C++ Getting Started

C++ Get Started

To start using C++, you need two things:

- A text editor, like Notepad, to write C++ code
- A compiler, like GCC, to translate the C++ code into a language that the computer will understand

There are many text editors and compilers to choose from. In this tutorial, we will use an IDE (see below).

C++ Install IDE

An IDE (Integrated Development Environment) is used to edit AND compile the code.

Popular IDE's include Code::Blocks, Eclipse, and Visual Studio. These are all free, and they can be used to both edit and debug C++ code.

Note: Web-based IDE's can work as well, but functionality is limited.

We will use **Code::Blocks** in our tutorial, which we believe is a good place to start.

You can find the latest version of Codeblocks at http://www.codeblocks.org/. Download the `mingw-setup.exe` file, which will install the text editor with a compiler.

C++ Quickstart

Let's create our first C++ file.

Open Codeblocks and go to **File > New > Empty File**.

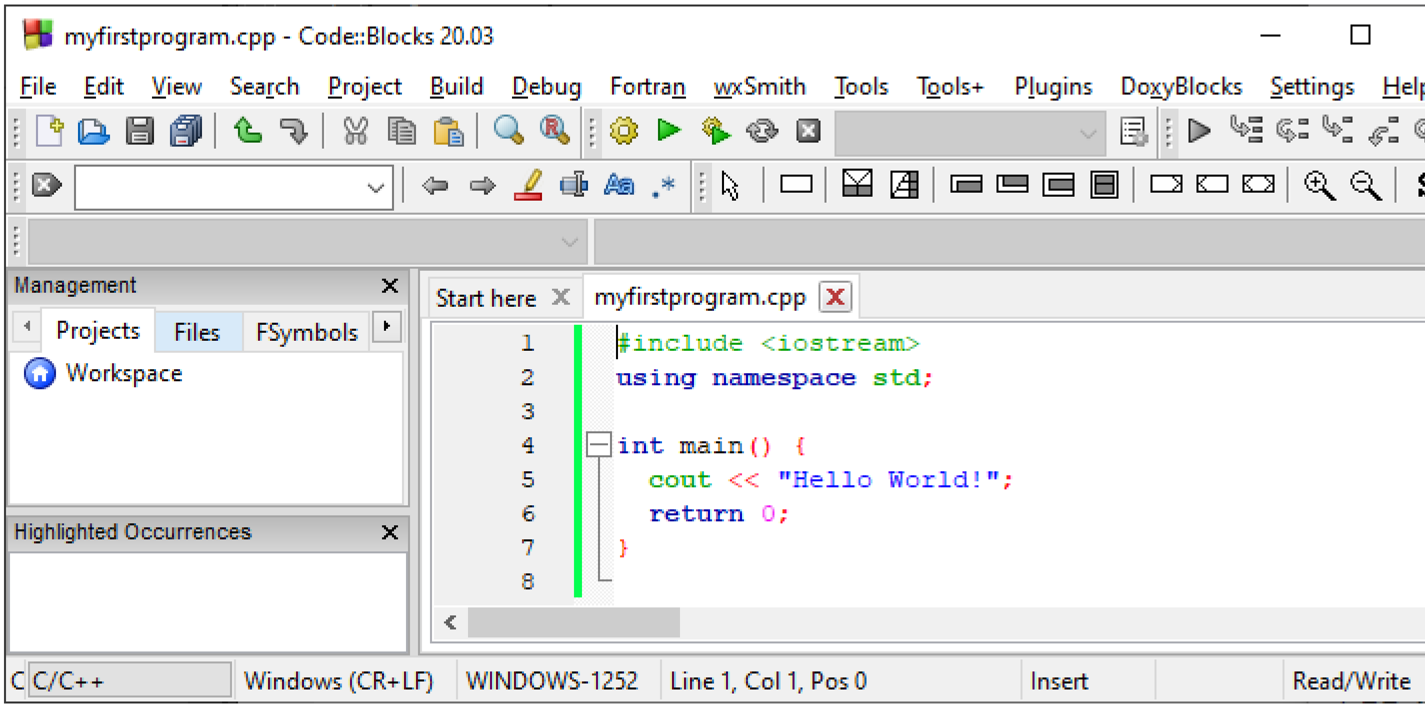
Write the following C++ code and save the file as `myfirstprogram.cpp` (**File > Save File as**): myfirstprogram.cpp

```
#include <iostream>
using namespace std;

int main() {
  cout << "Hello World!";
  return 0;
}
```

Don't worry if you don't understand the code above - we will discuss it in detail in later chapters. For now, focus on how to run the code.

In Codeblocks, it should look like this:



```
#include <iostream>
using namespace std;

int main() {
  cout << "Hello World!";
  return 0;
}

```

Then, go to **Build > Build and Run** to run (execute) the program. The result will look something to this:

```
Hello                                                       World!
Process   returned   0   (0x0)   execution   time   :   0.011   s
Press any key to continue.
```

Congratulations! You have now written and executed your first C++ program.

C++ Syntax

Let's break up the following code to understand it better:

Example

```
#include <iostream>
using namespace std;

int main() {
  cout << "Hello World!";
  return 0;
}
```

Example explained

Line 1: `#include <iostream>` is a **header file library** that lets us work with input and output objects, such as`cout` (used in line 5). Header files add functionality to C++ programs.

Line 2: `using namespace std` means that we can use names for objects and variables from the standard library.

Don't worry if you don't understand how `#include <iostream>` and `using namespace std` works. Just think of it as something that (almost) always appears in your program.

Line 3: A blank line. C++ ignores white space. But we use it to make the code more readable.

Line 4: Another thing that always appear in a C++ program, is `int main()`. This is called a **function**. Any code inside its curly brackets `{}` will be executed.

Line 5: `cout` (pronounced "see-out") is an **object** used together with the *insertion operator* (`<<`) to output/print text. In our example it will output "Hello World!".

Note: Every C++ statement ends with a semicolon `;`.

Note: The body of `int main()` could also been written as:
`int main () { cout << "Hello World! "; return 0; }`

Remember: The compiler ignores white spaces. However, multiple lines makes the code more readable.

Line 6: `return 0` ends the main function.

Line 7: Do not forget to add the closing curly bracket `}` to actually end the main function.

Omitting Namespace

You might see some C++ programs that runs without the standard namespace library. The `using namespace std`line can be omitted and replaced with the `std` keyword, followed by the `::` operator for some objects:

Example

```
#include <iostream>

int main() {
  std::cout << "Hello World!";
  return 0;
}
```

It is up to you if you want to include the standard namespace library or not.

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C++ Output (Print Text)

The `cout` object, together with the `<<` operator, is used to output values/print text:

Example

```
#include <iostream>
using namespace std;

int main() {
  cout << "Hello World!";
  return 0;
}
```
Try it Yourself »

You can add as many cout objects as you want. However, note that it does not insert a new line at the end of the output:

Example

```
#include <iostream>
using namespace std;

int main() {
  cout << "Hello World!";
  cout << "I am learning C++";
  return 0;
}
```

C++ New Lines

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New Lines

To insert a new line, you can use the \n character:

Example

```
#include <iostream>
using namespace std;

int main() {
  cout << "Hello World! \n";
  cout << "I am learning C++";
  return 0;
}
```
Try it Yourself »

Tip: Two \n characters after each other will create a blank line:

Example

```
#include <iostream>
using namespace std;

int main() {
  cout << "Hello World! \n\n";
  cout << "I am learning C++";
  return 0;
}
```

Another way to insert a new line, is with the `endl` manipulator:

Example

```
#include <iostream>
using namespace std;

int main() {
  cout << "Hello World!" << endl;
  cout << "I am learning C++";
  return 0;
}
```

Try it Yourself »

Both `\n` and `endl` are used to break lines. However, `\n` is most used.

But what is \n exactly?

The newline character (`\n`) is called an **escape sequence**, and it forces the cursor to change its position to the beginning of the next line on the screen. This results in a new line.

Examples of other valid escape sequences are:

Escape Sequence	**Description**
\t	Creates a horizontal tab
\\	Inserts a backslash character (\)
\"	Inserts a double quote character

C++ Comments

Comments can be used to explain C++ code, and to make it more readable. It can also be used to prevent execution when testing alternative code. Comments can be singled-lined or multi-lined.

Single-line Comments

Single-line comments start with two forward slashes (`//`).

Any text between `//` and the end of the line is ignored by the compiler (will not be executed).

This example uses a single-line comment before a line of code:

Example

```
// This is a comment
cout << "Hello World!";
```

Try it Yourself »

This example uses a single-line comment at the end of a line of code:

Example

```
cout << "Hello World!"; // This is a comment
```

C++ Multi-line Comments

Multi-line comments start with `/*` and ends with `*/`.

Any text between `/*` and `*/` will be ignored by the compiler:

Example

```
/* The code below will print the words Hello World!
to the screen, and it is amazing */
cout << "Hello World!";
```

Try it Yourself »

C++ Variables

Variables are containers for storing data values.

In C++, there are different **types** of variables (defined with different keywords), for example:

- `int` - stores integers (whole numbers), without decimals, such as 123 or -123
- `double` - stores floating point numbers, with decimals, such as 19.99 or -19.99
- `char` - stores single characters, such as 'a' or 'B'. Char values are surrounded by single quotes
- `string` - stores text, such as "Hello World". String values are surrounded by double quotes
- `bool` - stores values with two states: true or false

Declaring (Creating) Variables

To create a variable, specify the type and assign it a value:

Syntax

```
type variableName = value;
```

Where *type* is one of C++ types (such as `int`), and *variableName* is the name of the variable (such as **x** or **myName**). The **equal sign** is used to assign values to the variable.

To create a variable that should store a number, look at the following example:

Example

Create a variable called **myNum** of type `int` and assign it the value **15**:

```
int myNum = 15;
cout << myNum;
```

Try it Yourself »

You can also declare a variable without assigning the value, and assign the value later:

Example

```
int myNum;
myNum = 15;
cout << myNum;
```

Try it Yourself »

Note that if you assign a new value to an existing variable, it will overwrite the previous value:

Example

```
int myNum = 15;  // myNum is 15
myNum = 10;  // Now myNum is 10
cout << myNum;  // Outputs 10
```

Try it Yourself »

Other Types

A demonstration of other data types:

Example

```
int myNum = 5;               // Integer (whole number without decimals)
double myFloatNum = 5.99;    // Floating point number (with decimals)
char myLetter = 'D';         // Character
string myText = "Hello";     // String (text)
bool myBoolean = true;       // Boolean (true or false)
```

You will learn more about the individual types in the Data Types chapter.

Display Variables

The `cout` object is used together with the `<<` operator to display variables.

To combine both text and a variable, separate them with the `<<` operator:

Example

```
int myAge = 35;
cout << "I am " << myAge << " years old.";
```

Try it Yourself »

Add Variables Together

To add a variable to another variable, you can use the `+` operator:

Example

```
int x = 5;
int y = 6;
int sum = x + y;
cout << sum;
```

Try it Yourself »

C++ Declare Multiple Variables

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Declare Many Variables

To declare more than one variable of the **same type**, use a comma-separated list:

Example

```
int x = 5, y = 6, z = 50;
cout << x + y + z;
```

Try it Yourself »

One Value to Multiple Variables

You can also assign the **same value** to multiple variables in one line:

Example

```
int x, y, z;
x = y = z = 50;
cout << x + y + z;
```

C++ Identifiers

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C++ Identifiers

All C++ **variables** must be **identified** with **unique names**.

