

University of Toronto
Department of Electrical and Computer Engineering

ECE241- Digital Systems

Midterm Examination

October 1999

Last Name: _____

First Name: _____

Student Number: _____

Signature: _____

Duration: **1.5 Hours**

No aids permitted.

Answer ALL questions on this test paper. There is extra space at the end if you need it.

EXAMINER'S REPORT

1 _____ / 15

2 _____ / 5

3 _____ / 8

4 _____ / 8

5 _____ / 14

TOTAL: _____ / 50

Question 1 — [15 marks]

- a** Derive the truth table for the following 6-input 1-output function. The six inputs are the variables $X_1, X_2, X_3, X_4, X_5,$ and X_6 . The output, f , should be a 1 when the majority of the inputs (i.e. **more** than half) are a 1. You must put your answer into the K-maps provided below.

K-map for f :

x_3x_4	x_1x_2	00	01	11	10
00					
01					
11					
10					

x_3x_4	x_1x_2	00	01	11	10
00					
01					
11					
10					

x_3x_4	x_1x_2	00	01	11	10
00					
01					
11					
10					

x_3x_4	x_1x_2	00	01	11	10
00					
01					
11					
10					

- b For the five-input logic function specified in the below Karnaugh map, determine the minimal cost two-level sum-of-products expression.

K-map for f :

	x_1x_2	00	01	11	10
x_3x_4	00	1	0	0	1
	01	0	0	0	1
	11	1	0	0	0
	10	1	0	1	X

$X_5 = 0$

	x_1x_2	00	01	11	10
x_3x_4	00	X	0	0	1
	01	0	0	1	0
	11	0	0	0	1
	10	1	0	X	1

$X_5 = 1$

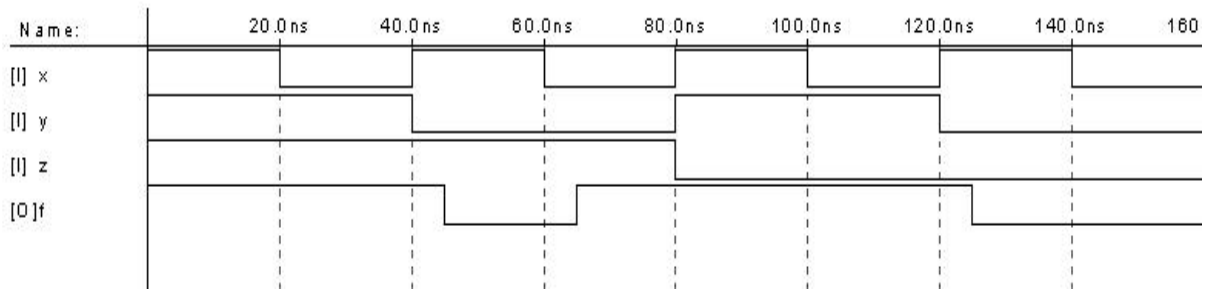
Give the minum cost sum-of-products expression for f :

Give the cost, as defined in class, **counting the NOT gates and their inputs**, of this expression:

Cost = _____

Question 2 — [5 marks]

- a** A timing diagram from an Altera maxplus2 timing simulation is shown below. What function was implemented? **Give your answer only as a sum of minterms.**



ANSWER: _____

- b** Write the single line of VHDL code necessary to implement the function $f = xyz + x\bar{y}\bar{z}$.

