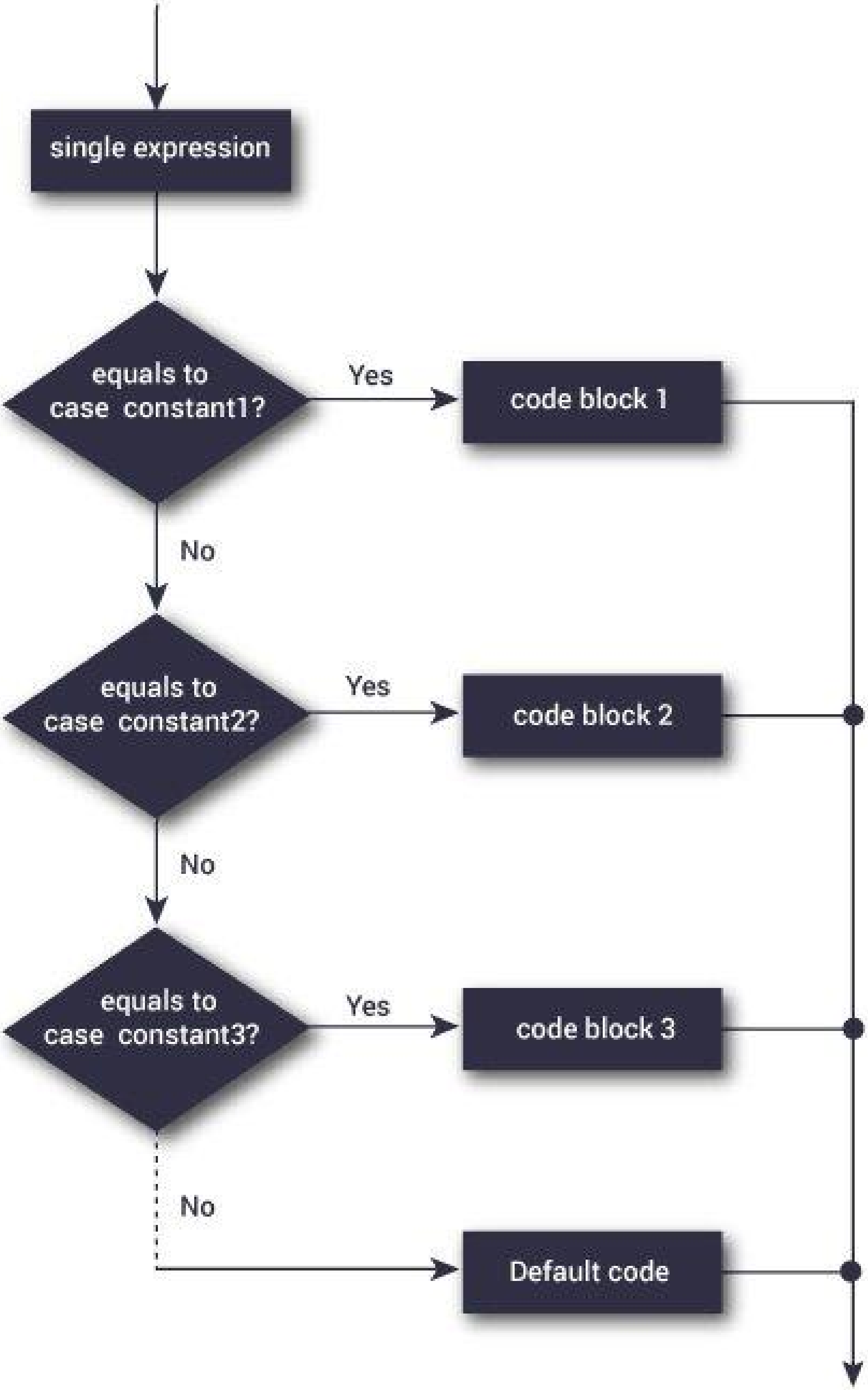
How does the switch statement work?

The expression is evaluated once and compared with the values of each case label.

- If there is a match, the corresponding statements after the matching label are executed. For example, if the value of the expression is equal to constant2, statements after case constant2: are executed until break is encountered.
- If there is no match, the default statements are executed.

If we do not use break, all statements after the matching label are executed.
By the way, the default clause inside the switch statement is optional.

switch Statement Flowchart



Example: Simple Calculator

```
// Program to create a simple calculator
#include <stdio.h>
int main() {
    char operator;
    double n1, n2;
    printf("Enter an operator (+, -, *, /): ");
    scanf("%c", &operator);
    printf("Enter two operands: ");
    scanf("%lf %lf",&n1, &n2);

    switch(operator)
    {
        case '+':
            printf("%.1lf + %.1lf = %.1lf",n1, n2, n1+n2);
            break;

        case '-':
            printf("%.1lf - %.1lf = %.1lf",n1, n2, n1-n2);
            break;

        case '*':
            printf("%.1lf * %.1lf = %.1lf",n1, n2, n1*n2);
            break;

        case '/':
            printf("%.1lf / %.1lf = %.1lf",n1, n2, n1/n2);
            break;

        default:
            printf("Error! operator is not correct");
    }
    return 0;
}
```

Output

```
Enter an operator (+, -, *,): -
Enter two operands: 32.5
12.4
32.5 - 12.4 = 20.1
```

The - operator entered by the user is stored in the operator variable. And, two operands 32.5 and 12.4 are stored in variables n1 and n2 respectively.

Since the operator is -, the control of the program jumps to

printf("%.1lf - %.1lf = %.1lf", n1, n2, n1-n2);

Finally, the break statement terminates the switch statement.

C Functions

In this tutorial, you will be introduced to functions (both user-defined and standard library functions) in C programming. Also, you will learn why functions are used in programming.

A function is a block of code that performs a specific task.

Suppose, you need to create a program to create a circle and color it. You can create two functions to solve this problem:

- create a circle function
- create a color function

Dividing a complex problem into smaller chunks makes our program easy to understand and reuse.

Types of function

There are two types of function in C programming:

- Standard library functions
- User-defined functions

Standard library functions

The standard library functions are built-in functions in C programming.

These functions are defined in header files. For example,

- The printf() is a standard library function to send formatted output to the screen (display output on the screen). This function is defined in the stdio.h header file.
  Hence, to use the printf()function, we need to include the stdio.h header file using #include <stdio.h>.
- The sqrt() function calculates the square root of a number. The function is defined in the math.h header file.

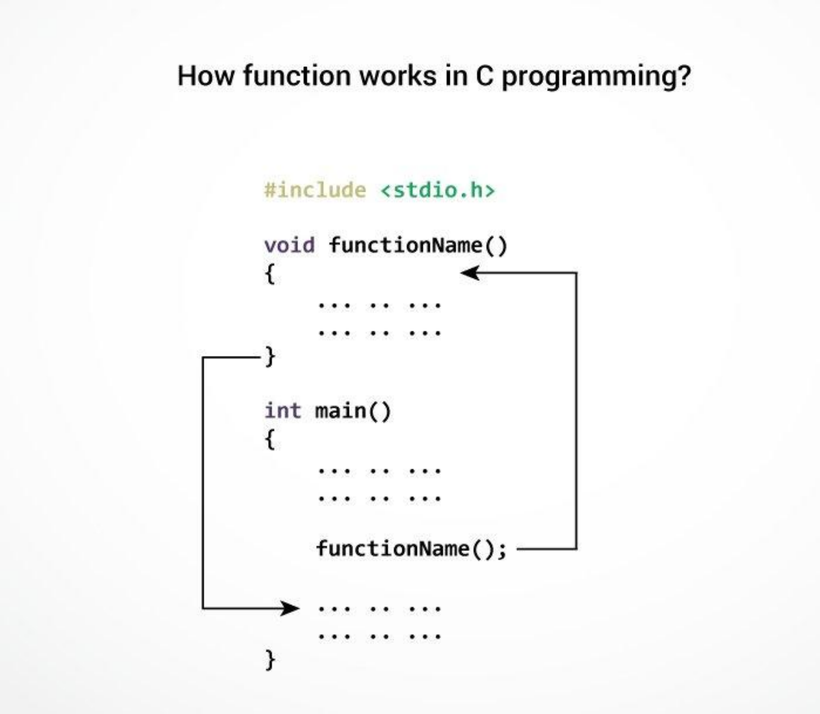
User-defined function

You can also create functions as per your need. Such functions created by the user are known as user-defined functions.

