CS/ECE 252: INTRODUCTION TO COMPUTER ENGINEERING
COMPUTER SCIENCES DEPARTMENT
UNIVERSITY OF WISCONSIN-MADISON

Prof. Mark D. Hill
TAs Marc de Kruijf & Sanghamitra Roy

Midterm Examination 3
In Class (50 minutes)
Wednesday, April 11, 2007
Weight: 15%

CLOSED BOOK, NOTE, CALCULATOR, PHONE, & COMPUTER.

The exam in two-sided and has **SEVEN** pages, including two blank pages and a copy of the ***LC-3 Instruction Set handout*** on the final page (please feel free to detach this final page, but insert it into your exam when you turn it in).

Plan your time carefully, since some problems are longer than others.

NAME: _____

ID# _____

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

Problem 1 (4 points)

a) Register R1 contains x7531 and register R2 contains x8642. What will be the values of the condition codes N, Z, and P after executing the instruction AND R3, R1, R2. Please explain.

b) Will a branch instruction predicated on all three Z, N, and P condition codes (i.e. the instruction is BRnzp) ever cause the PC not to jump to the target address/label? Please explain. Note that when the machine is first initialized, the condition code is set to Z.

Problem 2 (4 points)

Imagine that bit 9 (the 10^{th} bit) of the LD instruction is part of the PCoffset field rather than the destination register field.

a) What would be the range of addresses that we could load from relative to the current PC?

b) How many choices of register would we have to load the data into?

Problem 3 (3 points)

There is an LC-3 instruction that can be used to clear bits (i.e. set them to '0'). Write the instruction that will clear the three least significant (rightmost) bits of register R1 and store the result in register R1. Note that the thirteen most significant bits of register R1 must retain their original values. Write the answer in both machine language and in symbolic form.

LC3 Machine Instruction:

The instruction in either symbolic or assembly notation:

Problem 4 (6 points)

The program below checks to see if bit 3 (the 4th bit) of R0 is a one. If the bit is set (if it is a one), the program adds the value 4 to whatever is in R1, otherwise it does nothing. Insert the missing ISA machine language instructions. Adding comments to each machine language instruction will assist in awarding partial credit.

Address	ISA Instruction
x3000	0101 0100 1010 0000
x3001	0001 0100 1010 1000
x3002	
x3003	0000 0100 0000 0001
x3004	
x3005	1111 0000 0010 0101

Problem 5 (5 points)

There is something wrong with the following code sequence. Explain what happens when we try to execute it. Comments are provided to save you the effort of decoding the machine language.

Address	ISA Instruction
x3000	0101 0000 0010 0000 ; R0 <- R0 AND 0
x3001	0000 0010 0000 0001 ; BRp x3003
x3002	0001 0000 0010 0001 ; R0 <- R0 ADD 1
x3003	0000 0011 1111 1101 ; BRp x3001

Explanation of what is wrong:

Problem 6 (4 points)

a) Give a name and short phrase describing each of *three* ways to refine a programming task into smaller sub-tasks.

b) What is the difference between *syntax* errors and the other types of programming errors discussed in lecture?

Problem 7 (4 points)

We are about to execute the following program:

Address	ISA Instruction
x3000	1110 0000 0000 1110 ; LEA R0, x00E
x3001	0010 0010 0000 1110 ; LD R1, x00E
x3002	0110 0100 1100 1110 ; LDR R2, R3, x0E
x3003	1111 0000 0010 0101 ; HALT

The state of the machine before the program starts is given below:

Registers R0 and R1 contain x200E
Memory location x200E contains x3258
Memory location x300E contains x92FE
Memory location x3010 contains x2257

Registers R2 and R3 contain x3001
Memory location x2257 contains x0000
Memory location x300F contains x3010
Memory location x3258 contains x0001

What will be the final contents of registers R0-R3 when we reach the HALT instruction? Write your answers in hexadecimal format.

Register	Initial contents	Final contents
R0	x200E	
R1	x200E	
R2	x3001	
R3	x3001	

Scratch Sheet 1 (in case you need additional space for some of your answers)

Scratch Sheet 2 (in case you need additional space for some of your answers)

LC-3 Instruction Set (Entered by Mark D. Hill on 03/14/2007; last update 03/15/2007)

PC': incremented PC. setcc(): set condition codes N, Z, and P. mem[A]:memory contents at address A. SEXT(immediate): sign-extend immediate to 16 bits. ZEXT(immediate): zero-extend immediate to 16 bits. Page 2 has an ASCII character table.