Assignment#1: full score: 100; due in class on 2/2/Wednesday

Name: _____ Score: _____/ 100

1. (10 pts) **Base Conversions**
   a. Convert the following signed binary number to decimal. Assume it is in 2's complement representation.

      $(10011000)_2$ = ( )$_{10}$

   b. Convert the following decimal number to an unsigned binary.

      $(150.625)_{10}$ = ( )$_2$

   c. Convert the following binary to Octal and Hexadecimal.

      $(1000011110.1011011)_2$ = ( )$_8$ = ( )$_{16}$

2. (5 pts) **Two's Complement Operations**

Perform the following 2's complement operations and indicate whether overflow occurs. Assume that operands are 8-bit two's complement representation. Show all your work.

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11000110 - 10001011
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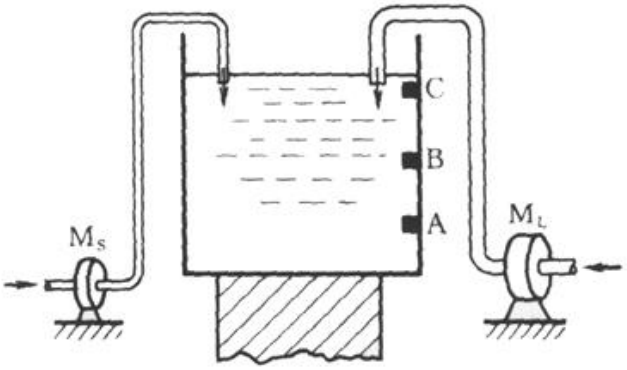
3. (15 pts) **Short-answer Questions**

a. (4 pts) Given function F as $F = A + \overline{B\,\overline{C} + \overline{D + E}}$, express F in a Sum-of-Product (SOP) form.

b. (7 pts) Given a logic expression as $F(A,B,C,D) = \sum m(1,5,6,7,11,12,13,15)$ (1) identify all prime implicants, and (2) obtain its minimum SOP expression. Show work to receive partial credits.

4. (10 pts) **Combinational Circuit Design**: As shown below, a water tank uses a small water pump (M_S) and a large water pump (M_L) to pump water. There are three water level sensors, A, B, and C, installed in the water tank. When the water level is below a water level sensor, the sensor provides a high voltage signal; while the water level is above a water level sensor, the sensor outputs a low voltage. When the water level is above C, both water pumps should stop pumping water into the tank. When the water level is below C and above B, water pump M_S works alone. When the water level is below B and above A, water pump M_L works alone. When the water level is below A, both pumps will work at the same time. Design a minimal circuit that controls the operations of water pumps (i.e., to turn the water pumps on and off automatically based on the sensors' outputs).

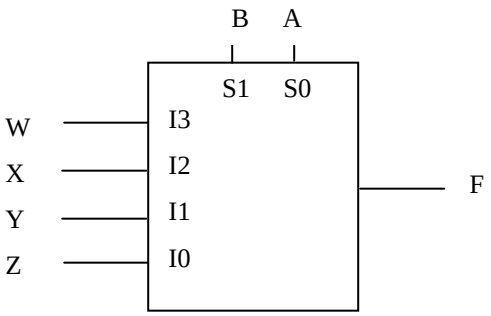


(1) What is the block diagram of the circuit?

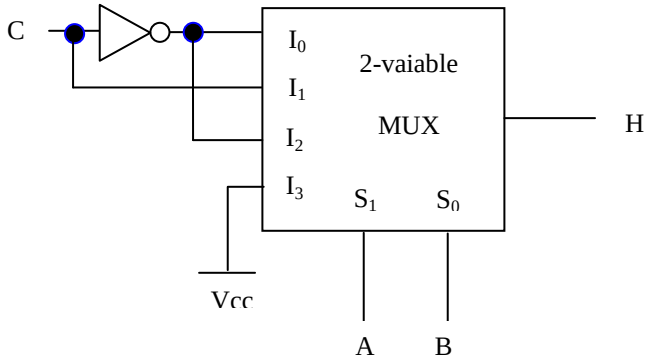
(2) Derive the truth table for the proposed circuit.

