CS061 - Programming Assignment 1

Objective

The purpose of this assignment is to familiarize you with the basics of LC-3 assembly language programming, the LC3Tools editor and emulator, and rudimentary debugging.

Your Tasks

Implement the LC-3 program from the image below.

Note: This is *almost*, but not *quite*, the same program you worked on in Lab 1: it uses a DO-WHILE loop to multiply one number by another by repeated adding.

First (as with all your labs and assignments) go to the Assignments page in Canvas, and under Programming Assignments download the assignment 1 zip file to your assignments/assn1 folder in your cs account, and unzip it in place.

Type the code from the image below into your assignment1.asm file using the LC3Tools editor (see instructions below).

*Again, the registers are assigned differently from your Lab 1 exercise, so **don't** copy that!*
*But **do** use the (AND with 0) technique discussed in the "TIP" paragraph in lab 1.*

To edit and run your code, launch the LC3Tools application. If you have not already installed LC3Tools, you can find it for your platform here. Navigate to the application (LC3Tools.exe on Windows, LC3Tools on Mac and LC3Tools-2.0.1-AppImage on Linux) and launch it. In the Editor tab of the program and open the code in the file called `assignment1.asm`.

Once you have completed the code, press the wrench icon to assemble your program. When the program is assembled with no syntax errors, go to the Simulator tab to run your program.

***Remember**: whenever you run simpl, you must ALWAYS keep the Text Window open so you can see warnings & error messages from the emulator!*

Now place a *breakpoint* at the beginning of the DO-WHILE loop by clicking the exclamation point (AKA bang) inside a hexagon next to the DO_WHILE label.

Now, when you press the "Run" button (it looks like a play button), LC3Tools will execute each line of code until it reaches the breakpoint, where it will pause and wait for you to press Run again; it will continue doing this until it no longer encounters the breakpoint, at which time it will continue executing until the HALT instruction.

Lastly, create a table in your .asm file (see the image below) to record the register contents for *each* register (R0 through R7) as you repeatedly press the Run button and iterate through the loop, as follows:

- Before entering the loop (i.e. the first time the program halts at the breakpoint)
- After each iteration of the loop (each subsequent breakpoint pause)

- Note that since your breakpoint is at the start of the loop, the register values after the *last* iteration will just be the values when the program has ended, as suggested by the naming of the last row in the image below.