These unique names are called **identifiers**.

Identifiers can be short names (like x and y) or more descriptive names (age, sum, totalVolume).

Note: It is recommended to use descriptive names in order to create understandable and maintainable code:

Example

```
// Good
int minutesPerHour = 60;

// OK, but not so easy to understand what m actually is
int m = 60;
```

Try it Yourself »

The general rules for naming variables are:

- Names can contain letters, digits and underscores
- Names must begin with a letter or an underscore (_)
- Names are case sensitive (`myVar` and `myvar` are different variables)
- Names cannot contain whitespaces or special characters like !, #, %, etc.
- Reserved words (like C++ keywords, such as `int`) cannot be used as names
- ## Constants

- When you do not want others (or yourself) to change existing variable values, use the `const` keyword (this will declare the variable as "constant", which means **unchangeable and read-only**):

- **Example**

-
  ```
  const int myNum = 15;  // myNum will always be 15
  myNum = 10;  // error: assignment of read-only variable 'myNum'
  ```
- Try it Yourself »

You should always declare the varC++ User Input

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C++ User Input

You have already learned that `cout` is used to output (print) values. Now we will use `cin` to get user input.

`cin` is a predefined variable that reads data from the keyboard with the extraction operator (`>>`).

In the following example, the user can input a number, which is stored in the variable `x`. Then we print the value of `x`:

Example

```
int x;
cout << "Type a number: "; // Type a number and press enter
cin >> x; // Get user input from the keyboard
cout << "Your number is: " << x; // Display the input value
```

Run example »

Good To Know

`cout` is pronounced "see-out". Used for **output**, and uses the insertion operator (`<<`)

`cin` is pronounced "see-in". Used for **input**, and uses the extraction operator (`>>`)

Creating a Simple Calculator

In this example, the user must input two numbers. Then we print the sum by calculating (adding) the two numbers:

Example

```
int x, y;
int sum;
cout << "Type a number: ";
cin >> x;
cout << "Type another number: ";
cin >> y;
sum = x + y;
cout << "Sum is: " << sum;
```

Run example »

There you go! You just built a basic calculator!

C++ Exercises

Exercise:

Use the correct keyword to get user input, stored in the variable x:

```
int x;
cout << "Type a number: ";
      >>      ;
```

- iable as constant when you have values that are unlikely to change:

- **Example**

-
  ```
  const int minutesPerHour                                        = 60;
  const float PI = 3.14;
  ```
- Try it Yourself »

C++ Data Types

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C++ Data Types

As explained in the Variables chapter, a variable in C++ must be a specified data type:

Example

```
int myNum = 5;               // Integer (whole number)
float myFloatNum = 5.99;     // Floating point number
double myDoubleNum = 9.98;   // Floating point number
char myLetter = 'D';         // Character
bool myBoolean = true;       // Boolean
string myText = "Hello";     // String
```

Try it Yourself »

Basic Data Types

The data type specifies the size and type of information the variable will store:

Data Type	**Size**	**Description**
`boolean`	1 byte	Stores true or false values
`char`	1 byte	Stores a single character/letter/number, or ASCII values
`int`	2 or 4 bytes	Stores whole numbers, without decimals
`float`	4 bytes	Stores fractional numbers, containing one or more decimals. Sufficient fo digits

`double`	8 bytes	Stores fractional numbers, containing one or more decimals. Sufficient fo digits

You will learn more about the individual data types in the next chapters.

C++ Exercises

Exercise:

Add the correct data type for the following variables:

```
      myNum = 9;
      myDoubleNum = 8.99;
      myLetter = 'A';
      myBool = false;
      myText = "Hello World";
```

C++ Numeric Data Types

Numeric Types

Use `int` when you need to store a whole number without decimals, like 35 or 1000, and `float` or `double` when you need a floating point number (with decimals), like 9.99 or 3.14515.

int

```
int myNum = 1000;
cout << myNum;
```

Try it Yourself »

float

```
float myNum = 5.75;
cout << myNum;
```

Try it Yourself »

double

```
double myNum = 19.99;
cout << myNum;
```

Try it Yourself »

The **precision** of a floating point value indicates how many digits the value can have after the decimal point. The precision of `float` is only six or seven decimal digits, while `double` variables have a precision of about 15 digits. Therefore it is safer to use `double` for most calculations.

Scientific Numbers

A floating point number can also be a scientific number with an "e" to indicate the power of 10:

Example

```
float f1 = 35e3;
double d1 = 12E4;
cout << f1;
cout << d1;
```

C++ Boolean Data Types

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Boolean Types

A boolean data type is declared with the bool keyword and can only take the values true or false.

When the value is returned, true = 1 and false = 0.

Example

```
bool isCodingFun = true;
bool isFishTasty = false;
cout << isCodingFun;  // Outputs 1 (true)
cout << isFishTasty;  // Outputs 0 (false)
```

Try it Yourself »

Boolean values are mostly used for conditional testing, which you will learn more about in a later chapter.

C++ Character Data Types

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Character Types

The char data type is used to store a **single** character. The character must be surrounded by single quotes, like 'A' or 'c':

Example

```
char myGrade = 'B';
cout << myGrade;
```

Try it Yourself »

Alternatively, you can use ASCII values to display certain characters:

Example

```
char a = 65, b = 66, c = 67;
cout << a;
cout << b;
cout << c;
```

Try it Yourself »

Tip: A list of all ASCII values can be found in our ASCII Table Reference.

C++ String Data Types

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String Types

The `string` type is used to store a sequence of characters (text). This is not a built-in type, but it behaves like one in its most basic usage. String values must be surrounded by double quotes:

Example

```
string greeting = "Hello";
cout << greeting;
```

To use strings, you must include an additional header file in the source code, the `<string>` library:

Example

```
// Include the string library
#include <string>

// Create a string variable
string greeting = "Hello";

// Output string value
cout << greeting;
```

Try it Yourself »

You will learn more about strings, in our C++ Strings Chapter.

C++ Operators

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C++ Operators

Operators are used to perform operations on variables and values.

In the example below, we use the + **operator** to add together two values:

Example

```
int x = 100 + 50;
```

Try it Yourself »

Although the + operator is often used to add together two values, like in the example above, it can also be used to add together a variable and a value, or a variable and another variable:

Example

```
int sum1 = 100 + 50;        // 150 (100 + 50)
int sum2 = sum1 + 250;      // 400 (150 + 250)
int sum3 = sum2 + sum2;     // 800 (400 + 400)
```

Try it Yourself »

C++ divides the operators into the following groups:

- Arithmetic operators
- Assignment operators
- Comparison operators
- Logical operators
- Bitwise operators

Arithmetic Operators

Arithmetic operators are used to perform common mathematical operations.

Operator	**Name**	**Description**	**Example**
+	Addition	Adds together two values	x + y
-	Subtraction	Subtracts one value from another	x - y

*	Multiplication	Multiplies two values	x * y
/	Division	Divides one value by another	x / y
%	Modulus	Returns the division remainder	x % y
++	Increment	Increases the value of a variable by 1	++x
--	Decrement	Decreases the value of a variable by 1	--x

C++ Exercises

Test Yourself With Exercises

Exercise:

Multiply 10 with 5, and print the result.

cout << 10 ____ 5;

Submit Answer »

Start the Exercise

C++ Assignment Operators

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Assignment Operators

Assignment operators are used to assign values to variables.

In the example below, we use the **assignment** operator (=) to assign the value **10** to a variable called **x**:

Example

```
int x = 10;
```

Try it Yourself »

The **addition assignment** operator (+=) adds a value to a variable:

Example

```
int x = 10;
x += 5;
```

Try it Yourself »

A list of all assignment operators:

Operator	Example	Same As
=	x = 5	x = 5
+=	x += 3	x = x + 3
-=	x -= 3	x = x - 3
*=	x *= 3	x = x * 3
/=	x /= 3	x = x / 3
%=	x %= 3	x = x % 3
&=	x &= 3	x = x & 3
|=	x |= 3	x = x | 3
^=	x ^= 3	x = x ^ 3
>>=	x >>= 3	x = x >> 3
<<=	x <<= 3	x = x << 3

C++ Comparison Operators
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Comparison Operators
Comparison operators are used to compare two values (or variables). This is important in programming, because it helps us to find answers and make decisions.
The return value of a comparison is either 1 or 0, which means **true** (1) or **false** (0). These values are known as **Boolean values**, and you will learn more about them in the Booleans and If..Else chapter.
In the following example, we use the **greater than** operator (>) to find out if 5 is greater than 3:
Example

```
int x = 5;
int y = 3;
cout << (x > y); // returns 1 (true) because 5 is greater than 3
```

Try it Yourself »

A list of all comparison operators:

Operator	Name	Example
==	Equal to	x == y
!=	Not equal	x != y
>	Greater than	x > y
<	Less than	x < y
>=	Greater than or equal to	x >= y
<=	Less than or equal to	x <= y

You will learn much more about comparison operators and how to use them in a later chapter.

Logical Operators

As with comparison operators, you can also test for **true** (`1`) or **false** (`0`) values with **logical operators**.

Logical operators are used to determine the logic between variables or values:

Operator	Name	Description	Example
&&	Logical and	Returns true if both statements are true	x < 5 && x < 10
||	Logical or	Returns true if one of the statements is true	x < 5 || x < 4
!	Logical not	Reverse the result, returns false if the result is true	!(x < 5 && x < 10)

You will learn much more about **true** and **false** values in a later chapter.

C++ Strings

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C++ Strings

Strings are used for storing text.

A `string` variable contains a collection of characters surrounded by double quotes:

Example

Create a variable of type `string` and assign it a value:

```
string greeting = "Hello";
```

To use strings, you must include an additional header file in the source code, the `<string>` library:

Example

```
// Include the string library
#include <string>

// Create a string variable
string greeting = "Hello";
```

Try it Yourself »

C++ String Concatenation

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String Concatenation

The `+` operator can be used between strings to add them together to make a new string. This is called **concatenation**:

Example

```
string firstName = "John ";
string lastName = "Doe";
string fullName = firstName + lastName;
cout << fullName;
```

Try it Yourself »

In the example above, we added a space after firstName to create a space between John and Doe on output. However, you could also add a space with quotes (`" "` or `' '`):

Example

```
string firstName = "John";
string lastName = "Doe";
string fullName = firstName + " " + lastName;
cout << fullName;
```

Try it Yourself »

Append

A string in C++ is actually an object, which contain functions that can perform certain operations on strings. For example, you can also concatenate strings with the `append()` function:

Example

```
string firstName = "John ";
string lastName = "Doe";
string fullName = firstName.append(lastName);
cout << fullName;
```

C++ Numbers and Strings

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Adding Numbers and Strings

WARNING!

C++ uses the + operator for both **addition** and **concatenation**.

Numbers are added. Strings are concatenated.

