Student ID: _____

CS 151
Midterm

Name : _____ , _____
(Last Name) (First Name)

Student ID : _____

Signature : _____

Instructions:

1. Please verify that your paper contains **10 pages** including this cover.
2. Write down your Student-Id on the top of each page of this quiz.
3. This exam is **closed book**. No notes or other materials are permitted.
4. Total credits of this midterm are **55 points.**
5. To receive credit you must show your work clearly.
6. **For possible re-grade request make sure that your write clearly.**
7. Calculators are **NOT** allowed.

Student ID: _____

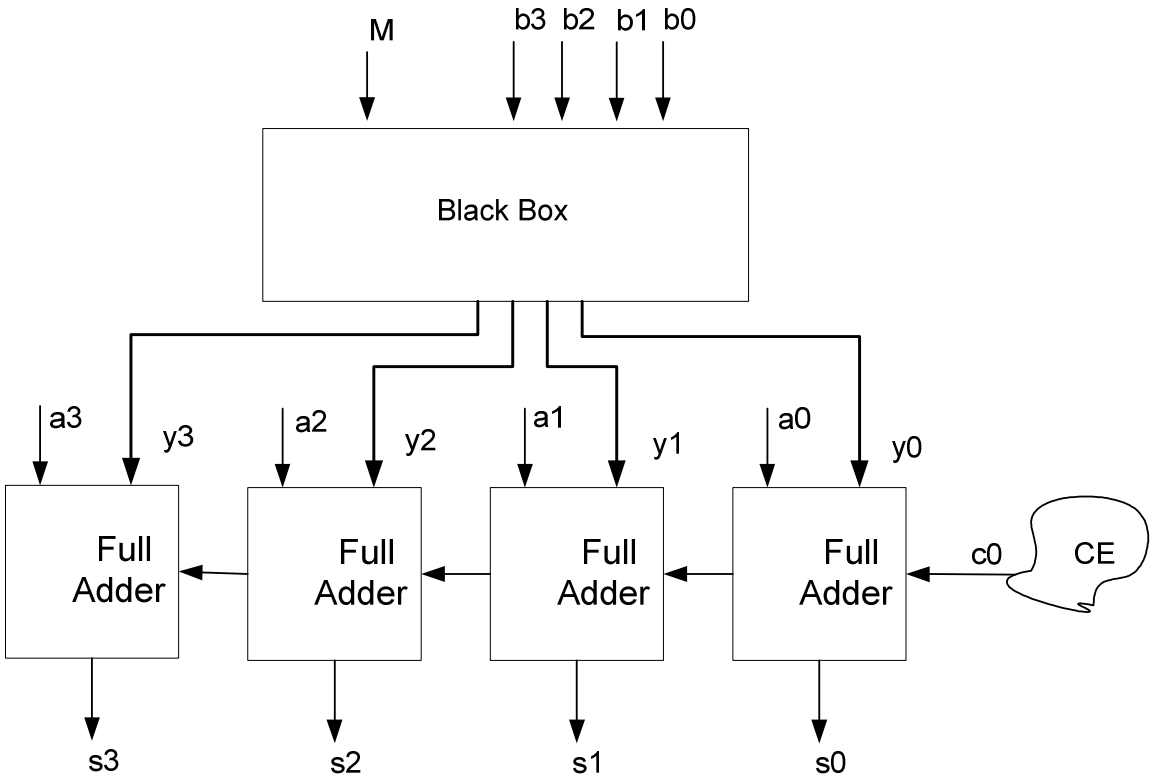
Q1: [ALU] [15 points]

We are going to design a 4-bit Arithmetic Unit (AU) with the following functional table:

M1	M0	Function Name	F(A,B)
0	0	Add A and B	A+B
0	1	Subtract B from A	A-B
1	0	Decrement A	A-1
1	1	Add A and 2*B and 2	A+2*B+2

A and B are two 4-bit binary numbers a3a2a1a0 and b3b2b1b0.
M1, M0 are the control inputs to this AU.

For doing this, the blocks labeled "Black Box" and CE (Carry Extender) in the following block diagram should be designed:



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a. Fill the following table for y3, y2, y1, y0 and c0 based on the inputs of the AU which are a3, a2, a1, a0, b3, b2, b1, b0, M1 and M0. **[10 points]**

M1	M0	y3	y2	y1	y0	c0
0	**0**	b3	b2	b1	b0	0
0	**1**	b3’	b2’	b1’	b0’	1
1	**0**	1	1	1	1	0
1	**1**	b2	b1	b0	1	1

b. Using the table that you reached in part (a), derive the logic equations for y1, y0and c0. **[5 points]**

