ECE 109 Sections 602 to 605
Exam 2 Fall 2007
6 November, 2007

This is a closed book and closed notes exam. Calculators, PDA's, cell phones, and any other electronic or communication devices may not be used during this exam.

Violation of these rules will be considered a violation of the NCSU Code of Student Contact.

Please read and sign the following statement:

I have neither given not received unauthorized assistance on this test.

Name: ________________________________

This exam is to be turned in by 5:45 pm.

Show your work if you want it to be considered for partial (*and* full) credit!

Problem 1 (15 points) Data Path
In the table below, the columns correspond to two LC/3 instructions and the rows to the six phases of the LC/3 instruction cycle as described in the textbook. Within this table describe how the **PC, MAR, MDR, and register files** of the LC/3 datapath are used or modified in each instruction cycle phase for the two instructions. [The FETCH and DECODE rows only have one cell, since these two phases act similarly for all instructions.]

	`ADD R3, R4, #5`	`LDR R3, R4, #5`
FETCH		
DECODE		
EVALUATE ADDRESS		
FETCH OPERANDS		
EXECUTE		
STORE RESULT		

Problem 2 (15 points) Memories

Using the symbol table shown below

BASIE	x3442
CARMICHAEL	x3462
DORSEY	x3482
ELLINGTON	x34A2

write the appropriate 16-bit LC-3 machine language word, in binary or hex, for each assembly language statement shown in the left column. Assume that the instruction is located at address x3400 in all cases. If the assembly language statement is illegal, state the reason why this is so.

ADD R0,R2,#12	
AND R7,R7,x12	
AND R7,R7,R7	
BRnp DORSEY	
BRpz BASIE	
LD R3,CARMICHAEL	
LEA R2,ELLINGTON	
NOT R5,R6	
STI R5,BASIE	
STR R3,R4,x14	
TRAP x55	

Problem 3 (15 points)

The binary program shown in the left column below is loaded into memory at location x3000. In the right column, write the LC/3 assembly instructions or appropriate psuedo-ops corresponding to this program. Be sure to include appropriate labels and .ORIG and .END statements.

Binary	Assembly
0101000000100000	
1010100000000101	
0000011000000001	
0001000000100001	
0001100100000100	
0000101111111100	
1111000000100101	
0100000000000000	

Problem 4 (15 points)

Assume that the eight LC/3 registers have the values shown on the left below and that the eight words of memory starting at memory location x3020 have the values shown on the right.

Register	*Value*
R0	x0000
R1	x0001
R2	x0002
R3	x0003
R4	x0004
R5	x0005
R6	x4444
R7	x5555

Address	*Value*
x3020	x0000
x3021	x0001
x3022	x0002
x3023	x0003
x3024	x0004
x3025	x0005
x3026	x6666
x3027	x7777

For ***six*** *of the following* ***seven unanswered*** *cases* shown below, write either a single LC/3 instruction or a series of two LC/3 instructions to load the value stored in the specified memory location into register 5. Assume that each instruction is located at memory address x3010.

Only three of the seven require the use of two instructions. Because I'm only grading six of the seven, you can miss one without penalty. In the difficult cases, you'll do well to give an explanation of your strategy.

x3021	LD R5,x10
x3111	
x4424	
x4444	
x4464	
x6666	
x6667	
x8888	

Problem 5 (40 points)

In this long question of many parts, write little (many only two or three instructions long) LC/3 programs to solve the following small problems. Answers that are unnecessary long or complicated will not receive full credit.

Write LC/3 code to set R3 to 5.

Write LC/3 code to turn "off" bits 3 to 0 of register R2. For example, if R2 contains x8ADE, it should be set to x8AD0. In other words, "and" R2 with xFFF0.

Write LC/3 code to set R5 from R3, according to the following formula:

```
     R5 = 3*R3 + 1
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Write LC/3 code to subtract R3 from R4. The result should be stored in R5. This is like computing the following equation:

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     R5 = R4-R3
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Write LC/3 code to compare R4 to zero and to (1) set R5 to R4, if R4 is positive, or (2) set R5 to 0, if R4 is negative. (This is similar to the IRS directive: "Enter line 4 in line 5, if line 4 is a positive number. Otherwise, enter 0".)

This exam was originally distributed with a 5th page with two more LC/3 programming subproblems for Problem 5. However, as the exam was taken those two pages were removed.