

COMP2113 Programming Technologies / ENGG1340 Computer Programming II  
**Module 10. C programming (Part 1) – printf() and scanf()**

## Objectives

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At the end of this self-learning lab, you should be able to:

- Point out some basic differences between C and C++.
- Write simple C programs that can get user input and display output on screen with proper format.

Note that **C**: We will be using the C11 standard, so make sure that your compiler option is set appropriately. We suggest to use the following command to compile your C program:

```
gcc -pedantic-errors -std=c11 your_program.c
```

## Section 1. Background

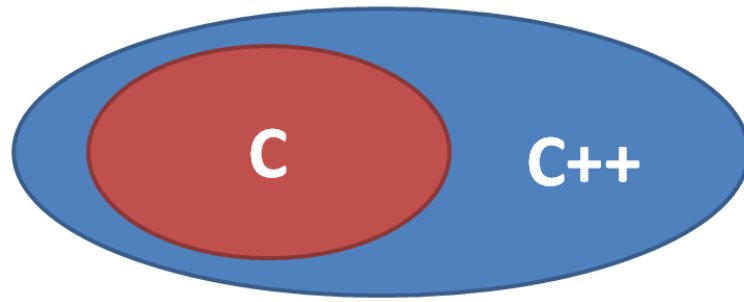
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- The C programming language is a predecessor of C++. We learn this older language mainly for two reasons.
  - C is a more low-level language and less functionality is provided. E.g., there is no classes or STL. In return, **the programs are usually faster than their C++ counterpart.**
  - A lot of existing systems like Linux and Unix use C extensively. For the operating systems and networking area, many libraries are available in C only.
- This chapter gives a brief introduction to C. You will get familiar with it once you study the courses **operating systems** and **networking**.

### Some history

- The C programming language was designed by Dennis Ritchie at Bell Laboratories in the early 1970s.
- The C language was standardized in 1989 by ANSI (American National Standards Institute) known as **ANSI C**.
- C programming language became International standard (ISO) in 1990 which was adopted by ANSI and is known as C89.
- As part of the normal evolution process the standard was updated in 1995 (C95) and 1999 (C99).





- C++ extends C to include support for Object Oriented Programming and other features that facilitate large software development projects.
  - In other word, a valid C program is also a valid C++ program.
  - **However, the reverse is not true**, because some functionality used in C++ is not available in C.

## Section 2. Hello World

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It is very easy for a C++ programmer to write C program, what you need is to know the syntax of C. Let's start from a **Hello World** program!



- Let's browse to ~/module10/

```
$ cd module10
```

- Consider the file hello.c

```
$ vi hello.c
```

```
//Filename: hello.c
1 #include <stdio.h>
  int main(){
2  printf( "Hello world!\n" );
  return 0;
  }
```

### Code explanations:

- First of all, we usually name the source code of a C program with extension “.c”.
- **Commenting** is the same as C++ (i.e., you can use // and /\* \*/ ) for marking comments in a C program.

- 1 The preprocessing directive `#include <stdio.h>` stands for standard I/O. `<iostream>` is not present in C.
  - **NO namespace in C:** We do not need to use the namespace `std`, since there is no namespace in C.
- 2 **printf() instead of cout** - In C we use the `printf()` function to print a string. Objects like `cout`, `cin` and `endl`, which are part of the `<iostream>` library, are not available in C.
  - As there is no `endl`, we use the escape character “`\n`” to signify the newline in the output string.



## How to compile a C program source file?

- To compile the program, use the `gcc` command. It will compile the source file `hello.c` and generate the executable named `hello`. Let's skip “`-pedantic-errors -std=c11`” here for simplicity.

```
gcc hello.c -o hello
```



- As a remark, any C program is also a C++ program, so you can also compile a C program using the `g++` compiler. Again let's skip “`-pedantic-errors -std=c11`” here for simplicity.

```
g++ hello.c -o hello
```



- Let's try to compile the program using `gcc`.

```
$ gcc -pedantic-errors -std=c11 hello.c -o hello
```

- Run the code, simply the same as running a C++ executable.

```
$ ./hello
```

```
Hello World!
```

- For illustration purpose, let's try to compile the program using g++.

```
$ g++ -pedantic-errors -std=c11 hello.c -o hello
```

- Run the code, it should work as expected 😊. Easy 😊

```
$ ./hello
Hello World!
```

### Section 3. printf() for output



How do I **display output** in a C program?

- As we have seen, printing a string can be done by `printf()` and passing a string literal as the input parameter. The definition of the `printf()` function is included in the `<stdio.h>` header file.

```
printf( "Hello world!\n" );
```

- To print the value of a **variable**, we include the corresponding **conversion specifiers** inside the string literal and supply the variables inside the `printf()` function.
- As an example, the following function prints the value of the `int` variable `a` on screen.

```
int a = 10;
printf( "The value of a is %d.\n", a );
```

- The `%d` is called the conversion specifier for integer values.
- The value of the variable `a` (an `int` variable) will be inserted in the conversion specifier `%d` in the string literal. Therefore the output is "The value of a is 10."
- The following table shows some popular conversion specifiers.

Variable type	Conversion specifier
<code>int</code>	<code>%d</code>
<code>float</code>	<code>%f</code>
<code>double</code>	<code>%f</code>
<code>char</code>	<code>%c</code>

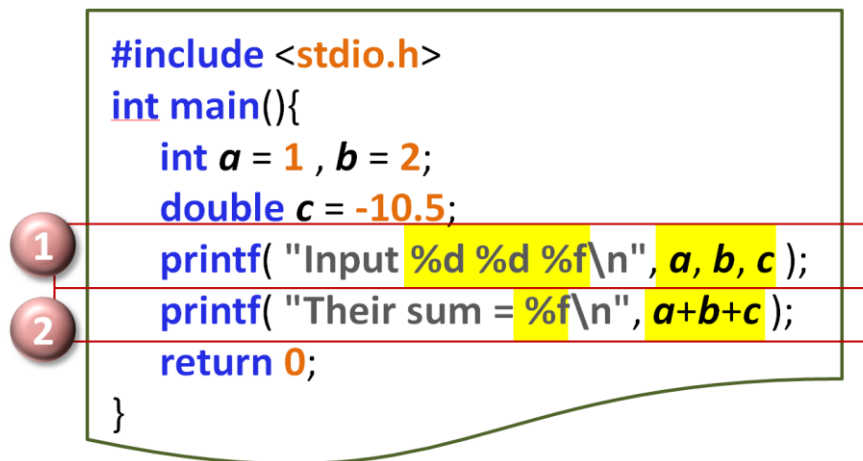
String	%s
Removing trailing zeros for <code>float</code> and <code>double</code>	%g

- Please note that the table is not a complete list of all conversion specifiers, please refer to the following URL if you want to output variables of various types.

<http://www.cplusplus.com/reference/cstdio/scanf/>

- Let's consider `output1.c` as an illustration of the use of `printf()`.

```
$ vi output1.c
```



```
#include <stdio.h>
int main(){
    int a = 1, b = 2;
    double c = -10.5;
    printf( "Input %d %d %f\n", a, b, c );
    printf( "Their sum = %f\n", a+b+c );
    return 0;
}
```

### Code explanations:

- Reminded that the preprocessing directive that include input and output handling in C is `#include <stdio.h>` (NOT `<iostream>`). And there is no namespace in C.

#### 1 Multiple conversion specifiers printed in order

- In this example we will print "Input 1 2 -10.500000". It is because we have three conversion specifiers in order : `%d %d %f`, and in the value part we have `a, b, c`:
  - The value of `int` variable `a` will be printed in the position of the first specifier `%d`.
  - The value of `int` variable `b` will be printed in the position of the second specifier `%d`.
  - The value of `double` variable `c` will be printed in the position of the third specifier `%f`.

- From this example we learn that we can include more than one specifiers inside the string literal, and the specifiers may appear in the middle of the string literal.

#### 2 We can provide an expression in the value part, but the conversion specifier has to match the result of the expression.

