Computer Project 2

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1. We know that the maximum value for ϕ is $2\pi N$ and the maximum value for z is L. Thus we know $k = \frac{L}{2\pi N}$. Spherical coordinates can be converted to Cartesian coordinates in the following way:
$x' = Rcos\phi'$
$y' = Rsin\phi'$
$z' = \frac{L}{2\pi N}\phi'$

2. The Biot Savart Law is: $B(r) = \frac{\mu_0}{4\pi} I \int \frac{dl' \times \hat{\boldsymbol{\imath}}}{\boldsymbol{\imath}^2}$
In our case:
$\vec{dl'} = (-Rsin\phi'\hat{x'} + Rcos\phi'\hat{y'} + \frac{L}{2\pi N}\hat{z'})d\phi'$
$\boldsymbol{\imath} = (x - Rcos\phi')\hat{x} + (-Rsin\phi')\hat{y} + (z - \frac{L}{2\pi N})\hat{z}$
$\hat{\boldsymbol{\imath}} = \frac{(x-Rcos\phi')\hat{x}+(-Rsin\phi')\hat{y}+(z-\frac{L}{2\pi N})\hat{z}}{\sqrt{(x-Rcos\phi')^2+(-Rsin\phi')^2+(z-\frac{L}{2\pi N})^2}}$
$(\vec{dl'} \times \boldsymbol{\imath})\hat{x} = ((Rcos\phi'(z - \frac{L}{2\pi N}) - (z - \frac{L}{2\pi N})(-Rsin\phi'))d\phi'$
$(\vec{dl'} \times \boldsymbol{\imath})\hat{y} = ((z - \frac{L}{2\pi N})(x - Rcos\phi') + Rsin\phi'(z - \frac{L}{2\pi N}))d\phi'$
$(\vec{dl'} \times \boldsymbol{\imath})\hat{z} = (-Rsin\phi'(-Rsin\phi') - Rcos\phi'(x - Rcos\phi'))d\phi'$
Thus:
$B(r)\hat{x} = \frac{\mu_0}{4\pi} I \int \frac{Rcos\phi'(z-\frac{L}{2\pi N})-(\frac{L}{2\pi N})(-Rsin\phi')}{((x-Rcos\phi')^2+(-Rsin\phi')^2+(z-\frac{L}{2\pi N})^2)^{3/2}} d\phi'$
$B(r)\hat{y} = \frac{\mu_0}{4\pi} I \int \frac{(\frac{L}{2\pi N})(x-Rcos\phi')+Rsin\phi'(z-\frac{L}{2\pi N})}{((x-Rcos\phi')^2+(-Rsin\phi')^2+(z-\frac{L}{2\pi N})^2)^{3/2}} d\phi'$
$B(r)\hat{z} = \frac{\mu_0}{4\pi} I \int \frac{-Rsin\phi'(-Rsin\phi')-Rcos\phi'(x-Rcos\phi')}{((x-Rcos\phi')^2+(-Rsin\phi')^2+(z-\frac{L}{2\pi N})^2)^{3/2}} d\phi'$

4. The ideal solenoid has a magnetic field of 1.25663 T. The real solenoid has a magnetic field of 12.5662 T. This is not, as far as I can tell, an error with my code but is rather due to the fact that the solenoid is a real solenoid with finite length.

5. I'm not quite sure how to use the streamline function, as in I'm not quite sure what the best starting locations and zoom settings are.

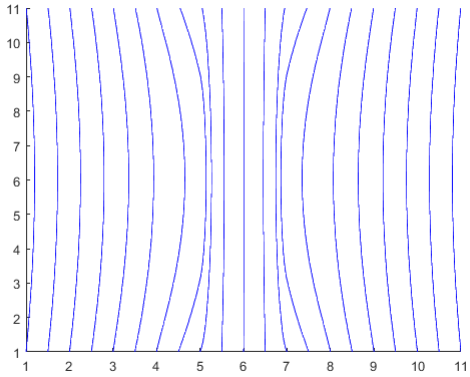

Figure 1: Streamline graph. Axes not to scale, X is horizontal Z is vertical.

6. The numeric answer is 0.3810, but the ideal answer would be 1.2566.

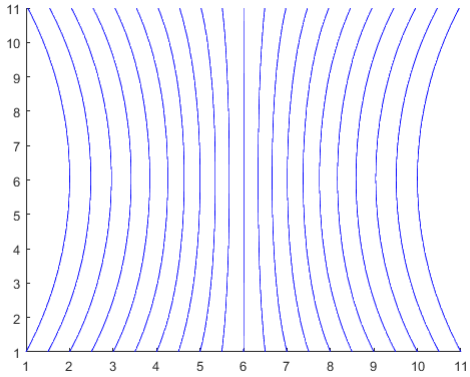

Figure 2: Streamline graph. Axes not to scale, X is horizontal Z is vertical.

7. The numeric answer is 1.3541e-04, but the ideal answer would be 0.0126.

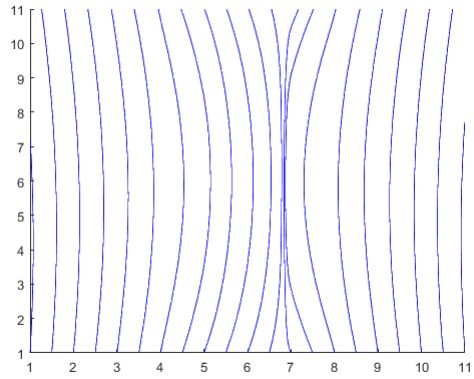

Figure 3: Streamline graph. Axes not to scale, X is horizontal Z is vertical.