Group Number: 9

NAMES (FIRST AND LAST NAME): Harrison Goss
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In-Class Assignment 2

ELEN 21/COEN 21 – Fall 2022
Instructor: Maria Kyrarini
Date: 10/18/2022
Time: 1 hour and 30 minutes
Number of Problems: 4

Important Notes:

- Be sure to read all the problems carefully and answer all questions.
- Be sure to answer all parts of each question.
- **Submit only one answer for each question.**
- Multiple solutions for one question will not be graded.
- **Clearly SHOW and EXPLAIN all the steps of your work.**
- **Answers without detailed explanations will NOT be graded (excluding Problem 1).**
- The Engineering School Honor Code applies.

1	20
2	39
3	17
4	12
Total	88

Jennifer Jin

Boolean Algebra Properties

5*a*.	$x \cdot 0 = 0$	10*a*.	$x \cdot y = y \cdot x$	*Commutative*
5*b*.	$x + 1 = 1$	10*b*.	$x + y = y + x$	
6*a*.	$x \cdot 1 = x$	11*a*.	$x \cdot (y \cdot z) = (x \cdot y) \cdot z$	*Associative*
6*b*.	$x + 0 = x$	11*b*.	$x + (y + z) = (x + y) + z$	
7*a*.	$x \cdot x = x$	12*a*.	$x \cdot (y + z) = x \cdot y + x \cdot z$	*Distributive*
7*b*.	$x + x = x$	12*b*.	$x + y \cdot z = (x + y) \cdot (x + z)$	
8*a*.	$x \cdot \overline{x} = 0$	13*a*.	$x + x \cdot y = x$	*Absorption*
8*b*.	$x + \overline{x} = 1$	13*b*.	$x \cdot (x + y) = x$	
9.	$\overline{\overline{x}} = x$	14*a*.	$x \cdot y + x \cdot \overline{y} = x$	*Combining*
		14*b*.	$(x + y) \cdot (x + \overline{y}) = x$	
		15*a*.	$\overline{x \cdot y} = \overline{x} + \overline{y}$	*DeMorgan's theorem*
		15*b*.	$\overline{x + y} = \overline{x} \cdot \overline{y}$	
		16*a*.	$x + \overline{x} \cdot y = x + y$	
		16*b*.	$x \cdot (\overline{x} + y) = x \cdot y$	
		17*a*.	$x \cdot y + y \cdot z + \overline{x} \cdot z = x \cdot y + \overline{x} \cdot z$	*Consensus*
		17*b*.	$(x + y) \cdot (y + z) \cdot (\overline{x} + z) = (x + y) \cdot (\overline{x} + z)$	

D	Q(t+1)
0	0
1	1

T	Q(t+1)
0	Q(t)
1	$\overline{Q(t)}$

J	K	Q(t+1)
0	0	Q(t)
0	1	0
1	0	1
1	1	$\overline{Q(t)}$

Q_t	Q_{t+1}	J	K
0	0	0	d
0	1	1	d
1	0	d	1
1	1	d	0

1	1	$\emptyset(t)$
1	0	1
0	1	0
0	0	$\emptyset(t)$
2	K	$\emptyset(t+1)$

1	1	
0	0	
D	$\emptyset(t+1)$	

	1	$\emptyset(t)$
	0	$\emptyset(t)$
	T	$\emptyset(t+1)$

Problem 1 (20 points)

True/False questions – Circle the correct answer (**no explanation is needed**).

i. The decimal value of the following 2's complement number 10010011 is -115.	**True/False**
ii. Latch is an edge-sensitive device, while Flip-flop is a level-sensitive device.	**True/False**
iii. An arithmetic logic unit (ALU) is a digital circuit used to perform only arithmetic operations.	**True/False**
iv. A D-flip flop and a NOT gate are only needed to implement a T-flip flop.	**True/False**
v. We wrote our full names and our group number on page 1.	**True/False**

20

Problem 2 (40 points)

