Lecture 2: Basic C++ I/O and Expression

Class page: https://github.com/tsung-wei-huang/cs1410-40

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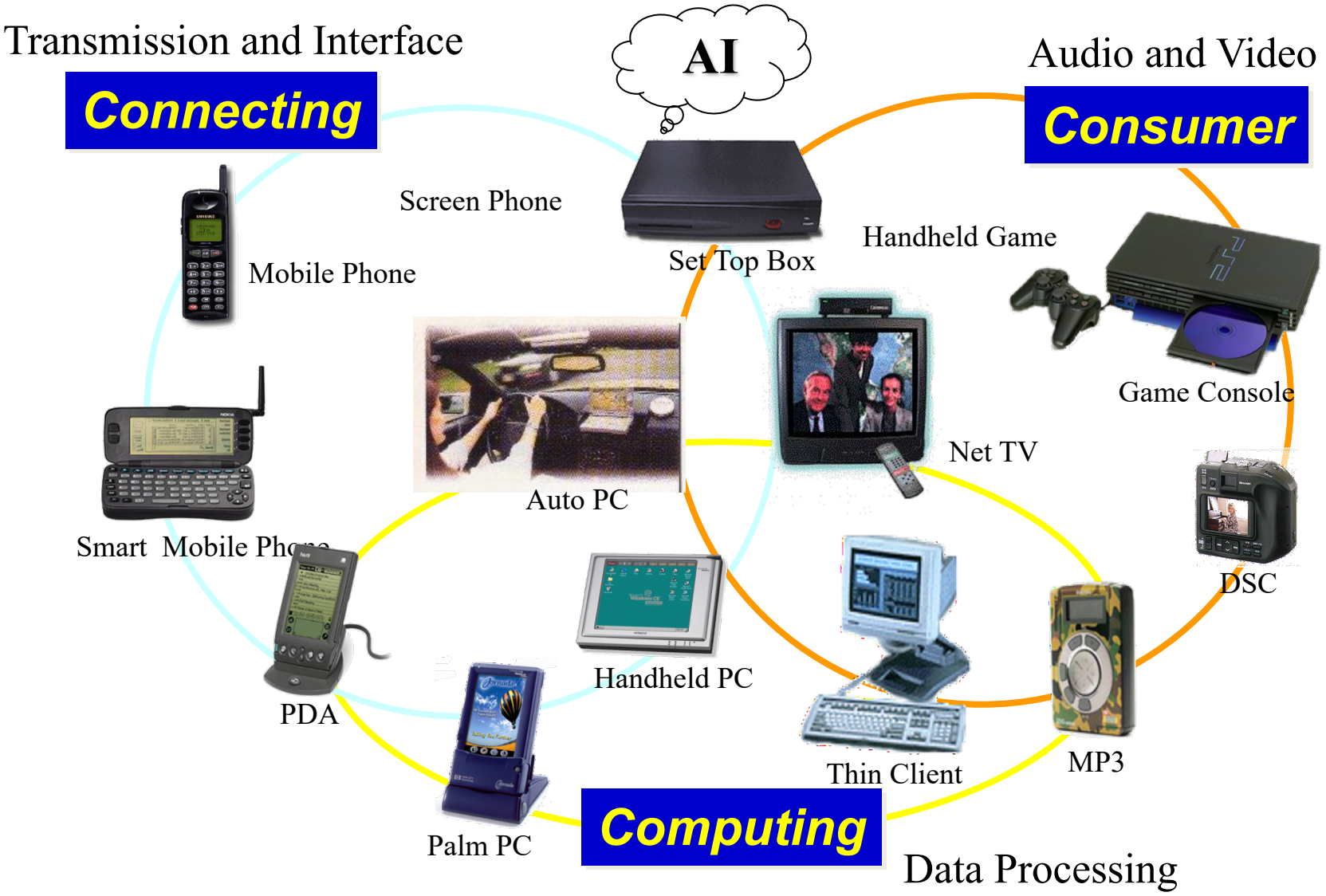
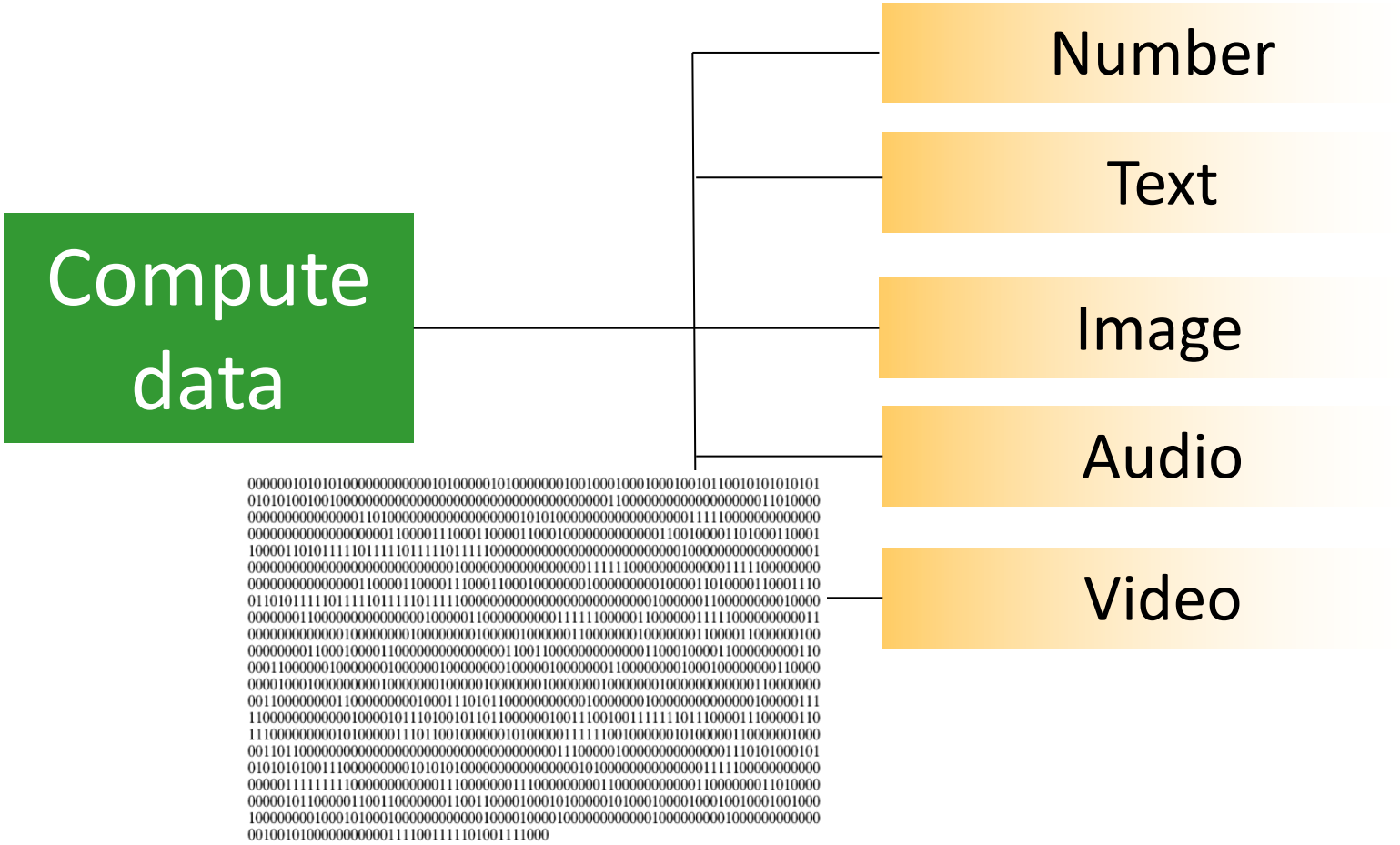
Announcement

- Lab – virtual or physical?

Our World is Driven by Computing

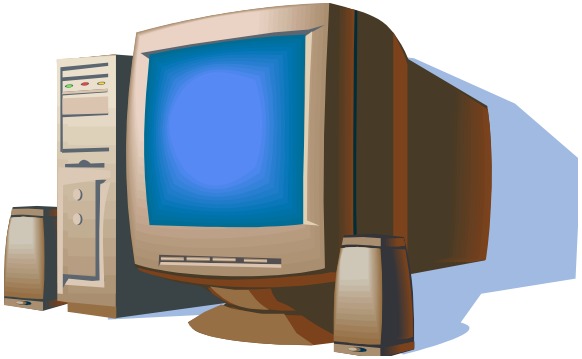


Computing Plays a Key Role



Computer see everything in binary (0 and 1)

