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Computer Science Department

CSM51A/EEM16 Midterm Exam

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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)	11
5 (20)	20
Total (100)	91

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.

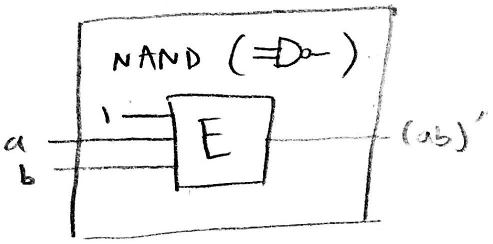
a	b	c	E(a,b,c)
0	0	0	0
0	0	1	1
0	1	0	1
0	1	1	1
1	0	0	1
1	0	1	1
1	1	0	1
1	1	1	0

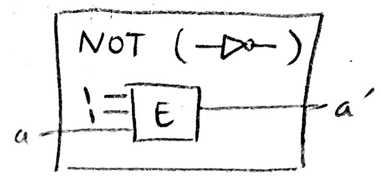
$E(1,1,a) = a'$ (NOT)

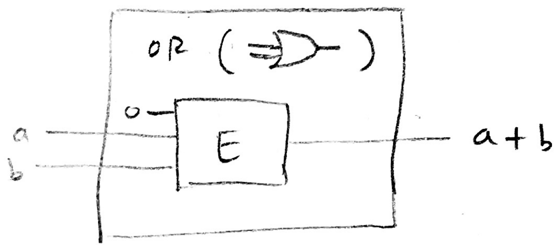
$E(0,a,b) = a+b$ (OR)

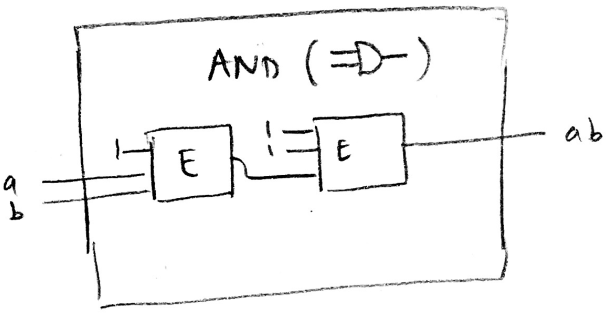
$E(1,a,b) = NAND(a,b)$ (NAND)

$E(1,1,E(1,a,b)) = ((ab)')' = ab$ (AND)

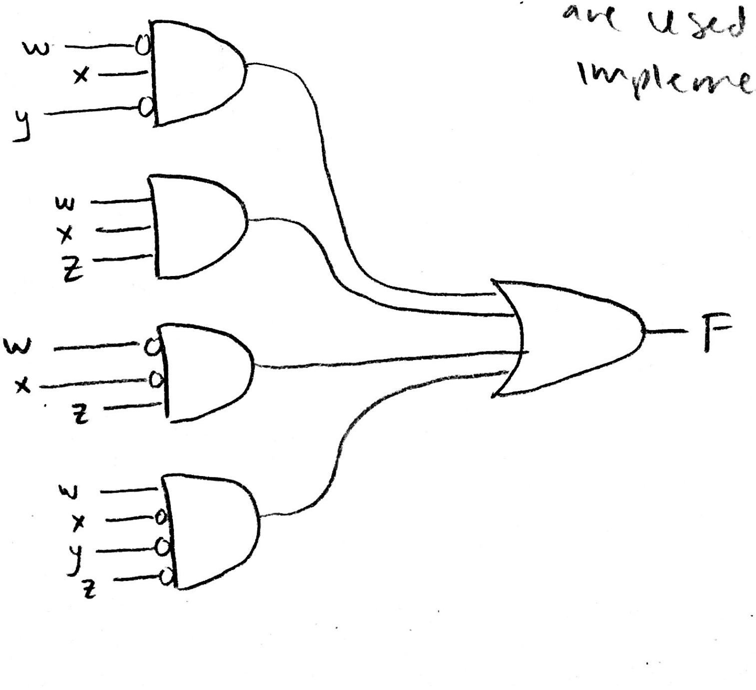








Using these gate definitions (provided only with gate E), we can implement F. Regular gate symbols are used, but assume they have been implemented as Above.



