# Midterm Exam

(February 20th @ 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 |
|---|---|---|---|
| 36 | | | |
| | | | 101011 |
| | 000100101000 | | |

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** |
| -31 | | | |
| | | 101111 | |
| | | | 011011 |
| | | | 100000 |
| | | 110 | |
| | 110011 | | |

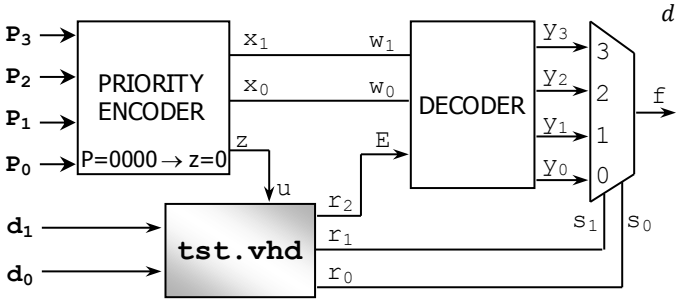
c) Convert the following decimal numbers to their 2's complement representations. (3 pts)

✓ -17.125 ✓ 32.75

## PROBLEM 2 (15 PTS)

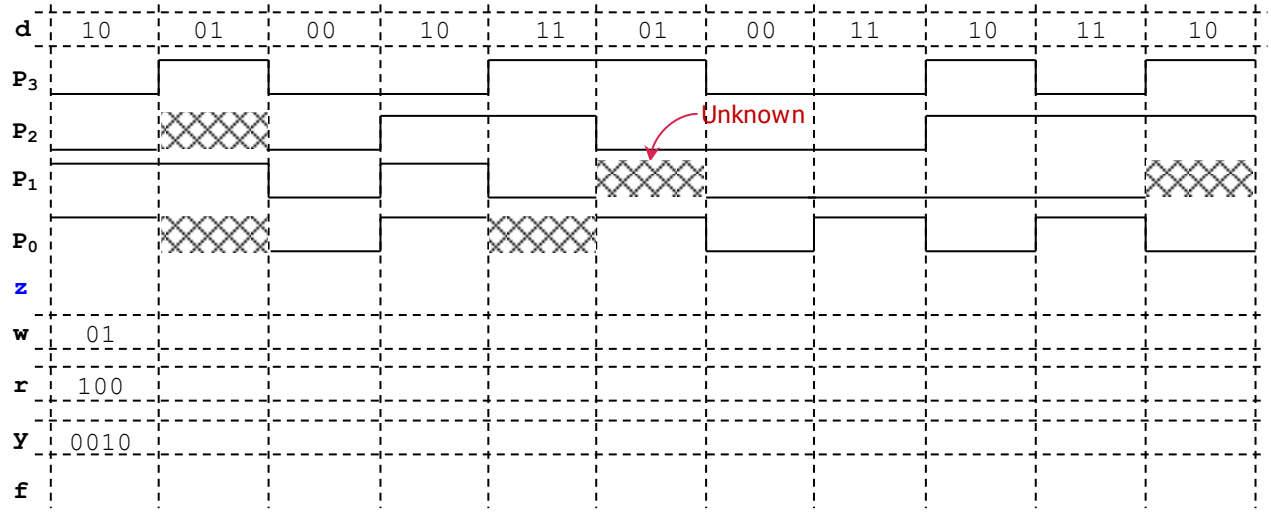
- Complete the timing diagram of the following circuit. The VHDL code (`tst.vhd`) corresponds to the shaded circuit.

