PHYS 102:General Physics2 KOÇ UNIVERSITY Fall Semester 2016

College of Sciences

Section Quiz 9 December 09, 2016

Closed book. Duration: 10 minutes

Name: Student ID: Signature:

Using Ampere's law, calculate the magnetic field B of a solenoid of length L = 2 cm with N = 20 turns, carrying a current of I = 3 A. (You may take $\pi = 3$.)

Ampere's law $\oint \vec{B} \cdot d\vec{l} = \mu_0 I$

$$\Rightarrow BL = \mu_0 N I$$

$$\Rightarrow B = \frac{\mu_0 N I}{L} = \frac{4\pi \times 10^{-7} \times 20 \times 3}{2 \times 10^{-2}} \approx 3.6 \times 10^{-3} \, T$$

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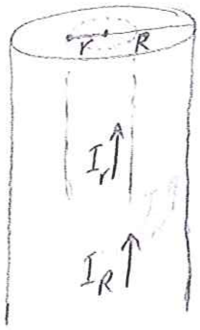
Consider a solid cylinder of radius R = 0.25 m that caries a current of 3 A where the current per unit area (current density J) is constant. Use Ampere's law to calculate the magnetic field of the cylinder at radius r = 0.125 m.

$$I_r = \int \vec{J} \cdot d\vec{A} = J\pi r^2 \longrightarrow J = \frac{I_r}{\pi r^2}$$

$$J = \frac{I_R}{\pi R^2} \Rightarrow I_r = I_R \left(\frac{r}{R}\right)^2$$



Ampere's law $\oint \vec{B} \cdot d\vec{l} = \mu_0 I_r$

$$\Rightarrow B \cdot (2\pi r) = \mu_0 I_r \longrightarrow B = \frac{\mu_0}{2\pi r} I_R \left(\frac{r}{R}\right)^2$$

$$\Rightarrow B = \frac{\mu_0 I_R}{2\pi} \frac{r}{R^2} = \frac{4\pi \times 10^{-7} \times 3 \times 125 \times 10^{-3}}{2\pi \times 0.25 \times 0.25} = 1.6 \times 10^{-6} \text{ T}$$

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Section **Quiz 9** **December 09, 2016**

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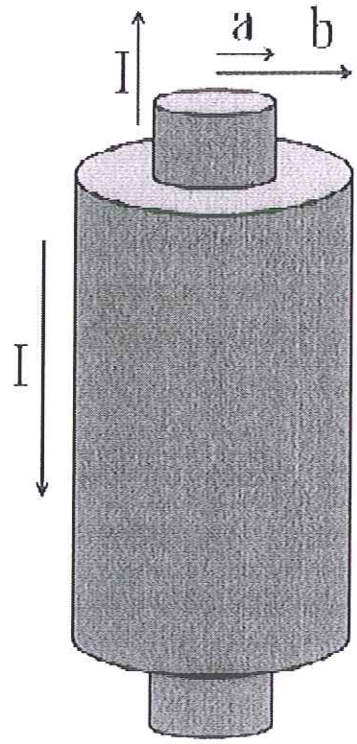
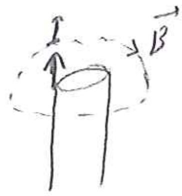
Equal and opposite currents I = 3 A are carried on the surfaces of long concentric thin cylinders of radii a = 0.25 m and b = 0.5 m, as shown in the sketch. Calculate the magnetic field as a function of radius r for (i) r < a, (ii) a < r < b, and (iii) r > b.





$$I_{encl} = \begin{cases} 0 & r<a \\ I & a<r<b \\ 0 & r>b \end{cases}$$

Ampere's law $\oint \vec{B}\cdot d\vec{l} = \mu_0 I_{encl} \Rightarrow BL = B(2\pi r) = \mu_0 I_{encl}$

$$\Rightarrow B = \frac{\mu_0 I_{encl}}{2\pi r} = \frac{(4\pi \times 10^{-7} \times 3)\,m}{2\pi r} = \frac{6\times 10^{-7}\,m}{r}\ T$$

$$\Rightarrow B = \begin{cases} 0 & r<a \\ \frac{6\times 10^{-7}\,m}{r}\ T & a<r<b \\ 0 & r>a \end{cases}$$