CS/ECE 252: INTRODUCTION TO COMPUTER ENGINEERING

UNIVERSITY OF WISCONSIN—MADISON

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Examination 4
In Class (50 minutes)
Friday, May 11, 2012
Weight: 17.5%

NO: BOOK(S), NOTE(S), CALCULATORS OF ANY SORT.

This exam has 11 pages, including a blank page at the end. Plan your time carefully, since some problems are longer than others. You must turn in pages 1 to 11.

LAST NAME: _____

FIRST NAME:_____

SECTION: _____

CAMPUS ID# _____

EMAIL ID _____

Question	Maximum Points	Points
1	6	
2	4	
3	5	
4	4	
5	2	
6	5	
7	4	
Total	**30**	

Problem 1 (6 points)
An LC-3 assembly language program is given below.

```
      .ORIG x3000
      LEA   R0, STR1
      LEA   R1, STR2
LOOP  LDR   R2, R0, #0
      BRz   DIFF
      LDR   R3, R1, #0
      BRz   DIFF
      ADD   R0, R0, #1
      ADD   R1, R1, #1
      BRnzp LOOP
DIFF  LDR   R2, R0, #0
      LDR   R3, R1, #0
      NOT   R3, R3
      ADD   R3, R3, #1
      ADD   R3, R2, R3
      BRp   OUT1
      BRn   OUT2
      BRz   OUT3
OUT1  LEA   R0, STR1
      BRnzp DONE
OUT2  LEA   R0, STR2
      BRnzp DONE
OUT3  LEA   R0, STR3
DONE  PUTS
      HALT

STR1  .STRINGZ "There's a lady who's sure all that glitters is gold"
STR2  .STRINGZ "Unsealed on a porch a letter sat"
STR3  .STRINGZ "I close my eyes only for a moment and the moment's gone"
```

Note: there are 52 characters in the first string (including null)

a. Fill in the symbol table created by the first pass of the assembler on the above program for the following labels / symbols (3 points)

Label	**Address**
LOOP	
DIFF	
OUT1	
OUT2	
STR1	
STR2	

b. What does the above program do? Give your answer in **one** or **two** sentences. (1 point)

c. What is the output of this program? (2 points)

Problem 2 (4 points) 1 point each

Answer the following short answer questions in **one** or **two** sentences.

a. What are the two methods for accessing I/O devices?

b. Define and contrast callee-save and caller-save.

c. Give one example of a syntax error using the AND **immediate** instruction and explain the error.

d. Is there a problem with using X1 as a label in an LC-3 assembly program? Why or why not?

Problem 3 (5 points)
The following LC-3 subroutine implements the PUTS service routine. This means it will output the string stored at the address stored in R0 and then return to normal execution.

```
      .ORIG x0227
      ST    R1, R1_TMP
      ST    R2, R2_TMP
L1    LDI   R2, DSR

      _________________
      LDR   R1, R0, #0
      BRz   DONE

      _________________
      ADD   R0, R0, #1
      BRnzp L1
DONE  LD    R2, R2_TMP
      LD    R1, R1_TMP

      _________________

DSR    .FILL    xFE04   ; Address of DSR
DDR    .FILL    xFE06   ; Address of DDR
R1_TMP    .FILL 0
R2_TMP    .FILL 0
```

a. Fill in the blanks. **There should be one instruction per line and no NOPs.** (3 points)

b. Assume the above assembly code is a service routine that is a part of the LC-3 OS. Suppose we can call it using TRAP x22. Where is the address of the trap vector, and what are its contents? (2 points)

Give all answers in hex

Address of TRAP vector	**Contents at this memory location**

Problem 4 (4 points)

