

171.301 Introduction to Electromagnetic Theory

HW 8

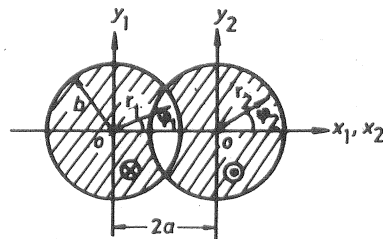
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- 1) A loop of flexible conducting wire of length L lies in a magnetic field of strength B going inwards normal to the plane of the loop. Argue that when a clockwise current is passed through the loop, it opens into a circle. Also, calculate the tension developed in the wire in terms of B , L and I (the clockwise current).
- 2) Using Ampere's circuital law, find the current distribution that produces the following field –

$$\begin{aligned}
 B &= J_0 r^2 \hat{\phi} & 0 < r < a \\
 &\frac{J_0 a^3}{r^2} \hat{\phi} & a < r < b \\
 &0 & b < r < \infty
 \end{aligned}$$

Note: r is the cylindrical radial coordinate.

- 3) A system of conductors has a cross section given by the intersection of two circles of radius b with centers separated by $2a$. The conducting portion is shown shaded, the unshaded lens shaped region being a vacuum. The conductor on the left carries a uniform current density J going into the page, and the other conductor carries a uniform current density J coming out of the page. Assume that the magnetic permeability of the conductor is the same as that of the vacuum. Find the magnetic field at all the points x, y in the vacuum enclosed between the two conductors.



4a) Calculate the magnetic field by first finding the vector magnetic potential at a point due to a long straight wire carrying a steady current I .

b) Find the vector magnetic potential in the region $a < r < b$ for the given volume current density –

$$\begin{aligned}
 J(r, \phi, z) &= 0 & 0 < r < a \\
 &= \frac{J_0 r}{a} \hat{z} & a < r < b \\
 &= 0 & b < r < \infty
 \end{aligned}$$

5) A coaxial cable with inner conductor of radius ‘a’ carries a current $I \hat{z}$ and outer conductor at radius ‘b’ carries a current $-I \hat{z}$. There is no current in the region $a < r < b$. Find the vector magnetic potential at r for $a < r < b$.

Hint: A will have only a z -component which will be a function of r (cylindrical radial coordinate) only. You may need to use Ampere’s Law to get rid of all the constants of integration.

6) Find the torque between two circular loops of wire, carrying the same currents I , and of the same radius R , when they are located at a distance L apart ($L \gg R$). Their axes are parallel and the currents are in the same direction. Express the torque in terms of the angle between their axes and the line joining the centers.

