Important

In order to receive credit for this exam you must comply with the policies stated on this page, and you must be able to sign the integrity commitment at the bottom of this page.

You are permitted to use the textbook for this course during the exam.

You are permitted to use your own personal course notes for ECE 2060 during the exam.

You are permitted to use the ECE 2060 Carmen site for this course (the lecture section Carmen site - Class Number 9487) during the exam.

You are permitted to use the equation sheet that is provided with the exam.

You are permitted to use a calculator.

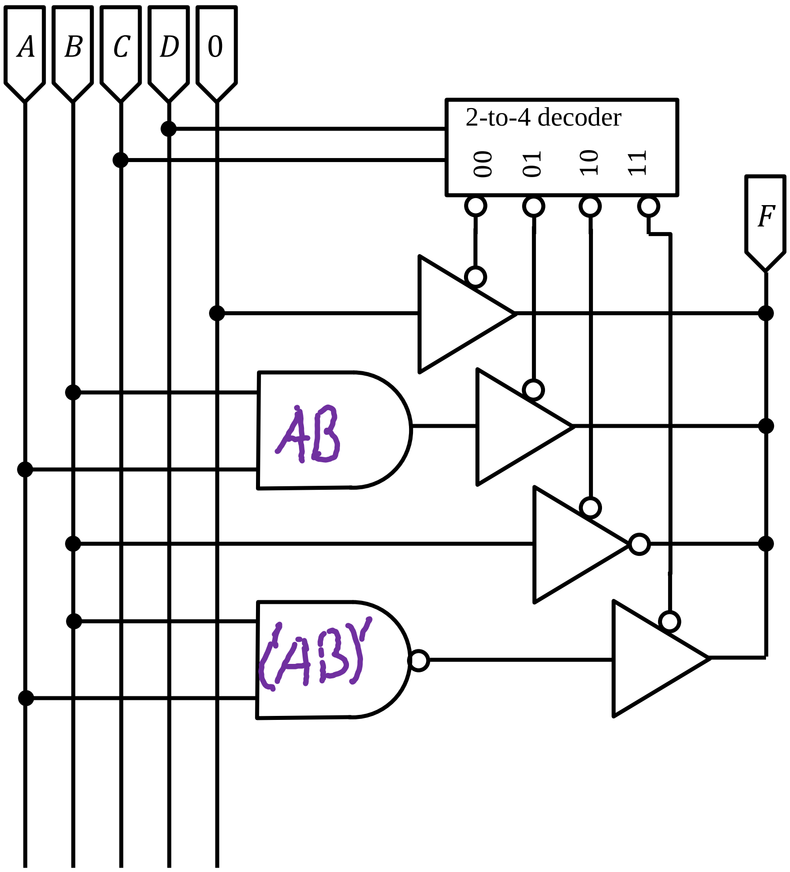
Integrity Commitment: By signing below I attest that:

1. I will not obtain help from any other person, by any means. The work and answers I submit for the exam will be the product of my effort alone.
2. I will not use any resources other than those stated above (no other books, no other notes, no other online materials or resources, etc.)
3. I will not share my work with anyone else by any means until after the solutions to the exam have been posted on Carmen.

Signature: [illegible]	Date: 3/7/23
Print Name: Gage Farmer	

1. [10 points] Complete the truth table and K-map, and determine the reduced SOP expression for $F(A,B,C,D)$. Do not change any of the typed labels in the truth table or K-map.

   The order of the values for the decoder output labels is CD.



A	B	C	D	F
0	0	0	0	1
0	0	0	1	Z
0	0	1	0	1
0	0	1	1	1
0	1	0	0	0
0	1	0	1	Z
0	1	1	0	0
0	1	1	1	0
1	0	0	0	1
1	0	0	1	Z
1	0	1	0	1
1	0	1	1	1
1	1	0	0	0
1	1	0	1	Z
1	1	1	0	1
1	1	1	1	0

CD \ AB	00	01	11	10
00	1	X	1	1
01	0	X	0	0
11	1	X	1	1
10	0	X	1	0

$F(A,B,C,D) = C'D' + CD + BC$

2. [8 points] Implement both functions using a ROM.

$F(A,B,C) = A'C' + BC' + AB$

$G(A,B,C) = AB' + B'C + AC$

a) (2 pts) for showing sufficient and accurate preliminary work. A blank truth table and blank K-Maps are provided in case you would like to use any of them. If you use them add unambiguous headings to any truth-table columns you use and do not change any of the typed labels or values.

