Instructions: This exam booklet has 7 numbered pages and 9 problems. Two blank pages are added at the end for your scratch work.

The exam is closed book and notes. Calculators are not permitted. For partial credit, show your work. *Answer all problems.* Good Luck!

Your Name:_____ Key _____

Your Student ID: _____

Your Instructor:_____

Your Section #:_____ ; Your Lecture Times:_____

Problem	Max Points	Score
1	4	4
2	6	6
3	6	6
4	4	4
5	6	6
6	6	6
7	4	4
8	4	4
9	10	10
Total	50	50

Problem 1 (4 points)

Perform the arithmetic shown in the table below. The numbers in the leftmost column are decimal. Represent each decimal number using 8-bit binary signed representation. An example is shown in the first row. Do the rest of the calculations in the same way. If the calculation produces an overflow, write **"OVERFLOW"** and scratch the answer.

	Sign-Magnitude	2's Complement
12 + 5	0 0 0 0 1 1 0 0 + 0 0 0 0 0 1 0 1 0 0 0 1 0 0 0 1	0 0 0 0 1 1 0 0 + 0 0 0 0 0 1 0 1 0 0 0 1 0 0 0 1
120 + 45	OVERFLOW	OVERFLOW
120 + (- 45)	0 1 1 1 1 0 0 0 + 1 0 1 0 1 1 0 1 0 1 0 0 1 0 1 1	0 1 1 1 1 0 0 0 + 1 1 0 1 0 0 1 1 1 0 1 0 0 1 0 1 1 (Discard carry) 0 1 0 0 1 0 1 1

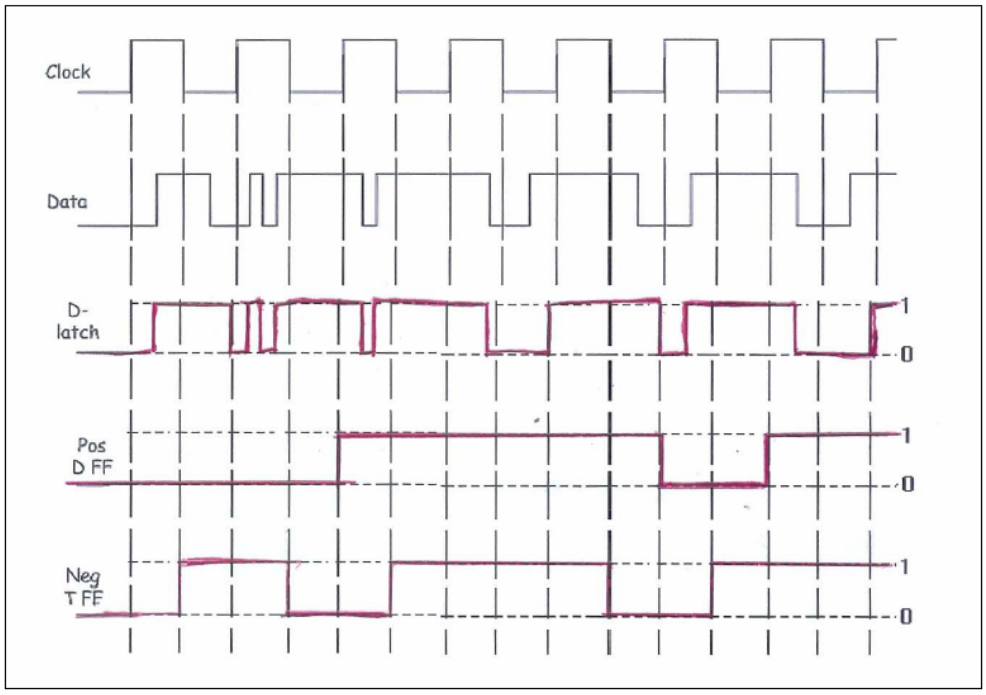
Problem 2 (6 points)

Using the following waveforms of a clock and data as inputs, finish the output waveform for:

(a) a D-latch. 2 marks

(b) a positive-edge triggered D Flip/Flop 2 marks

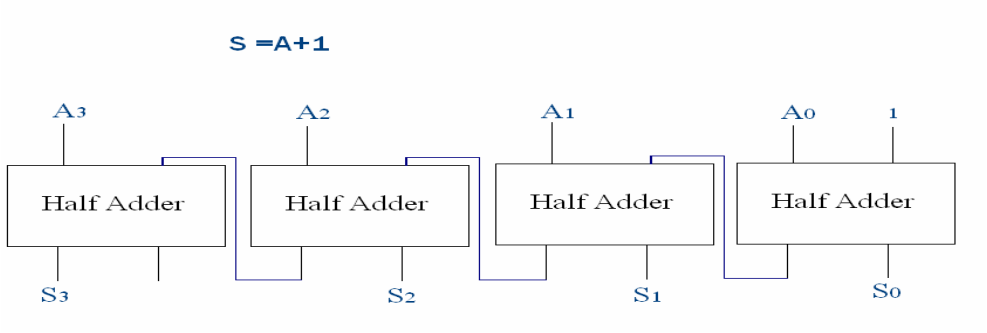
(c) a negative-edge triggered T Flip/Flop (using data as the toggle bit). 2 marks



