Department of Electrical and Computer Engineering
The University of Texas at Austin

EE 306, Fall 2013
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Exam 1, October 9, 2013

Name: Key

Problem 1 (20 points):_______

Problem 2 (20 points):_______

Problem 3 (20 points):_______

Problem 4 (20 points):_______

Problem 5 (20 points):_______

Total (100 points): 100

Note: Please be sure that your answers to all questions (and all supporting work that is required) are contained in the space provided.

Note: Please be sure your name is recorded on each sheet of the exam.

I will not cheat on this exam.

____
Signature

GOOD LUCK!

Name:____________________________________

Problem 1. (20 points):
Part a. (4 points):

R0 contains the ASCII code of a capital letter in the English alphabet. If the instruction

0001000000000001

is executed, we wish to end up with the lower case version of that letter in R0. What must be true of the values in the other registers before this instruction executes for this to happen?

R1 MUST CONTAIN x0020

Part b. (5 points):

Suppose we changed the LC-3 to have only four registers instead of 8. Fewer registers is in general a bad idea since it means loading from memory and storing to memory more often.

If we keep the basic format of all instructions as they currently are (and keep each instruction 16 bits), is there any benefit that could be had for operate (0001, 0101, 1001) instructions by reducing the number of registers to 4? Explain.

NOT gets no benefit
AND, ADD get larger immediates (7 bits)

Is there any benefit that could be had for load (0010) and store (0011) instructions by reducing the number of registers to 4? Explain.

LD, ST get one more bit for larger offset

Is there any benefit that could be had for conditional branch (0000) instructions by reducing the number of registers to 4? Explain.

No benefit. BR is not affected by bits needed for registers.

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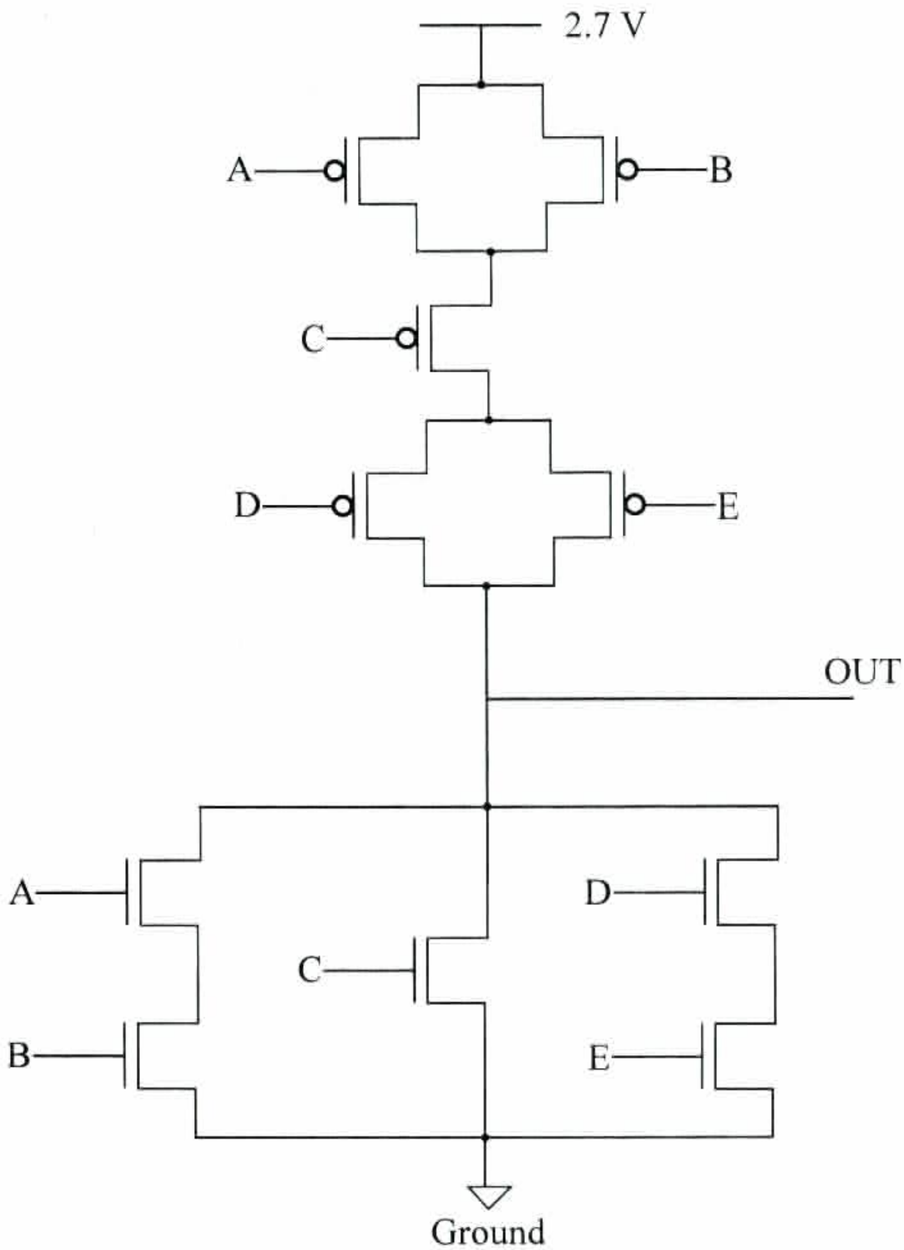
Part c. (4 points):

