Name _____

First Last

Student ID # _____

University of California

Los Angeles

Computer Science Department

CSM51A/EEM16 Midterm Exam

Winter Quarter 2016

February 8th 2016

This is a closed book exam. Absolutely nothing is permitted except pen, pencil and eraser to write your solutions. Any academic dishonesty will be prosecuted to the full extent permissible by university regulations.

Time allowed 100 minutes.

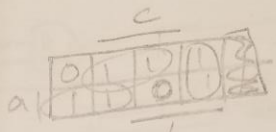
Problem (possible points)	Points
1 (20)	20
2 (20)	20
3 (20)	20
4 (20)	12
5 (20)	20
Total (100)	92

20

Problem 1 (20 points)

Use only the "E" gate defined below to implement Boolean function:
F=w'xy'+wxz+w'x'z+wx'y'z'
You may also use constants 0 and 1 as inputs.

a	b	c	E(a,b,c)	
0	0	0	0	
0	0	1	1	→ a'b'c
0	1	0	1	→ a'bc'
0	1	1	1	→ a'bc
1	0	0	1	→ ab'c'
1	0	1	1	→ ab'c
1	1	0	1	→ abc'
1	1	1	0	

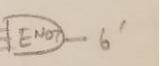


$E(a,b,c) = ab' + a'c + bc'$

$F = w'xy' + wxz + w'x'z + wx'y'z'$

NOT gate

$E(1,b,1) = b'$



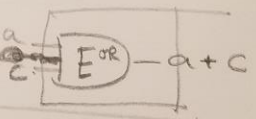
$E(0,0,c) = c$

$E(a,1,c) = a'c + c' = a' + c'$

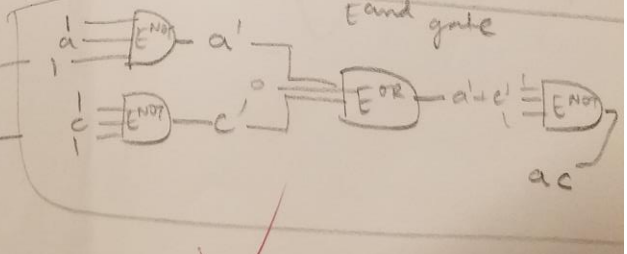