Problem 3 (6 points)

(a) (3 points) Using only four blocks, each of which is a half adders, design a 4-bit combinational circuit incrementer. The input is a 4-bit unsigned number X, {X3, X2, X1, X0), and the output is Y, {Y3, Y2, Y1, Y0} such that Y = X + 1 with a carry bit C4

Solution

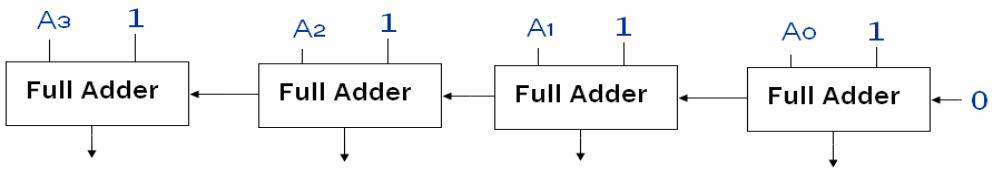


Block diagram : 1 point
Each input number : (A : 1 point) & (1: 1 point)

(b) (3 points) Using only four blocks, each of which is a full adders, design a 4-bit combinational circuit decrementer. The input is a 4-bit unsigned number X, {X3, X2, X1, X0), and the output is Y, {Y3, Y2, Y1, Y0} such that Y = X – 1.

Solution

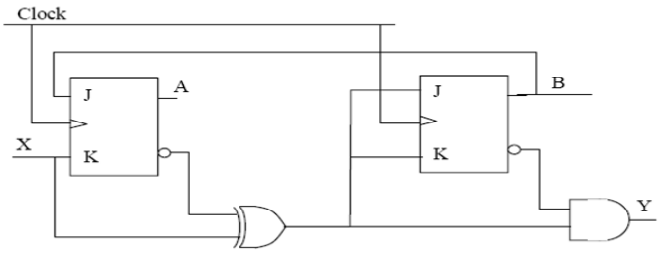
A-1= A + 2's complement of 1= A+ 1111



Block diagram : 1 point
Each input number : (A : 1 point) & (1111: 1 point)

Problem 4 (4 points)

A sequential circuit has two JK flip-flops, an input X, and an output Y. The logic diagram of this circuit is shown below. Complete the state table of the circuit which is also shown below.



Solution

PS A(t)B(t)	NS: A(t+1)B(t+1)		Output Y(t)	
	X = 0	X = 1	X = 0	X = 1
00	01	00	1	0
01	10	11	0	0
10	10	01	0	1
11	11	00	0	0

Problem 5 (6 points)

A sequential circuit has three ***D*** flip flops named ***A, B*** and ***C***; one input ***X,*** and one output ***Y.*** The state diagram of the circuit is show below. Design the circuit by treating the unused states as don't care conditions. Your design should include:

(a) A state table corresponding to the given state diagram

State Table : 2 points

A	*B*	*C*	*X*		*A*	*B*	*C*	*Y*	D_A	D_B	D_C
0	0	0	0		0	1	1	0	0	1	1
0	0	0	1		1	0	0	1	1	0	0
0	0	1	0		0	0	1	0	0	0	1
0	0	1	1		1	0	0	1	1	0	0
0	1	0	0		0	1	0	0	0	1	0
0	1	0	1		0	0	0	1	0	0	0
0	1	1	0		0	0	1	0	0	0	1
0	1	1	1		0	1	0	0	0	1	0
1	0	0	0		0	1	0	0	0	1	0
1	0	0	1		0	1	1	0	0	1	1
1	0	1	0		X	X	X	X	X	X	X
1	0	1	1		X	X	X	X	X	X	X
1	1	0	0		X	X	X	X	X	X	X
1	1	0	1		X	X	X	X	X	X	X
1	1	1	0		X	X	X	X	X	X	X
1	1	1	1		X	X	X	X	X	X	X

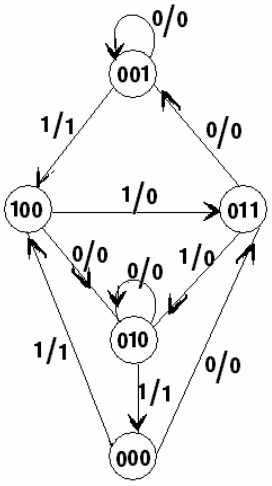
(b) Three simplified flip flop input functions: D_A , D_B , and D_C.