How user-defined function works?

```
#include <stdio.h>
void functionName()
{
   ... .. ...
   ... .. ...
}
int main()
{
   ... .. ...
   ... .. ...

   functionName();
   ... .. ...
   ... .. ...
}
```

The execution of a C program begins from the main() function.
When the compiler encounters functionName();, control of the program jumps to
void functionName()
And, the compiler starts executing the codes inside functionName().
The control of the program jumps back to the main() function once code inside the function definition is executed.



How function works in C programming?

```
#include <stdio.h>

void functionName()
{
    ... .. ...
    ... .. ...
}

int main()
{
    ... .. ...
    ... .. ...

    functionName();

    ... .. ...
    ... .. ...
}
```

Types of User-defined Functions in C Programming

In this tutorial, you will learn about different approaches you can take to solve the same problem using functions.
These 4 programs below check whether the integer entered by the user is a prime number or not.
The output of all these programs below is the same, and we have created a user-defined function in each example. However, the approach we have taken in each example is different.

Example 1: No arguments passed and no return value

```
#include <stdio.h>
void checkPrimeNumber();
int main()
{
   checkPrimeNumber();    // argument is not passed
   return 0;
}

// return type is void meaning doesn't return any value
void checkPrimeNumber()
{
   int n, i, flag = 0;

   printf("Enter a positive integer: ");
   scanf("%d",&n);

   for(i=2; i <= n/2; ++i)
   {
      if(n%i == 0)
      {
         flag = 1;
      }
   }
   if (flag == 1)
      printf("%d is not a prime number.", n);
   else
      printf("%d is a prime number.", n);
}
```

The checkPrimeNumber() function takes input from the user, checks whether it is a prime number or not and displays it on the screen.
The empty parentheses in checkPrimeNumber(); statement inside the main() function indicates that no argument is passed to the function.
The return type of the function is void. Hence, no value is returned from the function.

Example 2: No arguments passed but a return value

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

int main()
{
    int n, i, flag = 0;

   // no argument is passed
    n = getInteger();

    for(i=2; i<=n/2; ++i)
    {
        if(n%i==0){
            flag = 1;
            break;
        }
    }

    if (flag == 1)
        printf("%d is not a prime number.", n);
    else
        printf("%d is a prime number.", n);

    return 0;
}

// returns integer entered by the user
int getInteger()
{
    int n;

    printf("Enter a positive integer: ");
    scanf("%d",&n);

    return n;
}
```

The empty parentheses in the n = getInteger(); statement indicates that no argument is passed to the function. And, the value returned from the function is assigned to n.
Here, the getInteger() function takes input from the user and returns it. The code to check whether a number is prime or not is inside the main() function.

Example 3: Argument passed but no return value

```
#include <stdio.h>
void checkPrimeAndDisplay(int n);

int main()
{
    int n;

    printf("Enter a positive integer: ");
    scanf("%d",&n);

    // n is passed to the function
    checkPrimeAndDisplay(n);

    return 0;
}

// return type is void meaning doesn't return any value
void checkPrimeAndDisplay(int n)
{
    int i, flag = 0;

    for(i=2; i <= n/2; ++i)
    {
        if(n%i == 0){
            flag = 1;
            break;
        }
    }
    if(flag == 1)
        printf("%d is not a prime number.",n);
    else
        printf("%d is a prime number.", n);
}
```

The integer value entered by the user is passed to the checkPrimeAndDisplay() function.

Here, the checkPrimeAndDisplay() function checks whether the argument passed is a prime number or not and displays the appropriate message.

Example 4: Argument passed and a return value

```
#include <stdio.h>
int checkPrimeNumber(int n);
int main()
{
    int n, flag;

    printf("Enter a positive integer: ");
    scanf("%d",&n);

    // n is passed to the checkPrimeNumber() function
    // the returned value is assigned to the flag variable
    flag = checkPrimeNumber(n);
    if(flag == 1)
        printf("%d is not a prime number",n);
    else
        printf("%d is a prime number",n);

    return 0;
}

// int is returned from the function
int checkPrimeNumber(int n)
{
    int i;
    for(i=2; i <= n/2; ++i)
    {
        if(n%i == 0)
            return 1;
    }
    return 0;
}
```

The input from the user is passed to the checkPrimeNumber() function.
The checkPrimeNumber() function checks whether the passed argument is prime or not.
If the passed argument is a prime number, the function returns 0. If the passed argument is a non-prime number, the function returns 1. The return value is assigned to the flag variable.
Depending on whether flag is 0 or 1, an appropriate message is printed from the main() function.

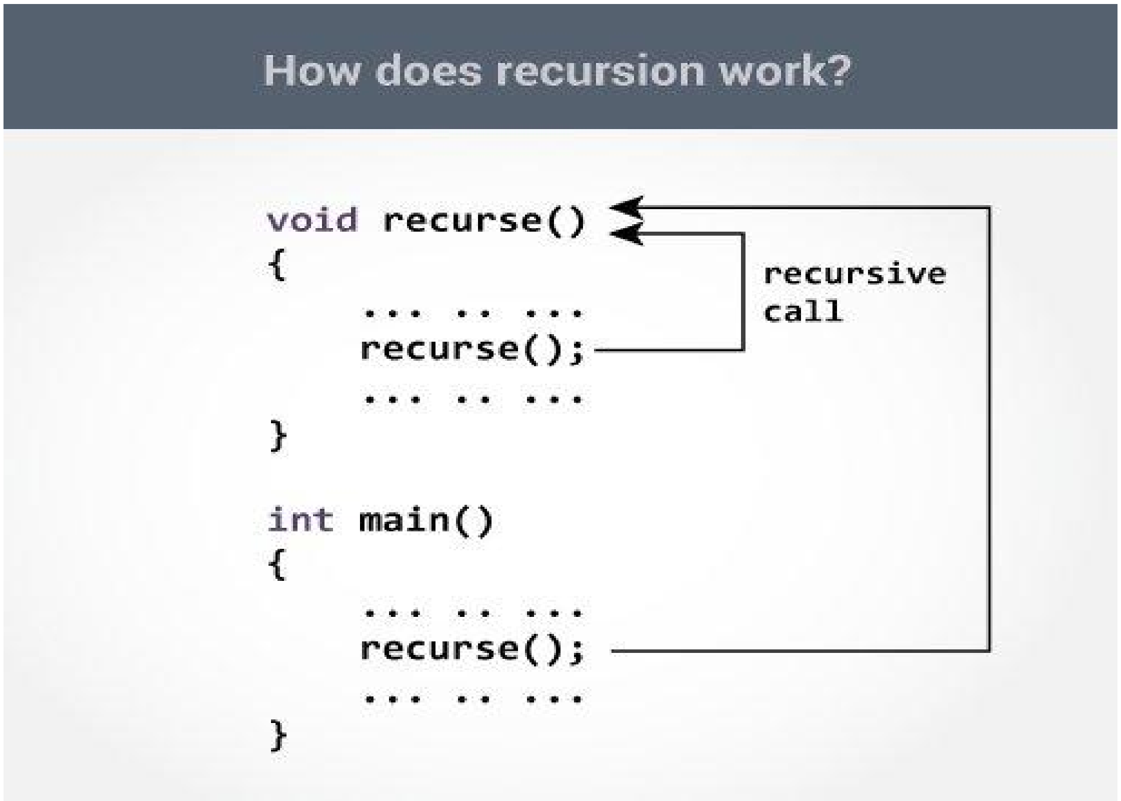
Which approach is better?
Well, it depends on the problem you are trying to solve. In this case, passing argument and returning a value from the function (example 4) is better.
A function should perform a specific task. The checkPrimeNumber() function doesn't take input from the user nor it displays the appropriate message. It only checks whether a number is prime or not

C Recursion

In this tutorial, you will learn to write recursive functions in C programming with the help of an example.
A function that calls itself is known as a recursive function. And, this technique is known as recursion.

How does recursion work?

