Name: ____________________

Problem	**Points**	**Score**
1a	10	
1b	10	
2a	10	
2b	10	
3a	10	
3b	10	
3c	10	
4a	10	
4b	10	
4c	10	
Total	**100**	

Notes:

1. The exam is closed book / closed notes. Students are allowed a copy sheet — only ONE standard US-size (8.5” x 11”) sheet of paper — on which they can write relevant information such as theorems.
2. Please show ALL work. Incorrect answers with no supporting explanations or work will be given no partial credit.
3. If I can’t read or follow your solution, it is wrong, and no partial credit will be given — PLEASE BE NEAT!
4. Please indicate clearly your answer to every problem.
5. There is sufficient space after each problem to write your solution. In case you need extra paper please see the instructor.
6. Calculators of any kind are not allowed.

Problem No. 1:

A conveyor belt is controlled by four buttons ABCD. The belt starts moving if any two of the four buttons are pressed. If all four buttons are pressed, the conveyor belt stops. If no buttons are pressed, the belt does not move. Pressing an odd number of buttons is not allowed.

a) Draw a truth table for the conveyor belt control network.

Solution:

b) Draw the corresponding Karnaugh map. Find a minimum expression for the output that controls the movement of the conveyor belt, and count the number of gates and gate inputs required for an AND-OR representation.

Solution:

Problem No. 2:

Imagine a world without Karnaugh maps! Only the Quine-McCluskey algorithm can help you find the minimum expression for the following problem.

$$Z(A, B, C, D) = \sum m(1, 3, 4, 5, 7, 8, 11, 14, 15) + \sum d(2, 9, 10)$$

a) Find all the prime implicants for Z by completing the following table of minterms using the Quine-McCluskey algorithm.

Solution:

1	0001 ✔
2	0010 ✔
4	0100 ✔
8	1000 ✔
3	0011 ✔
5	0101 ✔
9	1001 ✔
10	1010 ✔
7	0111
11	1011
14	1110
15	1111

1, 3	00 - 1
1, 5	0 - 01
1, 9	- 001
2, 3	001 -
2, 10	- 010
4, 5	010 -
8, 9	100 -
8, 10	10 - 0

b) Draw a prime implicant chart and find the minimum sum of products expression for Z.

Solution:

Problem No. 3:

The following 4-input 2-output network needs to be implemented:

$$X = \sum m(3, 5, 8, 9, 10, 11) + \sum d(2, 4, 13)$$
$$Y = \prod M(0, 1, 10, 11, 12, 13) \cdot \prod D(3, 6)$$

a) Draw the Karnaugh maps for X and Y, and find equations for a two-level multiple-output AND-OR network. Minimize the number of gates required.

Solution:

b) Draw the logic diagram for this network using AND and OR gates only. Count the number of gates and gate inputs.

Solution:

c) Implement the network for X and Y using only NAND gates.

Solution:

Problem No. 4:

A digital network has four inputs ABCD and three outputs XYZ. The input-output equations are as follows —

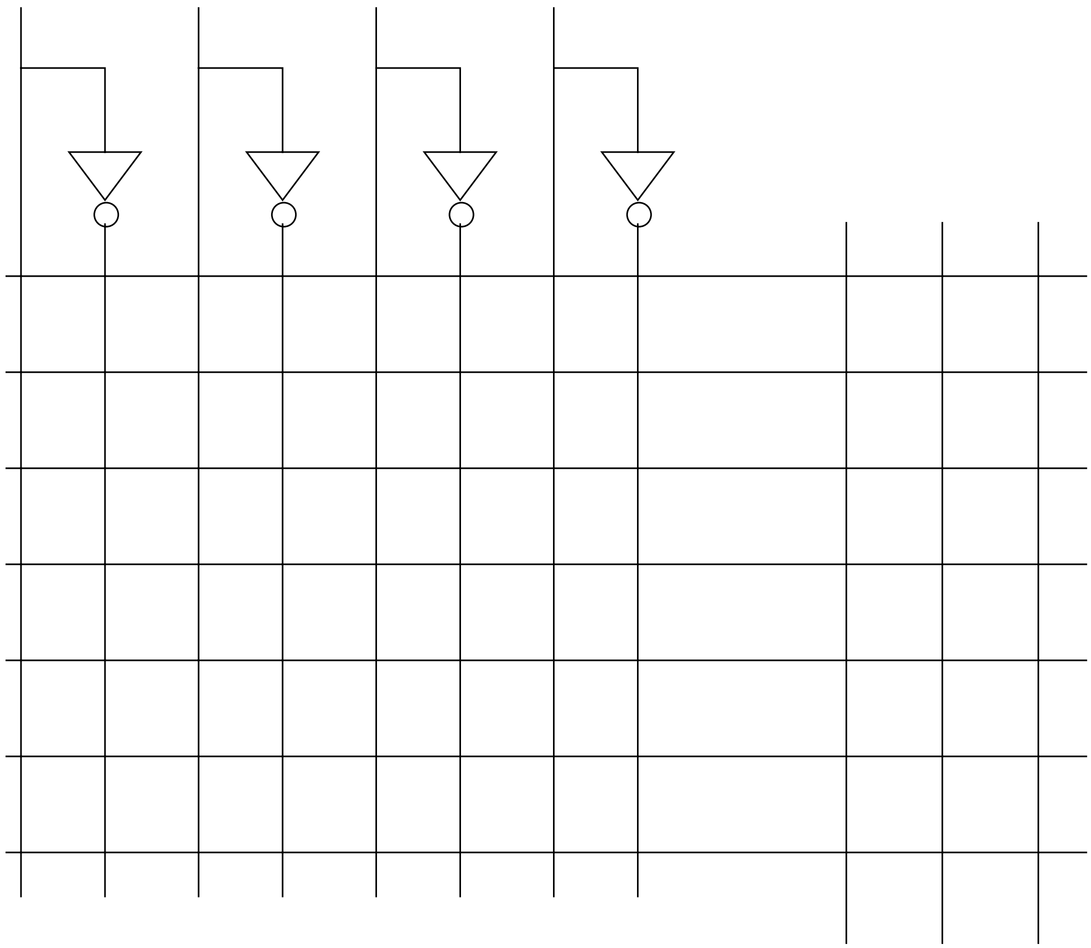
$$X = A'BD + BC' + AC'D' + CD$$
$$Y = ACD' + A'B$$
$$Z = AB'D + AD' + A'BD'$$

a) Implement the above network using the following PLA.

Solution:

b) Suppose that this network was implemented on a ROM. What is the required size of a ROM? What value is stored at the ROM address 0101? What is stored at 1100?

Solution:



c) Use a 8-to-1 multiplexer and implement the network for only the Z output.

Solution: