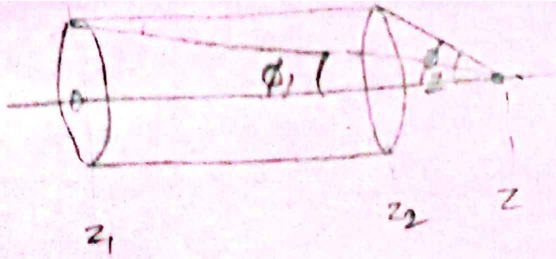


$$B_z = \frac{\mu_0 n I}{2}\left[\cos\phi_1(z) - \cos\phi_2(z)\right]$$

$$\cos\phi_1 = \frac{z}{\sqrt{z^2+R^2}}, \quad \cos\phi_2 = \frac{z-z_2}{\sqrt{(z-z_2)^2+R^2}}$$

$$B_r(r, z) = -\frac{r}{2}\frac{dB_z}{dz}$$

$$\cos\phi_1 = z\,(z^2+R^2)^{-1/2}$$

First

$$\frac{d}{dz}(\cos\phi_1) = z\left(-\frac{1}{\cancel{2}}\right)(z^2+R^2)^{-3/2}\cdot\cancel{2}z + 1\cdot(z^2+R^2)^{-1/2}$$

$$= -\frac{z^2}{z^2+R^2}\frac{1}{\sqrt{z^2+R^2}} + \frac{1}{\sqrt{z^2+R^2}}$$

$$= \frac{1}{\sqrt{z^2+R^2}}\left(1 - \frac{z^2}{z^2+R^2}\right)$$

$$= \frac{1}{\sqrt{z^2+R^2}}\left(\frac{\cancel{z^2}+R^2-\cancel{z^2}}{z^2+R^2}\right)$$

$$\frac{d}{dz}(\cos\phi_1) = \frac{R^2}{(z^2+R^2)^{3/2}}$$

Second

$$(\cos\phi_2(z)) = (z-z_2)\left[(z-z_2)^2+R^2\right]^{-1/2}$$

$$\frac{d}{dz}(\cos\phi_2) = (z-z_2)\left(-\frac{1}{\cancel{2}}\right)\left[(z-z_2)^2+R^2\right]^{-3/2}\cdot\cancel{2}(z-z_2) + \left[(z-z_2)^2+R^2\right]^{-1/2}$$

$$= \frac{1}{\sqrt{(z-z_2)^2+R^2}}\left[1 - \frac{(z-z_2)^2}{(z-z_2)^2+R^2}\right]$$

$$= \frac{1}{\sqrt{(z-z_2)^2+R^2}}\left[\frac{(z-z_2)^2+R^2-(z-z_2)^2}{(z-z_2)^2+R^2}\right]$$

$$\frac{d}{dz}(\cos\phi_2) = \frac{R^2}{\left[(z-z_2)^2+R^2\right]^{3/2}}$$

$$B_r = -\frac{r}{2}\,\frac{\mu_0 n I}{2}\,R^2\left[\frac{1}{(z^2+R^2)^{3/2}} - \frac{1}{[(z-z_2)^2+R^2]^{3/2}}\right]$$

$$= \frac{-\mu_0 n I R^2}{4}\,r\left[\frac{1}{(z^2+R^2)^{3/2}} - \frac{1}{[(z-z_2)^2+R^2]^{3/2}}\right]$$

$$B_x = \frac{-\mu_0 n I R^2}{4}\,x\left[\frac{1}{(z^2+R^2)^{3/2}} - \frac{1}{[(z-z_2)^2+R^2]^{3/2}}\right]\frac{x}{\sqrt{x^2+y^2}}\begin{pmatrix}1\\0\\0\end{pmatrix}$$

$$B_y = \frac{-\mu_0 n I R^2}{4}\,y\left[\frac{1}{(z^2+R^2)^{3/2}} - \frac{1}{[(z-z_2)^2+R^2]^{3/2}}\right]\frac{y}{\sqrt{x^2+y^2}}\begin{pmatrix}0\\1\\0\end{pmatrix}$$

$$B_z = \frac{\mu_0 n I}{2}\quad \frac{z}{\sqrt{z^2+R^2}} - \frac{z-z_2}{\sqrt{(z-z_2)^2+R^2}}$$

Task 1

Define B_func (x, y, z) that spits $B_x, B_y, B_z$ vector.

use

$$B_x = -10^{-3}\left(\frac{0.01}{4}\right)x\left[\frac{1}{(z^2+0.01)^{3/2}} - \frac{1}{[(z-0.2)^2+0.01]^{3/2}}\right]\frac{x}{\sqrt{x^2+y^2}}\begin{pmatrix}1\\0\\0\end{pmatrix}$$

this raises infinite error at $x=y=0$, so has to return zero that case

$$B_y = -10^{-3}\left(\frac{0.01}{4}\right)y\left[\frac{1}{(z^2+0.01)^{3/2}} - \frac{1}{[(z-0.2)^2+0.01]^{3/2}}\right]\frac{y}{\sqrt{x^2+y^2}}\begin{pmatrix}0\\1\\0\end{pmatrix}$$

$$B_z = \frac{10^{-3}}{2}\left[\frac{z}{(z^2+0.01)^{1/2}} - \frac{z-0.2}{[(z-0.2)^2+0.01]^{1/2}}\right]$$