NAME ____ S.ID. # __________________________

CS 270 – Computer Architecture Key comments in blue

Mid-term – Spring 2013

♦ **Instructions: The exam time is *1 hour 15* minutes. CLOSED BOOK.**

1. [10 pts]

a. Convert the following numbers to the other form:

Decimal	Binary (8 bit signed 2's comp.)
27	0001 1011
-26	1110 0110

Area for any calculations

b. Convert 0x21 into decimal: _____33__________

2. [10 pt] Convert the following numbers in the other form. Floating Point numbers use one sign bit, 8 bits for exponent and 23 bits of fraction. Note that exponent for ordinary normalized numbers is in excess 127 form.

Decimal	S	Exponent	Fraction
-5.5	1	1000 0001	0110 0000 0000 0000 0000 000
0.25	0	0111 1101	0000 0000 0000 0000 0000 000
0	0	0000 0000	0000 0000 0000 0000 0000 000

3. [10 pts]

a. Add these two signed numbers. Verify the result by converting all numbers into decimal.

```
0011 0011    __51__
1110 0110    __-26_
-----------------------
0001 1001    __25_
```

b. Represent the signed number 0011 0011 using **16 bits**, such that it has the same value.

-0000 0000 0011 0011 ___

c. Perform bit-wise OR of the two following strings.

```
0100 0101
0111 0000
-----------
0111 0101
```

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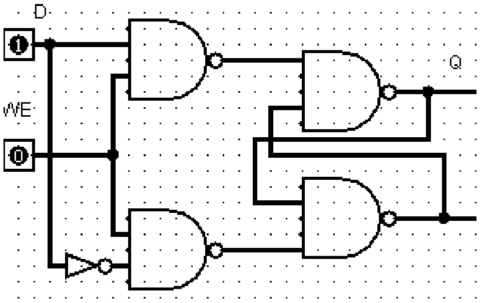
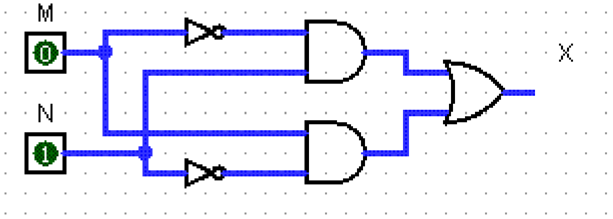
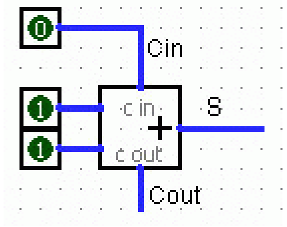
4. [8 pts] Give the logic values on all lines needed.



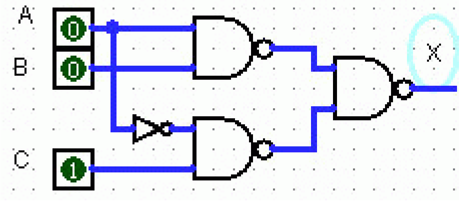
Q = same as before (accept 1 or 0)



X = 1



S = 0 Cout = 1 (This is a Full Adder)



X = 1

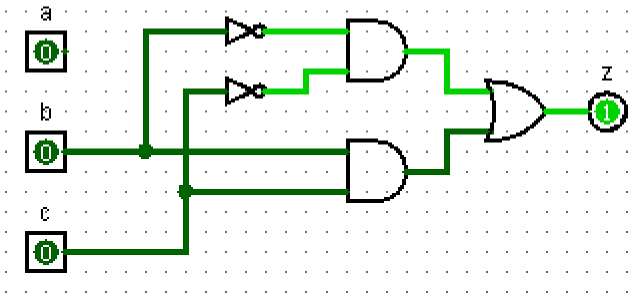
5. [8 pts] Design a combinational circuit that takes three inputs A, B, C and produces one output Z. The output is 1 when B and C are same, it is 0 otherwise. Show the truth table and write the minimized logic expression for Z as function of A, B, and C. Draw the logic diagram.

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

A\BC	00	01	11	10
0	1		1	
1	1		1	

Z = B'C' + BC

Logic Diagram



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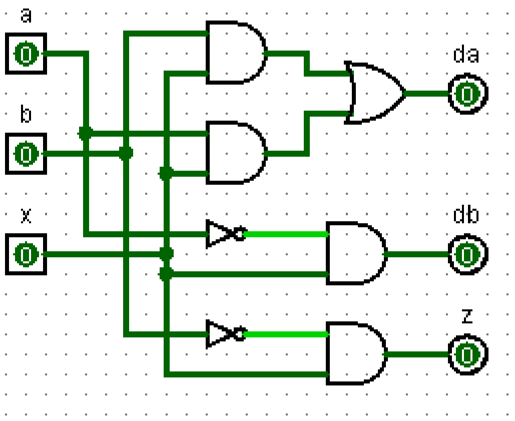
6. [8 pts] A State Machine uses two flip-flips with inputs D_A and D_B and outputs A and B. The combinational part of the circuit is described by the equations (where X is an external input and Z is an output):

$D_A = AX + BX$ $D_B = A'X$ $Z = B'X$

a. Draw a diagram of the complete circuit using AND, OR gates, inverters, D flip-flops, and a clock input.



