Department of Electrical and Computer Engineering
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EE 306, Fall, 2008
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Exam 2, November 12th, 2008

Name:_____

Problem 1 (35 points):_____

Problem 2 (15 points):_____

Problem 3 (15 points):_____

Problem 4 (20 points):_____

Problem 5 (15 points):_____

Total (100 points):_____

Note: Please be sure that your answers to all questions (and all supporting work that is required) are contained in the space provided.

Note: Please be sure your name is written legibly on each sheet of the exam.

I will not cheat on this exam.

_____
Signature

GOOD LUCK!

Name:_____

Problem 1 (35 points)

Part a (6 points): Perform Pass one of the LC-3 Assembler (create the symbol table) for the following LC-3 Assembly Language program:

```
         .ORIG x4040
         LD    R1,A
AGAIN    BRzp  SKIP
         ADD   R0,R1,R1
         TRAP  x23
         BRnzp AGAIN
HELP     .STRINGZ "Hello, Again"
A        .BLKW #10
SKIP     TRAP x25
B        .FILL x0200
         .END
```

Symbol	Address

Part b (6 points): The following assembly language program has **at most** 3 bugs.

```
         .ORIG x7000
         LD    R1,A
         LD    R2,B
         ADD   R1,R1,R1
         .FILL x1842
         .FILL xD07F
         TRAP  x25
A        .BLKW x200
B        .BLKW x1
         .END
```

Circle the instructions that have bugs, labeling each circle 1, 2, 3, etc. In the following boxes, one box per bug, state whether the bug will show up at Assemble time, Link time, or Run time, and explain why.

1:

2:

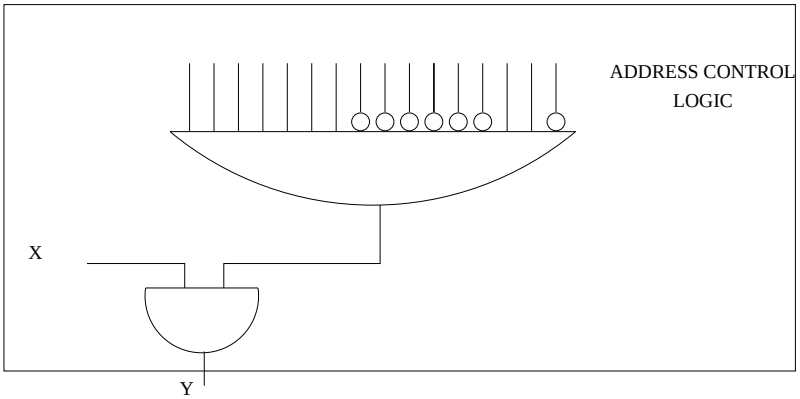
3:

Name:_____

Part c (7 points): What does the following program do?

```
        .ORIG x3000
        LD R1, NUM
        LDR R1, R1, #0
        BRzp SKIP
        NOT R1, R1
        ADD R1, R1, #1
SKIP    ADD R0, R1, #0
        HALT
NUM     .FILL x4000
        .END
```

Part d (7 points): In class, we have discussed the Address control logic which generates the control signals for the Memory and the I/O device registers. We have included Figure 8.9 with this exam for your reference, if needed. Part of that logic is the 16-input AND gate and 2 input AND gate shown below.



What does the input at X signify?(be **specific**)

What is the purpose of the output at Y?

Name:_____

Part e (7 points): The following assembly language program is assembled and then executed.

```
        .ORIG x3000
AGAIN   LD    R1,A
        NOT   R1,R1
        ST    R1,A
A       .FILL x0FDA
        BRnzp AGAIN
        .END
```

Will this program halt? If yes, explain why. If no, explain why not.

Name:_____

Problem 2 (15 points)

Part a: During one clock cycle of the correct execution of a particular LC-3 instruction, the values of select signals MARMUX, ADDR1MUX, and ADDR2MUX are as shown below, and highlighted on Figure 5.18, which we have provided.

Note: The highlights shown on Figure 5-18 apply **only** to Part a and are irrelevant to Part b of this problem.

MARMUX:	1	ADDR1MUX:	1	ADDR2MUX:	00

What is the opcode of the instruction being processed?

Part b: A different opcode is LD, which in machine language is 0010. During the execution of a LD instruction, after the instruction has been decoded, one clock cycle must be devoted to loading MAR with a proper address.

Specify the values of the select signals MARMUX, ADDR1MUX and ADDR2MUX that are necessary to load MAR appropriately.

MARMUX:		ADDR1MUX:		ADDR2MUX:	

Name:_____

Problem 3 (15 points)

A programmer wrote the following program which was assembled and executed. Execution started with PC at x3000.

```
          .ORIG x3000

          LEA R0, Message
          TRAP x01
          TRAP x22 ; What is the output here?
          TRAP x25

Message .STRINGZ "Cat in the hat."

         .END
```

Assume that the Trap Vector Table includes the following entries in addition to the ones we have previously used:

Memory Address	Memory Contents
x0000	x0100
x0001	x0102
x0002	x0107
x0003	x010A

Assume further that additional trap service routines have been loaded previously in memory as specified below:

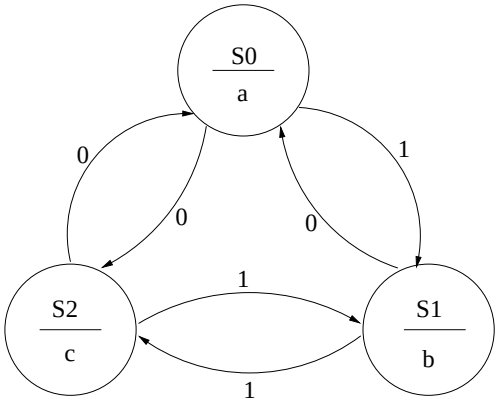
```
         .ORIG x0100

         LD R7, SaveR7
         RET
         ST R7, SaveR7
         TRAP x02
         AND R1, R1, #0
         STR R1, R0, #3
         RET
         AND R1, R1, #0
         STR R1, R0, #5
         TRAP x00
         RET
SaveR7 .BLKW #1

         .END
```

What is the result of execution of this program (in 20 words or fewer)?

Name:_____

Problem 4 (20 points)

The state machine shown below will produce an output sequence if it receives an input sequence. The intial state is S0.



For example, the input sequence 100 produces the output sequence bac.
We have written a program that simulates this state machine. Inputs are requested from the keyboard, and the corresponding outputs are shown on the screen. For example, for the input sequence shown above, the monitor would display

```
INPUT (either 0 or 1): 1
OUTPUT: b
INPUT (either 0 or 1): 0
OUTPUT: a
INPUT (either 0 or 1): 0
OUTPUT: c
```

Your job: Complete the program that simulates the state machine, by filling in each blank box with **one** missing line of LC-3 assembly language code.

Note: You can assume the person at the keyboard can type a 1 or a 0 without error (i.e., you do not have to test for wrong input).

```
        .ORIG  x3000
        LEA  R6, S0

Loop    [                                   ]

        TRAP x22
        TRAP x20 ; inputs a character
        TRAP  x21

        LD R1, NEGASCII
        ADD R0, R0, R1

        [                                   ]

        LDR R6, R6,#0
        LD R0, NEWLINE
        TRAP x21
        LEA  R0, OUTPUT
        TRAP x22

        [                                   ]

        TRAP x21
        LD R0, NEWLINE
        TRAP x21
        BRnzp LOOP

S0      .FILL S2
        .FILL S1
        .FILL x0061

S1      .FILL S0
        .FILL S2
        .FILL x0062

S2      .FILL [          ]
        .FILL [          ]
        .FILL [          ]

NEGASCII .FILL xFFD0 ; the value -48
OUTPUT   .STRINGZ       "OUTPUT:"
INPUT    .STRINGZ       "INPUT (either 0 or 1):"
NEWLINE  .FILL x000A

.END
```

Name:_____

Problem 5 (15 points)

The table below shows the partial contents of the MAR and the MDR for seven consecutive memory accesses during execution of a program. We call such a sequence a "memory trace."

Your job: Complete all entries in the memory trace, and explain what, if anything, is displayed on the monitor before the program halts.

Memory Access	MAR	MDR (bit 15 … bit 0)
1	x3000	0 0 1 0 0 0 0 0 0 0 1 0 1 1 1 1
2		
3		0 0 0 0 1 1 1
4	x3022	0 0 1 1 0 0 0 0 0 0 0 0 0 0 0 0
5		
6	x3024	1 1 1 1 0 0 0 0 0 0 1 0 0 0 0 1
7	x3025	1 1 1 1 0 0 0 0 0 0 1 0 0 1 0 1

The original assembly language program contained the line:

LABEL .FILL xF025

In performing its job the Assembler created the symbol table entry:

LABEL x3030