```
void recurse()
{
    ... .. ...
    recurse();
    ... .. ...
}

int main()
{
    ... .. ...
    recurse();
    ... .. ...
}
```



How does recursion work?

```
void recurse()
{
      ... .. ...
      recurse();
      ... .. ...
}

int main()
{
      ... .. ...
      recurse();
      ... .. ...
}
```

The recursion continues until some condition is met to prevent it.
To prevent infinite recursion, if...else statement (or similar approach) can be used where one branch makes the recursive call, and other doesn't.

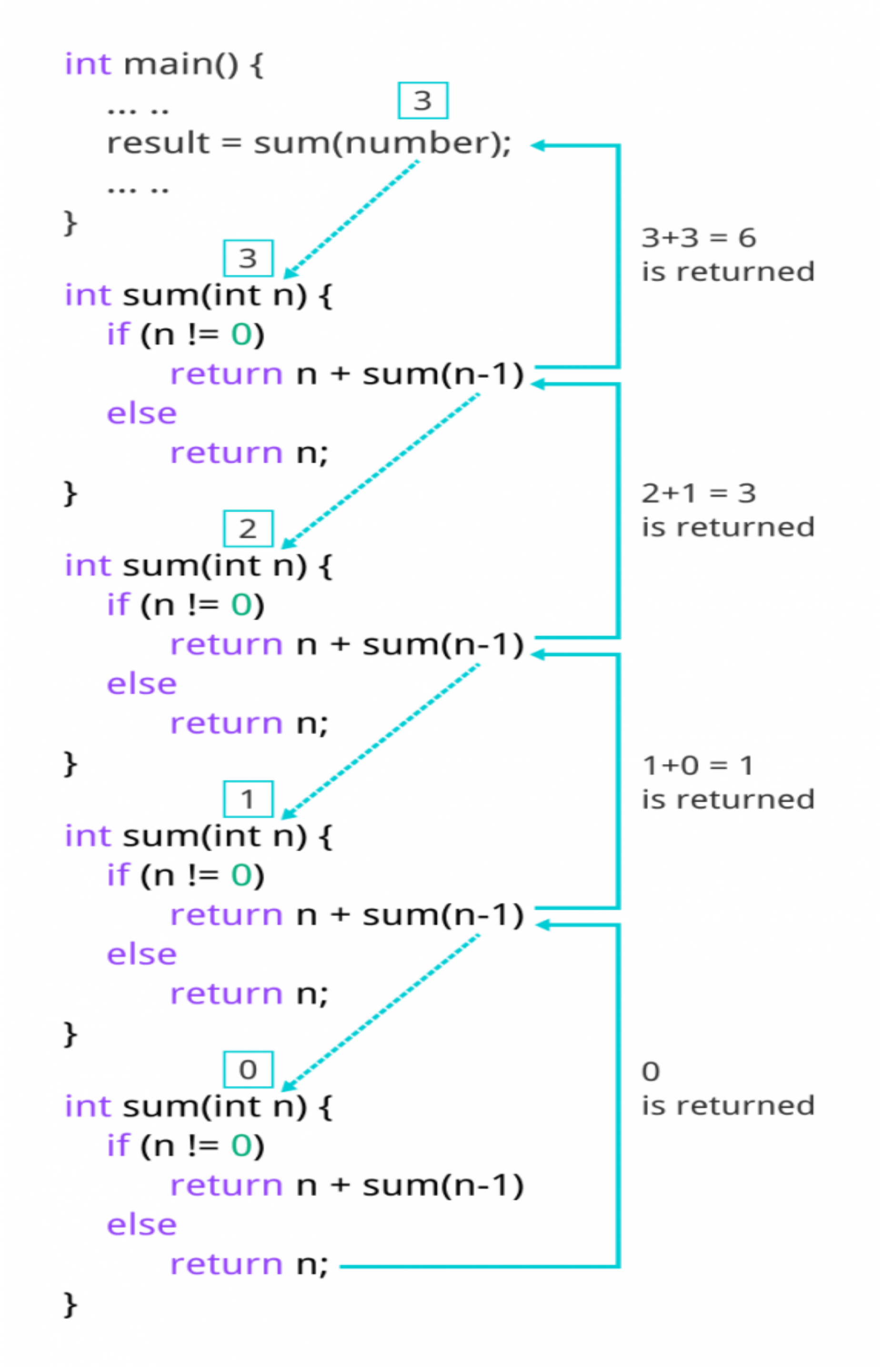
Example: Sum of Natural Numbers Using Recursion

```
#include <stdio.h>
int sum(int n);

int main() {
   int number, result;

   printf("Enter a positive integer: ");
   scanf("%d", &number);

   result = sum(number);

   printf("sum = %d", result);
   return 0;
}

int sum(int n) {
   if (n != 0)
      // sum() function calls itself
      return n + sum(n-1);
   else
      return n;
}
```

Output :

```
Enter a positive integer:3
sum = 6
```

Initially, the sum() is called from the main() function with number passed as an argument.
Suppose, the value of n inside sum() is 3 initially. During the next function call, 2 is passed to the sum() function. This process continues until n is equal to 0.
When n is equal to 0, the if condition fails and the else part is executed returning the sum of integers ultimately to the main() function.



```
int main() {
    ... ..
    result = sum(number);
    ... ..
}

int sum(int n) {
    if (n != 0)
        return n + sum(n-1)
    else
        return n;
}

int sum(int n) {
    if (n != 0)
        return n + sum(n-1)
    else
        return n;
}

int sum(int n) {
    if (n != 0)
        return n + sum(n-1)
    else
        return n;
}

int sum(int n) {
    if (n != 0)
        return n + sum(n-1)
    else
        return n;
}
```

Advantages and Disadvantages of Recursion :

Recursion makes program elegant. However, if performance is vital, use loops instead as recursion is usually much slower.

That being said, recursion is an important concept. It is frequently used in data structure and algorithms. For example, it is common to use recursion in problems such as tree traversal.

C Storage Class

In this tutorial, you will learn about scope and lifetime of local and global variables. Also, you will learn about static and register variables.

Every variable in C programming has two properties: type and storage class.

Type refers to the data type of a variable. And, storage class determines the scope, visibility and lifetime of a variable.

There are 4 types of storage class:

1. automatic
2. external
3. static
4. register

Local Variable

The variables declared inside a block are automatic or local variables. The local variables exist only inside the block in which it is declared.

Let's take an example.

```
#include <stdio.h>

int main(void) {

  for (int i = 0; i < 5; ++i) {
     printf("C programming");
  }

 // Error: i is not declared at this point
  printf("%d", i);
  return 0;
}
```

When you run the above program, you will get an error undeclared identifier i. It's because i is declared inside the for loop block. Outside of the block, it's undeclared.

Let's take another example.

