PHY 103N: PHYSICS 2, (2007-2008, Semester -II) *(SAR/HW)*

Department of Physics, I.I.T. Kanpur

Assignment - 6 **EMF, Faraday's Law, Induction**

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1. Calculate the typical time the electron would take to traverse around a circuit of copper wire of length 10 m that lights up a 100 W bulb by a DC voltage of about 100 V, given the number density of electrons in copper 8.5×10^{22} per cm^3 and a 2 mm diameter wire. What qualitative difference would arise in the electron motion if the current is AC?

2. A metallic sphere of radius R is moved with a constant velocity $v_o\hat{\imath}$ in an uniform magnetic field $B_o\hat{k}$. Find (a) the electric field inside the sphere,
   (b) the induced charge density (Surface or Bulk) in the sphere,
   (c) the electric dipole moment of the charge distribution and
   (d) the potential difference between $y = \pm R$ of the sphere.

3. A metal ring placed on top of a Solenoid will jump up several feet in the air, the moment you switch on a current, why? What would happen to a similarly placed metal ring, if you switch off the current?

4. A square loop of side a and resistance R lies at a distance d from a long straight wire carrying a current I. If the wire is cut, the current drops to zero. Determine the direction of the current flow in the loop. Also determine the total charge that flows through this loop.
   See the figure on the next page.

5. Two long coaxial cylindrical shells of radii a and b ($b > a$) are placed with their axis along the z - axis. A current I goes through the inner shell in the z-direction and returns through the outer shell (the current is uniformly distributed on the surface). If $I = I_o e^{-t/\tau}$, find the induced electric field everywhere.

6. Two large plates at $z = \pm d/2$ carry slowly varying surface currents $K(t)\hat{\imath}$ and $-K(t)\hat{\imath}$ respectively. Find the induced electric field everywhere.

7. A toroidal coil of 2000 turns with square cross-section is wound over a magnetic ring with inner radius 10 mm, outer radius 15 mm and magnetic susceptibility $\chi_m = 500^\dagger$. A very long straight wire is placed along the axis of the toroid. Find the mutual inductance between the wire and the toroid.
   † Definition of magnetic susceptibility: $\vec{M} = \chi_m \vec{H}$

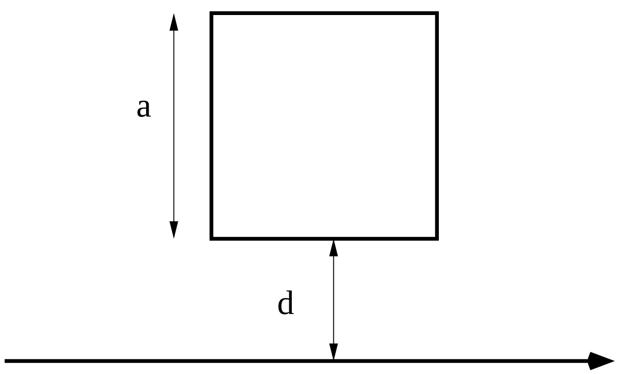

Figure 1: Figure for Problem 4