$(a \cdot b)' = a' + b'$

$E(a,0,c) = a + a'c$

$E(a,0,c) = a + c$ OR-gate



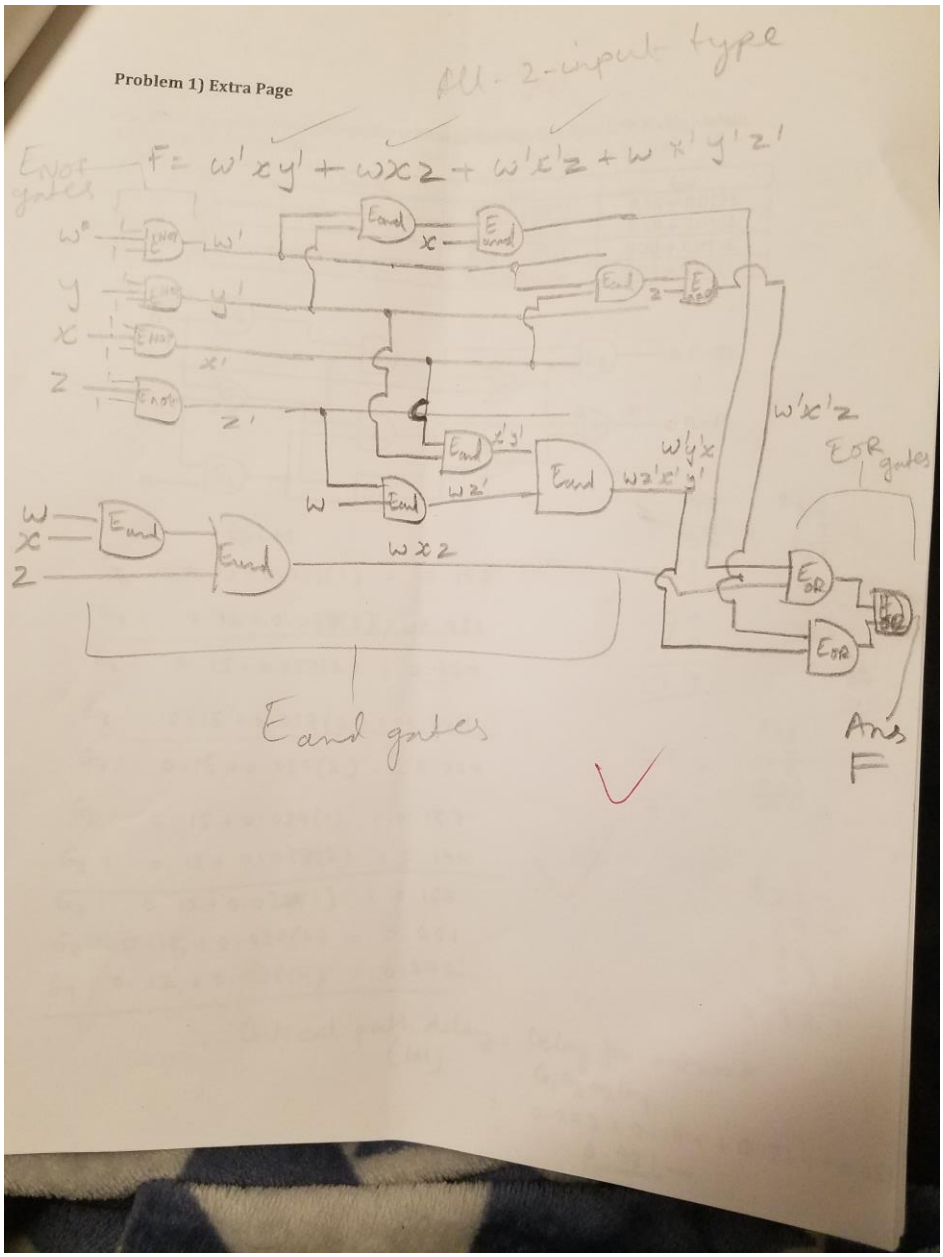
$(a'+c')' = ac$



Problem 1) Extra Page

All 2-input type

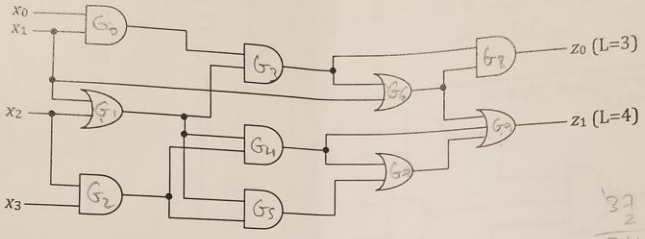
$F = w'xy' + wxz + w'x'z + wx'y'z'$



Problem 2 (20 points) 20

Given the network below, calculate the critical path delay. Consider L → H delay when calculating the critical path.

Gate	Fan-in	t_{pLH}	t_{pHL}
AND	2	$0.15 + 0.037L$	$0.16 + 0.017L$
AND	3	$0.20 + 0.038L$	$0.18 + 0.018L$
OR	2	$0.12 + 0.037L$	$0.20 + 0.019L$
OR	3	$0.12 + 0.038L$	$0.34 + 0.022L$



t_{pLH}

G_0 : $0.15 + 0.037(1) = 0.187$

G_1 : $0.12 + 0.037(3) = 0.231$

G_2 : $0.15 + 0.037(2) = 0.224$

G_3 : $0.15 + 0.037(2) = 0.224$

G_4 : $0.15 + 0.037(2) = 0.224$

G_5 : $0.15 + 0.037(1) = 0.187$

G_6 : $0.12 + 0.037(2) = 0.194$

G_7 : $0.12 + 0.037(1) = 0.157$

G_8 : $0.15 + 0.037(3) = 0.261$

G_9 : $0.12 + 0.038(4) = 0.272$

∴ Critical path delay (LH) = Delay for network $G_1 G_3 G_6 G_9$

$= 0.272 + 0.194 + 0.224 + 0.231$

$= 0.921$ ns

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Problem 3 (20 points)

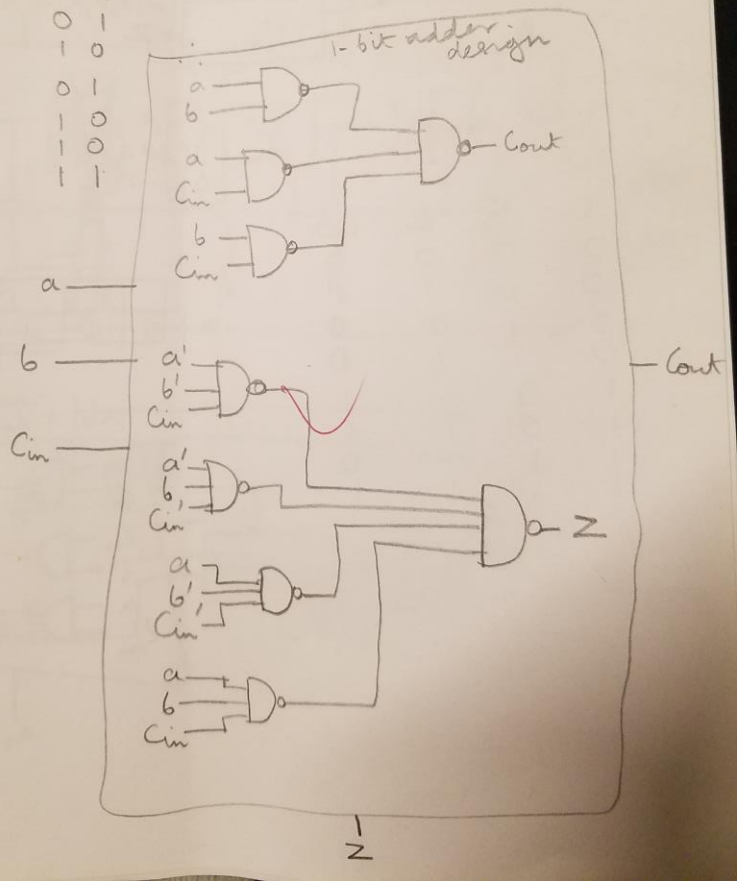
Four 4-bit numbers A,B,C, and D are given as inputs. E=A+B, F=C+D. Design a system that outputs the larger number between E and F. If E=F, output either E or F. You can use any type of gates to implement your design.

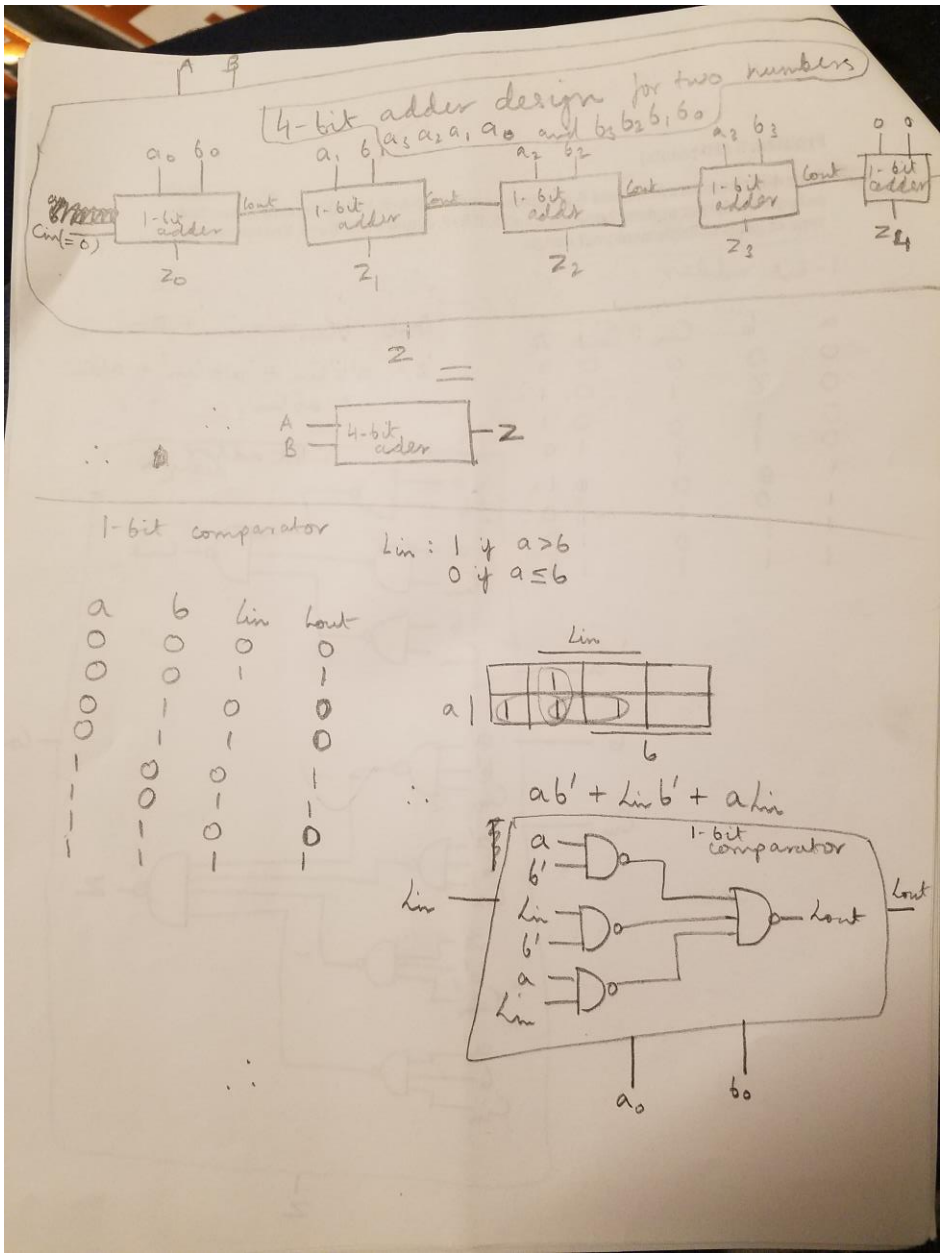
1-bit adder

a	b	Cin	Cout	Z
0	0	0	0	0
0	0	1	0	1
0	1	0	0	1
0	1	1	1	0
1	0	0	0	1
1	0	1	1	0
1	1	0	1	0
1	1	1	1	1

