University of California at Berkeley
College of Engineering
Department of Electrical Engineering and Computer Science

EECS150, Spring 2010

Homework Assignment 10: Combinational Logic
Due April 9^{nd}, 2pm

Homework submissions must be made via the course SVN repository. Email submissions will not be accepted! Please format your homework as plain text, or PDF. You may use PNG for any necessary figures. Use a CAD program or **neat** *scanned drawings for diagrams (Microsoft Visio is installed on the machines in 125 Cory).*

1. Consider the following logic function:

$$F = ab\bar{c} + a\bar{b}\bar{c} + \bar{a}bc + abc$$

   (a) Minimize this logic function using K-maps.

   (b) Can you further optimize this circuit, for transistor count, beyond your answer in part a? If so, perform these optimizations and report the number of transistors that your solution requires.

2. DDCA 2.19

3. DDCA 2.24

4. Consider the following function expressed in two-level `and`/`or` form.

   (a) Using algebraic manipulation, express the function in three-level `or`/`and`/`or` form:

$$F = ac + ad + bc + bd + e$$

   (b) Now assume that you can only use two-input `and` and `or` gates to implement this function. For both the two-level and the three-level forms, determine the cost in transistors, and the delay in terms of "gate delay." Assume that gate delay is given by the square of the number of inputs.

5. DDCA 3.24, show the implementation down to the level of the next-state transition table and output logic truth table.

6. Repeat DDCA 3.24 using one-hot encoded states.

7. Just for fun, consider the 6 variable K-Map:

ef = 00

cd \ ab	00	01	11	10
00	0	1	0	0
01	1	0	0	1
11	1	1	0	0
10	1	1	0	1

ef=01

cd \ ab	00	01	11	10
00	0	1	0	1
01	1	0	1	0
11	1	1	0	0
10	0	0	0	1

ef=10

cd \ ab	00	01	11	10
00	0	1	1	0
01	0	1	0	1
11	1	1	0	1
10	0	0	0	1

ef=11

cd \ ab	00	01	11	10
00	0	1	1	1
01	0	1	1	0
11	1	1	0	1
10	0	0	1	1

Find a minimized boolean expression for this K-Map.

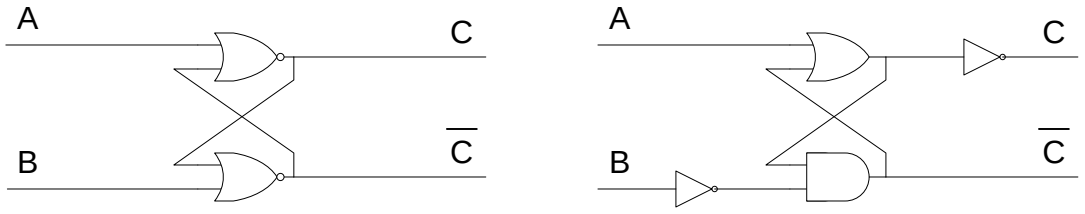
8. The Evil Cardinal has taken 10 valiant Bears prisoner. He then offers the Bears a game: he will bury them all, in a line, up to their necks in sand so that each Bear will only be able to see the Bears in front of him. He will then place a red or white skullcap on the head of each Bear. Each Bear will then be required to call out the color of the skullcap on his own head. If at least nine of the 10 Bears call out the correct color, the Bears will all be set free; if more than one gets it wrong, theyre all dead. Each Bear can only call out "red" or "white"; no other communication is permitted. However, they can confer ahead of time to decide on a strategy. What strategy will permit the Bears to be set free, rather than suffering an ignominious fate (to add insult to permanent injury, the Cardinal is planning to execute the Bears with an Axe)?

9. Design a finite state machine with no inputs (other than clk) that implements a gray-code counter with the following count sequence:

$$000, 010, 110, 100, 101, 111, 011, 001, 000, 010, \cdots$$

The outputs (and states) are named `x[2:0]`. For your answer write out the minimized logic Boolean equations for `x[2:0]`.

10. With the midterm over with, we are giving you another chance to conquer cross-coupled gate systems. Shown on the left of this figure:



is a circuit called an S-R latch. The circuit on the right is a mystery. Prove that these two circuits are or are not equivalent. *Hint:* Consider tools that you have learned since the midterm. For scratch work, feel free to use this waveform diagram: