CSE 220: Systems Programming

Introduction to C

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Why C?

There are dozens of programming languages. Why C?

C is “high level” — but not very.

- C provides functions, structured programming, complex data types, and many other powerful abstractions
- …yet it also exposes many architectural details

Most operating system kernels are written in C.

Many runtimes and virtual machines are written in C.

C influences many other languages.
Effective C programming requires that you master the machine. You must be aware of its architecture and details of operation.

We will be using C in Linux on x86-64.

The dialect of C we will use is C99.\(^1\)

The compiler we will use is gcc.

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\(^1\)K&R describes ANSI C (C89), but we will discuss the differences when important.
CSE 220 and C

That said, **CSE 220 is not (only) about learning C.**

**CSE 220 teaches you systems concepts, and you will implement them in C.**

We **will not cover** all details of C syntax.

We will cover key ideas and **particularly important syntax.**

You should consult:

- The C Programming Language (K&R)
- Unix man pages
- Given code
On Precision

In this course I will attempt to be precise, but must simplify some things.

Usually this is because the details:

- are unnecessarily confusing, or
- require knowledge you are not expected to have.

If something here conflicts with the standard or the compiler, the standard or compiler wins.

I will try to mark imprecise statements with a pilcrow: ¶.
The C language exposes a particular machine model.

Data is stored in memory at accessible addresses.

The CPU manipulates data stored in memory.

Program code is executed as a series of instructions:

- Also stored in memory
- Though possibly not accessible
A Dedicated Computer

Most modern, multi-tasking OSes (including Unix) provide a particular model.

That model is that each process has its own dedicated machine.

Each process appears to have:

- A dedicated CPU
- Private, dedicated memory
- Private input and output facilities

That isn’t strictly true, but it is approximated by the OS.

The OS provides mechanisms to share resources in this model.
Programs as Instructions

C programs\(^2\) are translated into machine instructions. The computer executes these instructions in order.

Instructions are things like:

- Add two numbers together
- Compare a number to zero
- Store a number to a location in memory

As we will see, it’s all numbers.

\(^2\)Indeed, all programs!
Administrivia

On attendance:
- Attendance to every lecture is mandatory
- Attendance to every lab is mandatory

On AI:
- The AI quiz is due next Friday
- Don’t use online resources for your assignments
- Don’t talk details with your classmates

On Lab 01:
- Lab 01 is due next Friday
main()

Every C program starts with the function `main()`.

```c
int main() {
    return 0;
}
```

Every C function:
- takes zero or more arguments
- returns a single value

All arguments are pass-by-value, which means they are copies of whatever is passed to them.

C program statements end with a semicolon (;").
Program Arguments

The `main()` function is given two arguments:

- **Return value**
  ```c
  int main()
  ```

- **Argument list**
  ```c
  int argc,
  char *argv[]
  ```
Program Arguments

The `main()` function is given two arguments:

```c
int main(int argc, char *argv[])
```

First argument

The first is an integer containing the number of arguments passed to the program on the command line.
Program Arguments

The `main()` function is given two arguments:

\[
\text{int } \text{main}(\text{int } \text{argc}, \text{ char } *\text{argv}[]) \quad \text{Second argument}
\]

The first is an `integer` containing the number of arguments passed to the program on the command line.

The second is the program arguments as an `array of strings`. (We will discuss strings and arrays more later.)
Program Arguments

The `main()` function is given two arguments:

```c
int main(int argc, char *argv[])
```

The first is an integer containing the number of arguments passed to the program on the command line.

The second is the program arguments as an array of strings. (We will discuss strings and arrays more later.)

Each argument has a type and a name.
Aside on Slide Syntax

```bash
$ gcc program.c -o program
```

The $ indicates the terminal prompt.

- Please do not type this — you will get an error!
- You should type everything that follows the $

This is a good time to brush up on your Unix basics:

- Quick tutorial:
  https://www.digitalocean.com/community/tutorials/an-introduction-to-linux-basics

- Comprehensive tutorial
  https://ryanstutorials.net/linuxtutorial/
Compiling the Example

Assume that this code is in trivial.c:

```c
int main()
{
    return 0;
}
```

We can compile it into an executable as follows:

```
$ gcc trivial.c
```

This will produce the file a.out, which is a native binary.

You can run the binary as follows:

```
$ ./a.out
$   
```

³K&R uses cc, which will also work.
Developing Hello World

“Hello World” is a classic first program when learning a language.

We will develop a Hello World together.
C is a **high level language** used in **systems programming**.

**Architectural details** are important in C.

The C/POSIX model is:
- A **dedicated machine** for each program
- Sequential execution of program instructions
- Data is stored in accessible, **addressed memory**

We explored some trivial C programs.
Next Time …

- Variables
- Strings
- Looping
Optional Readings

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