CP Lab 3: Programming, with some iteration

Instructions

The purpose of this Lab is to help you get more programming experience with C, and introduce you to using iteration or loops in your programming. We will be building on what you have done in the previous lab and in your classes.

You will use the if-statement construct and also the for and while loop constructs.

We know some of you did not all finish the whatday.c program within Lab2 last week. We hope you have made progress in developing and debugging that program in your own time. Please now take the opportunity to submit your ‘What Day’ if you haven’t already done so, or, if you still have some small issues to resolve, ask for help with this.

This lab is taking place on the DICE machines in Forrest Hill-3.D02 (FH-3.D02) on Thu 5 Oct, Mon 9 Oct and Tue 10 Oct (you have been allocated to one particular slot). Monday and Thursday also have lab FH-3.D01. If you want to continue the work in your own time, please use the machines on Levels 1 and 3 of Forrest Hill, which are all DICE.

Aims

• Get you extra experience with the DICE system, and its use for C programming.

• Get you more familiar with the basics of imperative programming.

• Reinforce the idea of ‘program planning’.

• Allow you to finish your whatday.c program from the sheet for Lab2, and submit it.

• Write a ‘time-conversion’ program making use of the basic concepts of assignment-to-variables, input, output and the if-statement (with a complex boolean condition).

• Give you extra experience of using certain parameters with printf, including showing you how to print a value in a fixed-width format.

• Use the return value from scanf to detect whether input succeeded.

• Give you experience of using the for-statement and the while-statement.

You will need to complete everything in this Lab sheet in order to establish a firm foundation for C programming.

Prerequisites

You should have attended your scheduled Lab session in week 3, and completed Lab sheet 2 during that session. If not, please catch up on Lab sheet 2 before proceeding with this one.

Stage A Getting started

• Log into one of the DICE computers, and get a terminal in your home directory as in previous labs. From the home directory, create a subdirectory called lab3 by entering the following from the command line:


mkdir lab3

• We will not immediately move into the lab3 directory. In Lab2, we discussed the development of a template program template.c. You should have created this file during Lab2. Assuming you have template.c created in your lab2 sub-directory1, you can make a copy of that to appear inside the lab3 directory, as follows:


cp lab2/template.c lab3/

If you did not create template.c in Lab 2, please return to the sheet for Lab2 and work through ‘Stage 2: Program Planning’ on that sheet, before continuing with this lab.

• – If you still have work to do on whatday.c from Lab2, move into the lab2 sub-directory to complete this 2


cd lab2

– Otherwise, more likely, you are ready to start work on the new programming tasks for Lab3, in which case, move straight into the lab3 sub-directory:


cd lab3

• In doing your work …

* Develop your programs carefully

* Please ask for help when you want it!

* Try to tick off each of the tasks.

Stage B Clock

Time is often represented in 24-hour format; however, it can also be represented in 12-hour format, with the added notation of AM and PM. In this first program we will consider the problem of converting from 24-hour format to 12-hour format.

This task is in some sense similar to the ‘What day’ program at the end of Lab2; however, this is an easier task.

Your program must do the following steps (i)–(iv):

(i) Ask the user to enter a time in 24 hour format. This has three stages:

– Use printf to tell the user your program will ask for a time in 24-hour format.

– Use printf to ask for the hour (in 24-hour format) and read this with scanf.

– Use printf to ask for the minutes and read this with scanf.

1If you have got your original template.c saved within a different directory than lab2, then you will have to use a different path-and-name to lab2/template.c, please ask your Demonstrator to help, if you have difficulty.

2Once you are done, you will later type cd ~/lab3 to move to the lab3 directory to continue with Lab3.
(ii) Next the ‘error checking’ step. Write an if-statement where the boolean condition tests whether the inputs represent a correct time in the 24-hour clock, to output an error message if it is not correct; and, otherwise to enter the ‘main branch’ of the if-statement, and compute the 12-hour equivalent.

- The boolean condition for the if will need to be a complex boolean condition using && or ||, because we will need to check minutes as well as hours.

(iii) Within the ‘main branch’ of your program, you must compute whether or not the time is ‘AM’, ‘PM’, ‘noon’ (12h 00min) or ‘midnight’ (00h 00min). Then you must print out (using printf) the time in the form **:** AM or **:** PM, 12:00 noon or 12:00 midnight. (Technically, 00:00 is 12:00 AM and 12:00 is 12:00 PM, but many people find this confusing.)

