Homework #3 assigned 4/4/01     due 4/11/01

HW3.1  Consider a p-MOS inverter consisting of a p-MOS driver transistor with \( W/L = 6 \) and a p-MOS load device with \( W/L = 1 \). The power supply voltage, \( V_{DD} \), is -10 V and the gate of the load device is connected to \( V_{DD} \). Calculate and plot the transfer characteristic (output voltage versus input voltage) of this inverter for an input voltage varying from 0 V to -10 V. The p-MOS devices are made on a n-type, 2 \( \times \) \( 10^{15} \) cm\(^{-3} \) doped substrate, have an aluminum gate, \( \Phi_M = 3.94 \) V, \( \chi = 4.05 \) V, and a 0.08 \( \mu \)m thick gate oxide. Use the table in the back of the book for the physical constants and use a hole mobility of 450 cm\(^2\)/Vs.

HW3.2  Repeat 3.1 for an inverter whose load device has \( W/L = 0.5 \), and plot the transfer characteristic on the same plot.

HW3.3  Repeat 3.1 for an inverter with a resistor as load device (\( R = 5 \) K\( \Omega \)), and plot the transfer characteristic again on the same plot.

HW3.4  Design a circuit (analog or digital) with about 10 p-MOS transistors. The circuit can include resistors and capacitors but not inductors. Assume a metal gate process. Provide a circuit diagram, indicating the values of the circuit parameters. Calculate the \( W/L \) ratio of all the p-MOS transistors in your circuit.

HW3.5  Assume a silicon metal gate CMOS process where the gate metal is aluminum (\( \Phi_M = 3.94 \) V, \( \chi = 4.05 \) V) and the gate oxide is 0.1 \( \mu \)m thick.

a)  Find the n and p-type doping concentrations for the substrate and the well for which the threshold voltages of the n-MOS and p-MOS transistor are \( V_{Tn} = 1 \) Volt and \( V_{Tp} = -1 \) Volt. Solve this problem graphically by plotting \( V_{Tn} \) and \( V_{Tp} \) versus doping concentration. Make sure that your solution is within 10 % of the exact solution by scaling the graph appropriately. Provide the graph with your solution.

b)  Is a p-type well or an n-type well required to satisfy the above threshold voltage requirement? How does this compare to the example in the book?