```
int main() {
    int n1; // n1 is a local variable to main()
}

void func() {
   int n2;  // n2 is a local variable to func()
}
```

In the above example, n1 is local to main() and n2 is local to func().

This means you cannot access the n1 variable inside func() as it only exists inside main(). Similarly, you cannot access the n2 variable inside main() as it only exists inside func().

Global Variable

Variables that are declared outside of all functions are known as external or global variables. They are accessible from any function inside the program.

Example 1: Global Variable

```
#include <stdio.h>
void display();

int n = 5;  // global variable

int main()
{
   ++n;
   display();
   return 0;
}

void display()
{
   ++n;
   printf("n = %d", n);
}
```

Output

```
n = 7
```

Suppose, a global variable is declared in file1. If you try to use that variable in a different file file2, the compiler will complain. To solve this problem, keyword extern is used in file2 to indicate that the external variable is declared in another file.

Register Variable

The register keyword is used to declare register variables. Register variables were supposed to be faster than local variables.

However, modern compilers are very good at code optimization, and there is a rare chance that using register variables will make your program faster.

Unless you are working on embedded systems where you know how to optimize code for the given application, there is no use of register variables.

Static Variable

A static variable is declared by using the static keyword. For example;
static int i;
The value of a static variable persists until the end of the program.

Example 2: Static Variable

```
#include <stdio.h>
void display();

int main()
{
   display();
   display();
}
void display()
{
   static int c = 1;
   c += 5;
   printf("%d  ",c);
}
```

Output

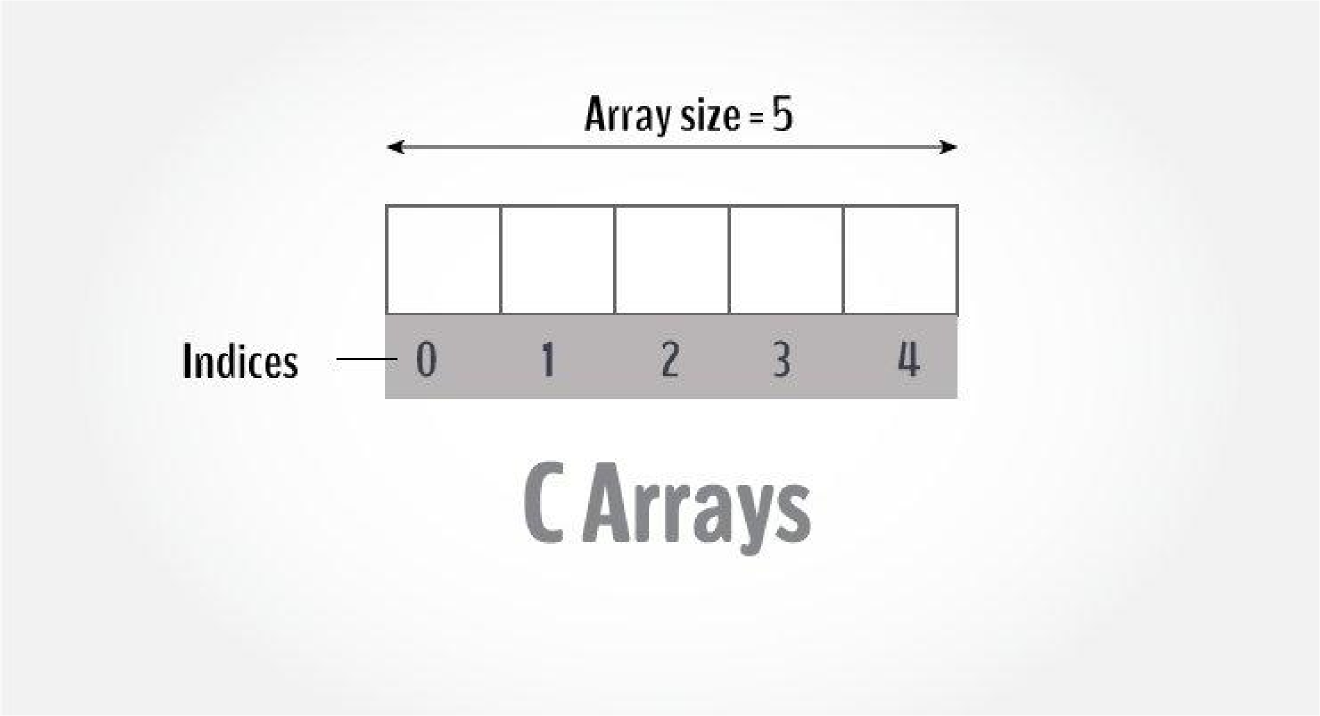
```
                  6 11
```

During the first function call, the value of c is initialized to 1. Its value has increased by 5. Now, the value of c is 6, which is printed on the screen.

During the second function call, c is not initialized to 1 again. It's because c is a static variable. The value c is increased by 5. Now, its value will be 11, which is printed on the screen.

C Arrays

In this tutorial, you will learn to work with arrays. You will learn to declare, initialize and access elements of an array with the help of examples.



Arrays in C

An array is a variable that can store multiple values. For example, if you want to store 100 integers, you can create an array for it.

```
int data[100];
```

How to declare an array?

```
dataType arrayName[arraySize];
```

For example,

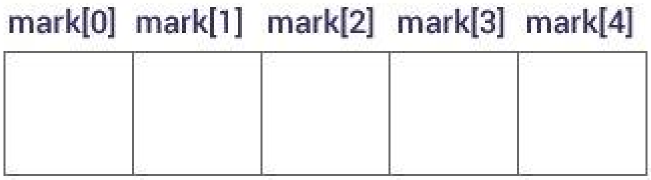
```
float mark[5];
```

Here, we declared an array, mark, of floating-point type. And its size is 5. Meaning, it can hold 5 floating-point values.

It's important to note that the size and type of an array cannot be changed once it is declared.

Access Array Elements

You can access elements of an array by indices.
Suppose you declared an array mark as above. The first element is mark[0], the second element is mark[1] and so on.



mark[0]	mark[1]	mark[2]	mark[3]	mark[4]

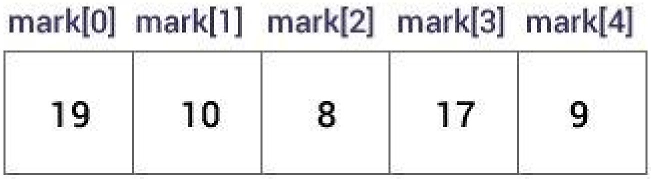
Declare an Array

Few keynotes:

- Arrays have 0 as the first index, not 1. In this example, mark[0] is the first element.
- If the size of an array is n, to access the last element, the n-1 index is used. In this example, mark[4]
- Suppose the starting address of mark[0] is 2120d. Then, the address of the mark[1] will be 2124d. Similarly, the address of mark[2] will be 2128d and so on.
  This is because the size of a float is 4 bytes.

How to initialize an array?

It is possible to initialize an array during declaration. For example,
int mark[5] = {19, 10, 8, 17, 9};
You can also initialize an array like this.
int mark[] = {19, 10, 8, 17, 9};
Here, we haven't specified the size. However, the compiler knows its size is 5 as we are initializing it with 5 elements.



mark[0]	mark[1]	mark[2]	mark[3]	mark[4]
19	10	8	17	9

Initialize an Array

Here,
mark[0] is equal to 19
mark[1] is equal to 10
mark[2] is equal to 8
mark[3] is equal to 17
mark[4] is equal to 9

Change Value of Array elements

```
int mark[5] = {19, 10, 8, 17, 9}

// make the value of the third element to -1
mark[2] = -1;

// make the value of the fifth element to 0
mark[4] = 0;
```

Input and Output Array Elements

Here's how you can take input from the user and store it in an array element.

