# Basics of C

## A Simple Program.

simple.c:

```
/* CPE 101                                                          */
/* Alex Dekhtyar                                                    */
/* A simple program                                                 */
/* This is a comment!
                                                    It ends here -> */

#include <stdio.h>                          /*       preprocessor directive */

#define KMPERMILE 1.6                       /* preprocessor directive       */

int main() {                                /*  main()  function: beginning */

   int miles;                               /* integer variable declaration */
   float km;                                /* float  variable declaration  */

   printf("\n\nMiles2Kilometers'R'US!\n");       /* output                   */
   printf("\n");
   printf("How many miles? ");

   scanf("%d", &miles);                     /* input                        */

   km  = miles * KMPERMILE;                 /* assignment statement         */

   printf("%d miles is %f kilometers\n", miles, km);    /* formatted output */

   return 0;                                /* return statement             */

   }                                        /* end of main() function       */
```

# Anatomy

**C Program.** A C program consists of a sequence of comments, preprocessor directives, declarations and definitions.

simple.c program contains comments, preprocessor directives and a function definition (but no declarations. More on declarations - later in the course).

**Comments.** Comments are ignored by the C compiler.

Comments must be enclosed in `/*` and `*/`.

A single comment can span multiple lines.

```
/* This is a comment in C */
/* This is
                        a comment too */
```

**Preprocessor directives.** C comes with a preprocessor, a program that runs prior to submitting the C program to the compiler. C preprocessor plays a number of functions, but the most important ones are:

- Inclusion of multiple (library) files into the C program being compiled.
- Declaration of constants.

Preprocessor directives are instructions in the C source file that are read (parsed) and executed by the C preprocessor. We concentrate on two preprocessor directives now, will learn more about others later in the course:

- Inclusion of external C library files is achieved using the `#include` directive.

  Example. The `#include` preprocessor directive from `simple.c` brings in the external library of input-output functions. Both printf and scanf (see below) are functions from the `stdio.h` library.

- Constants are declared using `#define` preprocessor directive.

```
#include <stdio.h>
#define KMPERMILES 1.6
```

**main() function definition.** In order to *compile into an executable file*, a C program **must** contain the definition of the main() function. In any C program, the first statement to be executed is the first statement of its main() function. (i.e, execution starts at the beginning of the main() function).

In ANSI C (and we are studying the ANSI C standard) the definition of main() is as follows:

```
int main() {
 <declarations>

 <statements>

 return 0;
}
```

Here, `<declarations>` is a sequence of variable declarations and `<statements>` is the sequence of steps (instructions) to be executed.

**Variables.** Variable is a named collection (sequence) of memory cells, which, at *different times* can contain different content (values). Variables have three key properties:

- Name. Variable name allows us to refer to the variable in the program (rather than referring to a specific memory address or addresses).

  It provides a *level of abstraction* between the code in a high-level langauge (like C) and the code in machine language.

- Type. The type of a variable is information about the class of values that can be stored in the variable. Type of a variable affects two things:

  1. the number of memory cells reserved for the variable, and
  2. the interpretation of the content of the variable.

- Content. The actual value(s) stored in the memory.

**Variable Types.** C has a wide range of types: from very simple to very complex. A table of some simple variable types is shown below.

| C type | Explanation | Range | number of bytes |
|---|---|---|---|
| `int` | Integer numbers | -32767 ... 32767 | 2 |
| `float` | Floating point decimals | $-3.4^{38} \ldots 3.4^{38}$ | 6 (?) |
| double | Double precision floating point decimals | $-1.7^{308} \ldots 1.7^{308}$ | 10 (?) |
| char | a single character | -128 ... 127 | 1 |
| void | no type | none | 0 |

**Variable declarations.** A variable declaration has the syntax:

```
<type> <VariableName1>, <VariableName2>,...<VariableNameN>;
```

Here, `<type>` is one of C types (or one of user-created types — more about it at the end of the course), and `<VariableName1>, ...,<VariableNameN>` are the names of the variable. A variable declaration can include one or more variable names. It must end with a semicolon (";").

**Variable Names, Reserved Words and Identifiers.** Variable names, dubbed user-defined identifiers are formed as follows:

- An identifier must consist of only letters (`'a'...'z', 'A',...'Z'`), digits ('0',..., '9') and underscores ('_').
- An identifier **cannot** begin with a digit.
- An identifier cannot be a **C reserved word**, nor can it be a **C standard identifier**.

**Reserved Words.** Some words (identifiers) are used in C language and have special meaning. They cannot be used as variable names, and their occurrence in C programs is interpreted according to special rules of C syntax.

