ECE 150 Digital Logic Design, Fall 2023
Homework 1: due September 13th before class

Complete the following problems. Show your work through equations, diagrams, and a demo of any circuit built during class.

Use the TTL ICs for the multiplier *xor* CMOS ICs (not both together)!

Problem 1 (Number Systems)**.**

(a) Convert 33_{10} to:

  (a) Base 2
  (b) Base 6
  (c) Base 16

(b) Convert the following values to base 10:

  (a) $1001\ 0010\ 1101_2$
  (b) 273_8
  (c) $3DB_{16}$

Problem 2 (Arithmetic)**.**

(a) Convert $FC9_16$ to binary and octal without converting to base 10.

(b) Perform the addition 33_{10} + 17_{10} in binary.

(c) Perform the subtraction 17_{10} - 33_{10} in binary (using two's complement).

(d) Give the largest number (in decimal) representable by:

  (a) 4 Hex symbols.
  (b) N symbols from Base B.

Problem 3 (Boolean Algebra)**.**
Use boolean algebra to simplify these expressions:

(a) $X = \bar{A}BC + \bar{B}C + \bar{A}\bar{B}C$

(b) $Y = \bar{A}\ \overline{BC} + \overline{A + C}$

(c) $Z = \overline{\overline{(A + B)}C} + AB\bar{C}$

Problem 4 (Logic Diagram)**.**
Consider the diagram in Figure 1:

(a) Write a boolean expression for Z.

(b) Fill out a truth table for the diagram.

(c) Simplify the expression using a Karnaugh map.

(d) Use the simplified expression to draw a sum of products implementation of the circuit.

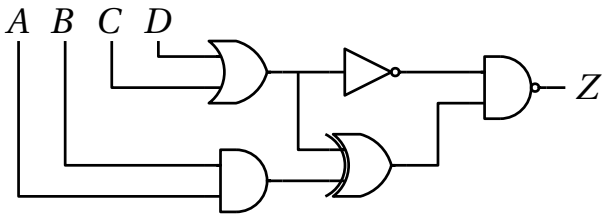

Figure 1: logic diagram

Problem 5 (2 Bit Multiplier)**.**
Consider the multiplication of two two-bit (unsigned) binary numbers, $A_1A_0 \times B_1B_0$, where A_1 and B_1 are the most significant bits of A and B.

(a) How many bits are required to represent all possible outputs of $A \times B$?

(b) Fill out a truth table for the two-bit multiplication.

(c) Simplify expressions for each output variable using Karnaugh maps.

(d) Draw an implementation of the circuit based on your expressions.

Problem 6 (2 Bit Multiplier Circuit)**.**
Using a single breadboard, and any of the following IC chips in the lab,

- NOT, AND, OR, NAND, NOR, XOR, XNOR

implement a 2 Bit multiplier circuit from the previous problem.
You must:

- Use red wire for 5V and black for ground
- Provide inputs $A_1A_0B_1B_0$ via a 4-input DIP switch with pull-down resistors.
- Display your outputs on LEDs with current limiting resistors in series.

You may want to rearrange your previous boolean expressions to use as few IC chips as possible. If so, draw a logic diagram of your final implemented circuit.
You will demo your circuit at the start of class on the due date.