Modern C++

An effective short way

By

Mustapha Ossama Abdelhalim

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# Starter and Installation

Modern C++ starts with C11, this book introduce C11 and later on, the moving to C17 section

## For windows

1. Go to [winlibs.com](https://winlibs.com/)
2. Determine which list you will choose from UCRT runtime if you are using windows 10 or 11, or choose MSVCRT runtime if you are using older versions of windows.
3. If you will use the gcc for application that runs only on windows choose MCF threads, if you are using application that runs on windows and later maybe used on Linux distribution; choose POSIX threads

I will choose Win64 in UCRT runtime in POSIX thread section as I have windows 10 x64 and have 7zip installed see Figure 1 gcc releases

Figure 1 gcc releases

See this video for more details [LINK](https://www.youtube.com/watch?v=COZw6XetvR0)

## For Linux

Gcc is installed by default in ubuntu distribution

A screenshot of a computer

Description automatically generatedAfter downloading and extracting, move the mingw to c directory and get the bin path in environment variable and make sure to delete the old gcc form environment variables if exists. See Figure 2 adding bin folder path to environment variables

Figure 2 adding bin folder path to environment variables

A screen shot of a computer error

Description automatically generatedType in cmd gcc –version and you should see that gcc installed see Figure 3 verifying gcc installation

Figure 3 verifying gcc installation

# Basics

In this chapter, the Basics of C++ will be introduced as a refresher, the following topics will be introduced:

* **First program**
  + Compilation Hello World
* **Variables and Data Types**
  + Primitive types: int, char, float, double, bool
  + Derived types: arrays, pointers, references
  + User-defined types: structs, enums, classes
* **Operators and Expressions**
  + Arithmetic operators: +, -, \*, /, %
  + Relational operators: ==, !=, >, <, >=, <=
  + Logical operators: &&, ||, !
  + Bitwise operators: &, |, ^, ~, <<, >>
  + Assignment operators: =, +=, -=, \*=, /=, %=, &=, |=, ^=, <<=, >>=
  + Increment and decrement operators: ++, --
  + Conditional operator: ?:
* **Control Structures**
  + Conditional statements: if, if-else, nested if, switch-case
  + Looping statements: for, while, do-while
  + Jump statements: break, continue, goto, return

## Introduction

A **programming language** is set of instruction to perform a task, that’s it

In this book we will use notepad++ (even the simple preinstalled notepad will work fine) and compile our program in command prompt CMD, also its completely fine to use any integrated development environment (IDE), but make sure that you are using C11 gcc version.

C++ language has two types of files headers files(.h files) and source files (.cpp files), to compile the program and make it executable for windows (aka converted to .exe files to run on windows). you will use the following command in cmd

g++ -std=c++11 name.cpp -o name.exe

let’s break it down

* **g++** is the gcc command to perform compilation
* **-std-c++11** is flag to specify the version of c11
* **name.cpp** is our source file
* **-o** is the flag for output the .exe file
* **name.exe** is the name of output

## Hello World

1. Lets compile our first program !

#include<iostream>

int main**(){**

std**::**cout**<<**"Hello World"**;**

**return** 0**;**

**}**

* #include<iostream>

is library that permit us to output data and take input from user

* int main(){

return 0;}

Is the entry point for our program, all programs and applications should have that function (later functions will be expressed)

* std::cout<<”hello world”;

is the command to output hello world on the screen

1. make a file named Hello.cpp for example
2. type the code above
3. open cmd in the same directory as the file Hello.cpp
4. type: g++ -std=c++11 Hello.cpp -o Hello.exe
5. to run the program type: Hello.exe

the output should be as follows in Figure 4 first programA screenshot of a computer

Description automatically generated

Figure 4 first program

## Variables and data types

C++ has types to declare each variable, each variable should have a keyword to define if it integer (like 10, 99, and120) or decimal aka float like (10.2, 0.2, and 22.8) or character (like ‘a’ , ‘b’ and ‘c’) , this declaration specify:

* + How the variable stored in memory and takes how much of program memory
  + How operation change that variable

The types in C++ is as follows in Figure 5 Types in C++ :

Figure 5 Types in C++

## Primitive datatypes

Primary (primitive) data types are compiler dependent that means that the data types could be stored in different sizes for different compilers, in gcc compiler:

Type the following to examine the sizes of different datatypes, for example int (integer saved in 4 bytes in gcc).

#include<iostream>

**using** **namespace** std**;**

int main**(){**

cout**<<**"char has: "**<<sizeof(**char**)<<**endl**;**

cout**<<**"wide char has: "**<<sizeof(**wchar\_t**)<<**endl**;**

cout**<<**"int has: "**<<sizeof(**int**)<<**endl**;**

cout**<<**"float has: "**<<sizeof(**float**)<<**endl**;**

cout**<<**"double has: "**<<sizeof(**double**)<<**endl**;**

cout**<<**"long has: "**<<sizeof(**long**)<<**endl**;**

cout**<<**"long double has: "**<<sizeof(**long double**)<<**endl**;**

**return 0;**

**}**

A computer screen with white text

Description automatically generatedThe output should be in gcc compiler (maybe different for other compilers) see Figure 6:

Figure 6 datatypes sizes in gcc compiler

WHY we use different types of primitive (primary) variables?