Some of the reserved words in C are:

| type | reserved words |
|---|---|
| Type names | `int`, `float`, `double`, `bool`, `char`, `void` |
| C control structures | `if`, `while`, `for`, `return`, `case`, `switch`, `break`, `continue`, `goto`, `do` |
| misc. | `sizeof`, `typedef`, `union`, `struct` |

**Standard Identifiers.** Standard identifiers are the names of C functions from the standard C library. The complete list of these identifiers is found in **Appendix B** of your textbook.

Some standard identifiers you have already seen are `printf` and `scanf`.

**I/O functions.** C does not have statements for input and output. But it does have two standard library functions which are used for input and output.

**printf().** `printf()` is the output function.

`printf("string");` outputs the string. Strings must be enclosed in double quotes.

`printf("formatted string", <variable1>,...,<variableN>);` — formatted output. Format placeholders ("%d" for integer, "%f" for floating point, "%c" for character) are inserted into the the `"formatted string"`. When output is generated, they are replaced with the values of variables in the variable list, in the order of appearance.

Example.

```
printf{"%d miles is %f kilometers\n", miles, km);
```

Let's assume that `miles` has value 1 and `km` has value 1.6. What the line above will produce as output is:

```
1 miles is 1.600000 kilometers
```

**scanf().** `scanf()` is the input function.

`scanf("format", &<variable1>,..., & <variableN>)` reads from the standard input stream the values of variables whose names are `<variable1>`,... `<variableN>`.

The format string consists of the format placeholders: "%d", "%lf" (for floating point numbers), "%c".

Example

```
scanf("%d", &miles);
```

reads an integer value from the standard input (keyboard, by default) into the variable `miles`.

**Note** the use of the ampersand (&) in front of the variable name. While the *real* meaning of this symbol will be discussed at the end of the course, for now, it suffices to say that the *presence of the & in front of the variable name, gives the* `scanf` *function the* ***permission/ability*** *to* ***change the value of the variable****.*

**Note:** Both `printf` and `scanf` functions are part of the standard C library of functions. Standard C library consists of a number of header files, each containing the code for a set of "like-minded" functions.

All standard input/output functions reside in the `stdio.h` header file. This is why, **any C program that contains input or output** must contain the

```
#include <stdio.h>
```

preprocessor directive.

## Constants

Constants are values used throughout the program. In C, each constant must come with a type, and each type has its own syntax for constant values.

Via the preprocessor `#define` directive, we can *name* some of the constants and use their names, rather than values in computations.

**Integer constants.** Integer constants can be either signed or unsigned. Examples of signed integer constants are:

```
-1  +123  -643054 +23456
```

Examples of unsigned integer constants are:

```
0 1 999  34235  785
```

**Note:** Integer constants in C **may not** contain commas separating the orders. That is, `12,390` is **NOT** a correct integer constant.

**Floating point constants.** Floating point constants come in two different forms: the decimal point notation and the exponent notation and can be signed or unsigned. The decimal point constants have the form `IntegerPart.DecimalPart`. Examples of such constants are:

```
1.0  0.001  -12.12  3.1415926  +100000.00001  .434
```

The constants in the exponent notation have the form

```
<Integer>.<Decimal>e<Exponent>
```

or

```
<Integer>.<Decimal>e-<Exponent>
```

The value of such a constant is Integer.Decimal$\times 10^{\text{Exponent}}$ (or Integer.Decimal$\times 10^{-\text{Exponent}}$). The following are valid floating point constants:

```
2e-2  1.2e3  4.5e-5 6e+2
```

Their values are respectively:

$$2 \times 10^{-2} = 0.02; 1.2 \times 10^{3} = 1200; 4.5 \times 10^{-5} = 0.000045; 6 \times 10^{2} = 600.$$

The following are **invalid** floating point constants

```
20       /* no decimal point - it's an integer constant */
45e0.45  /* the exponent must be an integer              */
3.342e   /* no exponent                                  */
344,453e200 /* comma is not allowed                      */
```

**Character constants.** Character constants are individual (ASCII) characters in single quotes ('). Examples of character constants are

```
'a'  'b' 'C' 'D' 'T' '3' '&' '"' ' ' '_' '~'
```

The following are **NOT** valid character constants:

```
"a"        /* this is a one-character string, but not a character */
'ab'       /* only one character allowed inside single quotes     */
```

**String constants.** A string constant is any text inside double quotation marks (”). Examples are:

```
"a"  "Hello, world!" "Train station" "LOL" "1234"  "20,234" "/.?>$342?5^%%" "\n" "\t"
```

String constants can include special characters (escape sequences).

| Symbol | meaning |
|---|---|
| `\n` | new line |
| `\r` | carriage return |
| `\t` | tab |
| `\b` | backspace |
| `\\` | \ (backslash) |
| `%%` | % (percent) |
| `\'` | ’ (single quote) |
| `\"` | ” (double quote) |