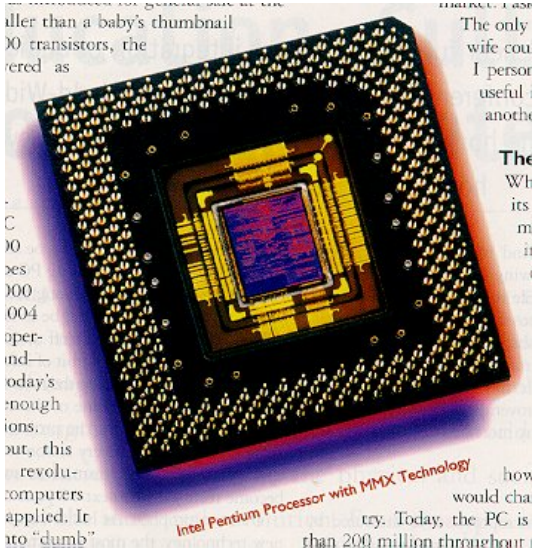
Hardware vs Software



The focus of this course

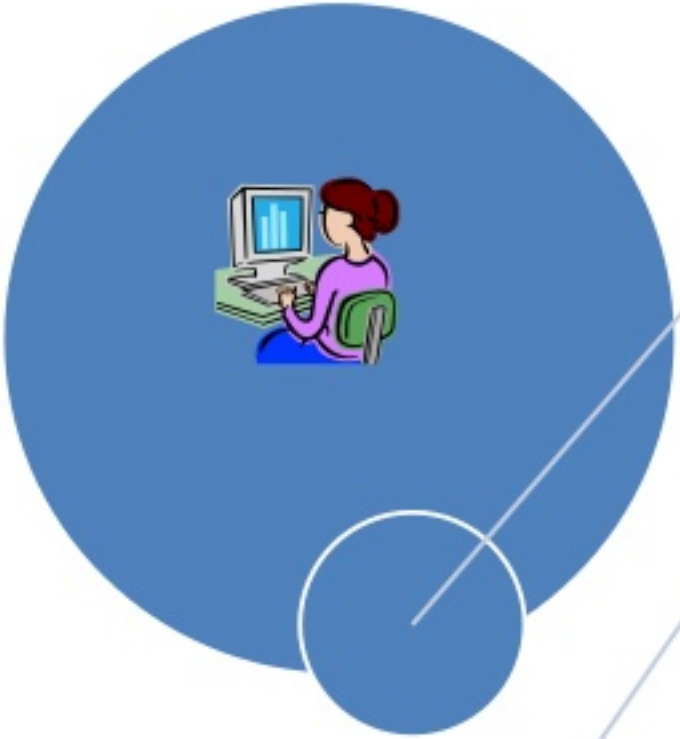
```
main ()
{
   say hello;
   go to internet;
   goodbye;
}
```

Software



Hardware

What is Software?



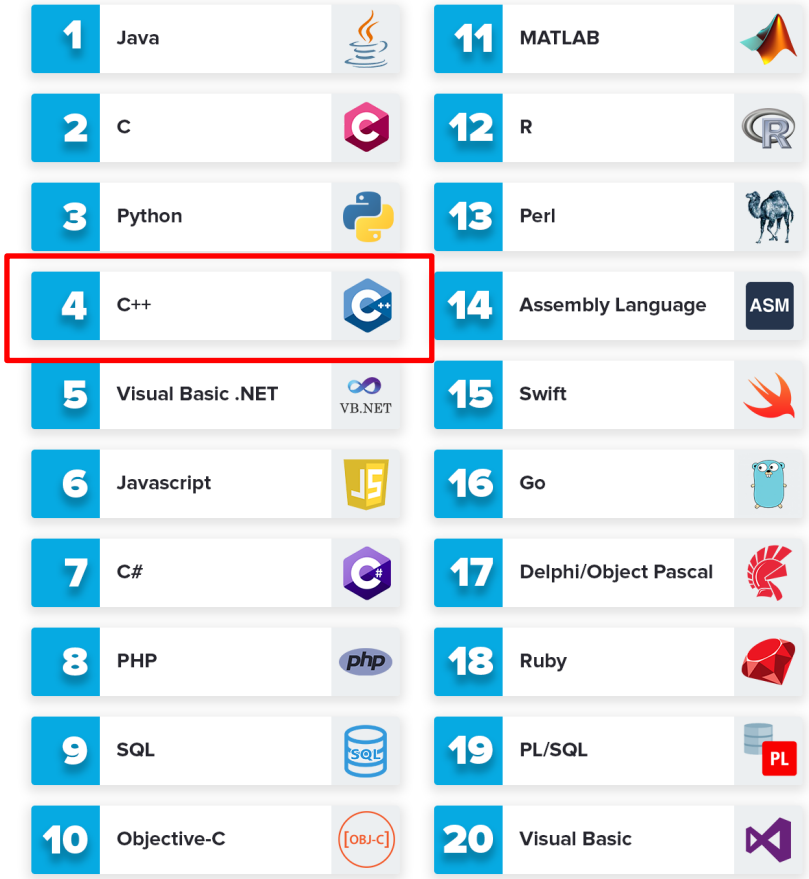
Software is a general term for the various kinds of programs used to operate computers and related devices. (The term hardware describes the physical aspects of computers and related devices.)

How do We Talk to Computers?

- **Like we talk to human through "language"**
  - English, Mandarin, Hindi, … => depending on countries
  - C++, PHP, Python, JS, … => depending on applications

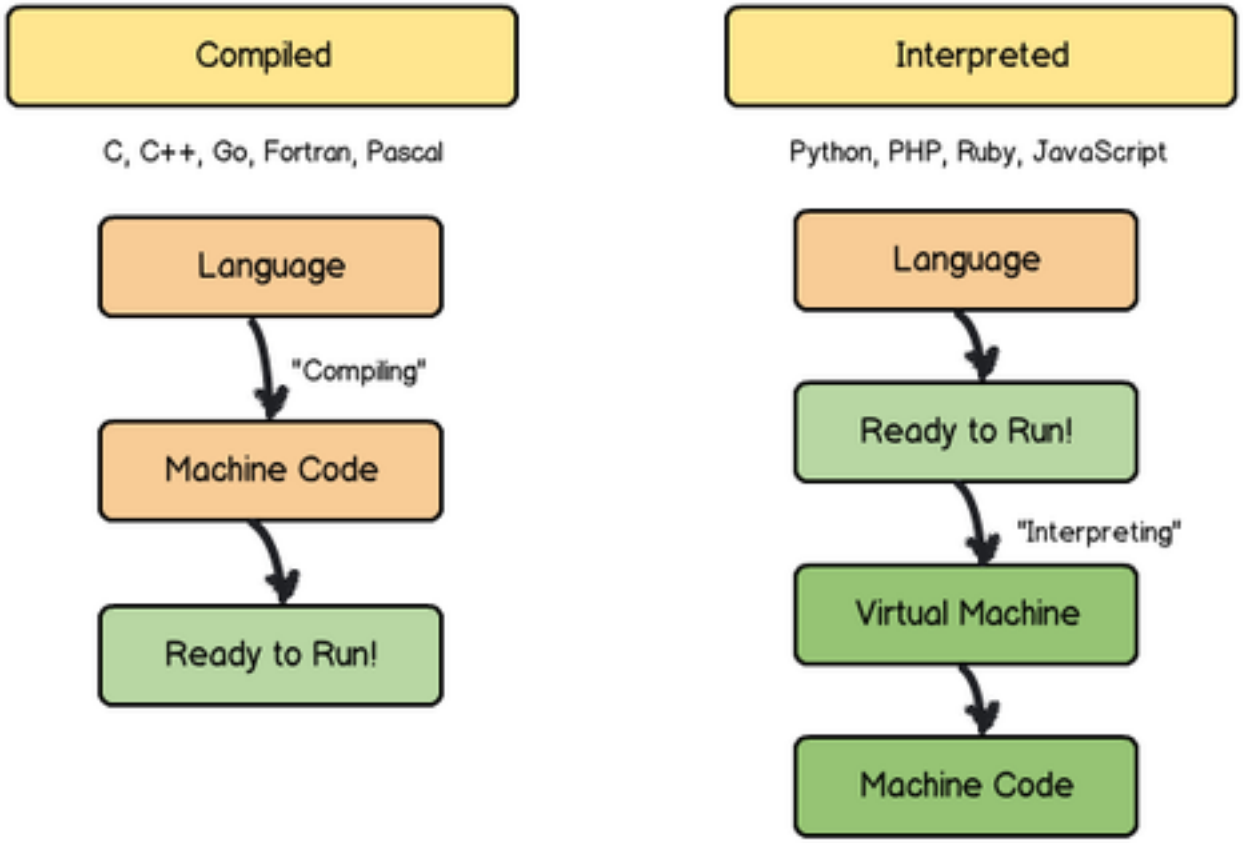
Top 10 Programming Languages

Rank	Language	Type	Score
1	Python		100.0
2	Java		96.3
3	C		94.4
4	C++		87.5
5	R		81.5
6	JavaScript		79.4
7	C#		74.5
8	Matlab		70.6
9	Swift		69.1
10	Go		68.0



