Electrical and Computer Engineering
ECE3712 Electromagnetic Fields and Waves

MATLAB Project on Magnetostatics

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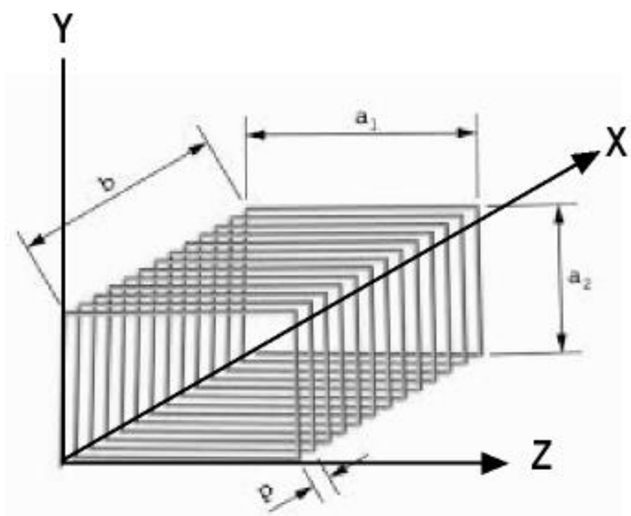
A rectangular solenoid a_1 (Z direction) by a_2 (Y direction) consists of a single layer of N turns over a length b (X direction) or a pitch p = b/N and is in air ($\mu = \mu_o$). The first turn of the rectangular solenoid begins at the origin (0, 0, 0) and is wound in a clockwise direction and carries a DC current I. It can be assumed that the turns are essentially rectangular loops each with a DC current I and the pitch can be ignored.



Using the discrete summation solution in MATLAB of the integral form of the Biot-Savart Law with discrete DC current carrying lengths ΔL, determine the resulting **H** at an arbitrary point P(x,y,z).

$$\mathbf{H} = \int \frac{I\, d\mathbf{L} \times \mathbf{a}_R}{4\pi R^2}$$

$$\mathbf{H} = \sum \frac{I\, \Delta\mathbf{L} \times \mathbf{a}_R}{4\pi R^2}$$

The point P(x,y,z) should be entered as a variable for x, y and z should range from:

$$-2b \leq x \leq 3b \quad -a_1 \leq z \leq 2a_1 \quad -a_2 \leq y \leq 2a_2$$

Out of range entries should be *flagged.* For the lengths a_1 and a_2 use your birth date in cm and birth month in cm with the smaller (or equal) number as a_2 and the larger (or equal) number as a_1. For the distance $b = (a_1 + a_2)/2$. For example, June 16th means $a_2 = 6$ cm, $a_1 = 16$ cm and $b = 11$ cm.

The number of turns N is your birth year minus 1900. If the year is 1995 then N = 95. The current I is the last three digits of your TU ID in mA (hopefully not 000).

You should use a value for ΔL that can approximate the integral formulation for **H** from the discrete summation. To show this you are to compare a ΔL = 0.1 x 0.1 cm (1 x 1 mm) solution to that obtained for 0.01 x 0.01 cm (0.1 x 0.1 mm) and 0.001 x 0.001 cm (10 μm x 10 μm) for the resultant **H**.

Plot you results for the resulting **H** in Cartesian coordinates. Plot the results for **H** for: *1.* x as a variable $-2b \leq x \leq 3b$ and $y = a_2/2$ and $z = a_1/2$ fixed; and *2.* z as a variable $-a_1 \leq z \leq 2a_1$ and $y = a_2/2$ and $x = b/2$.

For these data comment on the uniformity of the resultant **H**.

It may be possible to solve for **H** in closed form using the integral form of the Biot-Savart Law for additional project credit. If so, compare the result for the discrete summation to the integral solution.

Queries and concerns for you project should be directed to the Instructor in a timely manner.

This project is to be written using the *Project Report Format* and hard copy is due no later than 3 PM Monday December 4, 2017 in class. Late submission can be done via email to the Instructor for time and date stamping but with hard copy immediately afterwards. Late submission will result in a grade reduction of one-half a letter grade per day.

This project is an example of a non-cylindrical solenoid.