Lecture 3

C Programming Basics

Fundamentals of Computer and Programming

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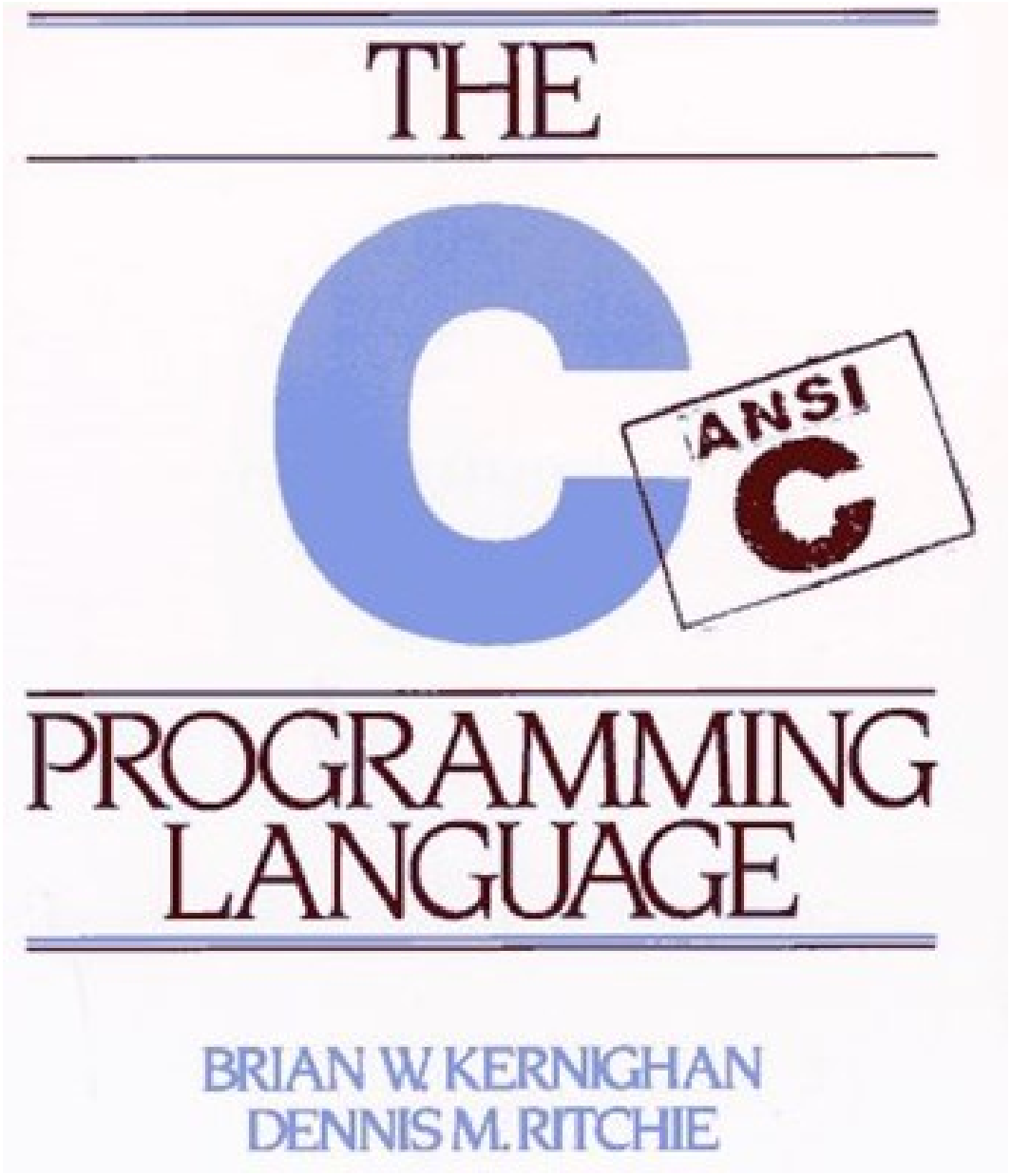
What We Will Learn

- What is the **C**
- Variables
  - Types
- Values
- Casting
- Constants & Definition


THE
C
ANSI
C
PROGRAMMING
LANGUAGE
BRIAN W. KERNIGHAN
DENNIS M. RITCHIE

The C Language

- *C* is a *general-purpose* programming language
- *C* is developed by *Dennis Ritchie* at *Bell Laboratories* (1972) – Now C18
- *C* is one of the widely used languages
  - Application development
  - System programs, most operating systems are developed in C: **Unix**, **Linux**
  - Many other languages are based on it

Programming in C Language

- **C** programming language
  - A set of notations for representing programs
- **C** standard libraries
  - A set of developed programs (functions)
- **C** programming environment
  - A set of tools to aid program development

The First Example

- Write a program that prints

  “Hello the CE juniors :-)”

The First C Program

```c
#include <stdio.h>


int main(void){
  printf("Hello the CE juniors :-) \n");
  return 0;
}
```


General Rules

- C is case sensitive: **`main`** is not **`MaIn`**
- A "**;**" is required after each statement
- Each program should have a **`main`** function

```
int main(void){…
void main(void){…
main(){…
int main(int argc, char ** argv){…
```

  - Program starts running from the main

- You should follow coding style (beautiful code)

General Rules: Spaces

Equal Statements

`int main(void){`	`int main ( void) {`
`printf("abc");` `return 0;`	`printf ( "abc" ); return 0;`
`return 0;`	`return 0;`

General Rules: Spaces

Not Equal Statements

`int main(void){`	`intmain(void) {`
`printf("abc def");`	`printf("abcdef");`

Comments

```
/* Our first

C program */
#include <stdio.h>
int main(void){
  //This program prints a simple message
  printf("Hello the CE juniors :-) \n");
  return 0;
}
```

The First C Program

- You should
  - Develop the source code of program
  - Compile
  - Run
  - Debug
- All of them can be done in IDE
  - Code::Blocks, Dev-C++
  - CLion
  - VS Code, Eclipse,

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Variables

- “write a program to calculate the sum of two numbers given by user”
- Solving problems
  - Input data → Algorithm → Output date
- What we need
  - Implementing the algorithm
    - Named Functions
    - We will discuss later
  - Storing the input/output data
    - Variables

Variables (cont'd)

- Data is stored in the main memory
- Variables
  - Are the name of locations in the main memory
    - We use names instead of physical addresses
  - Specify the coding of the location
    - What do the "01"s means?
    - What is the type of data?

Variables

- Variables in the C

  <Qualifier> <Type> <Identifier>;

- <Qualifier>
  - Is optional
  - We will discuss later
- <Type>
  - Specifies the coding
- <Identifier>
  - Is the name

Types: Integers

- Integer numbers
  - Different types, different sizes, different ranges

Type	Size	Unsigned	Signed
`short`	16Bits	$[0, 2^{16} - 1]$	$[-2^{15}, 2^{15} - 1]$
`int`	32Bits	$[0, 2^{32} - 1]$	$[-2^{31}, 2^{31} - 1]$
`long` or `long int`	32/64 Bits	$[0, 2^{32\|64} - 1]$	$[-2^{31\|63}, 2^{31\|63} - 1]$
`long long` or `long long int`	64 Bits	$[0, 2^{64} - 1]$	$[-2^{63}, 2^{63} - 1]$

Types: Float & Double

- Floating point number
  - float 32 bits
  - double 64 bits
  - long double 96 bits

- Limited precision
  - float: 8 digits precision
    - 1.0 == 1.00000001
  - double: 16 digits precision
    - 1.0 == 1.0000000000000001

Overflow & Underflow

- All types have limited number of bits
  - Limited range of number are supported
  - Limited precision
- Overflow
  - Assign a very big number to a variable that is larger than the limit of the variable
- Underflow
  - Assign a very small number to a variable that is smaller than the limit of the variable

Example

Types: Char

- Character
  - Type: **`char`**
- Single letters of the alphabet, punctuation symbols
- Should be single quotation
  - ‘a’, ‘^’, ‘z’, ‘0’, ‘1’, ‘\n’, ‘\”’, ‘\0’

Types: Booleans

- `#include <stdbool.h>`
- Logics (Boolean): **`bool`**
- Only two values: **`false`** , **`true`**

Variables: Identifier

- The name of variables: identifier
- Identifier is string (single word) of
  - Alphabet
  - Numbers
  - “_”
- But
  - Cannot start with digits
  - Cannot be the key-words (reserved words)
  - Cannot be duplicated
  - Should not be library function names: printf

Variables: Identifier

- Use readable identifiers:
  - Do not use `memorystartaddress`
    - Use `memory_start_address`
  - Do not use `xyz`, `abc`, `z`, `x`, `t`
    - Use `counter`, `sum`, `average`, `result`, `parameter`, …
  - Do not be lazy
    - Use meaningful names

C reserved words (cannot use for identifiers)

_Bool	default	if	sizeof	while
_Complex	do	inline	static	
_Imaginary	double	int	struct	
auto	else	long	switch	
break	enum	register	typedef	
case	extern	restrict	union	
char	float	return	unsigned	
const	for	short	void	
continue	goto	signed	volatile	

C++ reserved words (cannot use for identifiers)

```
asm             bool          catch          class
const_cast      delete        dynamic_cast   explicit
export          false         friend         inline
mutable         namespace     new            operator
private         protected     public         reinterpret_cast
static_cast     template      this           throw
true            try           typeid         typename
using           virtual       wchar_t
```


Variable Identifiers

- Valid identifiers

```
student    grade    sum
 all_students   average_grade_1
```

- Invalid identifiers

```
 if    32_test    wrong*    $sds$
```

Variables: Declaration (اعلان)

- Reserve memory for variable: declaration
  - <type> <identifier>;
- A variable must be declared before use

```
char test_char;
int sample_int;
long my_long;
double sum, average, total;
int id, counter, value;
```

Variable Type Effect (in complied Lang.)

- Important note: the type of variable is *NOT* stored in the main memory
  - After compiling the program → NO type is associated to memory locations!!!
- So, what does do the type?!
  - It determines the "*operations*" that work with the memory location
- *E.g.:*
  - `int x, y, z;` `z = x + y;`
  - `float a, b, c;` `c = a + b;`

Integer + and = Performed by ALU

Float + and = Performed by FPU

Variables: Initial Values

- What is the initial value of a variable?
  - In C: we do not know.
  - In C: it is not 0.

We need to assign a value to each variable before use it.

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Constants in C

- Values
  - Numeric
    - Integer numbers
    - Float numbers
  - Char
  - Strings
- Symbolic constant
- Constant variables

Values

- Variables
  - Save/restore data (value) to/from memory
- Declaration specifies the type and name (identifier) of variable
- Assigning value to the variable: assignment
  - <identifier> = <value>;
  - Compute the <value> and save result in memory location specified by <identifier>

Values: Examples

```
int i, j;
long l;
float f;
double d;

i = 10;
j = 20;
f = 20.0;
l = 218;
d = 19.9;
```

Value Types

- Where are the values stored?!

```
int x = 20;
x = 30 + 40;
```

  - In main memory
    - There is a logical section for these constant values
- So, we need to specify the type of the value
  - The coding of 01s of the value
- The type of value is determined from the value itself

Values (literals): Integers

- Valid integer values

  10, -20, +400; //**Decimal** integer literal
  0x12A, 0X12A; //**Hexadecimal** integer literal
  017; //**Octal** integer literal
  5000L; // **long int** integer literal

- Invalid integer values

10.0, -+20, -40 0, 600,000, 5000 L, 019;

Values (literals): Float & Double

- Valid numbers:

  0.2; .5; -.67; 20.0; 60e10; 7e-2

  12.5f; // float literal

  12.5L; // long double literal

- Invalid numbers:

  0. 2; 20. 0; 20 .0; 7 e; 6e; e12

Values (literals): Chars

- Char values
  - Should be enclosed in single quotation
  - ‘a’, ‘^’, ‘z’, ‘0’, ‘1’, ‘\n’, ‘\”, ‘\0’
- Each character has a code: ASCII code
  - ‘A’: 65; ‘a’: 97; ‘1’: 49; ‘2’: 50; ‘\0’ : 0
- Character vs. Integer
  - ‘1’ != 1 ; ‘2’ != 2
  - ‘1’ == 49 But 1 == 1

Effect of Value Types

- The type of values have the same effect of the type of variables
  - It determines the "*operations*" that work on the values
- E.g.
  - `int z;`
  - `float c;`

```
z = 10 + 20;
c = 1.1 + 2.2;
```

Integer + and = Performed by ALU

Float + and = Performed by FPU

Values: Initialization

```
int i = 20;

int j = 0x20FE, k = 90;

int i, j = 40;

char c1 = 'a', c2 = '0';

bool b1 = true;

float f1 = 50e4;

double d = 50e-8;
```

Values: From memory to memory

```
int i, j = 20;

i = j;              // i = 20

double d = 65536; // d = 65536.0

double b = d;       // b = 65536.0

d = b = i = j = 0;

// j = 0, i = 0, b = 0.0, d = 0.0
```

Basic Input Output

To read something: **`scanf`**

Integer: **`scanf`**("%d", &int_variable);

Float: **`scanf`**("%f", &float_variable);

Double: **`scanf`**("%lf", &double_variable);

To print something: **`printf`**

Integer: **`printf`**("%d", int_variable);

Float: **`printf`**("%f", float_variable);

Message: **`printf`**("message");

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Casting

- What is the casting?
  - When the type of variable and value are not the same
  - Example: Assigning double value to integer variable
- It is not a syntax error in C (only warning)
  - But can cause runtime errors
- It is useful (in special situations)
  - But we should be very very careful

Implicit casting

- Implicit (ضمنی)
  - We don’t say it
  - But we do it

```
char f2 = 50e6; /* cast from double to char */

int i = 98.01;  /* cast from double to int */
```

Explicit casting

- Explicit (صریح)
  - We say it
  - And we do it

```
int i = (int) 98.1; /* cast from double to  int */

char c = (char) 90; /* cast from int to char */
```

Casting effects

- Casting from small types to large types
  - There is not any problem
  - No loss of data

```
int i;
short s;
float f;
double d;
s = 'A';    // s = 65
i = 'B';    // i = 66
f = 4566;   // f = 4566.0
d = 5666;   // d = 5666.0
```

Casting effects (cont'd)

- Casting from large types to small types
  - Data loss is possible
    - Depends on the values

```
float f = 65536;        // 65536.0
double d = 65536;       // 65536.0
short s = 720;          // 720

char c = (char) 65536;      // c = 0
short s = (short) 65536;    // s = 0
int i = 1.22;         // i = 1
int j = 1e23;         // j = ???
```

Casting effects (cont'd)

- Casting to Boolean
  - If value is zero → false
  - If values is not zero → true

```
bool b2 = 'a', b3 = -9, b4 = 4.5;   //true
bool b5 = 0, b6 = false; b7 = '\0'; //false
```

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Constant Variables!!!

- Constants
  - Do not want to change the value
  - Example: pi = 3.14
- We can only *initialize* a constant variable
  - We MUST initialize the constant variables (why?!)
- **`const`** is a qualifier

```
const int STUDENTS = 38;
const long int MAX_GRADE = 20;
int i;
i = MAX_GRADE;
STUDENTS = 39; //ERROR
```

Definitions

- Another tool to define constants
  - Definition is not variable
    - We define definition, don't declare them
  - Pre-processor replaces them by their values before compiling

```
#define STUDENTS  38
int main(void){
   int i;
   i = STUDENTS;
   STUDENTS = 90;  //ERROR! What compiler sees: 38 = 90
```

Definitions

```
#define NAME “Test”

#define AGE (20 / 2)

#define MIN(a, b) (((a)<(b))?(a):(b))

#define MAX(a, b) (((a)>(b))?(a):(b))

#define MYLIB
```

Summary

- Simple programs in C
- Two basics
  - Variables
    - Types
  - Values
    - Types
- Casting
  - The type mismatch
- Constant variables & definitions

Reference

- Reading Assignment: Chapter 2 of “C How to Program”