CS/ECE 252: INTRODUCTION TO COMPUTER ENGINEERING

UNIVERSITY OF WISCONSIN—MADISON

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Examination 3
In Class (50 minutes)
Wednesday, April 7, 2017
Weight: 17.5%

NO: BOOK(S), NOTE(S), CALCULATORS OR ELECTRONIC DEVICES OF ANY SORT.
The exam has ten pages. You must turn in the pages 1-9. Circle your final answers. Plan your time carefully since some problems are longer than others. Use the blank sides of the exam for scratch work.

LAST NAME: _____
FIRST NAME: _____
ID#: _____

Problem	Maximum Points	Points Earned
1	3	
2	3	
3	4	
4	5	
4	5	
6	3	
7	3	
Total	26	

Problem 1

Write all the missing comments for the LC-3 binary code shown in the table below. (3 points)

Address	Instruction	Comment
0x3000	0010 000 000101011	R0 <- M[0x302C]
0x3001	0010 001 000101011	
0x3002	1001 011 001 111111	R3 <- NOT (R1)
0x3003	0001 011 011 1 00001	
0x3004	0001 010 000 0 00 011	R2 <- R0 + R3
0x3005	0000 100 000000010	
0x3006	0011 000 000100111	
0x3007	0000 111 000000001	
0x3008	0011 001 000100101	
0x3009	1111 0000 0010 0101	HALT

Problem 2

Given the initial values at the following registers and memory locations, fill in the values at the memory locations below after each instruction is executed. The instructions are executed **in order**. So, instruction at location x4000 has finished execution before instruction at x4001 begins, and so on. You may assume that all other registers and memory locations are set to 0.

Address	Initial Memory Values
R0	x4021
R1	x4022
R2	x4023
x4020	x4021
x4021	x4022
x4022	xFFFE

Address	LC-3 Binary Instruction	Values at memory locations after execution

x4000	0110 010 000 000001	Value at x4020: Value at x4021: Value at x4022:
x4001	0001 001 010 0 00 001	Value at x4020: Value at x4021: Value at x4022:
x4002	0111 010 001 000000	Value at x4020: Value at x4021: Value at x4022:

Problem 3 The following pseudo-code presents an algorithm to check if the data present in R1 is greater than 3. The table below shows an incomplete LC-3 binary program that implements this logic. **Assume that R1 has been initialized to the data value being checked.**

```
R1 = R1 - 3
R2 = 0
If R1 > 0 then:
        R2 = 1
end if
HALT
```

Assume PC is x3000 when execution of the program starts.

Address	Instruction
0x3000	0101 010 010 1 00000
0x3001	
0x3002	
0x3003	0001 010 010 1 00001
0x3004	1111 0000 00100101

a) Complete the code to implement the algorithm in the above table by filling in the missing LC-3 binary instructions in memory locations 0x3001 and 0x3002.

b) By looking at the algorithm logic above, a student incorrectly concludes that if R2 = 1 at the **end** of program execution, the value in R1 at program **start** must be **greater than** 3. Provide at least one example of a value in R1 for which the above conclusion is incorrect.

c) Which of the following programming construct does the above algorithm use?

i) Iterative

ii) Conditional

Problem 4

a) Briefly explain what the following LC-3 instruction does:

```
0000 111 000 0 00000
```

b) Which of the following instructions **does not** change the condition code of LC-3 after execution? **You must explain your answer for full credit.**

```
a) 0001 010 000 000 001
b) 0110 011 010 000011
c) 0111 011 010 000011
d) 1010 110 000000011
```

c) How many memory accesses does the STI instruction in LC-3 ISA make? **You must explain your answer for full credit.**

d) Briefly explain the difference between syntax errors and logical errors.

e) The following instruction is located in memory at 0x3000.

```
0000 111 00000111
```

What is the value of PC after the instruction finishes execution? Assume n = 1, z = 0, p = 0 before the instruction begins execution.

Problem 5

The following table shows an incomplete program located in memory. Assume PC = x3000 before the program starts execution.

Address	Instruction	Comments
0x3000		R1 <- NOT (R1)
0x3001		R2 <- NOT (R2)
0x3002		R3 <- R1 AND R2
0x3003	1001 011 011 1 11111	R3 <- NOT R3

0x3004		M[x4000] <- R3
0x3005	1111 0000 00100101	HALT
0x3006	0100 0000 0000 0000	.FILL x4000

a) Fill in the missing LC-3 binary instructions from the comments provided.

b) The following table shows the values in select registers and condition flags before the execution of the above program begins. Write the values in these locations just **after** the program finishes execution (i.e. after HALT has finished execution).

Register/Condition flag	Value before execution starts	Value after execution completes
R1	0x000A	
R2	0x000B	
R3	0x0000	
n	1	
p	0	
z	0	
M[x4000]	0x0000	

Problem 6

a) Write a **single** LC-3 instruction to load the number x2FF0 into R5. Your instruction will be located at x3000.

b) Write a **single** LC-3 instruction to store the data from register R3 into memory address x4010. Your instruction will be located at x4000.

c) Write **up to two** LC-3 instructions that will subtract the number 30 from R2 and place the result in R3.

Problem 7

The tables below show the contents of a few memory locations and registers before and after an LC-3 instruction at location x2000 is executed. Identify the instruction located at **x2000** given the information below. Write its LC-3 16-bit binary form and comment what it does. **Explain how you arrived at your answer for full credit.**

	Before	After
R0	xFF35	xFF35
R1	xF911	xF911
R2	x67F9	x0146
R3	x0912	x0912
R4	x8231	x8231
R5	xE981	xE981
R6	x0901	x0901
R7	x3040	x3040
x304D	x1091	x1091
x304E	x7684	x7684
x304F	x0146	x0146
x3050	xEFFF	xEFFF
x3051	x1021	x1021
x3052	x99DF	x99DF
x3053	x4782	x4782

Instruction:

LC-3 Binary Form	Comment

Explanation: