B3-1,2,3,4

Sunday, April 7, 2024 10:46 PM

1.) Given a current distribution, I can identify all the sources that contribute to the magnetic field at an arbitrary location

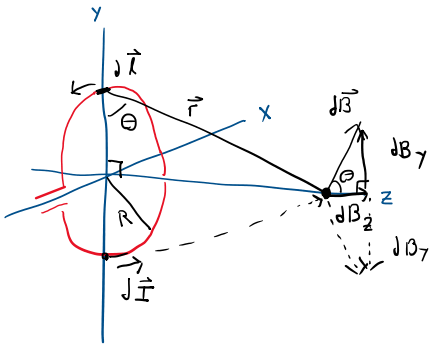
2.) I can estimate the direction and magnitude of the magnetic field due to a segment of current at an arbitrary location

3.) I can numerically calculate the magnetic field due to a segment of current at an arbitrary location

4.) I can identify which sources make the largest contribution to a magnetic field at an arbitrary location and draw an approximate magnetic field map based on this knowledge

1.) Circular loop

$$dB = \frac{\mu_0}{4\pi}\frac{I\,d\vec{l}\times\hat{r}}{r^2}$$



dB_y will cancel with component from opposite side of loop.

$$\vec{l} = \langle R\cos\theta, R\sin\theta, 0\rangle$$

$$\vec{r} = \langle -R\cos\theta, -R\sin\theta, z\rangle$$

$$d\vec{l} = \langle -R\sin\theta\,d\theta, R\cos\theta\,d\theta, 0\rangle$$

Choosing $\theta = \pi/2$

$$\vec{r} = \langle 0, -R, z\rangle \quad r = \sqrt{R^2+z^2}$$

$$d\vec{l} = \langle -R\,d\theta, 0, 0\rangle$$

$$d\vec{l}\times\hat{r} = \langle 0, -Rz\,d\theta, R^2\,d\theta\rangle$$

cancels

$$d\vec{B} = \frac{\mu_0}{4\pi}\frac{I\langle 0, -Rz\,d\theta, R^2\,d\theta\rangle}{(R^2+z^2)^{3/2}}$$

$$\propto I R^2\,d\theta$$

$$dB = \frac{\mu_0}{4\pi}\frac{I R^2 d\theta}{(R^2+z^2)^{3/2}}\hat{z}$$

$$B = \int_0^{2\pi} \frac{\mu_0}{4\pi}\frac{I R^2 d\theta}{(R^2+z^2)^{3/2}}\hat{z} = \frac{\mu_0}{2}\frac{I R^2}{(R^2+z^2)^{3/2}}\hat{z}$$

$$B = \frac{\mu_0}{2}\frac{I R^2}{(R^2+z^2)^{3/2}}$$

$z << R$

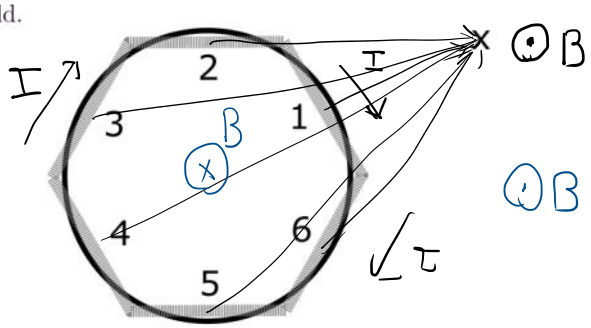
$$B = \frac{\mu_0 I R^2}{2R^3} = \frac{\mu_0 I}{2R}$$

$z >> R$

$$B = \frac{\mu_0 I R^2}{2z^3}$$

2.)

6. (10 points) **Current creates magnetic fields (Biot-Savart)** Current travels clockwise in the loop of wire shown below, and you are interested in the magnetic field at the indicated location. You approximate the loop with six segments. The following questions are one way to get a rough estimate of the direction of the magnetic field.



(a) Rank the magnitude of the magnetic field contributed by each segment from largest to smallest. If some of the segments seem like they might contribute similar-magnitude magnetic fields, indicate that they're similar and briefly explain why.

(b) What is the direction of the magnetic field due to the segment with the largest contribution?

a.)

1 > 2 = 6 > 3 = 5 > 4

b.) The direction of the magnetic field due to segment 1 would be out of the page.

The magnetic field would be out of the page everywhere outside of the loop and into the page everywhere inside the loop.