If you add two numbers, the result will be a number:

Example

```
int x = 10;
int y = 20;
int z = x + y;      // z will be 30 (an integer)
```

Try it Yourself »

If you add two strings, the result will be a string concatenation:

Example

```
string x = "10";
string y = "20";
string z = x + y;   // z will be 1020 (a string)
```

Try it Yourself »

If you try to add a number to a string, an error occurs:

Example

```
string x = "10";
int y = 20;
string z = x + y;
```

C++ String Length

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String Length

To get the length of a string, use the `length()` function:

Example

```
string txt = "ABCDEFGHIJKLMNOPQRSTUVWXYZ";
cout << "The length of the txt string is: " << txt.length();
```

Try it Yourself »

Tip: You might see some C++ programs that use the `size()` function to get the length of a string. This is just an alias of `length()`. It is completely up to you if you want to use `length()` or `size()`:

Example

```
string txt = "ABCDEFGHIJKLMNOPQRSTUVWXYZ";
cout << "The length of the txt string is: " << txt.size();
```

Access Strings

You can access the characters in a string by referring to its index number inside square brackets `[]`.

This example prints the **first character** in **myString**:

Example

```
string myString = "Hello";
cout << myString[0];
// Outputs H
```

Try it Yourself »

Note: String indexes start with 0: [0] is the first character. [1] is the second character, etc.

This example prints the **second character** in **myString**:

Example

```
string myString = "Hello";
cout << myString[1];
// Outputs e
```

Try it Yourself »

Change String Characters

To change the value of a specific character in a string, refer to the index number, and use single quotes:

Example

```
string myString = "Hello";
myString[0] = 'J';
cout << myString;
// Outputs Jello instead of Hello
```

C++ Special Characters

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Strings - Special Characters

Because strings must be written within quotes, C++ will misunderstand this string, and generate an error:

```
string txt = "We are the so-called "Vikings" from the north.";
```

The solution to avoid this problem, is to use the **backslash escape character**.

The backslash (\) escape character turns special characters into string characters:

Escape character	Result	Description
\'	'	Single quote
\"	"	Double quote

\\	\	Backslash

The sequence `\"` inserts a double quote in a string:

Example

```
string txt = "We are the so-called \"Vikings\" from the north.";
```

Try it Yourself »

The sequence `\'` inserts a single quote in a string:

Example

```
string txt = "It\'s alright.";
```

Try it Yourself »

The sequence `\\` inserts a single backslash in a string:

Example

```
string txt = "The character \\ is called backslash.";
```

Try it Yourself »

Other popular escape characters in C++ are:

Escape Character	**Result**
\n	New Line
\t	Tab

C++ User Input Strings

User Input Strings

It is possible to use the extraction operator `>>` on `cin` to store a string entered by a user:

Example

```
string firstName;
cout << "Type your first name: ";
cin >> firstName; // get user input from the keyboard
cout << "Your name is: " << firstName;

// Type your first name: John
// Your name is: John
```

However, `cin` considers a space (whitespace, tabs, etc) as a terminating character, which means that it can only store a single word (even if you type many words):

Example

```
string fullName;
cout << "Type your full name: ";
cin >> fullName;
cout << "Your name is: " << fullName;

// Type your full name: John Doe
// Your name is: John
```

From the example above, you would expect the program to print "John Doe", but it only prints "John".

That's why, when working with strings, we often use the `getline()` function to read a line of text. It takes `cin` as the first parameter, and the string variable as second:

Example

```
string fullName;
cout << "Type your full name: ";
getline (cin, fullName);
```

```
cout << "Your name is: " << fullName;

// Type your full name: John Doe
// Your name is: John Doe
```

C++ String Namespace

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Omitting Namespace

You might see some C++ programs that runs without the standard namespace library. The `using namespace std` line can be omitted and replaced with the `std` keyword, followed by the `::` operator for `string` (and `cout`) objects:

Example

```
#include <iostream>
#include <string>

int main() {
  std::string greeting = "Hello";
  std::cout << greeting;
  return 0;
}
```

Try it Yourself »

It is up to you if you want to include the standard namespace library or not.

C++ Math

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C++ Math

C++ has many functions that allows you to perform mathematical tasks on numbers.

Max and min

The `max(x,y)` function can be used to find the highest value of *x* and *y*:

Example

```
cout << max(5, 10);
```

Try it Yourself »

And the `min(x,y)` function can be used to find the lowest value of *x* and *y*:

Example

```
cout << min(5, 10);
```

Try it Yourself »

C++ <cmath> Header

Other functions, such as `sqrt` (square root), `round` (rounds a number) and `log` (natural logarithm), can be found in the `<cmath>` header file:

Example

```
// Include the cmath library
#include <cmath>

cout << sqrt(64);
cout << round(2.6);
cout << log(2);
```

Try it Yourself »

Other Math Functions

A list of other popular Math functions (from the `<cmath>` library) can be found in the table below:

Function	Description
abs(x)	Returns the absolute value of x
acos(x)	Returns the arccosine of x
asin(x)	Returns the arcsine of x
atan(x)	Returns the arctangent of x
cbrt(x)	Returns the cube root of x
ceil(x)	Returns the value of x rounded up to its nearest integer
cos(x)	Returns the cosine of x
cosh(x)	Returns the hyperbolic cosine of x
exp(x)	Returns the value of E^x
expm1(x)	Returns e^x -1
fabs(x)	Returns the absolute value of a floating x
fdim(x, y)	Returns the positive difference between x and y
floor(x)	Returns the value of x rounded down to its nearest integer
hypot(x, y)	Returns sqrt(x^2 +y^2) without intermediate overflow or underflow
fma(x, y, z)	Returns x*y+z without losing precision
fmax(x, y)	Returns the highest value of a floating x and y
fmin(x, y)	Returns the lowest value of a floating x and y
fmod(x, y)	Returns the floating point remainder of x/y
pow(x, y)	Returns the value of x to the power of y
sin(x)	Returns the sine of x (x is in radians)
sinh(x)	Returns the hyperbolic sine of a double value
tan(x)	Returns the tangent of an angle
tanh(x)	Returns the hyperbolic tangent of a double value

C++ Exercises

Exercise:

Use the correct function to print the highest value of x and y.

```
int x = 5;
int y = 10;
cout << [      ](x, y);
```

C++ Booleans

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C++ Booleans

Very often, in programming, you will need a data type that can only have one of two values, like:

- YES / NO
- ON / OFF
- TRUE / FALSE

For this, C++ has a `bool` data type, which can take the values `true` (1) or `false` (0).

Boolean Values

A boolean variable is declared with the `bool` keyword and can only take the values `true` or `false`:

Example

```
bool isCodingFun = true;
bool isFishTasty = false;
cout << isCodingFun;  // Outputs 1 (true)
cout << isFishTasty;  // Outputs 0 (false)
```

Try it Yourself »

From the example above, you can read that a `true` value returns `1`, and `false` returns `0`.

However, it is more common to return a boolean value by **comparing** values and variables (see next page).

C++ Boolean Expressions

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Boolean Expression

A **Boolean expression** returns a boolean value that is either `1` (true) or `0` (false).

This is useful to build logic, and find answers.

You can use a comparison operator, such as the **greater than** (`>`) operator, to find out if an expression (or variable) is true or false:

Example

```
int x = 10;
int y = 9;
cout << (x > y); // returns 1 (true), because 10 is higher than 9
```

Try it Yourself »

Or even easier:

Example

```
cout << (10 > 9); // returns 1 (true), because 10 is higher than 9
```

Try it Yourself »

In the examples below, we use the **equal to** (==) operator to evaluate an expression:

Example

```
int x = 10;
cout << (x == 10);  // returns 1 (true), because the value of x is equal to
10
```

Try it Yourself »

Example

```
cout << (10 == 15);  // returns 0 (false), because 10 is not equal to 15
```

Try it Yourself »

Real Life Example

Let's think of a "real life example" where we need to find out if a person is old enough to vote.

In the example below, we use the `>=` comparison operator to find out if the age (25) is **greater than OR equal to** the voting age limit, which is set to 18:

Example

```
int myAge = 25;
int votingAge = 18;

cout << (myAge >= votingAge); // returns 1 (true), meaning 25 year olds are
allowed to vote!
```

Try it Yourself »

Cool, right? An even better approach (since we are on a roll now), would be to wrap the code above in an `if...else` statement, so we can perform different actions depending on the result:

Example

Output "Old enough to vote!" if `myAge` is **greater than or equal to** 18. Otherwise output "Not old enough to vote.":

```
int myAge = 25;
int votingAge = 18;
```

```
if (myAge >= votingAge) {
  cout << "Old enough to vote!";
} else {
  cout << "Not old enough to vote.";
}

// Outputs: Old enough to vote!
```

Try it Yourself »

Booleans are the basis for all C++ comparisons and conditions.

You will learn more about conditions (`if...else`) in the next chapter.

C++ Exercises

Exercise:

Fill in the missing parts to print the values `1` (for true) and `0` (for false):

```
      isCodingFun = true;
      isFishTasty = false;
cout <<      ;
cout <<      ;
```

Submit Answer »

Start the Exercise

C++ If ... Else

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C++ Conditions and If Statements

You already know that C++ supports the usual logical conditions from mathematics:

- Less than: `a < b`
- Less than or equal to: `a <= b`
- Greater than: `a > b`
- Greater than or equal to: `a >= b`
- Equal to `a == b`
- Not Equal to: `a != b`

You can use these conditions to perform different actions for different decisions.

C++ has the following conditional statements:

- Use `if` to specify a block of code to be executed, if a specified condition is true
- Use `else` to specify a block of code to be executed, if the same condition is false
- Use `else if` to specify a new condition to test, if the first condition is false
- Use `switch` to specify many alternative blocks of code to be executed

The if Statement

Use the `if` statement to specify a block of C++ code to be executed if a condition is `true`.

Syntax

```
if (condition) {
  // block of code to be executed if the condition is true
}
```

Note that `if` is in lowercase letters. Uppercase letters (If or IF) will generate an error.

In the example below, we test two values to find out if 20 is greater than 18. If the condition is `true`, print some text:

Example

```
if (20 > 18) {
  cout << "20 is greater than 18";
}
```

Try it Yourself »

We can also test variables:

Example

```
int x = 20;
int y = 18;
if (x > y) {
  cout << "x is greater than y";
}
```

Try it Yourself »

Example explained

In the example above we use two variables, **x** and **y**, to test whether x is greater than y (using the `>` operator). As x is 20, and y is 18, and we know that 20 is greater than 18, we print to the screen that "x is greater than y".

C++ Exercises

Exercise:

Print "Hello World" if `x` is **greater than** `y`.

```
int x = 50;
int y = 10;
[      ] (x [      ] y) {
  cout << "Hello World";
}
```

Submit Answer »

Start the Exercise

C++ Else

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The else Statement

Use the `else` statement to specify a block of code to be executed if the condition is `false`.

Syntax

```
if (condition) {
  // block of code to be executed if the condition is true
} else {
  // block of code to be executed if the condition is false
}
```

Example

```
int time = 20;
if (time < 18) {
  cout << "Good day.";
} else {
  cout << "Good evening.";
}
// Outputs "Good evening."
```

Try it Yourself »

Example explained

In the example above, time (20) is greater than 18, so the condition is `false`. Because of this, we move on to the `else` condition and print to the screen "Good evening". If the time was less than 18, the program would print "Good day".

