PHYS-2201 Electricity and Magnetism
Assignment 9
Due: Thu, Nov. 26, 2015, by 3pm (at dropbox outside 3L24)

1. (5 points) Find the total capacitance of the circuit in Fig. 1.

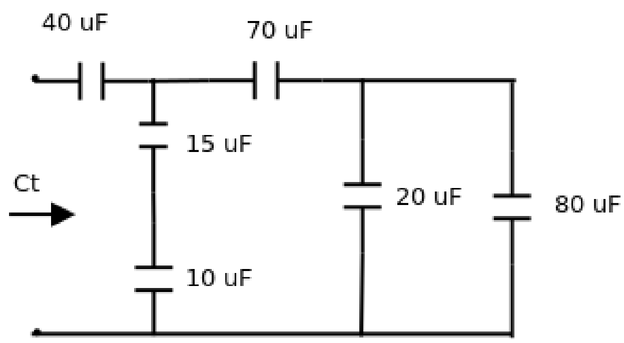

Figure 1: Problem 1.

2. (5 points) A spherical capacitor shown in Fig. 2 is filled with two different dielectric materials. The inner conductor has radius a, the first dielectric, κ_1, extends from radius a to radius b, and the second dielectric, κ_2, extends from radius b to the radius c of the outer conductor. Find an expression for the capacitance, C, in terms of the radii and dielectric constants.

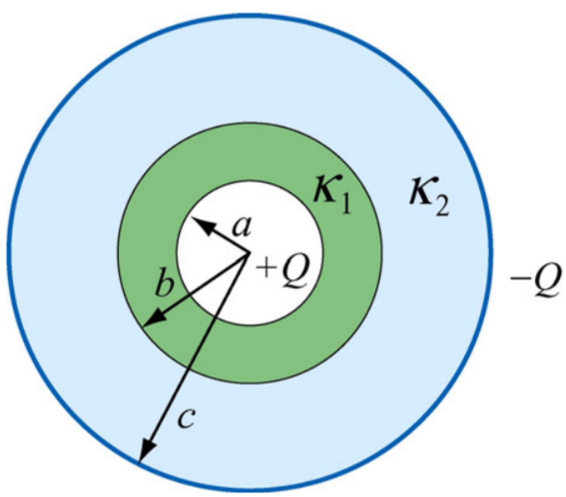

Figure 2: Problem 2 (sphere), and problem 3 (cylinder).

3. (5 points) This time interpret Fig. 2 as the end view of a cylindrical capacitor of length, L. Find an expression for the capacitance, C, in terms of the length, radii, and dielectric constants.

4. (5 points)

   (a) The current density across a cylindrical region of radius R varies according to the equation:

   $$J = J_0(1 - r/R), \tag{1}$$

   where r is the distance from the axis of the cylinder. The current density is a maximum J_0 at the axis r=0 and decreases linearly to zero at the surface $r = R$. Calculate the current in terms J_0 and the region's cross-sectional area $A = \pi R^2$.

   (b) Now suppose that current density was a maximum J_0 at the surface and decreased linearly to zero at the axis, so that:

   $$J = J_0 r/R. \tag{2}$$

   Calculate the current. Why is the result different for these two cases?

5. (5 points) A resistor in the shape of a truncated right circular cone is shown in FIG. 3. The end radii are a and b, and the height is L. If the taper is small, we may assume that the current density is uniform across any cross section.

   (a) Calculate the resistance of this object.

   (b) Show that your answer reduces to $\rho L/A$ for the special case of zero taper ($a = b$).

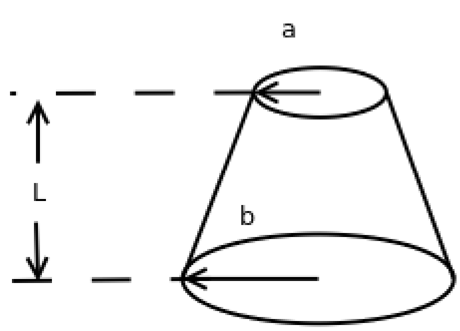

Figure 3: Problem 5.