- Note that we will need another if-statement to detect these different cases and create the appropriate output for each case. So we will end up with a program using ‘nested if-statements’ (where one new if-statement is created inside a ‘branch’ of a previous if-statement).

(iv) Finally at the end we must ‘return’ EXIT_SUCCESS.

For this task we have provided a handwritten plan of the program structure, similar to that used in a couple of earlier lectures. This ‘program plan’ is included on the next page, and the sections where (i), (ii), (iii) and (iv) must go are labelled on the plan. The plan also has extra detail in the form of ‘regions’ for different sections of code, and some text explaining what will be done in that ‘region’. You may find it helpful to fill in this basic plan with the details of your program, before you go near the computer.

Your first step will be to plan which variables you will need (certainly two for the inputs of hours and minutes, but maybe others also), and define these in the ‘variable declarations’ region.

Then work through the different phases (i), (ii), (iii), (iv) of the program, adding your code to the plan in handwritten format. Look back on your lecture notes to make sure you get the ‘syntax’ (the way of writing statements in C) correct.

Finally, once you are happy with your code, turn to your computer to type-up, compile and run.

printf and scanf notes:

- Use of scanf to enter input: remember to use the ‘magic ampersand’ when scanning in – for example, to read an integer into the int variable x, we use
  ```c
  scanf("%d", &x);
  ```

- You can use printf to output integers in fixed-width format, with leading zeros.
  For example, use %03d instead of %d if you want to print an integer as exactly 3 digits long, padded (if necessary) with leading zeros. The %3d tells it to use exactly three digits, the 0 in %03d means ‘pad with leading zeros’. (If the integer is > 999, all its digits will be printed, even though that’s more than 3 digits.)
Typing-up, compiling and running your code:

- Write your code in a program called timeformat.c.
  
  There is an easy way to start off this file, using the Unix copy command cp from the Terminal prompt as follows:
  
  cp template.c timeformat.c
  
  Then subsequently open timeformat.c in emacs to develop your code further:
  
  emacs timeformat.c
  
- Save your program when you are happy with it. Compile your program from the terminal prompt:
  
  gcc -Wall timeformat.c
  
  There may be some DEBUGGING to be done.
  
- When compilation is successful, the ‘executable’ will be created in the a.out file in your directory. Type ./a.out, followed by a, to run your program and test its results. You may need to modify the program further.
  
- Move your executable a.out for timeformat.c into a different file, for example timeformat, for future use. Then in the future, to ‘run’ the timeformat program, you will type the following:
  
  ./timeformat
  
- Finally, submit your program with:
  
  submit cp lab3 timeformat.c

Your result for timeformat.c

- A program which requests two input integers with printf, reads the inputs with scanf, and outputs with printf
- Program should be correct. To test:
  
  - Given the value 0 for hours and 20 for minutes, it should print 12:20 AM
  - Given the value 12 for hours and 35 for minutes it should print 12:35 PM
  - Given the value 13 for hours and 20 for minutes, it should print 01:20 PM
  - Given the value 18 for hours and 3 for minutes, it should print 06:03 PM.
  
  Apart from the problem-solving and use of if, you have also learned how to use printf to print out integers in a fixed-width format, and padded with leading 0s (see end of page 3 for this).
- Make sure you move a.out into timeformat before proceeding with the other tasks.
- Don’t forget to submit your source file.

Your result for averageof2.c

- Program should be correct. To test:
  
  - Given the values 5 and 15, it should return 10.00
  - Given the values 8 and 9, it should return 8.50

- Make sure you rename a.out into a file averageof2 (or similar) before proceeding.
- Submit your file as usual with:
  
  submit cp lab3 averageof2.c

Stage C Average of Two Numbers

Next write a simple program averageof2.c which takes as input two integers, and prints their average to two decimal places. As always a good start is to copy over template.c to averageof2.c

Recall in the previous lab you have learned how to work with real numbers in C (using double) and how to print these out via printf.

This program is a simple warm-up for stage D and E, when we will use the for and while constructs to solve a general version of ‘average’.