The following program reads two inputs from memory locations A and B and compares their contents. If M[A] = M[B], the program terminates with the value 1 in memory location COMPARE_RESULT, otherwise it stores zero in COMPARE_RESULT and terminates. What is the problem with the following code? How can you resolve it? Answer in **one** or **two** sentences in the box provided.

```
                .ORIG       x3000
                LD          R0, A
                LD          R1, B
                JSR         COMPARE
                HALT

COMPARE         ST          R7, R7_TMP
                JSR         NEG         ; compute -R0
                ADD         R0, R0, R1  ; compute R1-R0
                BRZ         STORE_ONE
STORE_ZERO      LD          R0, ZERO
                ST          R0, COMPARE_RESULT
                BR          END_COMP
STORE_ONE       LD          R0, ONE
                ST          R0, COMPARE_RESULT
END_COMP        LD          R7, R7_TMP
                RET

NEG             ST          R7, R7_TMP
                NOT         R0, R0
                ADD         R0, R0, #1
                LD          R7, R7_TMP
                RET

A               .BLKW       1
B               .BLKW       1
R7_TMP          .BLKW       1
COMPARE_RESULT  .BLKW       1

ZERO            .FILL       0
ONE             .FILL       1
                .END
```

Answer:

Problem 5 (2 points)

A programmer decides to design a variant of the LC-3 that does not need a keyboard status register. Instead, he creates a readable/writable keyboard data and status register (KBDSR). With the KBDSR, a program requiring keyboard input waits until a nonzero value appears in the KBDSR and reads this value into R0. The nonzero value is the ASCII value of the last key pressed. Then the program writes a zero into the KBDSR indicating that it has read the data. **Fill in the following blanks to implement this new scheme. (1 instruction per line)**

```
ZERO        LDI     R0, A
            BRz     ZERO

NONZERO     _______________________________

            _______________________________
            BRnzp   NEXT_TASK

A           .FILL   xFE00     ; Address of KBDSR
```

Problem 6 (5 points)

Select **only one answer** choice for the following questions about LC-3:

1. Suppose `JSRR R5` is stored at memory location x4009 and R5 contains x3002. The execution of JSRR instruction will cause:
    a. R7 to be loaded with x4010 and the PC to be loaded with x3002
    b. R7 to be loaded with x3003 and the PC to be loaded with x4009
    c. R7 to be loaded with x400A and the PC to be loaded with x3002
    d. R7 to be loaded with x3002 and the PC to be loaded with x400A
2. Which of the following is **not true** about interrupt driven I/O?
    a. It is more efficient than polling
    b. The device controls the interaction by sending a special signal to the processor when it is ready
    c. The processor must routinely check the status register for the device until new data arrives or the device is ready
    d. It has built in priority levels for different device requests
3. At the end of which phase of instruction cycle does an interrupt-driven I/O processor test for an interrupt signal?
    a. Fetch
    b. Decode
    c. Execute
    d. Store result
4. In LC-3, in what range of addresses are the trap vectors stored?
    a. x0000 - x00FF
    b. xFDFF - xFFFF
    c. xFF00 - xFFFF
    d. xFE00- xFFFF
5. Which one is the highest priority level?
    a. PL1
    b. PL7
    c. PL0
    d. They are all equal in priority

Problem 7 (4 points)

Suppose the LC-3 is modified such that the TRAP vector table exists in the range of addresses from 0x0000 to 0x0007. The following tables show the TRAP vector table and the relevant service routines.

TRAP vector table:

Address	Memory Content
0x0000	0x000A
0x0001	0x000F
0x0002	0x000E
0x0003	0x000A
0x0004	0x000B
0x0005	0x000D
0x0006	0x000F
0x0007	0x000C

Service routines:

Address	Label	Instruction
0x000A		LD R0, L2
0x000B		ADD R0, R0, #10
0x000C		RET
0x000D	L1	LD R0, L3
0x000E		BRn L1
0x000F		RET
0x0010	L2	.FILL x100A
0x0011	L3	.FILL x100B

Suppose we execute a TRAP x3 instruction at memory location xABCD. Show the MAR trace for the TRAP x3 call. **Give all the answers in HEX.**

You may not need to use all the blank boxes.

MAR Trace
xABCD

Scratch Page

LC-3 Instruction Set (Entered by Mark D. Hill on 03/14/2007; last update 03/15/2007)

PC': incremented PC. setcc(): set condition codes N, Z, and P. mem[A]:memory contents at address A.
SEXT(immediate): sign-extend immediate to 16 bits. ZEXT(immediate): zero-extend immediate to 16 bits.