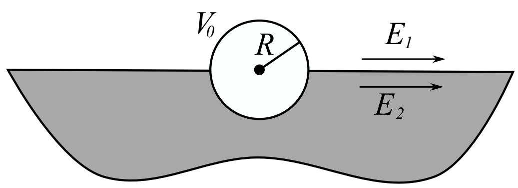
1. **A conducting sphere at potential V_0 is half embedded in linear dielectric material of susceptibility χ_e, which occupies the region $z < 0$. Justify that the potential everywhere is exactly the same as it would have been in the absence of the dielectric.**



2. **Find the magnetic field at point P for each of the steady current configurations shown below**

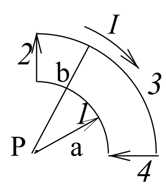


Fig.1

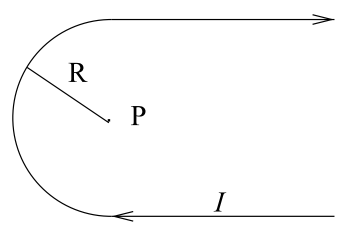


Fig. 2

3. **Two parallel, infinite line charges λ, a distance d apart are moving at a constant velocity $\vec{v}$. The direction of $\vec{v}$ is along the line charges. How great would v have to be in order for the magnetic attraction to balance the electrical repulsion?**

4. **A steady current I flows through a long cylindrical wire of radius a. Find the magnetic field both inside and outside the wire, if**

   (a) **The current is uniformly distributed over the outside surface of the wire.**

   (b) **The current is distributed in such a way that J is proportional to s.**

(c) Find the vector potential in both the cases above.

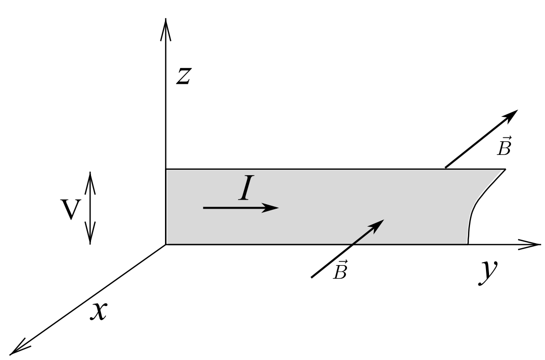
5. For a configuraion of charges and currents confined within a volume $\mathcal{V}$, show that

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

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

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

6. 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.



7. Two very large metal plates are held a distance d apart, one at potential 0, the other at potential V_0. A small metal hemisphere (radius $a << d$) is placed on the grounded plate, so that its

potential is likewise 0. If the region between the plates is filled with weakly conducting material of uniform conductivity σ, what current flows to the hemisphere?
(Generally for good conductors $\sigma \to \infty$ and $\vec{E} \to 0$. But here we consider finite conductivity σ)