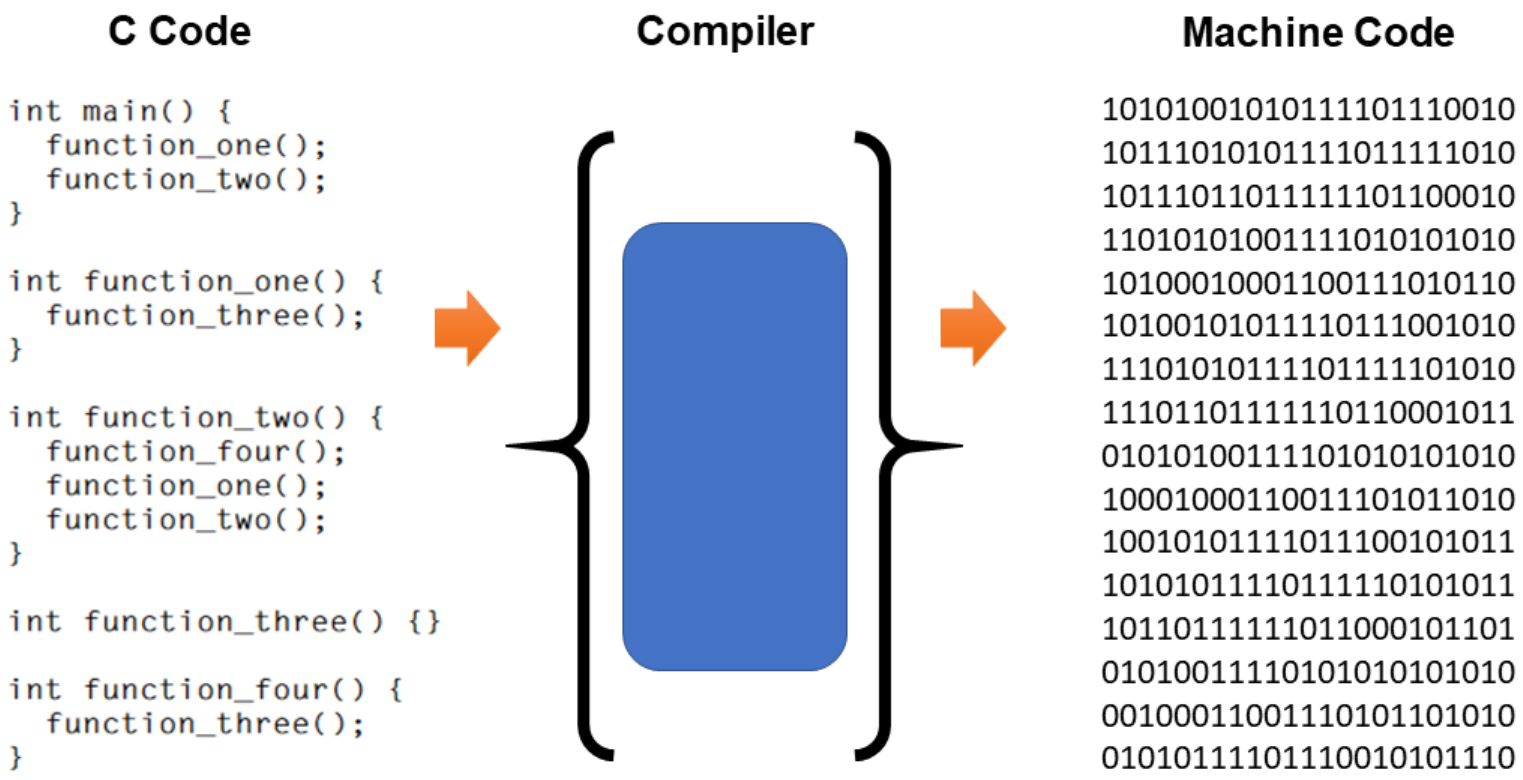
Two Types of Programming Languages

- **Compiled language vs Interpreted language**



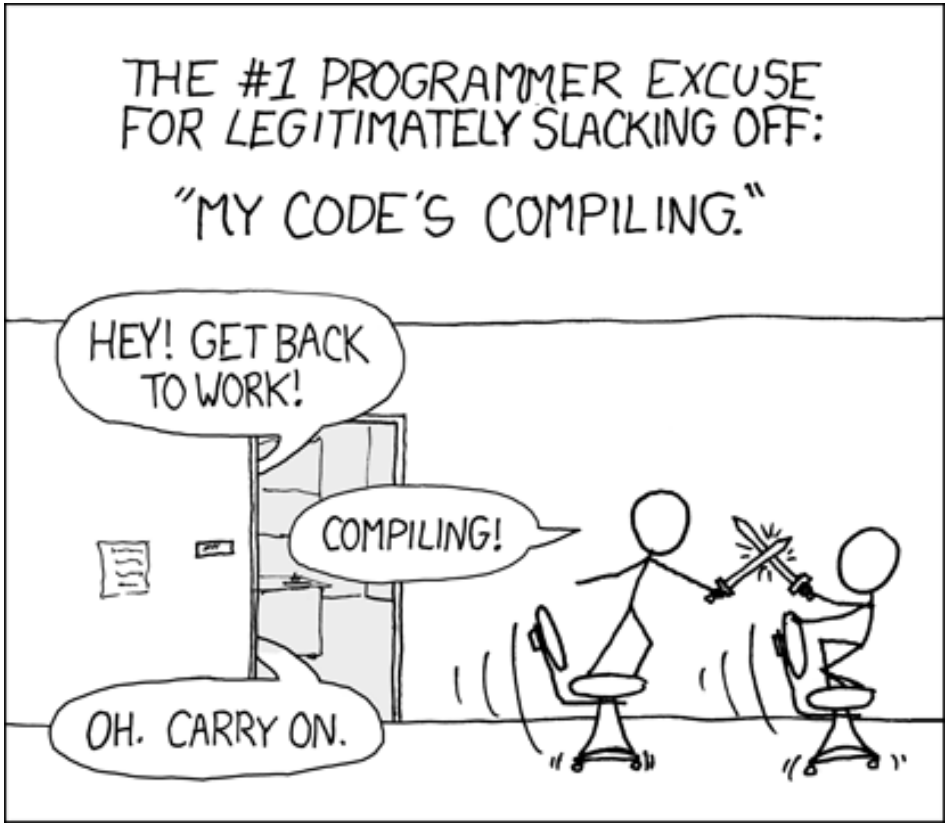
Compilation (e.g., C/C++)

- Compile your "entire" code to an executable



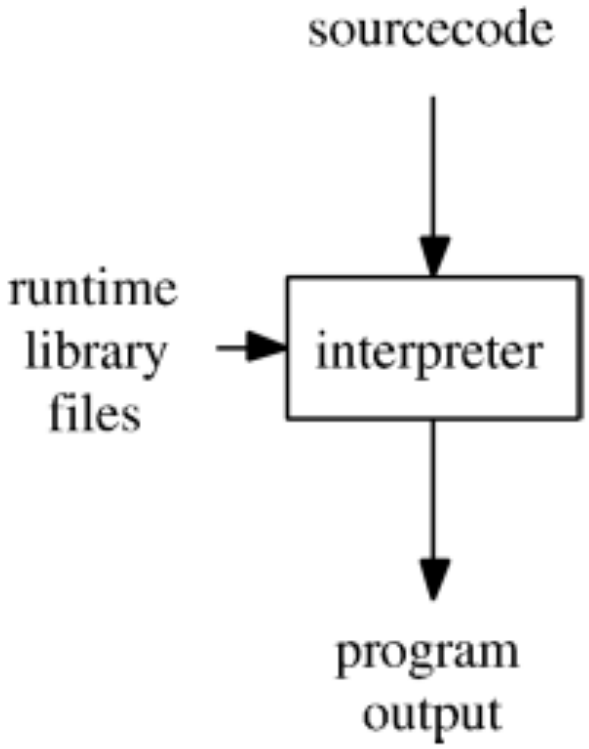
Compilation can be Very Long

- **May take *HOURS* to compile a large codebase …**
  - Do you know how long it takes to compile Google code?



Interpretation

- **Run your code line by line**



Interpretation can be Very Slow

Slowest things on earth:

Python

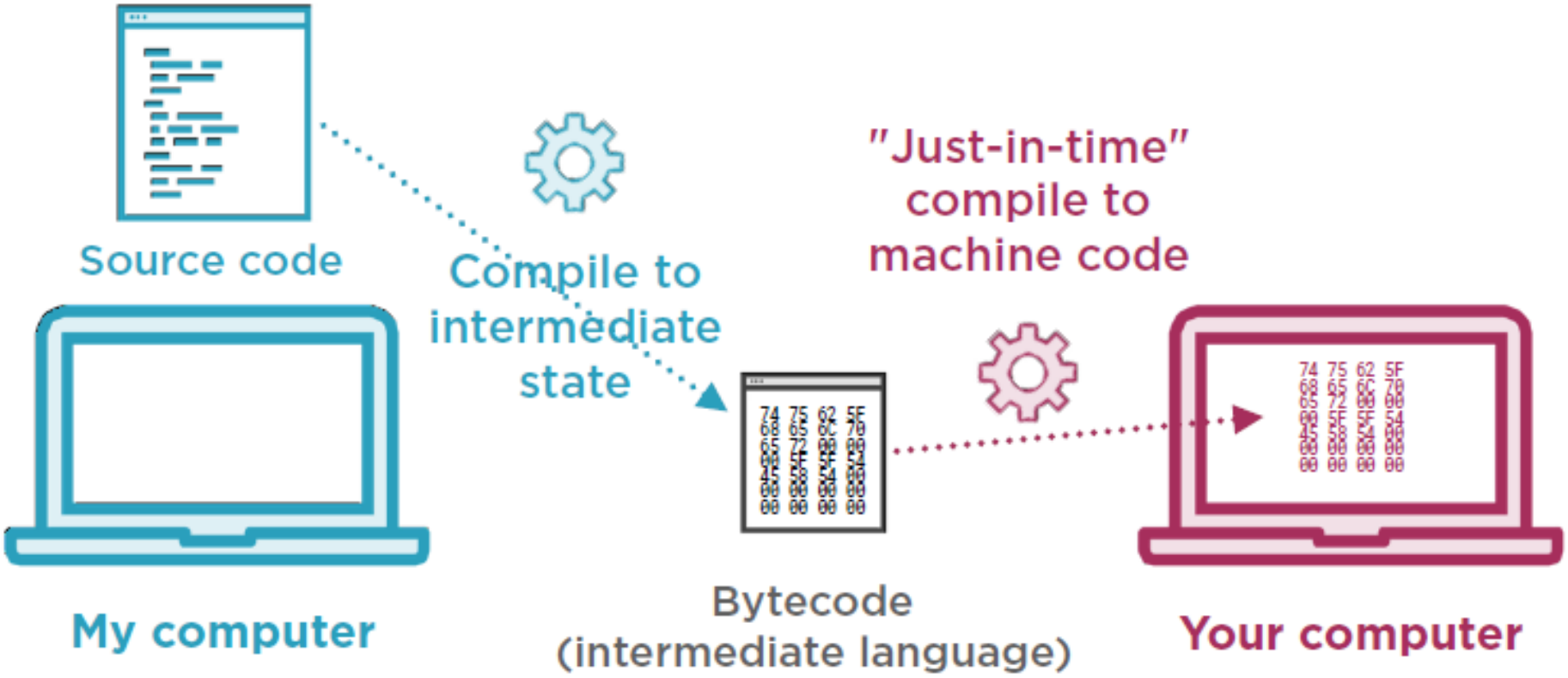
Pros and Cons

- **Again, real cost depends on applications**

Compiled		Interpreted	
PROS	CONS	PROS	CONS
ready to run	**not** cross platform	cross-platform	interpreter required
often **faster**	inflexible	simpler to test	often **slower**
source code is **private**	extra step	easier to debug	source code is **public**