```
// take input and store it in the 3rd element
scanf("%d", &mark[2]);

// take input and store it in the ith element
scanf("%d", &mark[i-1]);
```

Here's how you can print an individual element of an array.

```
// print the first element of the array
printf("%d", mark[0]);

// print the third element of the array
printf("%d", mark[2]);

// print ith element of the array
printf("%d", mark[i-1]);
```

Example 1: Array Input/Output

```
// Program to take 5 values from the user and store them in an array
// Print the elements stored in the array
#include <stdio.h>

int main() {
  int values[5];

  printf("Enter 5 integers: ");

  // taking input and storing it in an array
  for(int i = 0; i < 5; ++i) {
     scanf("%d", &values[i]);
  }

  printf("Displaying integers: ");

  // printing elements of an array
  for(int i = 0; i < 5; ++i) {
     printf("%d\n", values[i]);
  }
  return 0;
}
```

```
Output
Enter 5 integers: 1
-3
34
0
3
Displaying integers: 1
-3
34
0
3
```

Here, we have used a for loop to take 5 inputs from the user and store them in an array. Then, using another for loop, these elements are displayed on the screen.

Example 2: Calculate Average

```
// Program to find the average of n numbers using arrays
#include <stdio.h>
int main()
{
     int marks[10], i, n, sum = 0, average;
     printf("Enter number of elements: ");
     scanf("%d", &n);
     for(i=0; i<n; ++i)
     {
          printf("Enter number%d: ",i+1);
          scanf("%d", &marks[i]);
          // adding integers entered by the user to the sum variable
          sum += marks[i];
     }
     average = sum/n;
     printf("Average = %d", average);
     return 0;
}
```

Output :

```
Enter n: 5
Enter number1: 45
Enter number2: 35
Enter number3: 38
Enter number4: 31
Enter number5: 49
Average = 39
```

Here, we have computed the average of n numbers entered by the user.

Access elements out of its bound!

Suppose you declared an array of 10 elements. Let's say,

```
int testArray[10];
```

You can access the array elements from testArray[0] to testArray[9].

Now let's say if you try to access testArray[12]. The element is not available. This may cause unexpected output (undefined behavior). Sometimes you might get an error and some other time your program may run correctly.

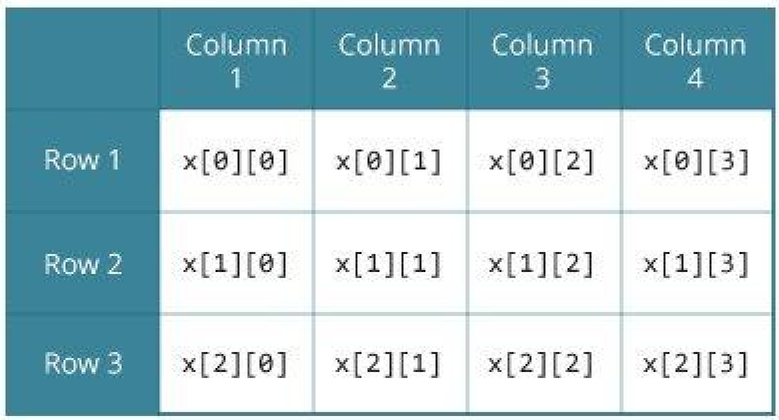
Hence, you should never access elements of an array outside of its bounds.

C Multidimensional Arrays

In this tutorial, you will learn to work with multidimensional arrays (two-dimensional and three-dimensional arrays) with the help of examples.
In C programming, you can create an array of arrays. These arrays are known as multidimensional arrays. For example,

```
float x[3][4];
```

Here, x is a two-dimensional (2d) array. The array can hold 12 elements. You can think the array as a table with 3 rows and each row has 4 columns.



	Column 1	Column 2	Column 3	Column 4
Row 1	x[0][0]	x[0][1]	x[0][2]	x[0][3]
Row 2	x[1][0]	x[1][1]	x[1][2]	x[1][3]
Row 3	x[2][0]	x[2][1]	x[2][2]	x[2][3]

Similarly, you can declare a three-dimensional (3d) array.
For example,

```
float y[2][4][3];
```

Here, the array y can hold 24 elements.

Initializing a multidimensional array

Here is how you can initialize two-dimensional and three-dimensional arrays:

Initialization of a 2d array

```
// Different ways to initialize two-dimensional array

int c[2][3] = {{1, 3, 0}, {-1, 5, 9}};

int c[][3] = {{1, 3, 0}, {-1, 5, 9}};

int c[2][3] = {1, 3, 0, -1, 5, 9};
```

Initialization of a 3d array

You can initialize a three-dimensional array in a similar way like a two-dimensional array. Here's an example,

```
int test[2][3][4] = {
    {{3, 4, 2, 3}, {0, -3, 9, 11}, {23, 12, 23, 2}},
    {{13, 4, 56, 3}, {5, 9, 3, 5}, {3, 1, 4, 9}}};
```

Example 1: Two-dimensional array to store and print values

```
// C program to store the temperature of two cities in a week and display it.
#include <stdio.h>
const int CITY = 2;
const int WEEK = 7;
int main()
{
  int temperature[CITY][WEEK];

  // Using nested loop to store values in a 2d array
  for (int i = 0; i < CITY; ++i)
  {
    for (int j = 0; j < WEEK; ++j)
    {
      printf("City %d, Day %d: ", i + 1, j + 1);
      scanf("%d", &temperature[i][j]);
    }
  }
  printf("\nDisplaying values: \n\n");

  // Using nested loop to display vlues of a 2d array
  for (int i = 0; i < CITY; ++i)
  {
    for (int j = 0; j < WEEK; ++j)
    {
      printf("City %d, Day %d = %d\n", i + 1, j + 1, temperature[i][j]);
    }
  }
  return 0;
}
```

```
Output
City 1, Day 1: 33
City 1, Day 2: 34
City 1, Day 3: 35
City 1, Day 4: 33
City 1, Day 5: 32
City 1, Day 6: 31
City 1, Day 7: 30
City 2, Day 1: 23
City 2, Day 2: 22
City 2, Day 3: 21
City 2, Day 4: 24
City 2, Day 5: 22
City 2, Day 6: 25
City 2, Day 7: 26

Displaying values:

City 1, Day 1 = 33
City 1, Day 2 = 34
City 1, Day 3 = 35
City 1, Day 4 = 33
City 1, Day 5 = 32
City 1, Day 6 = 31
City 1, Day 7 = 30
City 2, Day 1 = 23
City 2, Day 2 = 22
City 2, Day 3 = 21
City 2, Day 4 = 24
City 2, Day 5 = 22
City 2, Day 6 = 25
City 2, Day 7 = 26
```

Example 2: Sum of two matrices

```
// C program to find the sum of two matrices of order 2*2

#include <stdio.h>
int main()
{
  float a[2][2], b[2][2], result[2][2];

  // Taking input using nested for loop
  printf("Enter elements of 1st matrix\n");
  for (int i = 0; i < 2; ++i)
    for (int j = 0; j < 2; ++j)
    {
      printf("Enter a%d%d: ", i + 1, j + 1);
      scanf("%f", &a[i][j]);
    }

