# CS 61 - Programming Assignment 04

## Objective

The purpose of this assignment is to illustrate how the .FILL pseudo-op performs the task of translating textual numbers (such as the string "#5392") into actual numbers (i.e. five thousand three hundred and ninety two, represented of course as a 16-bit two's complement binary value).

## High Level Description

Prompt the user to enter in a signed multi-digit number (max 5 digits) from the keyboard. Convert the string of characters entered (as separate ascii codes for decimal numeric digits) into the 16-bit number they represent, and store the result in **R5**. The range of acceptable values is [-32768, +32767]; the absence of a sign means the number is positive.

## Your Tasks

Your program can be broken down into the following tasks:

Read in the '+' or '-'. If the character is a '-', remember to make the final result negative *(i.e. take the 2's complement of **R5** at the end).* If the result is positive then ... don't.

Convert the string of characters input by the user into the binary number they represent (see examples). To do this, you can follow this algorithm:

- Initialize **R5** to 0 *(**DO NOT** do this by LD'ing a 0 from memory! There is a much simpler & faster way!)*
- Convert each digit to binary as it is typed in, and add it to **R5**; if another digit is entered, multiply **R5** by 10, and repeat. Stop when you detect the ENTER (x0A):
  - For example, if the user types '2', then **R5** will contain
    ```
    #2 == b0000 0000 0000 0010
    ```
  - If the user then types a '3', making the string now read "23", then **R5** will contain
    ```
    2 x 10 + 3 == #23 == b0000 0000 0001 0111
    ```
  - If the user then types '4', making the string read "234", then **R5** will contain
    ```
    23 x 10 + 4 == #234 == b0000 0000 1110 1010
    ```

You must also perform ***input character validation*** with this assignment – i.e. reject any <u>*non-numeric*</u> input character.
That is, if the user enters "+23g", your program should "choke" on the 'g', print an error message (see sample output), and start over at the beginning with the initial prompt.
However, you do not have to detect overflow in this assignment – we will only test your code with inputs in the range [-32768, +32767].

**Expected/ Sample output**

***Output***

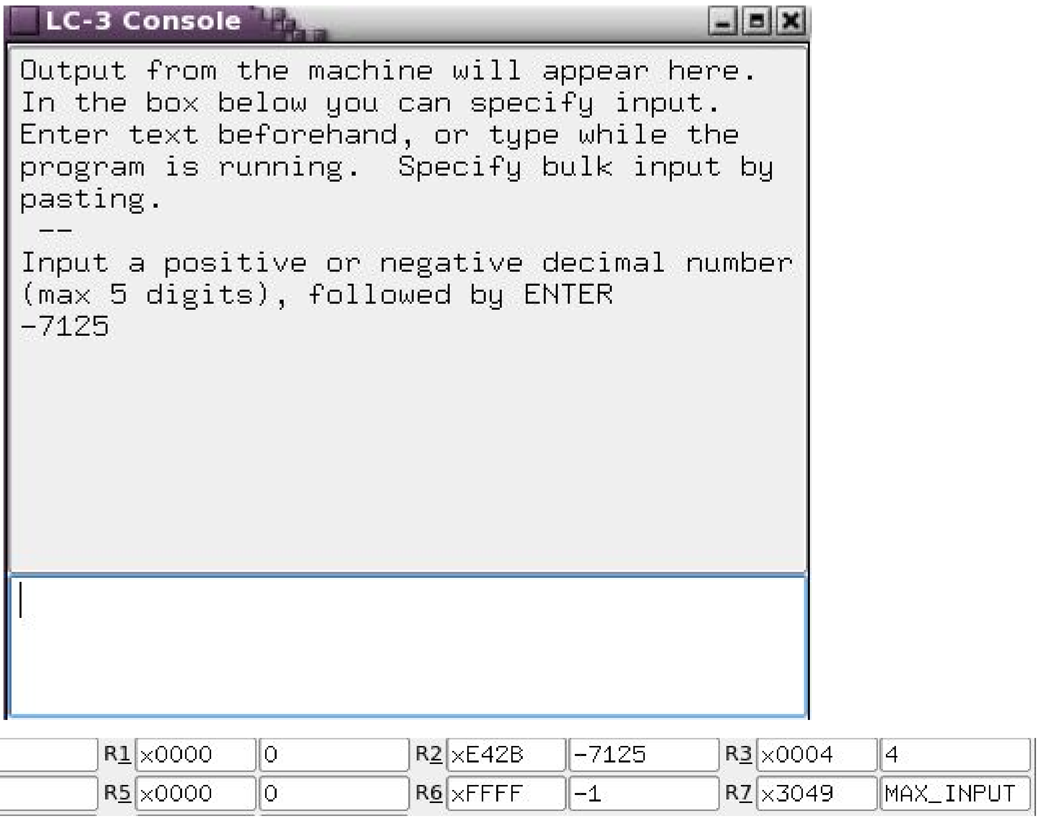
- Prompt
    - Input a positive or negative decimal number (max 5 digits), followed by ENTER
        - Newline terminated
- Error Message
    - ERROR INVALID INPUT
        - Newline terminated

