General Physics - E&M (PHY 1308) Lecture Notes

Homework003

SteveSekula, 6 September 2010 (created 5 September 2010)

no tags

Homework 3

Expectations for the quality of your handed-in homework are available at http://www.physics.smu.edu/sekula/phy1308/HomeworkPolicy.pdf. Failure to meet these guidelines will result in loss of points as detailed in that document. This assignment covers material from Wolfson Chapter 21.4-21.6 and 22.1. Each problem is worth 20 points, and the total assignment is worth 60 points.

This homework is due by 9am (start of class) on Monday, September 13

Reading Assignment:

Chapter 21.4-21.6, 22.1

Problems:

Problem SS-8

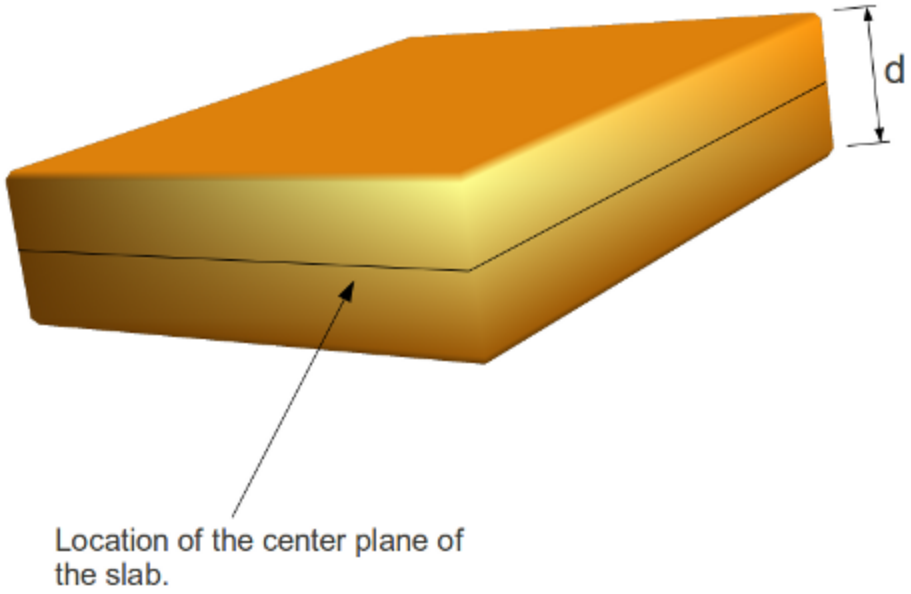
Let us model a copper electrode as a slab of charge that extends infinitely in two dimensions and has a thickness, d, in the third dimension, a shown below. The slab carries a uniform volume charge density ρ.

1. Find an expression for the electric field strength **inside** the slab, as a

function of the distance x from the center plane of the slab.

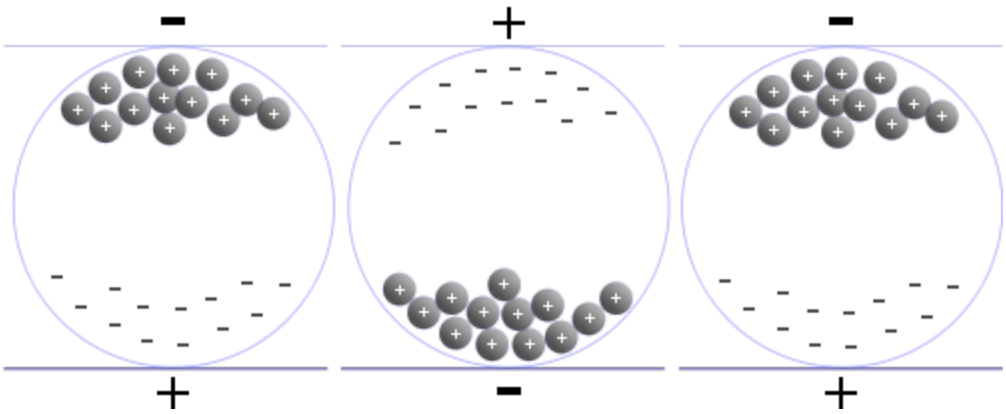
2. Find an expression for the electric field strength **outside** the slab, as a function of the distance x from the center plane of the slab.

3. If, instead, we placed the same charge on a real copper plate with the same dimensions (copper is an electrical conductor), how would the electric fields inside and outside the plate change?



Problem SS-9

Electrophoretic ink, or *E-Ink*, is a technology that allows images to be formed on a flat surface simply through the application of weak electric fields (c.f. the Amazon Kindle, or the Barnes and Noble Nook). The electric fields, depending on whether they originate from areas of positive or negative charge, cause small droplets of white material (the actual "ink"), suspended in a dark oil, to drift closer to or further away the surface of the "paper" (see illustration below).



1. Consider one of these small droplets, a white one made from titanium dioxide. Model it as a solid sphere, of radius R, that carries a volume charge density $\rho = \rho_0 e^{r/R}$, where ρ_0 is a constant and r is the distance from the center of the droplet. Find an expression for the electric field strength at the surface of the sphere.

2. It takes about 0.2 seconds for the page-turn to happen on an *E-Ink* based device. A "page-turn" corresponds to the movement of white particles closer or further away from the paper surface, as appropriate, to achieve the lettering on the new page. If each white droplet carries a charge of $-16e$, has a mass of $6.7 \times 10^{-15}\mathrm{kg}$, and has to cross a distance of $40.0\mu\mathrm{m}$ when going from the bottom to the top of the pixel, estimate the strength of the electric field to which the droplet is subjected. Assume there are no collisions during the movement of the droplet, and that the droplets are small compared to the dimensions of each pixel (which they are, in reality).

3. Using your answer from the last question, determine the electric potential across each pixel. If you didn't obtain an answer to the previous question, assume that $\vec{E} = (-3.0\hat{i})\mathrm{N/C}$, where $\hat{i}$ is a unit vector pointing from the bottom of the pixel to the top (this is not the correct numerical answer to the previous question).

4. How much work is done in moving the droplet through the potential difference in the previous question? If you were unable to obtain a numerical answer, assume $V = 1.2 \times 10^{-4}\,\mathrm{N \cdot m/C}$ (this is not the numerical answer to the previous question).