- In this case the expression is `a+b+c`, which is `int + int + double`, the result will be a double value, therefore we use the `%f` conversion specifier to print it in the output string.
- Let's try to compile the program and run it.

```
$ gcc -pedantic-errors -std=c11 output1.c -o output1
$ ./output1
1 2 -10.500000
```

```
Their sum = -7.500000
```

- Note that %f prints 6 digits after the decimal place; we will see how we can remove those trailing zeros later.
- What happen if we use the wrong conversion specifier? Let's try to see it if we change the 3<sup>rd</sup> conversion specifier to %d (an integer specifier), which is used to display a double value (Note: c is a double type variable).

```
printf( "Input %d %d %d\n", a, b, c );
```

- Let's try to compile the program and run it again. What will be display?

```
$ gcc -pedantic-errors -std=c11 output1.c -o output1
$ ./output1
1 2 0
Their sum = -7.500000
```

- As you notice, C is pretty primitive in outputing values on screen, and it is important to use the conversion specifier that matches the data type in C to display the right value.



How to print the sum as  
**-7.5** but not **-7.500000** ?

Note that if we want to **remove the trailing zeros** in the output of the **double / float** values, we can use the **%g** conversion specifier to do so 😊



- Let's try to update the conversion specifier for the sum of a, b, c from %f to %g to see the effect.

```
printf( "Input %d %d %g\n", a, b, c );
printf( "Their sum = %g\n", a+b+c );
```

- Compile the program and run it. What will be displayed?

```
$ gcc output1.c -o output1
$ ./output1
1 2 -10.5
Their sum = -7.5
```

- Note that the conversion specifier does not change the value of the variable. It just indicates how the data stored in the variable should be displayed.

## Section 4. No string class in C

- Note that C does not have a string class ☹. A string in C is simply an array of `char`.
- Consider the file `output2.c` that shows the printing of the content of a `char` array.

```
$ vi output2.c
```

```
#include <stdio.h>
int main(){
1   char name[] = "Alan";
   int age = 20;
   float weight = 60.5;
2   printf( "%s is %d years old and weights %g kg\n",
           name, age, weight );
}
```

### Code explanations:

- There is no string class in C, we can only use an array of `char` to represent string values.
  - In this example we define `name` as an array of `char`.
  - Same as C++, when we initialize the array variable in its declaration, we can choose not to specify the length of the array. After the line `char name[] = "Alan";` we have the following content for the `name` array.

<code>char name[i]</code>	A	l	a	n	\0
<i>i</i>	0	1	2	3	4

- Note that “\0” is the **null character** that signify the end of the string.
  - We will have more discussions on C-string in the next part.
- The `%s` conversion specifier means to print a string value of a `char` array, therefore we can supply a `char` array `name` to match `%s`.
    - The `printf()` function prints the array content of the `name` variable, and **when it reaches “\0” it understands that is the end of the string and stops outputting.**
  - Let's try to compile the program and run it.

```
$ gcc -pedantic-errors -std=c11 output2.c -o output2
$ ./output2
Alan is 20 years old and weights 60.5 kg
```



- The `printf()` function supports a number of advanced features.
  - For example, you can specify the width in which the data is printed by inserting an integer in the middle of the specifier.
  - If the width is larger than the actual length of the variable, the variable will be printed in a **right-justified manner**.
- Consider the file `output3.c` as an illustration.

```
$ vi output3.c
```

```
#include <stdio.h>
int main(){
  1 char p1[] = "Alan", p2[] = "Ben";
    int a1 = 9, a2 = 30;
    float w1 = 30, w2 = 40.25;
  2 printf( "123456789012345678901234567890\n");
    printf( "%8s %8s %8s\n", "Name", "Age", "Weight");
  3 printf( "??? ??? ???\n", p1, a1, w1);
    printf( "??? ??? ???\n", p2, a2, w2);
}
```

### Code explanations:

- 1 We define two `char` arrays `p1` and `p2`, and initialize the two arrays's values as "Alan" and "Ben", respectively.
- 2 We print the header row, since the name of the three columns are three string values (i.e., "Name", "Age" and "Weight"), we use "`%s %s %s`" as the conversion specifier.
  - We use "`%8s %8s %8s`" to format the width of the column, i.e., each column will be of width of 8 characters. Therefore the first column will have the Name printed right-justified in the column of width 8 characters.