C++ Else If

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The else if Statement

Use the `else if` statement to specify a new condition if the first condition is `false`.

Syntax

```
if (condition1) {
  // block of code to be executed if condition1 is true
} else if (condition2) {
  // block of code to be executed if the condition1 is false and condition2
is true
} else {
  // block of code to be executed if the condition1 is false and condition2
is false
}
```

Example

```
int time = 22;
if (time < 10) {
  cout << "Good morning.";
} else if (time < 20) {
  cout << "Good day.";
} else {
  cout << "Good evening.";
}
// Outputs "Good evening."
```

Try it Yourself »

Example explained

In the example above, time (22) is greater than 10, so the **first condition** is `false`. The next condition, in the `else if` statement, is also `false`, so we move on to the `else` condition since **condition1** and **condition2** is both `false` - and print to the screen "Good evening".

However, if the time was 14, our program would print "Good day."

C++ Short Hand If Else

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Short Hand If...Else (Ternary Operator)

There is also a short-hand if else, which is known as the **ternary operator** because it consists of three operands. It can be used to replace multiple lines of code with a single line. It is often used to replace simple if else statements:

Syntax

```
variable = (condition) ? expressionTrue : expressionFalse;
```

Instead of writing:

Example

```
int time = 20;
if (time < 18) {
  cout << "Good day.";
} else {
  cout << "Good evening.";
}
```

Try it Yourself »

You can simply write:

Example

```
int time = 20;
string result = (time < 18) ? "Good day." : "Good evening.";
cout << result;
```

Try it Yourself »

C++ Switch

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C++ Switch Statements

Use the `switch` statement to select one of many code blocks to be executed.

Syntax

```
switch(expression) {
  case x:
    // code block
    break;
  case y:
    // code block
    break;
  default:
    // code block
}
```

This is how it works:

- The `switch` expression is evaluated once
- The value of the expression is compared with the values of each `case`
- If there is a match, the associated block of code is executed
- The `break` and `default` keywords are optional, and will be described later in this chapter

The example below uses the weekday number to calculate the weekday name:

Example

```
int day = 4;
switch (day) {
  case 1:
    cout << "Monday";
    break;
  case 2:
    cout << "Tuesday";
    break;
  case 3:
    cout << "Wednesday";
    break;
  case 4:
    cout << "Thursday";
    break;
  case 5:
    cout << "Friday";
    break;
  case 6:
    cout << "Saturday";
    break;
  case 7:
    cout << "Sunday";
    break;
}
// Outputs "Thursday" (day 4)
```
Try it Yourself »

The break Keyword

When C++ reaches a `break` keyword, it breaks out of the switch block.

This will stop the execution of more code and case testing inside the block.

When a match is found, and the job is done, it's time for a break. There is no need for more testing.

A break can save a lot of execution time because it "ignores" the execution of all the rest of the code in the switch block.

The default Keyword

The `default` keyword specifies some code to run if there is no case match:

Example

```
int day = 4;
switch (day) {
  case 6:
    cout << "Today is Saturday";
    break;
  case 7:
    cout << "Today is Sunday";
    break;
  default:
    cout << "Looking forward to the Weekend";
}
// Outputs "Looking forward to the Weekend"
```
Try it Yourself »

C++ Exercises

Exercise:

Insert the missing parts to complete the following `switch` statement.

```
int day = 2;
switch ([     ]) {
[     ] 1:
    cout << "Saturday";
    break;
[     ] 2:
    cout << "Sunday";
    [     ];
}
```

Submit Answer »

Start the Exercise

C++ While Loop

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C++ Loops

Loops can execute a block of code as long as a specified condition is reached.

Loops are handy because they save time, reduce errors, and they make code more readable.

C++ While Loop

The while loop loops through a block of code as long as a specified condition is true:

Syntax

```
while (condition) {
  // code block to be executed
}
```

In the example below, the code in the loop will run, over and over again, as long as a variable (i) is less than 5:

Example

```
int i = 0;
while (i < 5) {
  cout << i << "\n";
  i++;
}
```

Try it Yourself »

Note: Do not forget to increase the variable used in the condition, otherwise the loop will never end!

C++ Exercises

Exercise:

Print i as long as i is less than 6.

```
int i = 1;
[        ] (i < 6) {
  cout << i << "\n";
  [        ];
}
```

Submit Answer »

Start the Exercise

C++ Do/While Loop

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The Do/While Loop

The `do/while` loop is a variant of the `while` loop. This loop will execute the code block once, before checking if the condition is true, then it will repeat the loop as long as the condition is true.

Syntax

```
do {
  // code block to be executed
}
while (condition);
```

The example below uses a `do/while` loop. The loop will always be executed at least once, even if the condition is false, because the code block is executed before the condition is tested:

Example

```
int i = 0;
do {
  cout << i << "\n";
  i++;
}
while (i < 5);
```

Try it Yourself »

Do not forget to increase the variable used in the condition, otherwise the loop will never end!

C++ For Loop

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C++ For Loop

When you know exactly how many times you want to loop through a block of code, use the `for` loop instead of a `while` loop:

Syntax

```
for (statement 1; statement 2; statement 3) {
  // code block to be executed
}
```

Statement 1 is executed (one time) before the execution of the code block.

Statement 2 defines the condition for executing the code block.

Statement 3 is executed (every time) after the code block has been executed.

The example below will print the numbers 0 to 4:

Example

```
for (int i = 0; i < 5; i++) {
  cout << i << "\n";
}
```

Try it Yourself »

Example explained

Statement 1 sets a variable before the loop starts (int i = 0).

Statement 2 defines the condition for the loop to run (i must be less than 5). If the condition is true, the loop will start over again, if it is false, the loop will end.

Statement 3 increases a value (i++) each time the code block in the loop has been executed.

Another Example

This example will only print even values between 0 and 10:

Example

```
for (int i = 0; i <= 10; i = i + 2) {
  cout << i << "\n";
}
```

Try it Yourself »

Nested Loops

It is also possible to place a loop inside another loop. This is called a **nested loop**.

The "inner loop" will be executed one time for each iteration of the "outer loop":

Example

```
// Outer loop
for (int i = 1; i <= 2; ++i) {
  cout << "Outer: " << i << "\n"; // Executes 2 times

  // Inner loop
  for (int j = 1; j <= 3; ++j) {
    cout << " Inner: " << j << "\n"; // Executes 6 times (2 * 3)
  }
}
```

Try it Yourself »

The foreach Loop

There is also a "**for-each** loop" (introduced in C++ version 11 (2011), which is used exclusively to loop through elements in an array (or other data sets):

Syntax

```
for (type variableName : arrayName) {
  // code block to be executed
}
```

The following example outputs all elements in an array, using a "**for-each** loop":

Example

```
int myNumbers[5] = {10, 20, 30, 40, 50};
for (int i : myNumbers) {
  cout << i << "\n";
}
```

Try it Yourself »

Note: Don't worry if you don't understand the example above. You will learn more about arrays in the C++ Arrays chapter.

C++ Exercises

Exercise:

Use a `for` loop to print "Yes" 5 times:

```
      (int i = 0; i < 5;      ) {
  cout <<      << "\n";
}
```

Submit Answer »

Start the Exercise

C++ Break and Continue

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C++ Break

You have already seen the `break` statement used in an earlier chapter of this tutorial. It was used to "jump out" of a `switch` statement.

The `break` statement can also be used to jump out of a **loop**.

This example jumps out of the loop when `i` is equal to 4:

Example

```
for (int i = 0; i < 10; i++) {
  if (i == 4) {
    break;
  }
  cout << i << "\n";
}
```

Try it Yourself »

C++ Continue

The `continue` statement breaks one iteration (in the loop), if a specified condition occurs, and continues with the next iteration in the loop.

This example skips the value of 4:

Example

```
for (int i = 0; i < 10; i++) {
  if (i == 4) {
    continue;
  }
  cout << i << "\n";
}
```

Break and Continue in While Loop

You can also use `break` and `continue` in while loops:

Break Example

```
int i = 0;
while (i < 10) {
  cout << i << "\n";
  i++;
  if (i == 4) {
    break;
  }
}
```

Try it Yourself »

Continue Example

```
int i = 0;
while (i < 10) {
  if (i == 4) {
    i++;
    continue;
  }
  cout << i << "\n";
  i++;
}
```

Try it Yourself »

C++ Exercises

Exercise:

Stop the loop if `i` is 5:

```
for (int i = 0; i < 10; i++) {
  if (i == 5) {
    ____;
  }
  cout << i << "\n";
}
```

C++ Arrays

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C++ Arrays

Arrays are used to store multiple values in a single variable, instead of declaring separate variables for each value.

To declare an array, define the variable type, specify the name of the array followed by **square brackets** and specify the number of elements it should store:

```
string cars[4];
```

We have now declared a variable that holds an array of four strings. To insert values to it, we can use an array literal - place the values in a comma-separated list, inside curly braces:

```
string cars[4] = {"Volvo", "BMW", "Ford", "Mazda"};
```

To create an array of three integers, you could write:

```
int myNum[3] = {10, 20, 30};
```

Access the Elements of an Array

You access an array element by referring to the index number inside square brackets `[]`.

This statement accesses the value of the **first element** in **cars**:

Example

```
string cars[4] = {"Volvo", "BMW", "Ford", "Mazda"};
cout << cars[0];
// Outputs Volvo
```

Try it Yourself »

Note: Array indexes start with 0: [0] is the first element. [1] is the second element, etc.

Change an Array Element

To change the value of a specific element, refer to the index number:

```
cars[0] = "Opel";
```

Example

```
string cars[4] = {"Volvo", "BMW", "Ford", "Mazda"};
cars[0] = "Opel";
cout << cars[0];
// Now outputs Opel instead of Volvo
```

Try it Yourself »

C++ Exercises

Exercise:

Create an array of type string called cars.

```
[    ] [    ] [4] = {"Volvo", "BMW", "Ford", "Mazda"};
```

Submit Answer »

Start the Exercise

C++ Arrays and Loops

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Loop Through an Array

You can loop through the array elements with the for loop.

The following example outputs all elements in the **cars** array:

Example

```
string cars[5] = {"Volvo", "BMW", "Ford", "Mazda", "Tesla"};
for (int i = 0; i < 5; i++) {
  cout << cars[i] << "\n";
}
```

Try it Yourself »

This example outputs the index of each element together with its value:

Example

```
string cars[5] = {"Volvo", "BMW", "Ford", "Mazda", "Tesla"};
for (int i = 0; i < 5; i++) {
  cout << i << " = " << cars[i] << "\n";
}
```

Try it Yourself »

And this example shows how to loop through an array of integers:

Example

```
int myNumbers[5] = {10, 20, 30, 40, 50};
for (int i = 0; i < 5; i++) {
  cout << myNumbers[i] << "\n";
}
```

Try it Yourself »

The foreach Loop

There is also a "**for-each** loop" (introduced in C++ version 11 (2011), which is used exclusively to loop through elements in an array:

Syntax

```
for (type variableName : arrayName) {
  // code block to be executed
}
```

The following example outputs all elements in an array, using a "**for-each** loop":

Example

```
int myNumbers[5] = {10, 20, 30, 40, 50};
for (int i : myNumbers) {
  cout << i << "\n";
}
```

C++ Omit Array Size

Omit Array Size

In C++, you don't have to specify the size of the array. The compiler is smart enough to determine the size of the array based on the number of inserted values:

```
string cars[] = {"Volvo", "BMW", "Ford"}; // Three array elements
```

The example above is equal to:

```
string cars[3] = {"Volvo", "BMW", "Ford"}; // Also three array elements
```

However, the last approach is considered as "good practice", because it will reduce the chance of errors in your program.

