Student Honor Pledge:
All work submitted is completed by me directly without the use of any unauthorized resources or assistance
Initials: _____

Midterm Exam

(February 16th @ 5:30 pm)

Presentation and clarity are very important! Show your procedure!

PROBLEM 1 (24 PTS)

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

Decimal	BCD	Binary	Reflective Gray Code
31			
			110001
	001001000111		

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**
			10110
		10000	
			01101
	11011		
-31			
		100110	

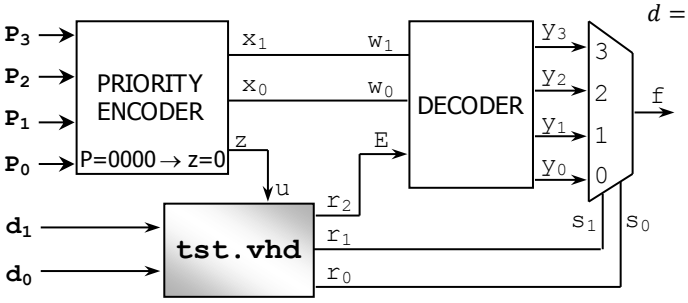
c) Convert the following decimal numbers to their 2's complement representations. (4 pts)

✓ -31.5 ✓ 25.25

PROBLEM 2 (18 PTS)

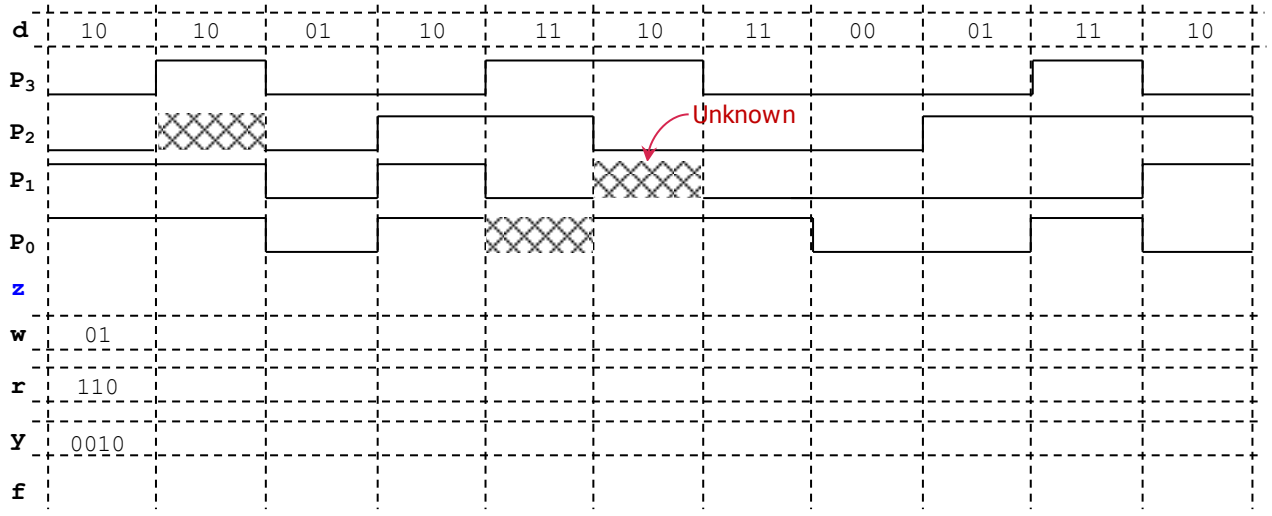
- Complete the timing diagram of the following circuit. The VHDL code (`tst.vhd`) corresponds to the shaded circuit.

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



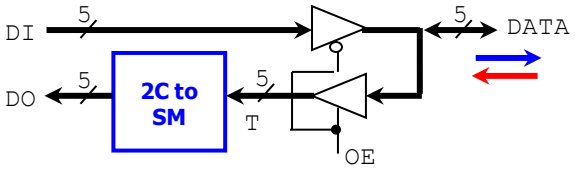

```
library ieee;
use ieee.std_logic_1164.all;
entity tst is
  port (d: in std_logic_vector(1 downto 0);
        r: out std_logic_vector(2 downto 0);
        u: in std_logic);
end tst;
```

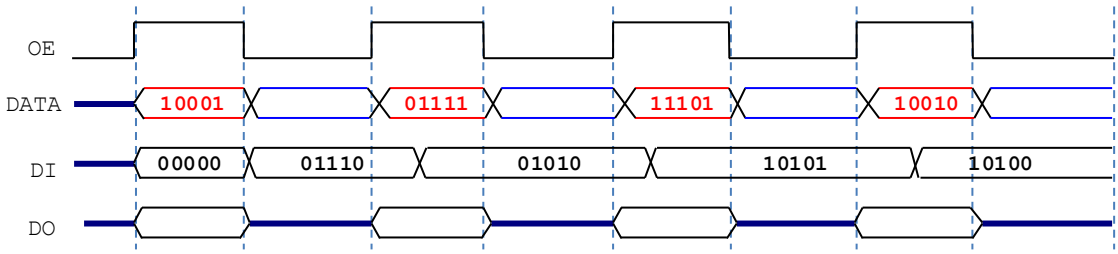
```
architecture bhv of tst is

begin

  process (d, u)
  begin

     r <= "11"&d(0);
     if u = '0' then
        r <= d&'0';
     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 treats the input T as a 5-bit signed (2C) number and converts it to the sign-and-magnitude representation with 5 bits.
  - ✓ Example: if T = 10110, then DO = 11010.



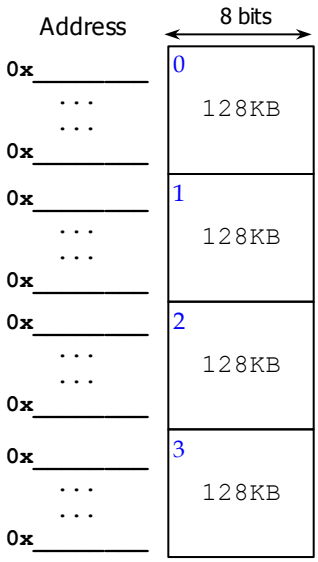


PROBLEM 4 (11 PTS)

- A microprocessor has a memory space of 512 KB. Each memory address occupies one byte.
  a) What is the address bus size (number of bits of the address) of this microprocessor?

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

  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.



PROBLEM 5 (18 PTS)

a) Perform the binary unsigned subtraction of these unsigned integers. Use the fewest number of bits n to represent both operators. Indicate every borrow from b_0 to b_n. Determine whether we need to keep borrowing from a higher byte. (6 pts)
   - ✓ `31 – 37`

b) Perform the binary operation of these numbers, where numbers are represented in 2's complement. Indicate every carry from c_0 to c_n. Use the fewest number of bits to represent the summands and the result so that overflow is avoided. (8 pts)
   - ✓ `31 – 37`

c) Perform binary multiplication of the following numbers that are represented in 2's complement arithmetic. (4 pts)
   - ✓ `-11 x 7`

PROBLEM 6 (17 PTS)

- A 3-input majority gate has an output value f that is 1 if there are more 1's than 0's on its inputs. The output f is 0 otherwise.
  a) Provide the simplified expression for f and sketch this circuit using logic gates. (5 pts)
  b) Implement the previous circuit using ONLY 2-to-1 MUXs (AND, OR, NOT, XOR gates are not allowed). (12 pts)