Massachusetts Institute of Technology
Department of Electrical Engineering and Computer Science

6.012
Microelectronic Devices and Circuits
Spring 1998

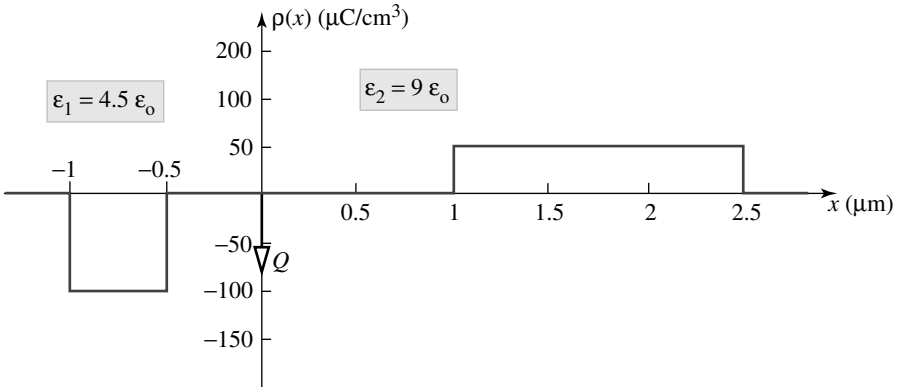
September 24, 1999- Homework #3
Due – October 1, 1999

Reading: Chapter 3.4 - 3.7

Problem 1 In the figure below there is a material interface at $x = 0$ at which a sheet charge of value Q is located.

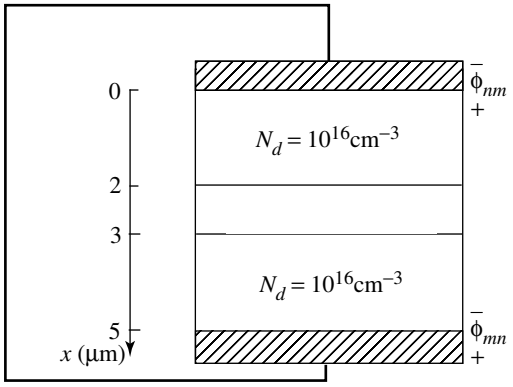
a) Find the value of Q such that the entire region is charge neutral.

b) Sketch the Electric field, $E(x)$ for $-2\ \mu m \le x \le 3\ \mu m$
c) Sketch the Potential, $\phi(x)$ for $-2\ \mu m \le x \le 3\ \mu m$



Problem 2 The silicon structure below is in thermal equilibrium. It consists of two pn junctions that are separated by 1 μm. The n-type to metal contact potential, ϕ_{nm} = 400 mV.

a) Find the minimum value of N_a such that the p-type region is completely depleted.
b) Plot the Electric field $E(x)$ through the structure for the value of N_a calculated in part (a).
c) Plot the potential $\phi(x)$ including the contact potential through the structure for the value of N_a calculated in part (a).



Problem 3 Voltage controlled oscillators are used in most RF circuits to select a particular frequency to receive. They are made with tank circuits where the inductor value is fixed and the capacitor value is controllable by changing the voltage. Pn junction diodes are often used for these circuits.

a) Given an inductance of 5 nH and a pn junction diode with $N_a = 10^{16}$ cm^{-3} and $N_d = 10^{19}$ cm^{-3} calculate the area of the capacitor to make the resonant frequency 1 GHz when the voltage across the diode is 0 V.

b) If the maximum electric field in the junction before breakdown is 5 x 10^5 V/cm what is the maximum voltage that can be placed across the diode?

c) Plot the range or frequencies that can be tuned with the range of tuning voltages from 0 V to the voltage calculated in (b).

Problem 4 Howe & Sodini P3.10