C++ Software Engineering

for engineers of other disciplines

Module 1

"C++ Syntax"

1st Lecture: Hello World!

ALTEN

Autumn 2021

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Work Environment

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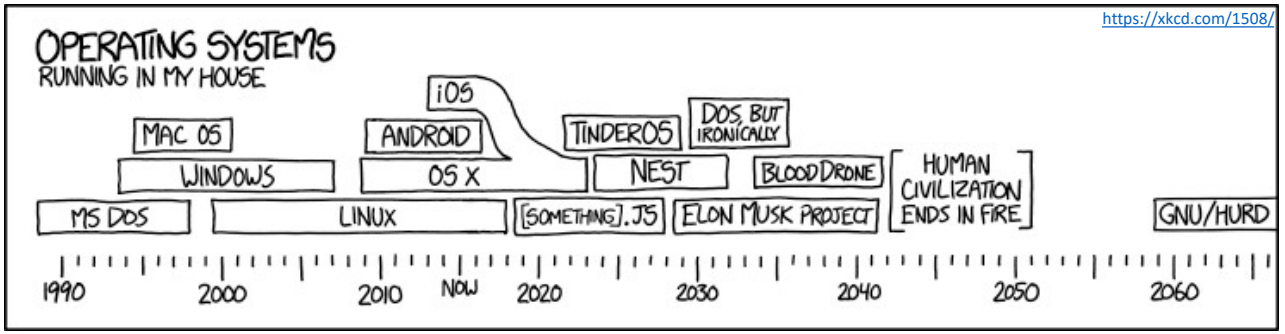
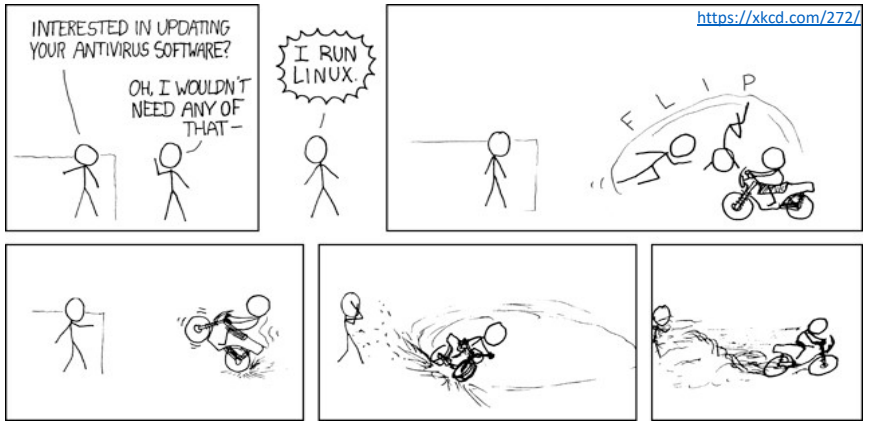
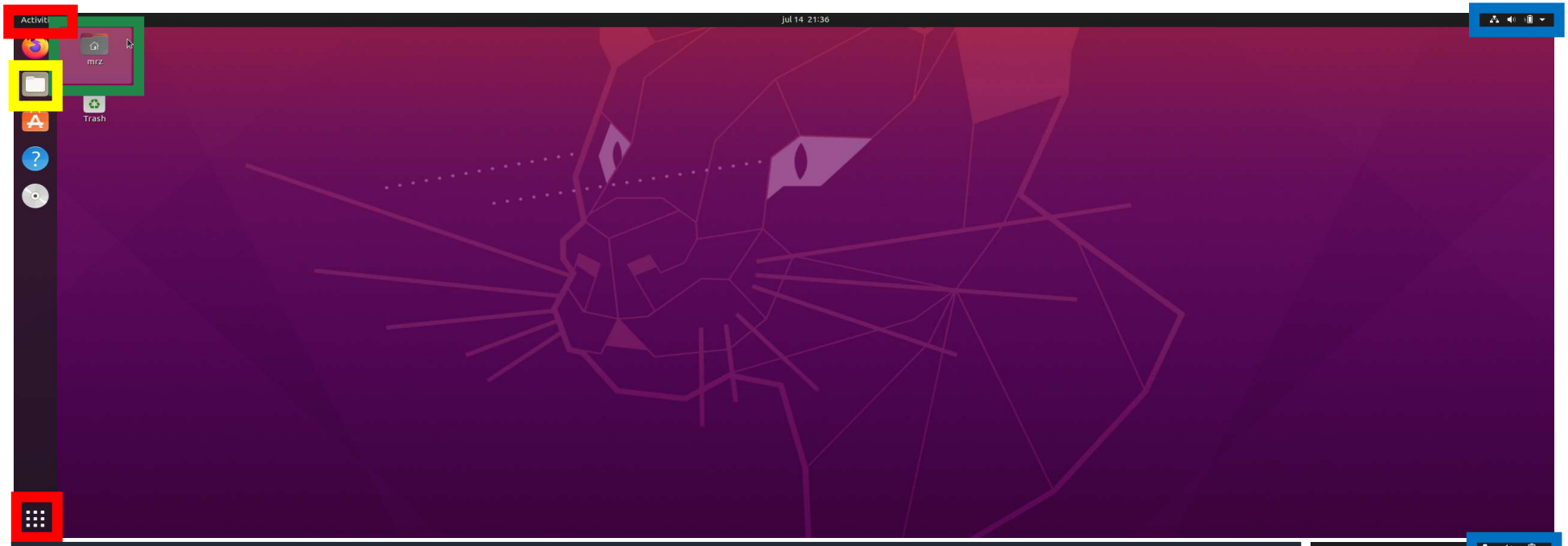
- Operating System
  - GNU
  - Linux
  - Debian
  - Ubuntu

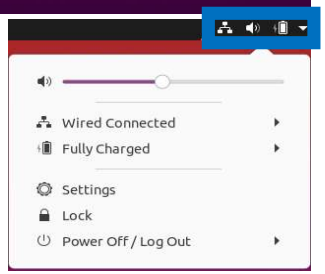


ubuntu





- Click on the corners highlighted by the **red boxes** in the above screenshot to search for applications, settings, and etc. The same could be achieved by pressing the *"Windows key"* on your keyboards. Press the *"Escape Key"* `[Esc]` to exit the menu.
- The **blue box** is the system tray, where you can find system controls, and network manager. Click on the tray to expand the illustrated menu.
- The **yellow box** is the file explorer, and the **green box** opens a file explorer in your "*home*" directory.



Development Environment

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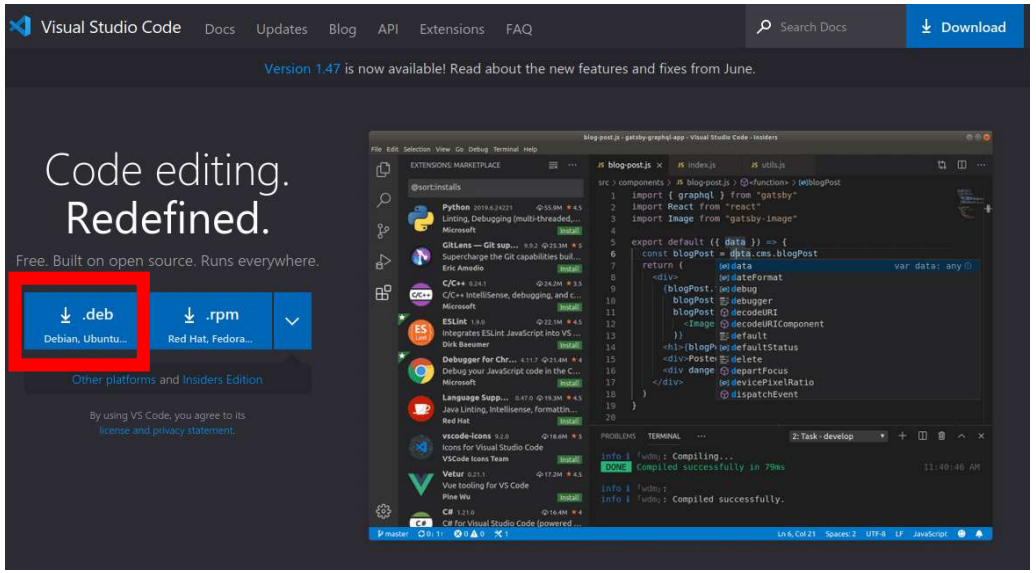
- Integrated Development Environment (IDE)
  - Integrates:
    - Text Edition Environment
    - Compilation Environment
    - Execution Environment
    - Debugging Environment
    - And many more Environments!
  - Boosts Productivity
  - Personal Preferences Matter!

- Terminal Emulator
  - Command-Line Interface to OS's Services
  - GNOME (bash shell)

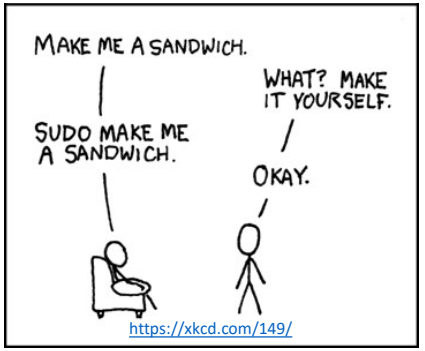
IDE

- https://code.visualstudio.com/
- Download the *.deb* file
- Install either by:
    - Finding the file in Downloads folder and double clicking on it!
    - Or opening Terminal and typing in the following:

```
$> sudo apt install ~/Downloads/code + [TAB]
```



- **sudo** (SuperUser Do) is the command used to elevate privilege to Super User (administrator).
- **apt** (Advanced Package Tool) is a CLI program for installing and removing software in Ubuntu. **apt** takes options (optional), commands (mandatory), and arguments (optional, depending on the command) as input i.e. `apt [options] command (arguments)`. In the above example, there is no option provided, and **install** is the command telling **apt** to install the package. **install** requires an argument which is the path to the package we want to install. Running **apt** requires super user privilege.
- ~ (tilde) is the path to the user's home directory.
- Press **(TAB)** key for auto compilation.



https://xkcd.com/149/

Double Check!

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- Let's make sure we have the essential packages installed first!
  - Open a terminal and type-in the below command:

```
$> sudo apt install build-essential gdb
```

- In the above command the argument provided to the **install** command is not a path to a local file. Thus, **apt** will look in the registered repositories for a package with the same name to fetch and install them.
- **build-essential** is a package containing GNU's C/C++ compilers and libraries, and more development tools and libraries. For more details, please visit https://packages.ubuntu.com/xenial/build-essential.
- **gdb** is the GNU C/C++ debugger.

Workspace

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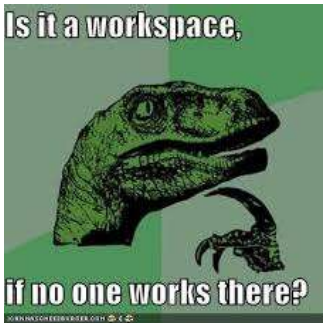
- Usually, the folder where all the project artifacts reside. Projects are most often synced with a revision control tools.
- IDEs create files in workspace folders to save project related settings (more to come on this, in future lectures!)
- Create a folder in you home directory and call it `projects`
  - You can create a folder either through file explorer or terminal:

```
$> mkdir ~/projects
```

- Create a folder for our coming project `HelloWorld` and add that folder to your VSCode workspace:
  - You can do this either through VSCode menus or through terminal:

```
$> mkdir ~/projects/HelloWorld
$> cd ~/projects
$> code .
```

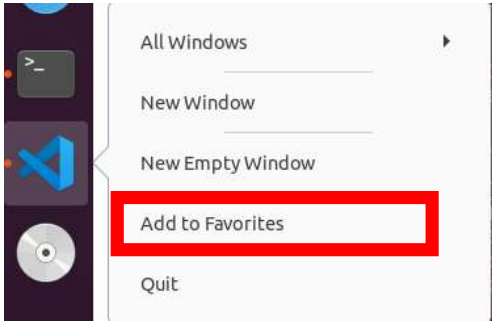
  - This will open an instance of VSCode for our currently empty workspace.

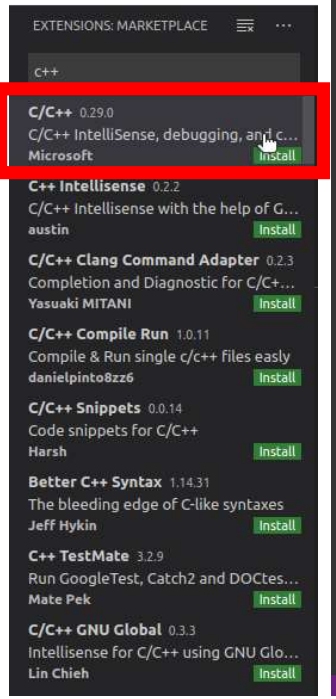


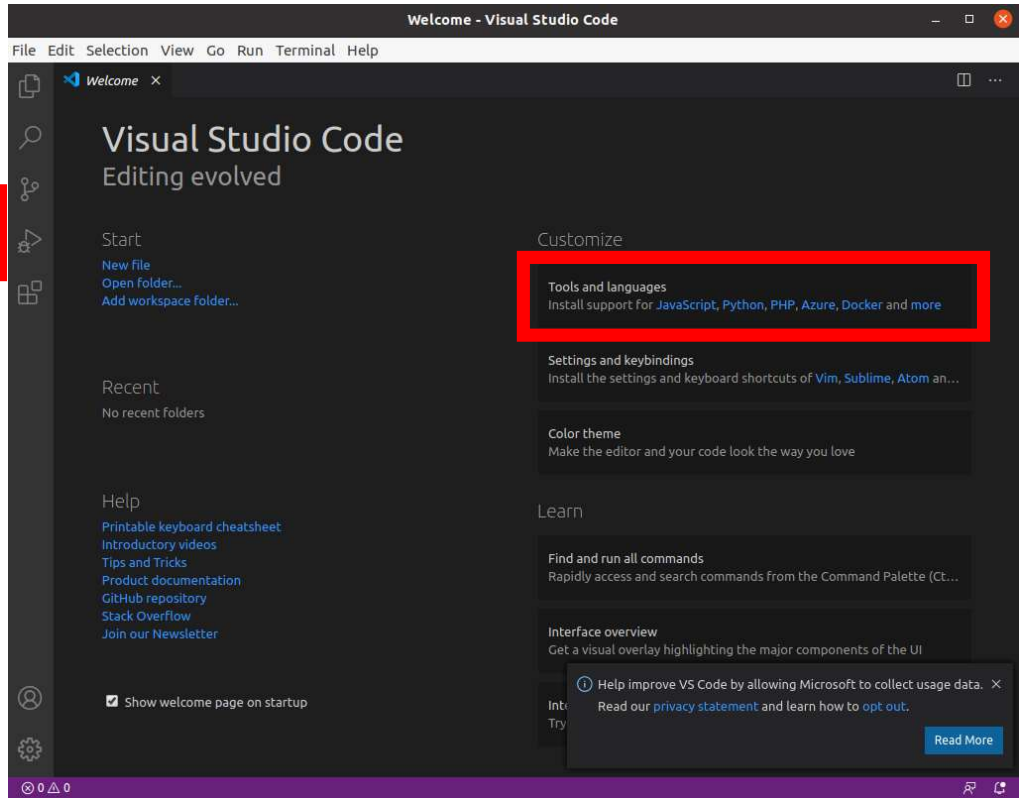
- **mkdir** (MaKe DIRectory) creates the folder provided as its argument if the user running the command has privileges to create the folder on the specified path, such as user's home directory.
- **code** is the Visual Studio Code and opens an instance on the provided path and makes it a workspace, if it is not already.
- At any stage while typing in commands in the terminal, one could use **(TAB)** key for suggestions on compilation of the command.

Visual Studio Code

- Extension based IDE with a marketplace for add-ons
- Click on "*Tools and Languages*" or `[Ctrl+Shft+x]`
- Install C/C++ extension by Microsoft







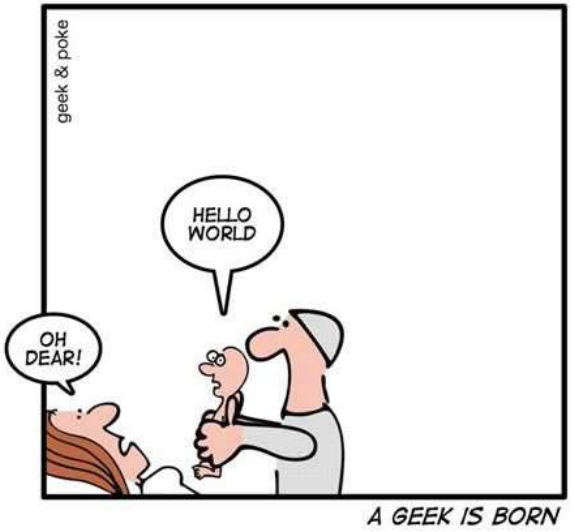
- All the keyboard shortcuts could be found here: https://code.visualstudio.com/shortcuts/keyboard-shortcuts-linux.pdf
- Once you opened VSCode, right click on the logo and add to favorite for easier access in future.

Hello World!

- Create a new file `[Ctrl+N]` and paste the following:

```
#include <iostream>

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



- Save the file `[Ctrl+S]` and name the file `helloworld.cpp` – make sure the file is in `HelloWorld` folder. Once you save the file, *syntax highlighting* should be enabled for you, as depicted below.

- **cpp** is a file extension used for C++ source code.

Turning Text To Binary – In Theory

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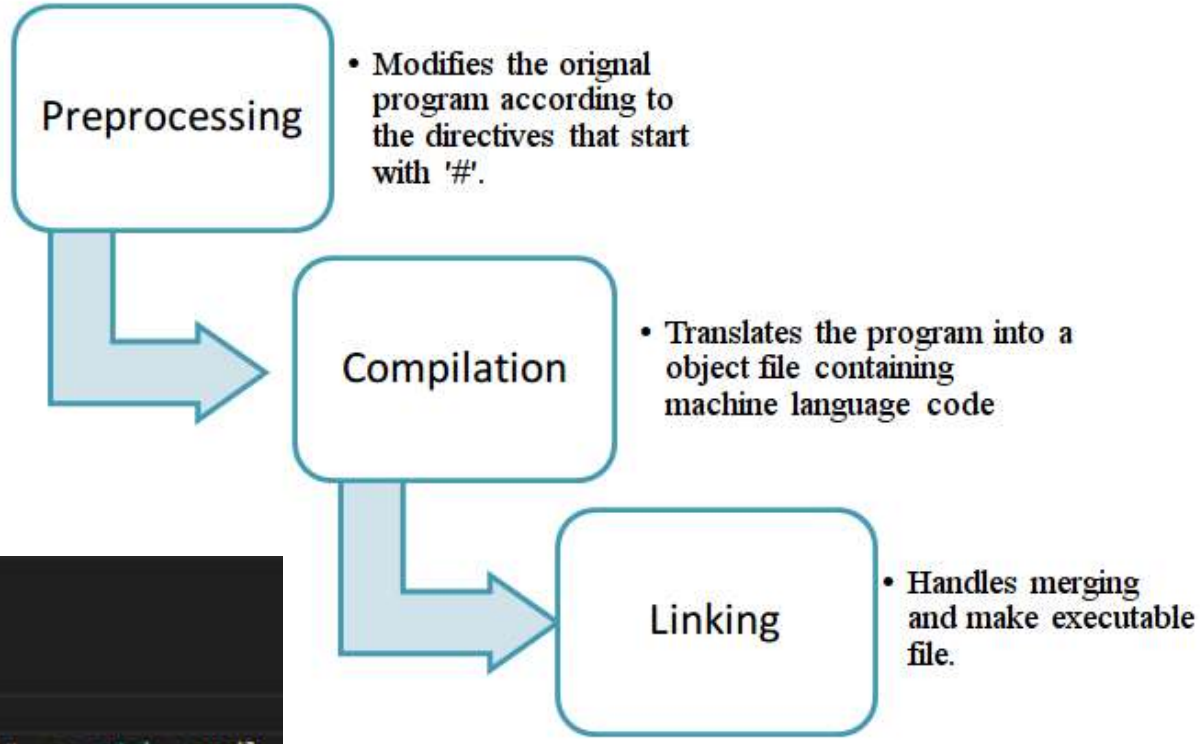
- Software Building Procedure



http://www.cplusplus.com/articles/2v07M4Gy/Selection_101.png

```
helloworld.cpp > main()
1   #include <iostream>
2
3   int main() {
4       std::cout << "Hello World!" << std::endl;
5   }
```

Turning Text To Binary – In Action

- Open a terminal and navigate to the project directory:

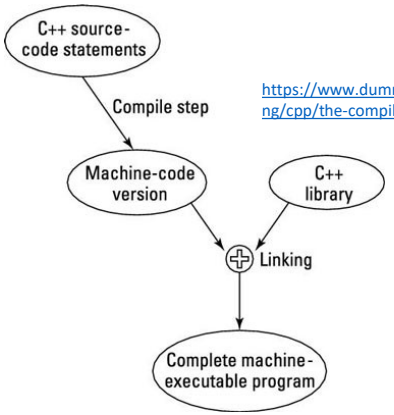
```
$> cd ~/projects/HelloWorld
```

- Compile the cpp file and name the output binary `hw`:

```
$> g++ helloworld.cpp -o hw
```

- Run the executable:

```
$> ./hw
```



https://www.dummies.com/programming/cpp/the-compilation-process-in-c/

helloworld.cpp > main()

```cpp
#include <iostream>

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

- **cd** (Change Directory) is the command for navigating to a different path. The path one wants to navigate to is provided as the argument to **cd**.
- **g++** is the GNU C++ compiler. It takes as input the source codes (.cpp files). It also receives *flags*; these are the options which has **– (hyphen/dash)** as prefix. Here **–o** *flag* indicates the name of the output binary and it requires an argument which is the name of the binary.
- Executables could be executed by invoking the path to them. In the above example, since we are in the folder where the binary exists, we use **. (dot)** which points to the current directory we are at.

C++ Source Code Structure

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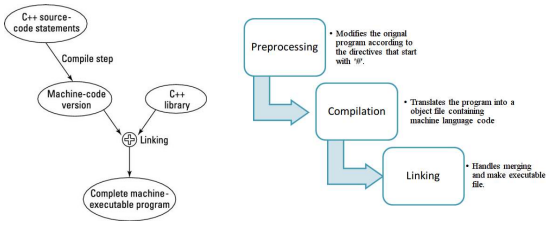
- g++ knows stuff!