  // Taking input using nested for loop
  printf("Enter elements of 2nd matrix\n");
  for (int i = 0; i < 2; ++i)
    for (int j = 0; j < 2; ++j)
    {
      printf("Enter b%d%d: ", i + 1, j + 1);
      scanf("%f", &b[i][j]);
    }
  // adding corresponding elements of two arrays
  for (int i = 0; i < 2; ++i)
    for (int j = 0; j < 2; ++j)
    {
      result[i][j] = a[i][j] + b[i][j];
    }
  // Displaying the sum
  printf("\nSum Of Matrix:");
  for (int i = 0; i < 2; ++i)
    for (int j = 0; j < 2; ++j)
    {
      printf("%.1f\t", result[i][j]);

      if (j == 1)
        printf("\n");
    }
  return 0;
}
```

Output

```
Enter elements of 1st matrix
Enter a11: 2;
Enter a12: 0.5;
Enter a21: -1.1;
Enter a22: 2;
Enter elements of 2nd matrix
Enter b11: 0.2;
Enter b12: 0;
Enter b21: 0.23;
Enter b22: 23;

Sum Of Matrix:
2.2     0.5
-0.9    25.0
```

Example 3: Three-dimensional array

```
// C Program to store and print 12 values entered by the user

#include <stdio.h>
int main()
{
  int test[2][3][2];

  printf("Enter 12 values: \n");

  for (int i = 0; i < 2; ++i)
  {
    for (int j = 0; j < 3; ++j)
    {
      for (int k = 0; k < 2; ++k)
      {
        scanf("%d", &test[i][j][k]);
      }
    }
  }

  // Printing values with proper index.

  printf("\nDisplaying values:\n");
  for (int i = 0; i < 2; ++i)
  {
    for (int j = 0; j < 3; ++j)
    {
      for (int k = 0; k < 2; ++k)
      {
        printf("test[%d][%d][%d] = %d\n", i, j, k, test[i][j][k]);
      }
    }
  }

  return 0;
}
```

Pass arrays to a function in C

In this tutorial, you'll learn to pass arrays (both one-dimensional and multidimensional arrays) to a function in C programming with the help of examples.
In C programming, you can pass an entire array to functions. Before we learn that, let's see how you can pass individual elements of an array to functions.

Pass Individual Array Elements

Passing array elements to a function is similar to passing variables to a function.

Example 1: Pass Individual Array Elements

```
#include <stdio.h>
void display(int age1, int age2) {
  printf("%d\n", age1);
  printf("%d\n", age2);
}

int main() {
  int ageArray[] = {2, 8, 4, 12};

  // pass second and third elements to display()
  display(ageArray[1], ageArray[2]);
  return 0;
}
```

Output

```
8
4
```

Here, we have passed array parameters to the display() function in the same way we pass variables to a function.

```
// pass second and third elements to display()
display(ageArray[1], ageArray[2]);
```

We can see this in the function definition, where the function parameters are individual variables:

```
void display(int age1, int age2) {
  // code
}
```

Example 2: Pass Arrays to Functions

```
// Program to calculate the sum of array elements by passing to a function

#include <stdio.h>
float calculateSum(float num[]);

int main() {
  float result, num[] = {23.4, 55, 22.6, 3, 40.5, 18};

  // num array is passed to calculateSum()
  result = calculateSum(num);
  printf("Result = %.2f", result);
  return 0;
}

float calculateSum(float num[]) {
  float sum = 0.0;

  for (int i = 0; i < 6; ++i) {
    sum += num[i];
  }

  return sum;
}
```

Output

```
Result = 162.50
```

To pass an entire array to a function, only the name of the array is passed as an argument.

```
result = calculateSum(num);
```

However, notice the use of [] in the function definition.

```
float calculateSum(float num[]) {
... ..
}
```

This informs the compiler that you are passing a one-dimensional array to the function.

Pass Multidimensional Arrays to a Function

To pass multidimensional arrays to a function, only the name of the array is passed to the function (similar to one-dimensional arrays).

Example 3: Pass two-dimensional arrays

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

```
void displayNumbers(int num[2][2]);
int main() {
  int num[2][2];
  printf("Enter 4 numbers:\n");
  for (int i = 0; i < 2; ++i) {
    for (int j = 0; j < 2; ++j) {
      scanf("%d", &num[i][j]);
    }
  }
  // pass multi-dimensional array to a function
  displayNumbers(num);
  return 0;
}
void displayNumbers(int num[2][2]) {
  printf("Displaying:\n");
  for (int i = 0; i < 2; ++i) {
    for (int j = 0; j < 2; ++j) {
      printf("%d\n", num[i][j]);
    }
  }
}
```

Output :

```
Enter 4 numbers:
2
3
4
5
Displaying:
2
3
4
5
```

Notice the parameter int num[2][2] in the function prototype and function definition:

```
// function prototype
void displayNumbers(int num[2][2]);
```

This signifies that the function takes a two-dimensional array as an argument. We can also pass arrays with more than 2 dimensions as a function argument.

When passing two-dimensional arrays, it is not mandatory to specify the number of rows in the array. However, the number of columns should always be specified.

For example,

```
void displayNumbers(int num[][2]) {
  // code
}
```

C Pointers

In this tutorial, you'll learn about pointers; what pointers are, how do you use them and the common mistakes you might face when working with them with the help of examples.

Pointers are powerful features of C and C++ programming. Before we learn pointers, let's learn about addresses in C programming.

Address in C

If you have a variable var in your program, &var will give you its address in the memory.

We have used address numerous times while using the scanf() function.

```
scanf("%d", &var);
```

Here, the value entered by the user is stored in the address of var variable. Let's take a working example.

```
#include <stdio.h>
int main()
{
  int var = 5;
  printf("var: %d\n", var);
  // Notice the use of & before var
  printf("address of var: %p", &var);
  return 0;
}
```

Output

```
var: 5
address of var: 2686778
```

Note: You will probably get a different address when you run the above code.

C Pointers

Pointers (pointer variables) are special variables that are used to store addresses rather than values.

Pointer Syntax

Here is how we can declare pointers.

```
int* p;
```

Here, we have declared a pointer p of int type.

You can also declare pointers in these ways.

```
int *p1;
int * p2;
```

Let's take another example of declaring pointers.

```
int* p1, p2;
```

Here, we have declared a pointer p1 and a normal variable p2.

Assigning addresses to Pointers

Let's take an example.

```
int* pc, c;
c = 5;
pc = &c;
```

Here, 5 is assigned to the c variable. And, the address of c is assigned to the pc pointer.

Get Value of Thing Pointed by Pointers

To get the value of the thing pointed by the pointers, we use the * operator. For example:

```
int* pc, c;
c = 5;
pc = &c;
printf("%d", *pc);   // Output: 5
```

Here, the address of c is assigned to the pc pointer. To get the value stored in that address, we used *pc.

Note: In the above example, pc is a pointer, not *pc. You cannot and should not do something like *pc = &c;

By the way, * is called the dereference operator (when working with pointers). It operates on a pointer and gives the value stored in that pointer.

Changing Value Pointed by Pointers

Let's take an example.

```
int* pc, c;
c = 5;
pc = &c;
c = 1;
printf("%d", c);    // Output: 1
printf("%d", *pc);  // Ouptut: 1
```

We have assigned the address of c to the pc pointer.

Then, we changed the value of c to 1. Since pc and the address of c is the same, *pc gives us 1.

Let's take another example.

```
int* pc, c;
c = 5;
pc = &c;
*pc = 1;
printf("%d", *pc);  // Ouptut: 1
printf("%d", c);    // Output: 1
```

We have assigned the address of c to the pc pointer.

Then, we changed *pc to 1 using *pc = 1;. Since pc and the address of c is the same, c will be equal to 1.

Let's take one more example.