Omit Elements on Declaration

It is also possible to declare an array without specifying the elements on declaration, and add them later:

Example

```
string cars[5];
cars[0] = "Volvo";
cars[1] = "BMW";
...
```

Try it Yourself »

C++ Array Size

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Get the Size of an Array

To get the size of an array, you can use the `sizeof()` operator:

Example

```
int myNumbers[5] = {10, 20, 30, 40, 50};
cout << sizeof(myNumbers);
```

Result:

```
20
```

Try it Yourself »

Why did the result show `20` instead of `5`, when the array contains 5 elements?

It is because the `sizeof()` operator returns the size of a type in **bytes**.

You learned from the Data Types chapter that an `int` type is usually 4 bytes, so from the example above, *4 x 5 (4 bytes x 5 elements)* = ***20 bytes***.

To find out how many elements an array has, you have to divide the size of the array by the size of the data type it contains:

Example

```
int myNumbers[5] = {10, 20, 30, 40, 50};
int getArrayLength = sizeof(myNumbers) / sizeof(int);
cout << getArrayLength;
```

Result:

```
5
```

Try it Yourself »

Loop Through an Array with sizeof()

In the Arrays and Loops Chapter, we wrote the size of the array in the loop condition (`i < 5`). This is not ideal, since it will only work for arrays of a specified size.

However, by using the `sizeof()` approach from the example above, we can now make loops that work for arrays of any size, which is more sustainable.

Instead of writing:

```
int myNumbers[5] = {10, 20, 30, 40, 50};
for (int i = 0; i < 5; i++) {
  cout << myNumbers[i] << "\n";
}
```

It is better to write:

Example

```
int myNumbers[5] = {10, 20, 30, 40, 50};
for (int i = 0; i < sizeof(myNumbers) / sizeof(int); i++) {
  cout << myNumbers[i] << "\n";
}
```

Try it Yourself »

Note that, in C++ version 11 (2011), you can also use the "for-each" loop:

Example

```
int myNumbers[5] = {10, 20, 30, 40, 50};
for (int i : myNumbers) {
  cout << i << "\n";
}
```

Try it Yourself »

It is good to know the different ways to loop through an array, since you may encounter them all in different programs.

C++ Multi-Dimensional Arrays

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Multi-Dimensional Arrays

A multi-dimensional array is an array of arrays.

To declare a multi-dimensional array, define the variable type, specify the name of the array followed by square brackets which specify how many elements the main array has, followed by another set of square brackets which indicates how many elements the sub-arrays have:

```
string letters[2][4];
```

As with ordinary arrays, you can insert values with an array literal - a comma-separated list inside curly braces. In a multi-dimensional array, each element in an array literal is another array literal.

```
string letters[2][4] = {
  { "A", "B", "C", "D" },
  { "E", "F", "G", "H" }
};
```

Each set of square brackets in an array declaration adds another **dimension** to an array. An array like the one above is said to have two dimensions.

Arrays can have any number of dimensions. The more dimensions an array has, the more complex the code becomes. The following array has three dimensions:

```
string letters[2][2][2] = {
  {
    { "A", "B" },
    { "C", "D" }
  },
  {
    { "E", "F" },
    { "G", "H" }
  }
};
```

Access the Elements of a Multi-Dimensional Array

To access an element of a multi-dimensional array, specify an index number in each of the array's dimensions.

This statement accesses the value of the element in the **first row (0)** and **third column (2)** of the **letters** array.

Example

```
string letters[2][4] = {
  { "A", "B", "C", "D" },
  { "E", "F", "G", "H" }
};

cout << letters[0][2];  // Outputs "C"
```

Try it Yourself »

Remember that: Array indexes start with 0: [0] is the first element. [1] is the second element, etc.

Change Elements in a Multi-Dimensional Array

To change the value of an element, refer to the index number of the element in each of the dimensions:

Example

```
string letters[2][4] = {
  { "A", "B", "C", "D" },
  { "E", "F", "G", "H" }
};
letters[0][0] = "Z";

cout << letters[0][0];  // Now outputs "Z" instead of "A"
```
Try it Yourself »

Loop Through a Multi-Dimensional Array

To loop through a multi-dimensional array, you need one loop for each of the array's dimensions.

The following example outputs all elements in the **letters** array:

Example

```
string letters[2][4] = {
  { "A", "B", "C", "D" },
  { "E", "F", "G", "H" }
};

for (int i = 0; i < 2; i++) {
  for (int j = 0; j < 4; j++) {
    cout << letters[i][j] << "\n";
  }
}
```
Try it Yourself »

This example shows how to loop through a three-dimensional array:

Example

```
string letters[2][2][2] = {
  {
    { "A", "B" },
    { "C", "D" }
  },
  {
    { "E", "F" },
    { "G", "H" }
  }
};

for (int i = 0; i < 2; i++) {
  for (int j = 0; j < 2; j++) {
    for (int k = 0; k < 2; k++) {
      cout << letters[i][j][k] << "\n";
    }
  }
}
```
Try it Yourself »

Why Multi-Dimensional Arrays?

Multi-dimensional arrays are great at representing grids. This example shows a practical use for them. In the following example we use a multi-dimensional array to represent a small game of Battleship:

Example

```
// We put "1" to indicate there is a ship.
bool ships[4][4] = {
  { 0, 1, 1, 0 },
  { 0, 0, 0, 0 },
  { 0, 0, 1, 0 },
  { 0, 0, 1, 0 }
};

// Keep track of how many hits the player has and how many turns they have
played in these variables
int hits = 0;
int numberOfTurns = 0;

// Allow the player to keep going until they have hit all four ships
while (hits < 4) {
  int row, column;

  cout << "Selecting coordinates\n";

  // Ask the player for a row
  cout << "Choose a row number between 0 and 3: ";
  cin >> row;

  // Ask the player for a column
  cout << "Choose a column number between 0 and 3: ";
  cin >> column;

  // Check if a ship exists in those coordinates
  if (ships[row][column]) {
    // If the player hit a ship, remove it by setting the value to zero.
    ships[row][column] = 0;
    // Increase the hit counter
    hits++;

    // Tell the player that they have hit a ship and how many ships are left
    cout << "Hit! " << (4-hits) << " left.\n\n";
  } else {
    // Tell the player that they missed
    cout << "Miss\n\n";
  }

  // Count how many turns the player has taken
  numberOfTurns++;
}

cout << "Victory!\n";
cout << "You won in " << numberOfTurns << " turns";
```

C++ Structures (struct)

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C++ Structures

Structures (also called structs) are a way to group several related variables into one place. Each variable in the structure is known as a **member** of the structure.

Unlike an array, a structure can contain many different data types (int, string, bool, etc.).

Create a Structure

To create a structure, use the `struct` keyword and declare each of its members inside curly braces.

After the declaration, specify the name of the structure variable (**myStructure** in the example below):

```
struct {             // Structure declaration
  int myNum;         // Member (int variable)
  string myString;    // Member (string variable)
} myStructure;        // Structure variable
```

Access Structure Members

To access members of a structure, use the dot syntax (`.`):

Example

Assign data to members of a structure and print it:

```
// Create a structure variable called myStructure
struct {
  int myNum;
  string myString;
} myStructure;

// Assign values to members of myStructure
myStructure.myNum = 1;
myStructure.myString = "Hello World!";

// Print members of myStructure
cout << myStructure.myNum << "\n";
cout << myStructure.myString << "\n";
```

Try it Yourself »

One Structure in Multiple Variables

You can use a comma (`,`) to use one structure in many variables:

```
struct {
  int myNum;
  string myString;
} myStruct1, myStruct2, myStruct3; // Multiple structure variables separated
with commas
```

This example shows how to use a structure in two different variables:

Example

Use one structure to represent two cars:

```
struct {
  string brand;
  string model;
  int year;
} myCar1, myCar2; // We can add variables by separating them with a comma
here

// Put data into the first structure
myCar1.brand = "BMW";
myCar1.model = "X5";
myCar1.year = 1999;

// Put data into the second structure
myCar2.brand = "Ford";
myCar2.model = "Mustang";
myCar2.year = 1969;

// Print the structure members
cout << myCar1.brand << " " << myCar1.model << " " << myCar1.year << "\n";
cout << myCar2.brand << " " << myCar2.model << " " << myCar2.year << "\n";
```
Try it Yourself »

Named Structures

By giving a name to the structure, you can treat it as a data type. This means that you can create variables with this structure anywhere in the program at any time.

To create a named structure, put the name of the structure right after the `struct` keyword:

```
struct myDataType { // This structure is named "myDataType"
  int myNum;
  string myString;
};
```

To declare a variable that uses the structure, use the name of the structure as the data type of the variable:

```
myDataType myVar;
```

Example

Use one structure to represent two cars:

```
// Declare a structure named "car"
struct car {
  string brand;
  string model;
  int year;
};

int main() {
  // Create a car structure and store it in myCar1;
  car myCar1;
  myCar1.brand = "BMW";
  myCar1.model = "X5";
  myCar1.year = 1999;

  // Create another car structure and store it in myCar2;
  car myCar2;
  myCar2.brand = "Ford";
  myCar2.model = "Mustang";
  myCar2.year = 1969;

  // Print the structure members
  cout << myCar1.brand << " " << myCar1.model << " " << myCar1.year << "\n";
  cout << myCar2.brand << " " << myCar2.model << " " << myCar2.year << "\n";

  return 0;
}
```

C++ References

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Creating References

A reference variable is a "reference" to an existing variable, and it is created with the & operator:

```
string food = "Pizza";  // food variable
string &meal = food;    // reference to food
```

Now, we can use either the variable name food or the reference name meal to refer to the food variable:

Example

```
string food = "Pizza";
string &meal = food;

cout << food << "\n";  // Outputs Pizza
cout << meal << "\n";  // Outputs Pizza
```

Try it Yourself »

C++ Memory Address

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Memory Address

In the example from the previous page, the `&` operator was used to create a reference variable. But it can also be used to get the memory address of a variable; which is the location of where the variable is stored on the computer.

When a variable is created in C++, a memory address is assigned to the variable. And when we assign a value to the variable, it is stored in this memory address.

To access it, use the `&` operator, and the result will represent where the variable is stored:

Example

```
string food = "Pizza";

cout << &food; // Outputs 0x6dfed4
```

Try it Yourself »

Note: The memory address is in hexadecimal form (0x..). Note that you may not get the same result in your program.

And why is it useful to know the memory address?

References and **Pointers** (which you will learn about in the next chapter) are important in C++, because they give you the ability to manipulate the data in the computer's memory - **which can reduce the code and improve the performance**.

These two features are one of the things that make C++ stand out from other programming languages, like Python and Java.

C++ Pointers

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Creating Pointers

You learned from the previous chapter, that we can get the **memory address** of a variable by using the `&` operator:

Example

```
string food = "Pizza"; // A food variable of type string

cout << food;  // Outputs the value of food (Pizza)
cout << &food; // Outputs the memory address of food (0x6dfed4)
```

Try it Yourself »

A **pointer** however, is a variable that **stores the memory address as its value**.

A pointer variable points to a data type (like `int` or `string`) of the same type, and is created with the `*` operator. The address of the variable you're working with is assigned to the pointer:

Example

```
string food = "Pizza";  // A food variable of type string
string* ptr = &food;    // A pointer variable, with the name ptr, that
stores the address of food

// Output the value of food (Pizza)
cout << food << "\n";

// Output the memory address of food (0x6dfed4)
cout << &food << "\n";
```

```
// Output the memory address of food with the pointer (0x6dfed4)
cout << ptr << "\n";
```

Try it Yourself »

Example explained

Create a pointer variable with the name `ptr`, that **points to** a `string` variable, by using the asterisk sign `*` (`string* ptr`). Note that the type of the pointer has to match the type of the variable you're working with.

Use the `&` operator to store the memory address of the variable called `food`, and assign it to the pointer.

Now, `ptr` holds the value of `food`'s memory address.

Tip: There are three ways to declare pointer variables, but the first way is preferred:

```
string* mystring; // Preferred
string *mystring;
string * mystring;
```

C++ Exercises

Exercise:

Create a **pointer** variable with the name `ptr`, that should point to a `string` variable named `food`:

```
string food = "Pizza";
[      ] [      ] = &[      ];
```

C++ Dereference

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Get Memory Address and Value

In the example from the previous page, we used the pointer variable to get the memory address of a variable (used together with the & **reference** operator). However, you can also use the pointer to get the value of the variable, by using the * operator (the **dereference** operator):

Example

```
string food = "Pizza";  // Variable declaration
string* ptr = &food;    // Pointer declaration

// Reference: Output the memory address of food with the pointer (0x6dfed4)
cout << ptr << "\n";

// Dereference: Output the value of food with the pointer (Pizza)
cout << *ptr << "\n";
```

Try it Yourself »

Note that the * sign can be confusing here, as it does two different things in our code:

- When used in declaration (string* ptr), it creates a **pointer variable**.
- When not used in declaration, it act as a **dereference operator**.
- C++ Modify Pointers
- Modify the Pointer Value
- You can also change the pointer's value. But note that this will also change the value of the original variable:
-
- Example
- string food = "Pizza";
- string* ptr = &food;
-
- // Output the value of food (Pizza)
- cout << food << "\n";
-
- // Output the memory address of food (0x6dfed4)
- cout << &food << "\n";
-
- // Access the memory address of food and output its value (Pizza)
- cout << *ptr << "\n";
-
- // Change the value of the pointer
- *ptr = "Hamburger";
-
- // Output the new value of the pointer (Hamburger)
- cout << *ptr << "\n";
-
- // Output the new value of the food variable (Hamburger)
- cout << food << "\n";

C++ Functions

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A function is a block of code which only runs when it is called.

You can pass data, known as parameters, into a function.

Functions are used to perform certain actions, and they are important for reusing code: Define the code once, and use it many times.

Create a Function

C++ provides some pre-defined functions, such as `main()`, which is used to execute code. But you can also create your own functions to perform certain actions.

To create (often referred to as *declare*) a function, specify the name of the function, followed by parentheses **()**:

Syntax

```
void myFunction() {
  // code to be executed
}
```

Example Explained

- `myFunction()` is the name of the function
- `void` means that the function does not have a return value. You will learn more about return values later in the next chapter
- inside the function (the body), add code that defines what the function should do

Call a Function

Declared functions are not executed immediately. They are "saved for later use", and will be executed later, when they are called.

To call a function, write the function's name followed by two parentheses `()` and a semicolon `;`

In the following example, `myFunction()` is used to print a text (the action), when it is called:

Example

Inside `main`, call `myFunction()`:

```
// Create a function
void myFunction() {
  cout << "I just got executed!";
}

int main() {
  myFunction(); // call the function
  return 0;
}

// Outputs "I just got executed!"
```

Try it Yourself »

A function can be called multiple times:

Example

```
void myFunction() {
  cout << "I just got executed!\n";
}

int main() {
  myFunction();
  myFunction();
  myFunction();
  return 0;
}

// I just got executed!
// I just got executed!
// I just got executed!
```

Try it Yourself »

Function Declaration and Definition

A C++ function consist of two parts:

- **Declaration:** the return type, the name of the function, and parameters (if any)
- **Definition:** the body of the function (code to be executed)

```
void myFunction() { // declaration
  // the body of the function (definition)
}
```

Note: If a user-defined function, such as `myFunction()` is declared after the `main()` function, **an error will occur**:

Example

```
int main() {
  myFunction();
  return 0;
}

void myFunction() {
  cout << "I just got executed!";
}

// Error
```

Try it Yourself »

However, it is possible to separate the declaration and the definition of the function - for code optimization.

You will often see C++ programs that have function declaration above `main()`, and function definition below `main()`. This will make the code better organized and easier to read:

Example

```
// Function declaration
void myFunction();

// The main method
int main() {
  myFunction();  // call the function
  return 0;
}

// Function definition
void myFunction() {
  cout << "I just got executed!";
}
```

Try it Yourself »

C++ Exercises

Exercise:

Create a function named `myFunction` and call it inside `main()`.

```
void [      ]() {
  cout << "I just got executed!";
}

int main() {
  [      ];
  return 0;
}
```

Submit Answer »

Start the Exercise

C++ Function Parameters

Parameters and Arguments

Information can be passed to functions as a parameter. Parameters act as variables inside the function.

Parameters are specified after the function name, inside the parentheses. You can add as many parameters as you want, just separate them with a comma:

Syntax

```
void functionName(parameter1, parameter2, parameter3) {
  // code to be executed
}
```

The following example has a function that takes a `string` called **fname** as parameter. When the function is called, we pass along a first name, which is used inside the function to print the full name:

Example

```
void myFunction(string fname) {
  cout << fname << " Refsnes\n";
}

int main() {
  myFunction("Liam");
  myFunction("Jenny");
  myFunction("Anja");
  return 0;
}

// Liam Refsnes
// Jenny Refsnes
// Anja Refsnes
```

Try it Yourself »

When a **parameter** is passed to the function, it is called an **argument**. So, from the example above: `fname` is a **parameter**, while `Liam`, `Jenny` and `Anja` are **arguments**.

C++ Default Parameters

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Default Parameter Value

You can also use a default parameter value, by using the equals sign (=).

If we call the function without an argument, it uses the default value ("Norway"):

Example

```
void myFunction(string country = "Norway") {
  cout << country << "\n";
}

int main() {
  myFunction("Sweden");
  myFunction("India");
  myFunction();
  myFunction("USA");
  return 0;
}

// Sweden
// India
// Norway
// USA
```

Try it Yourself »

A parameter with a default value, is often known as an "**optional parameter**". From the example above, country is an optional parameter and "Norway" is the default value.

C++ Multiple Parameters

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Multiple Parameters

Inside the function, you can add as many parameters as you want:

Example

```
void myFunction(string fname, int age) {
  cout << fname << " Refsnes. " << age << " years old. \n";
}

int main() {
  myFunction("Liam", 3);
  myFunction("Jenny", 14);
  myFunction("Anja", 30);
  return 0;
}

// Liam Refsnes. 3 years old.
// Jenny Refsnes. 14 years old.
// Anja Refsnes. 30 years old.
```

Try it Yourself »

Note that when you are working with multiple parameters, the function call must have the same number of arguments as there are parameters, and the arguments must be passed in the same order.

C++ The Return Keyword

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Return Values

The void keyword, used in the previous examples, indicates that the function should not return a value. If you want the function to return a value, you can use a data type (such as int, string, etc.) instead of void, and use the return keyword inside the function:

Example

```
int myFunction(int x) {
  return 5 + x;
}

int main() {
  cout << myFunction(3);
  return 0;
}
```

```
// Outputs 8 (5 + 3)
```

Try it Yourself »

This example returns the sum of a function with **two parameters**:

Example

```
int myFunction(int x, int y) {
  return x + y;
}

int main() {
  cout << myFunction(5, 3);
  return 0;
}

// Outputs 8 (5 + 3)
```

Try it Yourself »

You can also store the result in a variable:

Example

```
int myFunction(int x, int y) {
  return x + y;
}

int main() {
  int z = myFunction(5, 3);
  cout << z;
  return 0;
}
// Outputs 8 (5 + 3)
```

C++ Functions - Pass By Reference

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Pass By Reference

In the examples from the previous page, we used normal variables when we passed parameters to a function. You can also pass a reference to the function. This can be useful when you need to change the value of the arguments:

Example

```
void swapNums(int &x, int &y) {
  int z = x;
  x = y;
  y = z;
}

int main() {
  int firstNum = 10;
  int secondNum = 20;

  cout << "Before swap: " << "\n";
  cout << firstNum << secondNum << "\n";

  // Call the function, which will change the values of firstNum and
secondNum
  swapNums(firstNum, secondNum);

  cout << "After swap: " << "\n";
  cout << firstNum << secondNum << "\n";

  return 0;
}
```

C++ Pass Array to a Function

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Pass Arrays as Function Parameters

You can also pass arrays to a function:

Example

```
void myFunction(int myNumbers[5]) {
  for (int i = 0; i < 5; i++) {
    cout << myNumbers[i] << "\n";
  }
}

int main() {
  int myNumbers[5] = {10, 20, 30, 40, 50};
  myFunction(myNumbers);
  return 0;
}
```

Try it Yourself »

Example Explained

The function (`myFunction`) takes an array as its parameter (`int myNumbers[5]`), and loops through the array elements with the `for` loop.

When the function is called inside `main()`, we pass along the `myNumbers` array, which outputs the array elements.

Note that when you call the function, you only need to use the name of the array when passing it as an argument `myFunction(myNumbers)`. However, the full declaration of the array is needed in the function parameter (`int myNumbers[5]`).

C++ Function Overloading

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Function Overloading

With **function overloading**, multiple functions can have the same name with different parameters:

Example

```
int myFunction(int x)
float myFunction(float x)
double myFunction(double x, double y)
```

Consider the following example, which have two functions that add numbers of different type:

Example

```
int plusFuncInt(int x, int y) {
  return x + y;
}

double plusFuncDouble(double x, double y) {
  return x + y;
}

int main() {
  int myNum1 = plusFuncInt(8, 5);
  double myNum2 = plusFuncDouble(4.3, 6.26);
  cout << "Int: " << myNum1 << "\n";
  cout << "Double: " << myNum2;
  return 0;
}
```

Try it Yourself »

Instead of defining two functions that should do the same thing, it is better to overload one.

In the example below, we overload the `plusFunc` function to work for both `int` and `double`:

Example

```
int plusFunc(int x, int y) {
  return x + y;
}

double plusFunc(double x, double y) {
  return x + y;
}

int main() {
  int myNum1 = plusFunc(8, 5);
  double myNum2 = plusFunc(4.3, 6.26);
  cout << "Int: " << myNum1 << "\n";
  cout << "Double: " << myNum2;
  return 0;
}
```

Try it Yourself »

Note: Multiple functions can have the same name as long as the number and/or type of parameters are different.