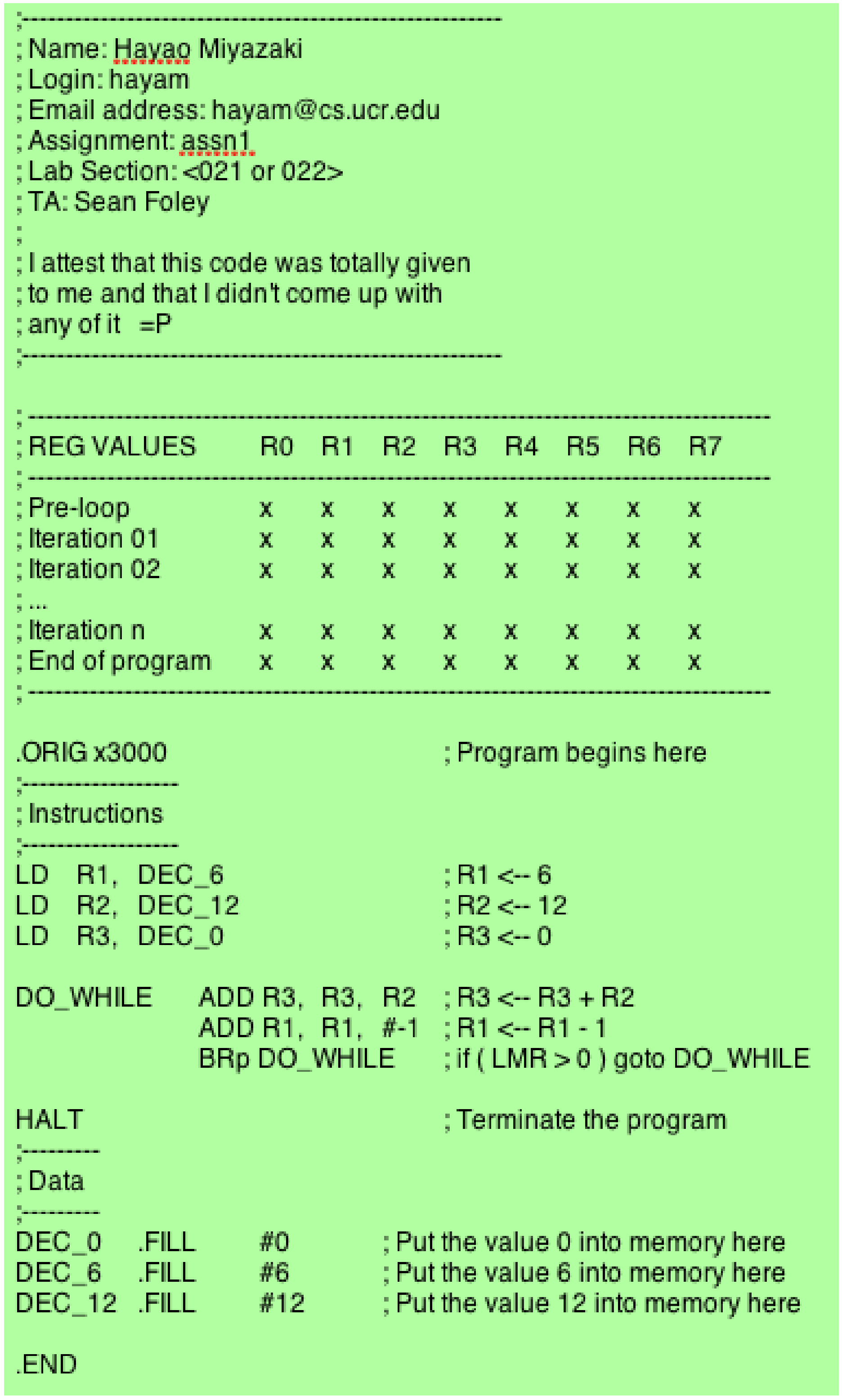
Before you run the code, try to answer this question: *How many rows do you think you will end up with in your table?*

Format your table like the one in the image below *(but obviously reporting the **actual** values from **ALL** eight registers, for **ALL** iterations of the loop!)*

The following program performs the action:

```
    R3 <-- 12 * 6    ; (i.e. multiply 12 by 6 and write the result into Register 3)
```

using the equivalent of a DO-WHILE loop:



```
;------------------------------------------------------
; Name: Hayao Miyazaki
; Login: hayam
; Email address: hayam@cs.ucr.edu
; Assignment: assn1
; Lab Section: <021 or 022>
; TA: Sean Foley
;
; I attest that this code was totally given
; to me and that I didn't come up with
; any of it   =P
;------------------------------------------------------

; -------------------------------------------------------------------------------
; REG VALUES        R0    R1    R2    R3    R4    R5    R6    R7
; -------------------------------------------------------------------------------
; Pre-loop          x     x     x     x     x     x     x     x
; Iteration 01      x     x     x     x     x     x     x     x
; Iteration 02      x     x     x     x     x     x     x     x
; ...
; Iteration n       x     x     x     x     x     x     x     x
; End of program    x     x     x     x     x     x     x     x
; -------------------------------------------------------------------------------

.ORIG x3000                             ; Program begins here
;-----------------
; Instructions
;-----------------
LD    R1,  DEC_6                        ; R1 <-- 6
LD    R2,  DEC_12                       ; R2 <-- 12
LD    R3,  DEC_0                        ; R3 <-- 0

DO_WHILE      ADD R3,  R3,  R2          ; R3 <-- R3 + R2
              ADD R1,  R1,  #-1         ; R1 <-- R1 - 1
              BRp DO_WHILE              ; if ( LMR > 0 ) goto DO_WHILE

HALT                                    ; Terminate the program
;---------
; Data
;---------
DEC_0     .FILL      #0          ; Put the value 0 into memory here
DEC_6     .FILL      #6          ; Put the value 6 into memory here
DEC_12    .FILL      #12         ; Put the value 12 into memory here

.END
```

Remember: Replace the instruction that zeros out R3 with the AND technique you learned in lab 1!

