CS/ECE 252: INTRODUCTION TO COMPUTER ENGINEERING

UNIVERSITY OF WISCONSIN—MADISON

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Examination 4
In Class (50 minutes)
Wednesday, Dec 14
Weight: 17.5%

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

This exam has 12 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 9.

LAST NAME: _____

FIRST NAME:_____

SECTION: _____

ID# _____

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

Q1. Syntax Error in LC-3 Assembly Codes (3 points)

a. (1 pt) Circle any illegal labels in an assembly language:

- NAND
- OR
- .FILL
- BLKW
- END
- ADD

b. (2 pt) The following program has multiple syntax errors. One of them, along with an explanation of the error, is indicated in the table below. In the two blank rows of the table, identify and explain two more syntax errors.

```
        .ORIG x3000
        LDI    R3, COUNT
        AND    R3, R3, M1
LOOP    LEA    R5, x2FF
        ADD    R5, R3, R4
        BRz    LOOP
        NOT    R3, R3, R3
HALT
M1       .FILL x5000
COUNT    .FILL #100
.END
```

Instruction	**Error**
AND R3, R3, M1	AND reg, reg, label is illegal
LOOP LEA R5, x2FF	x2FF is > PCoffset9 field for LEA
NOT R3, R3, R3	NOT reg, reg, reg is illegal

Q2. Two-Pass Assembly Process (5 points)

An assembly language LC-3 program is given below:

```
            .ORIG     x3000
L1          LEA       R1, L1
            AND       R2, R2, x0
            ADD       R2, R2, x3
            LD        R3, P1
L2          LDR       R0, R1, xC
            TRAP      x21             ; OUT (Write char)
            ADD       R3, R3, #-1
            BRz       GLUE
            ADD       R1, R1, R2
            BRnzp     L2
GLUE        HALT
P1          .FILL     x7
            .STRINGZ  "HGWioeTolhdceborymeee"
            .END
```

a. Fill in the symbol table created by the first pass of the assembler on the above program. **(2 points)**

Symbol Name	Address
L1	x3000
L2	x3004
GLUE	x300A
P1	x300B

b. After the program is assembled and loaded, what binary pattern is stored in memory location x3005? **(1 point)**
TRAP x21 -> 0xF021 -> 1111 0000 0010 0001

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

Q3. Logical Error (4 points)

We want the following code to shift the value at memory location M1 to the left by the number of bits stored at memory location M2, but there is **one** error in this code.

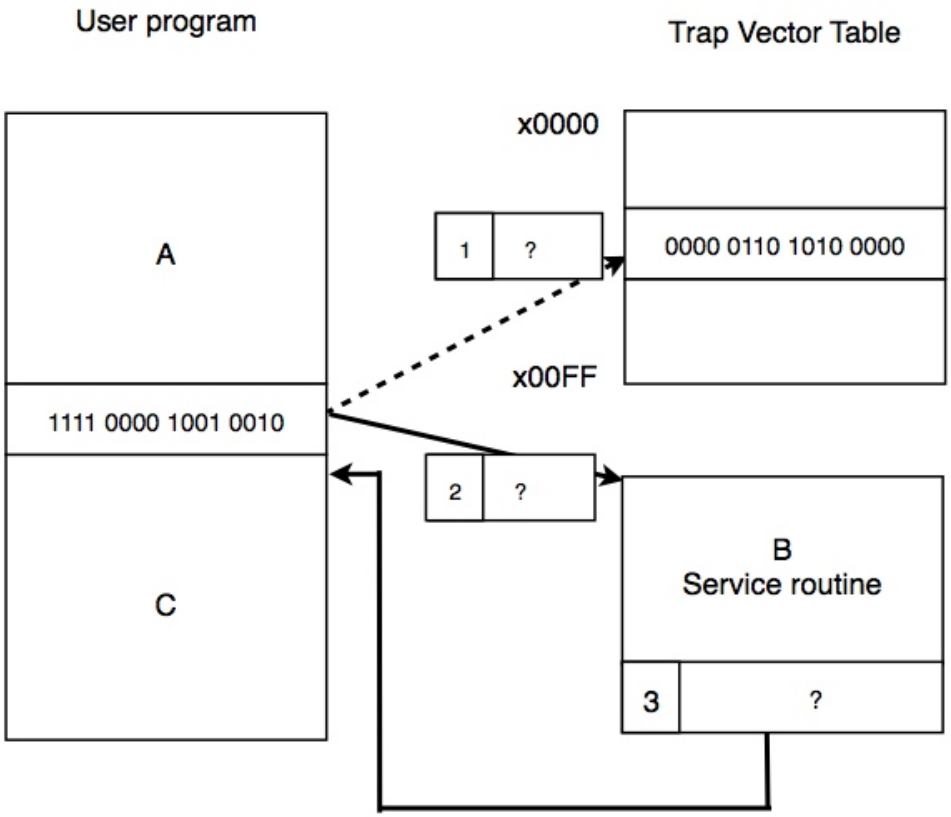
```
            .ORIG       x3000

            LD          R1, M1
            LD          R2, M2

LOOP        BRz         DONE
            ADD         R2, R2, #-1
            ADD         R1, R1, R1
            BR          LOOP
DONE        HALT


M1          .FILL       x0005
M2          .FILL       x0004
            .END
```

1. How many times does the instruction labeled LOOP get executed?**(2 points)**
   16+1 = 17 times

2. What is wrong with this program ?**(2 point)**
   ADD R2, R2, #-1 and ADD R1, R1, R1 are misplaced, they should exchange their location.