A properly working transistor circuit for implementing a logic function is one in which the output is always 1 or 0. The circuit below is an example of such that implements a 5 input logic function. Indicate on the truth table on the next page the input combinations for which the output is 1 by putting a 1 in the corresponding row of the output column. All other input combinations produce an output 0. It is not necessary to put the 0s in the output column.

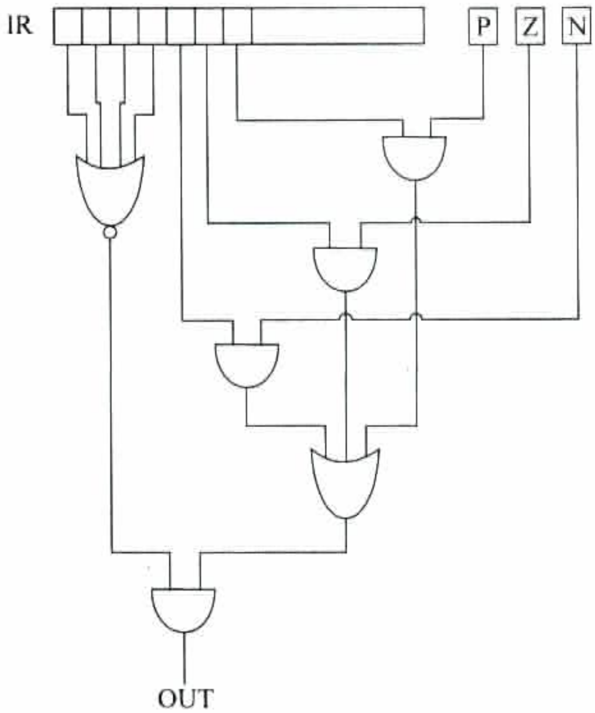


Name:____

A	B	C	D	E	OUT
0	0	0	0	0	1
0	0	0	0	1	1
0	0	0	1	0	1
0	0	0	1	1	0
0	0	1	0	0	0
0	0	1	0	1	0
0	0	1	1	0	0
0	0	1	1	1	0
0	1	0	0	0	1
0	1	0	0	1	1
0	1	0	1	0	1
0	1	0	1	1	0
0	1	1	0	0	0
0	1	1	0	1	0
0	1	1	1	0	0
0	1	1	1	1	0
1	0	0	0	0	1
1	0	0	0	1	1
1	0	0	1	0	1
1	0	0	1	1	0
1	0	1	0	0	0
1	0	1	0	1	0
1	0	1	1	0	0
1	0	1	1	1	0
1	1	0	0	0	0
1	1	0	0	1	0
1	1	0	1	0	0
1	1	0	1	1	0
1	1	1	0	0	0
1	1	1	0	1	0
1	1	1	1	0	0
1	1	1	1	1	0

Name:_______________________________________

Part d. (7 points): The logic diagram below produces the logical value OUT.



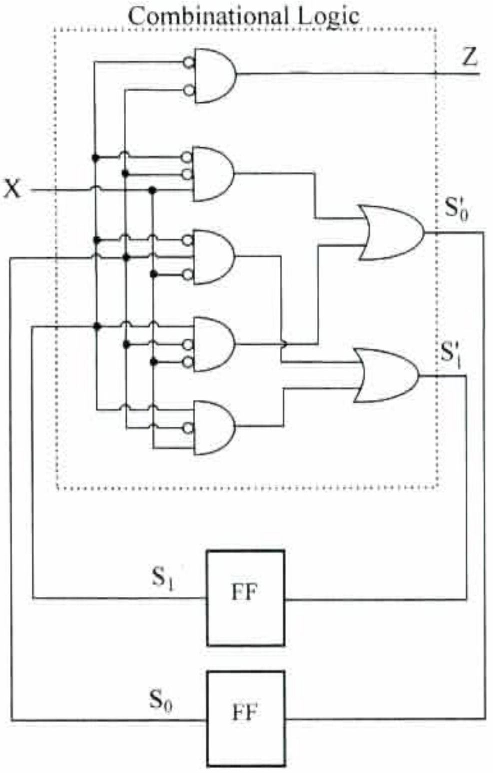
What do the values 0 or 1 for OUT signify?