C++ Recursion

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Recursion

Recursion is the technique of making a function call itself. This technique provides a way to break complicated problems down into simple problems which are easier to solve.

Recursion may be a bit difficult to understand. The best way to figure out how it works is to experiment with it.

Recursion Example

Adding two numbers together is easy to do, but adding a range of numbers is more complicated. In the following example, recursion is used to add a range of numbers together by breaking it down into the simple task of adding two numbers:

Example

```
int sum(int k) {
  if (k > 0) {
    return k + sum(k - 1);
  } else {
    return 0;
  }
}

int main() {
  int result = sum(10);
  cout << result;
  return 0;
}
```

Try it Yourself »

Example Explained

When the `sum()` function is called, it adds parameter `k` to the sum of all numbers smaller than `k` and returns the result. When k becomes 0, the function just returns 0. When running, the program follows these steps:

Since the function does not call itself when `k` is 0, the program stops there and returns the result.

The developer should be very careful with recursion as it can be quite easy to slip into writing a function which never terminates, or one that uses excess amounts of memory or processor power. However, when written correctly recursion can be a very efficient and mathematically-elegant approach to programming.

C++ OOP

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C++ What is OOP?

OOP stands for Object-Oriented Programming.

Procedural programming is about writing procedures or functions that perform operations on the data, while object-oriented programming is about creating objects that contain both data and functions.

Object-oriented programming has several advantages over procedural programming:

- OOP is faster and easier to execute
- OOP provides a clear structure for the programs
- OOP helps to keep the C++ code DRY "Don't Repeat Yourself", and makes the code easier to maintain, modify and debug
- OOP makes it possible to create full reusable applications with less code and shorter development time

Tip: The "Don't Repeat Yourself" (DRY) principle is about reducing the repetition of code. You should extract out the codes that are common for the application, and place them at a single place and reuse them instead of repeating it.

C++ What are Classes and Objects?

Classes and objects are the two main aspects of object-oriented programming.

Look at the following illustration to see the difference between class and objects:

class

Fruit

objects

Apple

Banana

Mango

Another example:

class

Car

objects

Volvo

```
Audi

Toyota
```

So, a class is a template for objects, and an object is an instance of a class.

When the individual objects are created, they inherit all the variables and functions from the class.

You will learn much more about classes and objects in the next chapter.

C++ Classes and Objects

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C++ Classes/Objects

C++ is an object-oriented programming language.

Everything in C++ is associated with classes and objects, along with its attributes and methods. For example: in real life, a car is an **object**. The car has **attributes**, such as weight and color, and **methods**, such as drive and brake.

Attributes and methods are basically **variables** and **functions** that belongs to the class. These are often referred to as "class members".

A class is a user-defined data type that we can use in our program, and it works as an object constructor, or a "blueprint" for creating objects.

Create a Class

To create a class, use the `class` keyword:

Example

Create a class called "`MyClass`":

```
class MyClass {        // The class
  public:              // Access specifier
    int myNum;         // Attribute (int variable)
    string myString;   // Attribute (string variable)
};
```

Example explained

- The `class` keyword is used to create a class called `MyClass`.
- The `public` keyword is an **access specifier**, which specifies that members (attributes and methods) of the class are accessible from outside the class. You will learn more about access specifiers later.
- Inside the class, there is an integer variable `myNum` and a string variable `myString`. When variables are declared within a class, they are called **attributes**.
- At last, end the class definition with a semicolon `;`.

Create an Object

In C++, an object is created from a class. We have already created the class named `MyClass`, so now we can use this to create objects.

To create an object of `MyClass`, specify the class name, followed by the object name.

To access the class attributes (`myNum` and `myString`), use the dot syntax (`.`) on the object:

Example

Create an object called "`myObj`" and access the attributes:

```
class MyClass {        // The class
  public:              // Access specifier
    int myNum;         // Attribute (int variable)
    string myString;   // Attribute (string variable)
};
```

```
int main() {
  MyClass myObj;  // Create an object of MyClass

  // Access attributes and set values
  myObj.myNum = 15;
  myObj.myString = "Some text";

  // Print attribute values
  cout << myObj.myNum << "\n";
  cout << myObj.myString;
  return 0;
}
```

Try it Yourself »

Multiple Objects

You can create multiple objects of one class:

Example

```
// Create a Car class with some attributes
class Car {
  public:
    string brand;
    string model;
    int year;
};

int main() {
  // Create an object of Car
  Car carObj1;
  carObj1.brand = "BMW";
  carObj1.model = "X5";
  carObj1.year = 1999;

  // Create another object of Car
  Car carObj2;
  carObj2.brand = "Ford";
  carObj2.model = "Mustang";
  carObj2.year = 1969;

  // Print attribute values
  cout << carObj1.brand << " " << carObj1.model << " " <<
carObj1.year << "\n";
  cout << carObj2.brand << " " << carObj2.model << " " <<
carObj2.year << "\n";
  return 0;
}
```

Try it Yourself »

C++ Exercises

Exercise:

Create an object of `MyClass` called `myObj`.

```
[      ] [      ];
```

Submit Answer »

Start the Exercise

C++ Class Methods

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Class Methods

Methods are **functions** that belongs to the class.

There are two ways to define functions that belongs to a class:

- Inside class definition
- Outside class definition

In the following example, we define a function inside the class, and we name it "`myMethod`".

Note: You access methods just like you access attributes; by creating an object of the class and using the dot syntax (`.`):

Inside Example

```
class MyClass {         // The class
  public:               // Access specifier
    void myMethod() {  // Method/function defined inside the class
      cout << "Hello World!";
    }
};

int main() {
  MyClass myObj;     // Create an object of MyClass
  myObj.myMethod();  // Call the method
  return 0;
}
```

Try it Yourself »

To define a function outside the class definition, you have to declare it inside the class and then define it outside of the class. This is done by specifiying the name of the class, followed the scope resolution `::` operator, followed by the name of the function:

Outside Example

```
class MyClass {         // The class
  public:               // Access specifier
    void myMethod();   // Method/function declaration
};

// Method/function definition outside the class
void MyClass::myMethod() {
  cout << "Hello World!";
}

int main() {
  MyClass myObj;     // Create an object of MyClass
  myObj.myMethod();  // Call the method
  return 0;
}
```

Try it Yourself »

ADVERTISEMENT

Parameters

You can also add parameters:

Example

```
#include <iostream>
using namespace std;

class Car {
  public:
    int speed(int maxSpeed);
};

int Car::speed(int maxSpeed) {
  return maxSpeed;
}

int main() {
  Car myObj; // Create an object of Car
  cout << myObj.speed(200); // Call the method with an argument
  return 0;
}
```

C++ Constructors

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Constructors

A constructor in C++ is a **special method** that is automatically called when an object of a class is created.

To create a constructor, use the same name as the class, followed by parentheses `()`:

Example

```
class MyClass {     // The class
  public:           // Access specifier
    MyClass() {     // Constructor
    cout << "Hello World!";
  }
};

int main() {
  MyClass myObj;    // Create an object of MyClass (this will call the
constructor)
  return 0;
}
```

Try it Yourself »

Note: The constructor has the same name as the class, it is always `public`, and it does not have any return value.

Constructor Parameters

Constructors can also take parameters (just like regular functions), which can be useful for setting initial values for attributes.

The following class have `brand`, `model` and `year` attributes, and a constructor with different parameters. Inside the constructor we set the attributes equal to the constructor parameters (`brand=x`, etc). When we call the constructor (by creating an object of the class), we pass parameters to the constructor, which will set the value of the corresponding attributes to the same:

Example

```
class Car {        // The class
  public:          // Access specifier
    string brand;  // Attribute
    string model;  // Attribute
    int year;      // Attribute
    Car(string x, string y, int z) { // Constructor with parameters
      brand = x;
      model = y;
      year = z;
    }
};

int main() {
  // Create Car objects and call the constructor with different values
  Car carObj1("BMW", "X5", 1999);
  Car carObj2("Ford", "Mustang", 1969);

  // Print values
  cout << carObj1.brand << " " << carObj1.model << " " <<
carObj1.year << "\n";
  cout << carObj2.brand << " " << carObj2.model << " " <<
carObj2.year << "\n";
  return 0;
}
```

Try it Yourself »

Just like functions, constructors can also be defined outside the class. First, declare the constructor inside the class, and then define it outside of the class by specifying the name of the class, followed by the scope resolution `::` operator, followed by the name of the constructor (which is the same as the class):

Example

```
class Car {         // The class
  public:           // Access specifier
    string brand;   // Attribute
    string model;   // Attribute
    int year;       // Attribute
    Car(string x, string y, int z); // Constructor declaration
};

// Constructor definition outside the class
Car::Car(string x, string y, int z) {
  brand = x;
  model = y;
  year = z;
}

int main() {
  // Create Car objects and call the constructor with different values
  Car carObj1("BMW", "X5", 1999);
  Car carObj2("Ford", "Mustang", 1969);

  // Print values
  cout << carObj1.brand << " " << carObj1.model << " " <<
carObj1.year << "\n";
  cout << carObj2.brand << " " << carObj2.model << " " <<
carObj2.year << "\n";
  return 0;
}
```

Try it Yourself »

C++ Access Specifiers

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Access Specifiers

By now, you are quite familiar with the `public` keyword that appears in all of our class examples:

Example

```
class MyClass {  // The class
  public:        // Access specifier
    // class members goes here
};
```

Try it Yourself »

The `public` keyword is an **access specifier.** Access specifiers define how the members (attributes and methods) of a class can be accessed. In the example above, the members are `public` - which means that they can be accessed and modified from outside the code.

However, what if we want members to be private and hidden from the outside world?

In C++, there are three access specifiers:

- `public` - members are accessible from outside the class
- `private` - members cannot be accessed (or viewed) from outside the class
- `protected` - members cannot be accessed from outside the class, however, they can be accessed in inherited classes. You will learn more about Inheritance later.

In the following example, we demonstrate the differences between `public` and `private` members:

Example

```
class MyClass {
  public:    // Public access specifier
    int x;   // Public attribute
  private:   // Private access specifier
    int y;   // Private attribute
};

int main() {
  MyClass myObj;
  myObj.x = 25;  // Allowed (public)
  myObj.y = 50;  // Not allowed (private)
  return 0;
}
```

If you try to access a private member, an error occurs:

```
error: y is private
```

Try it Yourself »

Note: It is possible to access private members of a class using a public method inside the same class. See the next chapter (Encapsulation) on how to do this.

Tip: It is considered good practice to declare your class attributes as private (as often as you can). This will reduce the possibility of yourself (or others) to mess up the code. This is also the main ingredient of the Encapsulation concept, which you will learn more about in the next chapter.

Note: By default, all members of a class are `private` if you don't specify an access specifier:

Example

```
class MyClass {
  int x;   // Private attribute
  int y;   // Private attribute
};
```

C++ Encapsulation

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Encapsulation

The meaning of **Encapsulation**, is to make sure that "sensitive" data is hidden from users. To achieve this, you must declare class variables/attributes as `private` (cannot be accessed from outside the class). If you want others to read or modify the value of a private member, you can provide public **get** and **set** methods.

