**Name:** _____

| Problem | Points | Score |
|---|---|---|
| 1a | 10 | |
| 1b | 10 | |
| 1c | 10 | |
| 2a | 10 | |
| 2b | 10 | |
| 2c | 10 | |
| 3a | 10 | |
| 3b | 10 | |
| 3c | 10 | |
| 3d | 10 | |
| **Total** | **100** | |

## Notes:

1. The exam is closed book / closed notes. Students are allowed a copy sheet — **both** sides of **two** standard US-size (8.5” x 11”) sheets 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.

7. Total time available is **3 hours**.

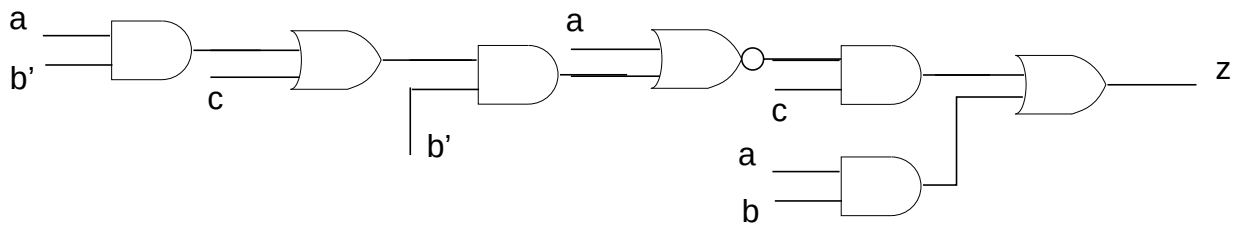
**Problem No. 1:**

**a)** Perform the following binary operations as specified. Assume that 2's complement is used to describe negative numbers in **ii**.

| | | | |
|---|---|---|---|
| **i.** | 00010 + 01111 | **ii.** | 10101 - 11010 |
| **iii.** | 1011 x 1001 | **iv.** | 1101010 ÷ 101 |

Indicate clearly if an overflow occurred, and the final answers for each.

**b)** Electronic Devices Inc. has hired you to analyze the following network and derive an equivalent minimized network. Find an expression for z, minimize it using only the laws of Boolean algebra and draw the resulting minimum network.



**c)** The MSU Electronic Design-athon takes place every semester, where students vie for the best network design for a given problem. This time, the judges are having trouble deciding between the top two contenders —

$$F = (X' + Y')(X \equiv Z) + (X + Y)(X \oplus Z)$$
$$G = (X \oplus Y) + Z'$$

Verify whether $F = G$ using only the laws of Boolean algebra.

**Problem No. 2:**

A mad scientist designing a 4-input 2-output combinational network has left his work incomplete with the following information: The inputs are ABCD. One of the network outputs X is given by

$$X = \sum m(1, 2, 4, 9, 13) + \sum d(5, 10, 12)$$

The following prime implicant chart is available for the other output Y.

| | 2 | 4 | 5 | 6 | 9 | 10 | 11 | 12 | 13 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|
| a'cd' (2, 6) | X | | | X | | | | | | |
| b'cd' (2, 10) | X | | | | | X | | | | |
| a'bd' (4, 6) | | X | | X | | | | | | |
| bc' (4, 5, 12, 13) | | X | X | | | | | X | X | |
| ad (9, 11, 13, 15) | | | | | X | | X | | X | X |
| ab'c (10, 11) | | | | | | X | X | | | |

**a)** Draw the K-map and obtain a minimum expression for X. Derive a minimum form expression for Y from the prime implicant chart so that a minimum implementation is realized for the complete network (i.e. a maximum number of prime implicants can be shared between X and Y).

**b)** Draw a minimum three-level AND-OR network for this problem. Do not use gates that have more than 3 inputs. Convert the network to an all-NAND form using the inversion bubbles method.

**c)** The outputs of the previous network are used to control the launch of a missile. The control output Z is 1 when only one of X or Y is 0. Use a 2-to-4 decoder and external logic gates to design the control network for Z with X and Y as inputs.

**Problem No. 3:**

A Moore sequential network has one input X and one output Z. Z is 1 if an input pattern of 011 is detected an odd number of times. Z = 0 if the number of occurrences of 011 at the input is even (or zero).

**a)** Draw a state graph for this network and the corresponding state table. Make sure that the number of states does not exceed 6.

**b)** Assign the states according to the three guidelines for optimal state assignment. Assign 000 for state 0. You do **not** have to derive the state and output equations for the network.

**c)** A sequential network uses three D flip-flops LMN, has one input P and an output W as described below —

$$D_L = MP$$
$$D_M = P'$$
$$D_N = P'N + L'N + PLN'$$
$$W = N'$$

Is this network Moore or Mealy? Draw the next state and output maps and derive the corresponding state table for this network. Assume that states corresponding to 110 and 111 do not appear at all.

**d)** Using the implication charts method, check if the two networks described in parts **a)** and **c)** are equivalent.