

Full Name: _____

Digital Logic Design, Fall 2009

Exam 1

September 29, 2009

Instructions:

- Make sure that your exam is not missing any sheets, then write your full name on the front.
- Write your answers in the space provided below the problem. If you make a mess, clearly indicate your final answer.
- The exam has a maximum score of 100 points.
- Show all work!!
- The problems are of varying difficulty. The point value of each problem is indicated. Pile up the easy points quickly and then come back to the harder problems.
- This exam is **CLOSED BOOK**. You are only allowed to use the single sheet of notes you made for this exam. Please hand in this sheet along with your test. If you did not use a sheet, just hand in a blank piece of paper with your name on it. Good luck!

1 (25):
2 (25):
3 (30):
4 (20):
TOTAL (100):

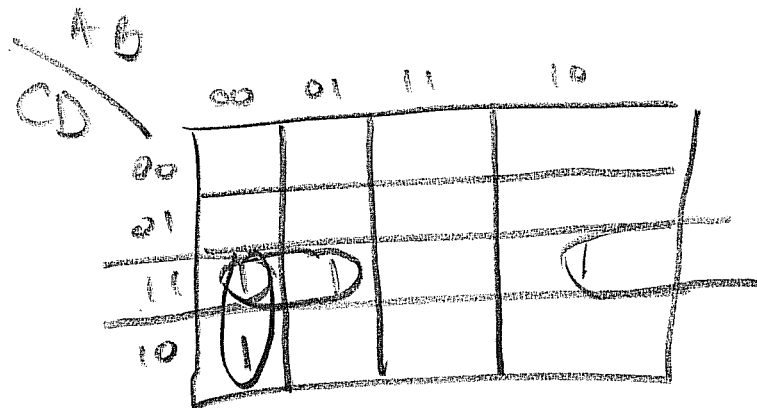
Problem 1. (25 points):

A local firm wants you to design a piece of combination logic that outputs a TRUE signal when an elevator reaches a floor that is a Lucas prime number. A Lucas prime number is a number that is related to a Fibonacci number series and has the following sequence:

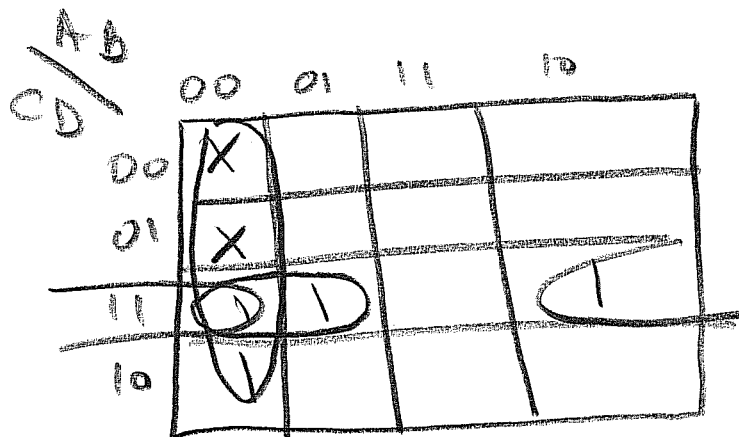
2, 3, 7, 11, 29, 47, ...

This piece of logic is used in a building that has only 16 floors, including the ground floor (i.e. 0 through 15 floors) . Please make sure you show a Sum of Products implementation that is fully simplified. Fifteen months after you demonstrate your implementation, suppose that the firm decides they tell you that the signal won't assert a TRUE signal if the elevator reaches the ground or first floors. Does this simplify the logic? Explain why or why not!

A	B	C	D	
0	0	0	0	0 ←
0	0	0	1	0 ←
0	0	1	0	1
0	0	1	1	1
0	1	0	0	0
0	1	0	1	0
0	1	1	0	0
0	1	1	1	1
1	0	0	0	0
1	0	0	1	0
1	0	1	0	0
1	0	1	1	1
1	1	0	0	0
1	1	0	1	0
1	1	1	0	0
1	1	1	1	0



$$L = \bar{A} \bar{B} C + \bar{A} C D + \bar{B} C D$$



Ground and 1st Floor are now Don't Care

$$L = \bar{A} \bar{B} + \bar{A} C D + \bar{B} C D$$

yes, its simplified by 1 Literal

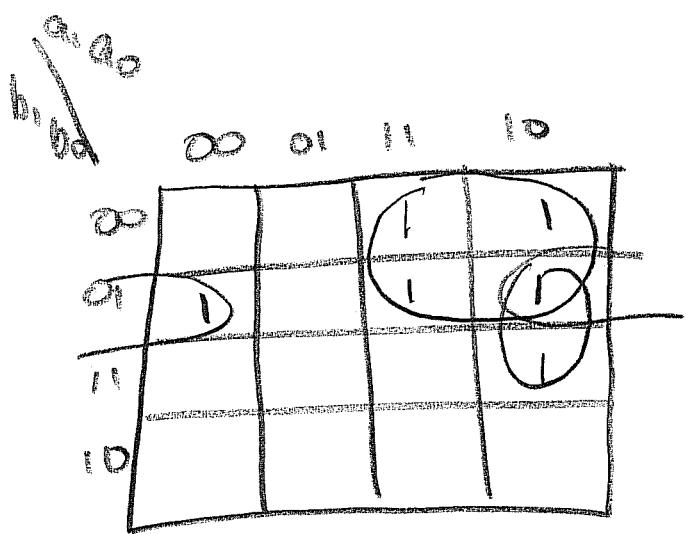
(continued)

Problem 2. (25 points):

Consider two 2-bit numbers $A = a_1, a_0$ and $B = b_1, b_0$, given in two's complement form. You are asked to design a circuit that takes these two numbers and produces an output s , such that $s = 1$ if and only if $A < B$. Otherwise, $s = 0$ for $A \geq B$.

a_1	a_0	b_1	b_0	S
0	0	0	0	0
0	0	0	1	1
0	0	1	0	0
0	0	1	1	0
0	1	0	0	0
0	1	0	1	0
0	1	1	0	0
0	1	1	1	0
1	0	0	0	1
1	0	0	1	1
1	0	1	0	0
1	0	1	1	1
1	1	0	0	1
1	1	0	1	1
1	1	1	0	0
1	1	1	1	0

- 00 = +0
- 01 = +1
- 10 = -2
- 11 = -1



$$S = a_1 \bar{b}_1 + a_1 \bar{a}_0 b_0 + \bar{a}_0 \bar{b}_1 b_0$$

(continued)

Problem 3. (30 points):

Sally, a recent OSU graduate, is asked to analyze the gate shown in Figure 1. Unfortunately, Sally's company only can purchase the gates shown in Table 1. Help Sally find an implementation of the design in Figure 1 using the gates in Table 1. Once you have the final design, analyze the timing of this circuit using the values shown in Table 1.

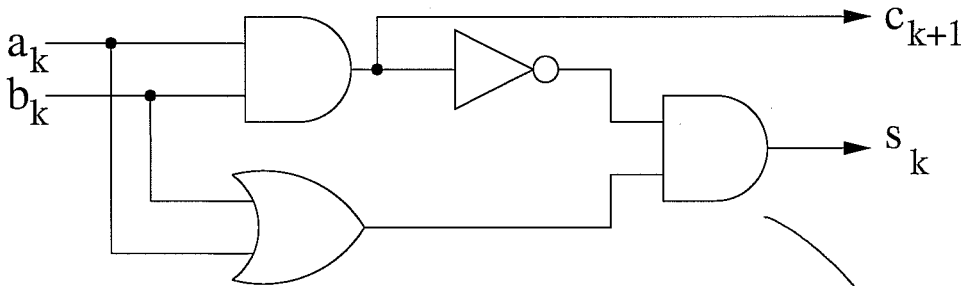
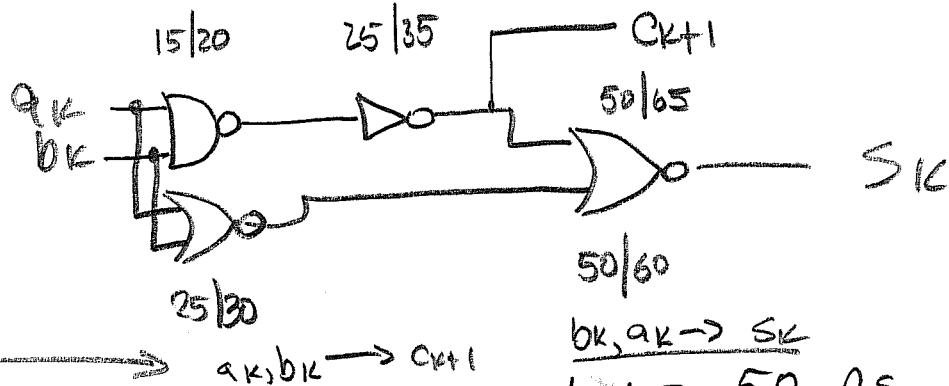
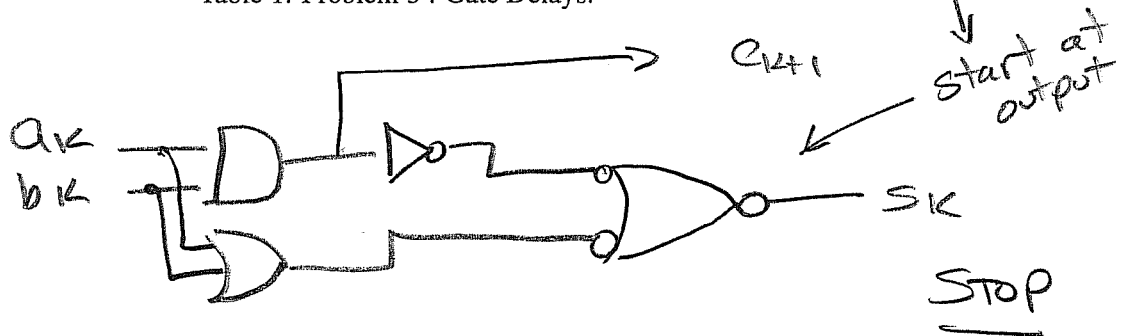


Figure 1: Problem 3 : Mystery Circuit.

Gate	Contamination Delay t_{cd} [ps]	Propagation Delay t_{pd} [ps]
2-input NOR	25	30
2-input NAND	15	20
Inverter	10	15

Table 1: Problem 3 : Gate Delays.



Need to show both values, since timing is for every implementation

$$t_{cd} = 25 \text{ ps}$$

$$t_{pd} = 35 \text{ ps}$$

$$t_{cd} = 50 \text{ ps}$$

$$t_{pd} = 65 \text{ ps}$$

contam. delay
critical path

(continued)

Problem 4. (20 points):

You have been hired by Orange Power Logic Systems as the lead engineer for their digital logic division. Your first job is to design a circuit that is similar to the seven segment display except that it is greatly simplified in two major ways. First, this part can only display the numbers: 0, 1, 3, ~~4~~ and 7. Second, it uses the 5 segment display system shown in Figure 2. Finally, show a schematic of your design, so your new colleagues can implement the design quickly.

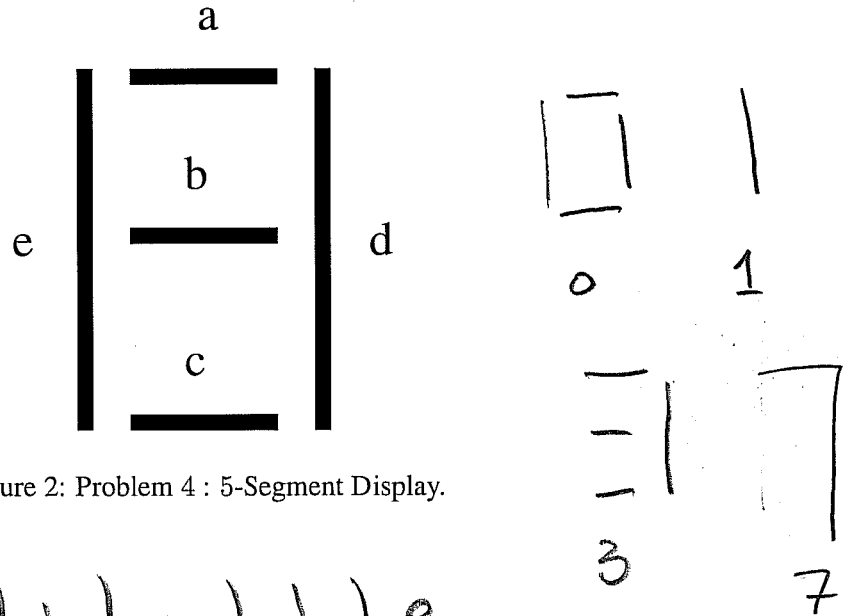


Figure 2: Problem 4 : 5-Segment Display.

a_2	a_1	a_0	a	b	c	d	e
0	0	0	1	0	1	1	1
0	0	1	0	0	0	1	0
0	1	0	x	x	x	x	x
0	1	1	-	-	-	-	0
1	0	0	x	x	x	x	x
1	0	1	x	x	x	x	x
1	1	0	x	x	x	x	x
1	1	1	-	0	0	-	0

(continued)

	$a_2 a_1$				
	a_0				
		00	01	11	10
0		1	X	X	X
1			1	1	X

$$a = \bar{a}_0 + a_1$$

	$a_2 a_1$				
	a_0				
		00	01	11	10
0			X	X	X
1			1		X

$$b = \bar{a}_2 a_1$$

	$a_2 a_1$				
	a_0				
		00	01	11	10
0		1	X	X	X
1			1		X

$$c = \bar{a}_2 a_1 + \bar{a}_2 \bar{a}_0$$

	$a_2 a_1$				
	a_0				
		00	01	11	10
0		1	X	X	X
1		1	1	1	X

$$d = 1 \text{ always true}$$

	$a_2 a_1$				
	a_0				
		00	01	11	10
0		1	X	X	X
1					X

$$e = \bar{a}_0$$

(continued)

