EE2703: ENDSEM EXAMINATION

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EE19B033

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1 Introduction:

The problem is to compute and plot the magnetic field B along the z-axis at a distance of 1cm to 1000 cm from the origin (wire). We plot the graphs and fit it the obtained data to $\mod |B| = cz^b$.

2 Pseudo Code:

- Construct a meshgrid (x,y,z) where size along x,y,z-direction are [3,3,1000] using np.linspace and np.meshgrid.
- .Write a function to calculate the direction and magnitude of current and plot Current in the x-y plane. Generate arrows using built-in quiver function.
- Plot the Current Element in the x-y plane using pylab library
- Write a function to calculate the direction and magnitude of current and plot Current in the x-y plane. Generate arrows using built-in quiver function.
- Write a function calc(l) that calculates and returns Rijk = mod rijk minus rl
- Calculate Aijk and Bz. Plot the variation of Bz along the z-axis.
- Using the least square method calculate the best fit for b. The built-in function to calculate least squares is np.linalg.lstsq.

3 Current Vectors:

We now calculate the current at each and every current element.

Code:

```
x=np.linspace(0,2,3)
z=np.arange(0,1000,1)
X,Y,Z=np.meshgrid(x,x,z)

radius=10
N=100
phi=np.linspace(0,2*np.pi,N)

rijk=np.array((X,Y,Z))
rl=np.vstack((radius*np.cos(phi).T,radius*np.sin(phi).T)).T
dl=2*np.pi*radius/N*np.vstack((np.cos(phi).T,np.sin(phi).T)).T
```

```
def c_(x,y):
    return np.array([np.sin(phi),-np.cos(phi)])
i_x,i_y=c_(rl[:,0],rl[:,1])
plt.figure(2)
plt.quiver(rl[:,0],rl[:,1],i_x,i_y,scale=40,headwidth=9,headlength=12,color='red')
plt.xlabel(r'x-axis$\rightarrow$',fontsize=15)
plt.ylabel(r'y-axis$\rightarrow$',fontsize=15)
plt.title('Current In Wire In x-y Plane',fontsize=10)
plt.grid()
plt.show()
```

Plot:

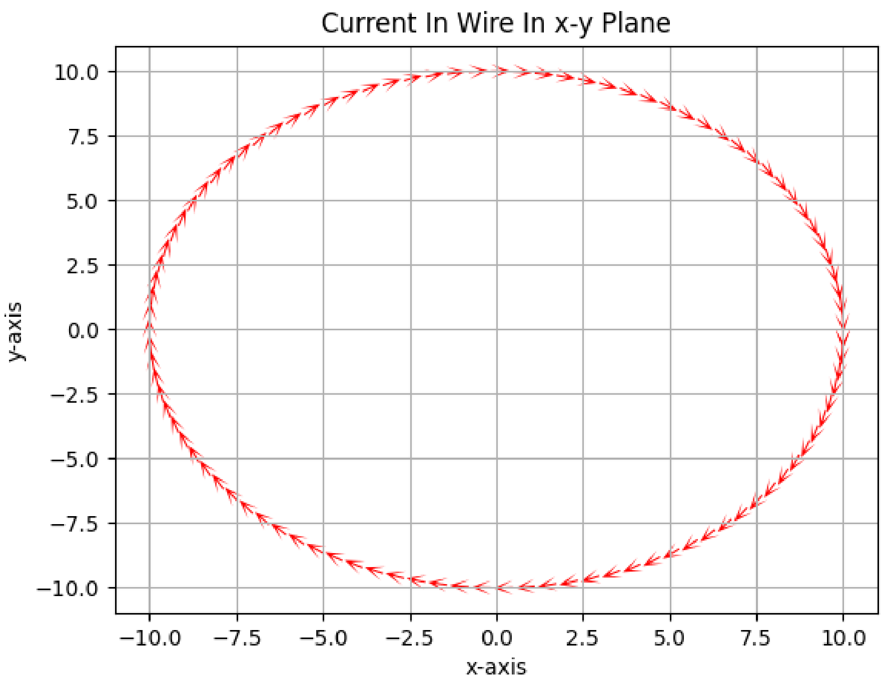

Figure 1: Current Elements In x-y Plane

Results and Discussions:

We observe that the magnitude of current is maximum near the x-axis and minimum near the y-axis

4 Magnetic field:

Code:

```
m1=np.tile(rijk,(100,1,1,1)).reshape((100,3,3,3,1000))
m2=np.hstack((rl,np.zeros((100,1)))).reshape((100,3,1,1,1))

def calc(l):
```

```
    return np.linalg.norm(m1-m2,axis=1)
R=calc(1)
cosA=np.cos(phi).reshape((100,1,1,1))
dl_x=dl[:,0].reshape((100,1,1,1))
dl_y=dl[:,1].reshape((100,1,1,1))
Ax=np.sum(cosA*dl_x*np.exp(1j*R/10)*dl_x/R,axis=0)
Ay=np.sum(cosA*dl_y*np.exp(1j*R/10)*dl_y/R,axis=0)

Bz=(Ay[1,0,:]-Ax[0,1,:]-Ay[-1,0,:]+Ax[0,-1,:])/(4)
plt.figure(3)
plt.loglog(z,np.abs(Bz))
plt.xlabel(r'z-axis$\rightarrow$',fontsize=15)
plt.ylabel(r'B(Magnetic Field)$\rightarrow$',fontsize=15)
plt.title('Magnetic Field Along z Axis',fontsize=15)
plt.grid()
plt.show()
```

Plot:

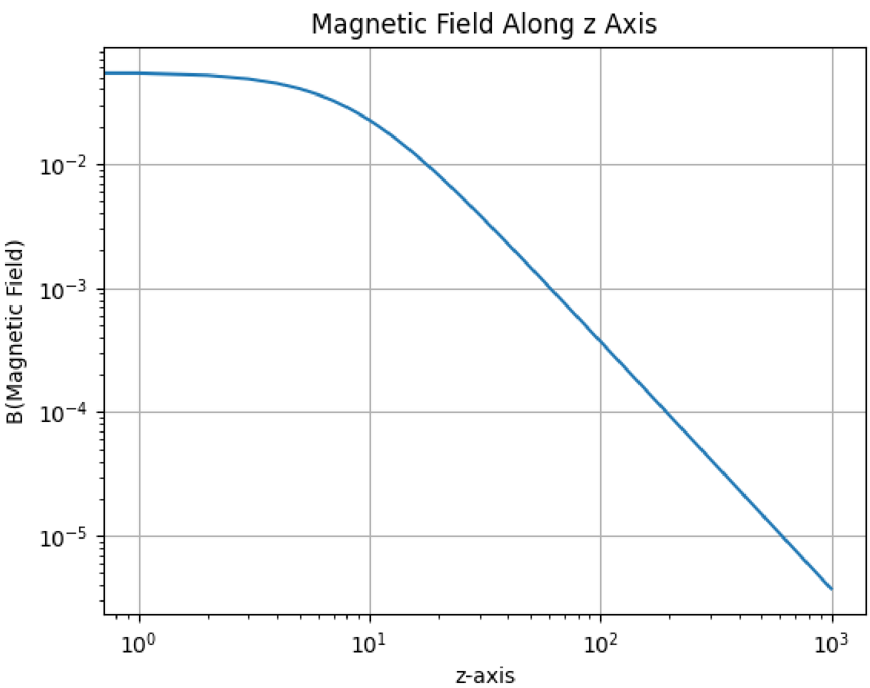

Figure 2: Currents In x-y Plane

Results and Discussions:

From the above figure we can say that the magnetic field decreases nonlinearly initially when we are close to the wire. This decrease slowly becomes linear for larger distances from the wire. This is due to the fact that at smaller distances the effect of z is dominant and this gives rise to the nonlinear behaviour but at larger distances the effect due to z becomes negligible compared to the exponential term giving rise to a linear graph in the log scale.

5 Least Square:

The dependence of magnetic field on z can be calculated using the least square method.

Code:

```
A=np.hstack([np.ones(len(Bz[50:]))[:,np.newaxis],np.log(z[50:])[:,np.newaxis]])
log_c,b=np.linalg.lstsq(A,np.log(np.abs(Bz[50:])),rcond=None) [0]
c=np.exp(log_c)
print("The Value Of b is:",b)
print("The Value Of c is:",c)
```

result:

```
The Value Of b is: -1.9969716983476835
The Value Of c is: 3.6755244843941615
```

Results and Discussions:

We can approximate the magnetic field to be of the form czb where b and c are constants and z is the height or depth of the point at which the magnetic field is being calculated from the wire. b is given by the slope in figure 3. On solving using least squares we get b as -1.9969716983476835 and c as 3.6755244843941615

Conclusion:

We can conclude that in the log scale the magnetic field has a non-linear dependence on z for small values of z. The dependence of magnetic field slowly becomes linear as we increase z. At large values of z, the magnetic field changes linearly with z in the log scale.