ANSWER: _____

Question 3 — [8 marks]

- a** Prove the following theorem: $xy + yz + \bar{x}z = xy + \bar{x}z$. Use only boolean logic axioms and identities to simplify the right-hand side into the left-hand side. **Show all your steps.**

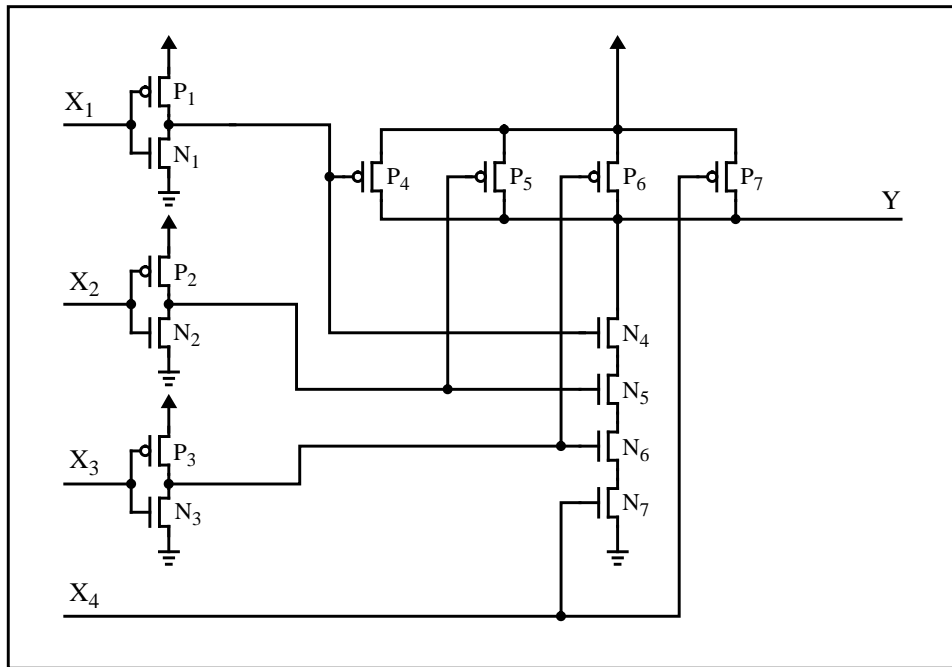
ANSWER:

b Implement the function $f = x\bar{y} + \bar{x}z + \bar{y}z$, **using only NOT and AND gates**. Give the schematic diagram.

ANSWER:

Question 4 — [8 marks]

- a Consider the circuit shown below with the following logic inputs: $X_1 = X_2 = 1$, $X_3 = X_4 = 0$. Write the state of each transistor (i.e. ON or OFF) in the table below. Also, give the logic level at the output, Y



Transistor	State (i.e. ON or OFF)	Transistor	State (i.e. ON or OFF)
P ₁		N ₁	
P ₂		N ₂	
P ₃		N ₃	
P ₄		N ₄	
P ₅		N ₅	
P ₆		N ₆	
P ₇		N ₇	

