

NCSU ECE 109 Sections 602 and 603 and UNCA CSCI 255.001

Exam 3 Spring 2009

21 April, 2009

This is a closed book exam. No notes are allowed other than the “handy table” distributed with the exam. Calculators, PDA's, cell phones, and other electronic or communication devices may not be used during this exam.

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

Please read and sign the following statement:

I have neither given nor received unauthorized assistance on this test.

Name: \_\_\_\_\_

**Problem 1 (12 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	1
0	0	1	0
0	1	0	1
0	1	1	0
1	0	0	0
1	0	1	0
1	1	0	1
1	1	1	0

**Problem 2 (6 points) Loopy code**

Examine the following LC-3 code. Briefly explain what it does when it executes. If it gets into an “infinite” loop (that is, it never reaches the HALT), explain why this happens. If it reaches the HALT, state the final values of the registers when the program halts.

```
                AND    R4, R4, #0
LOOP           ADD    R4, R4, #5
                AND    R5, R4, #2
                BRZ    LOOP
                HALT
```

**Problem 3 (4 points) Memory-mapped I/O**

Write a *short* section of LC-3 code that uses the LC-3 device registers to write the value stored in register R2 to the display. No calls to TRAP routines are allowed on this question.

**Problem 4 (4 points) TRAP routines**

Write a *very short* section of LC-3 code that uses TRAP routines to write the character stored in register R2 to the display. No reading or writing of device registers is allowed in answers to this question.

**Problem 5 (8 points) A few calculations**

Write short pieces of LC-3 code to solve the following problems. For full credit, do not modify any LC-3 registers other than R2. Neither of these should require more than three lines of code.

Set R2 to  $8 * R5$

Subtract R0 from R1 and store the result in R2

**Problem 6 (6 points) Memory**

A computer memory has 24-bit words stored in 64 k locations. What is the size of this memory in bits?

How many address bits are needed to address the 64 k words of this memory?

**Problem 7 (24 points) Hand assembled**

Use the symbol table shown below in this question.

BUNCOMBE	x3307
HAYWOOD	x3367
MACON	x33C7
MADISON	x3447

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 x3302 in all cases. If the assembly language statement is illegal, state the reason why.

ADD	R0, R2, #-16	
ADD	R7, R7, MACON	
AND	R2, R3, #16	
BR	MADISON	
BRz	BUNCOMBE	
JSR	MADISON	
LD	R0, R5	
LDR	R2, R3, #20	
LEA	R2, R3, #20	
SUB	R3, R4, R5	
STI	R3, HAYWOOD	
STR	R3, R4, x20	

**Problem 8 (16 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 x3220 have the values shown on the right.

<i>Register</i>	<i>Value</i>	<i>Address</i>	<i>Value</i>
R0	x0000	x3220	x0000
R1	x0000	x3221	x0000
R2	x2222	x3222	x2121
R3	x3333	x3223	x3131
R4	x0000	x3224	x0000
R5	x0000	x3225	x5151
R6	x6666	x3226	x0000
R7	x0000	x3227	x0000

For the eight addresses shown below, write a single LC/3 instruction to load the value **stored in** the specified memory location into register R1. (For example, when x3222 is specified, x2121 should be stored in R1.) Assume that each instruction is located at memory address x3200.

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

x0011	
x2121	
x2222	
x3200	
x3284	
x3384	
X6656	
x6676	

**Problem 9 (20 points) Assignment 4 Revisited**

Write an LC-3 *subroutine* that performs the following task:

If R0 is an ASCII digit ('0' to '9' – ASCII x30 to x39)

Set R1 to 1 and return

If R0 contains a dollar sign (ASCII x24),

Set R1 to 2 and return

Otherwise

Set R1 to 3 and return