Name Jorge Fuentes

First Last

Student ID # [redacted]

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)	16
5 (20)	20
Total (100)	96

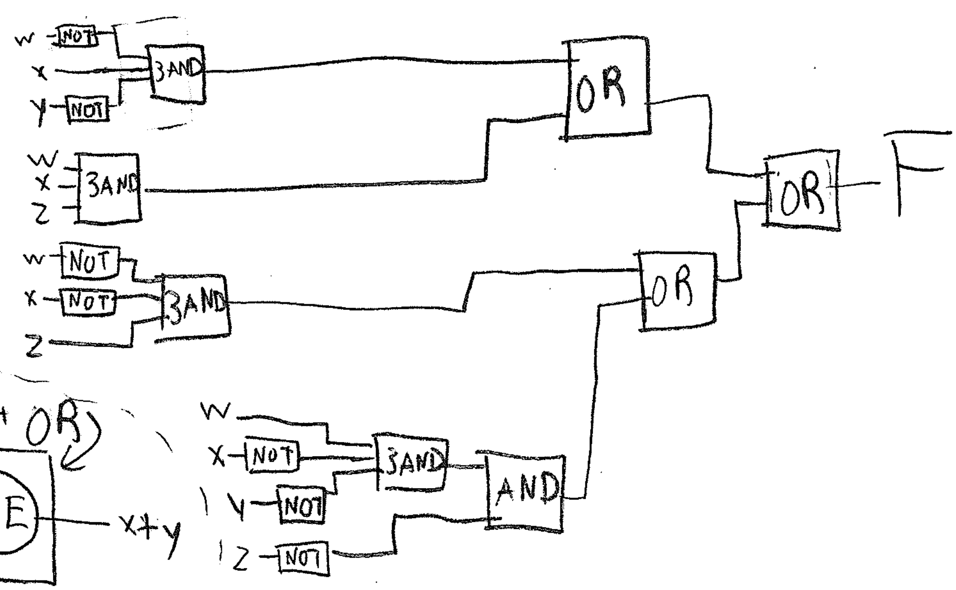
20

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
0	1	0	1
0	1	1	1
1	0	0	1
1	0	1	1
1	1	0	1
1	1	1	0

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

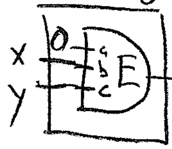


$E = (a+b+c)(a'+b'+c')$

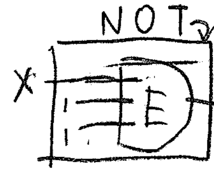
$a = 0 \quad b = b \quad c = c$ 2-input OR

$(b+c)1 = b+c$

OR



NOT



$b=1 \quad c=1$

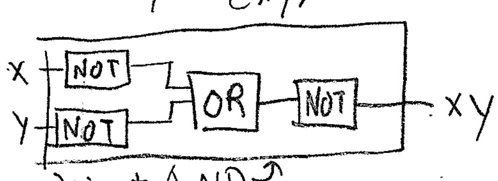
$\cancel{(a+1+1)}(a'+0+0) = a'$

$a=a \quad b=1 \quad c=1$ NOT

11	1
10	0
01	0
00	0

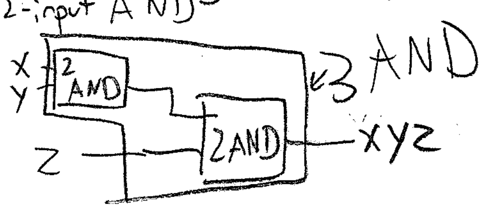
$x+y = (x'y')'$

$x'+y' = (xy)'$



2-input AND

3-input AND



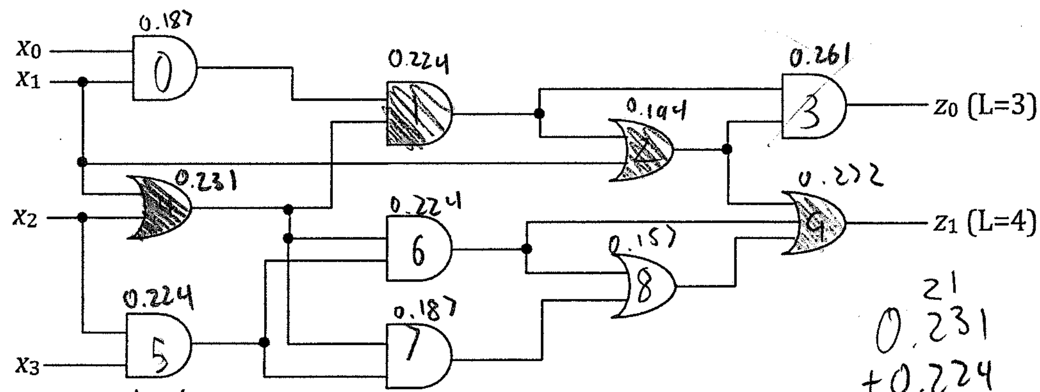
Problem 1) Extra Page

Problem 2 (20 points)