$y_1 = m_1'm_0'b_1 + m_1'm_0b_1' + m_1m_0' + m_1m_0b_0$

$y0 = m_1'm_0'b_0 + m_1'm_0b_0' + m_1m_0' + m_1m_0$

$c0 = m_1'm_0 + m_1m_0$

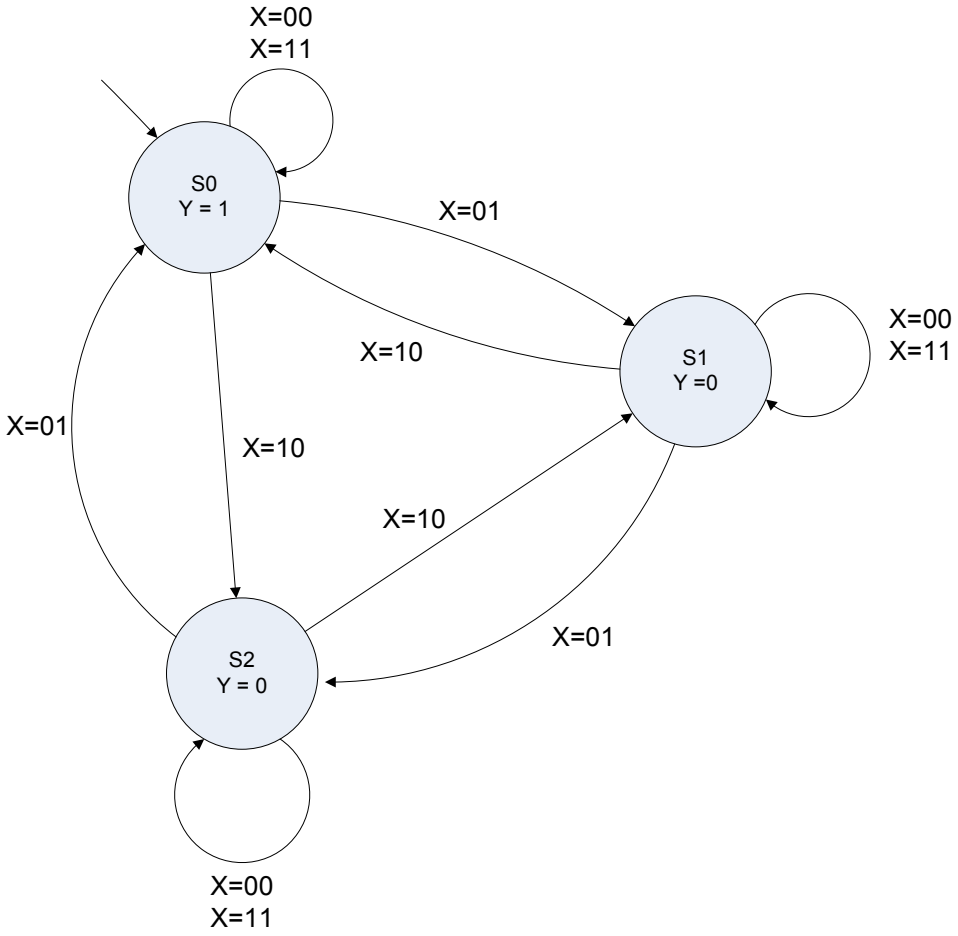
Student ID: _____

Q2: [FSM Design] [15 points]

Design an FSM for a circuit which has a 2-bit input X and an output Y. The output Y becomes 1 if the cumulative sum of the numbers in sequence X multiple of 3. Otherwise Y is 0.

For example:

X: 00 → 11 → 01 → 10 → 00 → 01 …
Y: 1 → 1 → 0 → 1 → 1 → 0 …



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Student ID: _____

Q3: [Component based design] [15 points]