***Example***

If the user enters "+7246", your program should read the '+', '7', '2', '4', '6' and end up with the value b0001 1100 0100 1110 in **R5** *(which corresponds to the number #7246, or x1C4E)*.

If the users enters "-14237", your program should read the '-', '1', '4', '2', '3', '7' and end up with the value `#-14237 == xC863 == b11001000 01100011` in **R5**.

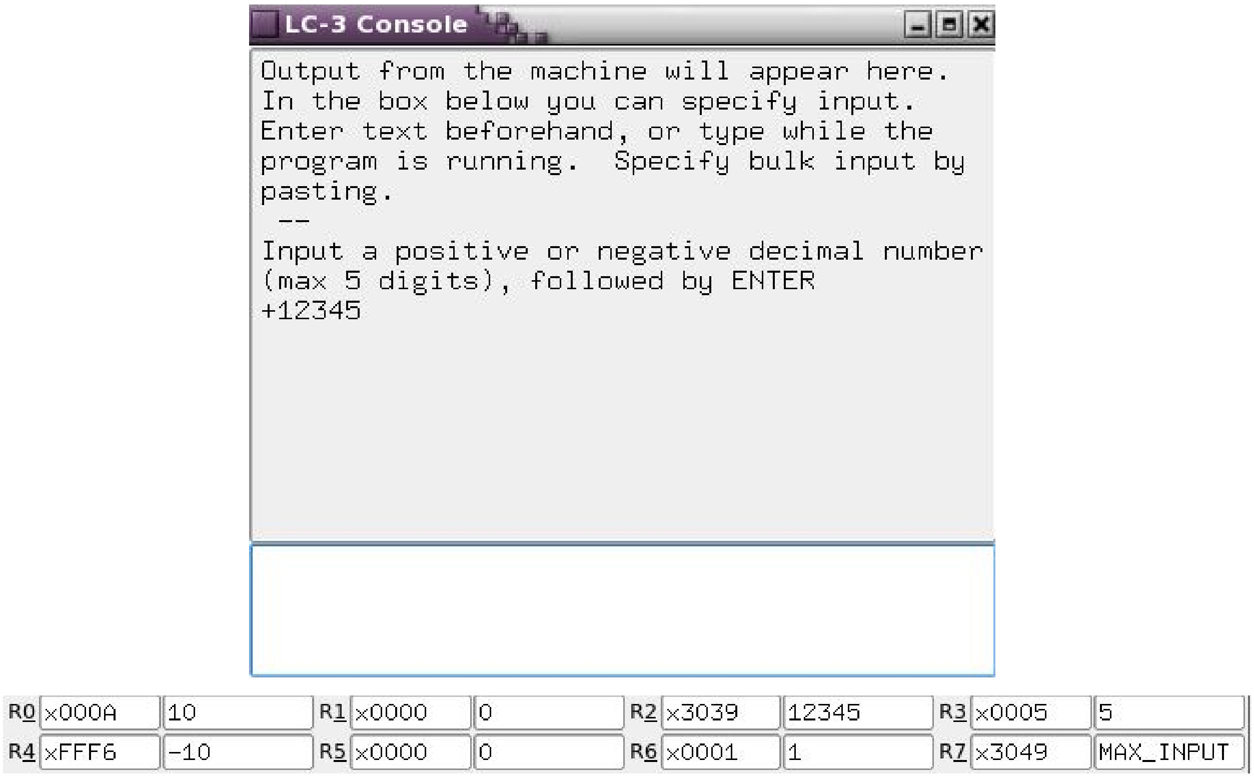
***<u>NOTE</u>: In the following examples, the final result is shown in R2.***
***This is NOT the register you will be using in your code - use the register specified above!!***



```
Output from the machine will appear here.
In the box below you can specify input.
Enter text beforehand, or type while the
program is running.  Specify bulk input by
pasting.
 --
Input a positive or negative decimal number
(max 5 digits), followed by ENTER
-7125
```