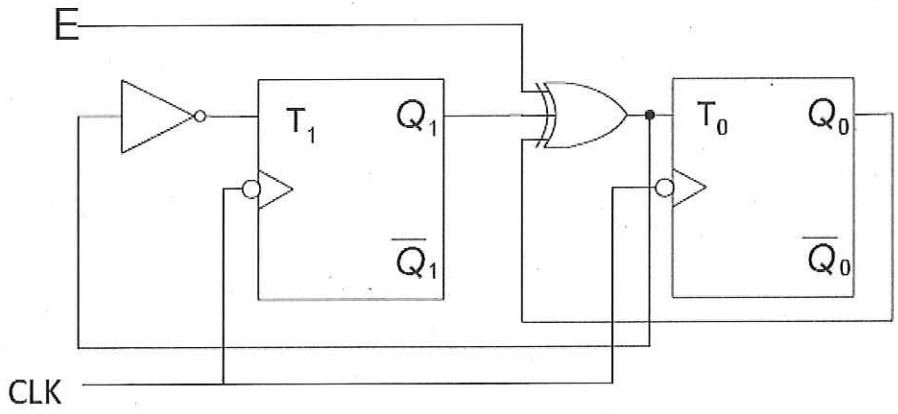
For the following sequential circuit, do the following:

(a) Write the truth table. [10 points]

(b) Redesign this circuit by replacing the T_1 Flip-Flop with negative edge D Flip-Flop, the T_0 Flip-Flop with negative edge JK Flip-Flop and a minimal AND-OR-NOT-XOR gate network. [20 points]

(c) Draw the circuit you have redesigned. [10 points]

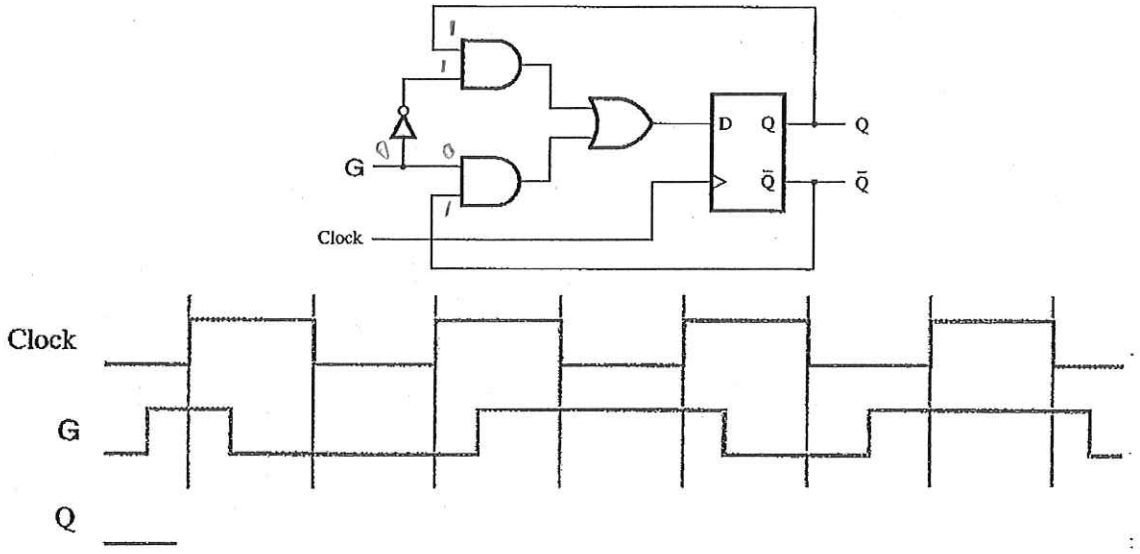
Reminder: $\overline{x \oplus y} = \bar{x} \cdot \bar{y} + x \cdot y$



Problem 3 (20 points)

a) Draw the timing diagram of the output Q of the following circuit. Consider that initially Q = 0. (15 pomts)

b) What circuit is this? (5 points)



Problem 4 (20 points)

The following two signed 2's complement numbers are given: A = 1001 0111 0101 and B = 1100 1001 0110.