Just-in-time Compilation

- A mix of both (e.g., JavaScript)



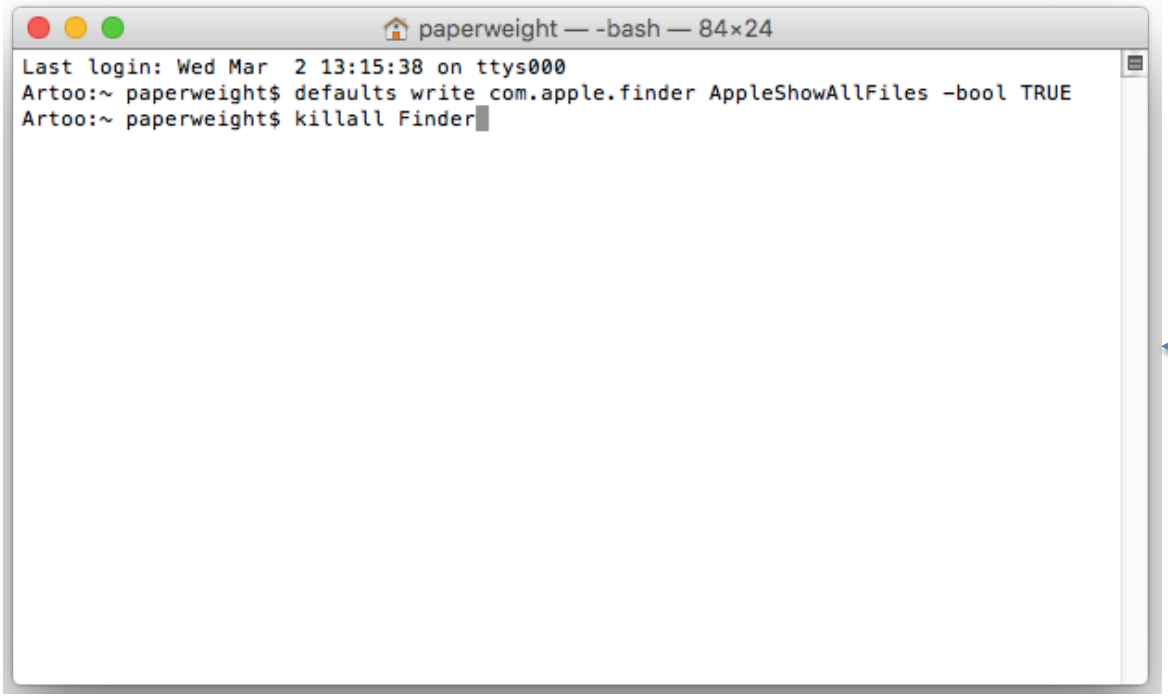
What Types of Language you will use?

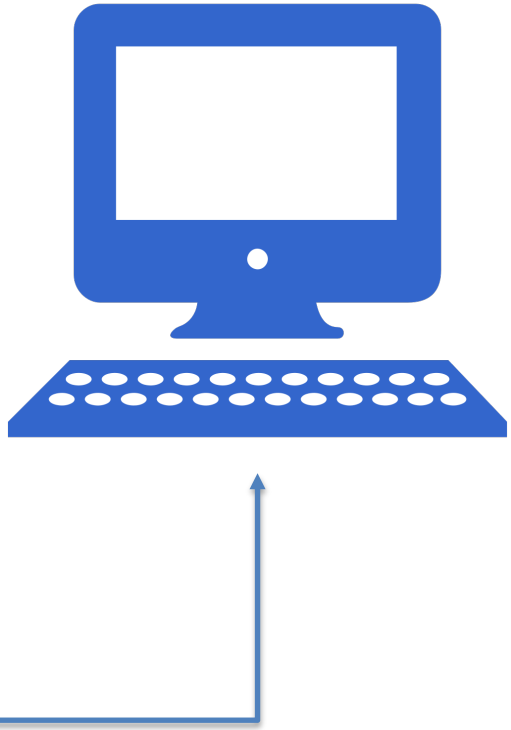
- ❑ I am doing embedded software for autonomous cars
- ❑ I am working on performance-critical applications
- ❑ I am building a high-frequency trading platform
- ❑ I am prototyping my software products
- ❑ I am building circuit design software
- ❑ I am creating my own website

Programming Environment

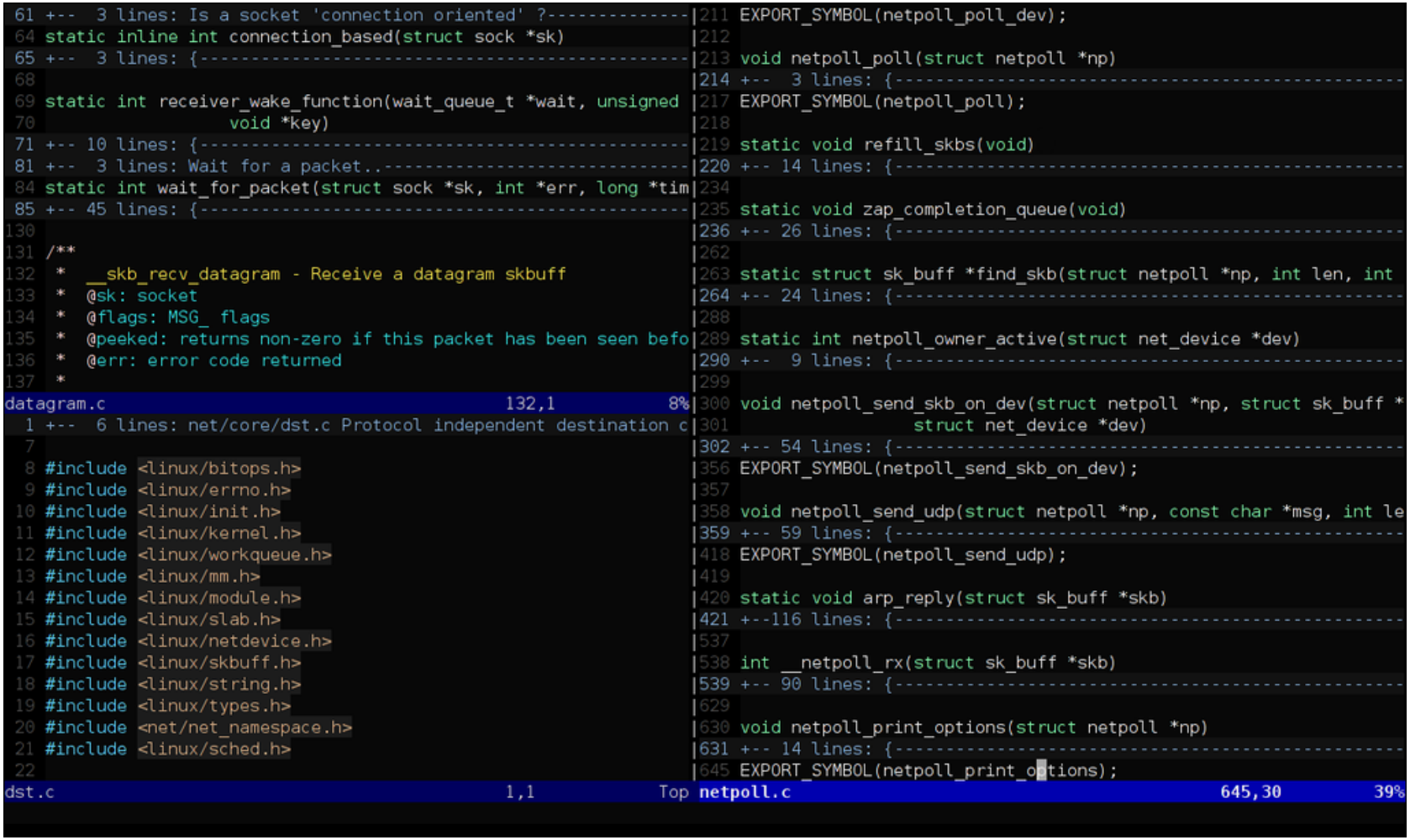
❑ Terminal

- ❑ A computer terminal is an electronic or electromechanical hardware device that can be used for *entering data into*, and displaying or printing data from, a computer or a computing system.



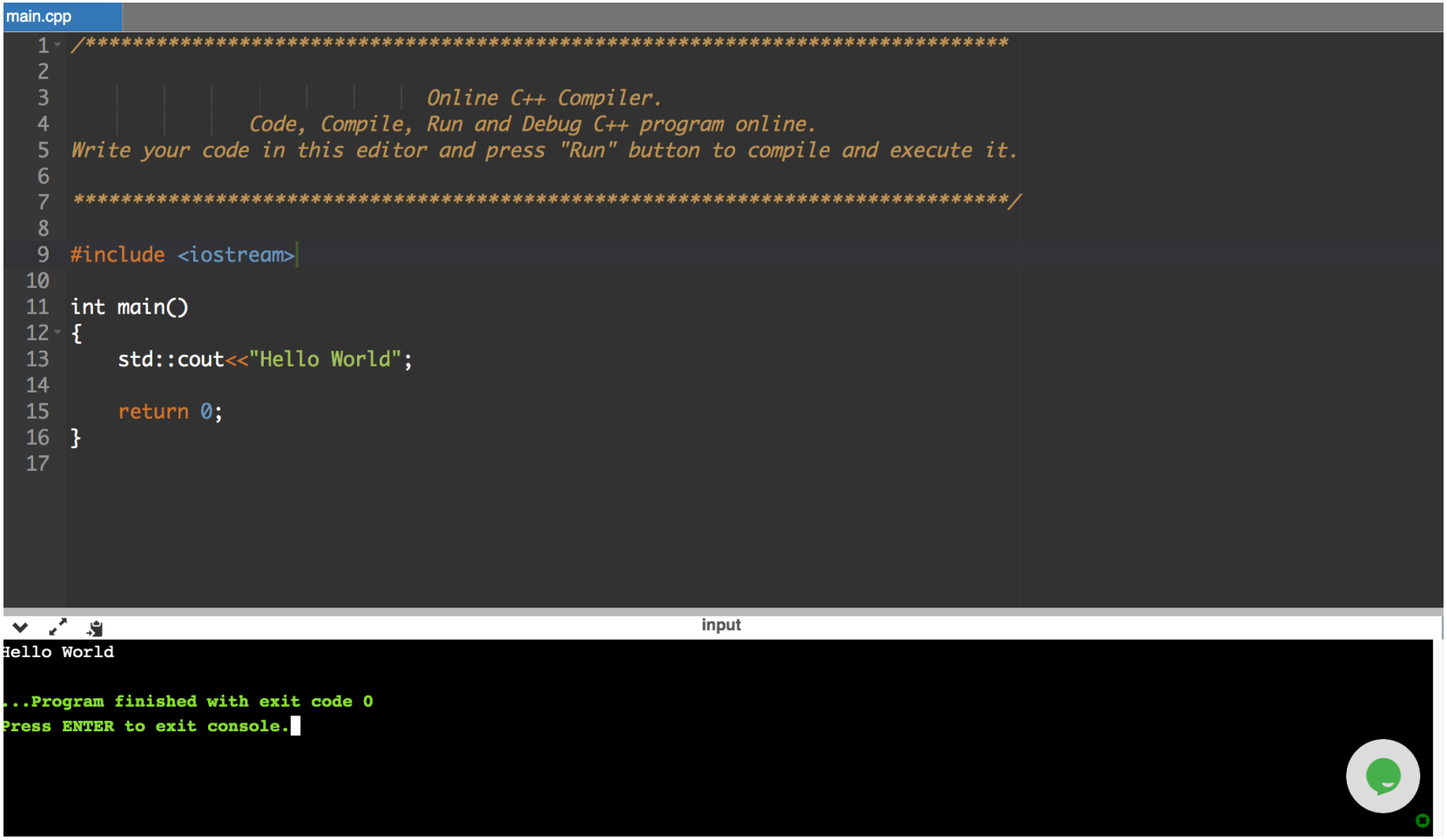


Editor (We will use VIM)



There are also online C++ Editors

- https://www.onlinegdb.com/online_c++_compiler



Output - I

```
1
2   // Text-printing program.
3   #include <iostream> // allows program to output data to the screen
4
5   // function main begins program execution
6   int main()
7   {
8      std::cout << "Welcome to C++!\n"; // display message
9
10     return 0; // indicate that program ended successfully
11  } // end function main
```

```
Welcome to C++!
```

Output - II

- A single statement can print multiple lines by using newline characters.
- Each time the \n (newline) is encountered, the screen cursor is positioned to the beginning of the next line.

```
1
2  // Printing multiple lines of text with a single statement.
3  #include <iostream> // allows program to output data to the screen
4
5  // function main begins program execution
6  int main()
7  {
8     std::cout << "Welcome\nto\n\nC++!\n";
9  } // end function main
```

```
Welcome
to

C++!
```

Header files #include <xxx>

Header files contain definitions of **Functions and Variables**, which is imported or used into any C++ program by using the pre-processor #include statement.

Header file have an extension ".h" which contains C++ function declaration and macro definition.

Why need of header files

When we want to use any function in our C++ program then first we need to import their definition from C++ library, for importing their declaration and definition we need to include header file in program by using #include.

Input - I

- The input stream object **std::cin** and the **stream extraction operator, >>**, can be used obtain data from the user at the keyboard.

```
1
2  // Addition program that displays the sum of two integers.
3  #include <iostream> // allows program to perform input and output
4
5  // function main begins program execution
6  int main()
7  {
8     // variable declarations
9     int number1; // first integer to add
10    int number2; // second integer to add
11    int sum; // sum of number1 and number2
12
13    std::cout << "Enter first integer: "; // prompt user for data
14    std::cin >> number1; // read first integer from user into number1
15
16    std::cout << "Enter second integer: "; // prompt user for data
17    std::cin >> number2; // read second integer from user into number2
18
19    sum = number1 + number2; // add the numbers; store result in sum
20
21    std::cout << "Sum is " << sum << std::endl; // display sum; end line
22 } // end function main
```

Input - II

```
9       int number1; // first integer to add
10      int number2; // second integer to add
11      int sum; // sum of number1 and number2
```

- **Declarations introduce the identifiers `number1`, `number2` and `sum` into programs; they are the names of variables.**
- **A variable is a location in the computer's memory where a value can be stored for use by a program.**
- **Variables `number1`, `number2` and `sum` are data of type int, meaning that these variables will hold integer values.**
- **All variables must be declared with a name and a data type before they can be used in a program.**
- **If more than one name is declared in a declaration, the names are separated by commas (,) → called comma-separated list.**
  - `int number1,number2;`

Input – III (other data types)

- **Data type `double` is for specifying real numbers, and data type `char` for specifying character data.**
  - Real numbers are numbers with decimal points, such as 3.4, 0.0 and –11.19.
- **A `char` variable may hold only a single lowercase letter, a single uppercase letter, a single digit or a single special character (e.g., $ or *).**
- **Types such as `int`, `double` and `char` are called fundamental types.**
- **Fundamental-type names are keywords and therefore must appear in all lowercase letters.**

Fundamental Data Types

- https://en.cppreference.com/w/cpp/language/types

Type specifier	Equivalent type	Width in bits by data model				
		C++ standard	LP32	ILP32	LLP64	LP64
`short`	`short int`	at least **16**	**16**	**16**	**16**	**16**
`short int`						
`signed short`						
`signed short int`						
`unsigned short`	`unsigned short int`					
`unsigned short int`						
`int`	`int`	at least **16**	**16**	**32**	**32**	**32**
`signed`						
`signed int`						
`unsigned`	`unsigned int`					
`unsigned int`						
`long`	`long int`	at least **32**	**32**	**32**	**32**	**64**
`long int`						
`signed long`						
`signed long int`						
`unsigned long`	`unsigned long int`					
`unsigned long int`						
`long long`	`long long int` (C++11)	at least **64**	**64**	**64**	**64**	**64**
`long long int`						
`signed long long`						
`signed long long int`						
`unsigned long long`	`unsigned long long int` (C++11)					
`unsigned long long int`						

Range of Data Types

Type	Size in bits	Format	Value range	
			Approximate	Exact
character	8	signed		**-128** to **127**
		unsigned		**0** to **255**
	16	unsigned		**0** to **65535**
	32	unsigned		**0** to **1114111** (**0x10ffff**)
integer	16	signed	**± 3.27 · 10^4**	**-32768** to **32767**
		unsigned	**0** to **6.55 · 10^4**	**0** to **65535**
	32	signed	**± 2.14 · 10^9**	**-2,147,483,648** to **2,147,483,647**
		unsigned	**0** to **4.29 · 10^9**	**0** to **4,294,967,295**
	64	signed	**± 9.22 · 10^{18}**	**-9,223,372,036,854,775,808** to **9,223,372,036,854,775,807**
		unsigned	**0** to **1.84 · 10^{19}**	**0** to **18,446,744,073,709,551,615**
floating point	32	IEEE-754	• min subnormal: **± 1.401,298,4 · 10^{-45}** • min normal: **± 1.175,494,3 · 10^{-38}** • max: **± 3.402,823,4 · 10^{38}**	• min subnormal: **±0x1p-149** • min normal: **±0x1p-126** • max: **±0x1.fffffep+127**
	64	IEEE-754	• min subnormal: **± 4.940,656,458,412 · 10^{-324}** • min normal: **± 2.225,073,858,507,201,4 · 10^{-308}** • max: **± 1.797,693,134,862,315,7 · 10^{308}**	• min subnormal: **±0x1p-1074** • min normal: **±0x1p-1022** • max: **±0x1.fffffffffffffp+1023**

C++ is a Strongly Typed System

Declare Variables

- **Using the fundamental data types**
  - e.g. int my_variable
- **A variable name is any valid identifier that is not a keyword.**
- **An identifier is a series of characters consisting of letters, digits and underscores (_) that does not begin with a digit.**
- **C++ is case sensitive—uppercase and lowercase letters are different, so `a1` and `A1` are different identifiers.**
- **Declarations of variables can be placed almost anywhere in a program, but they must appear before their corresponding variables are used in the program.**

Variable Naming is Important …

- **Tip 1: C++ allows identifiers of any length, but your C++ implementation may restrict identifier lengths. Use identifiers of 31 characters or fewer to ensure portability**
- **Tip 2: choose meaningful identifiers makes a program self-explanatory—a person can understand the program simply by reading it rather than having to refer to the manuals or comments**
  - int parent, PARENT;
  - int mom, dad;
  - Good naming is always fundamental to effective code reviews and collaboration

Adding Integers - I

```
13      std::cout << "Enter first integer: "; // prompt user for data
14      std::cin >> number1; // read first integer from user into number1
```

- A **prompt** directs the user to take a specific action.
- A `cin` statement uses the **input stream object cin** (of namespace `std`) and the **stream extraction operator**, **>>**, to obtain a value from the keyboard.
- Using the stream extraction operator with `std::cin` takes character input from the standard input stream, which is usually the keyboard.

Adding Integers - II

```
14      std::cin >> number1; // read first integer from user into number1
```

- When the computer executes an input statement, it waits for the user to enter a value for variable `number1`.
- The user types the number (as characters) then press the *Enter* key (or the Return key) to send the characters to the computer.
- The computer converts the character representation of the number to an integer and put the value to the variable `number1`.
- Any subsequent references to `number1` in this program will use this same value.

Adding Integers - III

```
19        sum = number1 + number2; // add the numbers; store result in sum
```

- **In this program, an assignment statement adds the values of variables `number1` and `number2` and assigns the result to variable `sum` using the assignment operator `=`.**
  - Most calculations are performed in assignment statements.
- **The = operator and the + operator are called binary operators because each has two operands.**

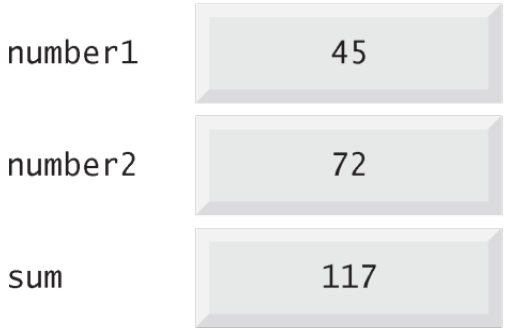
Adding Integers - IV

```
21      std::cout << "Sum is " << sum << std::endl; // display sum; end line
```

- `std::endl` **is a so-called stream manipulator.**
  - The name `endl` is an abbreviation for "end line"
- `std::endl` **outputs a newline and flushes the output buffer.**
  - Some systems may accumulate outputs in the machine (output buffer) and display them simultaneously on the screen.
  - `std::endl` forces any accumulated outputs to be displayed.
- **Using multiple stream insertion operators (<<) in a single statement is referred to as concatenating, chaining or cascading stream insertion operations.**
- **Calculations can also be performed in output statements.**

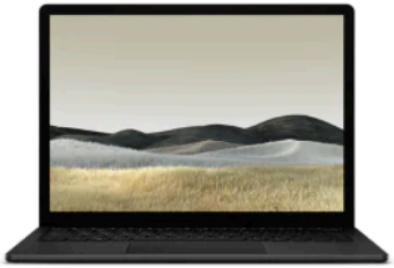
Memory Concepts

- Variable names such as `number1`, `number2` and `sum` actually correspond to **locations** in the computer's memory.
- Every variable has a **name**, a **type**, a **size** and a **value**.
- When a value is placed in a memory location, it **overwrites** the previous value in that location → **destructive**
- When a value is read out of a memory location, the process is **nondestructive**.



Yes, Memory is Limited

- **You may not create too many variables**
  - e.g. one trillion integers or more



Open gallery

Surface Laptop 3 - 13.5", Black (metal), Intel Core i5, 8GB, 256GB

♡ Wish list

Slim and stylish, available in 13.5" and 15" touchscreens, rich color options,[1] and two durable finishes. Make a powerful statement and get improved speed, performance, and all-day battery life.[2]

The Microsoft Store Promise for Surface
Shop with confidence at Microsoft Store. We're offering 60-day returns on Surface products, plus free digital workshops, remote learning opportunities, and more to help you get the most from your new device.*
Learn more >

Bundle and save with the Surface Laptop 3 Essentials Bundle
Includes your choice of Surface Laptop 3, Microsoft 365 and Microsoft Complete Protection Plan.
Build your bundle >

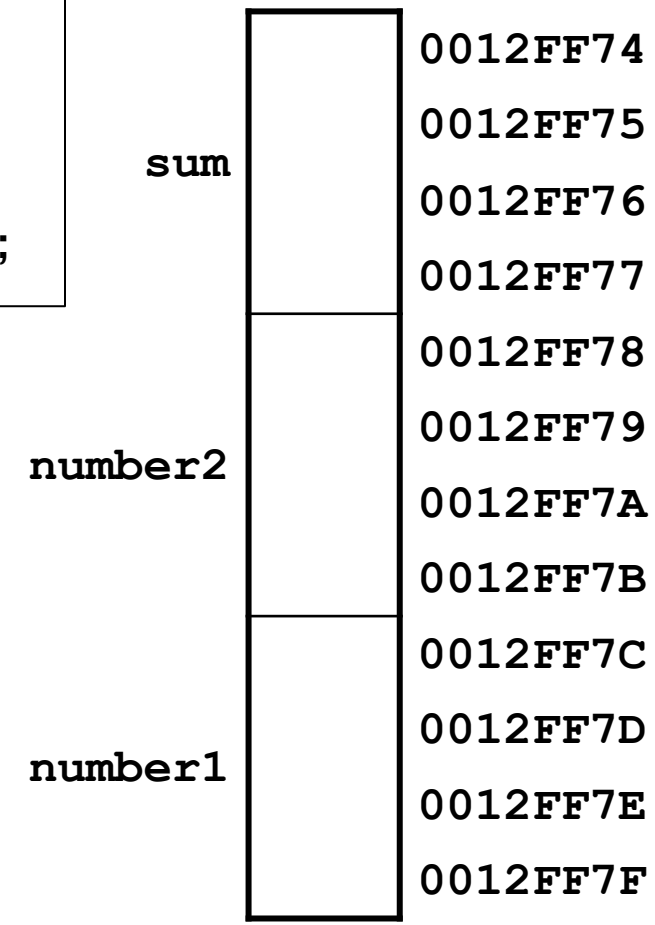
This literally means your program can run up to **8 GB** memory

Illustration

```
std::cout << "Enter first integer: ";
std::cin >> number1;
std::cout << "Enter second integer: ";
std::cin >> number2;
sum = number1 + number2;
std::cout << "Sum is " << sum << std::endl;
```

Output

Memory



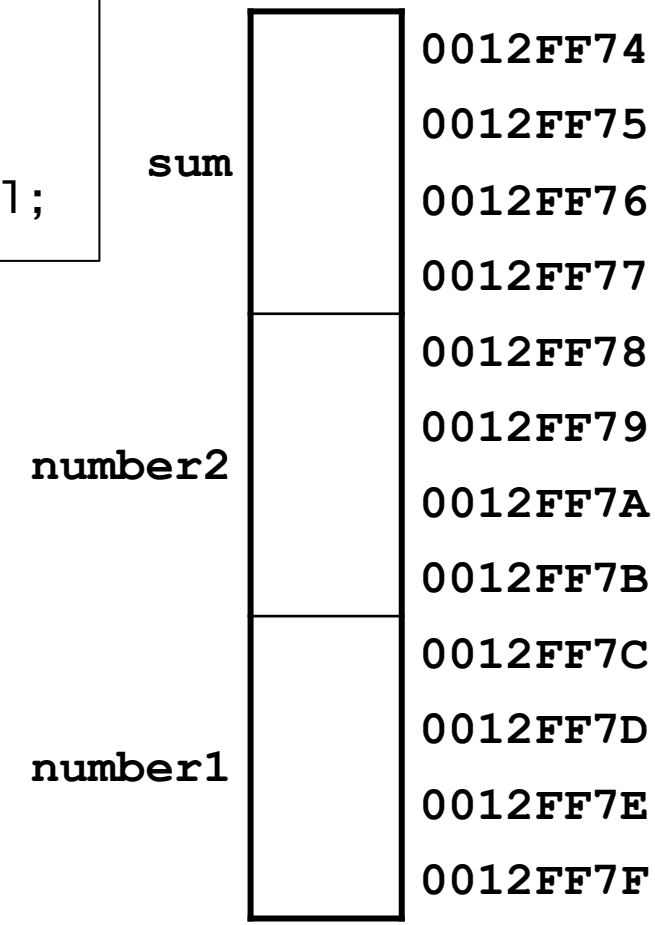
Illustration

```
std::cout << "Enter first integer: ";
std::cin >> number1;
std::cout << "Enter second integer: ";
std::cin >> number2;
sum = number1 + number2;
std::cout << "Sum is " << sum << std::endl;
```

Output

```
Enter first integer: _
```

Memory



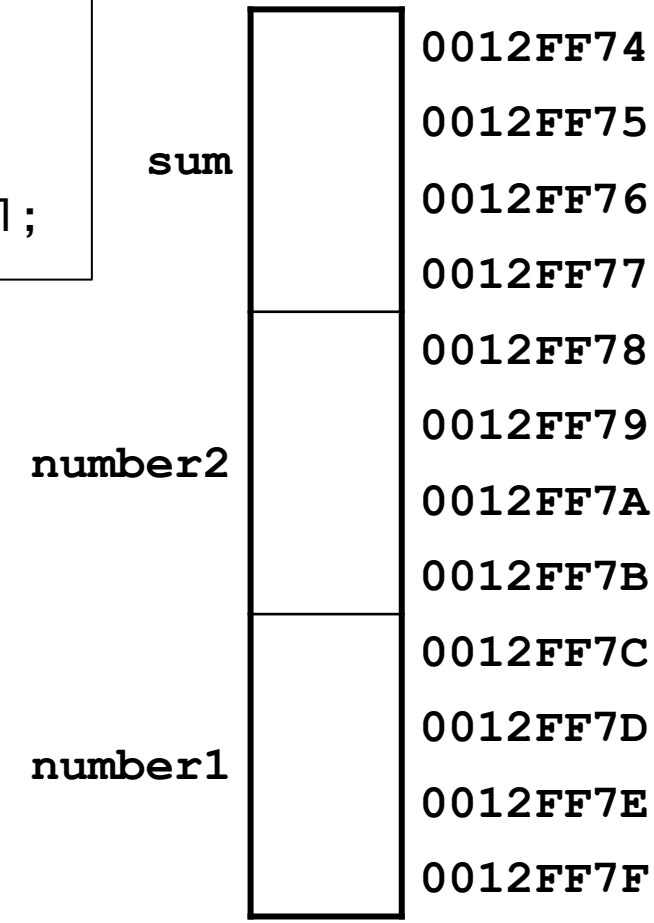
Illustration

```
std::cout << "Enter first integer: ";
std::cin >> number1;
std::cout << "Enter second integer: ";
std::cin >> number2;
sum = number1 + number2;
std::cout << "Sum is " << sum << std::endl;
```

