

Session 1 - An Introduction To C

About the session

The course starts gently by introducing basic programming concepts in C such as variables, types, functions, and loops. If you're an experienced programmer then feel free to skim through these sections to get to the more C-specific parts!

Contents

- [What is C](#)
- Hello World!
- Variables & Types
- Format Specifiers (%d, %s, %c)

Integer types (char, short, int, long, long long)

underflow/overflow

use of stdint library

unsigned integers

floating-point types

This should be SHORT as can be introduced similarly to integers

Comments

Positioned as a break in the Integer section

Functions

Revisiting the main function

Basic Loops

Arrays and exploring undefined behaviour

Suggested reading (K&R, relevant blogs etc)

What is C

C is a general purpose programming language that originated as the language for UNIX

Hello, World!

Let's start with the first program almost *everyone* writes.

```
#include <stdio.h>

main(){
    printf("hello world");
}
```

There are a few things to note already:

1. The **stdio** library is the **standard input/output** library which we'll use to print text to the console. Think of **libraries** as a collection of tools that other people have coded so that we don't have to; typically a library is dedicated to *one thing* and I'm sure you can guess what **stdio** is dedicated to.

We import it using the **include** *preprocessor directive*; don't worry, we'll learn more about what preprocessor directives are later! Just know that preprocessor directives start with a **#** (fun fact: also called an octothorpe), and that `#include <stdio.h>` tells C to copy all the code from `stdio` so that we get access to **printf** and everything else in that library.

2. All C programs start at the **main** function; not having a main will lead to an error!

```
undefined reference to 'WinMain'
```

The error I receive on my machine

It is similar to Java's main, which you may have already learned about in CS118, in that it is the first block of code run.

If you don't know what functions are yet, then just think of them as blocks of code. We will discuss them soon!

3. Statements in C, like using the **printf** function, end with a *semicolon*. This helps C read the program as semicolons tell it where one statement ends and another begins.

Okay so we've seen our first C program but how do we actually run it?

Running C Code

If you're working on DCS machines, then you should have the GNU C compiler installed.

If not then you should check by running the following command:

```
gcc --version
```

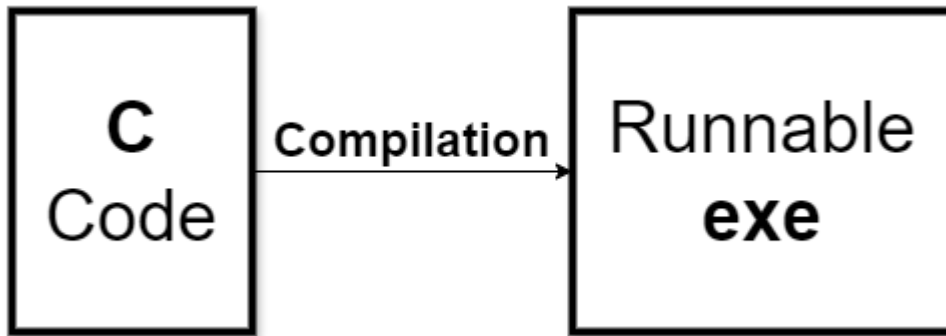
gcc stands for GNU Compiler Collection

If you do not have it installed, then follow the installation instructions from [here](#).

What is a compiler?

A compiler turns **high-level** code (such as **C**) into **low-level** machine code that the computer can run.

The idea is that **C** code is relatively portable so you can write some **C** code, give that code to multiple different machines and they'll be able to run it using their respective compilers.



- Compiling C code turns it into an exe
- You can run the exe with `./TheExe`

Compiling and Executing C Code

Use `gcc` to compile C code. As an example:

1. create a new file directly under the main folder (named C_Course-Introduction)
2. Call it `exampleToCompile.c`
3. Run the command `gcc exampleToCompile.c -o exampleProgram`

This should give you an exe named `exampleProgram.exe` that you can run using:

```
./exampleProgram
```

Note that the `-o` flag lets you name the exe and, by extension, place it in a specific folder. If you wrote `exes/exampleProgram` instead of `exampleProgram`, then it would place the newly created program in the `exes` folder (assuming this folder exists). This will make it easier to keep track of your files!

Using the above, see if you can figure out how to compile one of the c files inside of `cFiles`.

Exercise for Hello World

1. Try changing up the text outputted to the console. Note that **C** does not automatically insert *newlines* after each usage of `printf`!

```
#include <stdio.h>

main(){
    printf("hello ");
    printf("world");
}
```

So the above code outputs:

```
hello world
```

Key thing to note is that it's all on one line

If you want a newline, use `\n` which stands for the *newline* character.

```
#include <stdio.h>

main(){
    printf("hello\n");
    printf("world");
}
```

Have fun coding!

Variables

So we can interact with the console using `printf` but we need a way of handling data; at the very least, we need a way of storing input when we start reading input from the user.

Enter variables!

Variables have a name and a type (for what kind of data is stored). They also hold a value regardless of if you provide one!

Declaring with value

(image: Declaring a variable with a value)Declaring without value

(image: Declaring a variable without specified value)This is the difference between declaration and initialisation.