(a) Subtract number A from number B and show the result. DO NOT use decimal equivalents. [10 points]

(b) Is the result correct? Explain your answer. [10 points]

(2)

It would be good to explain*

a)

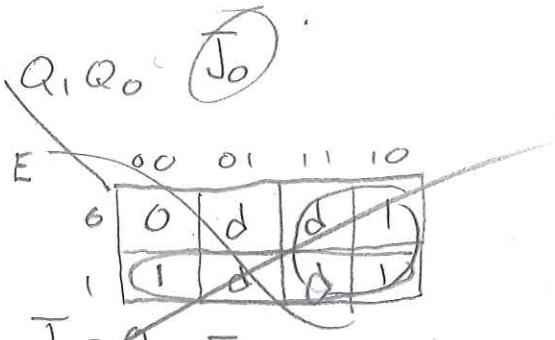
present states		input	next states		J_0	K_0	D_1	T_1	T_0
$Q_1(t)$	$Q_0(t)$	E	$Q_1(t+1)$	$Q_0(t+1)$					
0	0	0	1	0	0	d	1	1	0
0	0	1	0	1	1	d	0	0	1
0	1	0	0	0	d	1	0	0	1
0	1	1	1	1	d	0	1	1	0
1	0	0	1	1	1	d	0	0	1
1	0	1	0	0	0	d	0	1	0
1	1	0	0	1	d	0	0	1	0
1	1	1	0	0	d	1	1	0	1

NXOR

10

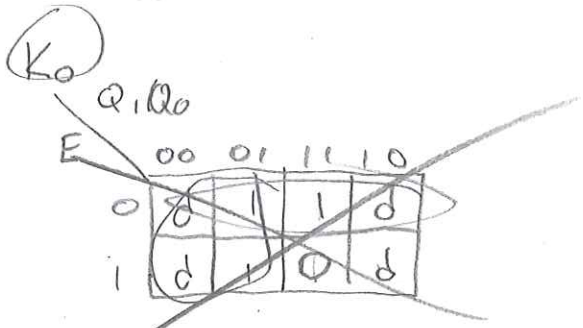
b) $T_1 = \overline{E \oplus Q_1(t) \oplus Q_0(t)}$ $\quad T_0 = E \oplus Q_1(t) \oplus Q_0(t)$

J_0



$J_0 = Q_1 + E$

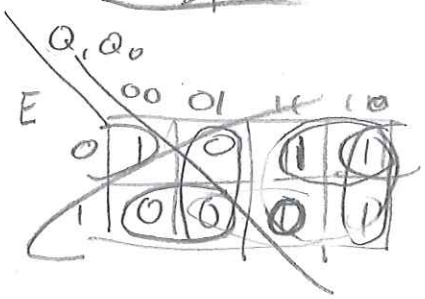
K_0



$K_0 = \overline{E} + \overline{Q_1}$

20

D_1



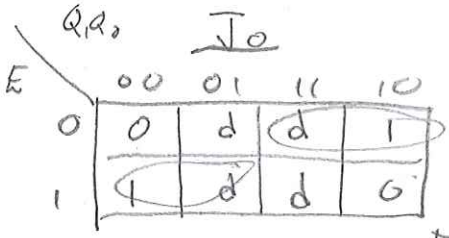
~~$D_1 = Q_1 + \overline{E} \cdot \overline{Q_0}$~~

$D_1 = Q_1 \cdot \overline{E} + \overline{E} \cdot \overline{Q_0} + Q_1 \cdot \overline{Q_0}$

~~$D_1 = \overline{Q_1 + Q_0} \cdot \overline{E} + Q_1 \cdot$~~

$D_1 = \overline{Q_0 \oplus E}$ ✓

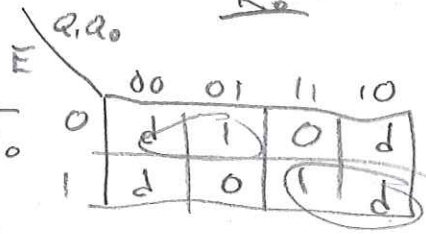
J_0



$J_0 = Q_1\overline{E} + \overline{Q_1}E$

✓ $J_0 = Q_1 \oplus E$

K_0



$K_0 = \overline{E}\,\overline{Q_1} + EQ_1$

✓ $K_0 = \overline{E \oplus Q_1}$

① $1001\,0011$ (7 6 5 4 3 2 1 0)

