University of California
College of Engineering
Department of Electrical Engineering and Computer Sciences

Problem Set #6
Due Wednesday, October 7, 1998

EECS105 **FALL, 1998**

1. Refer to Figure P3.10 in page 188 in your textbook. The IC structure shown in cross section in Fig. P3.10 is part of a voltage-controlled resistor.
   (a) What is the thickness t of the un-depleted n-type layer for $V_C = 0$? The distance between the metallurgical junctions between the n-type layer and the p^+ layers is $t_o = 1$ μm.
   (b) For what value of V_C does $t = 0$? This condition is called pinch-off.
   (c) Plot the sheet resistance of the n-type layer as a function of V_C.

2. In a particular CMOS technology, the p-type substrate has a doping concentration $N_a = 4\text{x}10^{16}$ cm^{-3}. The n-well doping is $N_d = 2.5\text{x}10^{17}$ cm^{-3}. The gate oxide for both the NMOS and PMOS transistors is $t_{ox} = 200$ Angstroms, and n^+ polysilicon is used for the gates of both types of transistors. For the MOS capacitor in the n-well,
   (a) what is the flatband voltage? What is the state of the capacitor in thermal equilibrium?
   (b) Calculate the threshold voltage V_{TOp}.
   (c) For the MOS capacitor in the p-type substrate, repeat (a) and (b).

3. In this problem you will size a CMOS inverter with process parameters: $V_{DD} = 5$ V $V_{Tn} = 0.7$ V, $V_{Tp} = -0.9$ V, $\mu_n = 500$ cm^2/Vs, $\mu_p = 200$ cm^2/Vs, $t_{ox} = 20$ nm, $\lambda_n = \lambda_p = 0.05$ V^{-1}. Assume equal channel lengths, $V_{DD} = 5$ V, and all other process parameters are unchanged.
   (a) Calculate the ratio W_n/W_p, such that $V_M = 2.5$ V.
   (b) When $V_{IN} = V_M$ we want the current through the inverter to be 1 mA. What are W_n and W_p assuming the channel length of both devices is 2 μm?
   (c) Sketch and label the voltage transfer characteristic.
   (d) What are NM_L and NM_H?

Please visit our web site: http://www-inst.EECS.Berkeley.EDU/~ee105/

***Please post your questions on our newsgroup*:** ucb.class.ee105

Please return your homework in 558 Cory Hall, to Cheryl Craigwell (cmc@eecs, 642-1237, fax 642-2739), or in class by 11:10am of the due date. Late homeworks will not be graded.

The first Mid Term will take place in one week - Wednesday, October 7 at 6pm in Sibley.