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



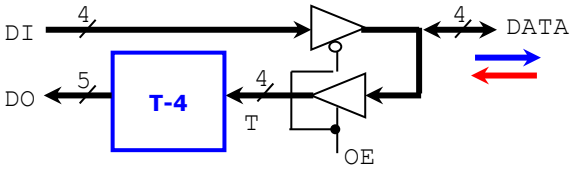

```
library ieee;
use ieee.std_logic_1164.all;
entity tst is
  port (d: in std_logic_vector(1 downto 0);
        r: out std_logic_vector(2 downto 0);
        u: in std_logic);
end tst;
```

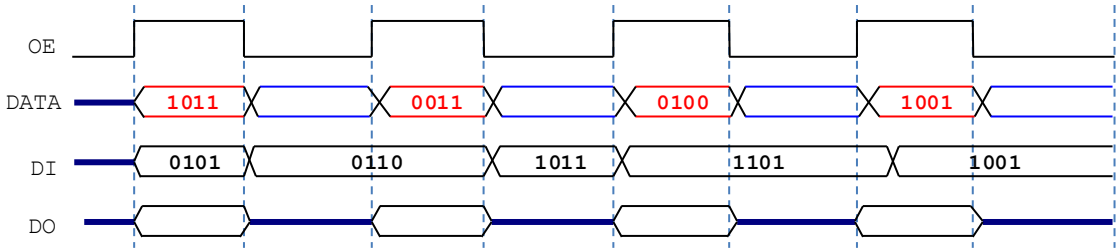
```
architecture bhv of tst is

begin

  process (d, u)
  begin

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

  end process;

end bhv;
```



## PROBLEM 3 (8 PTS)

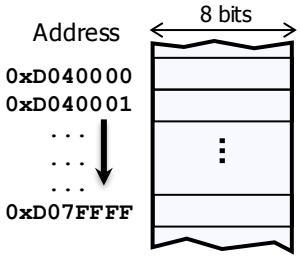
- Complete the timing diagram (signals $DO$ and $DATA$) of the following circuit. The circuit in the blue box computes the signed operation T-4, with the result having 5 bits. T is a 4-bit signed (2C) number.



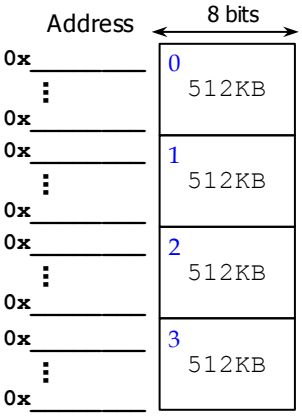




## PROBLEM 4 (12 PTS)

- A microprocessor has a 28-bit address line. The size of the memory contents of each address is 8 bits. The memory space is defined as the collection of memory positions the processor can address. (5 pts)
  - ✓ What is the address range (lowest to highest, in hexadecimal) of the memory space for this microprocessor? What is the size (in bytes, KB, or MB) of the memory space? 1KB = $2^{10}$ bytes, 1MB = $2^{20}$ bytes, 1GB = $2^{30}$ bytes
  - ✓ A memory device is connected to the microprocessor. Based on the memory size, the microprocessor has assigned the addresses `0xD040000` to `0xD07FFFF` to this memory device. (3 pts)
    - What is the size (in bytes, KB, or MB) of this memory device?
    - What is the minimum number of bits required to represent the addresses only for this memory device?




- A microprocessor has a memory space of 2 MB. The size of the memory contents of each address is 8 bits (1 byte). (7 pts)
  - ✓ 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?
  - ✓ 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. (5 pts)




## 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)
   - ✓ `17 + 50`
   - ✓ `39 - 41`

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)
   - ✓ `-36 + 50`
   - ✓ `-24 - 41`

c) Perform binary multiplication of the following numbers that are represented in 2's complement arithmetic. (3 pts)
   - ✓ `-7 x 9`

## PROBLEM 6 (10 PTS)

- Given two 4-bit unsigned numbers $A$, $B$, sketch the circuit that computes $|A-2B|$. For example: $A=1010, B=1110 \rightarrow |A-2B| = |10-2\times 14| = 18$. 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: $f(a,b,c,d) = (c \oplus d)(\overline{a \oplus b})$
  - ✓ 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)