COSC6364 Project Description

3D Computations – The Dipole Field

Report and Deliverables: COSC6364_Project_Instructions.pdf @ course MS Teams Channel

Maximum number of group members: 1

Project Description:
Computational processes are oten used in calculating the spatial distribution of fields in a variety of fields, in sciences and engineering. The purpose of this project is to perform fundamental computations in 3D assuming a magnetic dipole. The equation for the field generated by a magnetic dipole is:

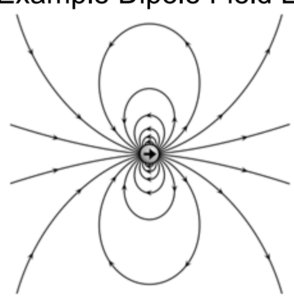
$$\overrightarrow{B} = \nabla \times \vec{A} = \left(\frac{d\overrightarrow{A_z}}{dy} - \frac{d\overrightarrow{A_y}}{dz}\right)\hat{\imath} + \left(\frac{d\overrightarrow{A_x}}{dz} - \frac{d\overrightarrow{A_z}}{dx}\right)\hat{\jmath} + \left(\frac{d\overrightarrow{A_y}}{dx} - \frac{d\overrightarrow{A_x}}{dy}\right)\hat{k},$$

$$\vec{A} = L \cdot \frac{\vec{m} \times \vec{R}}{\left|\vec{R}\right|^3},$$

$$L = \frac{\mu_0}{4\pi} = 9.8696\ \frac{Newton}{Ampere^2}$$

where $\vec{A}$ is the magnetic vector potential, $\hat{\imath}$, $\hat{\jmath}$, and $\hat{k}$ are the x, y, and z basis vectors, L is a physical constant, $\vec{m}$ is the magnetic moment of the dipole, and $\vec{R}$ is the Cartesian vector from the center of the dipole to the measurement location.

Figure 1: Example Dipole Field Lines in 2D



Tasks:
Implement your code, in Matlab, Python or C, to calculate the 3D distribution of the field generated by a point dipole.
Inputs of your code:

1. Point dipole parameters: (i) Location (X_d, Y_d, Z_d) in the 3D Cartesian coordinate system, (ii) Orientation defined with the angle φ measured relative to the X axis in the XY-plane and angle θ measured relative to the Z axis. (iii) Strength with a default value of 1.0
2. 3D Area of Calculation: (i) Location (X_v, Y_v, Z_v); default will be (X_v, Y_v, Z_v) = (X_d, Y_d, Z_d) and (ii) Size defined as X_c, Y_c, Z_c. This means that the area you perform calculations is,. For example in the X axis, from X_v-1/2X_c, X_v+1/2X_c.
3. Resolution of modeling: number of steps per axis N_x, N_y, N_z; this corresponds to N_x N_y N_z points and a step on the X axis of X_c/N_x, Y of Y_c/N_y and Z of Z_c/N_z

Outputs of your code:
The digitized function B that is a tensor containing the magnetic field vectors at each spatial position ($0 \le i < N_x$, $0 \le j < N_y$, $0 \le k < N_z$) within 3D Area. You should also calculate the gradient of the magnitude of B at each point. Report the following values for each point in a .csv file:

i, j, k, X_i, Y_j, Z_k, $B_{x,i}$, $B_{y,j}$, $B_{z,k}$, $B_{magntitude}$, $Gradient_x$, $Gradient_y$, $Gradient_z$

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