UNCA CSCI 255.001 and NCSU ECE 109 Sections 002, 602, 604, and 605
Final Exam Spring 2008
1 May, 2008

This is a closed book and closed notes exam. It is to be turned in by 4:45 pm. Calculators, PDA's, cell phones, and other electronic or communication devices may not be used during this exam. Please read and sign the following statement:

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

Name: _____

If you want partial credit for imperfect answers, explain the reason for your answer!

Problem 1 (6 points) Data Path

Once the following LC-3 instruction has been loaded into the IR and decoded

```
STR  R4,R5,#6
```

the actions listed below must be performed. Described how each of these actions is accomplished within the LC/3 data path by making specific reference to its components:

a) R5 and the immediate value #6 are added to generate a memory address

b) The generated memory address is sent to the memory module

c) The value in R4 is sent to the memory module and stored in memory.

Problem 2 (9 points) Hand assembled

The binary program shown in the left column below is loaded into memory starting at `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
0010010000000100	
0001000000000001	
0001010010111110	
0000001111111101	
1100000111000000	
1111111111111011	

Problem 3 (7 points) Floating point
Express the following three numbers in IEEE floating point notation. I've left some spaces between the major bit fields in the number. None of these answers should involve long calculations.

12.5 – –––––––– –––––––––––––––––––––––
0.125 – –––––––– –––––––––––––––––––––––
-12 – –––––––– –––––––––––––––––––––––

Problem 4 (4 points) Ranges
What is the largest number that be represented in 8-bit twos-complement notation?

What is the smallest number that can be represented in 8-bit twos-complement notation?

Problem 5 (4 points) Bitwise operations
Perform the following two bit-wise logical operations on 8-bit numbers expressed a two hexadecimal digits. Your answer should also be expressed in hexadecimal.

NOT(25) -->
AND(25,F0) -->

Problem 6 (6 points) Memories

a) How many **bits** are in a memory with 2K words and a word size of 64?

b) How many **bits** are required to address a memory with 16K words?

c) How many 8-bit words can be stored in a 1MB (1M byte) memory?

Problem 7 (6 points) Vocabulary

Compare and contrast three of the following four pairs of related terms. Cross out the one you do not want graded. Otherwise, I'll grade all four with equal weight.

Device data register vs Device status register
Combinational logic vs. Sequential logic
Assembly language vs. C
Programmed I/O vs Memory-mapped I/O

Problem 8 (3 points) C

What does the following program do when 255 and 109 are entered as input.

```
#include <stdio.h>
main() {
     int i, j ;
     scanf("%d", &i) ;
     scanf("%d", &j) ;
     i = i*2 ;
     j = j/2 ;
     printf("Your results are %d and %d", i, j) ;
}
```

(You most definitely do **not** need a calculator to solve this problem.)

Problem 9 (11 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 x1040 have the values shown on the right.

Register	***Value***
R0	x0000
R1	x0000
R2	x0000
R3	x0000
R4	x4111
R5	x5111
R6	x6111
R7	x7111

Address	***Value***
x1040	x4101
x1041	x5111
x1042	x6121
x1043	x7131
x1044	x0000
x1045	x0000
x1046	x0000
x1047	x0000

For the six addresses shown below, write a single LC/3 instruction to load the value **stored in** the specified memory location into register 4. (For example, when x1041 is specified, x5111 should be stored in R4.) Assume that each instruction is located at memory address x1020.

If this memory location cannot be loaded in one instruction, state why this is not possible.

x1052	
x1152	
x4101	
x4102	
x7131	
x7132	

Problem 10 (4 points)
Assuming the following symbol table with only one location

EGGHEAD	x3015

Write the appropriate 16-bit LC-3 machine language word, in binary or hex, for each assembly language statement shown in the left column of the table below. Assume that the instruction is located at address x3011 in both cases. If the assembly language statement is illegal, state the reason why.

LD R0,EGGHEAD	
ADD R2,R4,EGGHEAD	

Problem 11 (4 points) Adding
Add the following pairs of seven-bit two's complement numbers **and indicate which additions result in an overflow**.

1111111 + 1110100	1011111 + 1011111
0011000 + 0111111	0000111 + 1111001

Problem 12 (5 points) Transistors
In the space below, draw a CMOS implementation of a 2-input AND gate.

Problem 13 (6 points) Truth to Gates
Draw a circuit, at the gate level, that will implement the following truth table, where A, B, and C are inputs and where Z is the single output.

A	B	C	Z
0	0	0	0
0	0	1	0
0	1	0	1
0	1	1	1
1	0	0	0
1	0	1	0
1	1	0	0
1	1	1	1

Problem 14 (5 points) LC/3 programming
In this problem, write a section of LC/3 code that
1) tests the character in R0
2) sets R1 depending on the values of the character in R0
   a) R1 is set to 1, if the character in R0 is a space (ASCII x20)
   b) R1 is set to 0, if the character in R0 is not a space

Problem 15 (2 points) Simple L/3 subroutines
If Problem 14 were to be implemented as a subroutine that receives its input in R0 and returns its output in R1, what LC/3 instruction(s) would need to be added to your code?

Problem 16 (3 points) Not-so-simple LC/3 subroutines
Suppose Problem 14 were to be implemented as a subroutine that follows the LC/3 ABI presented in class (and pictured on the reference sheet) and the arguments were passed and returned on the stack.

Write a single LC/3 instruction that would load the input argument into R0.

Write a single LC/3 instruction that would store R1 into the return value slot for the subroutine.

(Big hint: Both of these instructions involve the use of register R5.)

Problem 17 (5 points)
Suppose R6 has the initial value of x5555. What are the values of register R1, R2, R3, R4, and R6 after the following sequence of PUSH and POP operations have been performed. Drawing the stack might increase your change of receiving partial credit. (Remember that in the PUSH operation R6 is decremented before a value is stored on the stack.)

```
PUSH  x2
PUSH  x3
POP   R1
PUSH  x5
PUSH  x7
POP   R2
PUSH  xB
POP   R3
POP   R4
```

PUSH x11

Problem 18 (10 points) LC/3 I/O

In this program you are going to write a little piece of LC/3 **twice** that

1) reads a character from the keyboard
2) outputs a single character to the display
   a) the output character is 'Y', if the input character is a space
   b) the output character is 'N', if the input character is not a space

(By the way, the ASCII value for space is `x20`, the ASCII value for 'Y' is `x59`, and the ASCII value for 'N' is `x4E`.)

First, write the code using the LC/3 `TRAP` routines. The names of the `TRAP` routines are on the reference sheet. This part should have a shorter answer than the next part.

Second, write the code using the LC/3 device data and status registers. This is part where you'll have to use polling. The addresses of the device registers are also on the reference sheet. You may use any `.FILL`'s you defined above in your answer here.