CS/ECE 252: INTRODUCTION TO COMPUTER ENGINEERING

UNIVERSITY OF WISCONSIN—MADISON

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Examination 4
In Class (50 minutes)
Wednesday, Dec 14, 2011
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 Errors in LC-3 Assembly Code (3 points)

a. Circle any illegal labels in an assembly language programs: **(1 point)**

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

b. 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. **(2 points)**

```
            .ORIG x3000
            LDI       R1, COUNT
            AND       R1, R1, M1
LOOP        LEA       R0, x2FF
            ADD       R0, R1, R2
            BRz       LOOP
            NOT       R1, R1, R1
            HALT
M1          .FILL     x4000
COUNT       .FILL     #100
            .END
```

Instruction	**Error**
`AND R1, R1, M1`	`Can't use a label as operand`

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  "GWHoeiolTdchboeymreee"
            .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	
L2	
GLUE	
P1	

b. After the program is assembled and loaded, what binary pattern is stored in memory location x3005? **(1 point)**

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

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.

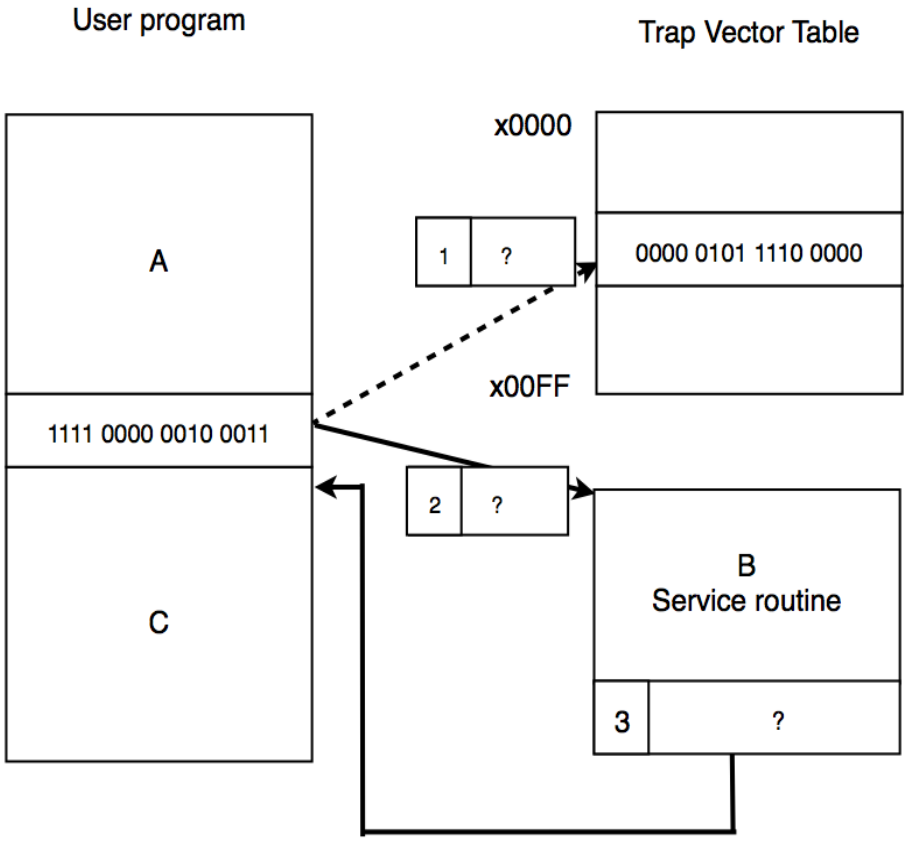
```
          .ORIG     x3000

          LD        R1, M1
          LD        R2, M2

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

M1        .FILL     x000C
M2        .FILL     x0004
          .END
```

a. How many times does the instruction labeled LOOP get executed? Explain. **(2 points)**

b. What is wrong with this program? Explain. **(2 points)**

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, 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

Q5. Traps and subroutines (5 points)

An LC-3 programmer wrote the code below to read 10 single digit decimal number 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        __, SAVEDREG    ; Save ?? upon call of trap
AGAIN     TRAP      x23             ; Get char
          LD        ____________    ; 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        __, SAVEDREG    ;
          BRp       AGAIN           ; More digit?
          LD        R1, COUNT       ;

          ____      ____________
          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

          ____      ____________
          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 display hardware does not check the DSR before writing to the DDR? (1 point)

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

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

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

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. .STRINGZ
    b. .BLKW
    c. .ORIG
    d. .FILL

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

3. Suppose `JSR label` is stored at memory location x3000. 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 = x3000
    d. R7 = x4000

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

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. It is more efficient than polling
    c. It has built in priority levels for different device requests
    d. The processor must routinely check the status register for the device until new data arrives or the device is ready

Scratch Page

ASCII Table

Character	*Hex*	*Character*	*Hex*	*Character*	*Hex*	*Character*	*Hex*
nul	00	sp	20	@	40	`	60
soh	01	!	21	A	41	a	61
stx	02	"	22	B	42	b	62
etx	03	#	23	C	43	c	63
eot	04	$	24	D	44	d	64
enq	05	%	25	E	45	e	65
ack	06	&	26	F	46	f	66
bel	07	'	27	G	47	g	67
bs	08	(	28	H	48	h	68
ht	09	)	29	I	49	i	69
lf	0A	*	2A	J	4A	j	6A
vt	0B	+	2B	K	4B	k	6B
ff	0C	,	2C	L	4C	l	6C
cr	0D	-	2D	M	4D	m	6D
so	0E	.	2E	N	4E	n	6E
si	0F	/	2F	O	4F	o	6F
dle	10	0	30	P	50	p	70
dc1	11	1	31	Q	51	q	71
dc2	12	2	32	R	52	r	72
dc3	13	3	33	S	53	s	73
dc4	14	4	34	T	54	t	74
nak	15	5	35	U	55	u	75
syn	16	6	36	V	56	v	76
etb	17	7	37	W	57	w	77
can	18	8	38	X	58	x	78
em	19	9	39	Y	59	y	79
sub	1A	:	3A	Z	5A	z	7A
esc	1B	;	3B	[	5B	{	7B
fs	1C	<	3C	\	5C	|	7C
gs	1D	=	3D	]	5D	}	7D
rs	1E	>	3E	^	5E	~	7E
us	1F	?	3F	_	5F	del	7F

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.