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| R0 | x000A | 10 | R1 | x0000 | 0 | R2 | xE42B | -7125 | R3 | x0004 | 4 |
| R4 | xFFF6 | -10 | R5 | x0000 | 0 | R6 | xFFFF | -1 | R7 | x3049 | MAX_INPUT |

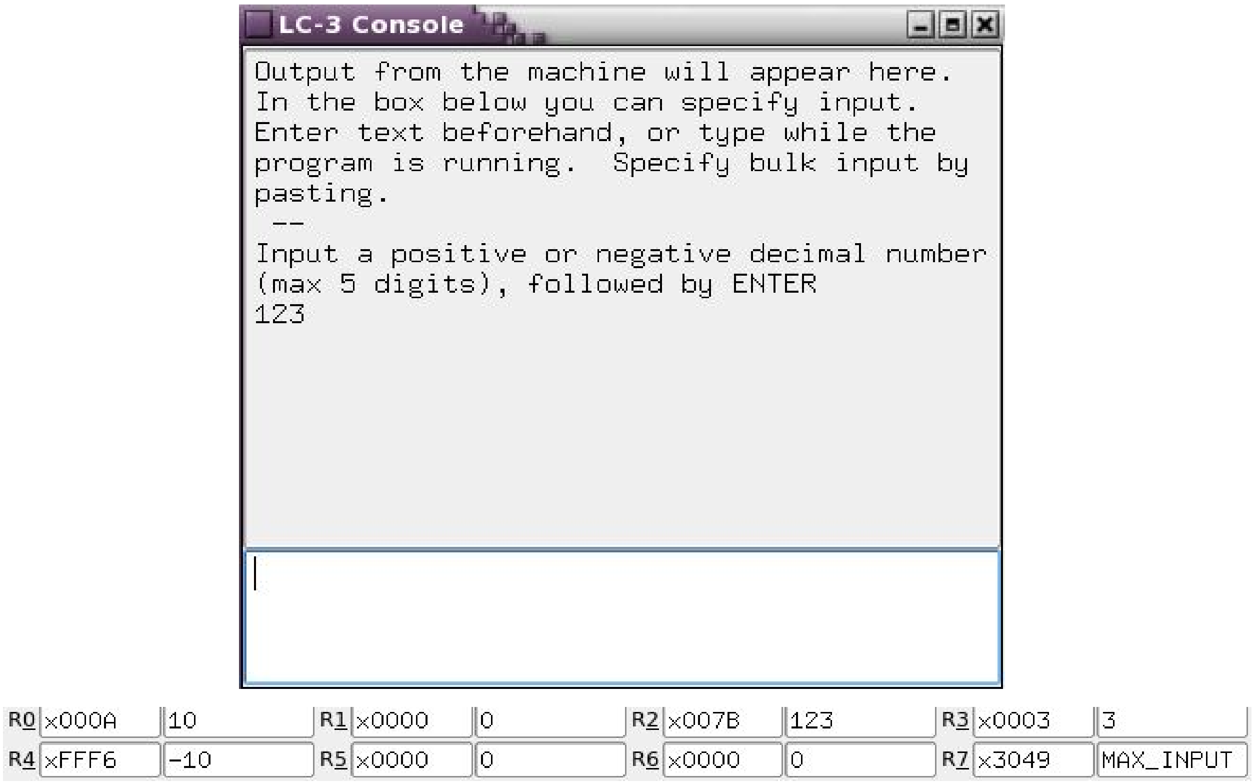
(Valid input with a negative sign)



```
LC-3 Console
Output from the machine will appear here.
In the box below you can specify input.
Enter text beforehand, or type while the
program is running.  Specify bulk input by
pasting.
 --
Input a positive or negative decimal number
(max 5 digits), followed by ENTER
+12345
```

```
R0 x000A 10    R1 x0000 0   R2 x3039 12345   R3 x0005 5
R4 xFFF6 -10   R5 x0000 0   R6 x0001 1       R7 x3049 MAX_INPUT
```