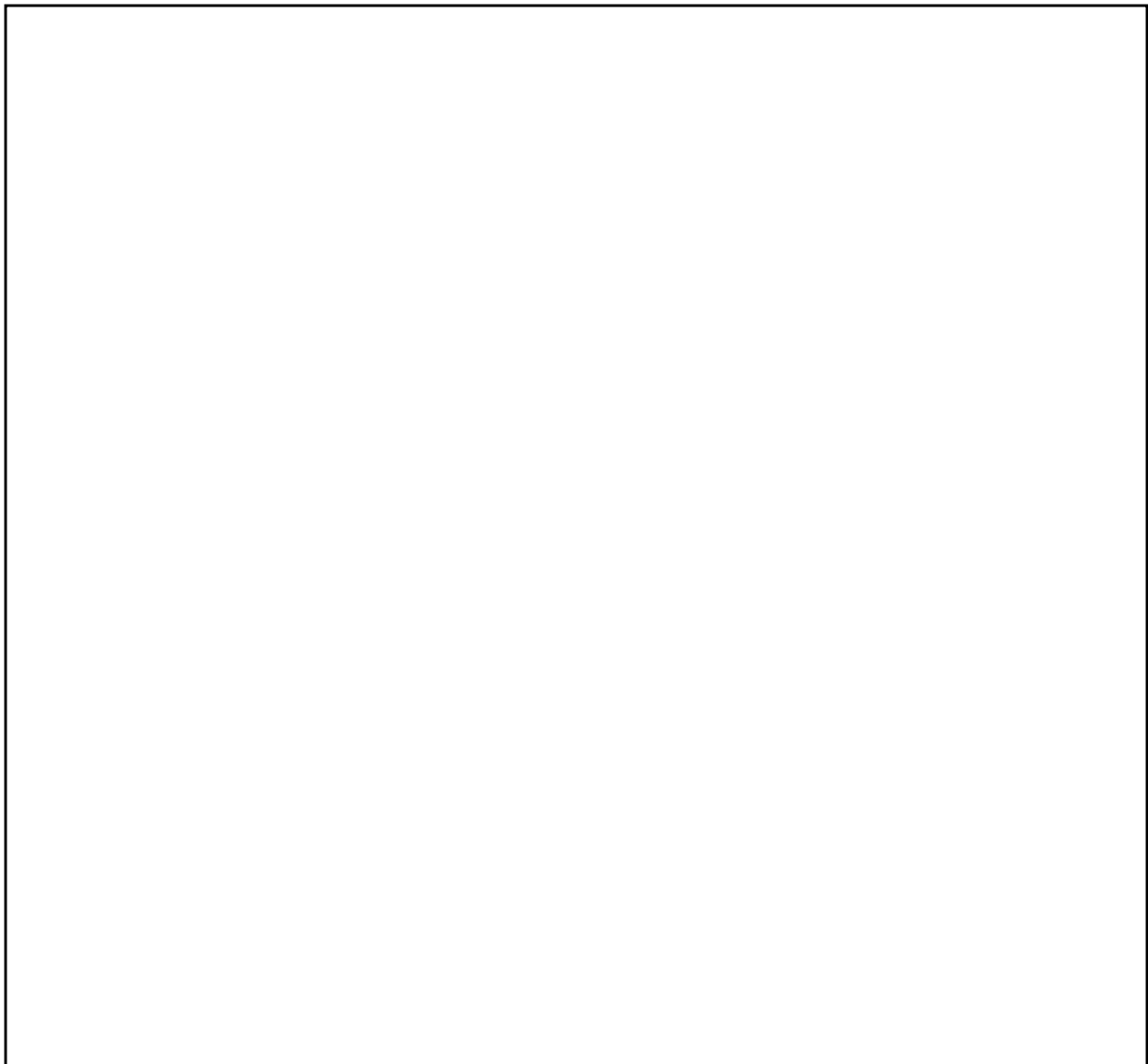
Logic level at Y: _____

b For circuit above, write a logic expression for Y in terms of X_1 , X_2 , X_3 and X_4 .

ANSWER: _____

c Draw the transistor-level schematic of another **CMOS logic** network which implements the same truth table as the circuit above using the fewest possible transistors.

ANSWER:



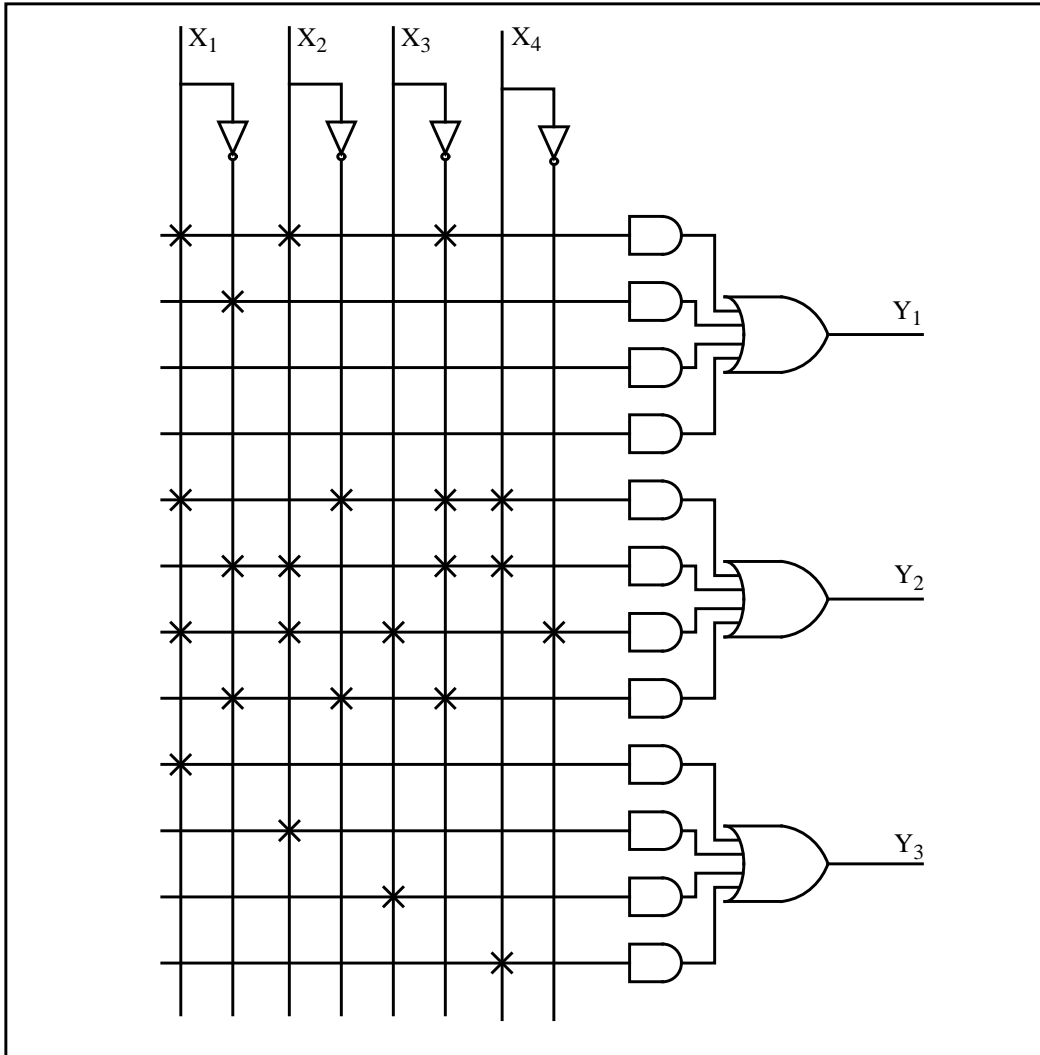
Question 5 — [14 marks]

READ THIS CAREFULLY: Throughout this question, the following convention will be used to represent the state of programmable switches in a Programmable Logic Device (PLD):



That is, in both cases there is a programmable switch attached between wire A and wire B.

- a Write a simple **sum-of-products** expression for each output in the following PLD (no simplification is necessary).



