PH 102 : Electromagnetism
Tutorial 2
March 17, 2020

Department of Physics
Indian Institute of Technology Guwahati

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1. Two long coaxial solenoids each carry current I, but in opposite directions, as shown in figure 1. The inner solenoid (radius a) has n_1 turns per unit length, and the outer one (radius b) has n_2. Find $\vec{B}$ in each of the three regions: (i) inside the inner solenoid, (ii) between them, and (iii) outside both.

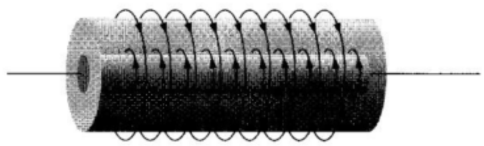
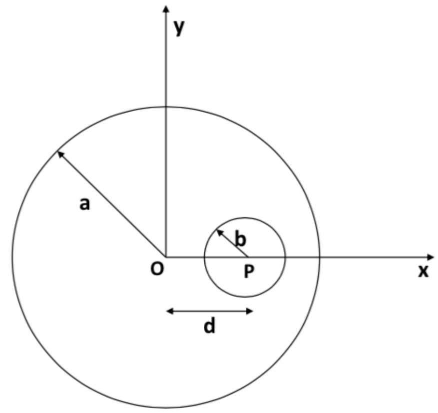


Figure 1: Figure for problem 1.

2. Consider a long current carrying (I) wire of radius R with a volume current density proportional to s^2 and in the $\hat{z}$ direction. Here, s is the distance from the axis of the wire.
(a) Find the proportionality constant.
(b) Find the magnetic field and the vector potential inside ($s < R$) the wire.
(c) Find the vector potential outside ($s > R$) the wire.

3. (a) Consider an infinitely long solid cylindrical wire of radius R. Inside the wire, magnetic vector potential is given by $\vec{A} = A_0 r \sin\phi \hat{z}$, A_0 being a constant.
(i) Find the magnetic field inside the wire.
(ii) Find the volume current density inside the wire.
(iii) Find the net current passing through the wire.
(iv) Find the magnetic field outside the wire.

(b) Consider an infinitely long cylinder of radius a carrying a uniform volume current $J_0\hat{z}$, with z-axis coming out of the plane in figure 2. The wire has an off-axis hole of radius b with centre P at a distance d from the axis of the cylinder, passing through the point O. What is the y component of magnetic field at any point within the hole?



Ampere's method Prfd

Figure 2: Figure for problem 3 (b)

(c) Consider an infinitely long solid cylinder of radius R to be made up of a dielectric material and to be made permanently polarised so that the polarisation is everywhere radially outward, with a magnitude proportional to the distance from the axis of the cylinder $\vec{P} = \frac{1}{2}P_0 r\hat{r}$, P_0 being a constant. If the cylinder is rotated with a constant angular velocity ω about its axis (which coincides with z-axis) without change in P, what is the magnetic field on the axis of the cylinder?

(d) Consider an infinitely long hollow cylinder of radius R carrying uniform surface current $\vec{K} = K\hat{z}$ with z-axis coinciding with the axis of the cylinder. Find out the magnetic field inside the cylinder $\vec{B}_{\text{inside}}$ and outside the cylinder $\vec{B}_{\text{outside}}$.

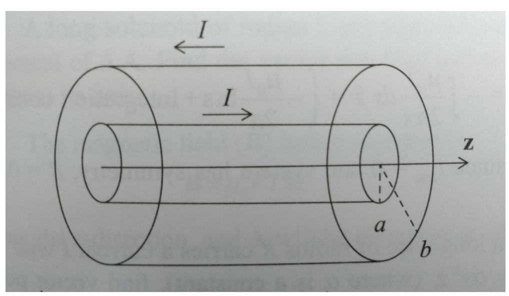


Figure 3: Figure for tutorial problem 4.

4. A long hollow coaxial wire has inner radius a and outer radius b. Uniform current I flows along its inner surface and return through the outer surface as shown in figure 3. Find vector potential at a distance s from its axis.

5. Show that for uniform magnetic field $\vec{B}$, the magnetic vector potential can be written as $\vec{A} = -\frac{1}{2}(\vec{r} \times \vec{B})$. Is this result unique, or are there other functions with the same properties?