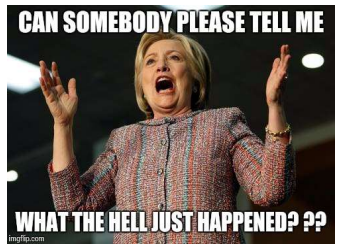
```
$> g++ helloworld.cpp -o hw
```

  - Keywords and symbols
  - Routine
  - Machine language (binary)

- g++ generates error if things are not as it expects them to be!

- g++ reads source code line by line from the beginning of the file





- Each line in source code starts with an identifiers. Identifiers either start with **#** (number sign) for preprocessing, or by a letter for compilation. Identifiers cannot start with digits nor characters, except for **_** (underscore / underline).
- Lines starting with **//** double slashes are comments and not considered by the compiler; same as the section of the code between **/*** and ***/**

```
helloworld.cpp > main()
1   #include <iostream>
2
3   int main() {
4       std::cout << "Hello World!" << std::endl;
5   }
```

```
#Some_PreProcessing_Stuff


function1_signature() {
// FUNCTION BODY
}
```

C++ Preprocessing

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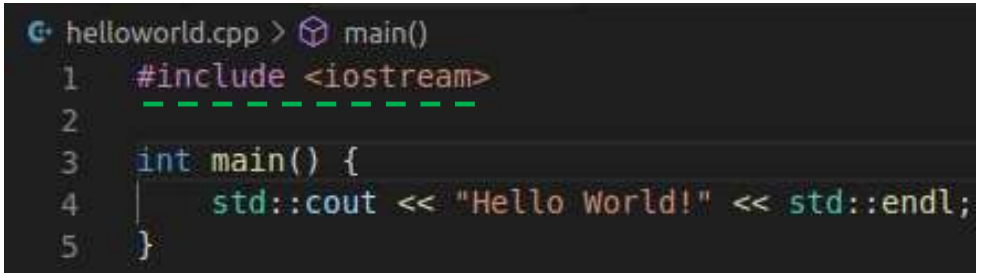
- Procedure prior to compilation performed by preprocessor
  - Gives the opportunity to impact compilation
  - Preprocessor prepares source code for compiler

- Preprocessor
  - Operators: **#**, `#@, ##, //, /**/`

  - Directives
    - They start with **#**: `#define, #error, #import, #undef, #elif, #if,` **`#include`**`, #using, #else, #ifdef, #line, #endif, #ifndef, #pragma`

"The preprocessor is a text processor that manipulates the text of a source file [...] the compiler ordinarily invokes the preprocessor in its first pass, the preprocessor can also be invoked separately to process text without compiling". https://docs.microsoft.com/en-us/cpp/preprocessor/preprocessor?view=vs-2019




```
helloworld.cpp > main()
1   #include <iostream>
2
3   int main() {
4       std::cout << "Hello World!" << std::endl;
5   }
```

- **`#include`** directives copies the whole contents of the file it is provided at the exact point the directive is used. The operation could be recursive for nested includes i.e. when a file which is included has its own **`#include`** directive. It is common practice for better readability and maintainability to always used this directive at the very beginning of the files.

C++ Operators

- Almost all the special characters are used in C++
- Same characters might operate differently in different contexts

> • = is the assignment operator in C++.

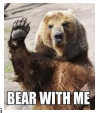
Compound assignment	Description
+=	addition and assignment
-=	subtraction and assignment
/=	multiplication and assignment
*=	division and assignment
%=	modulo and assignment
++	increasing by one unit
--	Decreasing by one unit

Comparison operator	Description
==	equal to
!=	not equal to
<	less than
>	greater than
<=	less than or equal to
>=	greater than or equal to

Arithmetic operator	Description
+	addition
-	subtraction
*	multiplication
/	division
%	modulo

Logical operator	Description
!	negation
&&	subtraction
||	multiplication

Precedence of Operators



Level	Precedence group	Operator	Description	Grouping
1	Scope	`::`	scope qualifier	Left-to-right
2	Postfix (unary)	`++ --`	postfix increment / decrement	Left-to-right
		`()`	functional forms	
		`[]`	subscript	
		`. ->`	member access	
3	Prefix (unary)	`++ --`	prefix increment / decrement	Right-to-left
		`~ !`	bitwise NOT / logical NOT	
		`+ -`	unary prefix	
		`& *`	reference / dereference	
		`new delete`	allocation / deallocation	
		`sizeof`	parameter pack	
		`(type)`	C-style type-casting	
4	Pointer-to-member	`.* ->*`	access pointer	Left-to-right
5	Arithmetic: scaling	`* / %`	multiply, divide, modulo	Left-to-right
6	Arithmetic: addition	`+ -`	addition, subtraction	Left-to-right
7	Bitwise shift	`<< >>`	shift left, shift right	Left-to-right
8	Relational	`< > <= >=`	comparison operators	Left-to-right
9	Equality	`== !=`	equality / inequality	Left-to-right
10	And	`&`	bitwise AND	Left-to-right
11	Exclusive or	`^`	bitwise XOR	Left-to-right
12	Inclusive or	`|`	bitwise OR	Left-to-right
13	Conjunction	`&&`	logical AND	Left-to-right
14	Disjunction	`||`	logical OR	Left-to-right
15	Assignment-level expressions	`= *= /= %= += -= >>= <<= &= ^= |=`	assignment / compound assignment	Right-to-left
		`?:`	conditional operator	
16	Sequencing	`,`	comma separator	Left-to-right

C++ Keywords

- Fundamental Datatypes
- Control Flows: Selections, Iteration Statements & Jump Statements

alignas, alignof, and, and_eq, asm, auto, bitand, bitor, **bool**, **break**, **case**, catch, **char**, **char16_t**, **char32_t**, class, compl, **const**, constexpr, const_cast, **continue**, **decltype**, **default**, delete, **do**, **double**, dynamic_cast, **else**, enum, explicit, export, extern, **false**, **float**, **for**, friend, **goto**, **if**, inline, **int**, **long**, mutable, namespace, new, noexcept, not, not_eq, **nullptr**, operator, or, or_eq, private, protected, public, register, reinterpret_cast, **return**, **short**, **signed**, **sizeof**, static, static_assert, static_cast, struct, **switch**, template, this, thread_local, throw, **true**, try, typedef, typeid, typename, union, **unsigned**, **using**, virtual, **void**, volatile, **wchar_t**, **while**, xor, xor_eq

- Identifiers created by developers shall not match these keywords.
- Different compilers might add specific keywords.
- C++ is **case-sensitive**.

Fundamental Datatypes

- Datatypes define the type of data.
- Could be used to define variables
  - Variables are declared as below:

```
SomeDatatype VariableName;
```

Character types	**`char`**
	`char16_t`
	`char32_t`
	`wchar_t`
Floating-point types	**`float`**
	`double`
	`long double`
Boolean type	**`bool`**
Void type	`void`
Null pointer	`decltype(nullptr)`

- Apart from the fundamental datatypes, there are other datatypes which we will discuss later. Developers can also create their custom datatypes, as well.
- Variable names are identifiers and the same restrictions for the names apply.
- **`signed`** keyword is not necessary, an integer is considered signed unless it is declared otherwise using **`unsigned`** keyword.

Integer types (signed)	`signed char`
	`signed short int`
	`signed` **`int`**
	`signed long int`
	`signed long long int`
Integer types (unsigned)	`unsigned char`
	`unsigned short int`
	`unsigned int`
	`unsigned long int`
	`unsigned long long int`

Variables

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- Variables could be assigned a value of their type.