$$D_A = A' B' x$$

$$D_B = A + C' x' + B C x$$

$$D_C = C x' + A x + A' B' x'$$

$$Y = A' B' x + A' C' x$$



Each simplified function : 1 point

Problem 6 (6 points)

Use negative edge triggered D flip-flops and any required logic gates to design a synchronous counter that repeats the sequence **0, 2, 7, 4, 3, 5** indefinitely. Make sure that you show the state diagram, state table, Karnaugh maps for the inputs of the FF, and the simplified Boolean functions of the inputs.

Solution

State table : (2 points)

Present State			Next State		
A	B	C	A	B	C
0	0	0	0	1	0
0	0	1	X	X	X
0	1	0	1	1	1
0	1	1	1	0	1
1	0	0	0	1	1
1	0	1	0	0	0
1	1	0	X	X	X
1	1	1	1	0	0

Input Equations (or from the logic diagram): (3 points, each input 1 point)

DA = B

DB = C'

DC = A'B + A C'

Logic Diagram: (1 point)

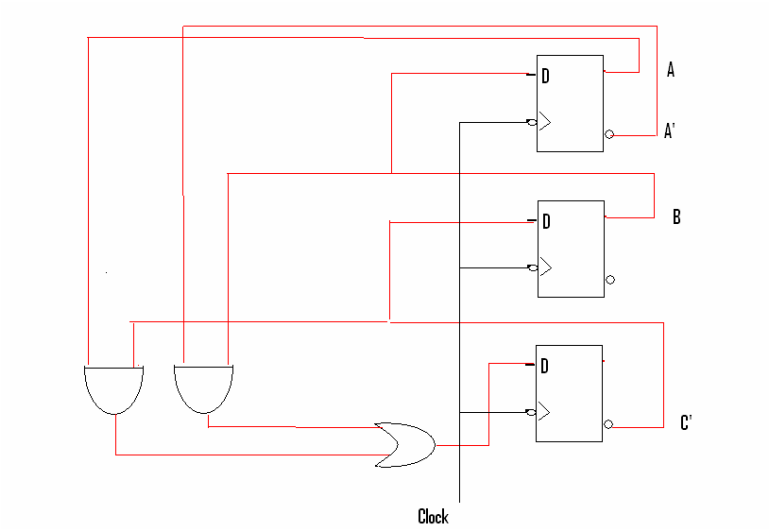
- **Negative edge : (0.5 point)**
- **Clock : (0.5 point)**

Students who check the unused states will get extra 1 point as a bonus

1 (001) ➔ 0 (000)

6 (110) ➔ 7 (111)

Circuit Diagram:



Problem 7 (4 points)

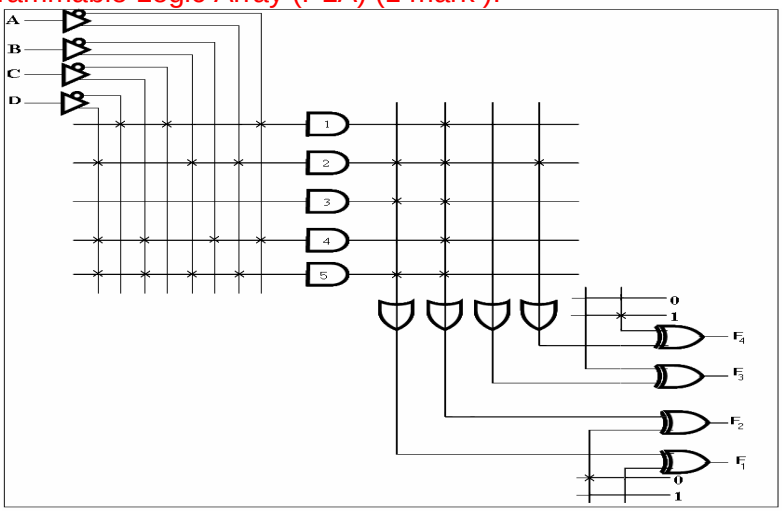
Use the figure below to answer the following questions

Solution

a- F2 = A`C`D`+ABD+A`B`CD+ABCD (each correct product term 1/2 mark).

b- F4=(ABD)` (1/2 mark for the correct product term)
(1/2 mark for the complement).

c- Programmable Logic Array (PLA) (1 mark).