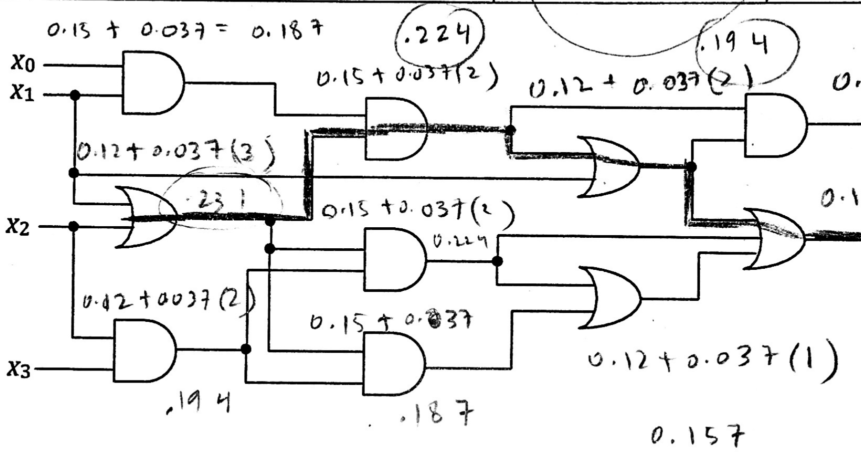
Problem 2 (20 points)

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

0.15
0.481



0.15 + 0.037(3) = .261

0.12 + 0.038(4) = .272

0.12
0.152
0.272

0.231	0.272	0.272
0.224	0.224	0.157
0.194	0.231	0.224
0.261		0.231
.910		.884

CRITICAL PATH DELAY: 0.921

0.272
0.194
0.224
0.231
.921

20

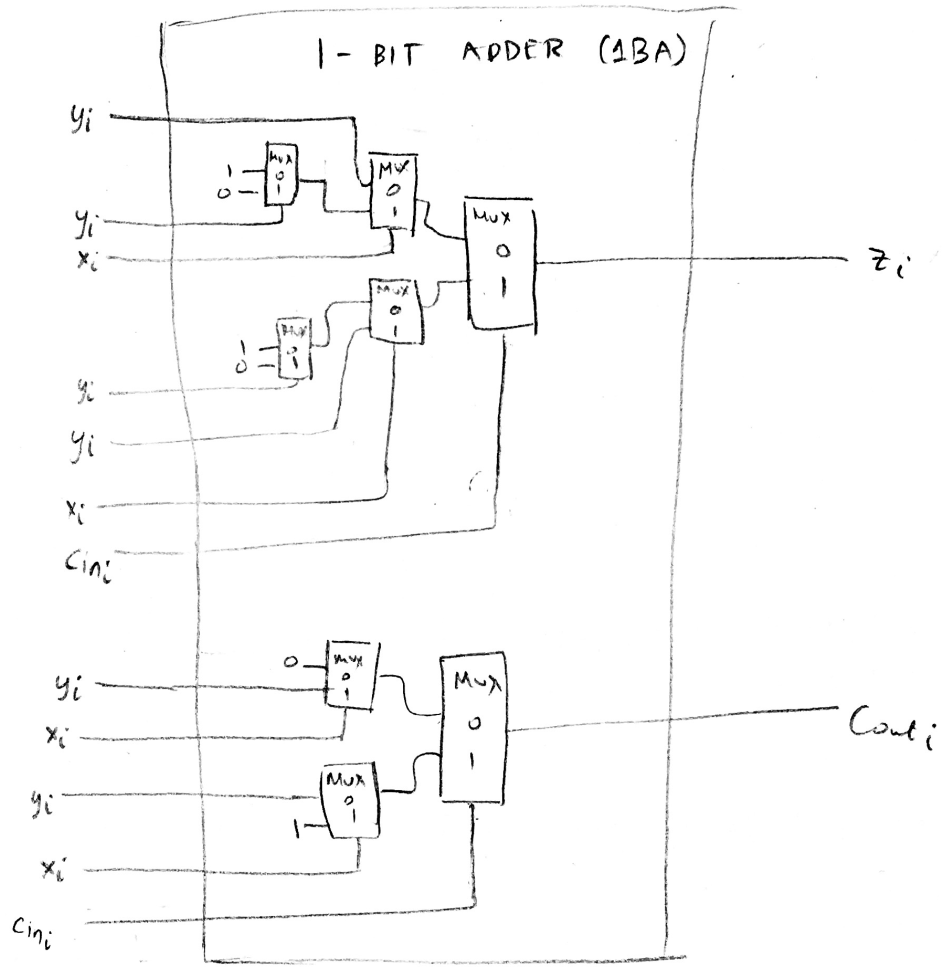
Problem 3 (20 points)