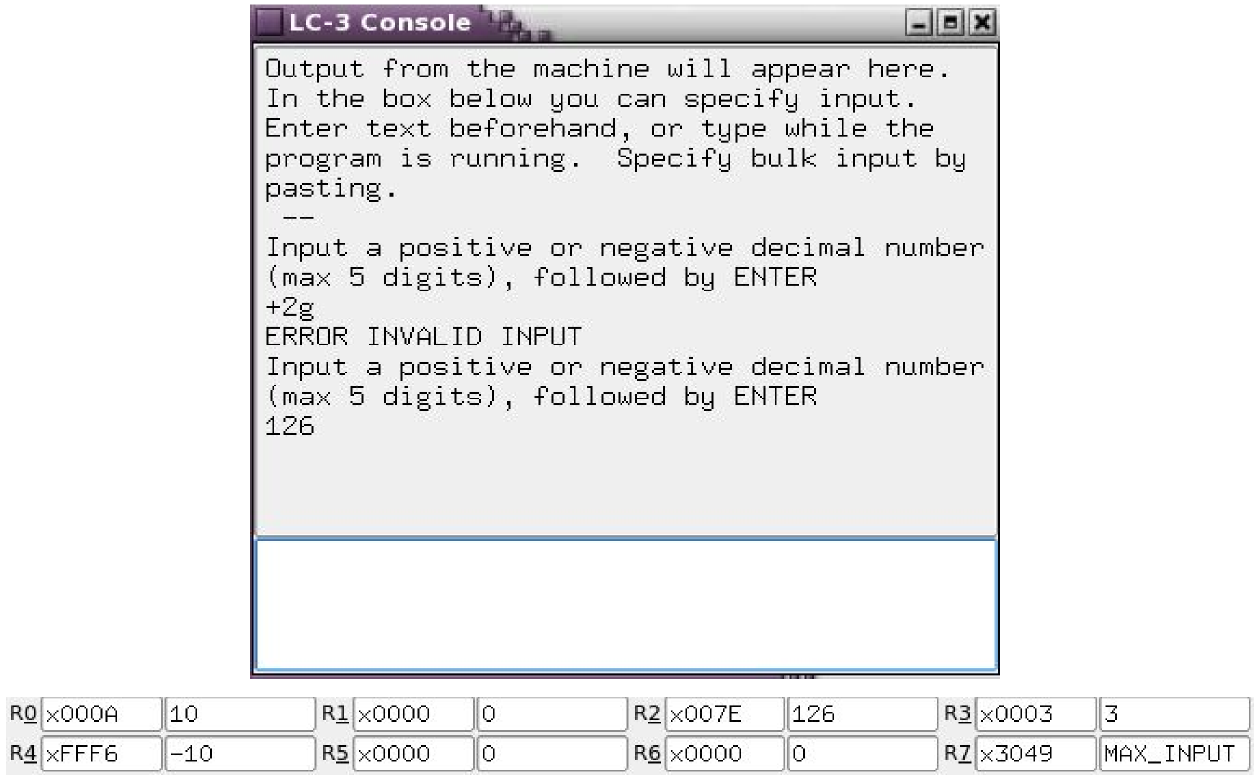
(Valid input with a positive sign)



```
LC-3 Console
Output from the machine will appear here.
In the box below you can specify input.
Enter text beforehand, or type while the
program is running.  Specify bulk input by
pasting.
 --
Input a positive or negative decimal number
(max 5 digits), followed by ENTER
123
```

```
R0 x000A 10    R1 x0000 0   R2 x007B 123   R3 x0003 3
R4 xFFF6 -10   R5 x0000 0   R6 x0000 0     R7 x3049 MAX_INPUT
```

