Midterm Exam

(February 14th @ 5:30 pm)

Presentation and clarity are very important! Show your procedure!

PROBLEM 1 (20 PTS)

a) Complete the following table. The decimal numbers are unsigned: (5 pts.)

Decimal	BCD	Binary	Reflective Gray Code
42			
			101101
	000101101001		

b) Complete the following table. The decimal numbers are signed. Use the fewest number of bits in each case: (12 pts.)

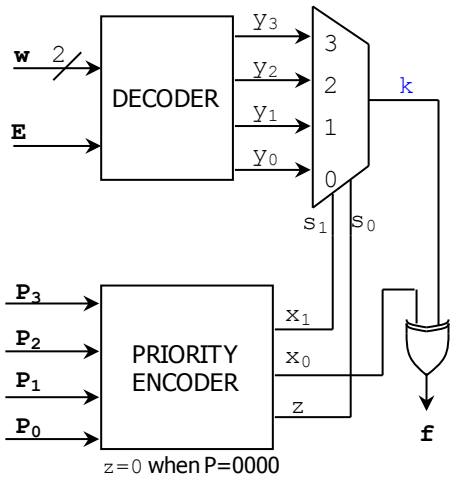
	REPRESENTATION		
Decimal	**Sign-and-magnitude**	**1's complement**	**2's complement**
	110101		
			100000
			0101101
-64			
			101000
		1011001	

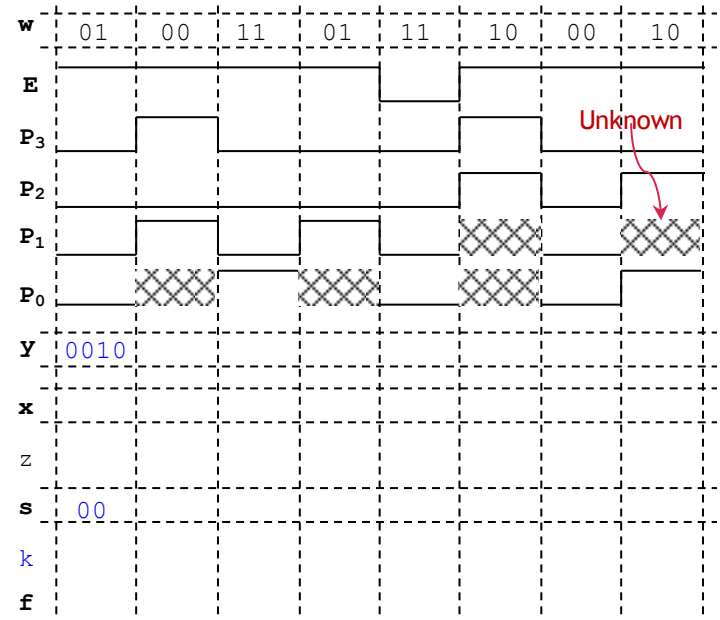
c) Convert the following decimal numbers to their 2's complement representations. (3 pts)

✓ -19.375 ✓ 16.125

PROBLEM 2 (15 PTS)

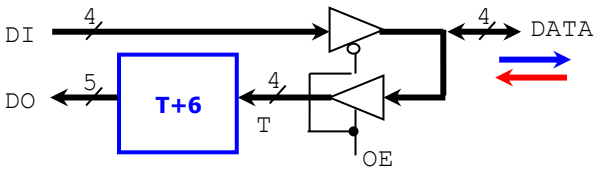
- Complete the timing diagram of the circuit shown below. $y = y_3y_2y_1y_0$, $x = x_1x_0$, $s = s_1s_0$.

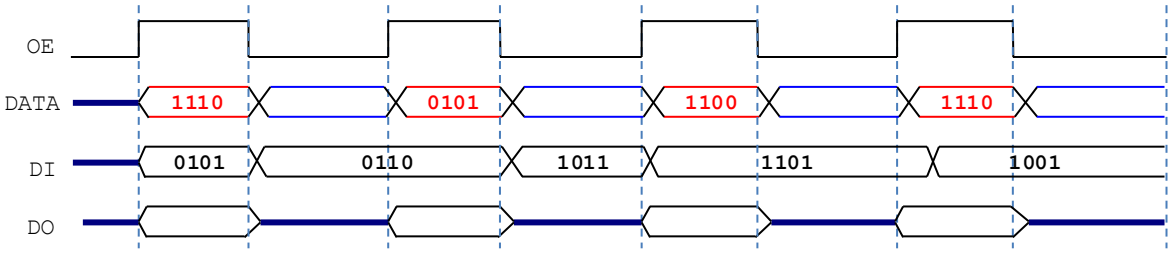




PROBLEM 3 (8 PTS)

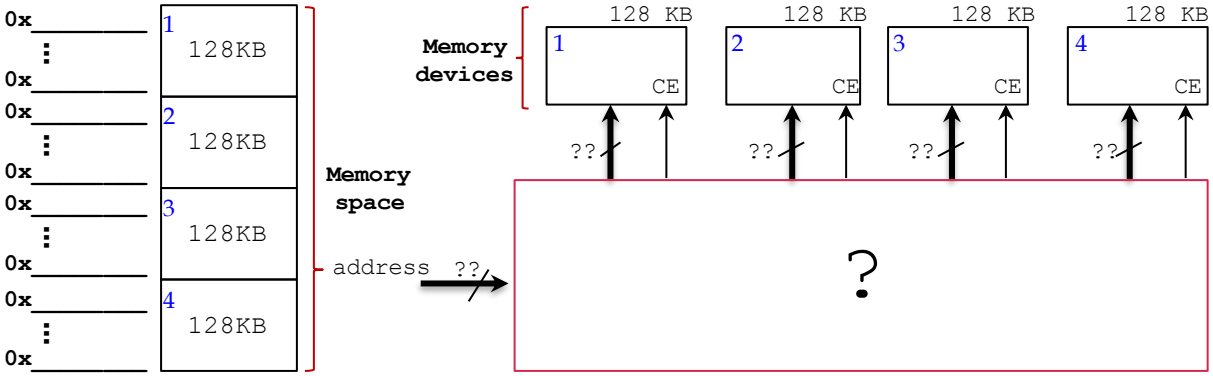
- Complete the timing diagram (signals *DO* and *DATA*) of the following circuit. The circuit in the blue box computes the summation T+6, with the result having 5 bits. T is an unsigned 4-bit number.





PROBLEM 4 (12 PTS)

- A microprocessor has a memory space of 512 KB. Each memory address occupies one byte. 1KB = 2^{10} bytes, 1MB = 2^{20} bytes, 1GB = 2^{30} bytes. We want to connect four 128 KB memory chips to this microprocessor.
  - ✓ What is the address bus size (number of bits of the address) of the microprocessor? (1 pt).
  - ✓ For a memory chip of 128 KB, how many bits do we require to address 128 KB of memory? (1 pt).
  - ✓ Complete the address ranges (lowest to highest, in hexadecimal) for each of the memory chips in the figure. (4 pts).
  - ✓ Sketch the circuit that: i) addresses the memory chips, and ii) enables only one memory chip (via CE: chip enable) when the address falls in the corresponding range. Example: if `address=0x2FFFF`, → only memory chip 2 is enabled (CE=1). If `address=0x6ABC0`, → only memory chip 4 is enabled.



PROBLEM 5 (17 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. (6 pts)
   - ✓ `49 + 18`
   - ✓ `38 - 42`

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)
   - ✓ `-37 + 50`
   - ✓ `-26 - 40`

c) Perform binary multiplication of the following numbers that are represented in 2's complement arithmetic. (3 pts)
   - ✓ `-6 x 9`

PROBLEM 6 (10 PTS)

- Given two 4-bit signed numbers A, B, sketch the circuit that computes $|A-2B|$. For example: $A=1010, B=0110 \rightarrow |A-2B| = |-6-2\times 6| = 18$. You can only use full adders and logic gates. Your circuit must avoid overflow: design your circuit so that the result and intermediate operations have the proper number of bits.

PROBLEM 7 (18 PTS)

- Sketch the circuit that implements the following Boolean function: $f(a,b,c,d) = (\overline{a \oplus b})(\overline{c \oplus d})$
  - ✓ Using ONLY 2-to-1 MUXs (AND, OR, NOT, XOR gates are not allowed). (12 pts)
  - ✓ Using two 3-to-1 LUTs and a 2-to-1 MUX. Specify the contents of each of the 3-to-1 LUTs. (6 pts)