To answer this question lets examine the following table

|  |  |  |  |
| --- | --- | --- | --- |
|  | details | Memory allocation (in GCC) | Syntax |
| char | Store characters (‘a’,’b’,etc ) and integers from -128 to 127 | 1 | char x = ‘a’; |
| wchar\_t | Store much more characters than char | 2 | wchar\_t x = L’あ’ |
| int | Store integer numbers till 2^31 positive integers and 2^31 negative integers | 4 | int x = 15; |
| float | Store decimal numbers | 4 | float x = 15.12; |

Also you have some modifiers like long/short and signed and unsigned

* Short: shorten integer to be usually stored in 2 bytes instead of 4 bytes which means that the value of short int will from 2^15 positives and 2^15 negatives not 2^31 positive integers and 2^31 negative integers.
* Long: will long the integers to be usually 12 bytes instead of 4 bytes which enlarge the range of that variable
* unsigned: signed (char or int or even short int) will store all bytes in positive for example, unsigned char has range of 0-255 while signed char (or char) has -128 to 127 (2^7 positives and 2^7 negatives)

back to our question, why we have different primitive data types?  
simply if I have variable that store integer variable of human age, I want only a variable that store positive integers of range 0 yrs old -150 yrs old, so char will be chosen or even short int (aka short) no need to take 4 bytes of integer as no human ever lived 2billion years !! so it waste of memory to choose int.

remember ! char variable store integers like 15 and characters like ‘a’ not only characters

what happen if:

1. what happen if: signed short int (aka short) which have range of -32768 to 32767, store number like 32770?

ans: the variable will overflow (aka return to zero and start to count gain the reminder) which mean that 32770is higher than the capability of unsigned short (32767) by 3 so the value will be 3 like in Figure 7 Variables overflow, note: same thing to unsigned short variable the start 0 and max is 65635 so if the number exceeds; it will start counting the reminder from 0.

Remember: when you exceed the variable range; overflow will happen



Figure 7 Variables overflow

1. what happen if: storing float number like 15.02 in integer variable like

int x = 15.02 ?

Ans: the float point (.02) will be truncated i.e. s is 15 only

SO always remember which primitive data types to choose !!;

Exercises on primitive (primary) Data types:

**Exercises** : introduction

Write C++ code to introduce someone, the introduction must include:

* + Name (string): like “Ahmed” , to declare string datatype called string like:

string name;

cin>>name;

* + Age (unsigned short) like 28
  + Salary (unsigned short) like 15000
  + GPA (float) like 3.5
  + NOTE: the data should be as input from user: to get input from user use cin>>var;

Answer:

#include <iostream>

**using** **namespace** std**;**

int main**()** **{**

string name**;**

unsigned short age**,**salary**;**

float gpa**;**

cout**<<**"enter your name"**<<**endl**;**

cin**>>**name**;**

cout**<<**"enter your age and salary "**<<**endl**;**

cin**>>**age**>>**salary**;**

cout**<<**"enter your gpa"**<<**endl**;**

cin**>>**gpa**;**

cout**<<**"Introduction\nMy name is:"**<<**name**<<**endl**;**

cout**<<**"I am "**<<**age**<<**"years old "**<<**"my salary is: "**<<**salary**<<**endl**;**

cout**<<**"my GPA is: "**<<**gpa**;**

**return** 0**;**

**}**

NOTE: \n between “ “ is as same as endl after cout which means start from new line (i.e start printing at the beginning of the new following line)

NOTE: using namesapace std; is used to write cout and cin without typing std::cout and std::cin

**Exercise** : bankClient

Write C++ program to show:

* Client name: string
* ID: int
* Deposit money: float

Answer in the GitHub repository: [LINK](https://github.com/MuOssama/MasteringCPP/tree/main/Basics/VariablesAndDatatypes)

All the previous was all about primitive datatypes, but how about derived and user defined datatypes? Recall Figure 5 Types in C++

**derived** datatypes are datatypes made from primitive

* Arrays
* Functions
* Pointers

**User defined** datatypes are datatypes that user build

* Struct
* Enum
* Union
* Class

Lets take them one by one:

## Derived datatypes

### Arrays

are list of some variables but must be same data type variable Like int list[3] clientAges; which means that we collect clientAges in one list instead of doing this: int client1Age; int client2Age; int client3Age;

So, to make the life easier we collect similar datatypes in one place called array

* + **Declaration**: datatype nameOfArray[number of item];

For example: int salaries[5];

* + **Accessing each element**: salaries[i] (i must be number from 0 to 4 as salaries have 5 items

The previous array called C-Array, C++ has much powerful arrays, these arrays have built-in method like size() and other to shorten your code

* + **Declaration**: array<datatype, itemNumbers> name;

For example: array<int, 5> salaries;

NOTE: don’t forget to include array (i.e #include <array>)

* + **Accessing each element**: salaries[i] (i must be number from 0 to 4 as salaries have 5 items

**Exercise** : arrays

Write C++ array of 5 integer contains some user salaries, don’t use c arrays, use C++ std array

#include<iostream>

#include<array>

**using** **namespace** std**;**

int main**(){**

array**<**int**,** 5**>**salaries**;**

//filling the array

**for(**int i**=**0**;**i**<**salaries**.**size**();**i**++){**

cout**<<**"enter the "**<<**i**<<**" element:"**;**

cin**>>**salaries**[**i**];**

cout**<<**"\n"**;**

**}**

//printing the array

**for(**int i**=**0**;**i**<**salaries**.**size**();**i**++){**

cout**<<**"the element "**<<**i**<<**" is: "**<<**salaries**[**i**]<<**"\n"**;**

**}**

**}**

### Functions

Imagine you want to intoduce 10 peaple (like in **Exercises 1**: introduction) the program was about 10 line for one person, do write same code for the 10 person (100 lines !!) OR you can write the code for general person once in a place called function and whenever you want to use that function, call that general function and specify your details

void introduction**(**string name**,** short age**,** short salary**,** float gpa **){**

cout**<<**"enter your name"**<<**endl**;**

cout**<<**"enter your age and salary "**<<**endl**;**

cout**<<**"enter your gpa"**<<**endl**;**

cout**<<**"Introduction\nMy name is:"**<<**name**<<**endl**;**

cout**<<**"I am "**<<**age**<<**"years old "**<<**"my salary is: "**<<**salary**<<**endl**;**

cout**<<**"my GPA is: "**<<**gpa**;**

**}**

You build the general function, you can now call it as many times as you want !!

introduction**(**“Ahmed”**,**26**,**15000**,**3.6**);**

introduction**(**Gamal**,**30**,**2500**,**3.8**);**

introduction**(**Mahmoud**,**22**,**1200**,**3.2**);**

we will know more about functions and pointers later.

## User-defined datatypes

### Structs

Struct is used when you want to declare and object that have many attributes (i.e. variable) but different data types, e.g you want to describe a student how have name (String), id (int), gpa (float), struct came to hold these attributes (variables) in one place called struct

**Example:** studentStruct

In this example, struct is made for student who have 3 atributes for example name (String), id (int), gpa (float).

//declaration

struct student**{**

string name**;**

int id**;**

float gpa**;**

**};**

int main**(){**

//create instance of a struct

student Ahmed**={**"Ahmed"**,**202410**,**3.45**};**

/\*Accessing

Accessing is done by dot operator .

\*/

cout**<<**"Name:"**<<**Ahmed**.**name**<<**" ID:"**<<**Ahmed**.**id**<<**" GPA:"**<<**Ahmed**.**gpa**<<**endl**;**

//Assigning an instance of struct

Ahmed**.**gpa **=** 3.58**;**

cout**<<**"Name:"**<<**Ahmed**.**name**<<**" ID:"**<<**Ahmed**.**id**<<**" GPA:"**<<**Ahmed**.**gpa**;**

**}**

NOTE: you can use comment to improve code readability:

* + - One line comment: using // comment
    - Multiline comment: using /\* comment \*/

1. **Declaration of struct**

struct name{

variable1;

variable2;

.

.

};

1. **Creating instance**
   * 1st way: after the deceleration

//declaration

struct student**{**

string name**;**

int id**;**

float gpa**;**

**};**

* + 2nd way: by using.. struct\_type struct\_name;

student Ahmed**={**"Ahmed"**,**202410**,**3.45**};**

NOTE: struct objects (instances) could be initialized of left to be assigned later

student Ahmed**;**

NOTE: in C++ you don’t have to use struct keyword in contrast in C

In C:

struct student Ahmed**={**"Ahmed"**,**202410**,**3.45**};**

in C++ struct is not necessary :

student Ahmed**={**"Ahmed"**,**202410**,**3.45**};**

1. **Accessing and Assigning**

Accessing done by dot operator

e.g cout**<<**"Name:"**<<**Ahmed**.**name**<<**" ID:"**<<**Ahmed**.**id**<<**" GPA:"**<<**Ahmed**.**gpa**<<**endl**;**

Assigning:

Ahmed**.**name=”Ahmed”;

**Exercise 3:** employee

Write a struct that refer to an employee that have name , salary, working hours

The answer in basics folder in the repository, see Figure 8 Exercise 3

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Description automatically generated

Figure 8 Exercise 3

1. **Methods**

Unlike C, in C++ we have methods in struct, methods are function inside structs or classes, Lets see how methods work

**Example:** structMethod

write employee struct that has name, salary, working hours, that get user data and print this data and apply bonus, so we must have 3 method(functions), see the output in Figure 9 Example

#include<iostream>

**using** **namespace** std**;**

struct employee**{**

string Name**;**

int salary**;**

short workingHrs**;**

//Method to enter employ data

void setData**(){**

cout**<<**"enter Name, Salary, Working Hrs respctivily:\n"**;**

//entering the employee data from user

cin**>>**Name**>>**salary**>>**workingHrs**;**

//printing the employee data

**}**

//Method to print employee data

void print**(){**

cout**<<**"employee: "**<<**Name**<<**" salary: "**<<**salary**<<**" working hours: "**<<**workingHrs**<<**endl**;**

**}**

//Method to apply bonus

char applyBonus**(**int bonus**){**

salary **=** salary **+** bonus**;**

**return** 's'**;**

**}**

**};**

int main**(){**

//create object of struct employee

employee emp1**;**

emp1**.**setData**();**

emp1**.**applyBonus**(**500**);**

emp1**.**print**();**

**}**

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Description automatically generated

Figure 9 Example

1. **Constructors**

Constructor is type of method that is called by default when an instance is made, the purpose of a constructor is to initialize the object, setting up initial values for its members and performing any setup required.

**Example:** structConstructor

#include <iostream>

**using** **namespace** std**;**

struct Person **{**

string name**;**

int age**;**

// Constructor

Person**(**string n**,** int a**)** **:** name**(**n**),** age**(**a**)** **{**

cout **<<** "Constructor called for " **<<** name **<<** endl**;**

**}**

// Member function to display person details

void display**()** const **{**

cout **<<** "Name: " **<<** name **<<** ", Age: " **<<** age **<<** endl**;**

**}**

**};**

int main**()** **{**

// Creating an object of the Person struct

Person person1**(**"John Doe"**,** 30**);**

// Displaying the details of person1

person1**.**display**();**

**return** 0**;**

**}**

1. Inheritance

Inheritance used to create a child class of parent class or struct , e.g. if we created a class for employee that has name and age and member function named (method) role that is either writing() or reviewing() , we could create child of struct that inherit name and age but in writers employee child struct, writing() method will be created and in reviewer child struct, reviewing() method will be created.