- Be careful, C++ is partially type-safe!
  - If a variable is assigned a value of different type, the compiler might not generate an error!
  - There are safe mechanism for type conversions -- more on this in future lectures.

```
bool condition1; // Variable is declared
condition1 = true; // Variable is assigned a value
bool condition2 = false; // Variable is assigned a value upon declaration
bool condition3 (true); // Variable is initialized upon declaration
bool condition4 {false};// Variable is uniformly initialized upon declaration


bool condition5,
     condition6 = true,
     condition7(false),
     condition8{true},
     condition9 = condition8;
```

- **`true`** and **`false`** are the two keywords defined in C++ for Boolean values. **`true`** is equal to 1 and **`false`** is 0: https://stackoverflow.com/questions/2725044/can-i-assume-booltrue-int1-for-any-c-compiler
- Initializing a variable and assigning a value upon declaration are VERY similar but they are **not** the exact same thing! We discuss this in detail in the coming lectures.

Constants

- Constant Variables are declared as below:

```
const SomeDatatype VariableName
```

- Constant variables are read-only
- Constant variables shall be assigned a value/initialized upon declaration

```
int v1 = 1, v2 = 2, v3 = 3;
const int constantValue = 100;
v1 = v1; //useless but allowed
v1 = v2; //assigning value of v2 to v1
v1 = v2 = v3;//assigning value of v3 to v1 and v2
v1 = constantValue; //allowed
constantValue = v1; //not allowed
```

```
error: assignment of read-only variable 'constantValue'
```

- Although there are myths that using const might improve performance, since the compiler could optimize the code better (which in some rare cases is true), the main reason for declaring const variables are maintainability and enforcing correctness: https://stackoverflow.com/questions/3435026/can-const-correctness-improve-performance
- Compiler generates an error and terminates compilation if an attempt is made to modify a **`const`** value after declaration.

Arrays

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- Arrays are declared using [ ]

```
SomeDatatype VariableName[]
```

- Arrays are NOT dynamic in size.
- Size of the array should be known to the compiler upon declaration.

```
int twoDimensionArray[2][2];
twoDimensionArray[0][0] = 432;
int threeDimensionArray[2][2][2] = {
    {{1,2},{3,4}},
    {{5,6},{7,8}}
};
```

- Array's elements could be accessed via their indices – arrays are index from 0 i.e. for an array of size N, the first element is at index 0 and the last element is stored in index N-1.
- If the size of the array is not defined upon declaration, compiler generates an error and terminates compilation.

```
error: storage size of 'arrayOfIntegers_3' isn't known
```

```
unsigned int arrayOfIntegers_3[]; // not allowed, the size is needed
unsigned int arrayOfIntegers_2[] = {1,2,3};// array of size 3 is declared and initialized upon declaration
unsigned int arrayOfIntegers_1[3];// array of size 3 is declared
arrayOfIntegers_1[0] = 53453; // first element of the array is assigned a value
arrayOfIntegers_1[1] = 29614; // second element of the array is assigned a value
arrayOfIntegers_1[2] = arrayOfIntegers_2[2]; // third element of the array is assigned a value
```

Control Flows: Selection

- They choose (executed) different paths (branches) depending on whether some conditions holds:
  - **`switch`** checks whether the expression matches any of the cases
  - **`if/else`** checks whether the condition holds

- It is considered a very good practice to always have a default case in our switch statements, although the need might not seem reasonable in some scenarios: https://stackoverflow.com/questions/4649423/should-switch-statements-always-contain-a-default-clause

```
switch (expression)
{
case constantExpression1:
    /* code */
    break;
case constantExpression2:
    /* code */
    break;
case constantExpression3:
    /* code */
    break;
default:
    break;
}
```

```
if (someCondition) {
    // DO SOMETHING
}

if (someCondition) {
    // DO SOMETHING
} else {
    // DO SOMETHING ELSE
}

if (someCondition) {
    // DO SOMETHING
} else if (anotherCondition) {
    // DO SOMETHING ELSE
} else {
    // DO NONE OF THE ABOVE
}
```

Control Flows: Iteration Statements

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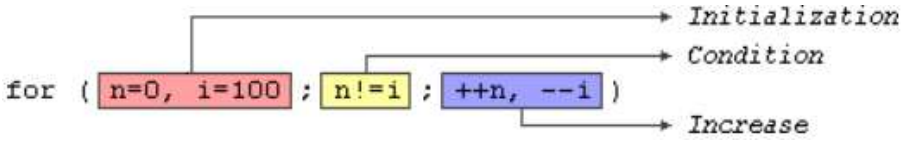
- They Iterate (loop) over some section of the code as long as a condition is **`true`**:
  - **`while`** iterates as long as provided condition holds.
  - **`do/while`** executes the segment provided to **`do`**, then checks for the condition in **`while`**, repeats as long as provided condition holds.
  - **`for`** checks whether the condition holds, then iterates once over the code, and finally execute the third expression provided to it, and repeats the same.

```
while (someCondition) {
    // DO SOMETHING
}
```

```
do {
    // DO SOMETHING
} while (someCondition);
```

```
/* for (variable initialization;
        condition on the variable;
        expression on the variable) */
for (unsigned int i = 0; i < SomeNumber; i++) {
    /* code */
}
```



http://www.cplusplus.com/doc/tutorial/control/

- **`for`** receives three inputs (lines of code), each separated by a "**`;`**". The first input is invoked only once and is used for initialization of the variable which the condition is checked against i.e. the second input. Prior to each iteration first the condition is checked, if it does not hold the loop ends.
- All three inputs to **`for`** loop are optional, **`for(;;)`** loops forever.

Control Flows: Jump Statements

ALTEN

- They are able to alter the flow of execution:
  - **`break`** jumps out of loop or switch selection as if the loop ends at that line
  - `continues` skips the rest of the loops and continues to the next iteration as if that line is the last line of the loop
  - `goto` jumps to the "*label*" provided to it. An identifier followed by a colon ":" is called a *label.*

```
for (unsigned int i = 0; i < SomeNumber; i++) {
    // CODE 1
    if (someOtherCondition) {
        /*
        if someOtherCondition holds,
        the iteration terminates and
        CODE 3 would be executed
        */
        break;
    }
    // CODE 2
}
// CODE 3
```

Control Flows: Jump Statements

ALTEN

- They are able to alter the flow of execution:
  - `break` jumps out of loop or switch selection as if the loop ends at that line
  - `continue` skips the rest of the loops and continues to the next iteration as if that line is the last line of the loop
  - `goto` jumps to the "*label*" provided to it. An identifier followed by a colon ":" is called a *label.*

```
while (someCondition) {
    // CODE 1
    if (anotherCondition) {
        /*
         if anotherCondition holds,
         CODE 2 would not be executed
         and loop starts from beginning
         by checking if someCondition holds
         */
        continue;
    }
    // CODE 2
}
```

Control Flows: Jump Statements

ALTEN

- They are able to alter the flow of execution:
  - `break` jumps out of loop or switch selection as if the loop ends at that line
  - `continues` skips the rest of the loops and continues to the next iteration as if that line is the last line of the loop
  - `goto` jumps to the "*label*" provided to it. An identifier followed by a colon ":" is called a *label.*

- `goto`s are inherited from C and are not considered a good practice: https://stackoverflow.com/questions/3517726/what-is-wrong-with-using-goto
- An identifier followed by a colon ":" is called a *label.*

```
    // CODE 1
label1:
    // CODE 2
    if (someCondition) {
        /* if someCondition holds,
         then the program jumps to
         label 1 and CODE 2
         */
        goto label1;
    }
    if (someOtherCondition) {
        /* if someOtherCondition holds,
         then the program jumps to label 2
         and CODE 3 would be executed
         */
        goto label2;
    }
    // CODE 3
label2:
    // CODE 4
```

Functions

- Functions are used to structure the code.
- Basic function declaration is as follows:

```
ReturnDatatype FunName(InputDatatype Input1_Name …){
    // FUNCTION BODY
}
```

```
void printChar(char _c) {
    std::cout << "The charachter is: " << _c << std::endl;
}
```

```
char char_a = 'a';
printChar(char_a);
printChar('a');
```

- **void** is used as a return datatype for functions without a return value.
- **main** if used as function name, define the entry point of the program i.e. is the first (only) function being invoked when program executed. If a branch of code is not accessible from the body of the main function, it will not be invoked throughout the execution.
- **size_t** is the same as **unsigned long int** -- it is the *defacto* type used for size. The definition is declared using **#define** preprocessing directive.

