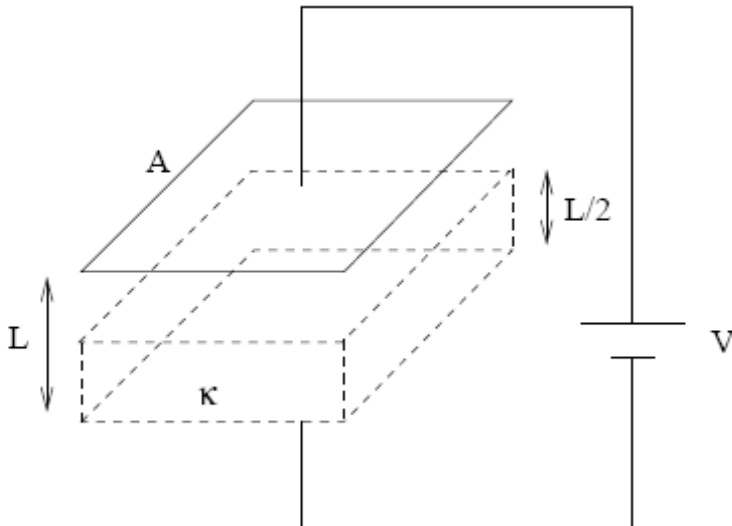


## Electrodynamics Problem 1

Twelve wires, each of resistance  $r$ , are connected to form the edges of a cube. Calculate the effective resistance  $R$  of this network across a body-diagonal of the cube.

## Electrodynamics Problem 2

Consider a capacitor connected to a battery of voltage  $V$ . Let the capacitor have an area  $A$ , and distance  $L$  between the plates. Assume that the capacitor has a layer of dielectric (of dielectric constant  $\kappa$ , so that  $\varepsilon = \kappa\varepsilon_0$ ) of thickness  $L/2$  on the lower plate, as shown in the figure.

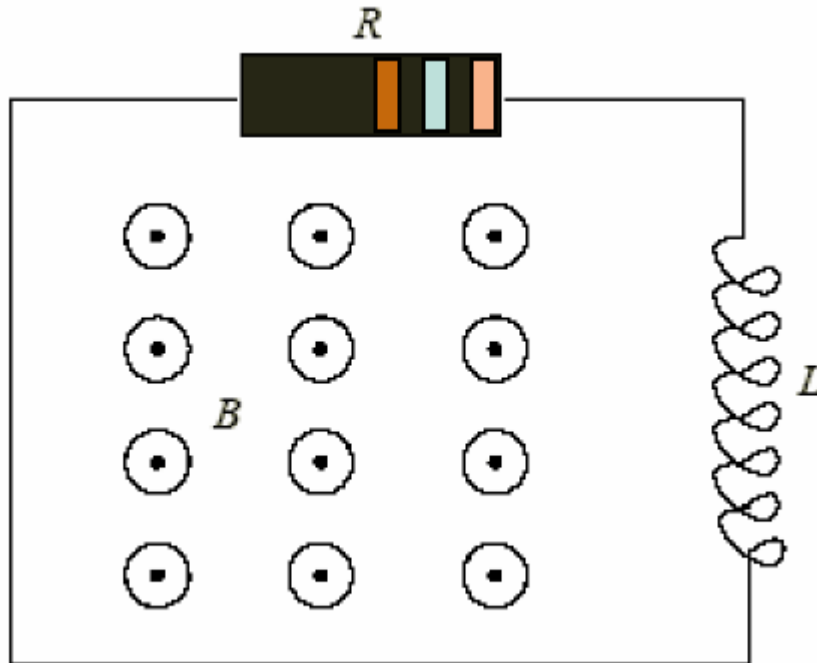


- Calculate the capacitance of the capacitor.
- Calculate the charge on the capacitor.
- Calculate the value of the electric displacement  $D$  in the capacitor.
- Calculate the value of the electric field inside the dielectric layer, and in the air above it.
- Calculate the electrostatic energy stored in the system. How would it change if the dielectric is removed?

## Electrodynamics Problem 3

A loop of wire of resistance  $R$  and a coil of self-inductance  $L$  encloses an area  $A$ . A spatially uniform magnetic field is applied perpendicular to the plane of the loop with the following time dependence:  $t < 0$  the field is zero; for  $0 < t < t_0$ ,  $B(t) = kt$ , while for  $t > t_0$ , the field now remains constant at  $B_0 = kt_0$ .

- a) Calculate the current  $I$  in the loop for all times  $t > 0$ , given that  $I = 0$  for  $t = 0$ .
- b) Make simple sketches of the current vs. time for  $t_0 < R/L$  and  $t_0 \gg R/L$ .



## Electrodynamics Problem 4

A static charge distribution produces a spherically radial electric field

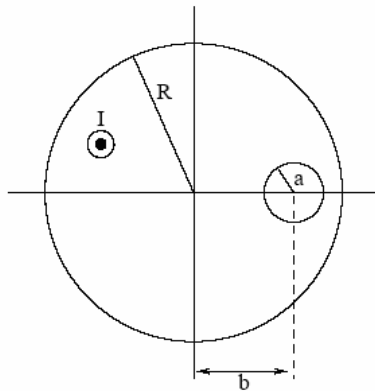
$$\vec{E} = A \frac{\exp(-br)}{r^2} \vec{r}$$

where  $A$  and  $b > 0$  are constants.

- 1) What is the charge density  $\rho(r)$ ? Make a sketch of the function.
- 2) What is the total charge  $Q$ ?

## Electrodynamics Problem 5

A very long, straight conductor with a circular cross section of radius  $R$  carries a current  $I$ . Inside the conductor is a cylindrical hole of radius  $a$  whose axis is parallel to the axis of the conductor but offset a distance  $b$  from the axis of the conductor. The current  $I$  is uniformly distributed across the cross section of the conductor and is directed out of the page. Find the magnetic field everywhere outside the conductor.



## Electrodynamics Problem 6

A thin circular copper ring rotates about an axis which is perpendicular to a uniform magnetic field  $H_0$ . The rotation axis is a diameter of the ring. The rotation of the ring slows down because the rotational energy is dissipated into Joule heating.

(a) Estimate the time  $\tau$  it takes for the angular frequency to decrease to  $1/e$  of its original value. In the calculation assume that the angular frequency varies with time as  $d\omega/dt = -\omega/\tau$ . Assume that the initial angular frequency of rotation,  $\omega_0$ , is much larger than  $1/\tau$ . Assume as well that you can average over times of the order of  $1/\omega_0$ .

Copper has conductivity  $\sigma = 5 \times 10^{17} \text{ s}^{-1}$  (cgs units) and density  $8.9 \text{ gcm}^{-3}$ . Assume that  $H_0$  is 200G and the radius of the ring is 10 cm. Note that  $G^2 = \text{erg/cm}^3$  has the units of an energy density.