Expression for Y_1 : _____

Expression for Y_2 : _____

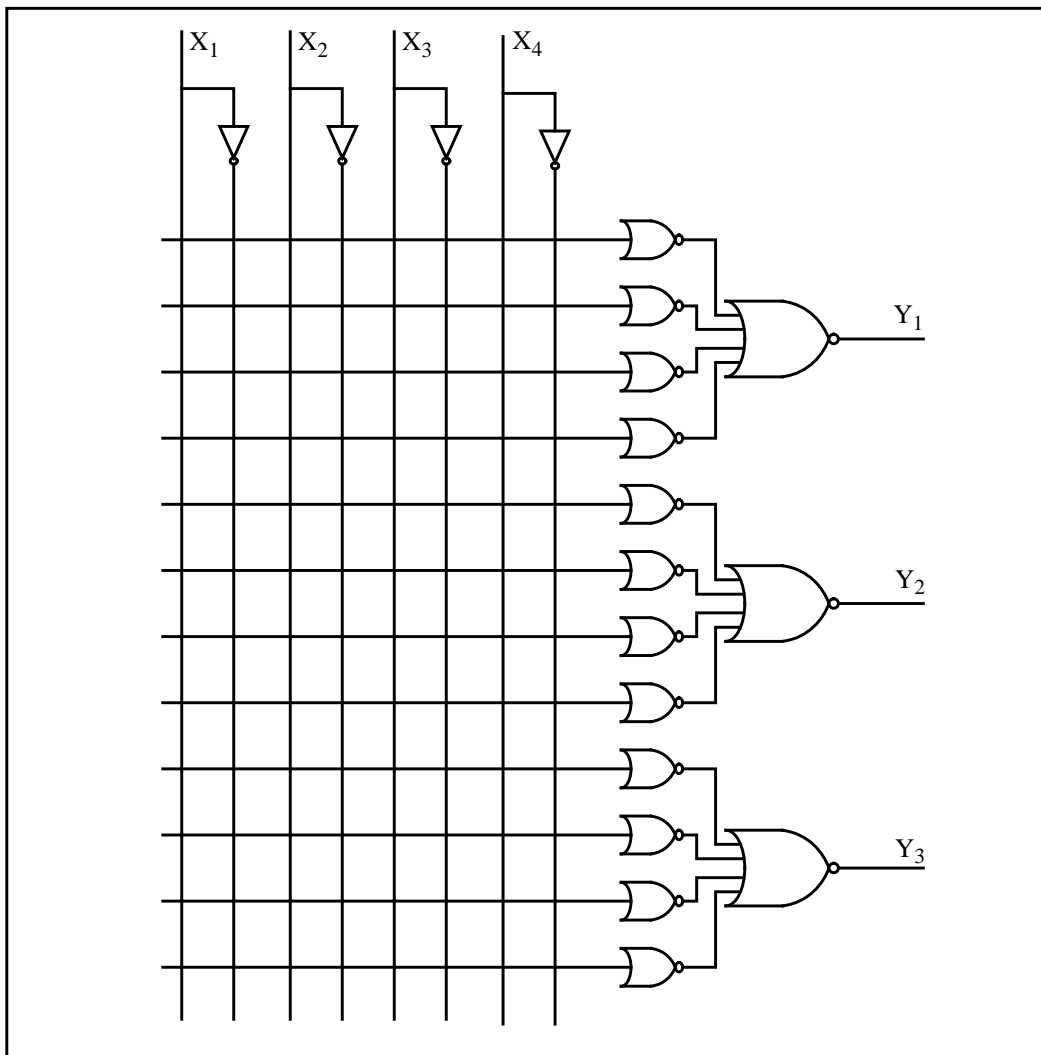
Expression for Y_3 : _____

b Using the convention stated above, fill in the schematic diagram on the next page to implement the following logic specifications (**NOTE: the PLD has a NOR-NOR structure**):

- Y_1 should be low (0) when all four inputs (i.e. $X_1, X_2, X_3,$ and X_4) are the same. Otherwise, Y_1 should be high (1).
- $Y_2 = \overline{(\overline{X_1}X_4 + X_2\overline{X_3})}$
- Y_3 is specified by the following truth table:

X_1	X_2	X_3	X_4	Y_3
0	0	0	0	1
0	0	0	1	0
0	0	1	0	0
0	0	1	1	1
0	1	0	0	1
0	1	0	1	1
0	1	1	0	1
0	1	1	1	0
1	0	0	0	1
1	0	0	1	1
1	0	1	0	1
1	0	1	1	1
1	1	0	0	0
1	1	0	1	1
1	1	1	0	1
1	1	1	1	1

ANSWER:



EXTRA SPACE - USE ONLY IF NEEDED

EXTRA SPACE - USE ONLY IF NEEDED

EXTRA SPACE - USE ONLY IF NEEDED

EXTRA SPACE - USE ONLY IF NEEDED