Both of these declare the variable (they tell C that memory must be reserved for the variable), but only the first initialises the variable with a value.

We will see soon that the variable that isn't initialised does have a value, but it might not be what you expect!

Integer variables

First, we'll explore the integer (positive/negative whole number) types!

(image: Using integers)1) Note the different ways we've initialised the variables a,b,c- all valid!

2. Notice that we're using `printf` differently. The previous use of `printf` was just passing it a piece of text; this current use of `printf` passes it a formatting piece of text, and the values to slot into the format.

As it's useful to output values in meaningful ways for debugging complex programs and even outputs for simple command-line programs, we'll take a closer look at using `printf`.

Format Specifiers (using `printf`)

The formatting piece of text includes format specifiers which begin with `%` and are replaced by the other values you pass `printf`; different values (or different displays of values) require different format specifiers.

For example, `%d` is used to stand in for a regular old base 10 integer (d for decimal). The pieces of text that we've been passing are called strings and so use `%s`.

(image: Example for time using `%s`, `%d`) (image) What did I mean by "different displays of values"? There's a smaller int data type called a char, with a tiny range of possible values (-128 to +127), and it's typically used to represent characters using ASCII rather than integers.

For those who don't know, ASCII is a standard encoding of integers to commonly used characters. To name a few: 65 is 'A', 66 is 'B', 67 is 'C'; 97 is 'a', 98 is 'b', 99 is 'c'; 33 is '!', 35 is '#'. Of course the digits too; they're encoded by the numbers 48-57.

So a char can be displayed as a number using `%d`, but also as a character using `%c`.

(image: Displaying both the character the char represents, and the number itself) (image) As a char can represent a subset of the values an int can, an int can also be used to display a character as it can be converted into a char very easily. So the following code is also valid: (image: Displaying both representations using an int)

(image) If you're concerned about not being able to display the `%` symbol, fret not! You can do this using `%%` which displays a single `%`.

Exercise for using chars

1. Try to spell your name out using chars! If you're feeling ambitious, try doing this using a mixture of capital and lower case letters.

Break from ints: Comments

We'll be using comments to help describe and explain bits of code; they don't do anything to the execution of the program, but you should use comments in your own C programs to help the reader quickly understand what is going on (often you in the future)!

(image) Use `//` for single-line comments. Let's see how they're used to showcase the increment operator (`++`), which increases a number by 1.

(image: Use of single-line comments) If you need to write something longer, then consider using multi-line comments.

To start a multi-line comment, use `/*`

To end a multi-line comment, use `*/`

(image: The full program; take note of the multi-line comment) Try to practice using comments in the exercises to get used to them!

If someone asks about Javadocs or a universal standard, send them <https://www.doxygen.nl>

Which int to use?

There are several ints (char, short, int, long, long long) to choose from, and generally you should choose them based on what they're used for e.g. chars for representing characters, shorts for small integers, longs for long integers.

For most use cases, the size taken up by an integer is negligible so most people tend to default to an int in a place where a short would be perfectly fine. This only really matters in situations where space is very valuable such as small embedded systems or storing a lot of integers. In fact, it can be beneficial to use an int as your future uses may require a larger range and arithmetic can actually be faster (although usually negligibly) if your machine's native size is 32-bit or 64-bit.

Despite the idea of C being a portable language, the size (and range) of integer types are machine-dependent; therefore, the C standard only specifies the minimum number of bytes for each type.

For instance, the minimum number of bytes for an int is 2 however most modern machines use 4.

Type

(Minimum) number of bytes

(Minimum) range of values

char

1

-128 to +127

short

(aka short int)

2

-32768 to +32767

int

2

-32768 to +32767

long

(aka long int)

4

-2147483648 to +2147483647

long long

(aka long long int)

8

-2^{63} to $+2^{63} - 1$

Overflow/Underflow - What if the number goes above/below the range?

Going above the range (overflow) of an int type will wrap around to the minimum value.

Similarly, going below the range (underflow) of an int type will wrap around to the maximum value.

(image: Integer overflow and underflow)Note that the decrement operator (`—`) subtracts 1 from a number.

Overflow/Underflow - Type Casting

When we saw that integers can be displayed as characters, we were actually converting integers to characters first: this is a type cast.

What if I want only positive numbers?

The standard integers we use are signed integers. As in, they have a sign (positive or negative). If you want to use only the positive range, then you can use unsigned integers by adding "unsigned" in the type!

What if I want a guaranteed size?

If the size of the int is crucial, such as in small embedded systems, you can use the `stdint` library.

Type

Number of bytes

Range of values

`int8_t`

1

-2^7 to $2^7 - 1$

`int16_t`

2

-2^{15} to $2^{15} - 1$

`int32_t`

4

-2^{31} to $2^{31} - 1$

`uint8_t`

1

0 to $2^8 - 1$

uint16_t

2

0 to $2^{16} - 1$

uint32_t

4

0 to $2^{32} - 1$

Most modern implementations also provide int64_t and uint64_t.

Using decimals: floats

Functions

Good code is often reusable and easily adaptable code.

Arrays

Next Session...

We'll be covering arguably the most important and famous topic in C: pointers.