**Example:** inheritance

#include <iostream>

#include <string>

// Base struct

struct Employee **{**

std**::**string name**;**

int age**;**

// Constructor for Employee

Employee**(**const std**::**string**&** n**,** int a**)** **:** name**(**n**),** age**(**a**)** **{}**

**};**

// Derived struct for Writer

struct Writer **:** public Employee **{**

// Constructor for Writer

Writer**(**const std**::**string**&** name**,** int age**)** **:** Employee**(**name**,** age**)** **{}**

// Specific method for Writer

void writing**()** const **{**

std**::**cout **<<** name **<<** " is writing a document." **<<** std**::**endl**;**

**}**

**};**

// Derived struct for Reviewer

struct Reviewer **:** public Employee **{**

// Constructor for Reviewer

Reviewer**(**const std**::**string**&** name**,** int age**)** **:** Employee**(**name**,** age**)** **{}**

// Specific method for Reviewer

void reviewing**()** const **{**

std**::**cout **<<** name **<<** " is reviewing a document." **<<** std**::**endl**;**

**}**

**};**

int main**()** **{**

// Create instances of Writer and Reviewer

Writer writer**(**"Alice"**,** 30**);**

Reviewer reviewer**(**"Bob"**,** 45**);**

// Use specific methods

writer**.**writing**();** // Output: Alice is writing a document.

reviewer**.**reviewing**();**// Output: Bob is reviewing a document.

**return** 0**;**

**}**

1. **Access Modifiers : Public, Private, Protected**

In the previous example, we could access display() method and any attribute (e.g name, age) anywhere, there are 3 places could a method or attribute called:

1. In the struct or class itself such enterData() call of age attribute check in the following example

struct Person **{**

string name**;**

int age**;**

// Member function to enter member data

void enterData**()** const **{**

cin **>>** name **>>** age**;**

**if(age<0)** cout **<<** “invalid age\n”;

**}**

// Member function to display person details

void display**()** const **{**

enterData();

cout **<<** "Name: " **<<** name **<<** ", Age: " **<<** age **<<** endl**;**

**}**

**};**

***All access modifiers are accessible within a class or struct***

1. In function like main() function after creating an instance of class of struct like person1.name = “void”, and person1.display();the following example:

int main**()** **{**

// Creating an object of the Person struct

Person person1**(**"John Doe"**,** 30**);**

// Displaying the details of person1

person1**.**name = “void”;

person1**.**display**();**

**return** 0**;**

**}**

***If age and name are private or protected, they wont be called outside the class or struct***

1. Last call or access of attributes and method (member function) is used in inheritance like public in line 12 the inheritance example:
2. // Base struct
3. struct Employee **{**
4. std**::**string name**;**
5. int age**;**
6. // Constructor for Employee
7. Employee**(**const std**::**string**&** n**,** int a**)** **:** name**(**n**),** age**(**a**)** **{}**
8. **};**
9. // Derived struct for Writer
10. struct Writer **:** public Employee **{**
11. // Constructor for Writer
12. Writer**(**const std**::**string**&** name**,** int age**)** **:** Employee**(**name**,** age**)** **{}**
13. // Specific method for Writer
14. void writing**()** const **{**
15. std**::**cout **<<** name **<<** " is writing a document." **<<** std**::**endl**;**
16. **}**

**};**

A screenshot of a computer

Description automatically generatedNote: the line struct Writer **:** public Employee is public inheritance see Figure 10 public, protected, private inheritance, members are attributes and methods

Figure 10 public, protected, private inheritance

The following table in Figure 11 Access Modifiers introduce how access modifiers work



Figure 11 Access Modifiers

For now we introduced only structs in user-defined data types, also we have union and enums

### Enum

Enum is abbreviation of enumeration, which used to give some related integers names as humans don’t remember and work with number well, e.g. if a worker get 500$ on Sunday and 600$ on Monday and 700$ on Tuesday ….. . an enum could hold these number and when we want give the worker 500$ on Monday, we could use Monday instead of using 500 number

**Example:** enum

Write C++ enum that define workday wage for a worker,

Sunday = 500, Monday = 600, Tuesday = 700, Wednesday = 800,

Thursday = 900, Friday = 1000, Saturday = 1100

#include<iostream>

**using** **namespace** std**;**

enum days**{**

Sunday **=** 500**,**

Monday **=** 600**,**

Tuesday **=** 700**,**

Wednesday **=** 800**,**

Thursday **=** 900**,**

Friday **=** 1000**,**

Saturday **=** 1100

**};**

int main**(){**

days workDay**;**

cout**<<**"Worker earned: "**<<**Sunday**<<**"$ wage"**<<**endl**;**

cout**<<**"Worker earned: "**<<**Monday**<<**"$ wage"**<<**endl**;**

cout**<<**"Worker earned: "**<<**Tuesday**<<**"$ wage"**<<**endl**;**

cout**<<**"Worker earned: "**<<**Wednesday**<<**"$ wage"**<<**endl**;**

cout**<<**"Worker earned: "**<<**Thursday**<<**"$ wage"**<<**endl**;**

cout**<<**"Worker earned: "**<<**Friday**<<**"$ wage"**<<**endl**;**

cout**<<**"Worker earned: "**<<**Saturday**<<**"$ wage"**<<**endl**;**

**}**

### Union

Union is user-defined data type that all attributes of that union share the same memory see Figure 12 Union vs struct, if I changed n in union; m will be changed too



