Homework 7 CS/ECE 252: Sec 1 & 2 [Due 1:00PM on Wed, Apr 23]

Primary contacts for this hw: Sujith Surendran [sujiths at cs dot wisc dot edu],
Murali Sivalingam [murali10 at cs dot wisc dot edu]

Important Notes:

- Answers to questions 1 and 2 should be handed in hard copy.
- Questions 3 and 4 must be submitted electronically to the Learn@UW dropbox. Submit only one archive file, named exactly like: <lastname1>[.zip|.tar.gz] to the dropbox folder homework7. You have to submit the .txt files for these problems (which contains the assembly code) and the files should be named hw7_p#.txt, i.e, the file for problem 3 should be named hw7_p3.txt. Since your code is tested automatically, it is important to stick to this naming convention, otherwise you will lose credit, even if your code is working correctly.
    - For example, if Sujith was to submit his code, he will put hw7_p3.txt (assembly code for problem 3) and hw7_p4.txt (assembly code for problem 4) into a folder called surendran (which is his last name). He will then zip / tar this folder, and submit it into homework7 dropbox.

- The programs which you write should always start at address x3000 and end with a HALT instruction (HALT).

- You can submit your code for problem 3 and 4 as many times as you want, until 1:00 PM on Wednesday, April 23, 2014. After that time we will consider your latest submission for grading.

Problem 1 (4 points)

Consider the following assembly program:

```
        .ORIG x3000
        AND R0, R0, #0
        LD R1, START
        LD R2, INPUT
        LD R3, BITS

LOOP    AND R4, R2, R1
        BRnp SKIP

        ADD R0, R0, #1
SKIP    ADD R1, R1, R1
        ADD R3, R3, #-1
        BRzp  LOOP
        ST R0, RESULT
        HALT

INPUT   .FILL x2222
START   .FILL x1
BITS    .FILL xF
RESULT  .BLKW #1

        .END
```

a) (2 Points) Run the program on PennSim and give a brief explanation of what the program does. (ie, specify how the value at RESULT relates to value at the INPUT after the execution of the program)

This will give the number of zeros in the INPUT and put this value in RESULT

b) (1 Point) How many times does the instruction at label LOOP execute?

16

c) (1 Point) What value will be contained in R1 after the execution of the program?

0

Problem 2 (6 Points)

Consider the following assembly code:

```
          .ORIG x4000
          LEA R3, INPUT
          LD R1, SIZE
          ADD R3, R3, R1
LOOP      LDR R0, R3, 0
          ADD R3, R3, -1
          ADD R1, R1,-1
          BRp LOOP
          HALT
INPUT      .STRINGZ  "1 Down, 3 to Go !!"
STRING    .BLKW 4
SIZE      .FILL x12
          .END
```

a) (4 Points) In the first pass, the assembler creates the symbol table. Fill in the symbol table created by the assembler for this program

Symbol Name / Label	Address
LOOP	4003
INPUT	4008
STRING	401B
SIZE	401F

b) (2 Points) In the second pass, the assembler creates a binary (.obj) version of the program, using the entries from the symbol table. Write the binary code generated for the first two instructions (LEA and LD)

LEA : 1110 0110 0000 0111
LD : 0010 0010 0001 1101

Problem 3 (8 Points)

Write a program which reads a string of lowercase alphabets starting at label "INPUT" and puts the ASCII value of the alphabet that has repeated maximum times in register R0. For example, if the string at INPUT is "abddeee", the value in R6 should be 0x65 (ASCII value of e).

Note:

- The string is always terminated by a NULL character (ASCII value 0x0). If the string is empty (the character at label INPUT is the NULL character), R0 should be set to 0.
- If there are are two such characters (both of which have got repeated the same number of times), you can take any one of those characters and place its ascii value in R0. (ie, if the string is "abddeeefff", the value stored in R0 can be 0x65 (ascii value of e) or 0x66 (ascii value of f).
- Use this template for writing your code: hw7_p3.txt

Solution : Refer hw7_p3_sol.txt

Problem 4 (12 Points)

Assume that you are appointed as a TA for this CS/ECE 252 course sometime in future, and assume that 20 students have enrolled in this course. After grading all the exams, you finally decided to use LC-3 for calculating the performance of the students. For doing so, assume you have stored the total marks of each of the students in consecutive memory locations starting at label 0x4000

Write a program in LC-3, which starts at memory location 0x3000 to do the following:

a) (2 Points) Calculate maximum marks obtained by student and store this value in the memory location corresponding to label "MAX_MARKS" (see template below)

b) (2 Points) Calculate minimum marks obtained by a student and store this value in memory location corresponding to label "MIN_MARKS"

c) (5 Points) Calculate the average marks of the class and store this value in memory location corresponding to label "AVG_MARKS". If this turns out to be a fraction, round it off to the next higher integer. For example, if the average turns out to be 30.02, the average is rounded off to 31.

d) (3 Points) Calculate the number of students who have scored below class average (after rounding off) and store this value in memory location corresponding to label "BELOW_AVG"

Note:

- You MUST use this template for writing your code: hw7_p4.txt
- You can assume that addition of marks of all the students will not generate any overflow
- You may use the script file (script_hw7p4.txt) for testing your code. The script has some default values for marks of students. However, please note that we will be finally testing your code with other values (not the default ones).
    - Before using the script, make sure that your code is getting compiled successfully
    - Open Pennsim and type "script script_hw7p4.txt" in the command line. This will run the tests, and if all tests are successful, you will see 4 true statements (for the default inputs) :
        - TRUE (check MAX_MARKS 100)
        - TRUE (check MIN_MARKS 70)
        - TRUE (check AVG_MARKS 84)
        - TRUE (check BELOW_AVG 10)

Solution : Refer hw7_p4_sol.txt