ECE 109 Sections 602 to 605
Final exam Fall 2007
13 December, 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 policy of the NCSU Code of Student Contact.

Please read and sign the following statement:

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

Name: ________________________________

This is a closed book exam! It is to be turned in by 4:00 pm.

Show your work if you want it to be considered for partial credit!

Problem 1 (6 points) Memories

a) How many **bits** are in a memory with 2K words and a word size of 32?

b) How many **bits** are required to address a memory with 64K words?

c) How many 16-bit words can be stored in a 2 KB memory?

Problem 2 (2 points) Overflow

Add the following pairs of six-bit two's complement numbers **and indicate which additions result in an overflow**.

110111 + 010010	010101 + 010101

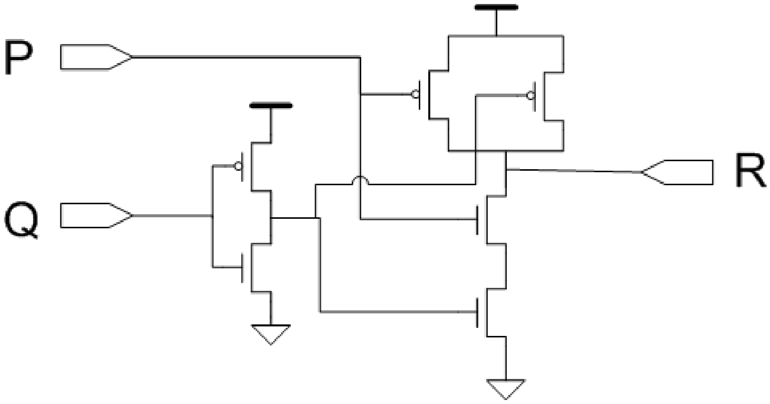
Problem 3 (2 points) Twos complement representation
Translate the following two decimal numbers into five-bit two's complement numbers. Show your work in the space below!

12	-11

Problem 4 (4 points) Fixed point numbers
Express 21.75 as a fixed point binary number. (Remember, 11.1 binary represents 3.5 decimal.)

Problem 5 (4 points) Logical foundations
In Chapter 2, we learned about deMorgan's law and twos-complement representation. How are these fundamental concepts used to perform the bitwise OR and arithmetic subtract operations in the LC/3?

Problem 6 (2 points) MOS to truth
Fill in the truth table on the right to represent the MOS circuit that is on the left. (This should be familiar.)



P	Q	R
0	0	
0	1	
1	0	
1	1	

Problem 7 (4 points) Truth to gates
Draw a circuit, at the gate level, that will implement the truth table, where Z in the single output variable, shown on the right below.

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

Problem 8 (4 points) Gates to MOS
Draw the MOS circuit that implements a 2-input OR gate.

Problem 10 (12 points) Vocabulary

Compare and contrast the following related pairs of terms. You may cross out one to indicate you don't want it graded. Otherwise I'll grade the first six you answer.

Assembly *versus* machine language

Combinational logic *versus* sequential logic

Conditional *versus* iterative execution

Interrupt-driven I/O *versus* pooling

Interrupt service routine *versus* system call

MAR *versus* MDR

Sign-extension *versus* sign-magnitude

Problem 10 (6 points) Assembling

Using the symbol table shown below

CASH	x4023
LYNN	x4057
NELSON	x40A3
PARTON	x4123

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.

AND R0,R5,#3	
AND R7,NELSON	
BRnzp LYNN	
BRp PARTON	
JSR R3	
JSR PARTON	
JSRR R5	
LEA R2,CASH	
RET	
SUB R3,R3,R3	
STR R7,R3	
STR R3,R6,#-3	
TRAP x15	

Problem 11 (6 points) Reverse engineering

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
0101100000100000	
0001100100100001	
0010011000000100	
1000000011000000	
0101101000111111	
0000011111111011	
1111000000100101	
0101000000000000	

Problem 13 (12 points) Being JSR'ed around

The following program ***really*** has been successfully assembled and simulated on the LC/3 software.

```
          .ORIG   x3000                ; instruction location
START     AND     R1,R1,#0             ; x3000
          LEA     R5,START             ; x3001
          LDI     R3,ADD1              ; x3002
          JSRR    R3                   ; x3003
          ADD     R1,R1,x9             ; x3004
          JSR     LABZ                 ; x3005
LABX      ADD     R1,R1,x3             ; x3006
LABZ      AND     R3,R1,x4             ; x3007
          BRp     STOP                 ; x3008
          RET                          ; x3009
STOP      STR     R1,R5,#12            ; x300A
          HALT                         ; x300B
ADD1      .FILL   ADD2                 ; x300C
ADD2      .FILL   LABX                 ; x300D
          .END
```

The last two .FILL's really are legal LC/3 pseudo-ops. If it makes you more comfortable, you can replace them with the following more obscure, though equivalent, pseudo-ops.

```
ADD1      .FILL   x300D
ADD2      .FILL   x3006
```

Your jobs is to describe what the LC/3 will do while executing this code until either (1) you have filled the following table or (2) the LC/3 executes the HALT trap. Put the address of each instruction in the left column and its action in the right column. I've filled in one for you.

x3000	Sets R1 to 0
x3001	

Problem 13 (16 points) LC/3 programming
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 stated in a C-like syntax. Answers that are unnecessary long or complicated may not receive full credit.

```
R3 = R5 + 18 ;
```

```
R5 = R7 - R3 ;
```

```
R4 = R3 ;
```

```
while (R1<93) {
     R1 = 3*R1 ;
}
```

```
if (R4 > 0 && R3>0) {
     R5 = 15 ;
}
```

```
if (R5 == 'n') {
    R5 = 'N' ;
}
```

Problem 14 (2 point) POP and PUSH

Draw the stack the results from the following sequence of pop and push operations and write the value retrieved on the two `POP` operations.

```
PUSH 15 ;
PUSH 109 ;
POP ;
PUSH 209 ;
PUSH 15 ;
POP ;
```

Problem 15 (4 points) Device registers

Using the keyboard status and data registers (`KBSR` and `KBDR`) and none of the LC/3 trap routines, write a silly LC/3 trap routine that reads one character from the keyboard and returns in `R0`, 1 if the character was 'y' or 'Y', and 0, otherwise. Except for `R0`, your routine should restore all registers that it modifies.

P.S. Your code would look the same if it was a subroutine rather than a trap routine.

Problem 16 (4 points) LC/3 subroutine
Write a LC/3 subroutine that receives in register R0 an LC/3 address. Your subroutine should then store zeros in the 15 LC/3 memory locations starting at the address stored in R0. To get full credit for this problem, you must use a loop.

Problem 17 (2 points) Invoking the subroutine
Show how to call the LC/3 subroutine you wrote in Problem 17 to set the 15 memory locations starting with `x5555` to 0.

Problem 18 (2 points) C starter
What is the purpose of the following line often seen at the beginning of a C program?

```
#include <stdio.h>
```

Problem 19 (2 points) Tracing C
What does the following C code print when it is executed?

```
#include <stdio.h>
main() {
     int i = 3 ;
     int j = 8 ;
     while (i<j) {
          printf(”%d\n”, i) ;
          i = i + 2 ;
     }
     printf(”%d\n”, i+20) ;
}
```

Problem 20 (4 points) Writing C
Write a complete C program that reads in two numbers, multiplies them together, and writes out both numbers along with their product.

Problem 21 (2 points) C I/O
Assuming that the following variable declarations have been made in C:

```
int i ;
float x ;
```

which of the following eight C statements are bad. (Write *good* or *bad* in the box.)

`printf(”%d”, i) ;`	`scanf(”%d”, i) ;`
`printf(”%f”, x) ;`	`scanf(”%d”, &i) ;`
`printf(”i = %d”, i) ;`	`printf(”%f %d”, x) ;`
`printf(this can't be right);`	`printf(”%d”, x) ;`

1	/8
2	/10
3	/10
4	/12
5	/12
6	/12
7	/12
8	/10
9	/10
10	/6
∑	/100