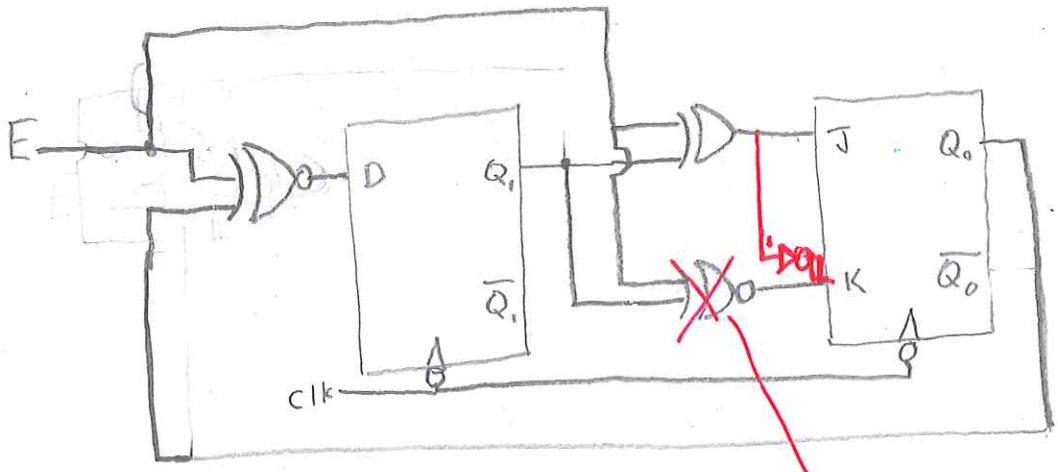
$-128 + 0 + 0 + 16 + 2 + 1$

$-128 + 19 = -109$

0 0
1 1

(2)

(c)



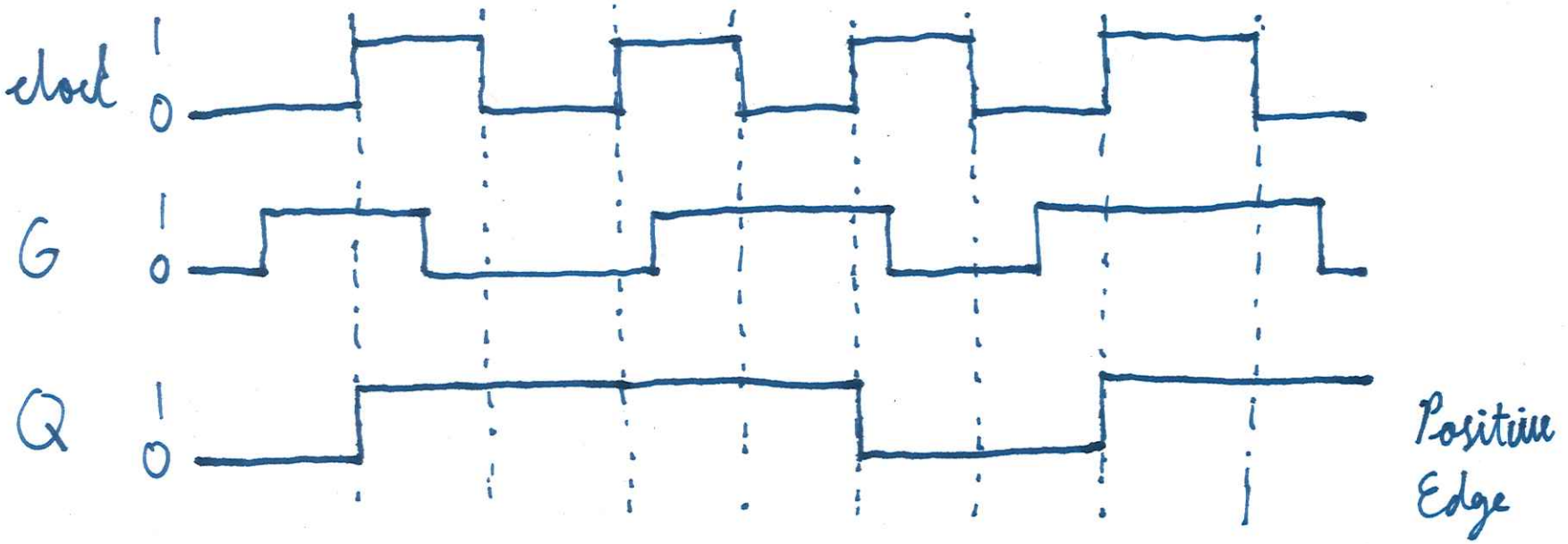
(9)

you can reuse the XOR

* XOR explanation

Q_1	Q_0	E	$Q_1 \oplus Q_0$	$Q_1 \oplus Q_0 \oplus E = T_0$
0	0	0	0	0
0	0	1	0	1
0	1	0	1	1
0	1	1	1	0
1	0	0	1	1
1	0	1	1	0
1	1	0	0	0
1	1	1	0	1