Q4. Trap Handling (3 points)

The figure shown below represents the flow control from a user program to an OS service routine and back when a trap instruction is called. The flow control goes from A within a user program, to B, the operating system service routine, and back to the user program C. Fill out the the three empty boxes below corresponding with question marks. Boxes 1 and 2 should be filled with addresses and box 3 should be filled with an instruction. Write your answers in hexadecimal.



1	2	3
x0092	x06A0	xC1C0

Q5. Traps and subroutines (5 points)

An LC-3 programmer wrote the code below to read 10 single-digit decimal numbers from the keyboard, compute their average, and display the ceiling of the resultant average on the monitor.

Fill in the blanks below with assembly code to complete the program.

```
            .ORIG     x3000

            AND       R2, R2, #0      ; R2 keeps track of the sum
            LD        R6, CHtoD       ; Char->Digit template
            LD        R5, DtoCH       ; Digit->Char template
            LD        R7, COUNT       ; Initialize to 10
            ST        R7, SAVEDREG    ; Save ?? upon call of trap
AGAIN       TRAP      x23             ; Get char
            LD        R7, SAVEDREG    ; Restore ?? before continuing
            ADD       R0, R0, R6      ; Convert to number
            ADD       R2, R2, R0      ; Add the new number to the sum
            ADD       R7, R7, -1      ; Decr counter
            ST        R7 , SAVEDREG   ;
            BRp       AGAIN           ; More digit?
            LD        R1, COUNT       ;
            JSR       DIV
            ADD       R0, R0,R5       ; Convert to char
            TRAP      x21             ; Output char
            HALT

; DIV subroutine
; Args: R2,R1  RET: R0=R2/R1

DIV         AND       R0, R0, #0      ; Initialize to 0
            NOT       R1, R1          ;
            ADD       R1, R1, #1      ; Negate R1
LOOPDIV     ADD       R0, R0, #1
            ADD       R2, R2, R1
            BRP       LOOPDIV
            RET

DtoCH       .FILL           x0030
CHtoD       .FILL           xFFD0
COUNT       .FILL           #10

SAVEDREG    .BLKW           1
            .END
```

Q6. Short Answer Questions (5 points)

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

1. What problem could occur if the keyboard hardware does not check the DSR before writing to the DDR? (1 point)

The DSR bit 15 indicates when the last character written in the DDR has been read by the display, so if we don't check we could overwrite the previous value before it has been displayed by the monitor.

2. What is the difference between asynchronous and synchronous I/O? (1 point)

Asynchronous I/O:
- Data is not sent at a fixed rate
- Needs some method of synchronization (e.g. handshaking) with the processor

Synchronous I/O
- Data is sent at a fixed rate
- Doesn't need additional synchronization

3. What is the difference between memory mapped I/O and special I/O instructions? (1 point)

Memory mapped I/O has reserved locations in memory that store the addresses of the I/O devices and corresponding registers whereas special I/O instructions use special opcodes for I/O.

4. Give one potential benefit and one potential drawback of RFID implants (2 points).

Benefits: storage of personal health information, usage as personal ID
Drawbacks: privacy concerns, concerns about body integrity

Q7. General Questions (5 points, 1 point each)

Circle the **best** answer for the following questions about LC-3:

1. Which of the following can be used only once per file?
   a. .BLKW
   b. .STRINGZ
   c. .FILL
   d. .ORIG

2. Which of the following is true about "callee-save"?
   a. Used by called routine to save registers used by the routine
   b. Save R7 before calling TRAP x23
   c. Save R0 before calling TRAP
   d. Used by calling routine to save and restore registers that will be used in the routine

3. Suppose the instruction `JSR label` is stored at memory location x4000. After the instruction is executed, which of the following is true if label=x3050 and R7=x4000 before execution?
   a. R7 = x3050
   b. R7 = x3001
   c. R7 = x4000
   d. R7 = x4001

4. Which bit in the KBSR is the interrupt enable bit?
   a. 12
   b. 13
   c. 14
   d. 15

5. Which of the following is **not true** about interrupt driven I/O?
   a. The device controls the interaction by sending a special signal to the processor when it is ready
   b. The processor must routinely check the status register for the device until new data arrives or the device is ready
   c. It has built in priority levels for different device requests
   d. It is more efficient than polling