CS/ECE 252: INTRODUCTION TO COMPUTER ENGINEERING

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

The exam has **ten** pages. **Circle your final answers**. Plan your time carefully since some problems are longer than others. You **must turn in the pages 1-9**. Use the blank sides of the exam for scratch work.

Note: LC-3 instruction set is provided on Page 10

LAST NAME: _____

FIRST NAME: _____

ID#: _____

Problem	Maximum Points	Points Earned
1	3	
2	2	
3	2	
4	6	
5	5	
6	6	
7	6	
Total	30	

Problem 1   **(3 points)**

a. **(1 point)** Which of the following LC-3 instructions performs R3 = R3 + R2?

    i.   `0001 011 010 0 00 010`
    ii.   `0001 011 010 0 00 011`
    iii.   `0001 010 010 0 00 011`
    iv.   `0001 010 011 0 00 011`

b. **(1 point)** The LC-3 branch instruction `0000 101 000011110` is located at memory address `0x4000`. If the branch is taken, what does that imply about the values of the condition codes before the instruction is executed?

    i.   Both N = 1 and Z = 1, and P = 0.
    ii.   Either N = 1 or Z = 1, and P = 0.
    iii.   Both N = 1 and P = 1, and Z = 0.
    iv.   Either N = 1 or P = 1, and Z = 0.

c. **(1 point)** Which of the following instructions loads the data at address `0x3010` into R2? Assume that R1 contains `0x3005`. Also, assume that each instruction below is located at address `0x3000`.

    i.   `0010 010 000001001`
    ii.   `0110 010 001 000101`
    iii.   `1110 010 000001001`
    iv.   Both i and ii, and not iii
    v.   Both ii and iii, and not i
    vi.   All three of them,ie, i, ii and iii.

3

Problem 2 (2 points)

Assume that the following instructions are a part of a program and that the second instruction (which is a branch) is taken:

```
0001 0000 0011 1000
0000 0100 0000 0111
```

What was the value of R0 just before executing these two instructions?

R0 = 8

Problem 3 (2 points)

An LDR instruction, located at `0x3000`, uses R1 as its base register. The value currently in R1 is `0x2000`.

a. **(1 point)** What is the largest address this instruction can load from?

Largest address = 0x2000 + 0x1F

b. **(1 point)** What is the smallest address this instruction can load from?

Smallest address = 0x2000 - 0x20

4

Problem 4 **(6 points)**

Given below are six instructions that writes some value into register R2. Assuming that initial values of R0 = 0x0081 and R1 = 3 before executing each of these instructions, specify which value is getting stored in R2 after executing each instruction. You can assume that each of these instructions is located at `0x3000`.

a. **(1 point)** `0001 010 001 0 00 000`

   R2 = 0x0084

b. **(1 point)** `0001 010 001 1 00000`

   R2 = R1+0 = 3

c. **(1 point)** `0101 010 001 0 00 000`

   R2 = R1 AND 0x3 = 0x1

d. **(1 point)** `0101 010 000 1 10000`

   R2 = 0x0080

e. **(1 point)** `1001 010 001 111111`

   R2 = 1111 1111 1111 1100 = 0xFFFC

f. **(1 point)** `1110 010 000000001`

   R2 = 0x3002

Problem 5 **(5 points)**

Assume that the initial value of R0 = 5 and that the initial value of R2 = 0.

a. **(3 points)** Fill in the three missing comments for the program below.

Instruction address	Instruction	Comments
0x3000	0001 010 010 1 00010	ADD R2, R2, #2
0x3001	0001 000 000 1 11111	ADD R0, R0, #-1
0x3002	0000 101 111111101	BRnp 0x3000
0x3003	1111 0000 0010 0101	HALT

b. **(2 points)** What is the value of R2 upon reaching the HALT instruction?

Loop repeats 5 times since R0 = 5
=> R2 = 2*5 = 10 = 0xA

Problem 6   **(3 points)**

Assume that the initial contents of R0 = `0x3010` and R1 = `0x3011`. Also, assume that the initial values of memory locations from `0x300F` to `0x3012` are all zeros.

For each of the instructions below, starting at `0x3000`, specify what the values of memory locations `0x300F` to `0x3012` are after executing each instruction.

Instruction address	Instruction	Values at memory locations after executing the instruction
0x3000	0011 000 000001111	Value at `0x300F`:0x0 Value at `0x3010`:0x3010 Value at `0x3011`:0x0 Value at `0x3012`:0x0
0x3001	0111 001 000 000010	Value at `0x300F`:0x0 Value at `0x3010`:0x3010 Value at `0x3011`:0x0 Value at `0x3012`:0x3011
0x3002	1011 001 00001111	Value at `0x300F`:0x0 Value at `0x3010`:0x3010 Value at `0x3011`:0x3011 Value at `0x3012`:0x3011

Problem 7   **(7 points)**

We are about to execute the program below. Assume that the condition codes before

execution are N = 1, Z = 0, P = 0.

Address	Instruction	Comments
0x3000	0011 001 000001011	Store R1 into location 0x300C
0x3001	0000 100 000000011	If N flag is set, branch to 0x3005
0x3002	0001 000 000 1 11011	R0 <- R0 - 5
0x3003	0101 010 010 0 00 000	R2 <- R2 AND R0
0x3004	1111 0000 0010 0101	HALT
0x3005	1010 010 000000100	LDI R2, 0x300A
0x3006	1111 0000 0010 0101	HALT

a. **(4 points)** Fill in the four missing instructions in the program above.

b. **(3 points)** Suppose a section in memory **before** execution of the program is as follows:

Address	Value
0x300A	0x300C
0x300B	0x300F
0x300C	0xACED
0x300D	0x300B

Given the initial values of the below registers, fill in the values after the program has completed execution (reached a HALT). Give your answers in **hex**.

Register	Initial Value	Final Value
R0	0xFACE	0xFACE
R1	0x1234	0x1234
R2	0x300A	0x1234