COM219 HW5

Q1 (15 points) Quiz in class.

Q2 (20 points) Derive the truth table for a 1-bit full subtractor that performs the operation **X-Y** on unsigned binary numbers. Use **x** and **y** as the inputs to this circuit together with $\mathbf{b_{in}}$ which represents borrow in (from the lower significant digit). The output will be **d** for difference and $\mathbf{b_{out}}$ for borrow out (that connects to the higher significant digit). Obtain simplified expressions for both outputs and draw the circuit diagram corresponding to these expressions. Also draw the block diagram of a 4-bit full subtractor using the 1-bit subtractor slice you designed.

Q3 (22 points)

a) Design an 8-to-1 multiplexer using only 4-to-1 multiplexers. Show all connections and properly label them.

b) Design a circuit that compares two two-bit numbers, **A** = a_1a_0 and **B** = b_1b_0, and outputs a 1 if **A** >= **B** (numbers interpreted in pure binary). Use only 8-to-1 MUXs and inverters.

Q4 (21 points) If all the gates in the figures in the text book given below have a propagation delay of 4 ns, and all other delays can be ignored, what is the earliest time after all inputs have been provided (assume this time is: t=0) that we can assume the output of each circuit has stabilized? Explain.

a) Figure 3-15.
b) A 1-bit ALU slice in Figure 3-18.
c) A 4-bit ALU similar to Figure 3-19.

Q5 (22 points) Design a combinational circuit that outputs an 8-bit number that is a function of its two 8-bit input numbers (**A**= $A_7A_6A_5A_4A_3A_2A_1A_0$ and **B**= $B_7B_6B_5B_4B_3B_2B_1B_0$). The table below shows the relationship between the control inputs M_1 and M_0 and the circuit's output in terms of the input numbers. The circuit will add **A** to 2 times **B** when the control input is M_1M_0=00; add **A** to 4 times **B** when M_1M_0=01; multiply **A** by 2 and add to 2 times **B** when M_1M_0=10; and multiply **A** by 2 and add to 4 times **B** when M_1M_0=11. Use only 1-bit full adders and 4-bit shifter/rotators we designed in class - you may represent them as blocks with appropriately labeled inputs and outputs. Assume that the result will fit into 8 bits. Try to use a minimum number of components and additional gates. Provide your answer on paper.

Control Input		**Output**
$\mathbf{M_1}$	$\mathbf{M_0}$	**(Inputs are A and B)**
0	0	**A**+2**B**
0	1	**A**+4**B**
1	0	2**A**+2**B**
1	1	2**A**+4**B**