**Question:** What should be the conversion specifiers in 3 so that the data of Alan and Ben will be printed in columns with 8 characters width and in right-justified manner?

- Compile and run `output3.c`

```
$ gcc output3.c -o output3
```

```
$ ./output3
```

```
123456789012345678901234567890
```

```
    Name        Age    Weight
```

```
  Alan          9       30
```

```
  Ben          30      40.25
```

- **Answer:** “%8s %8d %8f”. Please try.
- Note that the values printed are right justified in the column of 8-characters wide (the extra character in between each column is due to the space between two specifiers.).



## How do I read user input in a C program?

- C provides the `scanf()` function to read an input.
- We need to use the conversion specifiers to indicate the type of variable we are reading.
- **Then we provide the addresses of the variables that will store the value.**
- Consider the file `input1.c` as an illustration.

```
$ vi input1.c
```

### Code explanations:

- 1 The `scanf()` function is used to get user input (just like `cin` in C++). However the use of the `scanf()` function is a bit more complicated than `cin`.
- The conversion specifiers in `scanf()` are “%d%f”, which means that we will first read in an integer value, and then read in a float value.

The two values will be stored in variables `a` and `b` respectively.

- With this sequence of specifiers, the first input variable must be an `int` type variable, and the second variable must be a `float` type variable. The order has to be matched.
- Note that there is no space between the conversion specifiers inside `scanf()`.
- Reminded that we need to pass in the **addresses of the variables** `a` and `b` to `scanf()`, that is **&a** and **&b**, respectively. By passing the address it act likes **pass by reference** so that the value read from user input is updated to the variables `a` and `b` that we pass in.

**Important!** This is the C-style pass by reference technique, which we have to pass in the address of the memory cell that contain the value of the variable using the `&` operator when we call the `scanf()` function.

- 2 We use `%g` conversion specifier to output the result of `a*b` to remove the trailing zeros.
- Compile and run `input1.c`

```
$ gcc -pedantic-errors -std=c11 input1.c -o input1
$ ./input1
```

```
#include <stdio.h>
int main(){
    int a;
    float b;
    printf( "Enter an int and a float: " );
    scanf( "%d%f", &a, &b );
    printf( "Their product = %g\n", a*b );
}
```

```
Enter an int and a float: 11 12.5
Their product = 137.5
```



How about reading string value into a **char** array variable in a C program?

- There are many alternatives to read in string into a `char` array in C.
- In the following simplest approach, we define a `char` array variable that is large enough to store the string value, and use `scanf()` to read in user input into the `char` array.
- Consider the file `input2.c` as an illustration.

```
$ vi input2.c
```

```
#include <stdio.h>
int main(){
1  char name[100];
   printf( "What is your name? " );
2  scanf( "%s", name);
   printf( "Hello %s!", name );
}
```

#### Code explanations:

- 1 We define `name` as an array of `char`, the array contains 100 slots (Like C++, we must provide the size of the array if we do not initialize the array's content in the declaration).
- 2 We use the `%s` conversion specifier to indicate we are reading a string value into the `char` array, `scanf()` will append a **null character** `"\0"` at the end of the string.

- **Important technical note:** Note that the second parameter to `scanf()` is `name` but not `&name` because `name` is an array. `name` is actually a pointer that stores the **address of the first slot of the `char` array**. Therefore we do not need to use the address-of operator `"&"` when printing an array with `scanf()`.

Yes it is pretty confusing but this is the syntax requirement of C programming language :P

- Compile and run `input2.c`

```
$ gcc -pedantic-errors -std=c11 input2.c -o input2
$ ./input2
What is your name? Chim
Hello Chim!
```

### Checkpoint 10.1 (Please submit your answer to Moodle.)

This question was the **assignment one** in a level 1 C++ programming course



Write a C program that determines some of the results of an election using the largest remainder method.

The **largest remainder method** was used in Hong Kong Legislative Council Election several years ago.