Access Private Members

To access a private attribute, use public "get" and "set" methods:

Example

```
#include <iostream>
using namespace std;

class Employee {
  private:
    // Private attribute
    int salary;

  public:
    // Setter
    void setSalary(int s) {
      salary = s;
    }
    // Getter
    int getSalary() {
      return salary;
    }
};

int main() {
  Employee myObj;
  myObj.setSalary(50000);
  cout << myObj.getSalary();
  return 0;
}
```

Try it Yourself »

Example explained

The `salary` attribute is `private`, which have restricted access.

The public `setSalary()` method takes a parameter (`s`) and assigns it to the `salary` attribute (salary = s).

The public `getSalary()` method returns the value of the private `salary` attribute.

Inside `main()`, we create an object of the `Employee` class. Now we can use the `setSalary()` method to set the value of the private attribute to `50000`. Then we call the `getSalary()` method on the object to return the value.

Why Encapsulation?

- It is considered good practice to declare your class attributes as private (as often as you can). Encapsulation ensures better control of your data, because you (or others) can change one part of the code without affecting other parts
- Increased security of data

C++ Inheritance

Inheritance

In C++, it is possible to inherit attributes and methods from one class to another. We group the "inheritance concept" into two categories:

- **derived class** (child) - the class that inherits from another class
- **base class** (parent) - the class being inherited from

To inherit from a class, use the `:` symbol.

In the example below, the `Car` class (child) inherits the attributes and methods from the `Vehicle` class (parent):

Example

```
// Base class
class Vehicle {
  public:
    string brand = "Ford";
    void honk() {
      cout << "Tuut, tuut! \n" ;
    }
};

// Derived class
class Car: public Vehicle {
  public:
    string model = "Mustang";
};

int main() {
  Car myCar;
  myCar.honk();
  cout << myCar.brand + " " + myCar.model;
  return 0;
}
```

Why And When To Use "Inheritance"?

- It is useful for code reusability: reuse attributes and methods of an existing class when you create a new class.

C++ Multilevel Inheritance

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Multilevel Inheritance

A class can also be derived from one class, which is already derived from another class.

In the following example, `MyGrandChild` is derived from class `MyChild` (which is derived from `MyClass`).

Example

```
// Base class (parent)
class MyClass {
  public:
    void myFunction() {
      cout << "Some content in parent class." ;
    }
};

// Derived class (child)
class MyChild: public MyClass {
};

// Derived class (grandchild)
class MyGrandChild: public MyChild {
};

int main() {
  MyGrandChild myObj;
  myObj.myFunction();
  return 0;
}
```

C++ Multiple Inheritance

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Multiple Inheritance

A class can also be derived from more than one base class, using a **comma-separated list:**

Example

```
// Base class
class MyClass {
  public:
    void myFunction() {
      cout << "Some content in parent class." ;
    }
};

// Another base class
class MyOtherClass {
  public:
    void myOtherFunction() {
      cout << "Some content in another class." ;
    }
};
```

```
// Derived class
class MyChildClass: public MyClass, public MyOtherClass {
};

int main() {
  MyChildClass myObj;
  myObj.myFunction();
  myObj.myOtherFunction();
  return 0;
}
```

C++ Inheritance Access

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Access Specifiers

You learned from the Access Specifiers chapter that there are three specifiers available in C++. Until now, we have only used `public` (members of a class are accessible from outside the class) and `private` (members can only be accessed within the class). The third specifier, `protected`, is similar to `private`, but it can also be accessed in the **inherited** class:

Example

```
// Base class
class Employee {
  protected: // Protected access specifier
    int salary;
};

// Derived class
class Programmer: public Employee {
  public:
    int bonus;
    void setSalary(int s) {
      salary = s;
    }
    int getSalary() {
      return salary;
    }
};
```

```
int main() {
  Programmer myObj;
  myObj.setSalary(50000);
  myObj.bonus = 15000;
  cout << "Salary: " << myObj.getSalary() << "\n";
  cout << "Bonus: " << myObj.bonus << "\n";
  return 0;
}
```

C++ Polymorphism

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Polymorphism

Polymorphism means "many forms", and it occurs when we have many classes that are related to each other by inheritance.

Like we specified in the previous chapter; **Inheritance** lets us inherit attributes and methods from another class. **Polymorphism** uses those methods to perform different tasks. This allows us to perform a single action in different ways.

For example, think of a base class called `Animal` that has a method called `animalSound()`. Derived classes of Animals could be Pigs, Cats, Dogs, Birds - And they also have their own implementation of an animal sound (the pig oinks, and the cat meows, etc.):

Example

```
// Base class
class Animal {
  public:
    void animalSound() {
      cout << "The animal makes a sound \n";
    }
};

// Derived class
class Pig : public Animal {
  public:
    void animalSound() {
      cout << "The pig says: wee wee \n";
    }
};

// Derived class
class Dog : public Animal {
  public:
    void animalSound() {
      cout << "The dog says: bow wow \n";
    }
};
```

Remember from the Inheritance chapter that we use the `:` symbol to inherit from a class.

Now we can create `Pig` and `Dog` objects and override the `animalSound()` method:

Example

```
// Base class
class Animal {
  public:
    void animalSound() {
      cout << "The animal makes a sound \n";
    }
};

// Derived class
class Pig : public Animal {
  public:
    void animalSound() {
      cout << "The pig says: wee wee \n";
    }
};

// Derived class
class Dog : public Animal {
  public:
    void animalSound() {
      cout << "The dog says: bow wow \n";
    }
};

int main() {
  Animal myAnimal;
  Pig myPig;
  Dog myDog;

  myAnimal.animalSound();
  myPig.animalSound();
  myDog.animalSound();
  return 0;
}
```

Try it Yourself »

Why And When To Use "Inheritance" and "Polymorphism"?

- It is useful for code reusability: reuse attributes and methods of an existing class when you create a new class.

C++ Files

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C++ Files

The `fstream` library allows us to work with files.

To use the `fstream` library, include both the standard `<iostream>` **AND** the `<fstream>` header file:

Example

```
#include <iostream>
#include <fstream>
```

There are three classes included in the `fstream` library, which are used to create, write or read files:

Class	Description
`ofstream`	Creates and writes to files
`ifstream`	Reads from files

`fstream`	A combination of ofstream and ifstream: creates, reads, and writes to files

Create and Write To a File

To create a file, use either the `ofstream` or `fstream` class, and specify the name of the file.

To write to the file, use the insertion operator (`<<`).

Example

```
#include <iostream>
#include <fstream>
using namespace std;

int main() {
  // Create and open a text file
  ofstream MyFile("filename.txt");

  // Write to the file
  MyFile << "Files can be tricky, but it is fun enough!";

  // Close the file
  MyFile.close();
}
```

Why do we close the file?

It is considered good practice, and it can clean up unnecessary memory space.

Read a File

To read from a file, use either the `ifstream` or `fstream` class, and the name of the file.

Note that we also use a `while` loop together with the `getline()` function (which belongs to the `ifstream` class) to read the file line by line, and to print the content of the file:

Example

```
// Create a text string, which is used to output the text file
string myText;

// Read from the text file
ifstream MyReadFile("filename.txt");

// Use a while loop together with the getline() function to read the file
line by line
while (getline (MyReadFile, myText)) {
  // Output the text from the file
  cout << myText;
}

// Close the file
MyReadFile.close();
```

C++ Exceptions

C++ Exceptions

When executing C++ code, different errors can occur: coding errors made by the programmer, errors due to wrong input, or other unforeseeable things.

When an error occurs, C++ will normally stop and generate an error message. The technical term for this is: C++ will throw an **exception** (throw an error).

C++ try and catch

Exception handling in C++ consist of three keywords: `try`, `throw` and `catch`:

The `try` statement allows you to define a block of code to be tested for errors while it is being executed.

The `throw` keyword throws an exception when a problem is detected, which lets us create a custom error.

The `catch` statement allows you to define a block of code to be executed, if an error occurs in the try block.

The `try` and `catch` keywords come in pairs:

Example

```
try {
  // Block of code to try
  throw exception; // Throw an exception when a problem arise
}
catch () {
  // Block of code to handle errors
}
```

Consider the following example:

Example

```
try {
  int age = 15;
  if (age >= 18) {
    cout << "Access granted - you are old enough.";
  } else {
    throw (age);
  }
}
catch (int myNum) {
  cout << "Access denied - You must be at least 18 years old.\n";
  cout << "Age is: " << myNum;
}
```

Try it Yourself »

Example explained

We use the `try` block to test some code: If the `age` variable is less than `18`, we will `throw` an exception, and handle it in our `catch` block.

In the `catch` block, we catch the error and do something about it.
The `catch` statement takes a **parameter**: in our example we use an `int` variable (`myNum`) (because we are throwing an exception of `int` type in the `try` block (`age`)), to output the value of `age`.

If no error occurs (e.g. if `age` is `20` instead of `15`, meaning it will be be greater than 18), the `catch` block is skipped:

Example

```
int age = 20;
```

Try it Yourself »

You can also use the `throw` keyword to output a reference number, like a custom error number/code for organizing purposes:

Example

```
try {
  int age = 15;
  if (age >= 18) {
    cout << "Access granted - you are old enough.";
  } else {
    throw 505;
  }
}
catch (int myNum) {
  cout << "Access denied - You must be at least 18 years old.\n";
  cout << "Error number: " << myNum;
}
```

Try it Yourself »

Handle Any Type of Exceptions (...)

If you do not know the `throw` **type** used in the `try` block, you can use the "three dots" syntax (`...`) inside the `catch` block, which will handle any type of exception:

Example

```
try {
  int age = 15;
  if (age >= 18) {
    cout << "Access granted - you are old enough.";
  } else {
    throw 505;
  }
}
catch (...) {
  cout << "Access denied - You must be at least 18 years old.\n";
}
```

C++ How To Add Two Numbers

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Add Two Numbers

Learn how to add two numbers in C++:

Example

```
int x = 5;
int y = 6;
int sum = x + y;
cout << sum;
```

Try it Yourself »

Add Two Numbers with User Input

In this example, the user must input two numbers. Then we print the sum by calculating (adding) the two numbers:

Example

```
int x, y;
int sum;
cout << "Type a number: ";
cin >> x;
cout << "Type another number: ";
cin >> y;
sum = x + y;
cout << "Sum is: " << sum;
```

C++ Examples

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C++ Syntax

Create a simple "Hello World" program
Syntax Explained

C++ Output/Print

Use cout to output values/print textUsing many cout objectsInsert a new line with \nInsert a new line with endl
Output Explained

C++ Comments

Single-line comment before a line of codeSingle-line comment at the end of a line of codeMulti-line comment
Comments Explained

C++ Variables

Create an integer variableCreate a variable without assigning the value, and assign the value laterAssign a new value to an existing value (this will overwrite the previous value)Create an unchangeable variable with the const keywordCombine text and a variable on printAdd a variable to another variableDeclare many variables of the same type with a comma-separated listIdentifiers
Variables Explained

C++ User Input

Input a number and print the resultInput two numbers and print the sum
User Input Explained

C++ Data Types

A demonstration of different data typesCreate an int typeCreate a float typeCreate a double typeCreate boolean typesCreate a char typeCreate a string type

---

Data Types Explained