Figure 12 Union vs struct

**Example:** union

Write C++ union that holds char x=1 and short y=65535 , show the size of the that union and change value of x to 2 and print y and values

#include<iostream>

**using** **namespace** std**;**

union storage**{**

unsigned char x**;**

unsigned short y**;**

**};**

int main**(){**

storage var**;**

var**.**x **=** 1**;**

var**.**y **=** 65535**;**

cout**<<**"size of var is: "**<<sizeof(**var**)<<**endl**;**

cout**<<**"x y resp: "**<<(**unsigned short**)**var**.**x**<<**" "**<<**var**.**y**<<**endl**;**

var**.**x **=** 2**;**

cout**<<**"x y resp: "**<<(**unsigned short**)**var**.**x**<<**" "**<<**var**.**y**<<**endl**;**

**}**

You can see the output in Figure 13 union example, x is unsigned char that holds 1 byte, while y is unsigned short that holds 2 bytes, the first byte is shared by x and y

Like in Figure 14 union example explanation

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Figure 13 union example

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
|  |  |  |  |  |  |  |  | X = 255 | | | | | | | |
| Y = 65535 | | | | | | | | | | | | | | | |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  | when x changed to 2, y is affected as they have 1 byte shared | | | | | | | | |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 2nd byte | | | | | | | | 1st byte | | | | | | | |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
|  |  |  |  |  |  |  |  | X = 2 | | | | | | | |
| Y = 65282 | | | | | | | | | | | | | | | |

Figure 14 union example explanation

**Bitfield**

Bitfield is used in struct and union to specify bit values, e.g. if we have an 8bit register that we want to change every bit, we could do that.

**Example:** bitfield

Write a bitfield to mimic an 8bit register by union

#include<stdio.h>

**using** **namespace** std**;**

union Reg**{**

struct**{**

unsigned char B0**:**1**;**

unsigned char B1**:**1**;**

unsigned char B2**:**1**;**

unsigned char B3**:**1**;**

unsigned char B4**:**1**;**

unsigned char B5**:**1**;**

unsigned char B6**:**1**;**

unsigned char B7**:**1**;**

**}**Bits**;**

unsigned char byte**;**

**};**

int main**(){**

Reg DDRA**;**

DDRA**.**Bits**.**B0**=**1**;**

DDRA**.**Bits**.**B1**=**1**;**

DDRA**.**Bits**.**B2**=**1**;**

DDRA**.**Bits**.**B3**=**0**;**

DDRA**.**Bits**.**B4**=**0**;**

DDRA**.**Bits**.**B5**=**0**;**

DDRA**.**Bits**.**B6**=**0**;**

DDRA**.**Bits**.**B7**=**0**;**

printf**(**"%d"**,**DDRA**.**byte**);**

**}**

NOTE: in this example, printf must be used instead of cout, so we have to include stdio.h library

## Operators and Expressions

* Arithmetic operators: +, -, \*, /, %
* Relational operators: ==, !=, >, <, >=, <=
* Logical operators: &&, ||, !
* Bitwise operators: &, |, ^, ~, <<, >>
* Assignment operators: =, +=, -=, \*=, /=, %=, &=, |=, ^=, <<=, >>=
* unary operators (Increment and decrement): ++, --
* ternary operator: ?:

***#Let var1 = 4 and var2 = 3***

### Arithmetic operators: +, -, \*, /, %

Addition (+) e.g. var1 + var 2 = 4 + 3 =7

Subtraction (-) e.g. var1 - var 2 = 4-3=1

Multiplication (\*) var1 \* var 2 = 4\*3=12

Division (/) e.g. var1 / var 2 =4/3 = 1

Modulo or reminder (%) e.g. var1 % var 2 4%3 = 1

see Figure 15 Division and modulo

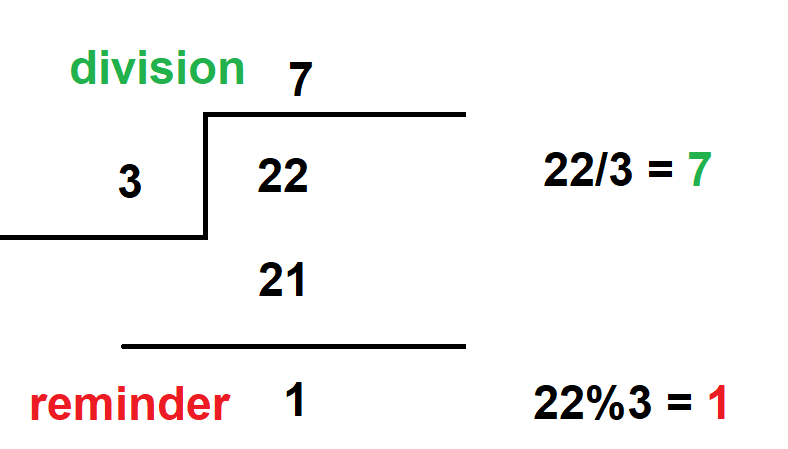


Figure 15 Division and modulo

### Relational operators: ==, !=, >, <, >=

These operators used to determine relational between variables i.e. make comparisons as follows:

Is var1 equal var2 : var1 == var2 (return false as 4 not equal 3)

Is var1 not equal var2 : var1 != var2 (return true as 4 not equal 3)

Is var1 bigger than var2 : var1 > var2 (return true as 4 bigger than 3)

Is var1 less than var2 : var1 < var2 (return false as 4 bigger than 3)

Is var1 bigger than or equal var2 : var1 >= var2 (return true as 4 bigger than 3)

### Logical operators: &&, ||, !

* && means **AND**
* || means **OR**
* !means **NOT**

**Example:** logicalOp

Whatif we want to combine 2 conditions?