Submission Instructions

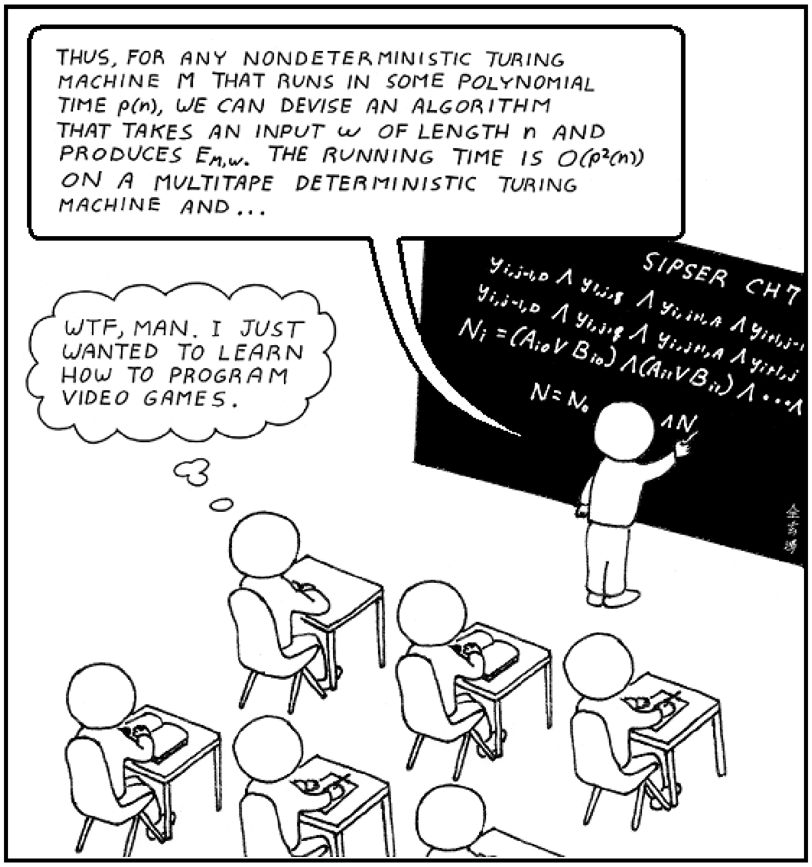
Submit your **assignment1.asm** file *(and ONLY that file!)* to the Programming Assignment 1 folder in Gradescope.

Note that there is no autograding for this assignment - you will be notified when it has been graded manually.

Rubric

- There is nothing for you to actually get wrong in this assignment (we give you the code!) - so the only way to mess up and lose points would be to fail to follow instructions.
  So get into the habit of reading the instructions fully & carefully :)
- This assignment has to be graded manually (i.e. we have to look at your code formatting and your register table); we will try to grade submissions at least once or twice a day.
  So don't leave it to the last day - you may need a second chance!! See the point above!
- For this and all assignments, use of the template given to you is **required**.

Comics??!Sweet!!!


THUS, FOR ANY NONDETERMINISTIC TURING MACHINE M THAT RUNS IN SOME POLYNOMIAL TIME p(n), WE CAN DEVISE AN ALGORITHM THAT TAKES AN INPUT w OF LENGTH n AND PRODUCES E_{M,w}. THE RUNNING TIME IS O(p²(n)) ON A MULTITAPE DETERMINISTIC TURING MACHINE AND...
WTF, MAN. I JUST WANTED TO LEARN HOW TO PROGRAM VIDEO GAMES.
SIPSER CH7

Source: https://xkcd.com/