```
int* pc, c, d;
c = 5;
d = -15;
pc = &c; printf("%d", *pc); // Output: 5
pc = &d; printf("%d", *pc); // Ouptut: -15
```

Initially, the address of c is assigned to the pc pointer using pc = &c;. Since c is 5, *pc gives us 5. Then, the address of d is assigned to the pc pointer using pc = &d;. Since d is -15, *pc gives us -15.

Example: Working of Pointers

Let's take a working example.

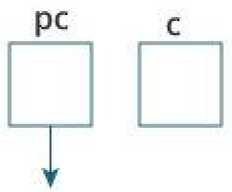
```
#include <stdio.h>
int main()
{
  int* pc, c;

  c = 22;
  printf("Address of c: %p\n", &c);
  printf("Value of c: %d\n\n", c);  // 22

  pc = &c;
  printf("Address of pointer pc: %p\n", pc);
  printf("Content of pointer pc: %d\n\n", *pc); // 22

  c = 11;
  printf("Address of pointer pc: %p\n", pc);
  printf("Content of pointer pc: %d\n\n", *pc); // 11

  *pc = 2;
  printf("Address of c: %p\n", &c);
  printf("Value of c: %d\n\n", c); // 2
  return 0;
}
```

Output

```
Address of c: 2686784
Value of c: 22

Address of pointer pc: 2686784
Content of pointer pc: 22

Address of pointer pc: 2686784
Content of pointer pc: 11

Address of c: 2686784
Value of c: 2
```

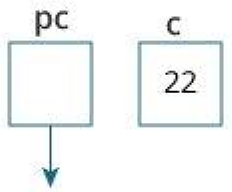
Explanation of the program

1. int* pc, c;



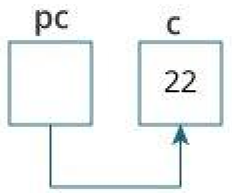
Here, a pointer pc and a normal variable c, both of type int, is created.
Since pc and c are not initialized at initially, pointer pc points to either no address or a random address. And, variable c has an address but contains random garbage value.

2. c = 22;



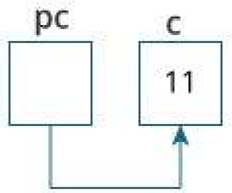
This assigns 22 to the variable c. That is, 22 is stored in the memory location of variable c.

3. pc = &c;



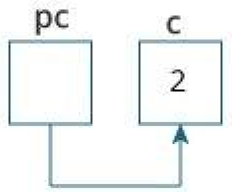
This assigns the address of variable c to the pointer pc.

4. c = 11;



This assigns 11 to variable c.

5. *pc = 2;



This change the value at the memory location pointed by the pointer pc to 2.

Common mistakes when working with pointers

Suppose, you want pointer pc to point to the address of c. Then,

```
int c, *pc;

// pc is address but c is not
pc = c;  // Error

// &c is address but *pc is not
*pc = &c;  // Error

// both &c and pc are addresses
pc = &c;  // Not an error

// both c and *pc values
*pc = c;  // Not an error
```

Here's an example of pointer syntax beginners often find confusing.

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

   printf("%d", *p);  // 5
   return 0;
}
```

Why didn't we get an error when using int *p = &c;?

It's because

```
int *p = &c;
```

is equivalent to

```
int *p:
p = &c;
```

In both cases, we are creating a pointer p (not *p) and assigning &c to it.

To avoid this confusion, we can use the statement like this:

```
int* p = &c;
```

C Programming Strings

In this tutorial, you'll learn about strings in C programming. You'll learn to declare them, initialize them and use them for various I/O operations with the help of examples.
In C programming, a string is a sequence of characters terminated with a null character \0. For example:

```
char c[] = "c string";
```

When the compiler encounters a sequence of characters enclosed in the double quotation marks, it appends a null character \0 at the end by default.
Memory Diagram

How to declare a string?

Here's how you can declare strings:

```
char s[5];
```

String Declaration in C
Here, we have declared a string of 5 characters.

How to initialize strings?

You can initialize strings in a number of ways.

```
char c[] = "abcd";

char c[50] = "abcd";

char c[] = {'a', 'b', 'c', 'd', '\0'};

char c[5] = {'a', 'b', 'c', 'd', '\0'};
```

String Initialization in C
Let's take another example:

```
char c[5] = "abcde";
```

Here, we are trying to assign 6 characters (the last character is '\0') to a char array having 5 characters. This is bad and you should never do this.

Assigning Values to Strings

Arrays and strings are second-class citizens in C; they do not support the assignment operator once it is declared. For example,

```
char c[100];
c = "C programming";  // Error! array type is not assignable.
```

Note: Use the strcpy() function to copy the string instead.

Read String from the user

You can use the scanf() function to read a string.
The scanf() function reads the sequence of characters until it encounters whitespace (space, newline, tab, etc.).

Example 1: scanf() to read a string

```
#include <stdio.h>
int main()
{
   char name[20];
   printf("Enter name: ");
   scanf("%s", name);
   printf("Your name is %s.", name);
   return 0;
}
```

Output

```
Enter name: Dennis Ritchie
Your name is Dennis.
```

Even though Dennis Ritchie was entered in the above program, only "Dennis" was stored in the name string. It's because there was a space after Dennis.
Also notice that we have used the code name instead of &name with scanf().
scanf("%s", name);
This is because name is a char array, and we know that array names decay to pointers in C.
Thus, the name in scanf() already points to the address of the first element in the string, which is why we don't need to use &.

How to read a line of text?

You can use the fgets() function to read a line of string. And, you can use puts() to display the string.

Example 2: fgets() and puts()

```
#include <stdio.h>
int main()
{
   char name[30];
   printf("Enter name: ");
   fgets(name, sizeof(name), stdin);  // read string
   printf("Name: ");
   puts(name);    // display string
   return 0;
}
```

Output

```
Enter name: Tom Hanks
Name: Tom Hanks
```

Here, we have used fgets() function to read a string from the user.

```
fgets(name, sizeof(name), stdlin); // read string
```

The sizeof(name) results to 30. Hence, we can take a maximum of 30 characters as input which is the size of the name string.

To print the string, we have used puts(name);.

Note: The gets() function can also be to take input from the user. However, it is removed from the C standard.

It's because gets() allows you to input any length of characters. Hence, there might be a buffer overflow.

Passing Strings to Functions

Strings can be passed to a function in a similar way as arrays.

Example 3: Passing string to a Function

```
#include <stdio.h>
void displayString(char str[]);

int main()
{
   char str[50];
   printf("Enter string: ");
   fgets(str, sizeof(str), stdin);
   displayString(str);     // Passing string to a function.
   return 0;
}
void displayString(char str[])
{
   printf("String Output: ");
   puts(str);
}
```

Strings and Pointers

Similar like arrays, string names are "decayed" to pointers. Hence, you can use pointers to manipulate elements of the string.

Example 4: Strings and Pointers

```
#include <stdio.h>

int main(void)
{
  char name[] = "Harry Potter";

  printf("%c", *name);
// Output: H
  printf("%c", *(name+1));
// Output: a
  printf("%c", *(name+7));
// Output: o

  char *namePtr;

  namePtr = name;
  printf("%c", *namePtr);
// Output: H
  printf("%c", *(namePtr+1));
// Output: a
  printf("%c", *(namePtr+7));
// Output: o
}
```

String Manipulations In C Programming Using Library Functions

In this article, you'll learn to manipulate strings in C using library functions such as gets(), puts, strlen() and more. You'll learn to get string from the user and perform operations on the string.
You need to often manipulate strings according to the need of a problem. Most, if not all, of the time string manipulation can be done manually but, this makes programming complex and large.
To solve this, C supports a large number of string handling functions in the standard library "string.h".
Few commonly used string handling functions are discussed below:

Function	Work of Function
strlen()	computes string's length
strcpy()	copies a string to another
strcat()	concatenates(joins) two strings
strcmp()	compares two strings
strlwr()	converts string to lowercase
strupr()	converts string to uppercase

Strings handling functions are defined under "string.h" header file.