The var1 is bigger than var2 **AND** var1 is odd:

The var1 is bigger than var2 **OR** var1 is odd:

The var1 is bigger than var2 **AND** var1 is not odd:

#include<iostream>

**using** **namespace** std**;**

int main**(){**

int var1 **=** 5**,** var2 **=** 6**;**

cout**<<**"The var1 is bigger than var2 AND var1 is odd: "**<<((**var2**>**var1**)&&(**var1**%**2 **==** 0**))<<**endl**;**

cout**<<**"The var1 is bigger than var2 OR var1 is odd: "**<<((**var2**>**var1**)||(**var1**%**2 **==** 0**))<<**endl**;**

cout**<<**"The var1 is bigger than var2 AND var1 is not odd: "**<<((**var2**>**var1**)** **&&** **(**var1**%**2 **!=** 0**))<<**endl**;**

**return** 0**;**

**}**

NOTE: false means 0 and true is anything except 0, the previous code should outputs: 0 1 1 (i.e. false true true)

### Bitwise operators: &, |, ^, ~, <<, >>

bitwise operators, used to change variable in bit level, if you have a 1-byte unsigned char of example, you can do operation on all these 8-bits freely like the following in the Figure 16 Bitwise operations :

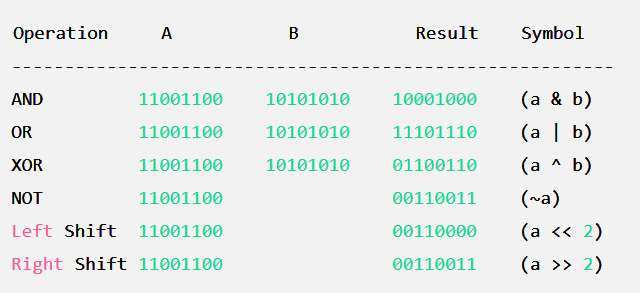


Figure 16 Bitwise operations

### Assignment operators: =, +=, -=, \*=, /=, %=, &=, |=, ^=, <<=, >>=

These operators used to assign variables, e.g.

var1 = 2 (set var1 to 2)

var1+=2 (means var1 =var1+2 which increment var1 by 2)

var1&=1 (means var1 = var1 & 1)

The following figure contains table of what are set, clr, tog, get bit

| **Operation** | **Original** | **Index** | **Result** | **Explanation** |
| --- | --- | --- | --- | --- |
| Set Bit | 11001100 | 2 | 11001100 | Bit at index 2 is already 1, no change. |
| Set Bit | 11001100 | 1 | 11001110 | Bit at index 1 is set to 1. |
| Clear Bit | 11001100 | 2 | 11001000 | Bit at index 2 is cleared to 0. |
| Clear Bit | 11001100 | 3 | 11000100 | Bit at index 3 is already 0, no change. |
| Toggle Bit | 11001100 | 2 | 11001000 | Bit at index 2 is toggled to 0. |
| Toggle Bit | 11001100 | 3 | 11000100 | Bit at index 3 is toggled to 0. |
| Get Bit (original) | 11001100 | 2 | 1 | Bit at index 2 is 1. |
| Get Bit (original) | 11001100 | 1 | 0 | Bit at index 1 is 0. |

Set bit: byte |= (1<<index) (Oring)

Clear bit: byte &=~ (1<<index) (Anding the complement )

Toggle bit: byte ^= (1<<index) (Xoring)

Get Bit: (byte>>index) & 1

**Example:** bitManipulation

In this example we want to make a struct named bit math that has 1 variable and 4 methods setBit(var, bit) clrBit(var, bit) togBit(var, bit) and getBit(var, bit)

NOTE: recall bitfield example and add the method mentioned: setBit() clrBit() ) togBit(var, bit) and getBit(var, bit)

#include<stdio.h>

**using** **namespace** std**;**

struct Register**{**

union Reg**{**

struct**{**

unsigned char B0**:**1**;**

unsigned char B1**:**1**;**

unsigned char B2**:**1**;**

unsigned char B3**:**1**;**

unsigned char B4**:**1**;**

unsigned char B5**:**1**;**

unsigned char B6**:**1**;**

unsigned char B7**:**1**;**

**}**Bits**;**

unsigned char byte**;**

**}**reg**;**

void setBit**(**int index**){**

reg**.**byte **|=** **(**1**<<**index**);**

**}**

void clrBit**(**int index**){**

reg**.**byte **&=~** **(**1**<<**index**);**

**}**

void togBit**(**int index**){**

reg**.**byte **^=** **(**1**<<**index**);**

**}**

int getBit**(**int index**){**

**return** **(**reg**.**byte**>>**index**)** **&** 1**;**

**}**

**};**

int main**(){**

Register DDRA**;**

DDRA**.**reg**.**byte **=** 0**;**

DDRA**.**setBit**(**0**);** //setting bit number 0

DDRA**.**setBit**(**1**);** //setting bit number 0

printf**(**"bit number 0 is %d\n"**,**DDRA**.**getBit**(**0**));**

printf**(**"bit number 1 is %d\n"**,**DDRA**.**getBit**(**1**));**

printf**(**"bit number 2 is %d\n"**,**DDRA**.**getBit**(**2**));**

**}**

NOTE: this is pretty hard solution, but fell easier way.

