

CS100 Lecture 1

The First C Program

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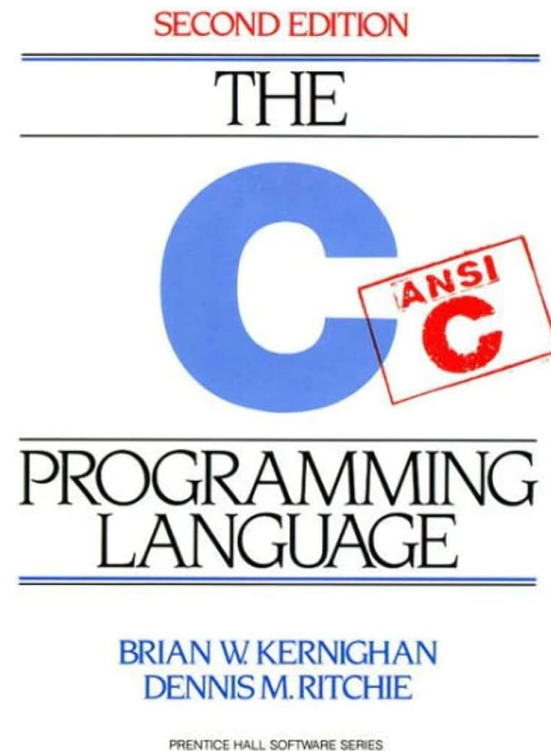
- Brief history of C
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 - Functions (basic) and the `main` function
 - `scanf` and `printf`

Brief history of C

The UNIX operating system and C

- In 1969, a small group of AT&T Bell Labs led by **Ken Thompson** and **Dennis Ritchie** began to develop UNIX.
- In 1973, UNIX kernel was rewritten in C.
- From 1969 to 1973, Dennis Ritchie developed C in Bell Labs.
- In 1978, Kernighan and Ritchie published **the K&R book**: *The C Programming Language*.

Dennis Ritchie and the K&R book



- Dennis M. Ritchie (1941 - 2011)
 - The inventor of C
 - Co-inventor of UNIX
 - ACM Turing Award (1983) with Ken Thompson for UNIX

Standardization of C

- "K&R C": Informal specification (the K&R book)
- ANSI C: Known as "C89"
 - American National Standards Institute
 - Came out in 1989
- ISO C standard: ISO/IEC 9899
 - International Organization for Standardization
 - First version: "C90" in 1990, the same standard as C89 with only formatting changes
 - C99 (1999), C11 (2011), C17 (2017/2018), C23 (2023)

The first C program

Hello World

```
#include <stdio.h>

int main(void) {
    printf("hello world\n");
    return 0;
}
```

- Save the code as `hello.c`.
- `gcc hello.c -o hello.exe` \Rightarrow generates `hello.exe`
- `.\hello.exe` \Rightarrow prints `hello world`, with a newline at the end.

The `main` function

Every C program coded to run in an execution environment contains the definition of a **function** named `main`, which is the designated start of the program.

```
// Other things (functions, structures, ...), if any ...

int main(void) {
    // The program starts here.
    statement_1;
    statement_2;
    // ...
    statement_n;
}
```

* What is a function?

A function in C

A function in mathematics: $f : S \mapsto T$, accepts some **arguments** and **returns** some value.

Example: $f(x) = x^2, x \in \mathbb{Z}$ accepts an integer argument, and **returns** its square.

Write it in C:

```
int f(int x) {  
    return x * x;  
}
```

A function in C

Example: $f(x, y) = x + y, x, y \in \mathbb{R}$

Write it in C:

```
double f(double x, double y) { // Two arguments
    return x + y;
}
```

`double` : double-precision floating-point number \Rightarrow will be covered in later lectures.

