Midterm Exam

(October 20th @ 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**
-31			
		101111	
			011011
			100000
		110	
	110011		

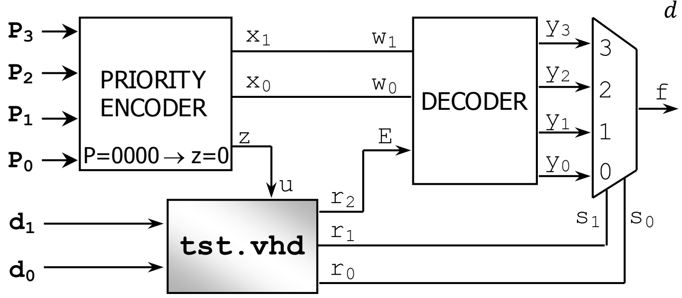
c) Convert the following decimal numbers to their 2's complement representations. (4 pts)

- ✓ -17.125
- ✓ 32.75

PROBLEM 2 (14 PTS)

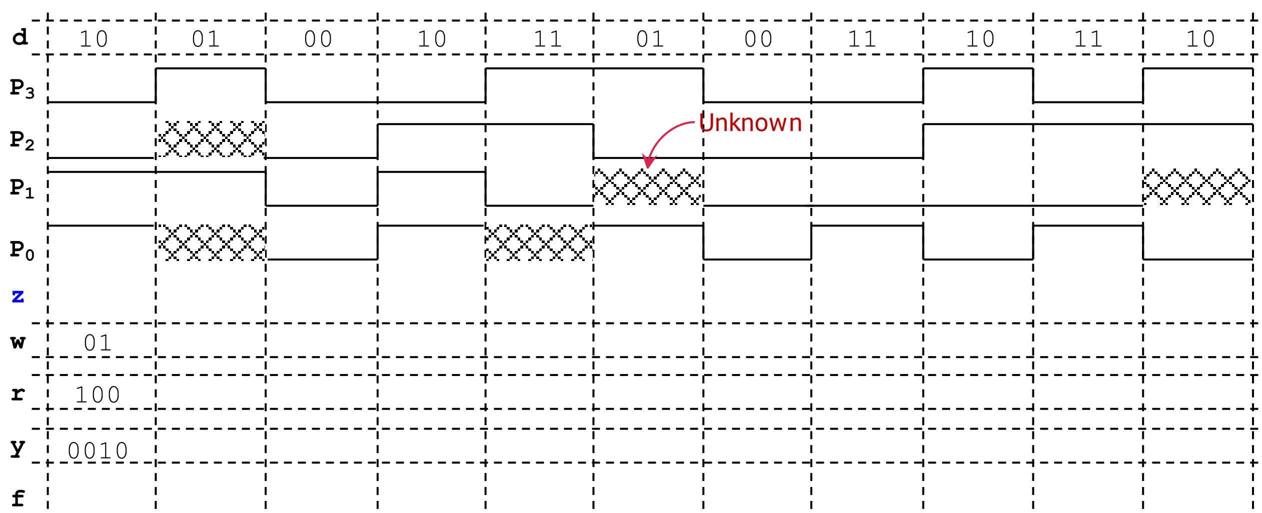
- Complete the timing diagram of the following circuit. The VHDL code (`tst.vhd`) corresponds to the shaded circuit.

$d = d_1d_0$, $w = w_1w_0$, $r = r_2r_1r_0$, $y = y_3y_2y_1y_0$



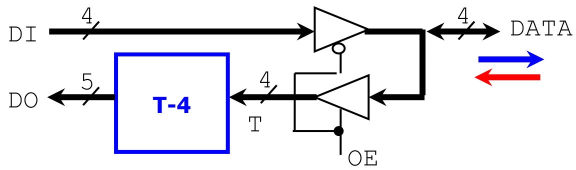

```
library ieee;
use ieee.std_logic_1164.all;
entity tst is
  port (d: in std_logic_vector(1 downto 0);
        r: out std_logic_vector(2 downto 0);
        u: in std_logic);
end tst;
```

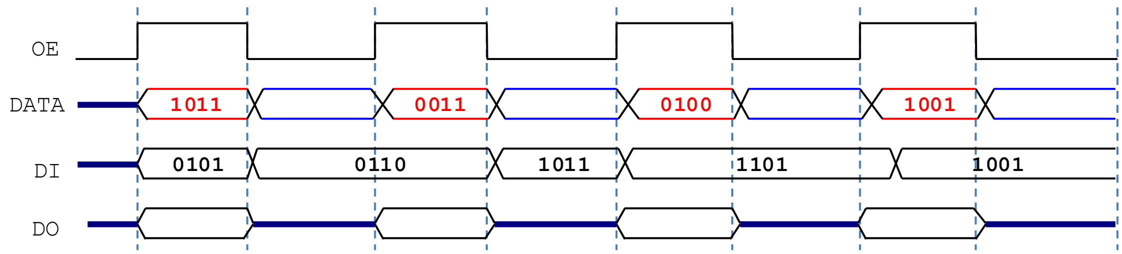
```
architecture bhv of tst is

begin

  process (d, u)
  begin

     r <= '1'&d;
     if u = '1' then
        r <= d&'0';
     end if;

  end process;

end bhv;
```



PROBLEM 3 (11 PTS)

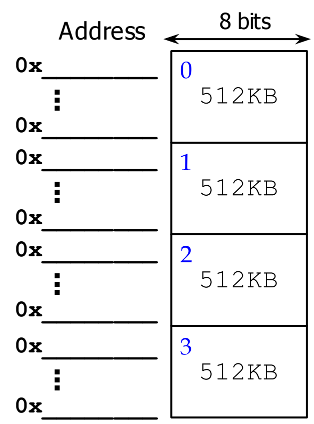
- Complete the timing diagram (signals DO and $DATA$) of the following circuit. The circuit in the blue box computes the signed operation T-4, with the result having 5 bits. T is a 4-bit signed (2C) number.
  - ✓ Example: if T=1010:
    DO = 1010 - 0100 = 11010 + 11100
    DO = 10110





PROBLEM 4 (10 PTS)

- A microprocessor has a memory space of 2 MB. Each memory address occupies one byte. 1 KB = 2^{10} bytes, 1 MB = 2^{20} bytes, 1 GB = 2^{30} bytes.
  - ✓ What is the address bus size (number of bits of the address) of this microprocessor?
  - ✓ What is the range (lowest to highest, in hexadecimal) of the memory space for this microprocessor? (1 pt.)
  - ✓ The figure (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.)

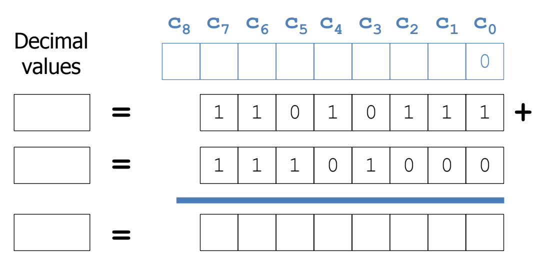


PROBLEM 5 (15 PTS)

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)

✓ `39 + 41` ✓ `39 - 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. (4 pts)

✓ `-7 x 9`

PROBLEM 6 (10 PTS)

- Sketch the circuit that computes $|A-B|$, where A, B are 4-bit <u>unsigned</u> numbers. For example, $A = 0101, B = 1101 \rightarrow |A-B| = |5-13| = 8$. 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 (18 PTS)

- Sketch the circuit that implements the following Boolean function: $f(a,b,c,d) = (c \oplus d)(\overline{a \oplus b})$
  - ✓ Using <u>ONLY</u> 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)