Formatted I/O: printf and scanf

CSC 100 Introduction to programming in C/C++, Summer 2022

Table of Contents

- 1. README
- 2. printf
- 3. Conversion specification
- 4. Integer decimal "d"
- 5. Floating point exponential "e"
- 6. Floating point fixed decimal "f"
- 7. Variable floating point "g"
- 8. scanf
- 9. Main traps
- 10. How scanf works
- 11. Ordinary characters in format strings
- 12. Confusing printf with scanf
- 13. Get coding: sample program

1. README

- There is much more to `scanf` and `printf` than we've seen
- I/O is where the pedal hits the metal - where man meets machine
- In this notebook: conversion specifications for printf and scanf

2. printf

When it is called, `printf` must be supplied with:

1. a format string, like `"The output is: %d\n`
2. any number of values to be inserted into the string at printing

3. Conversion specification

- A **conversion specification** is a placeholder like `d`
- Binary (machine) format is converted to printed (human) format

- General form: `%m.pX` where

WHAT		EXAMPLE
m	minimum field width	`%4d` prints `123` as `_123`
p	precision after point	`%.3f` prints `3.141593` as `3.142`
X	conversion specifier	`d`, `e`, `f`, `g`

- Examples:

```
printf("....|....|....|\n");
printf("%8d\n", 123); // print 123 on 8 places (right-aligned)
printf("%-8d\n", 123); // print 123 on 8 places (left-aligned)
printf("%10.3f\n", 3.141593); // print 3 decimals on 10 places (right)
printf("%-10.3f\n", 3.141593); // print 3 decimals on 10 places (left)
```

```
....|....|....|
     123
123
     3.142
3.142
```

4. Integer decimal "d"

- `d` displays an integer in decimal (= base 10) form. p is the minimum number of digits to display the integer. Default p=1.
- For example, the code below 1 prints numbers with different precision values:
  - `%d` displays `int` in decimal form (minimum amount of space)
  - `%5d` displays `int` in decimal form using 5 characters
  - `%-5d` displays `int` on 5 characters, left-justified
  - `%5.3d` displays `int` on 5 characters, at least 3 digits

```
int i = 40;
printf("....|....|\n");
printf("%d\n",i); // decimal form (minimum amount of space)
printf("%5d\n",i); // decimal form using 5 characters
printf("%-5d\n",i); // on 5 characters, left-justified
printf("%5.4d\n",i); // on 5 characters, at least 3 digits
```

```
....|....|
40
   40
40
 0040
```

5. Floating point exponential "e"

- `e` displays a floating-point number in exponential ("scientific") notation.
- `p` = digits after decimal point. If `p=0`, no decimal point is displayed.

What went wrong in the first two statements?

```
printf("....|....|....|\n");
printf("%e\n", 1);
printf("%100.3e\n", 1000.);
printf("%-.1e\n", 1.);
printf("%e\n", 1000000000000000.);
printf("%15.f\n", 1000000000000000.);
```

```
....|....|....|
4.940656e-324

1.0e+00
1.000000e+15
1000000000000000
```

6. Floating point fixed decimal "f"

That's `f` as we already know it from many other examples. The precision `p` is defined as for `e`. Trailing zeroes are shown.

```
printf("....|....|\n");
printf("%10.3f\n", 100.1);
```

```
....|....|
   100.100
```

7. Variable floating point "g"

- `g` displays a floating point number in either exponential format or fixed decimal format depending on the number's size.
- `p` is the maximum number of **significant** digits (**not** digits after the decimal point!) to be displayed.
- No trailing zeroes are shown. If there are no decimal digits after the decimal point, no decimal point is shown.

```
printf("%g\n%g\n%g\n", 299792458., 1.45e+03, 8000);
```

299792000.0
1450
3.9525e-320

8. scanf

- A `scanf` format string may contain ordinary characters and conversion specifications like `d`, `e`, `f`, `g`
- The conversions allowed with `scanf` are essentially the same as those used with `printf`
- The `scanf` format string tends to contain only conversion specs
- `[ ]`

  What will this sample input assign to the variables in 1 below?

  ```
  1  -20  .3   -4.0e3
  ```

  ```
  int i, j;
  float x, y;
  ```

```
scanf("%d%d%f%f", &i, &j, &x, &y);

printf("|%5d|%5d|%5.1f|%5.1f|\n", i, j, x, y);
```

9. Main traps

- The compiler will not check that specs and input match
- The & symbol may not miss in front of the input variable

10. How scanf works

- `scanf` tries to math input groups with specs
- For each spec, it tries to locate an item in input
- It reads the item, and stops when it can't match
- If an item is not read successfully, `scanf` aborts