5. (15 pts) **Decoders and MUXs**

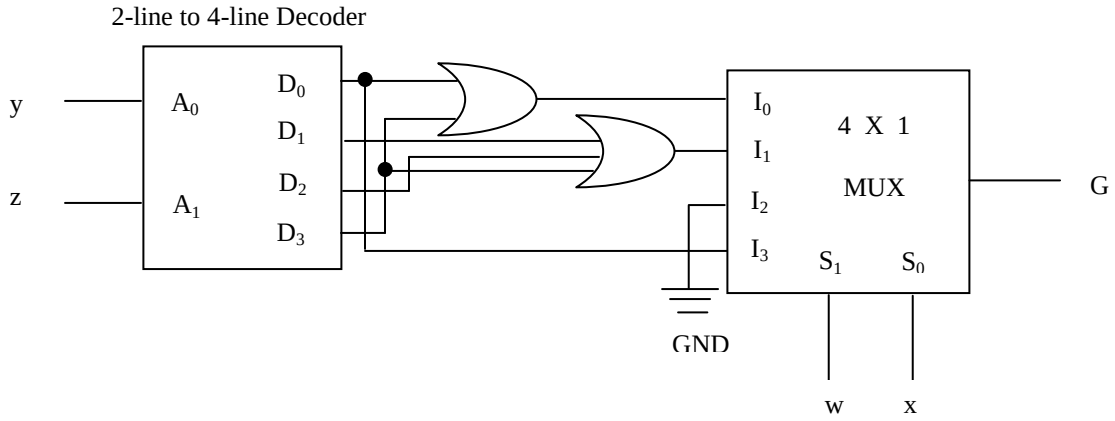
a. The following circuit includes a multiplexer with select inputs, A and B, and data inputs W, X, Y, and Z. Write an algebraic equation for F.



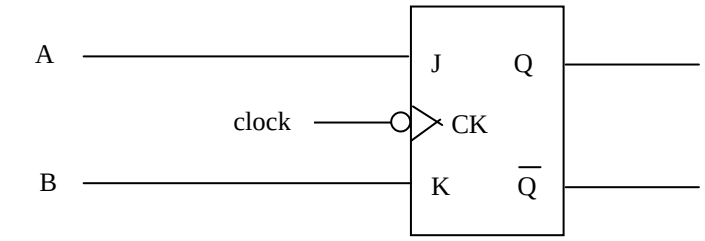
b. Given a combinational circuit shown below, derive its truth table.

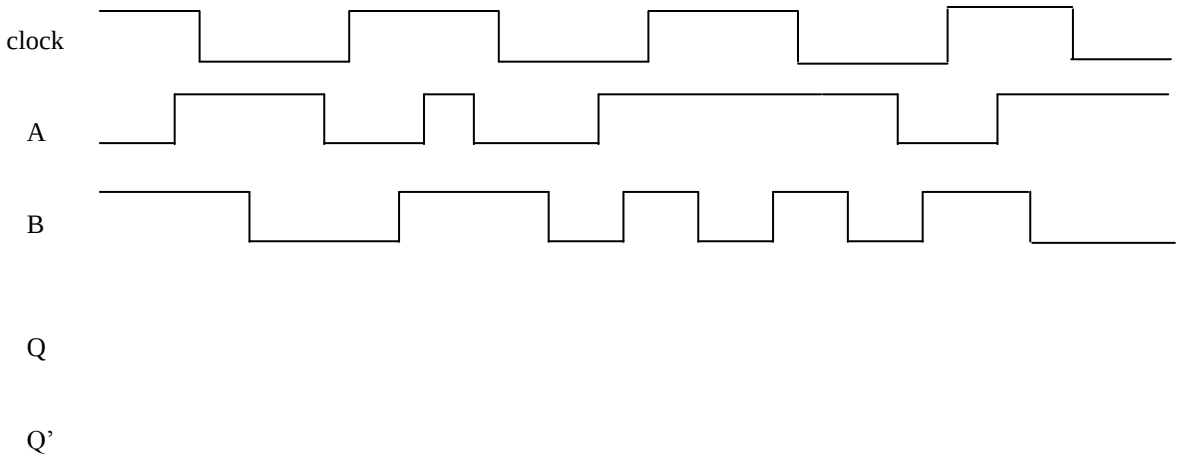


c. Given a combinational circuit that contains a MUX and a decoder as shown below, derive a Boolean expression for the function G as a function of w, x, y, and z.

