Midterm Exam

(October 17th @ 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
32			
			111101
	000100100101		

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
	110001		
			100000
		011010	
-31			
			1
		111	

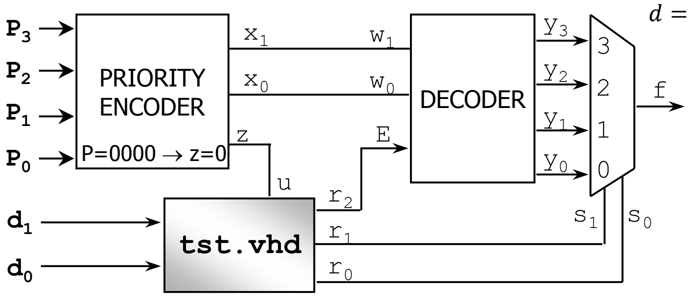
c) Convert the following decimal numbers to their 2's complement representations. (3 pts)

- ✓ -16.375
- ✓ 18.125

PROBLEM 2 (15 PTS)

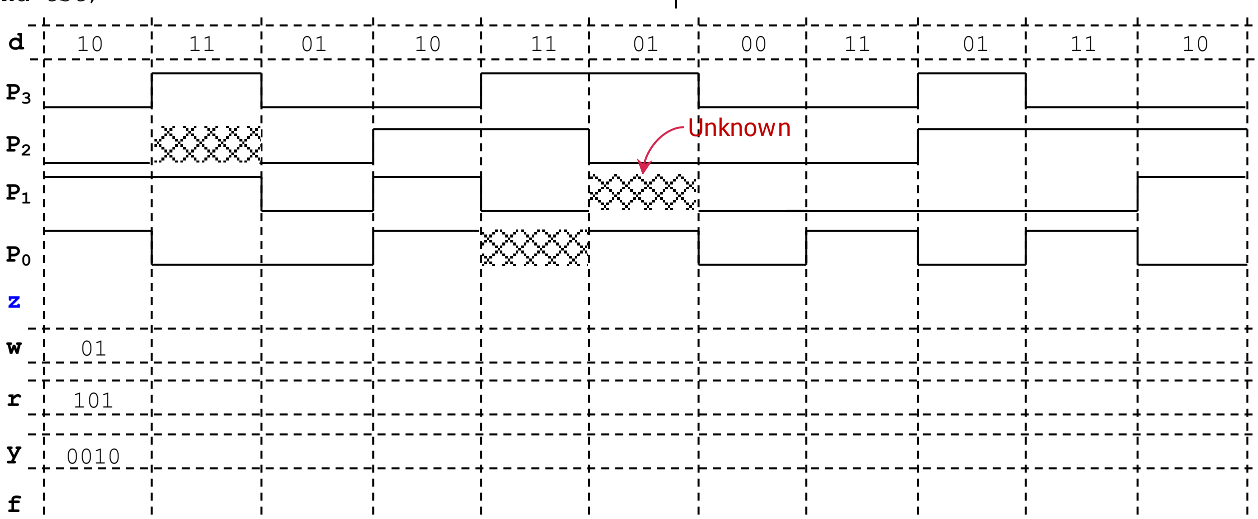
- Complete the timing diagram of the following circuit. The VHDL code (tst.vhd) corresponds to the shaded circuit.

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




```
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;
```

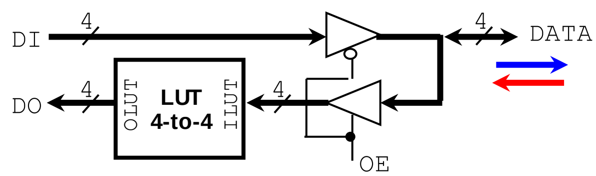
```
architecture bhv of tst is

begin

  process (d, u)
  begin

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

  end process;

end bhv;
```