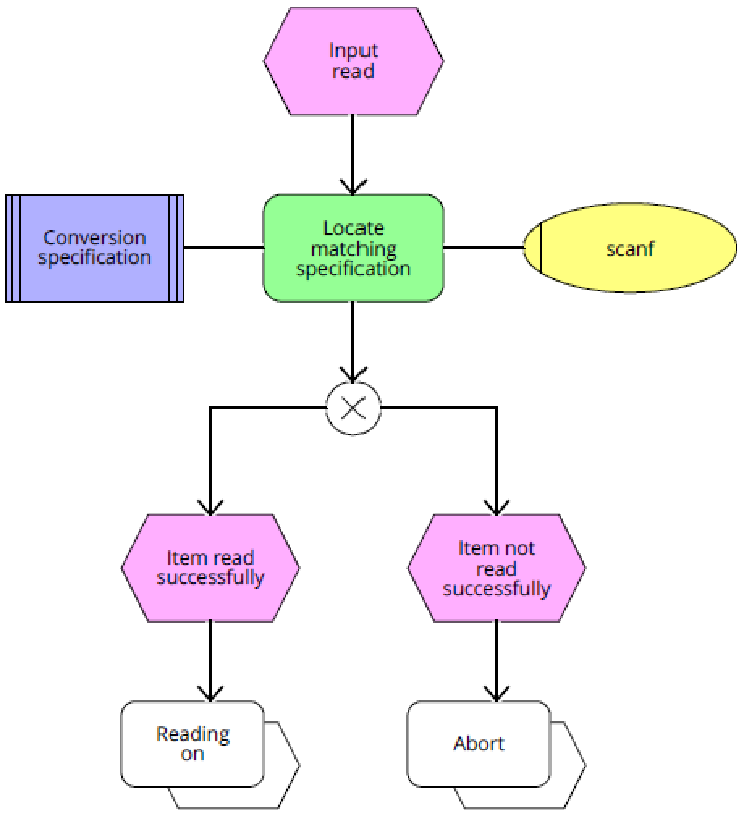
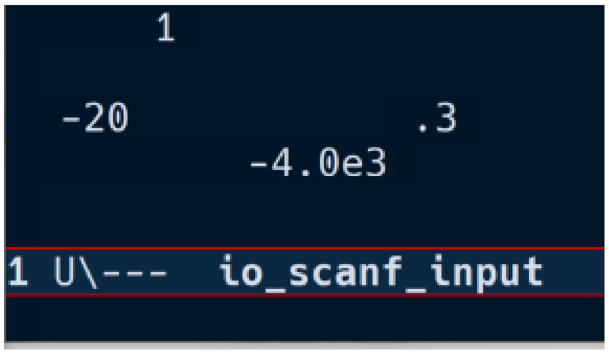


Figure 1: How scanf works

- White-space characters are ignored: SPC, TAB, new-line
- In 1 above, the lines can be on one line or spread over several lines:



```
     1

  -20        .3
         -4.0e3

1 U\---   io_scanf_input
```

Figure 2: Input file for tscanf

- `scanf` sees a character stream (`¤` = new-line, s=skip'd, r= read):

  ```
  ••1¤-20•••.3¤••••-4.0e3¤
  ssrsrrrsssrrssssrrrrrr
  ```

- When asked to read an integer (`%d` or `%i`), `scanf` searches for a digit, +/- sign, then reads until a non-digit
- When asked to read a float (`%f`, `%g`, `%e`), `scanf` looks for +/- sign, digits, decimal point, exponent (`e+02`, `e-02`)
- When used with `scanf`, `%e`, `%f`, `%g` are interchangeable
- When it finds a character that cannot be part of the current item, the character is returned to be read again during the scanning of the next input item or the next call of `scanf`

- The extended example below has the same spec as 1 - `"%d%d%f%f",&i,&j&x&y`

  ```
  1-20.3-4.0e3¤
  ```

  1. `%d`. Stores `1` in `i`, returns `-`
  2. `%d`. Stores `-20` in `j`, returns `.`
  3. `%f`. Stores `0.3` in `x`, returns `-`
  4. `%f`. Stores `-4.0 x 10^3` in `y`, returns `¤`

11. Ordinary characters in format strings

- `scanf` reads white-space until it reaches a symbol
- When it reaches a symbol, it tries to match to next input
- It now either continues processing or aborts

- Example:

  If the format string is `"%d/%d"` and the input is `•5/•96`, `scanf` succeeds.

  If the input is `•5•/•96` , `scanf` fails, because the `/` in the format string doesn't match the space in the input.

- To allow spaces after the first number, use `"%d /%d"` instead
- `[ ]`

Let's try it. Run the block 1 first with two input files:

- the input file `ord1` contains `•5/•96` and should succeed
- the input file `ord2` contains `•5 /•96` and should fail

```
int i,j;

scanf("%d/%d", &i, &j);

printf("|%5d|%5d|\n", i, j);
```

- `[ ]`

  Next, fix the `scanf` format string below to allow input from `ord2`:

```
int i,j;

scanf("%d / %d", &i, &j);

printf("|%5d|%5d|\n", i, j);
```

12. Confusing printf with scanf

- Calls to these only appear similar but they aren't
- Common mistakes:

  1. putting `&` in front of variables in a `printf` call

     ```
     printf("%d %d\n", &i, &j);  /*** WRONG ***/
     ```

  2. assuming that `scanf` should resemble `printf` formats

     ```
     scanf("%d, %d", &i, &j);
     ```

     - After storing `i`, `scanf` will try to match a comma with the next input character. If it's a SPC, it will abort.x
     - Only this input will work: `100, 100` but not `100 100`

  3. putting a `\n` character at the end of `scanf` string

     ```
     scanf("%d\n", &i);
     ```

     - To `scanf`, the new-line is a SPC. It will advance to the next white-space character
     - This can cause the program to hang (wait forever for input)

13. Get coding: sample program

- The 1 program prompts the user to add two fractions and then display their sum.

  Sample output:

```
Enter first fraction: 5/6
Enter second fraction: 3/4
The sum is 38/24
```

- `[ ]`

  Complete the format strings below so that the program runs as intended! The sample input is already stored in the `addfrac_input` file in the format shown.

  ```
  int num1, denom1, num2, denom2, result_num, result_denom;

  printf("Enter first fraction: ");
  scanf("%d/%d", &num1, &denom1);

  printf("Enter second fraction: ");
  scanf("%d/%d", &num2, &denom2);

  result_num = num1 * denom2 + num2 *denom1;
  result_denom = denom1 * denom2;

  printf("\nThe sum is %d/%d\n",result_num, result_denom);
  ```

  ```
  Enter first fraction: Enter second fraction:
  The sum is 38/24
  ```

Author: Marcus Birkenkrahe

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