A	*B*	*C*	F	G	M
0	0	0	1	0	m_0
0	0	1	0	1	m_1
0	1	0	1	0	m_2
0	1	1	0	0	m_3
1	0	0	0	1	m_4
1	0	1	0	1	m_5
1	1	0	1	0	m_6
1	1	1	1	1	m_7

F

BC \ *A*	0	1
00	1	
01		
11		1
10	1	1

$F = A'C' + AB$

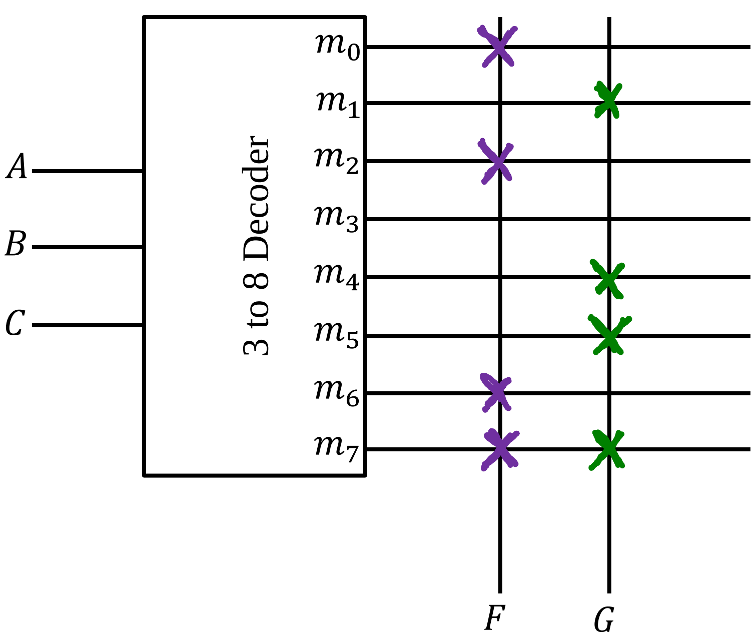
G

BC \ *A*	0	1
00		1
01	1	1
11		1
10		

$G = AB' + B'C + AC$

BC \ *A*	0	1
00		
01		
11		
10		

b) (6 pts) Show your solution by marking the proper line connections with ×s. Make your ×s robust enough that the locations are not ambiguous.



3. [8 points] Implement both functions using a minimal PLA.

$F(A,B,C) = A'C' + BC' + AB$

$G(A,B,C) = AB' + B'C + AC$

a) (2 pts) for showing sufficient and accurate preliminary work for the PLA implementation. A blank table and blank K-Maps are provided in case you would like to use any of them. If you use them add unambiguous headings to any columns you use and do not change any of the typed labels or values.

Product Terms	Inputs			Outputs		
	A	B	C	F	G	
A'C'	0	-	0	1	0	
AB	1	1	-	1	0	
AB'	1	0	-	0	1	
B'C	-	0	1	0	1	
AC	1	-	1	0	1	

F

BC \ A	0	1
00	1	
01		
11		1
10	1	1

F= A'C' + AB

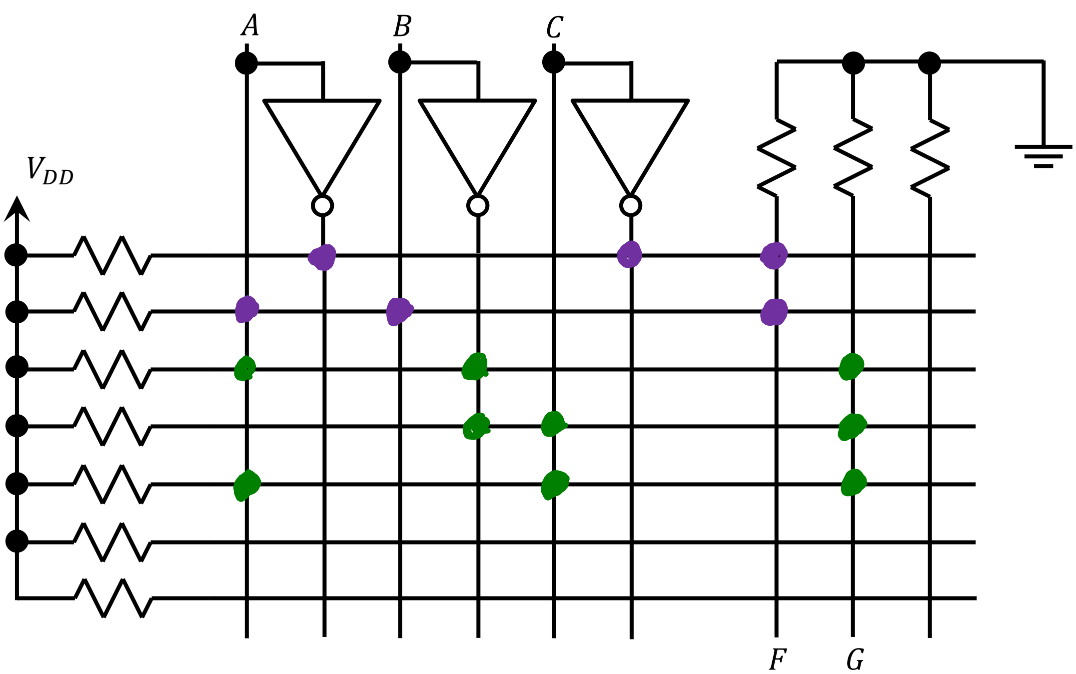
G

BC \ A	0	1
00		1
01	1	1
11		1
10		

G = AB' + B'C + AC

BC \ A	0	1
00		
01		
11		
10		

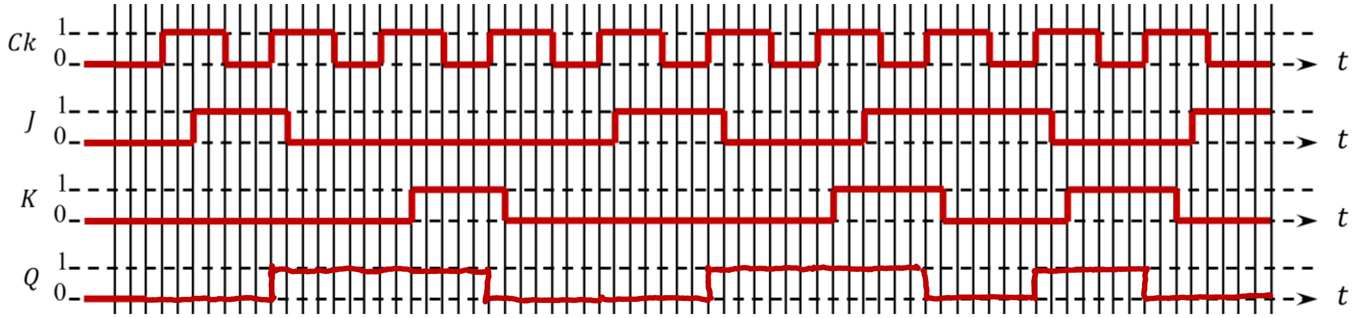
b) (6 pts) Show your solution by marking the proper line connections with dots. Make your dots robust enough that the locations of the dots are not ambiguous.



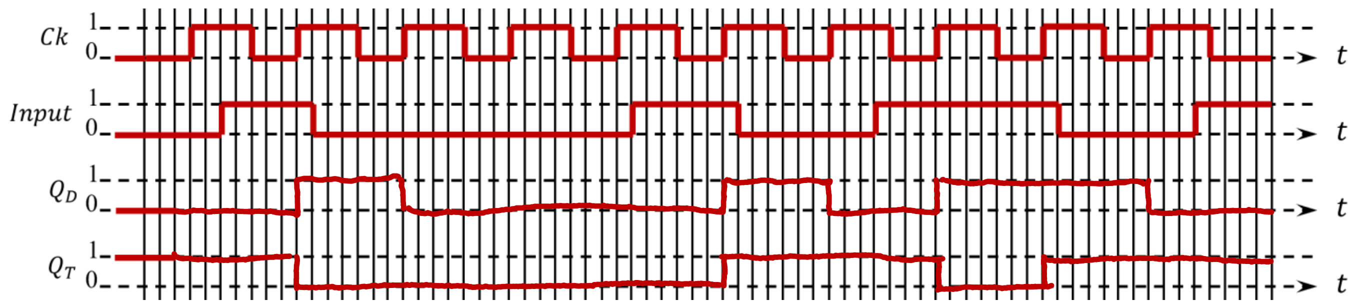
4. [24 points] For all parts of this problem the flip-flops have rising edge clocks. The starting state of the flip-flops is also shown.

   The clock frequency is so low, and hence the clock period is so long, that the delay between the active clock edge and the new flip-flop output is negligible on the time-scale of these diagrams.

a) (8 pts) Complete the timing diagram for this flip-flop.



b) (16 pts) Complete the timing diagram for the D flip on the line labeled Q_D and for the T flip-flop on the line labeled Q_T. The input waveform shown is the same for both flip-flops.



Equation Sheet

$$X + 0 = X$$
$$X + 1 = 1$$
$$X \cdot 1 = X$$
$$X \cdot 0 = 0$$

$$X + X = X$$
$$X \cdot X = X$$

$$(X')' = X$$

$$X + X' = 1$$
$$X \cdot X' = 0$$

$$XY = YX$$
$$X + Y = Y + X$$

$$(XY)Z = X(YZ) = XYZ$$

$$(X + Y) + Z = X + (Y + Z)$$
$$= X + Y + Z$$

$$X(Y + Z) = XY + XZ$$
$$X + YZ = (X + Y)(X + Z)$$

$$\overline{X + Y} = \bar{X}\bar{Y}$$
$$\overline{XY} = \bar{X} + \bar{Y}$$

Half Adder

$$S = X'Y + XY' = X \oplus Y$$
$$C = XY$$

Full Adder

$$S = X \oplus Y \oplus C_{in}$$
$$C_{out} = XY + XC_{in} + YC_{in}$$

$$Q^+ = S + R'Q \ (SR = 0)$$
$$Q^+ = D$$
$$Q^+ = JQ' + K'Q$$
$$Q^+ = TQ' + T'Q$$

Q	Q^+	S	R
0	0	0	X
0	1	1	0
1	0	0	1
1	1	X	0

Q	Q^+	J	K
0	0	0	X
0	1	1	X
1	0	X	1
1	1	X	0