Homework 6

Question 1

Consider an Iron sphere of radius R that carries a charge Q and a uniform magnetization $\vec{M} = M\hat{\mathbf{z}}$. The sphere is initially at rest.

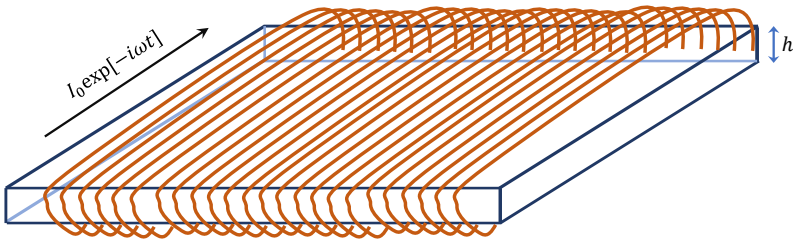
1. Find the electric and magnetic fields.
2. Compute the angular momentum stored in the electromagnetic fields.
3. Suppose the sphere is gradually (and uniformly) demagnetized (perhaps by heating it up). Find the total angular momentum imparted to the sphere in the course of the demagnetization.
4. Suppose instead of demagnetizing the sphere we discharge it, by connecting a grounding wire to the north pole. Assume the current flows over the surface in such a way that the charge density remains uniform. Calculate the angular momentum imparted to the sphere in the course of the discharge. **Hint**: Recall that the Lorentz force on a single charged particle is $\vec{F} = q\vec{E} + q\vec{v} \times \vec{B}$.

Question 2

A long cylinder of linear dielectric material (with radius a and susceptibility χ_e) is placed in an otherwise uniform electric field $\vec{E}_0$ which is **perpendicular** to the axis of the cylinder. Find the resulting field inside the cylinder.

Question 3

A coil in which a current $I_0 \exp(-i\omega t)$ is flowing, is wound around a wide plate which has conductivity σ and magnetic permeability μ. The plate thickness is $2h$, such that it is bounded by the planes $x = \pm h$.



The number of turns of the coil (which are parallel to one another) per unit length is n and the thickness of the coil is very small. Neglecting edge effects and using the quasi-static approximation:

1. Determine the magnitude of the magnetic field inside the plate.

2. Use the result of (1) to determine the behavior of the field in the limiting cases of a strong ($\delta \ll h$) and weak ($\delta \gg h$) skin effect ($\delta = c/\sqrt{2\pi\mu\sigma\omega}$).