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	$0.12 + 0.038L$	~~$0.34 + 0.022L$~~

L→H for AND&OR means everything L→H



Inputs - Load - Gate

0: 2-1-AND = 0.15+0.037 = 0.187
1: 2-2-AND - 0.15+0.074 = 0.224
2: 2-2-OR - 0.12+0.074 = 0.194
3: 2-3-AND - 0.15+0.111 = 0.261
4: 2-3-OR - 0.12+0.111 = 0.231
5: 2-2-AND - 0.224
6: 2-2-AND - 0.224
7: 2-1-AND - 0.187
8: 2-1-OR - 0.12+0.037 = 0.157
9: 3-4-OR - 0.12+0.152 = 0.272

0.231
+0.224
0.194
+ 0.272
$\boxed{0.921}$

4-1-2-9

.455
+.466
.921

0.038
x 4
.152

20

1
11
+11
111

Problem 3 (20 points)

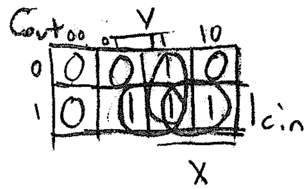
Four 4-bit numbers A,B,C, and D are given as inputs. E=A+B, F=C+D. Design a system that outputs the larger number between E and F. If E=F, output either E or F. You can use any type of gates to implement your design.

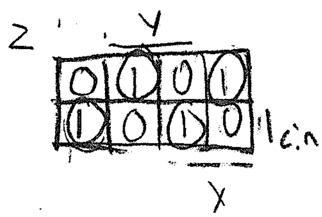
1) 1-bit adder with carryover

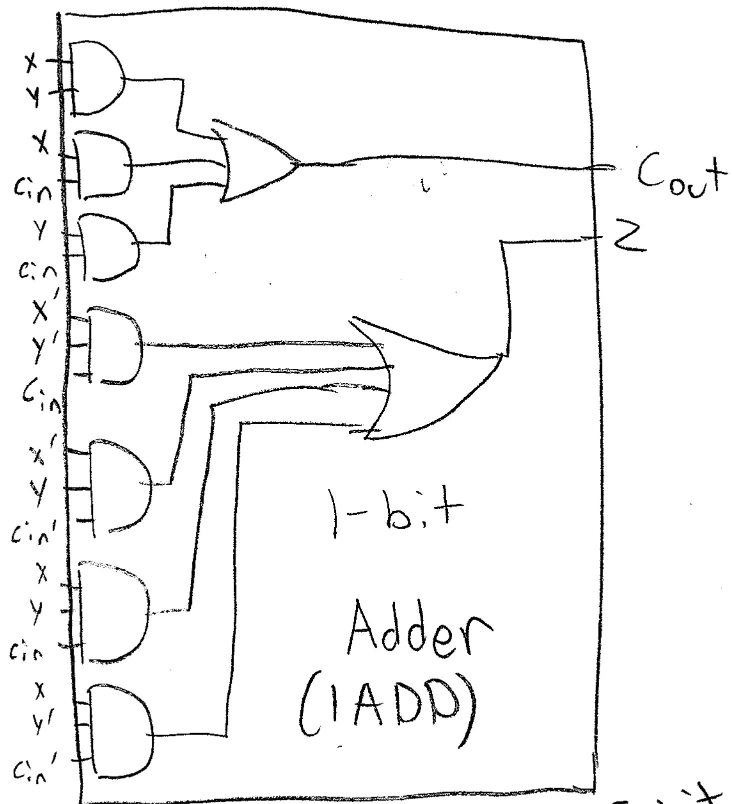
$z = x'y'c_{in} + x'yc_{in}' + xyc_{in} + xy'c_{in}'$