0 signifies: Don't branch

1 signifies: branch

Name:____

Problem 2. (20 points):
The logic diagram shown below is a finite state machine.



Your job:

a. Construct the truth table for the combinational logic:

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S1	S0	X	Z	S1’	S0’
0	0	0	1	0	0
0	0	1	1	0	1
0	1	0	0	1	0
0	1	1	0	0	0
1	0	0	0	0	1
1	0	1	0	1	0
1	1	0	0	0	0
1	1	1	0	0	0

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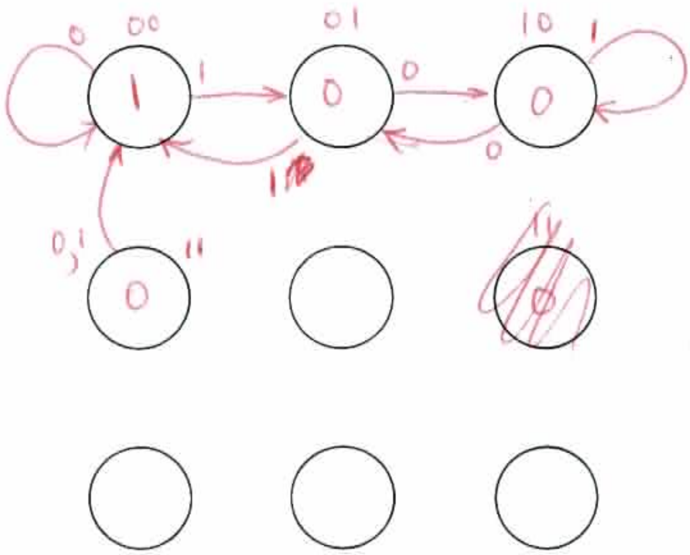
b. Complete the state machine (We have provided nine states. You will not need all of them. Use only as many as you need):



Name:____

Problem 3. (20 points): Floating point

Express the two floating point numbers $2\frac{13}{16}$ and $\frac{1}{16}$ in binary normalized form:

2 pts $2\frac{13}{16}$ [1.01101×2^1] $\frac{1}{16}$ [1×2^{-4}] 2 pts

We wish to design a nine-bit binary floating point data type, using the format of the IEEE standard. We want to be able to represent both of these two values **exactly** in **normalized**(i.e. not subnormal) form.

Your job:

a. Decide how many bits are necessary for the exponent, and how many bits are necessary for the fraction.

4 pts No. of exponent bits: [3] No. of fraction bits: [5]

b. Decide what the BIAS (also known as EXCESS) will have to be in order to be able to represent both values in normalized (i.e. not subnormal) form.
Hint: the BIAS 011 . . . 1 will not work.

6 pts BIAS: [101]

c. Show the binary representations of the two values $2\frac{13}{16}$ and $\frac{1}{16}$ in our new nine-bit binary floating point data type

$2\frac{13}{16}$	3 pts →	0	1	1	0	0	1	1	0	1
$\frac{1}{16}$	3 pts →	0	0	0	1	0	0	0	0	0

Name:____

Problem 4. (20 points):
We wish to invent a two-person game, which we will call XandY that can be played on the computer. Your job in this problem is contribute a piece of the solution.

The game is played with the computer and a deck of cards. Each card has on it one of four values (X, Y, Z, and N). Each player in turn gets five attempts to accumulate points. We call each attempt a round. After player A finishes his five rounds, it is player B's turn. Play continues until one of the players accumulates 100 points.
Your job today is to ONLY design a finite state machine to keep track of the STATE of the **current** round. Each round starts in the intial state, where X=0 and Y=0. Cards from the deck are turned over one by one. Each card transitions the round from its current state to its next state, until the round terminates, at which point we'll start a new round in the initial state.

The transistions are as follows:

X: The number of X's is incremented, producing a new state for the round.

Y: The number of Y's is incremented, producing a new state for the round.

Z: If the number of X's is less than 2, the number of X's is incremented, producing a new state for the round. If the number of X's is 2, the state of the current round does not change.

N: Other information on the card gives the number of points accumulated. N also terminates the current round.