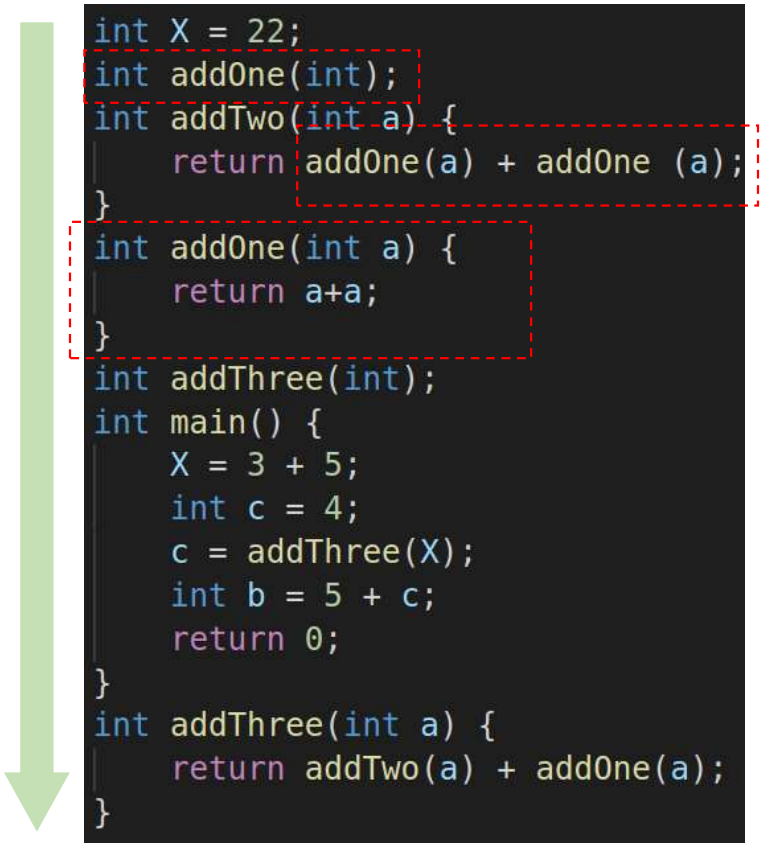
```
long int calcArraysTotalSum(int _array[], size_t _size) {
    long int sum = 0;
    for (size_t i = 0; i < _size; i ++) {
        sum += _array[i];
    }
    return sum;
}
```

```
int arrayOfIntegers[] = {100,200,300};
long int sum = calcArraysTotalSum(arrayOfIntegers,3);
```

DEMO!

Order

- Visibility order is downwards.
- Forward declaration could be used.



```
int X = 22;
int addOne(int);
int addTwo(int a) {
    return addOne(a) + addOne (a);
}
int addOne(int a) {
    return a+a;
}
int addThree(int);
int main() {
    X = 3 + 5;
    int c = 4;
    c = addThree(X);
    int b = 5 + c;
    return 0;
}
int addThree(int a) {
    return addTwo(a) + addOne(a);
}
```

Arrays & Strings

ALTEN

- There is no check on arrays' boundaries.
- Strings are ASCI code null terminated.
- Standard library provides **`string`**.

Element access

at	accesses the specified character with bounds checking (public member function)
operator[]	accesses the specified character (public member function)
front (C++11)	accesses the first character (public member function)
back (C++11)	accesses the last character (public member function)
data	returns a pointer to the first character of a string (public member function)
c_str	returns a non-modifiable standard C character array version of the string (public member function)
operator basic_string_view (C++17)	returns a non-modifiable string_view into the entire string (public member function)

https://en.cppreference.com/w/cpp/string/basic_string

```
int count,a[count],b[8],c[8][8]/*c[3][8]*/;
count = 8;
for (size_t i = 0; i < count; i++) {
    b[i] = i;
}
```

```
int main() {
    char a[3] = "abc";
    std::cout << a << std::endl;
    std::string a_string = "abc";
    return 0;
}
```

*	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
0	NUL	SOH	STX	ETX	EOT	ENQ	ACK	BEL	BS	TAB	LF	VT	FF	CR	SO	SI
1	DLE	DC1	DC2	DC3	DC4	NAK	SYN	ETB	CAN	EM	SUB	ESC	FS	GS	RS	US
2		!	"	#	$	%	&	'	(	)	*	+	,	-	.	/
3	0	1	2	3	4	5	6	7	8	9	:	;	<	=	>	?
4	@	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
5	P	Q	R	S	T	U	V	W	X	Y	Z	[	\	]	^	_
6	`	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o
7	p	q	r	s	t	u	v	w	x	y	z	{	|	}	~	

http://www.cplusplus.com/doc/ascii/

Size, Range & Overflow

ALTEN

- Fundamental datatypes have a range.
- Value higher than range is *overflow*.

```
sz.cpp: In function ‘int main()’:
sz.cpp:20:14: warning: overflow in conversion from ‘int’ to
 ‘char’ changes value from ‘256’ to ‘'\000'’ [-Woverflow]
   20 |     char a = 0x100;
      |              ^~~~~
```

```
std::cout << "Size of int is: "<< sizeof (int) << " Bytes." << std::endl;
std::cout << "Size of char is: "<< sizeof (char) << " Bytes." << std::endl;
std::cout << "Size of int[10] is: "<< sizeof (int[10]) << " Bytes." << std::endl;
std::cout << "Size of int64_t is: "<< sizeof (int64_t) << " Bytes." << std::endl;

std::cout << "Rang of int is from "<< std::numeric_limits<int>::min()
          << " to " << std::numeric_limits<int>::max() << std::endl;
std::cout << "Rang of int64_t is from "<< std::numeric_limits<int64_t>::min()
          << " to " << std::numeric_limits<int64_t>::max() << std::endl;
```

Types

- Type alias is with `using` keyword.
- With `typedef` you can create synonym for a type.
- It is also possible to detect type of a variable at run time using `decltype`.

```
using my_string = char[12];
typedef char my_string2[12];


int main () {
    my_string foo;
    my_string2 bar;

    decltype(bar) fancy;
```

Escape Sequences

ALTEN

```
std::cout << ">> Print\tHorizontalTAB" << std::endl;
std::cout << ">> Print\vVerticalTAB" << std::endl;
std::cout << ">> Print\fFromFeed" << std::endl;
std::cout << ">> Print\na new line." << std::endl;
std::cout << ">> Printt\bBackspace" << std::endl;
std::cout << ">> Print special characters: \' \" \\ \?" << std::endl;
```

Escape code	Description
\n	newline
\r	carriage return
\t	tab
\v	vertical tab
\b	backspace
\f	form feed (page feed)
\a	alert (beep)
\'	single quote (')
\"	double quote (")
\?	question mark (?)
\\	backslash (\)

if

Boolean Value	Operand	Boolean Value	Result
true	&&	true	true
true	&&	false	false
false	&&	false	false
false	&&	true	false
true	||	true	true
true	||	false	true
false	||	false	false
false	||	true	true

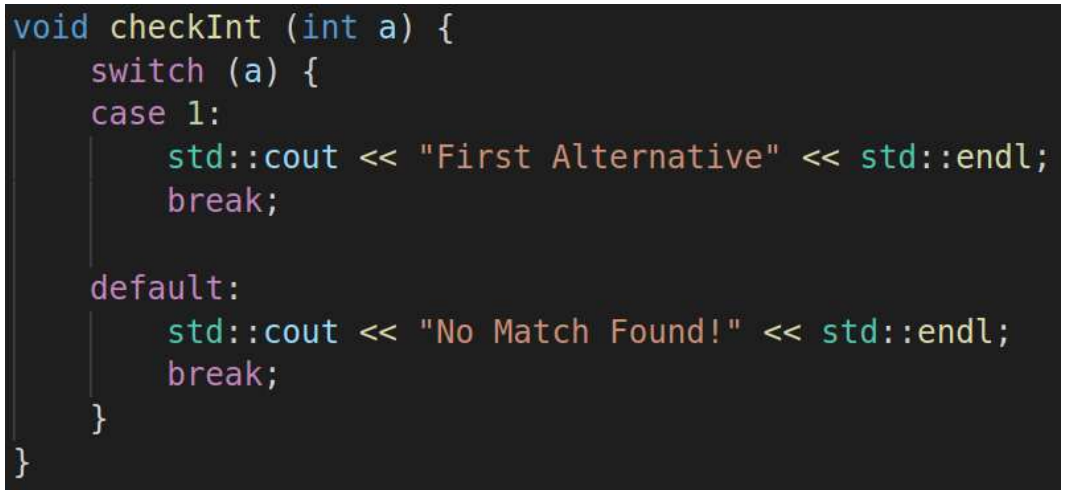
- **__LINE__** is a preprocessor Macro which *expands* to the line number. There are other useful Macros as well: https://stackoverflow.com/a/2849850

```
if ( (true == 1) && (false == 0) )
    std::cout << __LINE__ << std::endl;
```

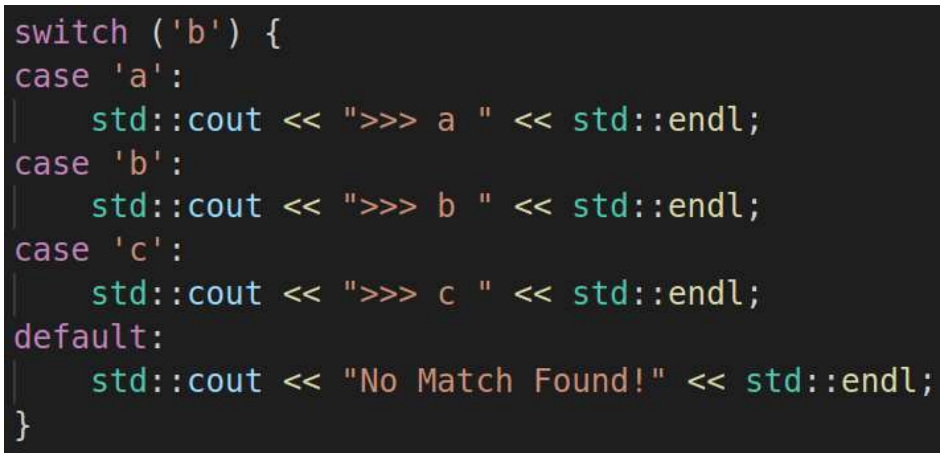
```
if (0)
    std::cout << __LINE__ << std::endl;
else if (100)
    std::cout << __LINE__ << std::endl;
```

```
if (return_true()  || return_false())
    std::cout << __LINE__ << std::endl;
std::cout << "----" << std::endl;

if (return_false() && return_true())
    std::cout << __LINE__ << std::endl;
std::cout << "----" << std::endl;
```

switch

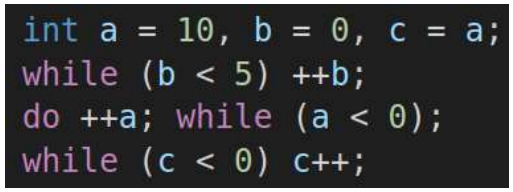


```cpp
void checkInt (int a) {
    switch (a) {
    case 1:
        std::cout << "First Alternative" << std::endl;
        break;

    default:
        std::cout << "No Match Found!" << std::endl;
        break;
    }
}
```

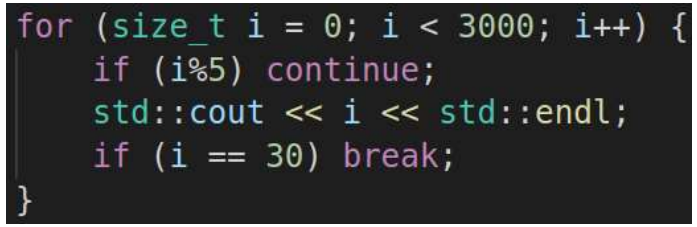


```cpp
switch ('b') {
case 'a':
    std::cout << ">>> a " << std::endl;
case 'b':
    std::cout << ">>> b " << std::endl;
case 'c':
    std::cout << ">>> c " << std::endl;
default:
    std::cout << "No Match Found!" << std::endl;
}
```

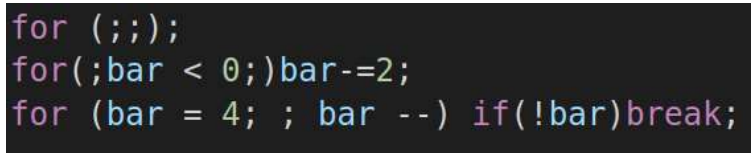
Loops



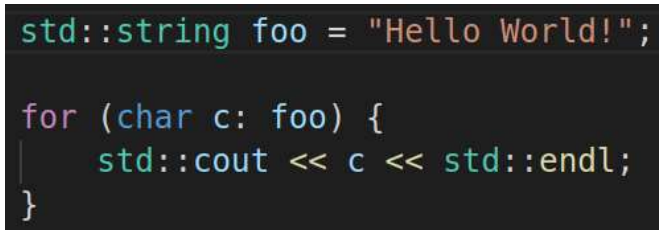
```
int a = 10, b = 0, c = a;
while (b < 5) ++b;
do ++a; while (a < 0);
while (c < 0) c++;
```



```
for (size_t i = 0; i < 3000; i++) {
    if (i%5) continue;
    std::cout << i << std::endl;
    if (i == 30) break;
}
```