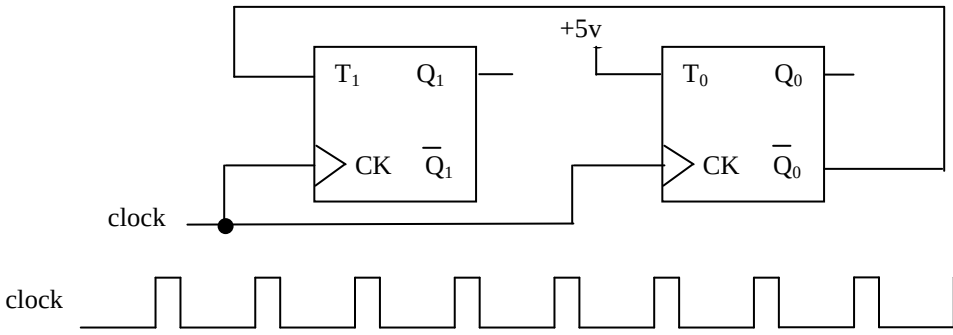


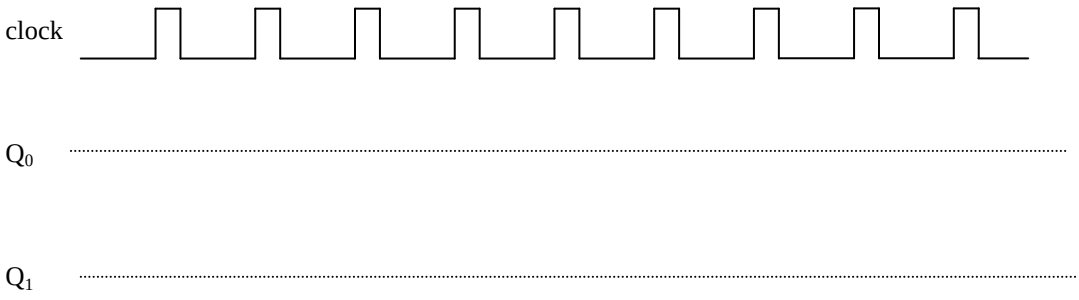
6. (10 pts) **Sequential Circuit Analysis: Assume the initial states for all flip-flops in the following questions are 0.**
   a. Shown below is a circuit built based on a JK flip-flop. Complete the timing diagram.



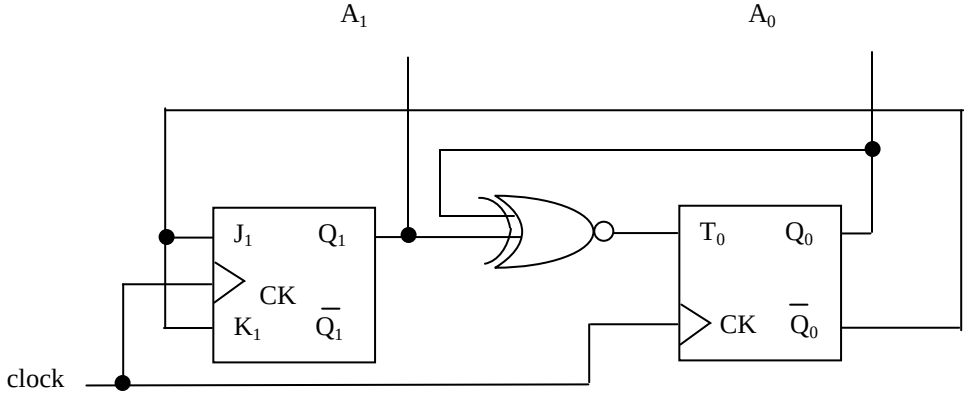


   b. Complete the timing diagram for the given circuit below. Assume that the initial state of each flip-flop is zero.

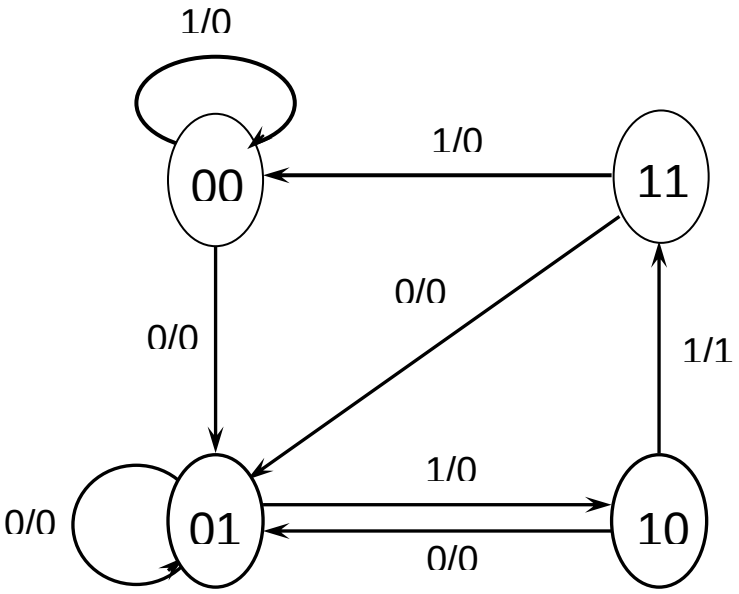




7. (8 pts) For the given circuit below, derive its state transition diagram. You may use any method learned for sequential circuit analysis. Detect to see if this sequential circuit is self-correcting. Explain.



8. (6 pts) Given a state diagram shown below, construct a state table for it. Notice that the system has one external input and one external output.



Answer:

9. (9 pts) In many occasions, we often need a counter that can count down. Use an SN74LS169 to design a truncated counter that has a counting sequence of:

   "10" => "9" => "8" => "7" => "6" => "5" => "4" => "3" => "2" => "1" => "10" => "9" => "8" => …… (repeat).

   Show your design with a circuit diagram that contains a SN74LS169 module. You should try to achieve the minimal design (i.e., use the least number of discrete gates). Label the devices used. Do not draw the internal circuit of SN74LS169.

Turnover: Q10 on the back!!

10. (10 pts) Design a binary sequence detector that recognizes a three-bit pattern of "101". Complete the **first step** in the sequential circuit design procedure. In other words, derive a state transition diagram for the sequence detector circuit to be built.

An example that shows the function of the circuit,

Input sequence via input x:	00111110111011010011110101 00...
Output sequence F:	00000000100010010000000010000...