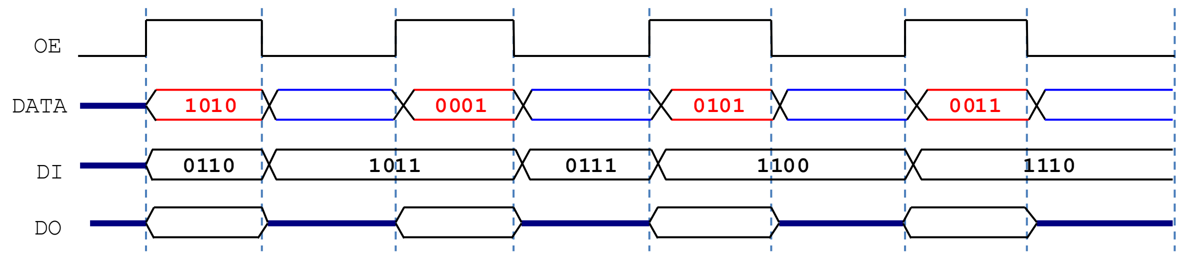


PROBLEM 3 (10 PTS)

- Given the following circuit, complete the timing diagram (signals DO and $DATA$).
  The LUT 4-to-4 implements the following function: $OLUT = \lceil sqrt(ILUT) \rceil$. For example: $ILUT = 1100 \rightarrow OLUT = 0100$

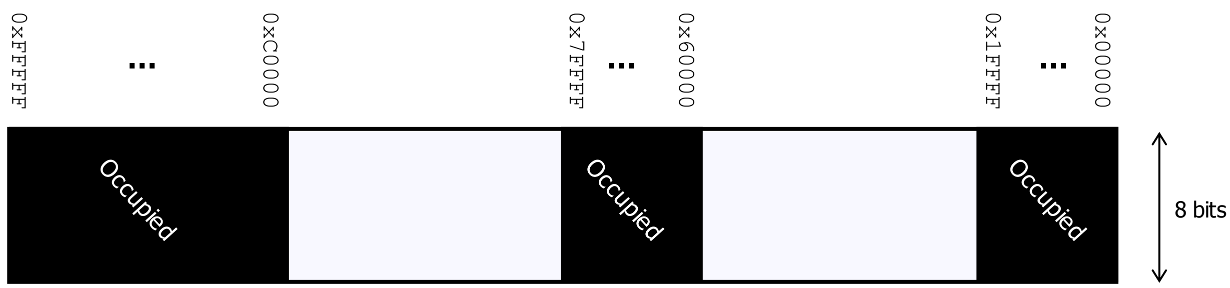
Input data to LUT is treated as an unsigned number.





PROBLEM 4 (11 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 (in bytes, KB, or MB) of the memory space? What is the address bus size of the microprocessor? (2 pts.)
  - ✓ If we have a memory chip of 128 KB, how many bits do we require to address those 128 KB of memory? (1 pt.)
  - ✓ We want to connect the 128 KB memory chip to the microprocessor. For optimal implementation, we must place those 128 KB in an address range where every address shares some MSBs. Provide a list of all the possible address ranges that the 128 KB memory chip can occupy. You can only use the non-occupied portions of the memory space as shown below.



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)
   - ✓ `29 - 50`
   - ✓ `42 + 36`

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)
   - ✓ `-79 + 62`
   - ✓ `-26 - 52`

c) Perform binary multiplication of the following numbers that are represented in 2's complement arithmetic. (3 pts)
   - ✓ `7 x -8`

PROBLEM 6 (11 PTS)

- Sketch the circuit that computes $|A - B| \times 4$, where A, B are 4-bit signed (2's complement) numbers. For example: $A = 1001, B = 0111 \rightarrow |A - B| \times 4 = 14 \times 4 = 56$. You can only use full adders and logic gates. Your circuit must avoid overflow.

PROBLEM 7 (16 PTS)

a) We want to design a circuit that determines whether two 2-bit numbers $A = a_1a_0, B = b_1b_0$ are equal: $f = 1\ if\ A = B, f = 0\ if\ A \neq B$. Sketch this circuit using logic gates. (4 pts)

b) Implement the previous circuit using ONLY 2-to-1 MUXs (AND, OR, NOT, XOR gates are not allowed). (12 pts)