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

Note: You have to include the code below to run string handling functions.

gets() and puts()

Functions gets() and puts() are two string functions to take string input from the user and display it respectively as mentioned in the previous chapter.

```
#include<stdio.h>
int main()
{
   char name[30];
   printf("Enter name: ");
   gets(name);     //Function to read string from user.
   printf("Name: ");
   puts(name);    //Function to display string.
   return 0;
}
```

C File Handling

In this tutorial, you will learn about file handling in C. You will learn to handle standard I/O in C using fprintf(), fscanf(), fread(), fwrite(), fseek() etc. with the help of examples.
A file is a container in computer storage devices used for storing data.

Why files are needed?

- When a program is terminated, the entire data is lost. Storing in a file will preserve your data even if the program terminates.
- If you have to enter a large number of data, it will take a lot of time to enter them all. However, if you have a file containing all the data, you can easily access the contents of the file using a few commands in C.
- You can easily move your data from one computer to another without any changes.

Types of Files

When dealing with files, there are two types of files you should know about:

1. Text files
2. Binary files

1. Text files

Text files are the normal .txt files. You can easily create text files using any simple text editors such as Notepad.
When you open those files, you'll see all the contents within the file as plain text. You can easily edit or delete the contents.
They take minimum effort to maintain, are easily readable, and provide the least security and takes bigger storage space.

2. Binary files

Binary files are mostly the .bin files in your computer.
Instead of storing data in plain text, they store it in the binary form (0's and 1's).
They can hold a higher amount of data, are not readable easily, and provides better security than text files.

File Operations

In C, you can perform four major operations on files, either text or binary:

1. Creating a new file
2. Opening an existing file
3. Closing a file
4. Reading from and writing information to a file

Working with files

When working with files, you need to declare a pointer of type file. This declaration is needed for communication between the file and the program.
FILE *fptr;

Opening a file - for creation and edit

Opening a file is performed using the fopen() function defined in the stdio.h header file.
The syntax for opening a file in standard I/O is:
ptr = fopen("fileopen","mode");

For example,
fopen("E:\\cprogram\\newprogram.txt","w");

fopen("E:\\cprogram\\oldprogram.bin","rb");

- Let's suppose the file newprogram.txt doesn't exist in the location E:\cprogram. The first function creates a new file named newprogram.txt and opens it for writing as per the mode 'w'. The writing mode allows you to create and edit (overwrite) the contents of the file.
- Now let's suppose the second binary file oldprogram.bin exists in the location E:\cprogram. The second function opens the existing file for reading in binary mode 'rb'. The reading mode only allows you to read the file, you cannot write into the file.

Mode	Meaning of Mode	During Inexistence of file
r	Open for reading.	If the file does not exist, fopen() returns NULL.
rb	Open for reading in binary mode.	If the file does not exist, fopen() returns NULL.
w	Open for writing.	If the file exists, its contents are overwritten. If the file does not exist, it will be created.
wb	Open for writing in binary mode.	If the file exists, its contents are overwritten. If the file does not exist, it will be created.

a	Open for append. Data is added to the end of the file.	If the file does not exist, it will be created.
ab	Open for append in binary mode. Data is added to the end of the file.	If the file does not exist, it will be created.
r+	Open for both reading and writing.	If the file does not exist, fopen() returns NULL.
rb+	Open for both reading and writing in binary mode.	If the file does not exist, fopen() returns NULL.
w+	Open for both reading and writing.	If the file exists, its contents are overwritten. If the file does not exist, it will be created.
wb+	Open for both reading and writing in binary mode.	If the file exists, its contents are overwritten. If the file does not exist, it will be created.
a+	Open for both reading and appending.	If the file does not exist, it will be created.
ab+	Open for both reading and appending in binary mode.	If the file does not exist, it will be created.

Closing a File

The file (both text and binary) should be closed after reading/writing.
Closing a file is performed using the fclose() function.
fclose(fptr);
Here, fptr is a file pointer associated with the file to be closed.

Reading and writing to a text file

For reading and writing to a text file, we use the functions fprintf() and fscanf().
They are just the file versions of printf() and scanf(). The only difference is that fprintf() and fscanf() expects a pointer to the structure FILE.

Example 1: Write to a text file

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

int main()
{
  int num;
  FILE *fptr;

  // use appropriate location if you are using MacOS or Linux
  fptr = fopen("C:\\program.txt","w");

  if(fptr == NULL)
  {
    printf("Error!");
    exit(1);
  }

  printf("Enter num: ");
  scanf("%d",&num);

  fprintf(fptr,"%d",num);
  fclose(fptr);

  return 0;
}
```

This program takes a number from the user and stores in the file program.txt.
After you compile and run this program, you can see a text file program.txt created in C drive of your computer. When you open the file, you can see the integer you entered.

Example 2: Read from a text file :

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

int main()
{
  int num;
  FILE *fptr;

  if ((fptr = fopen("C:\\program.txt","r")) == NULL){
     printf("Error! opening file");

     // Program exits if the file pointer returns NULL.
     exit(1);
  }

  fscanf(fptr,"%d", &num);

  printf("Value of n=%d", num);
  fclose(fptr);

  return 0;
}
```

This program reads the integer present in the program.txt file and prints it onto the screen.
If you successfully created the file from Example 1, running this program will get you the integer you entered.
Other functions like fgetchar(), fputc() etc. can be used in a similar way.

Reading and writing to a binary file

Functions fread() and fwrite() are used for reading from and writing to a file on the disk respectively in case of binary files.

Writing to a binary file

To write into a binary file, you need to use the fwrite() function. The functions take four arguments:

1. address of data to be written in the disk
2. size of data to be written in the disk
3. number of such type of data
4. pointer to the file where you want to write.

```
fwrite(addressData, sizeData, numbersData, pointerToFile);
```

Example 3: Write to a binary file using fwrite()

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

struct threeNum
{
  int n1, n2, n3;
};

int main()
{
  int n;
  struct threeNum num;
  FILE *fptr;

  if ((fptr = fopen("C:\\program.bin","wb")) == NULL){
     printf("Error! opening file");

     // Program exits if the file pointer returns NULL.
     exit(1);
  }

  for(n = 1; n < 5; ++n)
  {
    num.n1 = n;
    num.n2 = 5*n;
    num.n3 = 5*n + 1;
    fwrite(&num, sizeof(struct threeNum), 1, fptr);
  }
  fclose(fptr);

  return 0;
}
```

In this program, we create a new file program.bin in the C drive.
We declare a structure threeNum with three numbers - n1, n2 and n3, and define it in the main function as num.
Now, inside the for loop, we store the value into the file using fwrite().
The first parameter takes the address of num and the second parameter takes the size of the structure threeNum.
Since we're only inserting one instance of num, the third parameter is 1. And, the last parameter *fptr points to the file we're storing the data.
Finally, we close the file.

Reading from a binary file

Function fread() also take 4 arguments similar to the fwrite() function as above.
fread(addressData, sizeData, numbersData, pointerToFile);

Example 4: Read from a binary file using fread()

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

struct threeNum
{
  int n1, n2, n3;
};

int main()
{
  int n;
  struct threeNum num;
  FILE *fptr;

  if ((fptr = fopen("C:\\program.bin","rb")) == NULL){
     printf("Error! opening file");

     // Program exits if the file pointer returns NULL.
     exit(1);
  }

  for(n = 1; n < 5; ++n)
  {
    fread(&num, sizeof(struct threeNum), 1, fptr);
    printf("n1: %d\tn2: %d\tn3: %d\n", num.n1, num.n2, num.n3);
  }
  fclose(fptr);

  return 0;
}
```

In this program, you read the same file program.bin and loop through the records one by one.
In simple terms, you read one threeNum record of threeNum size from the file pointed by *fptr into the structure num.
You'll get the same records you inserted in Example 3.