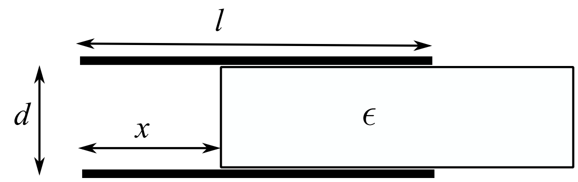
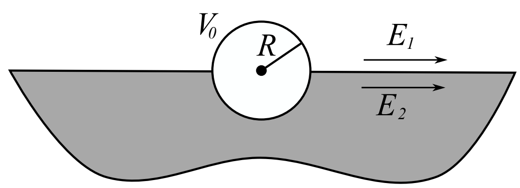
1. **A slab of linear dielectric material is partially inserted between the plates of a parallel plate capacitor whose area is l^2 and the distance between the plates is d. Find the force by which the slab is sucked inside the capacitor while it is charged to a potential V.**



2. **A conducting sphere at potential V_0 is half embedded in linear dielectric material of susceptibility χ_e, which occupies the region $z < 0$. Justify that the potential everywhere is exactly the same as it would have been in the absence of the dielectric.**



3. (a) **The electrostatic energy in a uniform dielectric medium is given as $\frac{\epsilon_0\epsilon_r}{2}\int_\tau |E|^2 d\tau$ whereas in free space it is given as $\frac{\epsilon_0}{2}\int_\tau |E|^2 d\tau$. Since we only account for the contribution to the energy by the free charges in the dielectric, we expect this energy to be lower than the actual electrostatic energy when the energy of the bound charges are also included which will be given by the second expression above. But since $\epsilon_r > 1$ we have**

$$\frac{\epsilon_0\epsilon_r}{2}\int_\tau |E|^2 d\tau \quad > \quad \frac{\epsilon_0}{2}\int_\tau |E|^2 d\tau$$

How do you explain this discrepancy?

(b) **Compare the electrostatic energy of two identical parallel plate capacitors with a charge Q on them. One of the**

capacitors is filled with a dielectric material of relative permitivity ϵ_r, and the other filled with free space.

(c) Compare the electrostatic energy of two identical parallel plate capacitors , both, charged to potential V. One of the capacitors is filled with a dielectric material of relative permitivity ϵ_r, and the other is filled with free space.

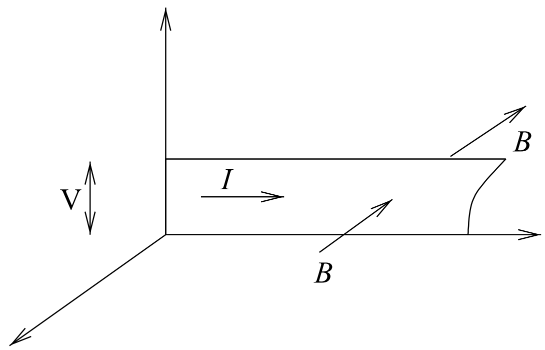
4. For a configuraion of charges and currents confined within a volume $\mathcal{V}$, show that

$$\int_{\mathcal{V}} \vec{\mathbf{J}} d\tau = \frac{d\vec{\mathbf{p}}}{dt}$$

where $\vec{\mathrm{p}}$ is the total dipole moment.

[Hint: Evaluate $\int_{\mathcal{V}} \vec{\nabla} \cdot (x\vec{J}) d\tau$]

5. A current I flows through a long rectangular strip of conductor of width a. The surface electron density on the strip is n. If the strip is placed in a magnetic field B perpendicular to its plane, the moving charges constituting the current experiences a force along the width of the strip.
(a) Calculate this force.
(b) As a result of this force charges get accumulated along the two edges of the strip. This produces an electric force which balances the magnetic force and an equilibrium sets in. This phenomenon is called the Hall effect and the electric potential difference between the two edges is called the Hall voltage. Find the Hall voltage in terms of B, I and the electron charge e. This effect is used in the Gaussmeter which measures the magnetic field.


B
V
I
B