Department of Physics
IIT Kanpur, Semester II, 2017-18

PHY103A: Physics II | # Homework # 6 | **Instructors: AKJ & SC**

Problem 6.1: Current densities and field in a cylindrical wire (Griffiths 3rd ed., Prob 5.5 & Prob. 5.13)

A steady current I flows down a long cylindrical wire of radius a (see Fig. 1).

(a) Suppose that the current is uniformly distributed over the outside surface of the wire. Find the surface current density K and the magnetic field inside and outside the wire.

(b) Suppose that the current is distributed in such a way that J is proportional to s, the distance from the axis. Find the volume current density J and the magnetic field inside and outside the wire.

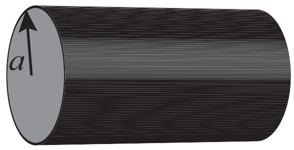

FIG. 1:

Problem 6.2: Consequences of the Continuity Equation (Griffiths 3rd ed., Prob 5.7)

For a configuration of charges with dipole moment $\mathbf{p}$ and currents with volume current density $\mathbf{J}$ within a volume $\mathcal{V}$, show that

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

Problem 6.3: Magnetic field at the center of a polygon (Griffiths 3rd ed., Prob 5.8)

(a) Find the magnetic field at the center of a regular n-sided polygon, carrying a steady current I. Let R be the distance from the center to a side.

(b) Using the limit $n \to \infty$, derive the formula for the magnetic field at the center of a circular loop.

Problem 6.4: Magnetic field due to a finite solenoid (Griffiths 3rd ed., Prob 5.11)

Fine the magnetic field at point P on the axis of a tightly wound solenoid consisting of n turns per unit length and carrying current I (see Fig. 2). Consider the turns to be essentially circular. Express your answer in terms of θ_1 and θ_2 as shown in Fig. 2.

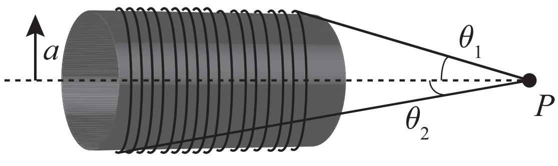

FIG. 2:

Problem 6.5: Magnetic field of a thick slab (Griffiths 3rd ed., Prob 5.14)

A thick slab extending from $z = -a$ to $z = a$ carries a uniform volume current $\mathbf{J} = J\hat{\mathbf{x}}$ as shown in Fig. 3. Find the magnetic field as a function of z, both inside and outside the slab.

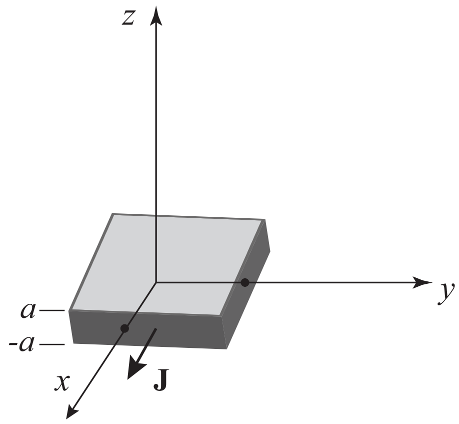

FIG. 3:

Problem 6.6: Helmholtz Coil (Griffiths 3rd ed., Prob 5.46)

Consider the two circular current loops shown in Fig. 4. Each loop has a radius R and carries a current I.

(a) Find the field $B(z)$ as a function of z and show that $\partial B/\partial z = 0$ at the midpoint ($z = 0$).

(b) Determine d such that $\partial^2 B/\partial z^2 = 0$ at the midpoint. What is the magnetic field at the midpoint ($z = 0$) in this case. (This particular arrangement is called the Helmholtz coil and is used to produce uniform magnetic fields.)

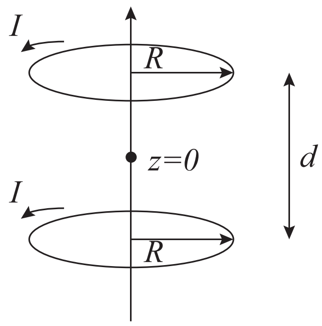

FIG. 4: