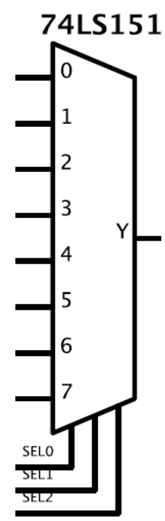
Physics 3150
Problem Set 5, 2014

Due Wednesday, April 6, 2016

1. Eggleston Problem 8-2.
2. Problem 8-4.
3. Using binary arithmetic with twos-complement numbers (i.e., signed binary integers), evaluate (a) 11 + 4, (a) 11 – 4, (b) 4 - 11, and (c) the product of -3 and 2. In each case, convert the result to a decimal representation to show that the answer is as expected. (Note: for the multiplication, you might want to limit yourself to a 4-bit word length for simplicity).
4. **"Invert-if-odd" circuit.** Using any standard logic chips that you like, design a circuit that accepts as inputs a square-wave clock signal and a four-bit binary number, and has a single digital output. The clock signal should appear without change at the output if the binary number is even, but it should be inverted if the binary number is odd. *Hint*: this is easier than it might first seem!
5. The figure shows an 8:1 digital multiplexer, for which the address lines SEL0…SEL2 select one of the eight data inputs Q0…Q7 to appear at the output Y.



   (a) By wiring each of the data inputs to either 1 (+5 V) or 0 (Ground), show that the chip can be "programmed" to produce an output of 1 if the 3-bit unsigned binary number applied to the address lines SEL0…SEL2 is divisible by 3, and 0 if it is not. Assume that the least significant bit is SEL0.

   (b) With a little cleverness, it is possible to add a fourth address bit SEL3 using only a single inverter. For each combination of the other three bits SEL0…SEL2, the output Y can depend on SEL3 in only four possible ways: (i) always 1, (ii) always 0, (iii) equal to SEL3, or (iv) equal to the inverse, $\overline{\text{SEL3}}$. By wiring each of the 8 data inputs Q0…Q7 to one of these four signals, modify your circuit so it correctly identifies all of the numbers between 0 and 15 that are divisible by 3.