A function in C

Syntax: `ReturnType FunctionName(Parameters) { FunctionBody }`

`FunctionBody` can also contain more complex statements:

```
int max(int a, int b) {  
    if (a < b)  
        return b;  
    else  
        return a;  
}
```

`if` statement \Rightarrow will be covered in later lectures.

A function in C

Syntax: `ReturnType FunctionName(Parameters) { FunctionBody }`

A function can have no arguments. To define such a function, write `void` in
Parameters :

```
int always42(void) {  
    return 42;  
}
```

We will introduce more on **functions** in later lectures.

The `main` function

Every C program coded to run in an execution environment contains the definition of a **function** named `main`, which is the designated start of the program.

According to the standard, the `main` function **must** has one of the following signatures:

1. `int main(void) { ... }`
2. `int main(int argc, char *argv[]) { ... }`
3. `/* another implementation-defined signature */`

For now, we only use the first one: `int main(void) { ... }`.

"signature": consisting of the return-type, parameters, and some other possible information

The `main` function

```
int main(void) {  
    printf("hello world\n");  
    return 0;  
}
```

The return value of `main`: Indicates whether the program exits successfully.

A program exits successfully if and only if its `main` function returns `0`.

The `main` function

A program exits successfully if and only if its `main` function returns `0`.

You may also see this somewhere else:



```
PROBLEMS  OUTPUT  DEBUG CONSOLE  TERMINAL  PORTS  GITLENS

For help, type "help".
Type "apropos word" to search for commands related to "word".
Warning: Debuggee TargetArchitecture not detected, assuming x86_64.
=cmd-param-changed,param="pagination",value="off"
Stopped due to shared library event (no libraries added or removed)
Loaded '/lib64/ld-linux-x86-64.so.2'. Symbols loaded.
[Thread debugging using libthread_db enabled]
Using host libthread_db library "/lib/x86_64-linux-gnu/libthread_db.so.1".

Breakpoint 1, main () at /home/gkxx/Courses/CS100/tmp/a.c:4
4      printf("hello world");
Loaded '/lib/x86_64-linux-gnu/libc.so.6'. Symbols loaded.
[Inferior 1 (process 6380) exited normally]
The program '/home/gkxx/Courses/CS100/tmp/a' has exited with code 0 (0x00000000).
```


The `main` function

A program exits successfully if and only if its `main` function returns `0`.

You may also see this somewhere else:

```
Build finished with error(s).
```

```
* The terminal process failed to launch (exit code: -1).  
* Terminal will be reused by tasks, press any key to close it.
```

The `main` function

It is ok to omit `return 0;` in `main` (*but not in other functions*):

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

According to the standard:

If the return type is compatible with `int` and control reaches the terminating `}`, the value returned to the environment is the same as if executing `return 0;`.

printf

Declared in the standard library header file `stdio.h`.

- That's why we need `#include <stdio.h>` in the beginning.

Writes something to the standard output.

```
printf("hello world\n");
```

- Prints `hello world`, with a newline `\n` at the end.
- Try this out: `printf("hello\nworld\n");`

Output vs return

```
int main(void) {  
    printf("hello world\n");  
    return 0;  
}
```

- What is the output of the program?
- What is the return value of `main` ?

Output vs return

```
int main(void) {  
    printf("hello world\n");  
    return 0;  
}
```

- What is the output of the program? \Rightarrow `hello world` with an ending newline.
- What is the return value of `main`? \Rightarrow `0`.

The "A+B" problem

Reads two integers from input (separated by whitespaces), and prints the sum of them.

```
#include <stdio.h>

int main(void) {
    int a, b; // declares two variables of type "int", named "a" and "b".
    scanf("%d%d", &a, &b);
    printf("%d\n", a + b);
    return 0;
}
```

The "A+B" problem

Reads two integers from input (separated by whitespaces), and prints the sum of them.



```
C a.c x
tmp > C a.c > main(void)
1  #include <stdio.h>
2
3  int main(void) {
4      int a, b;
5      scanf("%d%d", &a, &b);
6      printf("%d\n", a + b);
7      return 0;
8  }

PROBLEMS  OUTPUT  DEBUG CONSOLE  TERMINAL  PORTS  GITLENS

● gkxx@nodiscard-gkxx ~/C/C/tmp> gcc a.c -o a
● gkxx@nodiscard-gkxx ~/C/C/tmp> ./a
30 42
72
```

scanf

Also declared in `stdio.h`.

Reads something from **the standard input**.

Example: Reads two integers from the standard input, separated by whitespaces.

```
scanf("%d%d", &a, &b);
```

- `%d` : Indicates that an integer is expected, and will be stored into an `int` variable.
- `&` : The **address-of** operator \Rightarrow will be covered in later lectures.

For now, just remember to add `&` when passing things to `scanf`.

scanf

```
scanf("%d%d", &a, &b);
```

How should these two integers be separated? Try it out:

```
● gkxx@nodiscard-gkxx ~/C/C/tmp> ./a
30 42
72
● gkxx@nodiscard-gkxx ~/C/C/tmp> ./a
30      42
72
● gkxx@nodiscard-gkxx ~/C/C/tmp> ./a
30
42
72
```

scanf

```
scanf("%d%d", &a, &b);
```

`%d` will skip any leading whitespaces.

- "whitespace" refers to the character that looks "blank": space `' '`, newline `'\n'`, tab `'\t'`, etc.

More on the rules related to `scanf` will be covered in recitations.

`printf` printing an integer

Given `a = 30`, `b = 42` as input:

- `printf("%d\n", a + b);`

⇒ prints `72`, with a newline in the end.

- `printf("%d + %d equals %d\n", a, b, a + b);`

What is the output?

`printf` printing an integer

Given `a = 30`, `b = 42` as input:

- `printf("%d\n", a + b);`

⇒ prints `72`, with a newline in the end.

- `printf("%d + %d equals %d\n", a, b, a + b);`

⇒ prints `30 + 42 equals 72`, with a newline in the end.

Summary

Understand the following two programs:

```
#include <stdio.h>

int main(void) {
    printf("hello world\n");
    return 0;
}
```

```
#include <stdio.h>

int main(void) {
    int a, b;
    scanf("%d%d", &a, &b);
    printf("%d + %d equals %d\n",
           a, b, a + b);
    return 0;
}
```

- Why is `#include <stdio.h>` needed?
- What does `int main(void)` mean?
- What is the meaning of `return 0;` ?
Can it be omitted?
- How do we represent a newline?
- What does `%d` mean?
- How are whitespaces handled when reading integers with `scanf` ?

Summary

- Why is `#include <stdio.h>` needed?
 - `scanf` and `printf` are declared in the standard library header file `stdio.h`.
- What does `int main(void)` mean?
 - The `main` function is where the program starts. `int` is the return type and `void` indicates that this function accepts no arguments.
- What is the meaning of `return 0;` ? Can it be omitted?
 - A program returns `0` if it exits successfully. The `main` function of C will execute `return 0` automatically at the end if we don't write it explicitly.

Summary

- How do we represent a newline?
 - `'\n'`.
- What does `%d` mean?
 - Indicates that the type of the data being read or printed is `int`.
- How are whitespaces handled when reading integers with `scanf` ?
 - When reading `int` with `%d` in `scanf`, leading whitespaces are ignored.

Exercises

1. Run the following code. Try to understand what it means.

```
#include <stdio.h>

int max(int a, int b) {
    if (a < b)
        return b;
    else
        return a;
}

int main(void) {
    int a, b;
    scanf("%d%d", &a, &b);
    printf("%d\n", max(a, b));
    return 0;
}
```


Exercises

2. Try to modify the program above. Add some prompts for input and output. For example:

```
● gkxx@nodiscard-gkxx ~/C/C/tmp> ./a
Input two integers: 30 42
The larger one is 42.
```