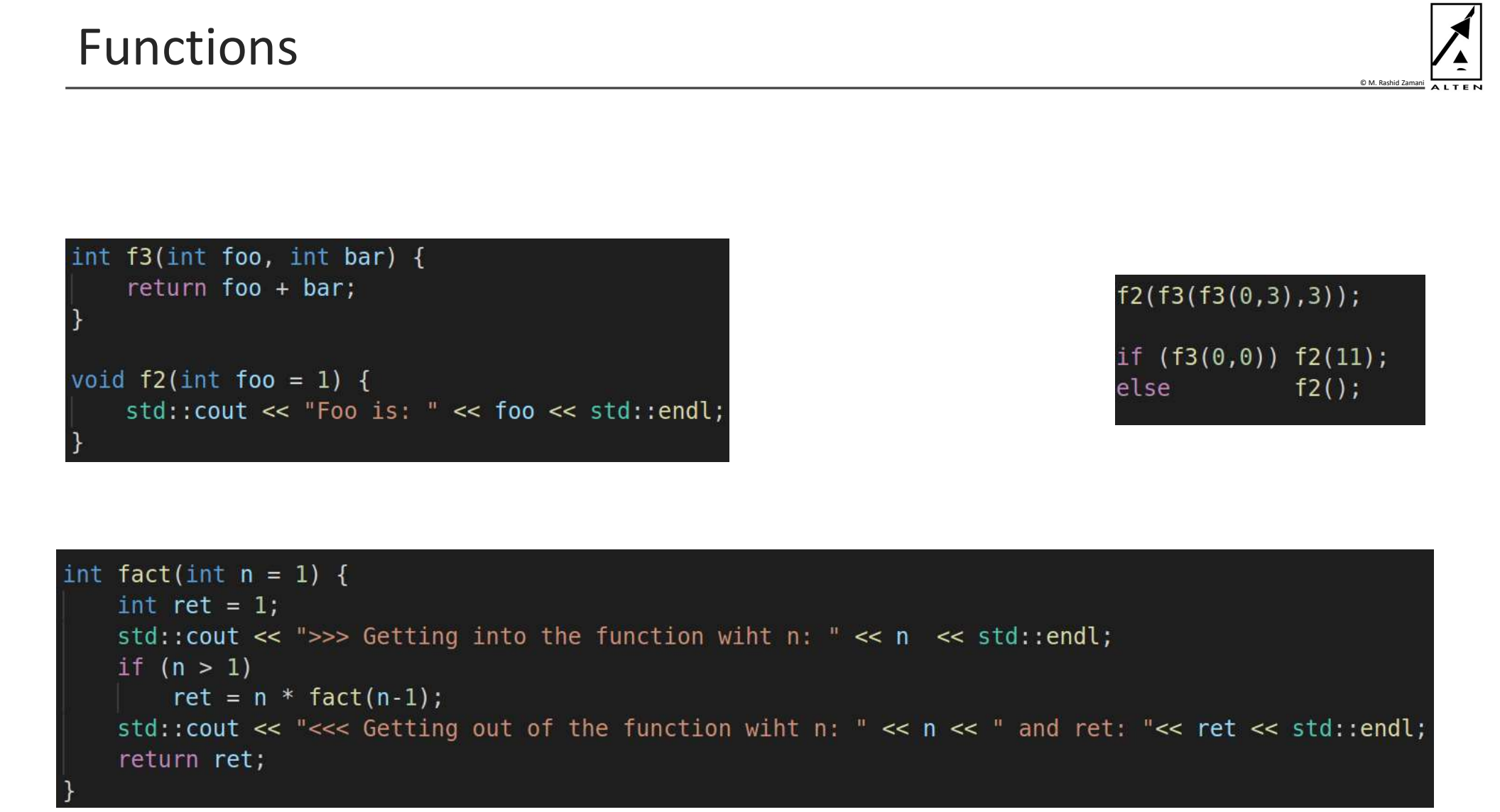


```
for (;;);
for(;bar < 0;)bar-=2;
for (bar = 4; ; bar --) if(!bar)break;
```



```
std::string foo = "Hello World!";

for (char c: foo) {
    std::cout << c << std::endl;
}
```

Functions



```
int f3(int foo, int bar) {
    return foo + bar;
}

void f2(int foo = 1) {
    std::cout << "Foo is: " << foo << std::endl;
}
```

```
f2(f3(f3(0,3),3));

if (f3(0,0)) f2(11);
else         f2();
```

```
int fact(int n = 1) {
    int ret = 1;
    std::cout << ">>> Getting into the function wiht n: " << n  << std::endl;
    if (n > 1)
        ret = n * fact(n-1);
    std::cout << "<<< Getting out of the function wiht n: " << n << " and ret: "<< ret << std::endl;
    return ret;
}
```

Header Files

13_header > C bar.h > ...

```h
#ifndef BAR_H
#define BAR_H
#include <iostream>

void appropriate1();
void appropriate2(int a, int b);

inline void advanceStuff() {
    std::cout << "Inline functions would be inserted wherever used!" << std::endl;
}


void badWayOfDoingThings(int a, int b) {
    if (a > b) std::cout << a << " is not bigget than " << b << std::endl;
    else std::cout << a << " is not bigget than " << b << std::endl;
}

#endif // BAR_H
```

13_header > bar.cpp > ...

```cpp
#include "bar.h"
void appropriate1() {
    std::cout << "Function Implementations";
    std::cout << "usually resides in source code." << std::endl;
}
void appropriate2(int a, int b){
    std::cout << "Between " << a << " and " << b << "..." << std::endl;
    if ( a > b ) {
        std::cout << "\n\t\t" << a << " is bigger!"<< std::endl;
    } else if ( a < b) {
        std::cout << "\n\t\t" << b << " is bigger!"<< std::endl;
    } else {
        std::cout << "\n\t\tNeither is bigger!"<< std::endl;
    }
}
```

13_header > foo.cpp > ...

```cpp
#include "bar.h"

int main() {

    appropriate1();
    appropriate2(3, 3);

    advanceStuff();


    badWayOfDoingThings(4, 8);

    return 0;
}
```

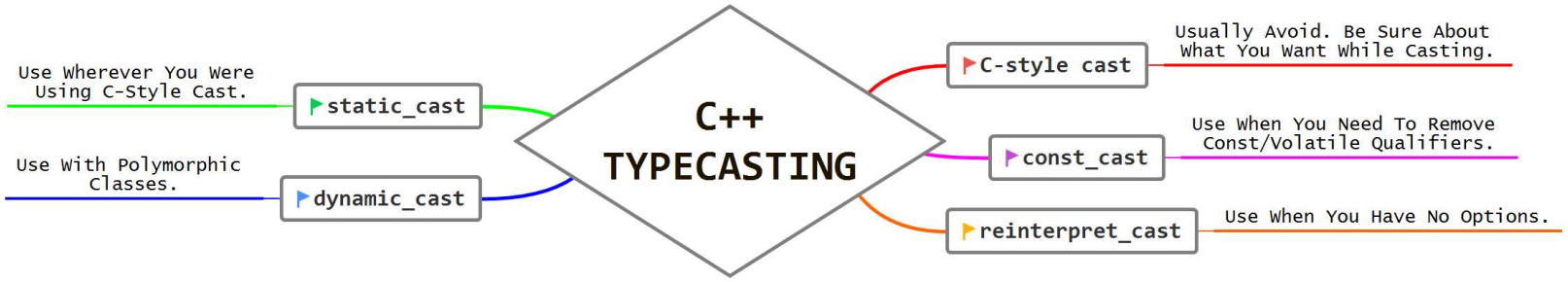
In the C and C++ programming languages, an ***#include guard****, sometimes called a* ***macro guard****,* ***header guard*** *or* ***file guard****, is a particular construct used to avoid the problem of double inclusion when dealing with the include directive.* https://en.wikipedia.org/wiki/Include_guard

```
g++ foo.cpp bar.cpp
```

Type Alias


```
float  f = 33.21;
int    i = -10;


float ff  = i;
int ii = f;
char c = i;
unsigned ui = c;
unsigned char uc = ui;



float fff = i/ii;
// C-Style Casting
float ffff = (float) i/ii;
```

```
std::cout << "i: " << i <<  " c: " << c << " c value: " << static_cast<int> (c) << std::endl;
std::cout << "ui: " << ui << " uc: " << uc << " uc value: " << static_cast<int> (uc)<< std::endl;
```



http://www.vishalchovatiya.com/cpp-type-casting-with-example-for-c-developers/