Output

```
Enter first integer: 45_
```

Memory



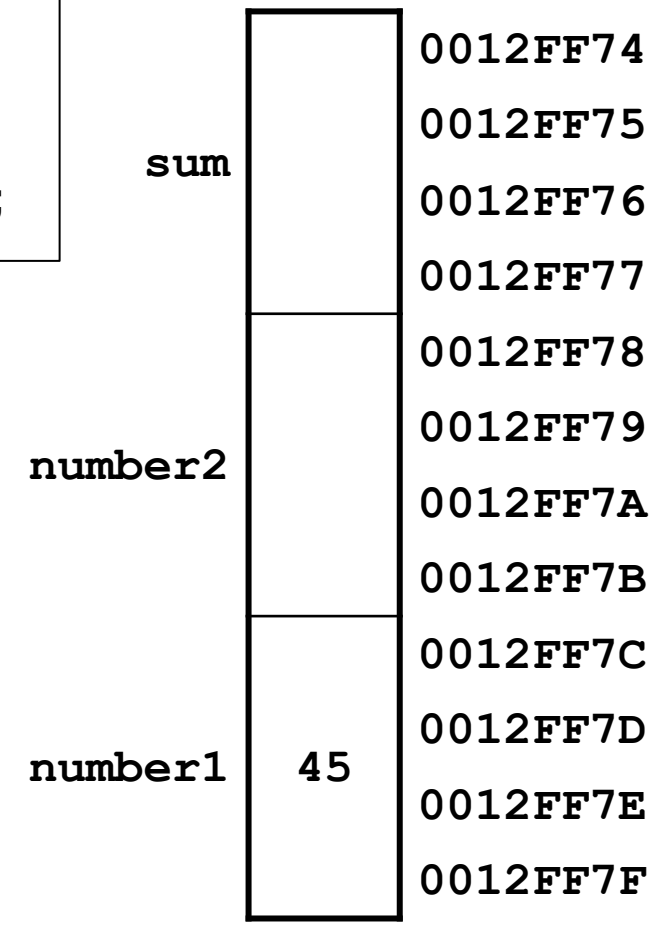
Illustration

```
std::cout << "Enter first integer: ";
std::cin >> number1;
std::cout << "Enter second integer: ";
std::cin >> number2;
sum = number1 + number2;
std::cout << "Sum is " << sum << std::endl;
```

Output

```
Enter first integer: 45
_
```

Memory



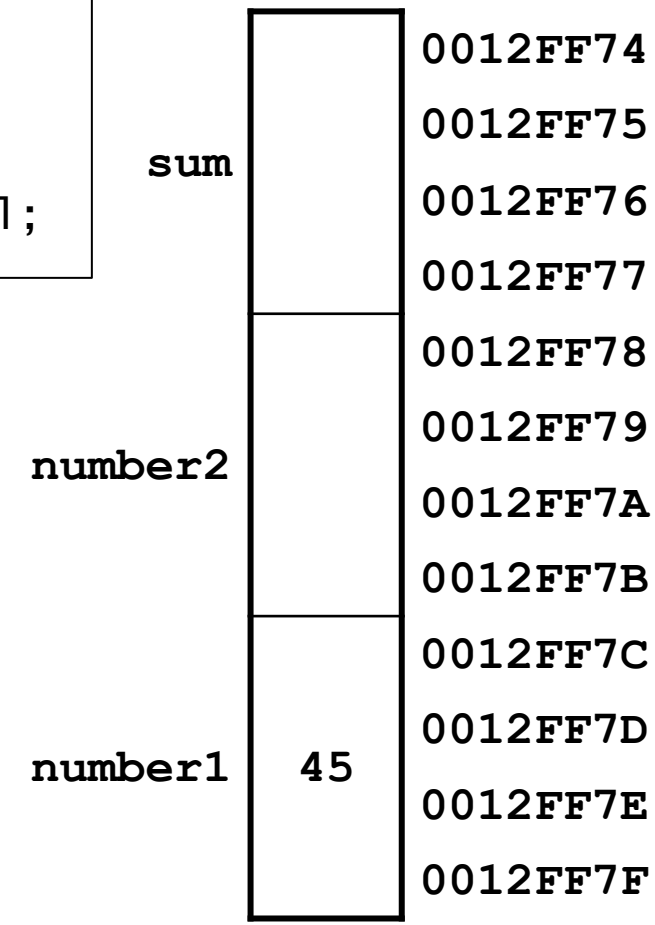
Illustration

```
std::cout << "Enter first integer: ";
std::cin >> number1;
std::cout << "Enter second integer: ";
std::cin >> number2;
sum = number1 + number2;
std::cout << "Sum is " << sum << std::endl;
```

Output

```
Enter first integer: 45
Enter second integer: _
```

Memory



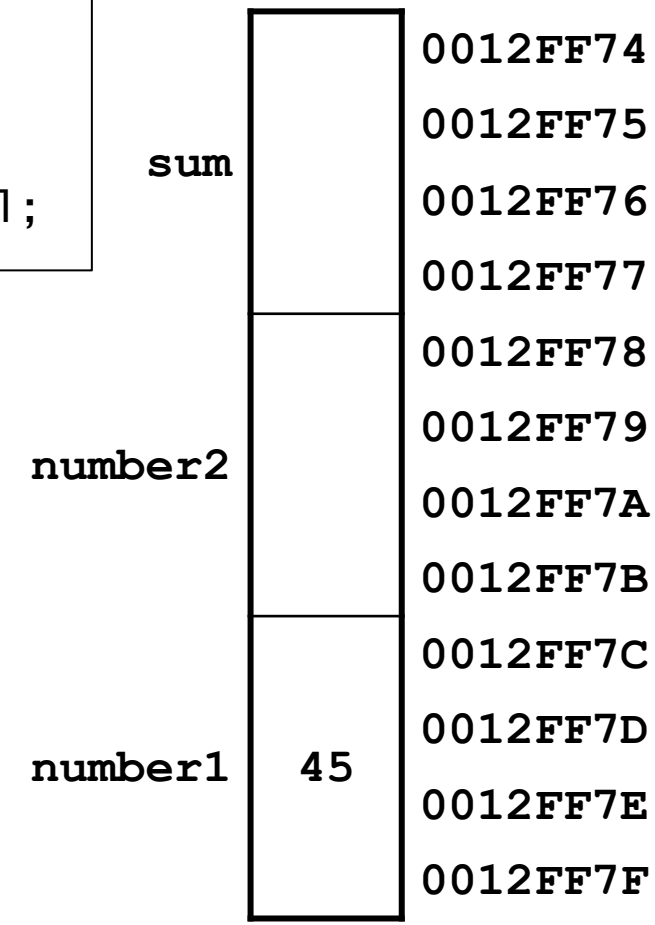
Illustration

```
std::cout << "Enter first integer: ";
std::cin >> number1;
std::cout << "Enter second integer: ";
std::cin >> number2;
sum = number1 + number2;
std::cout << "Sum is " << sum << std::endl;
```

Output

```
Enter first integer: 45
Enter second integer: 72_
```

Memory



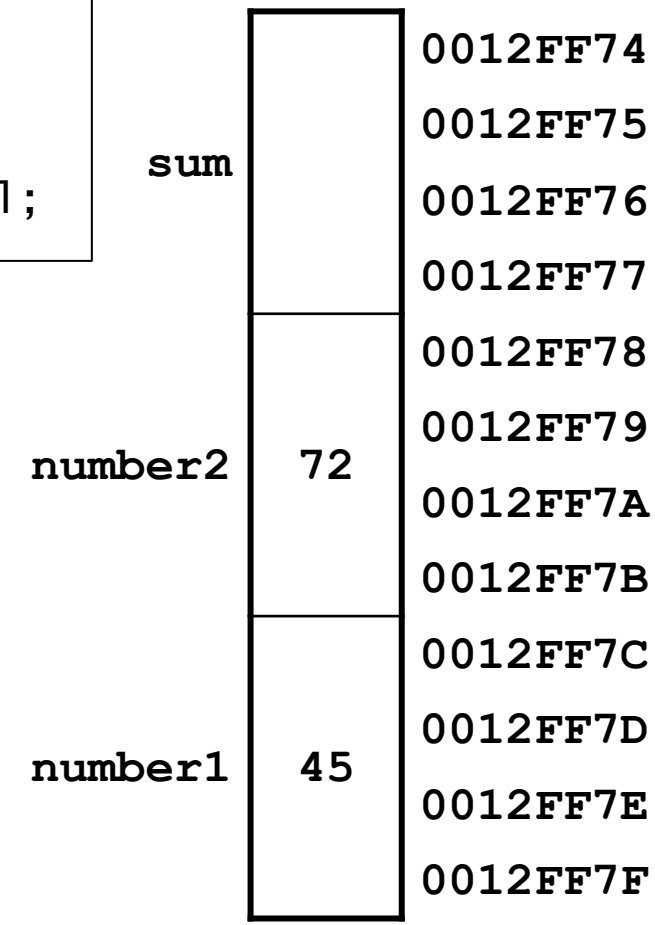
Illustration

```
std::cout << "Enter first integer: ";
std::cin >> number1;
std::cout << "Enter second integer: ";
std::cin >> number2;
sum = number1 + number2;
std::cout << "Sum is " << sum << std::endl;
```