Note: The complete diagram is expected which needs 2 flip-flops and clock signal.

b. Fill the state table for the circuit above.

Present state		Input	Next state		Output
A	**B**	**X**	**A**	**B**	**Z**
0	0	0			
0	0	1		1	1
0	1	0			
0	1	1	1	1	
1	0	0			
1	0	1	1		1
1	1	0			
1	1	1	1		

7. [6 pts]

a. With 8 bits, what is the total number of different possible combinations (For example 1111 1111 is one of them) that can be formed? Ans = ___256____

b. A computer uses a clock with clock-period equal to 0.25 nanoseconds. What is its clock frequency? __$1/0.25x10^{-9}$___ = __4 G_ Hz (show calculation). Accept if off by a factor of 10.

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8. [6 points] Simplify using Boolean algebra. Show intermediate steps.

(AB + A')' = (AB)'. (A')' = (A' +B'). A = AB' [Use Demorgan's law and simplify]

XYZ + X'YZ = (X+X'). YZ = Y Z

9. [9 pts] Fill in the blanks: Partial credit if off by a factor of 2

a. What is the total amount of memory LC3 can have in byte: _ 2 x __ = 128 **K bytes**

b. The maximum positive offset that you can specify in a BR instruction is __255_ .

c. The largest positive x that can be represented in instruction **ADD R1, #x** is ___15_

d. What would be placed in R3 when this program segment is executed

```
                LEA R0, String
                LDR  R3, R0, #0
String          .STRINGZ  "Zis"
```

Answer: __'Z'_______(a single character)__

e. Does the HALT instruction cause the computer to stop fetching any more instructions? Yes/No.

Explain ___calls a trap routine that transfer control to the OS________________________

10. [12 pts] These program segments must be written efficiently with as few instructions as possible.

a. Write a program segment that will move the contents of R0 into R1. (Hint: use an arithmetic instruction)

___ADD R1, R0, #0_____

b. Write a program segment that will place decimal number 1 in register R4.

__AND R4, R4, #0__________________

__ADD R4, R4, #1_________________________

c. . Write a program segment that will convert a number (between 0 and 9) in R1 into the corresponding ASCII character and place it in R0. Use a label ZASCII with a .fill

_LD R0, ZASCII______ Note: alternative code possible. LD R2, ZASCII ADD R0, R1, R2

_ADD R0, R1, R0__________________

__ZASCII .fill x0030______

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11. [13 pts] Here is the character count program we had seen.

```
 .ORIG   x3000
      AND     R2,R2,#0      ; R2 is counter, initialize to 0
      LD      R3,PTR        ; R3 is pointer to characters
      TRAP    x23           ; R0 gets character input
      LDR     R1,R3,#0      ; R1 gets the next character
;
; Test character for end of file
;
TEST    ADD     R4,R1,#-4     ; Test for EOT
      BRz     OUTPUT        ; If done, prepare the output
;
; Test character for match.  If a match, increment count.
;
      NOT     R1,R1
      ADD     R1,R1,R0      ; If match, R1 = xFFFF
      NOT     R1,R1         ; If match, R1 = x0000
      BRnp    GETCHAR       ; If no match, do not increment
      ADD     R2,R2,#1
;
; Get next character from the file
;
GETCHAR ADD     R3,R3,#1      ; Increment the pointer
      LDR     R1,R3,#0      ; R1 gets the next character to test
      BRnzp   TEST
;
; Output the count.
;
OUTPUT  LD      R0,ASCII      ; Load the ASCII template
      ADD     R0,R0,R2      ; Convert binary to ASCII
      TRAP    x21           ; ASCII code in R0 is displayed
      TRAP    x25           ; Halt machine
;
; Storage for pointer and ASCII template
;
ASCII   .FILL   x0030
PTR     .FILL   x4000
      .END
```

a. Assemble the instruction **AND R2,R2,#0**

0	1	0	1	**0**	**1**	**0**	0	1	0	**1**	0	0	0	0	0

b. Assemble the instruction **BRz OUTPUT**

0	0	0	0	**0**	**1**	**0**	0	0	0	0	0	1	0	0	0

c. In an execution of the program the character input is ‘d’, and the 10-word file starting at location x4000 has 3 “d” characters. There is a breakpoint set at TRAP x21, and thus execution halts just before this instruction. What would be the values in these registers (give decimal or hex integer or character):

R0 __x33___R1 _x04___ R2 __3_____ R3__x4009___ R4 ____0________