### unary operators (Increment and decrement): ++, --

increment and decrement is used on one operand (unary)

* post decrement/ increment

var1 = 5; cout<< var1++; //outputs 6

* pre decrement/increment

var1 = 5; cout<< ++var1; //outputs 5 but var1 after cout becomes 6

### ternary operator: ?:

Ternary operator is type of conditionals in C++

Syntax: (condition) what to do if true: what to do if false

e.g.

var1=5;

(var1%2==0) cout<<”even” :cout<<”odd”; // the output is “even”

## Control Structures

* Conditional statements: if, if-else, nested if, switch-case
* Looping statements: for, for range, while, do-while
* Jump statements: break, continue, goto, return

### Conditional statements: if, if-else, switch-cases

Program is set of instructions to perform a task, some instructions require certain conditions to be performed, e.g. if(day == Friday) give all workers weekend wage weekend Wage()

There are 2 types of conditionals: if, else if, else AND switch

**Switch case:**

Switch is used to check a variable

Syntax:

switch(variable){

case 1: instructions; break;

case 2: instructions; break;

case 3: instructions; break;

.

.

default: instructions;break

}

NOTE: case 1: means if variable == 1

case ‘a’: means if variable == ‘a’

NOTE: default is used when variable has value not include in cases

NOTE: don’t forgot to put break after any condition

NOTE: don’t make a variable case e.g. case var

**if, else if, else case:**

if else used when you want to check for conditions

Syntax:

if(condition){ instructions}

else if(condition){ instructions}

else { instructions}

NOTE: else if is not consider unless if conditional is not fulfilled

NOTE: else is not consider unless if conditional and else if conditionals are not fulfilled

NOTE: don’t make instructions between if- else if – else

e.g. if(x==5){ cout<<”5”’}

cin>>x; //wrong !!

else {cout<<” x is not 5;}

**Example**: switch

Write C++ code to determine whether the letter is vowel or not by using switch case, Vowels are: a, e, i, o, u . Consonants are the rest of the letters .

#include<iostream>

**using** **namespace** std**;**

int main**(){**

char x **=** ' '**;**

cout**<<**"enter a letter: "**;**

cin**>>**x**;**

**switch(**x**){**

**case** 'a'**:** cout**<<**"\n the letter "**<<**x**<<**" is Vowel\n"**;break;**

**case** 'e'**:** cout**<<**"\n the letter "**<<**x**<<**" is Vowel\n"**;break;**

**case** 'i'**:** cout**<<**"\n the letter "**<<**x**<<**" is Vowel\n"**;break;**

**case** 'u'**:** cout**<<**"\n the letter "**<<**x**<<**" is Vowel\n"**;break;**

**case** 'o'**:** cout**<<**"\n the letter "**<<**x**<<**" is Vowel\n"**;break;**

**default:** cout**<<**"\n the letter "**<<**x**<<**" is Consonant\n"**;** //break at last condition doesn’t matter

**}**

**}**

**Example**: ifElse

In switch example, if 5 is entered, the output is: the letter 5 is Consonants, as its in default case, but 5 is not letter, complete the previous code to check first if the input is letter

Hint: isalpha() use this to determine if the input is letter or not

#include<iostream>

**using** **namespace** std**;**

int main**(){**

char x **=** ' '**;**

cout**<<**"enter a letter: "**;**

cin**>>**x**;**

**if(**isalpha**(**x**)){**

**switch(**x**){**

**case** 'a'**:** cout**<<**"\n the letter "**<<**x**<<**" is Vowel\n"**;break;**

**case** 'e'**:** cout**<<**"\n the letter "**<<**x**<<**" is Vowel\n"**;break;**

**case** 'i'**:** cout**<<**"\n the letter "**<<**x**<<**" is Vowel\n"**;break;**

**case** 'u'**:** cout**<<**"\n the letter "**<<**x**<<**" is Vowel\n"**;break;**

**case** 'o'**:** cout**<<**"\n the letter "**<<**x**<<**" is Vowel\n"**;break;**

**default:** cout**<<**"\n the letter "**<<**x**<<**" is Consonant\n"**;** //break at last condition doesn’t matter

**}**

**}**

**else{**

cout**<<**'\n'**<<**x**<<**" is not letter"**<<**endl**;**

**}**

**}**

### Loops

What if we need to execute certain code many times? e.g. printing “hello” 100 time or until user enters quit

* We could type cout<<”hello” 100 times
* OR we could use loops

Loop is C++ are:

* for(start; end ;update){instructions}
* for (range){instructions}
* while(condition){instructions}
* do{instructions} while(condition)

**for loop**

**syntax:** for(start; end ;update){instructions}

e.g.

for(int itr=0;itr<10;itr++){

cout<<”hello ”<<itr<<” times<<endl;

}

Used when number of iterations is known, the previous example demonstrates printing hello itr times when such that itr starts with 0 and ends when itr = 9 (itr<10), and the update is how does the variable itr changers, in this case the update is itr is increased by 1 (i.e. itr++ means itr=itr+1 )