(3) a)



Q changes when G = 1 and clock = 0 → 1

$D = Q(t) + (\bar{G}) + G\,(\overline{Q(t)})$

(15)

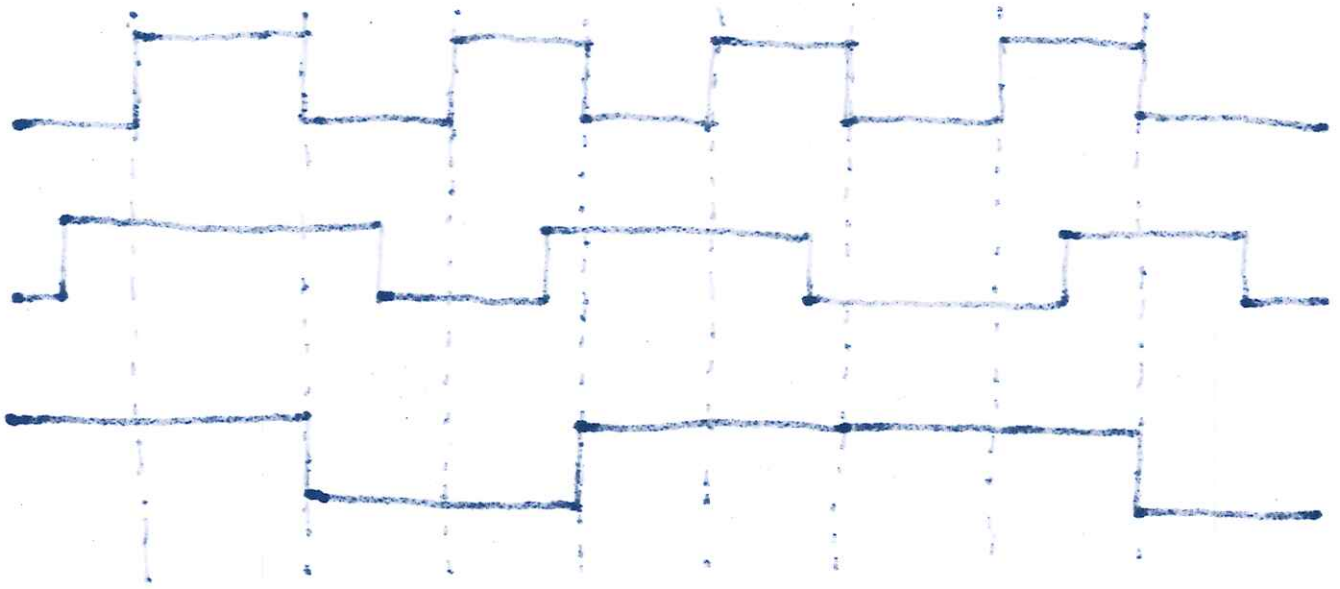
G	D → where is Q(t+1)?
0	Q
1	$\bar{Q}$

← T flip flop

(2) b) This is a T flip flop

Why?

(3) a)



Positive edge

Q change when C = 1 and clock: 0 → 1

$$Q = Q(\sigma)(\bar{C}) + C\,(\overline{Q(\sigma)})$$

C	Q
0	Q
1	$\bar{Q}$

↳ T flip flop

b) This is a T flip flop

In-Class Assigment #2

Group 9
(10/18/2022)

④ (a.) Flip A: from: A = 1001 0111 0101
to: -A = 0110 1000 1010

B - A = B + (-A)

C_{12} C_{11}

(1)1	1	11	11
	1100	1001	0110
+	0110	1000	1010
	0011	0010	0000

→

B
+ (-A)
B - A

(10)

(b.) Two ~~leftmost~~ carries are equal
Meaning: They are accurate.

↓
The carries??

(2)

$C_{11} \oplus C_{12} = 1 \oplus 1 = 0$ → no overflow → the result is correct.