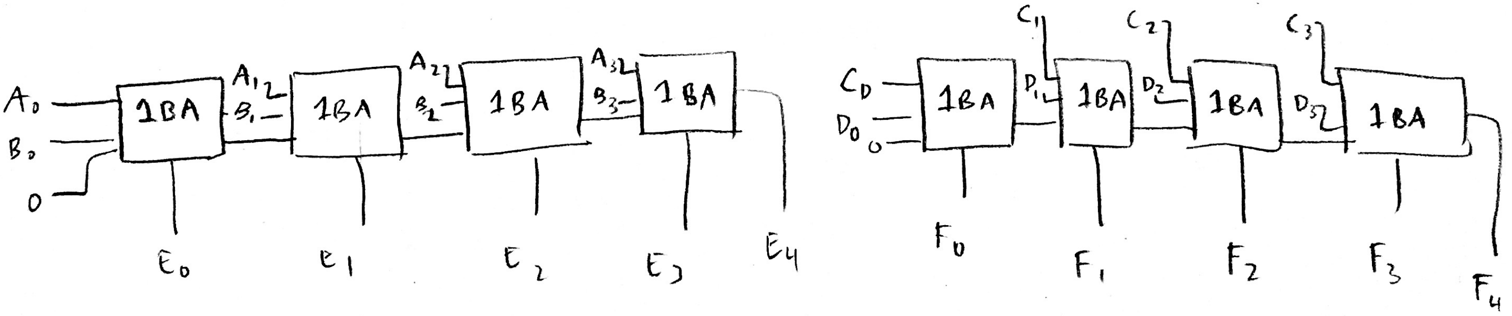
Four 4-bit numbers A,B,C, and D are given as inputs. E=A+B, F=C+D. Design a system that outputs the larger number between E and F. If E=F, output either E or F. You can use any type of gates to implement your design.

Cin_i	x_i	y_i	z_i	$Cout_i$
0	0	0	0	0
0	0	1	1	0
0	1	0	1	0
0	1	1	0	1
1	0	0	1	0
1	0	1	0	1
1	1	0	0	1
1	1	1	1	1

$$z_i = Cin_i'(x_i'y_i + x_iy_i') + Cin_i(x_i'y_i' + x_iy_i)$$

$$Cout_i = Cin_i'x_iy_i + Cin_i(x_i'y_i + x_i)$$



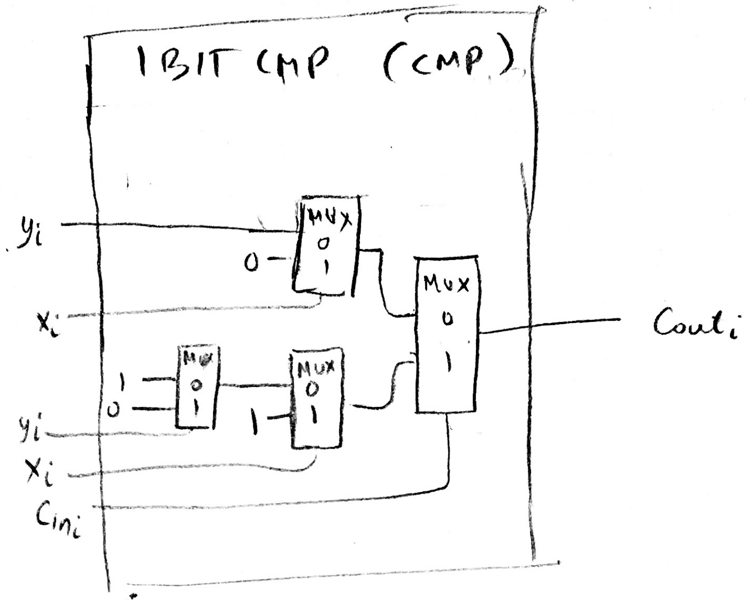


Problem 3) Extra Page

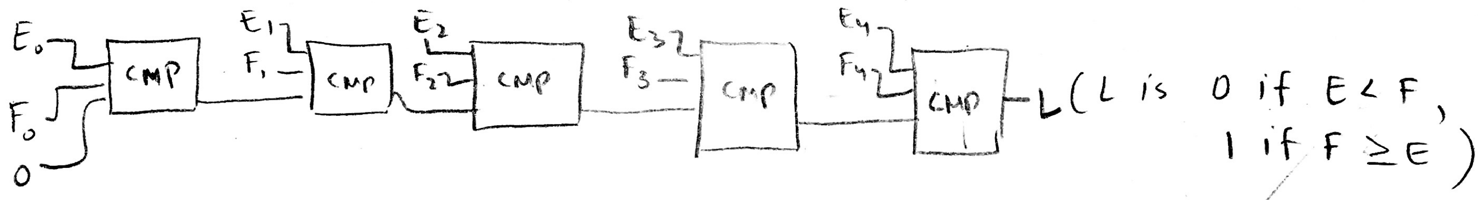
$$Cin/Cout = \begin{cases} 0 & \text{if } x > y \\ 1 & \text{if } y \leq x \end{cases}$$

Cin_i	x_i	y_i	$Cout_i$
0	0	0	0
0	0	1	1
0	1	0	0
0	1	1	0
1	0	0	1
1	0	1	0
1	1	0	1
1	1	1	1

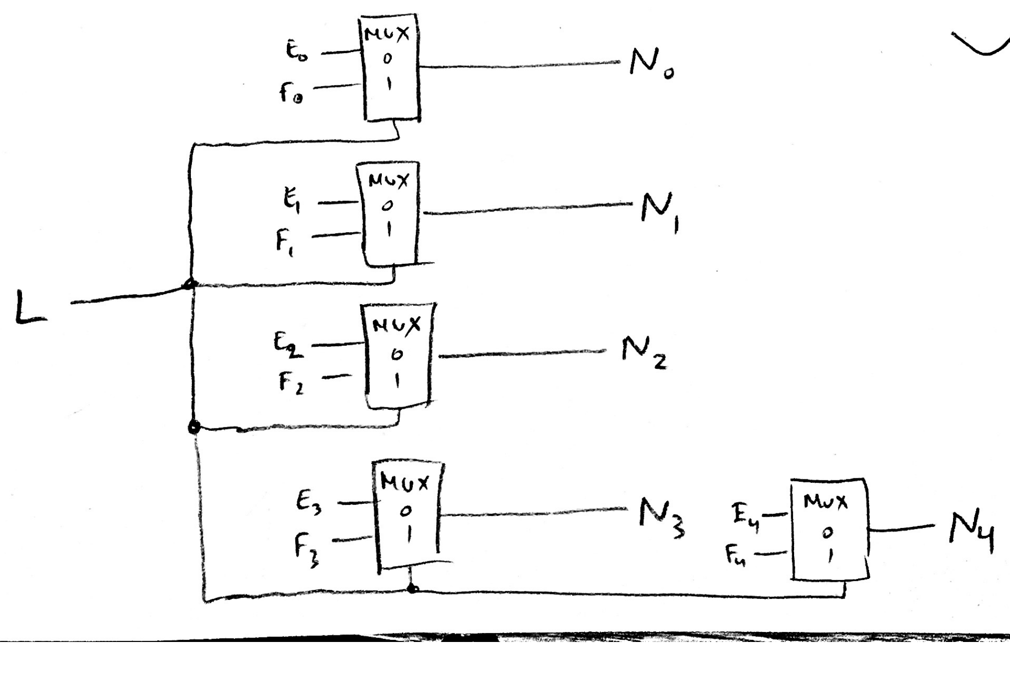
$$Cout_i = Cin_i' x_i' y_i + Cin_i(x_i' y_i' + x_i)$$



using E and F as found on prev page:



OUTPUT: ($N_4 N_3 N_2 N_1 N_0$ are digits of larger #)



11

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.

$P = M - N$

P.I. E.P.I.

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

X_0

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

X_2 X_3 X_1

X_0

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

X_2 X_3 X_1

N = 1.

M = 8

f 11

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).

0 1 2 3 4 5 6 7 8 ~~9 10 11 12 13 14 15~~
0 1 2 10 11 12 20 21 22 ~~100 101 102 110 111 112 120~~

x_3	x_2	x_1	x_0	y_1	y_0	z_1	z_0
0	0	0	0	0	0	0	0
0	0	0	1	0	0	0	1
0	0	1	0	0	0	1	0
0	0	1	1	0	1	0	0
0	1	0	0	0	1	0	1
0	1	0	1	0	1	1	0
0	1	1	0	1	0	0	0
0	1	1	1	1	0	0	1
1	0	0	0	1	0	1	0

$$y_1 = x_3'x_2x_1 + x_3x_2'x_1'x_0'$$

$$y_0 = x_3'(x_2'x_1x_0 + x_2x_1')$$

$$z_1 = x_3'(x_2'x_1x_0' + x_2x_1'x_0) + x_3x_2'x_1'x_0'$$

$$z_0 = x_3'x_2'x_1'x_0 + x_3'x_2x_1'x_0' + x_3'x_2x_1x_0$$

$$= x_3'x_2'x_1'x_0 + x_3'x_2(x_1'x_0 + x_1x_0)$$

$$= x_3'[x_2'x_1'x_0 + x_2(x_1'x_0 + x_1x_0)]$$