Problem 8 (4 points)

In the shift register circuit shown in Fig 1_a below, The following was done:

- All Flip Flops where reset.
- The Serial Input has the value "1", and then a clock pulse was sent.
- Q2 output was connected to the Serial Input, as shown below in Fig 1_b.

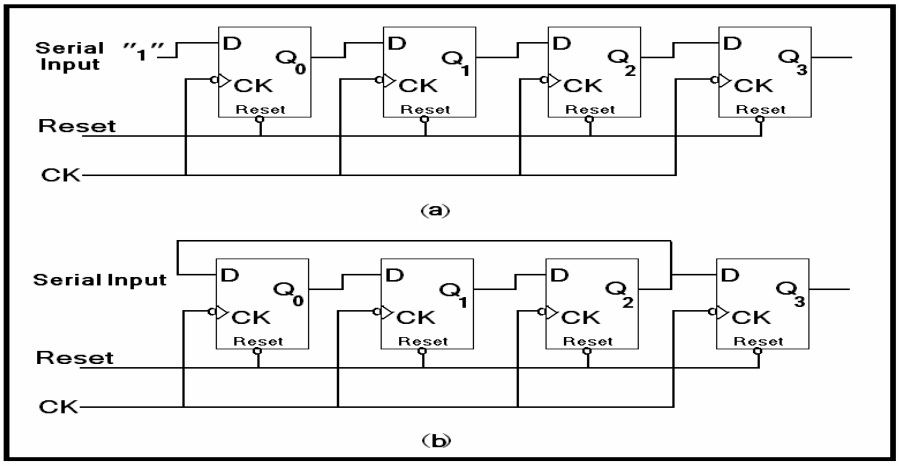


Fig. 1

Solution

Fill the following table: **each line one mark either 1 or 0**

Reset	Clock	Serial input	Q0	Q1	Q2	Q3
0	--	1	0	0	0	0
1	1	1	1	0	0	0
1	2	--	**0**	**1**	**0**	**0**
1	3	--	**0**	**0**	**1**	**0**
1	4	--	**1**	**0**	**0**	**1**
1	5	--	**0**	**1**	**0**	**0**

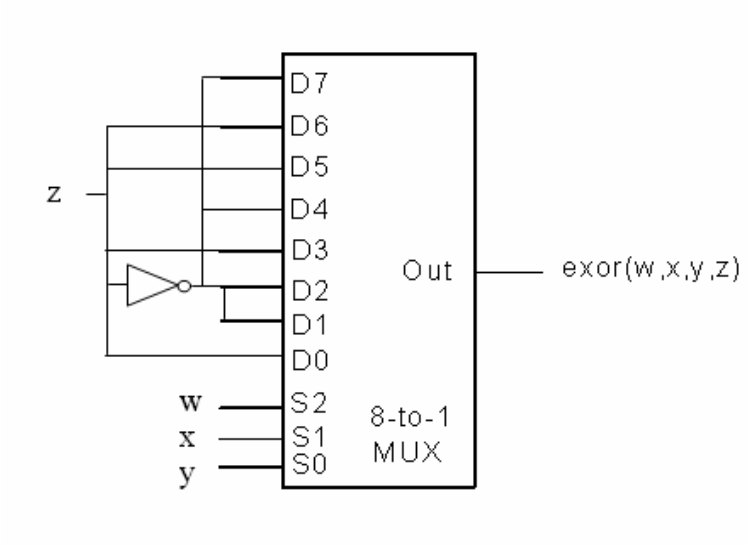
Problem 9 (10 points)

(4 points) (a) Use the 8-to-1 multiplexer below to implement an exclusive or function for four bits. This is also known as the "odd" function. The function exor(w,x,y,z) is to be:

exor(w,x,y,z) = w⊕x⊕y⊕z

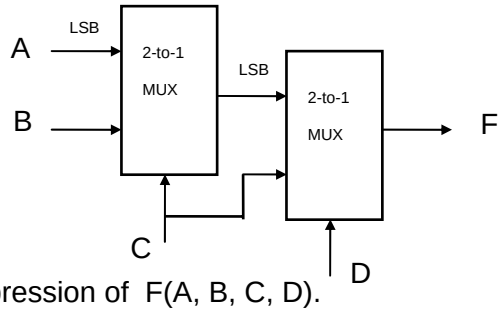
Draw the circuit in the space below. You may use only NOT, OR, and AND gates.

Solution



(6 points)(b) For the following combination of 2-to-1 MUXs, do the following:

Solution



1. Find the expression of F(A, B, C, D).

F = (AC' + BC) D' + CD = AC'D' + BCD' + CD

2. Draw the four-variable K-map.

F = Σ*m*(3, 6, 7, 8, 11, 12, 14, 15)

1. 1 point per product term.
2 -0.5 point for each missing or wrong minterm.