C++

Introduction

What is C++?

- C++ is a cross-platform language that can be used to create high-performance applications.
- C++ was developed by Bjarne Stroustrup, as an extension to the C language.
- C++ gives programmers a high level of control over system resources and memory.
- The language was updated 3 major times in 2011, 2014, and 2017 to C++11, C++14, and C++17.

Why Use C++

- C++ is one of the world's most popular programming languages.
- C++ can be found in today's operating systems, Graphical User Interfaces, and embedded systems.
- C++ is an object-oriented programming language which gives a clear structure to programs and allows code to be reused, lowering development costs.
- C++ is portable and can be used to develop applications that can be adapted to multiple platforms.
- C++ is fun and easy to learn!
- As C++ is close to C# and Java, it makes it easy for programmers to switch to C++ or vice versa

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/downloads/26. Download the mingw-setup.exe file, which will install the text editor with a compiler.

C++ Quickstart

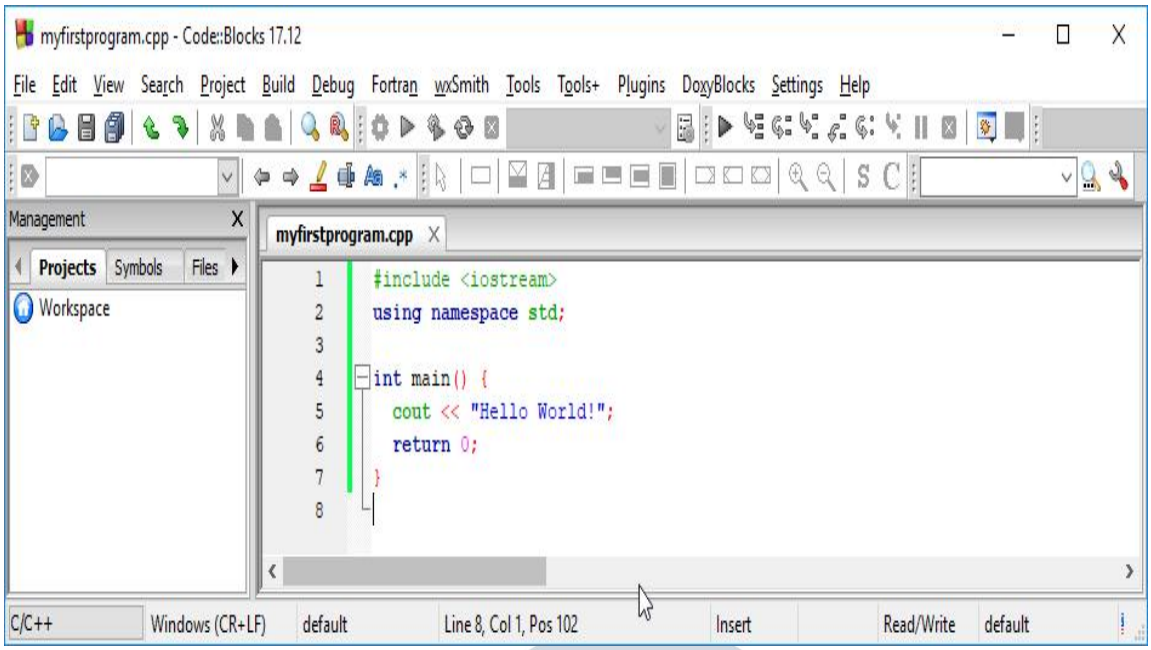
- Let's create our first C++ file.
- Open Codeblocks and go to **File > New > Empty File**.
- Write the following C++ code and save the file as myfirstprogram.cpp (**File > Save File as**):

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:



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.

Learning C++

When learning C++ at ditrp.com, you can use our "Try it Yourself" tool, which shows both the code and the result. This will make it easier for you to understand every part as we move forward:

myfirstprogram.cpp

Code:

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

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

Result:

```
Hello World!
```

C++ SYNTAX

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.

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;
}
```

C++ OUTPUT (PRINT TEXT)

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;
}
```


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

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;
}
```

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;
}
```

C++ COMMENTS

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!";
```

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!";
```

C++ VARIABLES

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, you must specify the type and assign it a value:

Syntax

type variable = *value*;

Where *type* is one of C++ types (such as int), and *variable* 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;
```

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

Example

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

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
```

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.";
```


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;
```

C++ Declare Multiple Variables

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;
```

C++ Identifiers

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;
```


C++ Constants

Constants

When you do not want others (or yourself) to override 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'
```

You should always declare the variable as constant when you have values that are unlikely to change:

Example

```
const int minutesPerHour = 60;
const float PI = 3.14;
```

C++ USER INPUT

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
```

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;
```

C++ DATA TYPES

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
```

Basic Data Types

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

Data Type	Size	Description
int	4 bytes	Stores whole numbers, without decimals
float	4 bytes	Stores fractional numbers, containing one or more decimals. Sufficient for storing 7 decimal digits
double	8 bytes	Stores fractional numbers, containing one or more decimals. Sufficient for storing 15 decimal digits
boolean	1 byte	Stores true or false values
char	1 byte	Stores a single character/letter/number, or ASCII values

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;
```

float

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

double

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

float vs. double

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

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)
```

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

C++ Character Data Types

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;
```

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

Example

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

C++ String Data Types

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;
```

C++ OPERATORS

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;
```

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)
```

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++ Assignment Operators

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;
```

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

Example

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

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

Comparison Operators

- Comparison operators are used to compare two values.
- **Note:** The return value of a comparison is either true (1) or false (0).
- 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
```

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

C++ Logical Operators

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)

C++ STRINGS

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";
```

C++ String Concatenation

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;
```

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;
```


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

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)
```

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)
```

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

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();
```

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();
```

C++ Access Strings

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
```

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
```

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++ USER INPUT STRINGS

User Input Strings

It is possible to use the extraction operator >> on cin to display 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 display 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

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;
}
```

C++ MATH

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);
```

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

Example

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

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);
```

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++ BOOLEANS

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)
```

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

However, it is more common to return boolean values from boolean expressions (see next page).

C++ BOOLEAN EXPRESSIONS

Boolean Expression

- A **Boolean expression** is a C++ expression that returns a boolean value: 1 (true) or 0 (false).
- You can use a comparison operator, such as the **greater than** (>) operator to find out if an expression (or a variable) is true:

Example

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

Or even easier:

Example

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

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
```

Example

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

Booleans are the basis for all C++ comparisons and conditions.
You will learn more about conditions (if...else) in the next chapter.

C++ IF ... ELSE

C++ Conditions and If Statements

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";
}
```

We can also test variables:

Example

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

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++ ELSE

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."
```

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

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."
```

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++ SWITCH

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)
```


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"
```

Note: The default keyword must be used as the last statement in the switch, and it does not need a break.

C++ WHILE LOOP

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++;
}
```

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

C++ Do/While Loop

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);
```


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

C++ FOR LOOP

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";
}
```

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";
}
```


C++ BREAK AND CONTINUE

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";
```

}

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;
 }
}
```

Continue Example

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

C++ ARRAYS

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

Example

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


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:

Example

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

Example

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

C++ Arrays and Loops

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[4] = {"Volvo", "BMW", "Ford", "Mazda"};
for(int i = 0; i < 4; i++) {
  cout << cars[i] << "\n";
}
```

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

Example

```
string cars[4] = {"Volvo", "BMW", "Ford", "Mazda"};
for(int i = 0; i < 4; i++) {
  cout << i << ": " << cars[i] << "\n";
}
```


C++ Omit Array Size

Omit Array Size

You don't have to specify the size of the array. But if you don't, it will only be as big as the elements that are inserted into it:

```
string cars[] = {"Volvo", "BMW", "Ford"}; // size of array is always 3
```

This is completely fine. However, the problem arise if you want extra space for future elements. Then you have to overwrite the existing values:

~~string cars[] = {"Volvo", "BMW", "Ford"};~~
string cars[] = {"Volvo", "BMW", "Ford", "Mazda", "Tesla"};

If you specify the size however, the array will reserve the extra space:
string cars[5] = {"Volvo", "BMW", "Ford"}; // size of array is 5, even though it's only three elements inside it

Now you can add a fourth and fifth element without overwriting the others:
cars[3] = "Mazda";
cars[4] = "Tesla";

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

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

C++ REFERENCES

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
```

C++ Memory Address

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
```

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

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)
```

- 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";
```


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++ Dereference

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";
```

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

- 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!"
```

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!
```

Function Declaration and Definition

A C++ function consist of two parts:

- **Declaration:** the function's name, return type, 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
```


- 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!";
}
```

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
```

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

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
```


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

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.
```

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

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)
```

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)
```

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

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++ FUNCTION OVERLOADING

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;
}
```

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;
```

}

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

C++ OOP

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	Objects
Fruit	Apple
	Banana
	Mango

Another example:

Class	Objects
Car	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

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;
```

```
}
```

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;
}
```


C++ CLASS METHODS

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;
}
```

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;
}
```

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

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;
}
```

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;
}
```

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;
}
```

C++ ACCESS SPECIFIERS

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
};
```

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 outsideworld?

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
```

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

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;
}
```

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

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

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

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

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;
}
```


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

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;
}
```

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;
```

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;
}
```


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

Add Two Numbers

Learn how to add two numbers in C++:

Example

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

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;
```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