Output

```
Enter first integer: 45
Enter second integer: 72
_
```

Memory



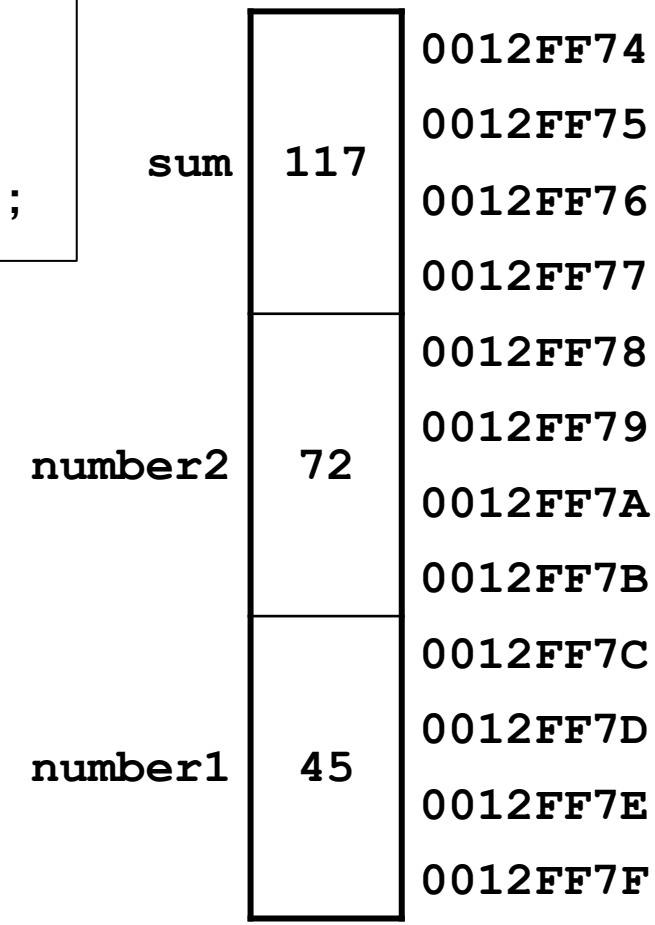
Illustration

```
std::cout << "Enter first integer: ";
std::cin >> number1;
std::cout << "Enter second integer: ";
std::cin >> number2;
sum = number1 + number2;
std::cout << "Sum is " << sum << std::endl;
```

Output

```
Enter first integer: 45
Enter second integer: 72
_
```

Memory



Illustration

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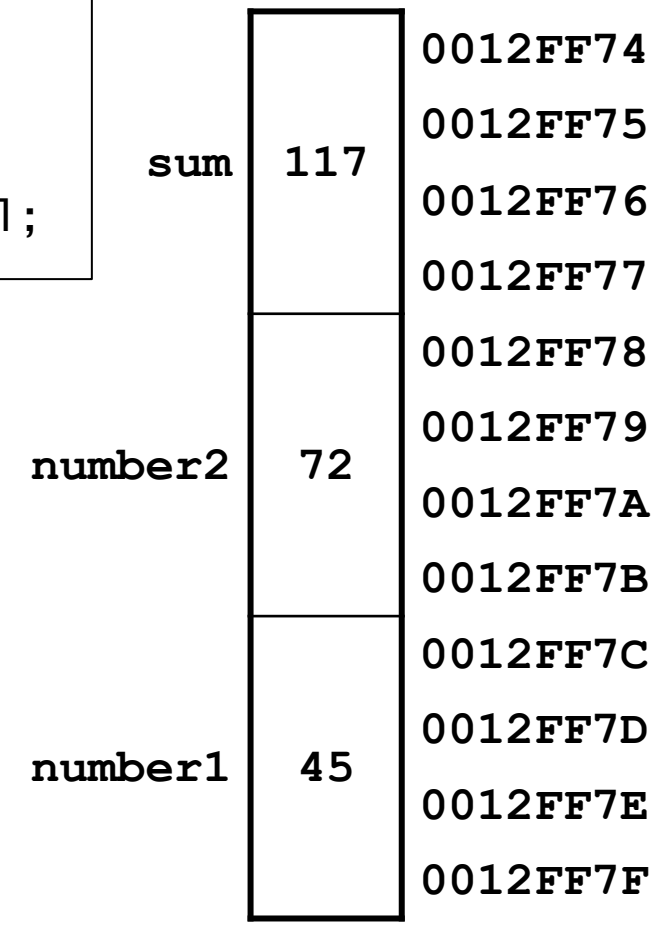
std::cout << "Enter first integer: ";
std::cin >> number1;
std::cout << "Enter second integer: ";
std::cin >> number2;
sum = number1 + number2;
std::cout << "Sum is " << sum << std::endl;
```

Output

```
Enter first integer: 45
Enter second integer: 72
Sum is 117_
```

Memory



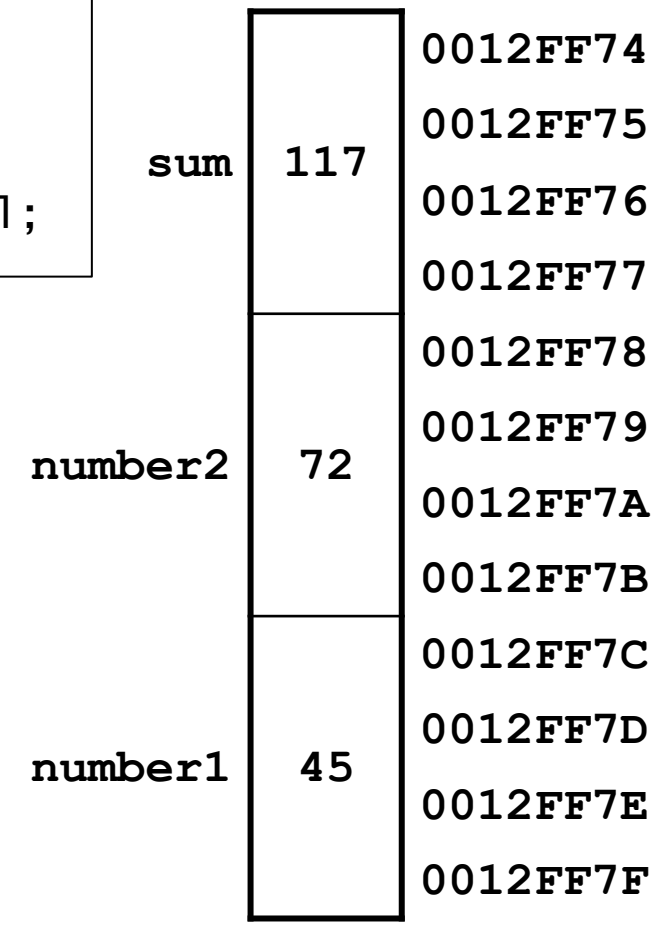
Illustration

```
std::cout << "Enter first integer: ";
std::cin >> number1;
std::cout << "Enter second integer: ";
std::cin >> number2;
sum = number1 + number2;
std::cout << "Sum is " << sum << std::endl;
```

Output

```
Enter first integer: 45
Enter second integer: 72
Sum is 117
Press any key to continue_
```

Memory



binary representation	hexadecimal	decimal
00000000 00000000 00000000 00000000	00000000	0
00000000 00000000 00000000 00000001	00000001	1
00000000 00000000 00000000 00000010	00000002	2
00000000 00000000 00000000 00000011	00000003	3
00000000 00000000 00000000 00000100	00000004	4
00000000 00000000 00000000 00000101	00000005	5
00000000 00000000 00000000 00000110	00000006	6
00000000 00000000 00000000 00000111	00000007	7
00000000 00000000 00000000 00001000	00000008	8
00000000 00000000 00000000 00001001	00000009	9
00000000 00000000 00000000 00001010	0000000A	10
00000000 00000000 00000000 00001011	0000000B	11
00000000 00000000 00000000 00001100	0000000C	12
00000000 00000000 00000000 00001101	0000000D	13
00000000 00000000 00000000 00001110	0000000E	14
00000000 00000000 00000000 00001111	0000000F	15

Value Representation

- **Binary, Octal, Decimal, Hex**
  - The six letters (in addition to the 10 integers) in hexadecimal represent: 10 (A), 11 (B), 12 (C), 13 (D), 14 (E), and 15 (F), respectively.

Name	Radix	Digits
Binary	**2**	**0,1**
Octal	**8**	**0,1,2,3,4,5,6,7**
Decimal	**10**	**0,1,2,3,4,5,6,7,8,9**
Hexadecimal	**16**	**0,1,2,3,4,5,6,7,8,9,A,B,C,D,E,F**

Common Arithmetic Operators

C++ operation	C++ arithmetic operator	Algebraic expression	C++ expression
Addition	+	$f + 7$	`f + 7`
Subtraction	-	$p - c$	`p - c`
Multiplication	*	bm or $b \cdot m$	`b * m`
Division	/	x / y or $\frac{x}{y}$ or $x \div y$	`x / y`
Modulus	%	$r \bmod s$	`r % s`

Summary

- **C++ input and output**
- **Variables, data types**
  - C++ is a strongly-typed system
- **Adding two integers**
- **Value representation (binary, hex, decimal)**
- **Arithmetic operators (+, -, *, /)**
- **Programming Assignment 1 is out!**
  - Email your solution to your section TA (see class page)
  - Due by class time on 9/2