**Example**: forLoop

Write C++ code to print even numbers from 10 to 20

#include <iostream>

**using** **namespace** std**;**

int main**(){**

**for(**int k**=**10**;** k**<=**20**;** k**=**k**+**2 **){**

cout**<<**"the number "**<<**k**<<**" is even\n"**;**

**}**

**return** 0**;**

**}**

**for range loop**

**syntax:** for(datatype item: list){instructions}

this is used to get the item of list (array or vector) without subscript Operator (i.e []), like python for loop

**Example**: forRangeLoop

print array of vowels without using subscriptor operator

#include <iostream>

#include<array>

**using** **namespace** std**;**

int main**(){**

array**<**char**,**5**>** vowels **=** **{**'a'**,**'e'**,**'u'**,**'i'**,**'o'**};**

//remember array<,> differs from c arrays (vowels[])

**for(**char x**:** vowels**)**

**{**cout**<<**x**<<**" is vowel"**<<**endl**;}**

**}**

**While loop**

**syntax:** while(condition){instructions}

while loop is used when number of iteration is unknown but the condition is clear

**Example**: whileLoop

Write C++ code to calculate the sum of user single integer input, e.g. if user entered 1251 the sum is 1+2+5+1 which is 9

NOTE: the algorithm is take the reminder and divide the number by 10

#include <iostream>

**using** **namespace** std**;**

int main**(){**

int x **=**0**,**sum**=**0**,** cont**=**0**;**

cout**<<**"enter a number "**;**

cin**>>**x**;**

cont **=** x**;**

**while(**x**/**10 **>** 0**){**

sum **+=** x**%**10**;**

x**=** x**/**10**;**

**}**

sum **+=** x**;** //adding the most left number

cout**<<**"the sum of "**<<**cont**<<**" is: "**<<** sum**;**

**}**

**Do While loop**

**syntax:** do{instructions} while(condition);

same as while loop but the instructions are done first, then check on condition, remember the whileLoop (previous example), we had to write the following line

sum **+=** x**;** //adding the most left number

as the condition is reaching before getting the most left number

I.e.

Sum=0 and x=123

Reminder and divide first time Sum=3 and x=12 (**(**x**/**10 **>** 0**)** check is valid)

Reminder and divide second time Sum=6 and x=1 (**(**x**/**10 **>** 0**)** check isn’t valid)

As 1/10 not bigger that 0 so number 1 (most left number of 123) is not added,

**Example**: doWhileLoop

Rewrite the whileLoop by by dowhile loop instead of while loop

#include <iostream>

**using** **namespace** std**;**

int main**(){**

int x **=**0**,**sum**=**0**,** cont**=**0**;**

cout**<<**"enter a number "**;**

cin**>>**x**;**

cont **=** x**;**

**do{**

sum **+=** x**%**10**;**

x**=** x**/**10**;**

**}**

**while(**x **>** 0**);**

cout**<<**"the sum of "**<<**cont**<<**" is: "**<<** sum**;**

**}**

### Jump statements: break, continue, goto, return

**break** is used in loops to get out of the loop

**continue** is used to skip an iteration in the loop

**goto** is used to jump to any line in the code

**return** is used in functions to get out the function

**Example**: breakContinue

In this example, break and continue are used to illustrate the difference, two for loops will be written, break will be used in one loop and continue in the other when the itr is equal 6, the break gets out when itr gets 6 but the continue, skips the 6 and continue the loop, see Figure 17 break and continue

#include <iostream>

**using** **namespace** std**;**

int main**(){**

**for(**int itr**=**0**;** itr**<=**10**;** itr**++){**

**if(**itr**==**6**)** {**continue;}**

**else{**cout**<<**"continue loop: "**<<**itr**<<**endl**;}**

**}**

**for(**int itr**=**0**;** itr**<=**10**;** itr**++){**

**if(**itr**==**6**)**{**break;}**

**else{**cout**<<**"break loop: "**<<**itr**<<**endl**;}**

**}**

**}**

A screen shot of a computer

Description automatically generated

Figure 17 break and continue

**Example**: goto

Print even number from 30 to 40 without using loops and use only one cout

#include <iostream>

**using** **namespace** std**;**

int main**(){**

int itr **=** 30**;**

a**:**

**if(**itr**%**2 **==**0**){**

cout**<<**"the number "**<<**itr**<<**" is even\n"**;**

**}**

itr**++;**

**if(**itr**<=**40**)**

**goto** a**;**

**}**

## Final project

Project Requirements: Sign-Up Application

We are developing a user registration application to store user names and ages.

We will use a struct to represent each user, stored in an array (limited to 100 records).

Users can add records and retrieve them by ID.

Steps to Complete:

1-Include necessary headers.

2-Define a struct for user records (Person), and declare an array of this type (Person records[100]).

3-Implement functions:

A-void AddRecord(const std::string& name, int age): Adds a new record.

B-FetchRecord(int id): Retrieves a record by ID.

C-Quit().

4-In main(), use a loop to present options (Add Record, Fetch Record, Quit).

Handle user input using a switch statement:

Case 1: Prompt for name and age, then call AddRecord().

Case 2: Prompt for ID, then call FetchRecord() and display the result.

Case 3: Exit the loop.

You can fine code in the github repository [LINK](https://github.com/MuOssama/MasteringCPP/blob/main/Basics/FinalProject/finalProject.cpp)

An example: see Figure 17 Final project snapshoot

A screenshot of a computer program

Description automatically generated

Figure 18 Final project snapshoot