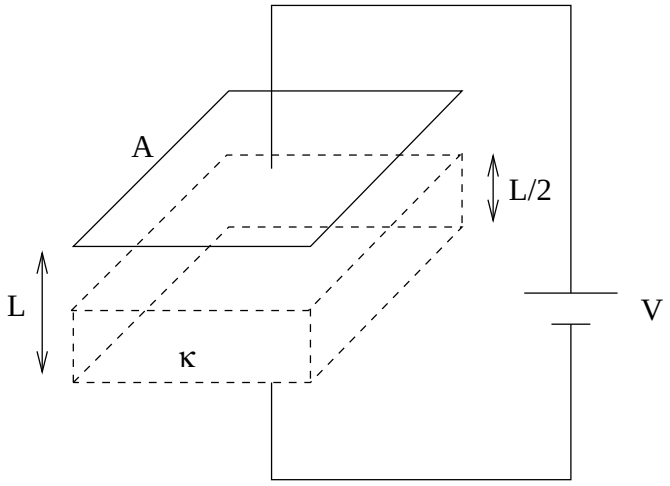
PHY6938 E & M Spring 98

Note: hand in questions 1, 2, and 3 as homework; we will work 4 in class on Friday.

1. Consider a capacitor connected to a battery of voltage V. Let the capacitor have an area A, and a distance L between the plates. Assume that the capacitor has a layer of dielectric (of dielectric constant κ, so that $\epsilon = \kappa\epsilon_0$) of thickness $L/2$ on the lower plate, as shown in the figure.



a) Calculate the capacitance of the capacitor.

b) Calculate the charge on the capacitor.

c) Calculate the value of the electric displacement D in the capacitor.

d) Calculate the value of the electric field inside the dielectric layer, and in the air above it.

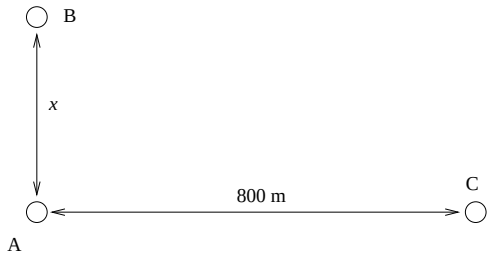
e) Calculate the electrostatic energy stored in the system. How would it change if the dielectric is removed?

2. A plasma generated inside a long hollow cylinder of radius R has the following charge distribution:

$$\rho(r) = \frac{\rho_0}{[1 + (r/a)^2]^2}$$

where r is the distance to the center and ρ_0 and a are constants. Determine the electric field everywhere.

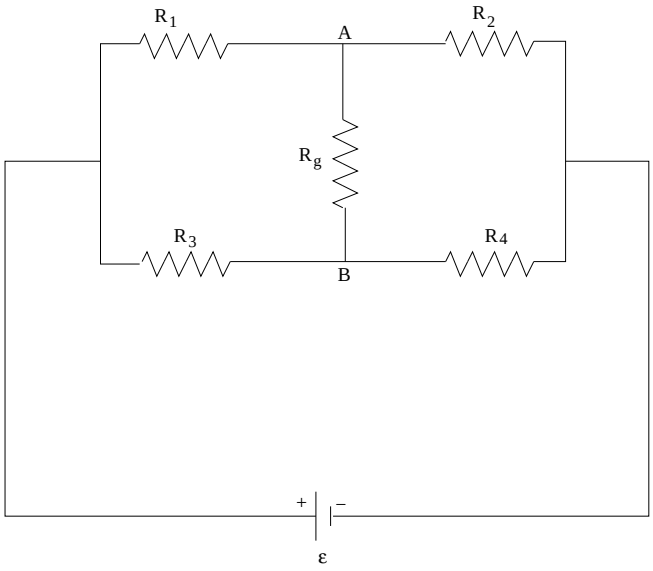
3. A radio transmitter at position A operates at a wavelength of 20 m.



a) Assuming the antenna is arranged so an approximately plane wave is emitted and the maximum electric field at the transmitter is 600 V/m, write the equation for the electric field for all time and space.

b) A second, identical transmitter is located at a distance x from the first transmitter, at position B. The transmitters are phase locked together such that the second transmitter is lagging $\pi/2$ out of phase with the first. Find the minimum distance between them, x, such that the electric field will be a maximum at position C, 800 m from the transmitter at position A.

4) Consider the Wheatstone bridge resistor circuit shown in the diagram below. The values of the resistors are $R_1 = 100\,\Omega$, $R_2 = 200\,\Omega$, $R_3 = 100\,\Omega$, and $R_4 = 400\,\Omega$. The galvanometer has a resistance of $R_g = 10\,\Omega$, and the battery supplies a voltage of $\varepsilon = 12$ V.



a) What is the current through the galvanometer?

b) What is the voltage difference between points A and B? What is the requirement on this voltage difference if the bridge is to be "balanced" (i.e. when no current flows through the galvanometer?