(Valid input with No sign)



```
Output from the machine will appear here.
In the box below you can specify input.
Enter text beforehand, or type while the
program is running.  Specify bulk input by
pasting.
 --
Input a positive or negative decimal number
(max 5 digits), followed by ENTER
+2g
ERROR INVALID INPUT
Input a positive or negative decimal number
(max 5 digits), followed by ENTER
126
```

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| R0 | x000A | 10 | R1 | x0000 | 0 | R2 | x007E | 126 | R3 | x0003 | 3 |
| R4 | xFFF6 | -10 | R5 | x0000 | 0 | R6 | x0000 | 0 | R7 | x3049 | MAX_INPUT |

(Invalid input)

**Note:**

- You must echo the digits as they are input (no "ghost writing").
- You do **not** have to output the converted binary number. It should “simply” be sitting happily in **R5**, where you can check it in simpl.
- What should happen when an error occurs?
    - Output the error message and reprompt the user for input
- Other Errors:
    - Nothing entered before ENTER
    - only sign is entered before ENTER
    - first character entered is neither a sign nor a digit
- ***REMEMBER: all outputs must be newline terminated***

Your code will obviously be tested with a range of different values:  Make sure you test your code likewise!

**Uh…help?**

Try to write this program out in C++/pseudocode before directly tackling it in LC3. Doing so often helps to simplify the process and usually only takes a few minutes to do if you think it through carefully.

To mark the distinction between a positive number and a negative one, set a “flag” (say… R5). If the first character is a ‘-‘, then put a negative number (like #-1) into R5. Otherwise, set R5 to #0 (i.e. non-negative). That way, after you translate the rest of the input characters into the number they represent, you can use a quick IF-statement (like BRn MAKE_NEGATIVE) to toss in the two lines of code it takes to take the 2’s complement of the result.

**Submission Instructions**

Submit to GitHub for testing, feedback and grading.

**Comments/Feedback**

Download the results.html file to see your grade and the reasons for any points deducted.

**Rubric**

- Grades fall into the following four ranges:

  (i) 8 - 10: pass (perhaps with minor errors - missing spaces, mis-spellings, etc.)

  (ii) 5 - 7: failed, but easily fixable (e.g. missing newlines)

  (iii) 1 - 4: failed - wrong output, you should probably throw it away and start over!

  (iv) 0: abject fail - no submission, or did not assemble *(same as fail, but even more embarrassing!)*
- Using the provided template is **required**.
- Not using memory address provided in the template will result in a failing score.

**Comics?!Sweet!!**

WANNA SEE AN OPTICAL ILLUSION?
HOLD YOUR KEYBOARD UP IN FRONT OF YOU AND LOOK AT THE HOME ROW.
NOW CROSS YOUR EYES A LITTLE SO THE 'G' AND 'H' OVERLAP.
KEEPING FOCUSED, LIFT THE KEYBOARD OVER YOUR HEAD.
EWW!
HA HA

Source: [http://xkcd.com/237/](http://xkcd.com/237/)