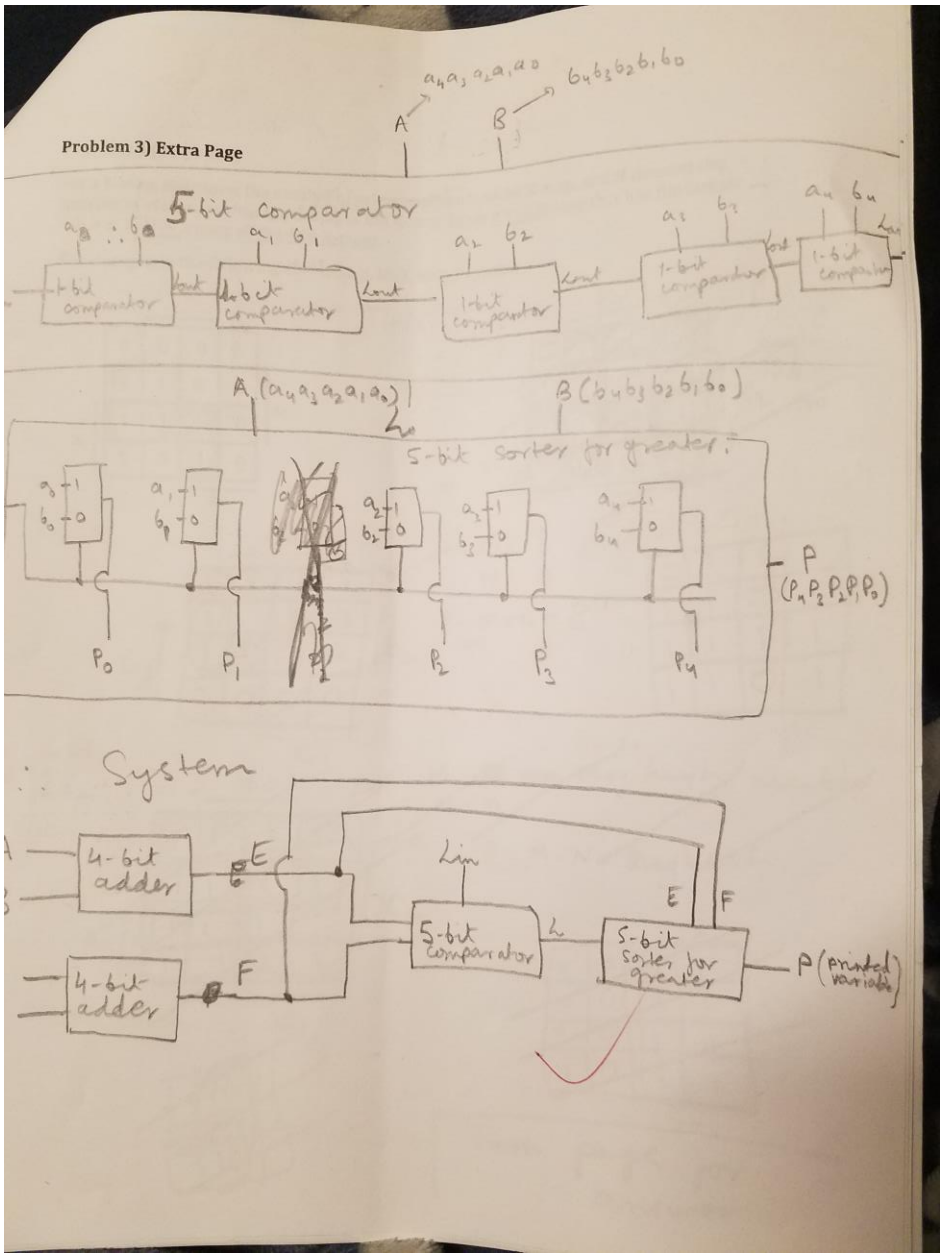
Cout: $bC_{in} + aC_{in} + ab$

Z: $a'b'C_{in} + a'bC_{in}' + ab'C_{in}' + abC_{in}$.




4-bit adder design for two numbers
1-bit adder
Cout
Cin(=0)
A
B
4-bit adder
Z
1-bit comparator
Lin : 1 if a>b
0 if a≤b
Lin
ab' + Lin b' + a Lin
1-bit comparator
Lout

Problem 3) Extra Page



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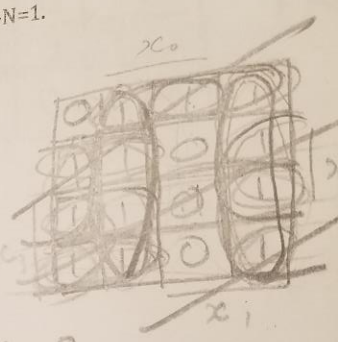
Problem 4 (20 points)

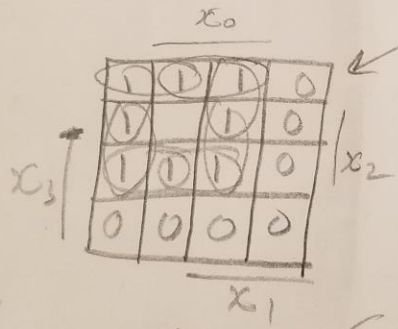
For a K-map, M denotes the number of prime implicants of the K-map, and N denotes the number of essential prime implicants of the K-map. Draw a 4×4 K-map that has the largest value of P=M-N among all the 4×4 K-maps.

For example, in the following 4×4 K-map, M=3, N=2, P=M-N=1.

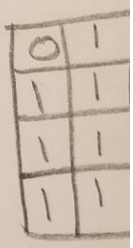
x_3 \ x_0	0	0	0	0
	1	1	0	0
x_2	1	1	1	0
	0	0	1	0

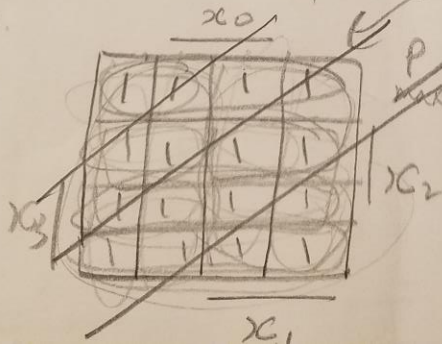
x_1



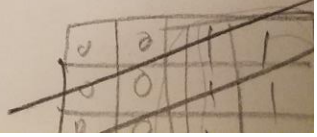


M = 8
N = 0
$P_{max} = M - N = 8$





M = very high
N = 0
P_{max} = M - N = higher



Problem 5 (20 points)

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Use only multiplexers to design a system with input $x \in (0,1,2,\ldots 8)$, outputs y and z that implements the following equation