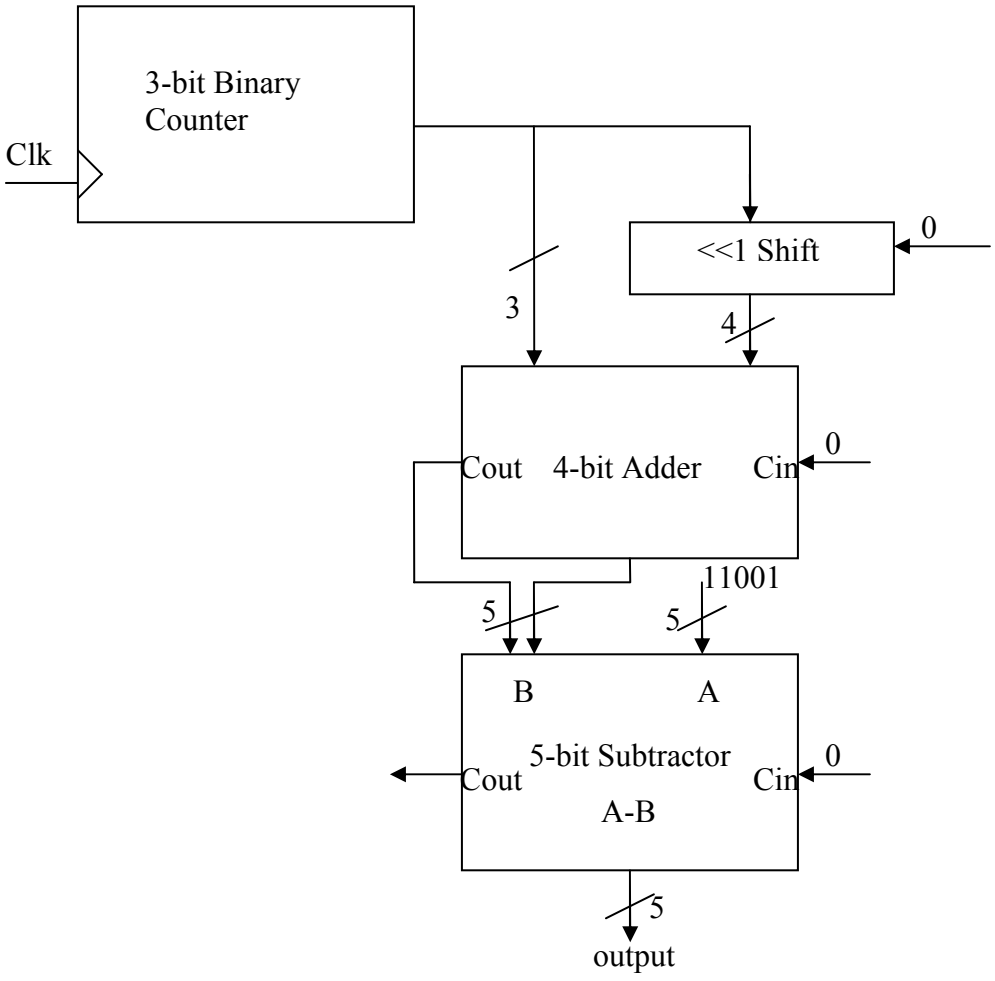
Using only one 3-bit binary counter and components as listed below, design a counter that generates the following sequence repeatedly:

(NOTE: The 3-bit counter starts counting from 0 to 7.)

25 → 22 → 19 → 16 → 13 → 10 → 7 → 4 → 25 …..

a) Shifter
b) Adder
c) Subtractor
d) Comparator

The output has the form of (25 – 3x)



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Student ID: _____

Q4: [Custom Design] [10 points]

Design a circuit which executes the following code:

If (A+B > 14)

Then S = C + D + 1

Else
S = C + D

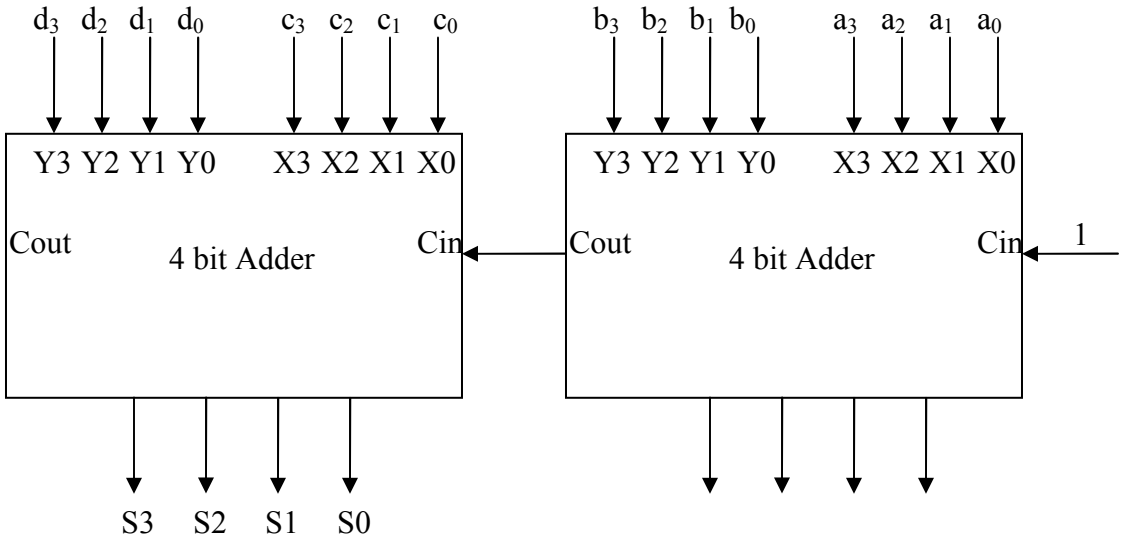
A, B, C and D are 4-bit binary numbers!

You can use the following components:

- Adder
- Comparator
- Subtractor
- Multiplexer
- Counter

HINT: There is a tricky solution to this problem which uses just adders. If you achieve designing this circuit using **only** 4-bit adders you can earn an **extra credit of 5 points**.

The tricky solution:



Student ID: _____

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The obvious solution: