Department of Electrical and Computer Engineering, Cornell University

ECE 3150: Microelectronics

Spring 2016

Homework 1 **Due on Feb. 04, 2016 at 7:00 PM**

Suggested Readings:

a) Lecture notes

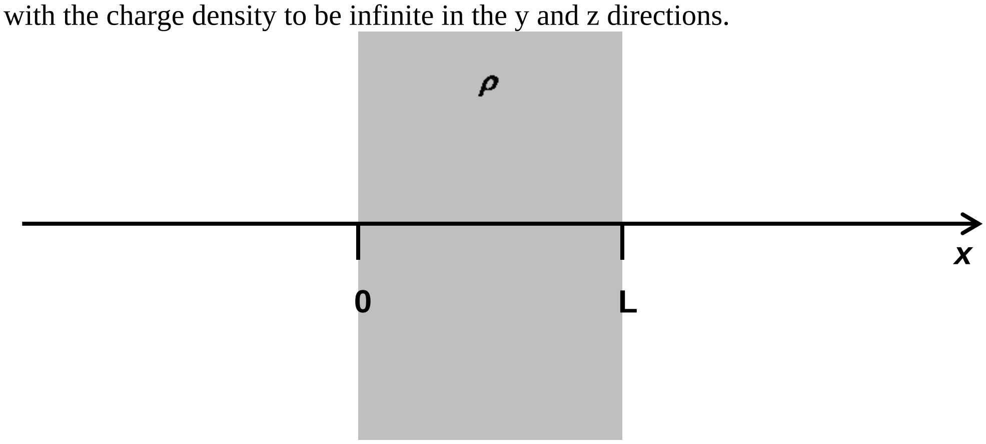
Important Note:

MAKE SURE THAT YOU INDICATE THE UNITS ASSOCIATED WITH YOUR NUMERICAL ANSWERS. OTHERWISE NO POINTS WILL BE AWARDED. Graders please make note.

Unless noted otherwise, always assume room temperature.

Problem 1.1: (Review of electrostatics)

Consider a region of space between **x=0** and **x=L** containing a uniform volume charge density of ρ (Coulombs/m^3), as shown below. The dielectric constant everywhere is ε_o.This is a 1D problem. Assume the region with the charge density to be infinite in the y and z directions.

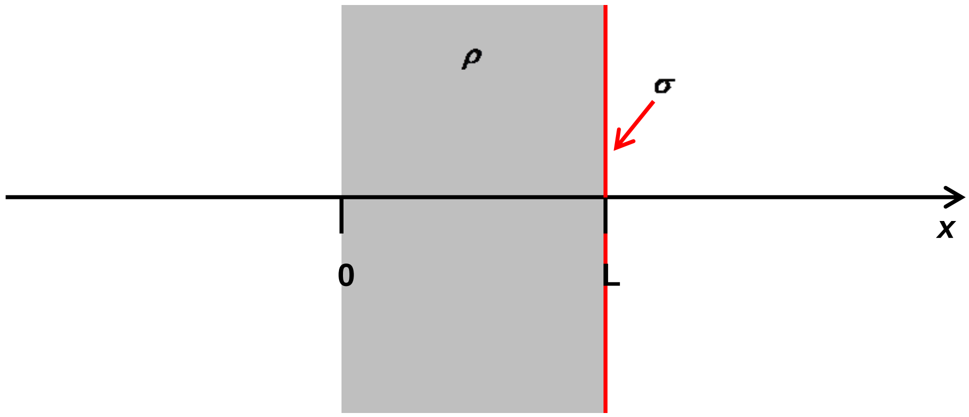


Suppose the electrostatic potential and the electric field at **x=0** are known and are $\phi(x=0)$ and $E_x(x=0)$, respectively.

a) In terms of the given quantities, find the electrostatic potential and the electric field for $0 < x < L$.

b) In terms of the given quantities, find the electrostatic potential and the electric field for $x > L$.

c) The above problem is now slightly modified. A charge sheet with a surface charge density of σ (Coulombs/m^2) is added in the y-z plane at $x = L$, as shown below. In terms of the given quantities, find the electrostatic potential and the electric field for $x > L$.



