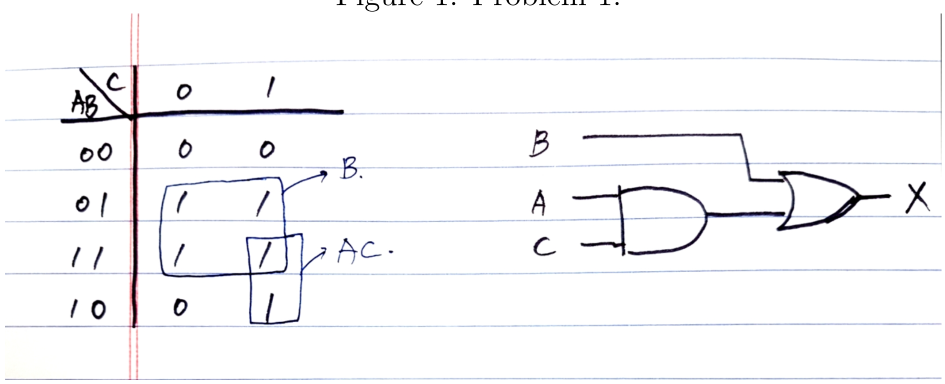
Digital Circuits: Homeworks #3 Solutions

1. **Logic Circuit.**
   Implement a logic circuit for the following truth table.

A	B	C	X
0	0	0	0
0	0	1	0
0	1	0	1
0	1	1	1
1	0	0	0
1	0	1	1
1	1	0	1
1	1	1	1

Solution: Logic Circuit
It is not hard to show that $X = B + AC$. We can implement a logic circuit for X using one AND gate and one OR gate. Figure 1 shows K-map and logic circuit.

Figure 1: Problem 1.



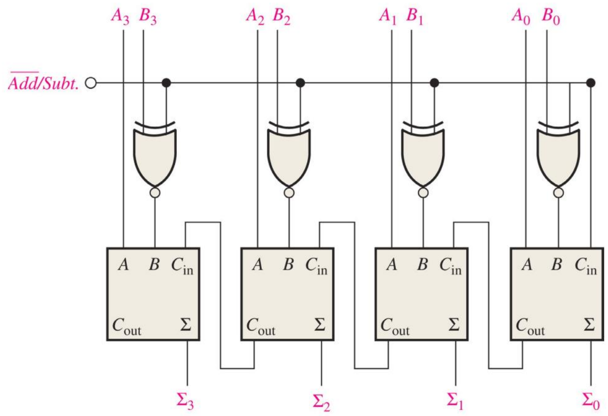
2. **Adder and Subtracter.**
   The circuit shown in Figure 2 is a 4-bit circuit that can add or subtract numbers in a form used in computers (positive numbers in true form; negative numbers in 1's complement form).

   (a) Explain what happens when the $\overline{Add}/Subt$ input is HIGH?

   (b) Explain what happens when the $\overline{Add}/Subt$ input is LOW?

Solution: Adder and Subtracter
When $\overline{Add}/Subt$ is LOW, all B_i's will be flipped. This implies that the circuit adds

Figure 2: Adder and Subtracter.

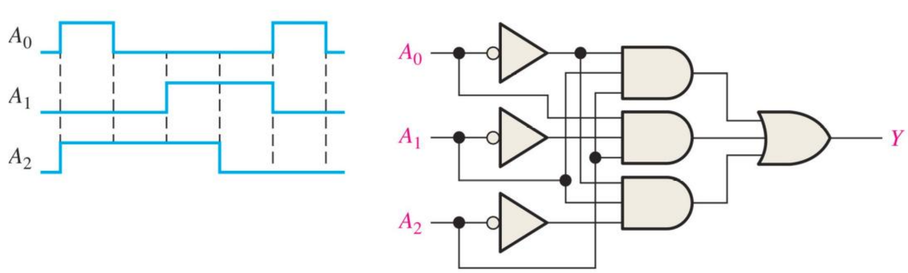


$A = A_3A_2A_1A_0$ and 1's complement of $B = B_3B_2B_1B_0$ which is essentially subtracting B from A.

When $\overline{Add}/Subt$ is HIGH, all B_i's will remain the same. This implies that the circuit adds $A = A_3A_2A_1A_0$ and $B = B_3B_2B_1B_0$ with $C_{in} = 1$ from the beginning. In other words, it computes $A + B + 1$.

3. **Decoder.**
   If the input waveforms are applied to the decoding logic as indicated in Figure 3, sketch the output waveform in proper relation to the inputs.

Figure 3: Decoder.



Solution: Decoder
$Y = 1$ if and only if $A_0 = 0, A_1 = 1, A_2 = 1$, or $A_0 = 1, A_1 = 0, A_2 = 1$, or $A_0 = 0, A_1 = 1, A_2 = 0$. Figure 4 shows the output waveform.

4. **Multiplexer.**
   For the multiplexer in Figure 5, input states are given by $D_0 = 1, D_1 = 0, D_2 = 0, D_3 = 1$. Then, determine the output waveform when the data-select inputs are sequenced as shown by the waveforms in Figure 6.

Figure 4: Problem 3.

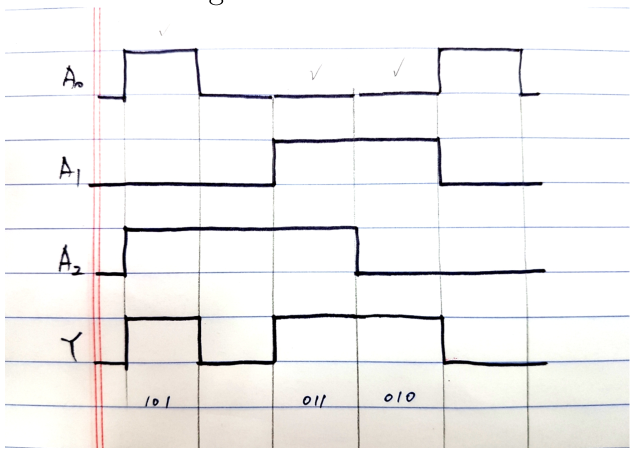
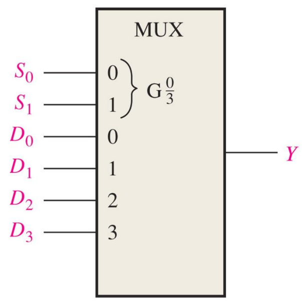


Figure 5: Multiplexer.



Solution: Multiplexer
The output will be 1 if and only if $S_0 = S_1 = 1$ or $S_0 = S_1 = 0$. Figure 7 shows the output waveform.

Figure 6: Data-Select Input Waveforms.

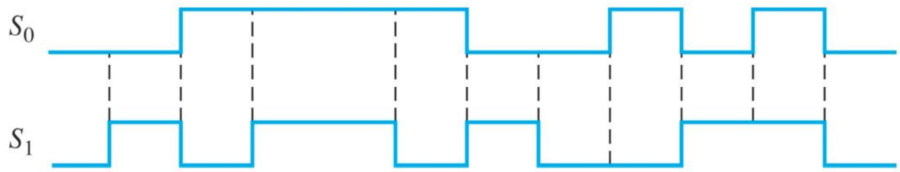


Figure 7: Problem 4.