Your result for averageof2.c

- Program should be correct. To test:
  
  - Given the values 5 and 15, it should return 10.00
  - Given the values 8 and 9, it should return 8.50

- Make sure you rename a.out into a file averageof2 (or similar) before proceeding.
- Submit your file as usual with:
  
  submit cp lab3 averageof2.c

Stage D Average of many numbers

Now we are going to write a program to solve a general version of the ‘average’ problem, where we will consider not just two inputs, but an arbitrary number of integers to average. The value output must be the average of the numbers, to two decimal places.

To solve this problem it will be necessary to use the concept of iteration (either using for or while), which was introduced in lecture 6 of CP.

In this stage we will assume that the first stage of your program involves asking the user up-front ‘How many integers’ they want to average, and to compute the average, and output this using printf.

Your result for averageof2.c

- Program should be correct. To test:
  
  - Given the values 5 and 15, it should return 10.00
  - Given the values 8 and 9, it should return 8.50

- Make sure you rename a.out into a file averageof2 (or similar) before proceeding.
- Submit your file as usual with:
  
  submit cp lab3 averageof2.c

Note we are assuming you made a copy of template.c within the lab3 sub-directory, as part of the ‘Getting started’ section.

In Maths/Computer Science, ‘arbitrary’ is a commonly-used word. It means ‘any’.
Things to take into account for `averagewithfor.c`:

- It may be helpful for you to draw up a ‘program plan’ for `averagewithfor.c` (as we did on page 4 for `timeformat.c`) and to develop your code on paper first.
- Remember as always you can create a ‘shell’ for `averagewithfor.c` by copying over `template.c` in the usual way (cp `template.c` `averagewithfor.c`); or you may prefer to start with a copy of `averageof2.c`.
- Your variables will be declared below the main. For this program, there are many ‘variable issues’: You will need a variable for the ‘number of integers to average’ which will be read from the user. You will need a variable to read in the different integers taken in for averaging.
- You will need a variable for the ‘Running total’. You will need to initialise the ‘Running total’ variable to 0 at the beginning of your program. `Initialisation` is always an issue for variables which are going to be updated in any way different from a direct ‘read-in’ with `scanf`
- You will need a ‘loop counter’ variable to use in your for.\(^5\) The ‘loop counter’ variable is usually an int, and often is named i, n or count in examples.
- Finally, you will need a variable to store the average. Your average will not necessarily be an integer, so you need to consider which type you will use for this variable (namely double). Also you must use casting of int variables when you are using them in an expression to create a double.

The usual commands are used to do the compilation and execution of the program. To compile:

```
 gcc -Wall averagewithfor.c
```

Once you have compiled your program (and the executable has been created in a.out) you can run it as usual with .a.out.\(^6\)

Once you have debugged your program, save it for future execution in a file called `averagewithfor` (different from `averagewithfor.c` , no .c extension) using the Unix ‘move’ command `mv`.

When you’re satisfied, submit your program in the same way as the others.

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**First ‘Average of Many’ program (for)**

- Testing.
  - You should get the result 8.00 in response to inputting 3 first, then the 3 numbers 7, 8 and 9
  - You should get the answer 2.75 in response to inputting 4 first, then the 4 numbers 6, 4, –7 and 8

  Do further tests to check correctness.

- Remember to submit your program.

- If you have time, extend your program to test that the first integer read, the ‘number of integers to average’, is at least 1.

  Use an `if`-statement to branch into either an error message (if the value is 0 or negative), or alternatively proceed with the main computation.

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**Second ‘Average of Many’ program (while)**

- Testing.
  - You should get the result 8.00 in response to inputting 7,8,9,–9,–x,–1.
  - You should get the answer 2.75 in response to inputting 6,3,4,–7,–8,–x,–1.

- Submit your program as with the others.

- Would it be possible to solve the ‘Average of many’ problem with a for-statement in the case where we do NOT ask for the number of integers at the start? Think about this.

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\(^5\)Check back through the Lecture 6 slides, or look at section 4.9 of ‘A book on C’, to remind yourself what this means, and how we use it.

\(^6\)Need to count up how many inputs, because we need this at the end in getting the average.

\(^7\)It’s possible to write this program without needing an explicit again variable. You’re free to do this if you see how!

\(^8\)ret, short for ‘return value’, is a traditional name for variables used in this way.