$$(x)_{10} = (yz)_3$$

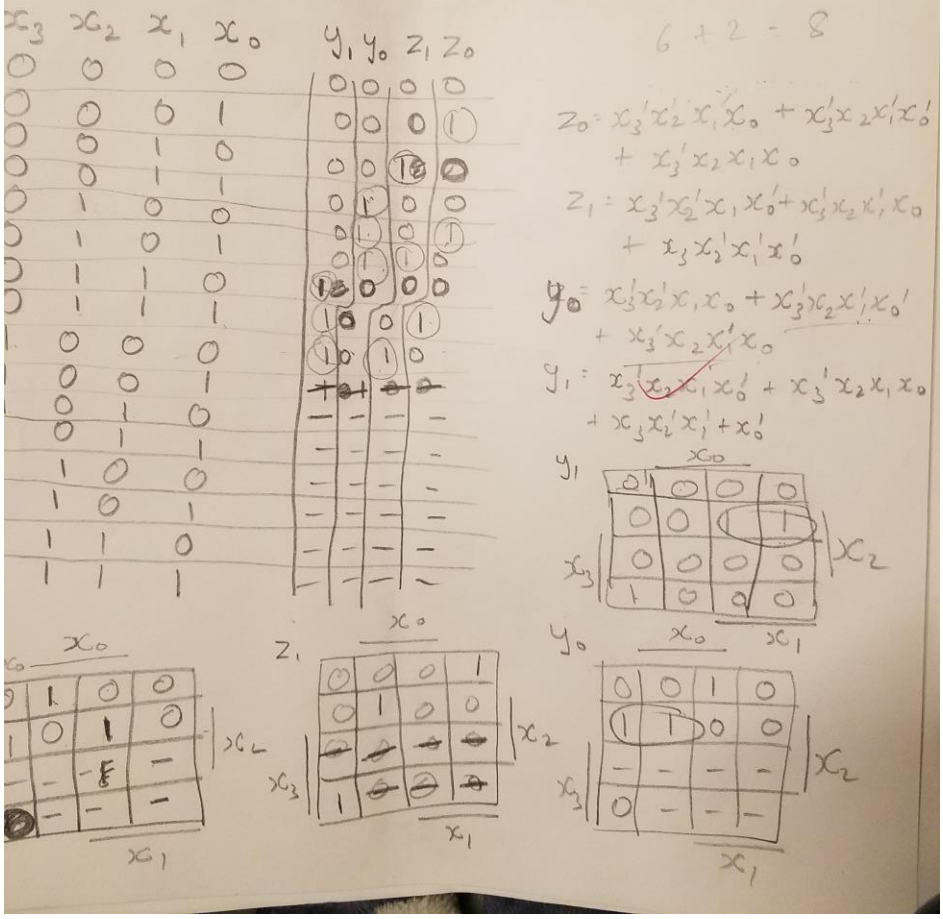
In the system, x is encoded as $x_3x_2x_1x_0$ in binary. y is encoded as y_1y_0 in binary, and z is encoded as z_1z_0 in binary.

Note that the outputs y and z represent the two digits of a base-3 number.

For example, if x=7 ($x_3x_2x_1x_0$=0111), then the system will solve: $(7)_{10} = (21)_3$. Thus $y = 2$ (y_1y_0=10) and $z = 1$ (z_1z_0=01).

2 2

6 + 2 = 8



Problem 5) Extra Page

$y_1 = x_2 x_1 x_3' + x_3 x_2' x_1' x_0'$

$y_1 x_3 = x_2' x_1' x_0'$

$y_1 x_3' = x_2 x_1$

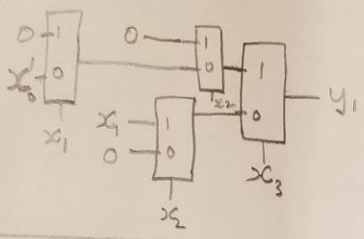
$y_1 x_3' x_2' = 0$

$y_1 x_3' x_2 = x_1$

$y_1 x_3' x_2' = 0$

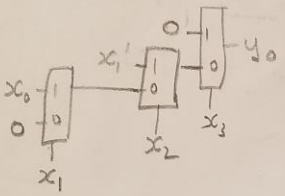
$y_1 x_3 x_2' = x_1' x_0'$

$y_1 x_3 x_2' x_1' = x_0'$



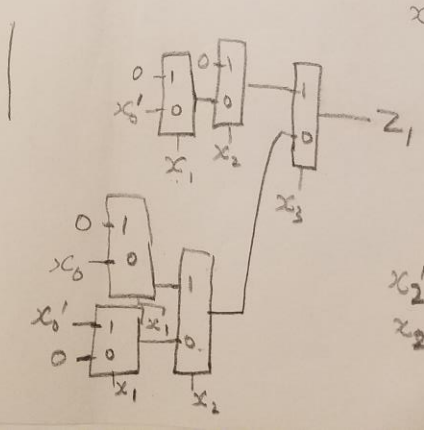
$y_0 = x_3' x_2 x_1' + x_3' x_2' x_1 x_0$

$x_2 x_1' + x_2' x_1 x_0$



$z_1 = x_3' x_2' x_1 x_0' + x_3' x_2 x_1' x_0 + x_3 x_2' x_1' x_0'$

$x_2' x_1' x_0'$



$x_2' x_1 x_0'$

$x_2 x_1' x_0$