Midterm Exam

(February 19th @ 5:30 pm)

Presentation and clarity are very important! Show your procedure!

PROBLEM 1 (15 PTS)

a) Complete the following table. The decimal numbers are unsigned: (6 pts.)

Decimal	BCD	Binary	Reflective Gray Code
89			
			1001100
		1001100	
	000100110101		

b) Complete the following table. Use the fewest number of bits in each case: (7 pts.)

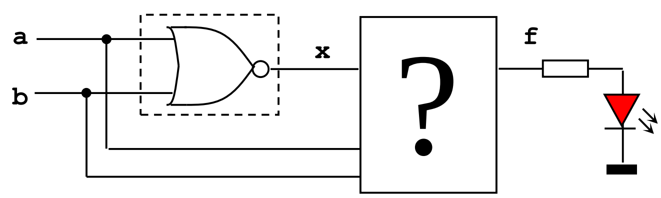
	REPRESENTATION		
Decimal	**Sign-and-magnitude**	**1's complement**	**2's complement**
	11011001		
		0110100	
		1001100	
			101100
			1000000

c) Convert the following decimal numbers to their 2's complement representations. (2 pts)

- ✓ -16.1875
- ✓ 37.3125

PROBLEM 2 (20 PTS)

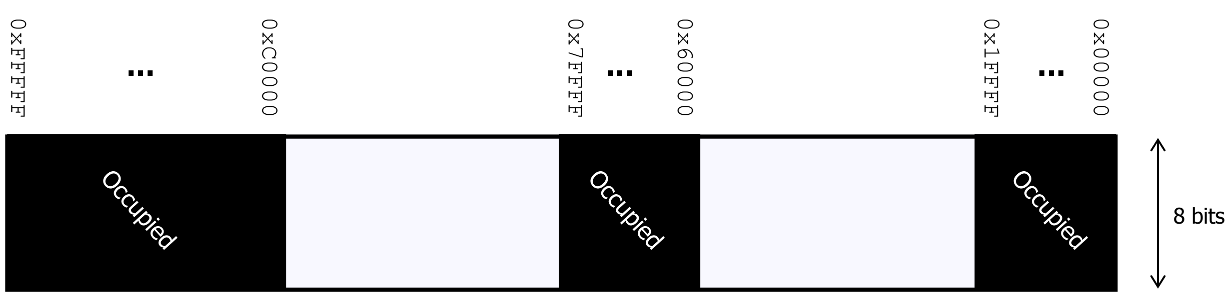
a) Using only 2-to-1 MUXs, design a circuit that verifies the logical operation of a NOR gate. f = '1' (LED ON) if the NOR gate does NOT work properly.
Assumption: when the NOR gate is not working, it generates 1's instead of 0's and vice versa.
Tip: Minimize your function first. (15 pts)



b) Implement the previous function f using only 4-to-1 MUXs. You might need to implement a NOT gate using a 4-to-1 MUX.

PROBLEM 3 (10 PTS)

- The figure below depicts the entire memory space of a microprocessor. Each memory address occupies one byte. 1KB = 2^{10} bytes, 1MB = 2^{20} bytes, 1GB = 2^{30} bytes
  - ✓ What is the size of the memory space? What is the address bus size of the microprocessor?
  - ✓ If we have a memory chip of 128KB, how many bits do we require to address those 128KB of memory?
  - ✓ We want to connect the 128KB memory chip to the microprocessor. The figure shows all the occupied portions of the memory space. Provide a list of all the possible ranges that the 128 KB memory chip can occupy.



PROBLEM 4 (20 PTS)

a) Perform the following additions and subtractions of the following unsigned integers. Use the fewest number of bits n to represent both operators. Indicate every carry (or borrow) from c_0 to c_n (or b_0 to b_n). For the addition, determine whether there is an overflow. For the subtraction, determine whether we need to keep borrowing from a higher byte. (8 pts)

- ✓ `51 + 15`
- ✓ `25 - 35`

b) Perform the following operations, where numbers are represented in 2's complement. Indicate every carry from c_0 to c_n. For each case, use the fewest number of bits to represent the summands and the result so that overflow is avoided. (8 pts)

- ✓ `-89 + 128`
- ✓ `-61 -13`

c) Get the multiplication result of the following numbers that are represented in 2's complement arithmetic with 4 bits. (4 pts)

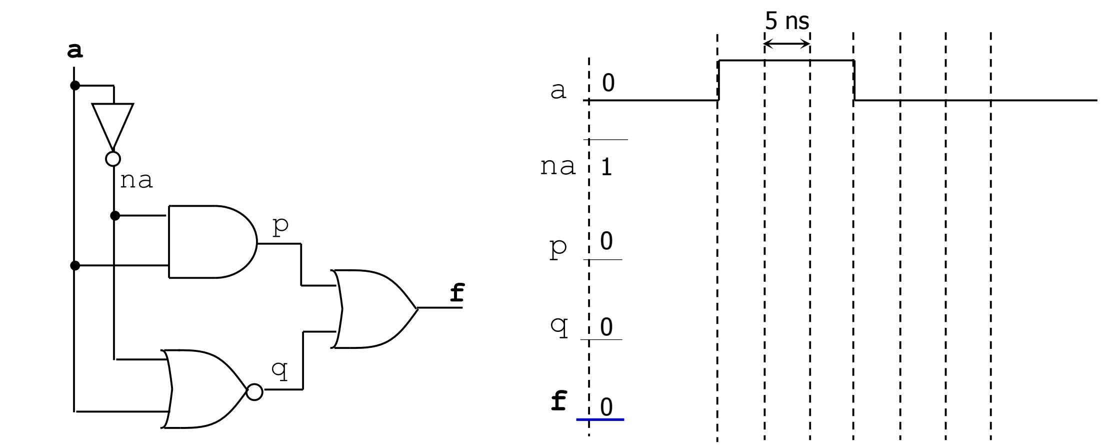
- ✓ `7 x -6.`

PROBLEM 5 (10 PTS)

- Given two 4-bit signed (2's complement) numbers A, B, sketch the circuit that computes $(A - B) \times 3$. You can use full adders and logic gates. Make sure your circuit avoids overflow.
- BONUS POINTS (+2 PTS): Use the fewest amount of hardware resources.

PROBLEM 6 (10 PTS)

- Complete the timing diagram of the digital circuit shown below. You must consider the propagation delays. Assume the propagation delay of every gate is 5 ns. The initial values of all signals are plotted in the figure.



PROBLEM 7 (15 PTS)

- Complete the timing diagram of the circuit shown below: