

Physics 106B: Classical Mechanics

Homework 7: Electrostatics

DUE: Thursday, March 8 2001

Remember: There will be no extensions for this homework except for medical reasons or extenuating circumstances. Note that for the rest of Phys106, you must solve integrals analytically, or by looking them up in a table, but you may not use Mathematica.

Reading Assignment: Jackson Chapter 2.9 - 2.11

Problem 1. A cubical box consists of five metal sides which are welded together and grounded. The top is made of a separate sheet insulated from the rest, and held at constant potential V_0 . Find the potential inside the box. All sides have length a .

Problem 2. Suppose the capacitance matrix of a two conductor system is known and parametrized in terms of their mutual capacity and their stray capacitances to ground. Initially, the conductors bear charges q_1 and q_2 respectively, and at $t = 0$, the two conductors are connected together through a resistor R . Assume that for $t \geq 0$, the voltage difference $V = \phi_2 - \phi_1$ between the conductors is related to the current i flowing through R by $V = iR$, where

$$i = \frac{dq_1}{dt} = \frac{-dq_2}{dt}$$

- i) find the potential of each conductor as a function of time.
- ii) What is the stored energy in the system at $t = 0$ and at $t = \infty$? Note that the difference is the energy converted to heat in the resistor.

In this problem, ignore any magnetic field effects – i.e., assume the stray inductance between the conductors is negligible.

Do Jackson problems 2.12, 2.17, 2.18

Presentation Problem 8- Assigned to group 8

For class Thursday, March 1.

Two infinitely long grounded metal plates at $y = 0$ and $y = \pi$ are connected at $x = \pm a$ by metal strips maintained at constant potential V_0 .

- (i) Write down the appropriate boundary conditions.
- (ii) Write Laplace's equation for the problem, and find the form of the general solutions.
- (iii) Find the potential inside the rectangular pipe in terms of a series expansion, and find all the coefficients in terms of the constants given in the problem.
- (iv) Make a 3-D sketch of the potential where the axes are x , y , and the potential Φ .

Presentation Problem 9- Assigned to group 9

For class Tuesday, March 6.

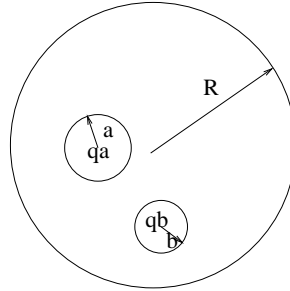
(This is a review problem.) Using Gauss's law, calculate the capacitance of

- i) two concentric conducting spheres with radii a , b , ($b > a$).
- ii) two concentric conducting cylinders of length L large compared to their radii, a , b , ($b > a$).
- iii) Calculate the attractive force between the parallel cylinders for both fixed charges on the conductors, and fixed potential difference between them.
- iv) What is the total electrostatic energy for the spherical and cylindrical capacitors expressed in terms of the charges on the conductors?

Presentation Problem 10- Assigned to group 10

For class Tuesday, March 6.

(This is a review problem). Two spherical cavities, of radii a and b are hollowed out from the interior of a (neutral) conducting sphere of radius R (see figure). At the center of each cavity a point charge is placed; call these charges q_a and q_b .



- (i) Find the surface charges σ_a , σ_b , and σ_R .
- (ii) What is the field outside the conductor?
- (iii) What is the field within each cavity?
- (iv) What is the force on q_a and q_b ?
- (v) Which of these answers would change if a third charge, q_c , were brought near the conductor?