Problem 1.2: (Semiconductors in equilibrium)

Consider the following three samples of silicon, each of which has different dopants and different doping levels:

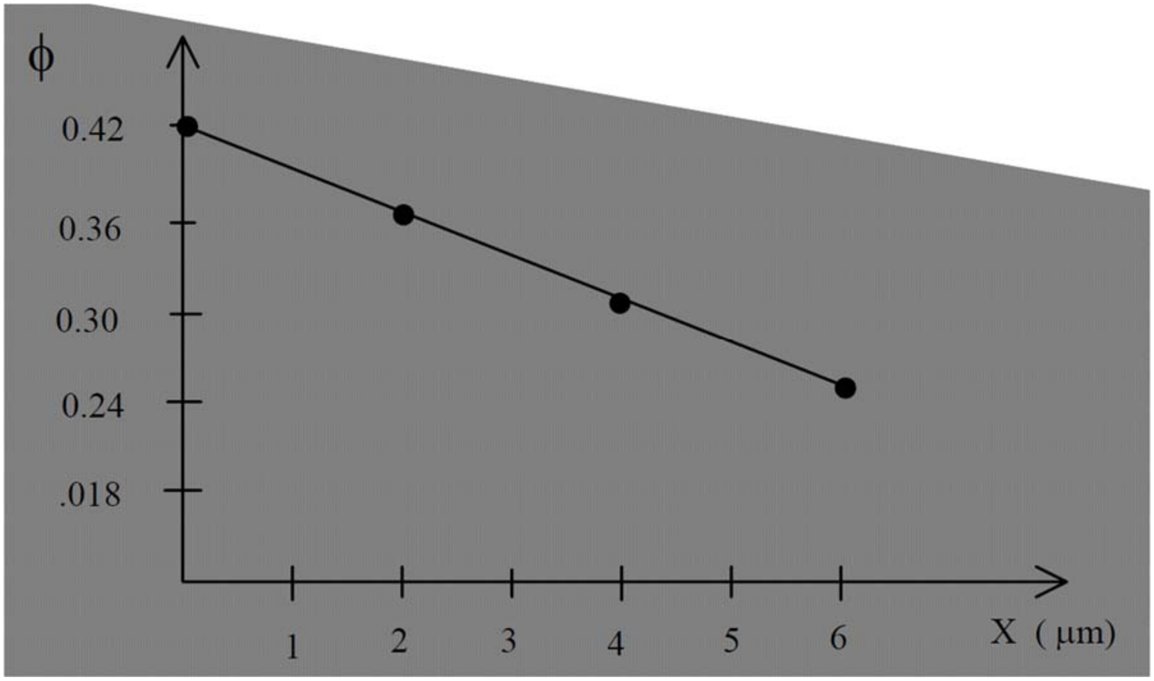
Sample A: 10^{17} cm^{-3} Arsenic dopant
Sample B: 10^{16} cm^{-3} Boron dopant AND $5\text{x}10^{15}$ cm^{-3} Phosphorous dopant
Sample C: Intrinsic (no dopants)

Complete a table like that shown below for these three samples. Assume that at room temperature the electron mobility, μ_n, is 1600 cm^2/V-s, the hole mobility, μ_p, is 600 cm^2/V-s, and the room temperature intrinsic carrier concentration in silicon, n_i, is 10^{10} cm^{-3}.

	Type (N or P)	n_o	p_o	Resistivity ρ	Potential ϕ_n or ϕ_p in Volts
Sample A					
Sample B					
Sample C					

Problem 1.3: (Currents in semiconductors)

Consider a doped semiconductor in thermal equilibrium in which the electrostatic potential (with respect to intrinsic silicon) has been measured and found to be as indicated in the figure below. Assume that $\mu_n = 1000 \text{ cm}^2/\text{V - s}$ and $\mu_p = 500 \text{ cm}^2/\text{V - s}$.



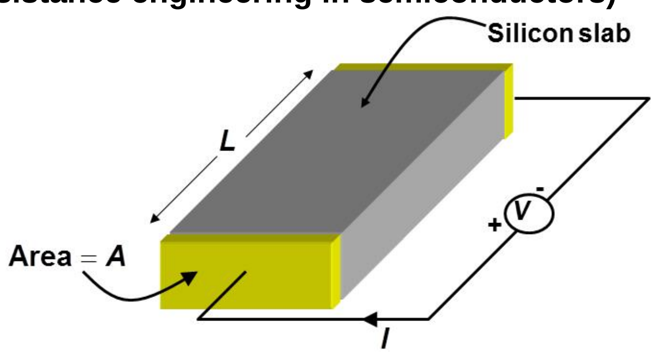
a) Plot the electron and hole concentrations (with units) vs x for $0 \le x \le 6\ \mu m$.

b) Plot the electric field (with units) vs x for $0 \le x \le 6\ \mu m$.

c) Calculate and plot the electron drift current density (with units) vs x for $0 \le x \le 6\ \mu m$.

d) Calculate and plot the electron diffusion current density (with units) vs x for $0 \le x \le 6\ \mu m$.

Problem 1.4: (Resistance engineering in semiconductors)



a) Consider a piece of P-doped silicon with an area A equal to 1.0 $sq\text{-}\mu m$ and length L equal to 10 μm. It is required that the resistance of this piece be 100 Ω. If the hole diffusivity is D_p is 27 cm^2/s, find the p-doping necessary to achieve the desired resistance value.