1. Candidates contest the election in the form of **lists**, and voters are required to select one candidate among all the participating lists.
2. The number of **votes** for each list is divided by a **quota** representing the number of votes required for a seat. The result of the division consists of an integer part and a fractional remainder.
3. Each list is first allocated a number of **seats** (called automatic seats) equal to the integer. When there are any seats unallocated, the lists with largest remainder will be allocated one additional seat.

Here's an example:

Suppose that there are 6 **seats** and 900,000 **votes** in total. To get one seat, a **quota** of 150,000 votes ( $= 900000/6$ ) is needed. If there are 8 **lists** with the following distribution of votes, the results of the election are shown in the last two rows.

List	1	2	3	4	5	6	7	8
Votes	80,000	120,000	400,000	60,000	6,000	180,000	34,000	20,000
Automatic Seats	0	0	2	0	0	1	0	0
Remainder	80,000	120,000	100,000	60,000	6,000	30,000	34,000	20,000

You are only required to determine two things:

1. Number of seats automatically obtained by each list.
2. The remainder after deducting the votes required for the automatic seats.

**Please note that you do not need to determine the additional seats obtained by the lists.**

The following is a sample run. (**Bolded text** is the user input; *italic text* is the output of your program.)

The diagram illustrates the flow of data in a sample program run. It features three main annotation boxes with arrows pointing to specific lines of text:

- Input by user.** This box has four arrows pointing to the bolded user inputs: **6**, **900000**, **8**, and **80000**.
- Result output by your program.** This box has two arrows pointing to the program's output for the first list: *Automatic seat for list 1: 0* and *Remainder for list 1: 80000*.
- The last output ends with "\n"** This box has one arrow pointing to the final line of output: *Remainder for list 8: 20000*.

The sample run text is as follows:

```
Total number of seats: 6
Total number of votes: 900000
Total number of lists: 8
Votes for list 1: 80000
Automatic seat for list 1: 0
Remainder for list 1: 80000
Votes for list 2: 120000
Automatic seat for list 2: 0
Remainder for list 2: 120000
Votes for list 3: 400000
Automatic seat for list 3: 2
Remainder for list 3: 100000
Votes for list 4: 60000
Automatic seat for list 4: 0
Remainder for list 4: 60000
Votes for list 5: 6000
Automatic seat for list 5: 0
Remainder for list 5: 6000
Votes for list 6: 180000
Automatic seat for list 6: 1
Remainder for list 6: 30000
Votes for list 7: 34000
Automatic seat for list 7: 0
Remainder for list 7: 34000
Votes for list 8: 20000
Automatic seat for list 8: 0
Remainder for list 8: 20000
```

- Of course you are not required to solve this problem again from scratch ☺ Please look at the C++ solution to this problem.

```
$ vi assign1.cpp
$ g++ -pedantic-errors -std=c11 assign1.cpp -o assign1_cpp
$ ./assign1_cpp
(You can test the code, it is error free)
```

- Your task is to create a C implementation of the `assign1.cpp`.

```
$ cp assign1.cpp assign1.c
$ vi assign1.c
```

- Compile and run `assign1.c`

```
$ gcc -pedantic-errors -std=c11 assign1.c -o assign1
$ ./assign1
(Test the code against the test case in the previous page)
```

Please submit the **assign1.c** source file to Moodle.



## References

- *Application programming in ANSI c (3<sup>rd</sup> edition)*, by Richard Johnsonbaugh & Martin Kalin. Prentice Hall.
- *Data Structures and Algorithm Analysis in C(2<sup>nd</sup> edition)*, by Mark Allen Weiss. Addison Wesley.
- Similer to C++, `scanf()` will stop reading once a space or newline is encountered.
- To read in a line of string incluing space into a variable, we need to use the `getline()` or `fgets()` function. Please refer to the following references if you want to learn more about those functions.
- Tutorial on `getline()`  
<http://crasseux.com/books/ctutorial/getline.html>
- Cprogramming.com  
<http://www.cprogramming.com/tutorial.html>  
<http://www.cprogramming.com/tutorial/c/lesson9.html>