CSI 250 - Homework Set #2

1. Prove that the following two equations are (or are not) equivalent (f is the same as last homework and notice the negation overline in g is negating the $+$):

$$f(A, B, C) = A\overline{B}C + \overline{A}\,\overline{B}\,\overline{C} + \overline{A}BC \tag{1}$$

$$g(A, B, C) = \overline{(AB + C)} + A \tag{2}$$

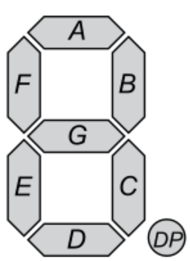
2. Use DeMorgan's Laws to remove all NAND and NOR from g. Show your steps. Remember that DeMorgan's Laws are:

$$\overline{AB} = \overline{A} + \overline{B} \tag{3}$$

and

$$\overline{A + B} = \overline{A}\,\overline{B} \tag{4}$$

3. A seven-segment display (those clock displays with 9 lines where only some of the lines are used to display different numbers) may display any number from 0 to 9. In binary, it only requires 4 bits (4 binary digits or switches) to distinguish between the numbers 0 through 9. (As shown in the binary table in the next question). So, it is possible to build a seven segment display that only requires 4 inputs even though there are seven different segments to be shown and 10 total different values that must be displayed. These inputs would describe the number to display. As such, each segment in the 7 segment display can be viewed as its own output function based on 4 inputs. The middle line, (G in the image) in a 7-segment display would not be on to display the numbers 0 (0000), 1 (0001), or 7 (0111). However, for all other inputs 2, 3, 4, 5, 6, 8 and 9, it should be on. Use a Karnaugh Map to find a simplified expression for G, given 4 bit input to the 7 segment display. If we do this for all 7 segments, we've reduced the number of switches required to light up our display from 7 to 4 with the addition of a little hardware, but you're only required to simplify the G segment here.



4. Implement two bit integer multiplication with simplest circuits using Karnaugh maps. Inputs are two two-bit integers: A, B and C, D. Output is four bits that is the multiplied values: WXYZ. You could write the bits out like this: A B * C D = WXYZ

   For your reference, here are all the decimal values from 0 to 9 with their binary equivalents:

$0000 = 0$	$0001 = 1$	$0010 = 2$	$0011 = 3$	$0100 = 4$
$0101 = 5$	$0110 = 6$	$0111 = 7$	$1000 = 8$	$1001 = 9$

   Hints: First draw out the multiplication table for two bit multiplication. This should have 16 entries. Turns out, this is also a truth table. Let's break down one line of that table: $2 * 2 = 4$ or in binary $10 * 10 = 0100$ There are 4 outputs here. W is 0. X is 1. Y is 0. Z is 0. Put all the entries of W into a proper K-map, draw your circles and get the simplest circuit for W, X, Y and Z.