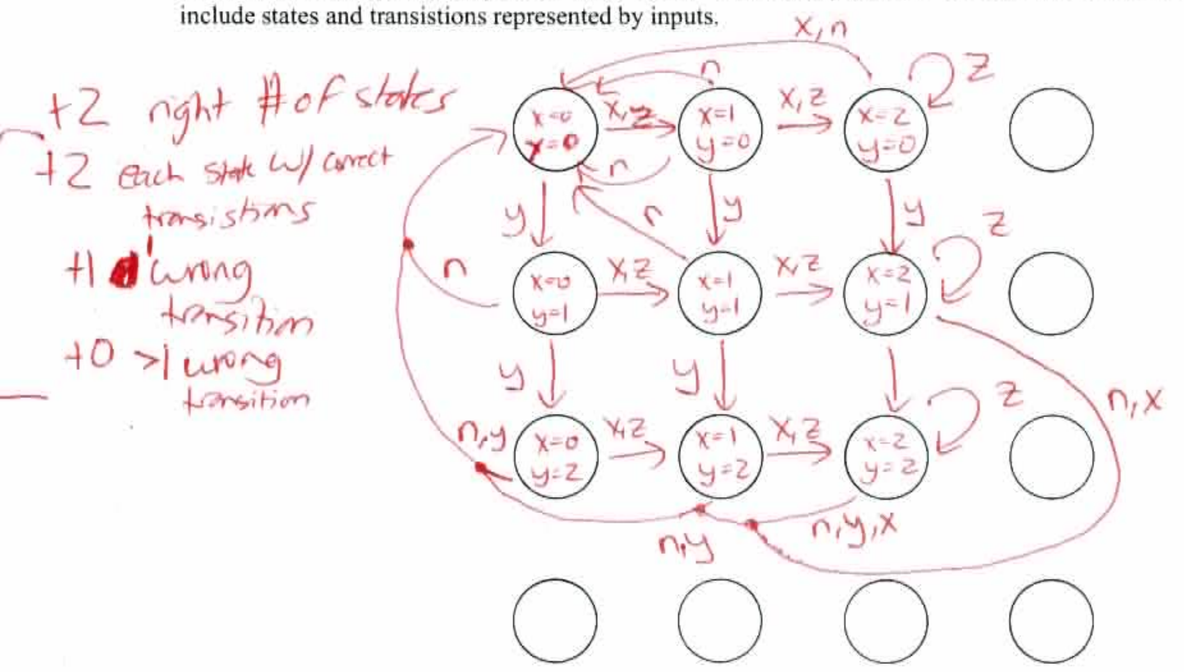
Important rule: If the number of X's or Y's reaches a count of 3, the current round is immediately terminated and another round is started. When a round starts, its state is X=0, Y=0.

Hint: Since the number of X's and Y's specify the state of the current round, how many possible states are needed to describe the state of the current round?

Hint: A state can not have X=3, because then the round would be finished, and we would have started a *new* current round.

On the diagram below, label each state. For each state draw an arrow showing the transition to the next state that would occur for each of the four inputs. (We have provided sixteen states. You will not need all of them. Use only as many as you need)

Note, we did not specify outputs for these states. Therefore, your state machine will not include outputs. It will only include states and transistions represented by inputs.



Name:____________________________________

Problem 5. (20 points):

You have been asked to design the volume control system in a stereo. The user controls the volume by using volume up and volume down buttons on the stereo. When the user presses the volume up button, the volume should increase by 1; when the user presses the volume down button, the volume should decrease by 1. The volume level is represented as a 4-bit unsigned value, ranging from 0 to 15. If the user presses volume up when the volume is already at the maximum level of 15, the volume should remain at 15; similarly, if the user presses volume down when the volume is already at the minimum level of 0, the volume should remain at 0. The memory location x3100 has been directly hooked up to the speakers so that reading bits 3 through 0 from that memory location will give the current speaker volume, while writing bits 3 through 0 of that memory location will set the new speaker volume.

When the user presses one of the volume buttons, the stereo hardware will reset the PC of the processor to x3000 and begin execution. If the user had pressed volume up, then memory location x3101 will be set to 1; otherwise, if the user had pressed volume down, then the memory location x3101 will be set to 0.

Below is the program that controls the volume on the stereo. Two of the instructions in the program have been left out. Your job: fill in the missing instructions so that the program controls the volume correctly as specified.

Address	Contents	Description
x3000	0010000011111111	R0 ← M[x3100]
x3001	0010001011111111	R1 ← M[x3101]
x3002	0000010000000100	Branch to x3007 if Z is set
x3003	0001 xxx 000 110001	RX ← RØ − 15
x3004	0000010000000101	Branch to x300A if Z is set
x3005	0001000000100001	R0 ← R0 + x0001
x3006	0000111000000011	Branch always to x300A
x3007	0001001000100000	R1 ← R0 + x0000
x3008	0000010000000001	Branch to x300A if Z is set
x3009	0001 000 00X 111111	RØ ← (R0 or R1) − 1
x300A	0011000011110101	M[x3100] ← R0
x300B	1111000000100101	TRAP x25