Midterm Exam

(February 14th @ 5:30 pm)

Presentation and clarity are very important! Show your procedure!

PROBLEM 1 (22 PTS)

a) Complete the following table. The decimal numbers are unsigned: (3 pts.)

Decimal	BCD	Binary	Reflective Gray Code
			101011
	000100101000		

b) Complete the following table. The decimal numbers are signed. Use the fewest number of bits in each case: (15 pts.)

	REPRESENTATION		
Decimal	**Sign-and-magnitude**	**1's complement**	**2's complement**
	110001		
			10000
-32			
			1111
			0101001
		1111	

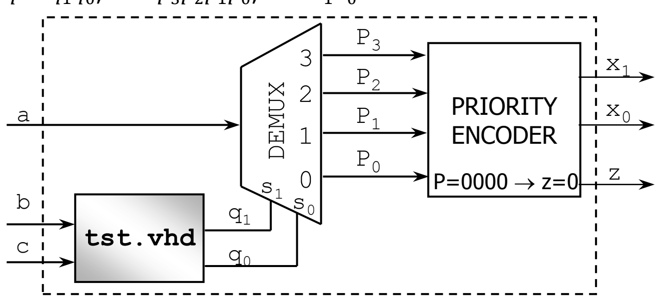
c) Convert the following decimal numbers to their 2's complement representations. (4 pts)

- ✓ -17.25
- ✓ 16.75

PROBLEM 2 (15 PTS)

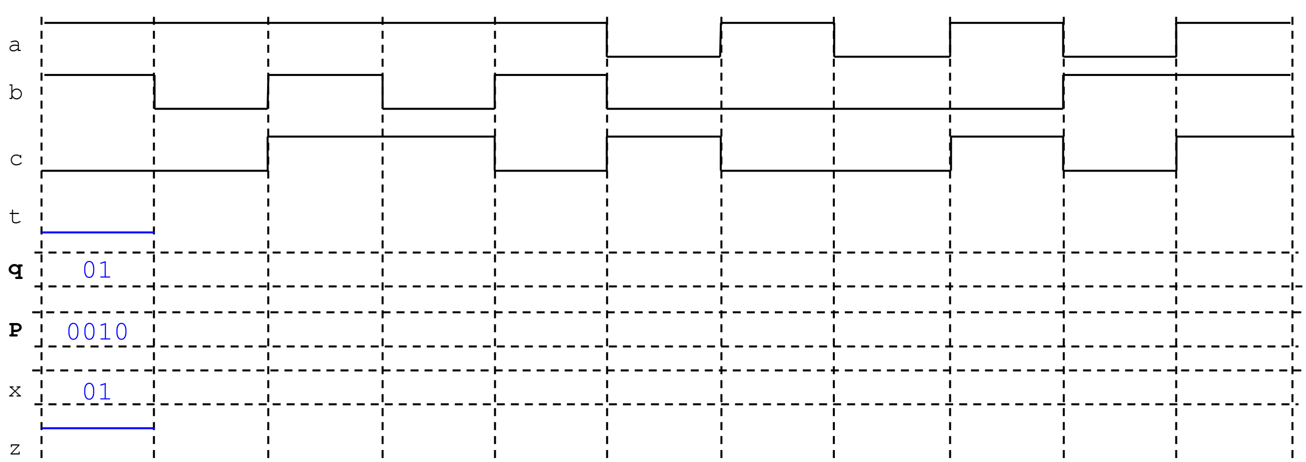
- Complete the timing diagram of the following circuit. The VHDL code (`tst.vhd`) corresponds to the shaded circuit.

$q = q_1q_0$, $P = p_3p_2p_1p_0$, $x = x_1x_0$



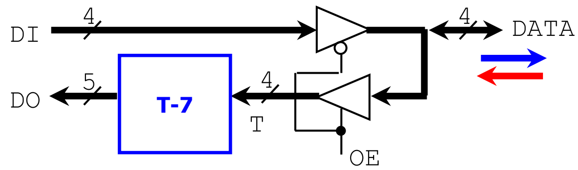

```
library ieee;
use ieee.std_logic_1164.all;

entity tst is
  port (b, c : in std_logic;
        q: out std_logic_vector(1 downto 0));
end tst;
```

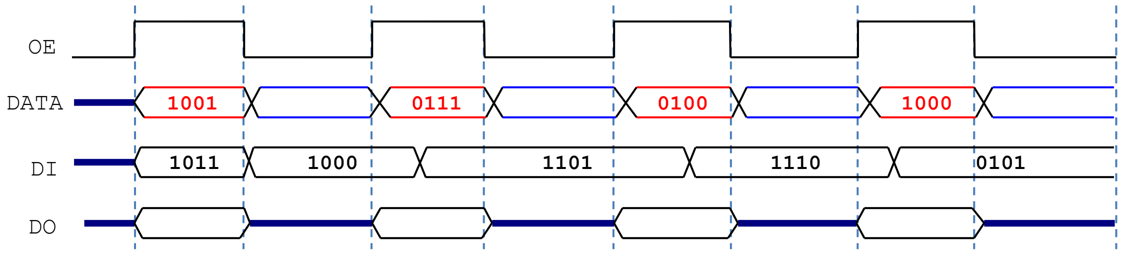
```
architecture bhv of tst is

   signal t: std_logic;

begin

  t <= b xnor c;
  process (b,c,t)
  begin
     q <= b & c;
     if t = '0' then
        q <= c & b;
     end if;
  end process;

end bhv;
```



PROBLEM 3 (12 PTS)

- Complete the timing diagram (signals *DO* and *DATA*) of the following circuit. The circuit in the blue box computes the signed operation T-7, with the result having 5 bits. T is a 4-bit signed (2C) number.
  - ✓ Example: if T=1010:
    DO = 1010-0111 = 11010 + 11001
    DO = 10011



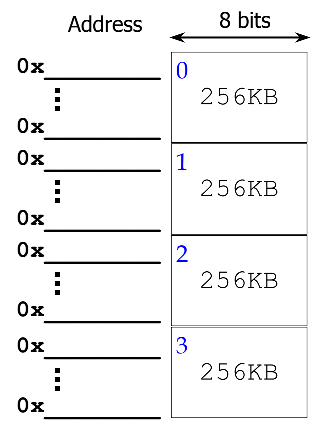


PROBLEM 4 (10 PTS)

- A microprocessor has a memory space of 1 MB. Each memory address occupies one byte. 1KB = 2^{10} bytes, 1MB = 2^{20} bytes, 1GB = 2^{30} bytes.
  a) What is the address bus size (number of bits of the address) of the microprocessor?

  b) What is the range (lowest to highest, in hexadecimal) of the memory space for this microprocessor? (1 pt.)

  c) The figure to the right shows four memory chips that are placed in the given positions:
  - ✓ Complete the address ranges (lowest to highest, in hexadecimal) for each of the memory chips. (8 pts)

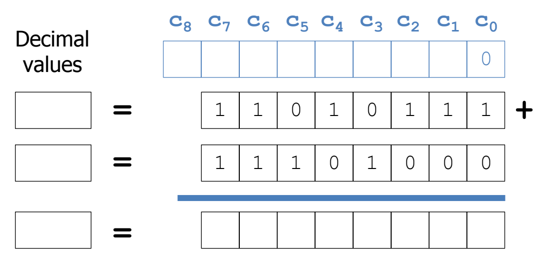


PROBLEM 5 (15 PTS)

a) Perform the following additions and subtractions of the following unsigned integers. Use the fewest number of bits n to represent both operators. <u>Indicate every carry (or borrow) from c_0 to c_n (or b_0 to b_n)</u>. For the addition, determine whether there is an overflow. For the subtraction, determine whether we need to keep borrowing from a higher bit. (6 pts)
- ✓ `37 + 41` ✓ `37 - 41`

b) The figure shows two 8-bit operands represented in 2's complement. Perform the 8-bit addition operation, i.e., complete all the carries and the summation bits. Also, indicate the corresponding decimal numbers for the 8-bit operands and the 8-bit result.

Does this 8-bit operation incur in overflow? Yes No
Value of the overflow bit: ______
Value of carry out bit: ______



c) Perform binary multiplication of the following numbers that are represented in 2's complement arithmetic. (3 pts)
- ✓ `1001 x 01001`

PROBLEM 6 (10 PTS)

- Sketch the circuit that computes $|A-B|$, where A, B are 4-bit <u>signed</u> numbers. For example, $A = 0101, B = 1101 \rightarrow |A-B| = |5-(-3)| = 8$. You can only use full adders (or multi-bit 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 (16 PTS)

- In a 4-to-2 priority encoder (like the one in Problem 2), it can be demonstrated that the output $x_0 = \overline{p_3}\,\overline{p_2}p_1 + p_3$.
  - ✓ Provide the simplified expression for x_0 and sketch this circuit using logic gates. (3 pts)
  - ✓ Implement x_0 using ONLY an 8-to-1 MUX. (3 pts).
  - ✓ Implement x_0 using ONLY 2-to-1 MUXs (AND, OR, NOT, XOR gates are not allowed) (10 pts).