$C_{out} = xy + xc_{in} + yc_{in}$

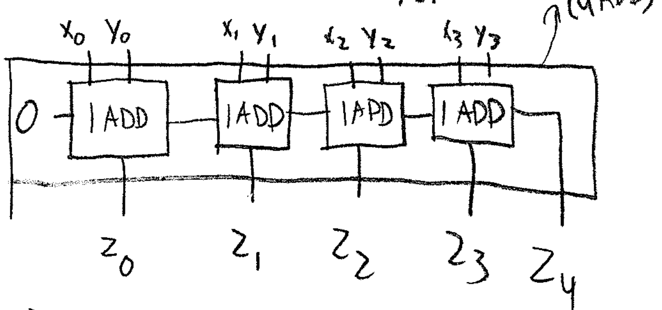
x	y	Cin	Cout	z
0	0	0	0	0
0	0	1	0	1
0	1	0	0	1
0	1	1	1	0
1	0	0	0	1
1	0	1	1	0
1	1	0	1	0
1	1	1	1	1







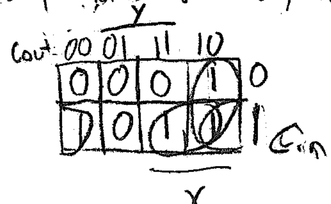
2) 4-bit adder - $X_3X_2X_1X_0$ $Y_3Y_2Y_1Y_0$ 4-bit ADDER (4ADD)



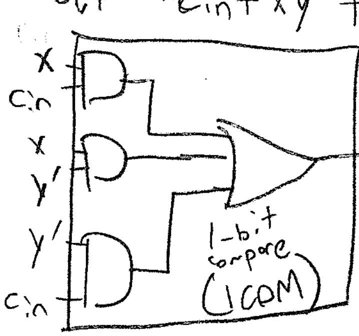
3) 1-bit comparator with carryover

$x \geq y \to 1$

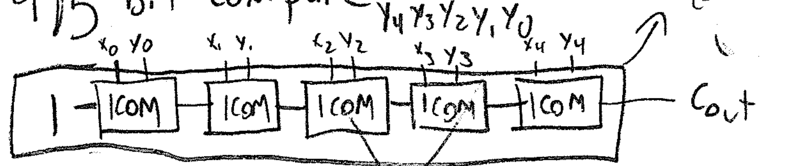
$x < y \to 0$



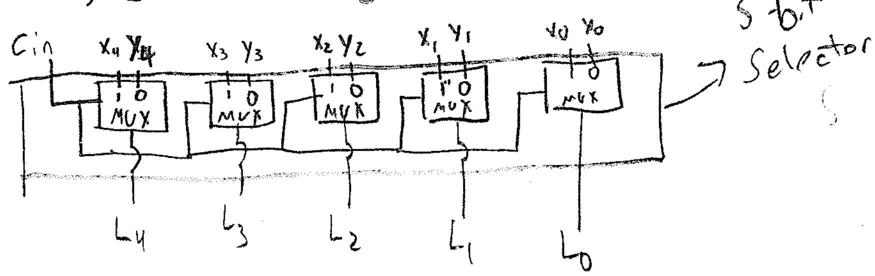
$C_{out} = xC_{in} + xy' + y'C_{in}$



4) 5-bit compare $X_4X_3X_2X_1X_0$ $Y_4Y_3Y_2Y_1Y_0$



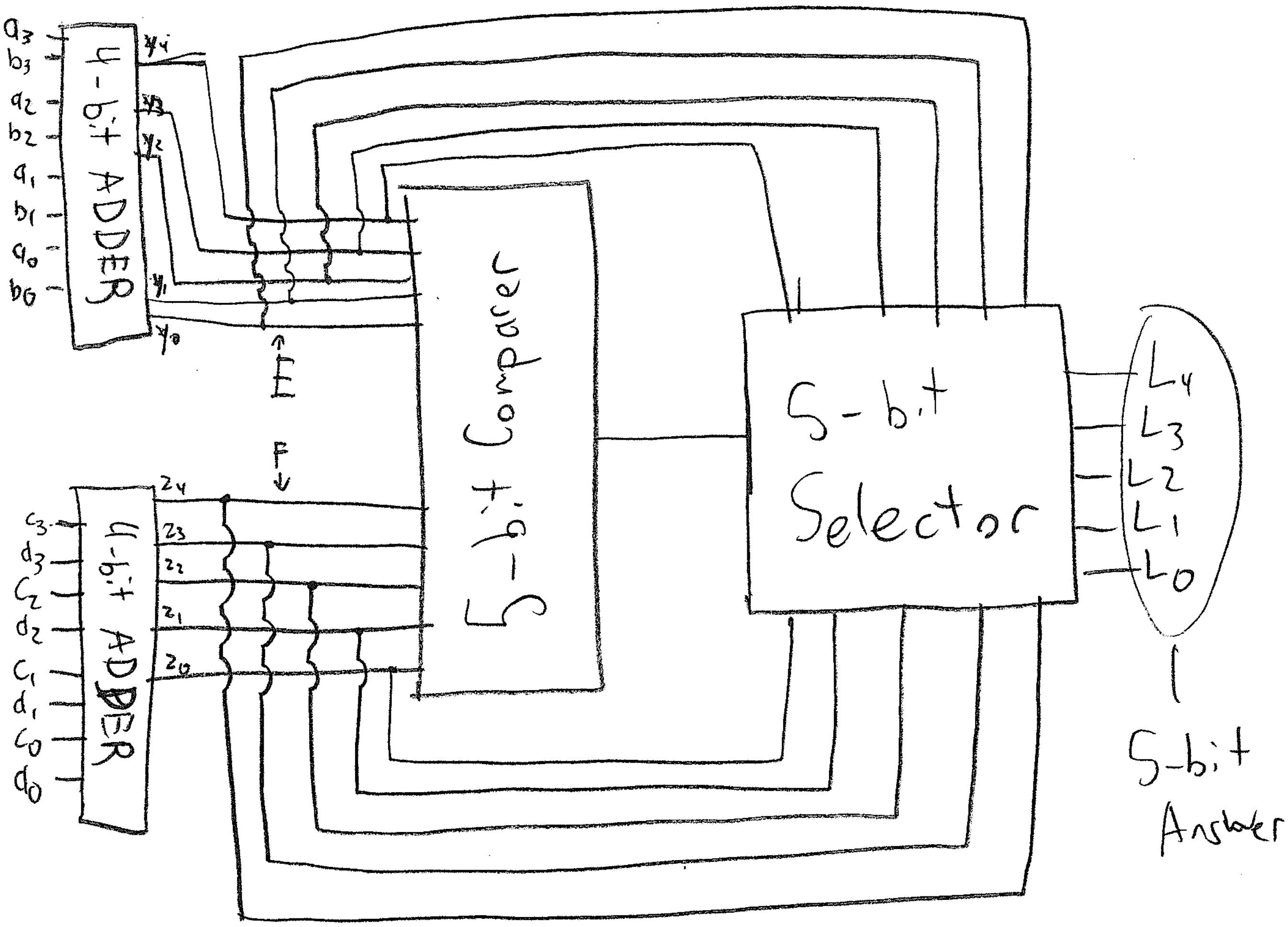
5) 5-bit Selector



Problem 3) Extra Page

A $a_3 a_2 a_1 a_0$
B $b_3 b_2 b_1 b_0$
C $c_3 c_2 c_1 c_0$
D $d_3 d_2 d_1 d_0$

6) Finish the Job



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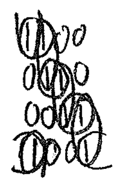
Problem 4 (20 points)

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.

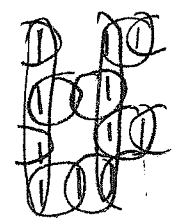
For example, in the following 4×4 K-map, M=3, N=2, P=M-N=1.

x_0 (columns 2–3), x_1 (columns 3–4), x_2 (rows 2–3), x_3 (rows 3–4)

0	0	0	0
1	1	0	0
1	1	1	0
0	0	1	0

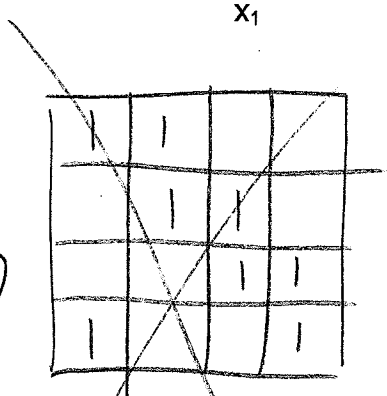


P=8

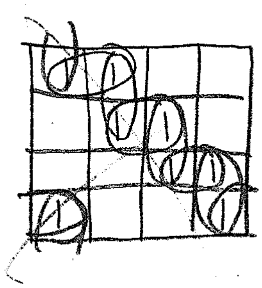


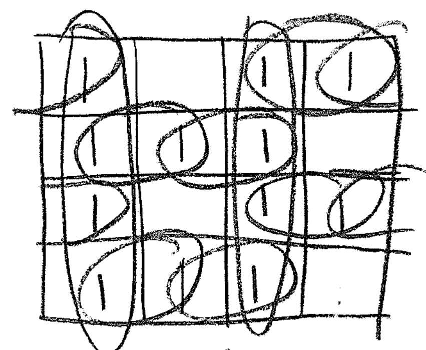
10

M=8
N=0



P=8





M=10
N=0

1	0	1	1
1	1	1	0
1	0	1	1
1	1	1	0

P = 10

winner

-4

4-bit
↑
0000
↑

20

Problem 5 (20 points)

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

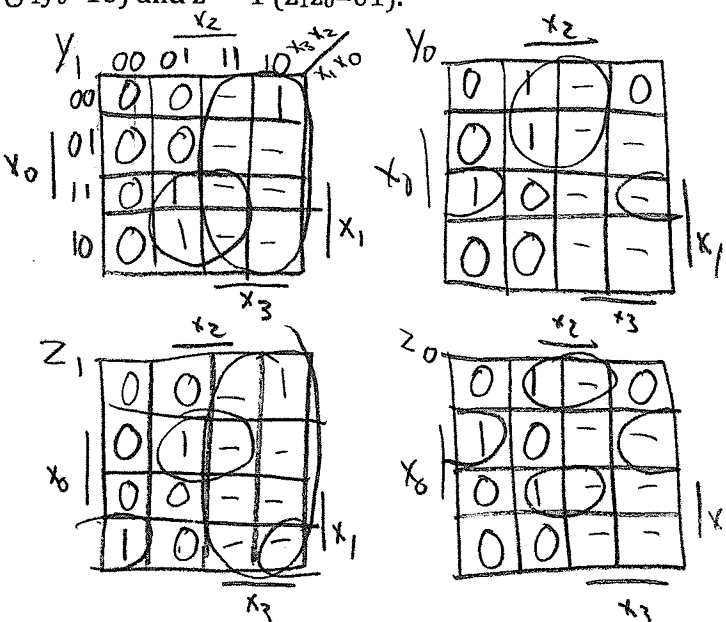
$$(x)_{10} = (yz)_3$$

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).

x	y z	$x_3x_2x_1x_0$	
0	→ 00	0000	→ 0000
1	→ 01	0001	→ 0001
2	→ 02	0010	→ 0010
3	→ 10	0011	→ 0100
4	→ 11	0100	→ 0101
5	→ 12	0101	→ 0110
6	→ 20	0110	→ 1000
7	→ 21	0111	→ 1001
8	→ 22	1000	→ 1010

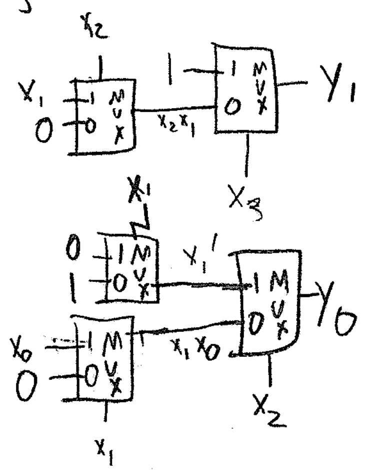


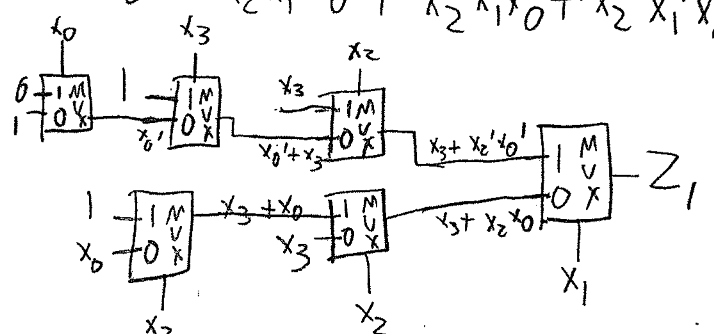
$$Y_1 = X_3 + X_2X_1$$

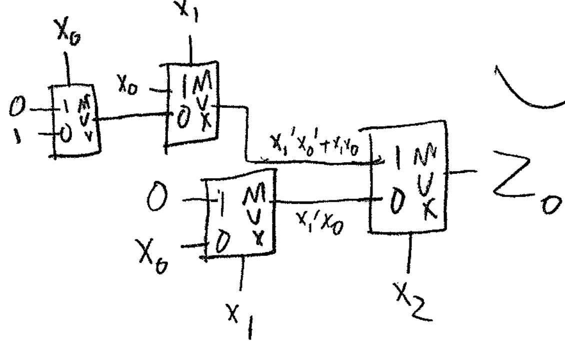
$$Y_0 = X_2X_1' + X_2'X_1X_0$$

$$Z_1 = X_3 + X_2X_1'X_0 + X_2'X_1X_0'$$

$$Z_0 = X_2X_1'X_0' + X_2X_1X_0 + X_2'X_1'X_0$$







Problem 5) Extra Page