Emag Lab-4

Electrical and Magnetic field plotting in Matlab

4(A)

A vector field **A** in two dimensional space is given as $\mathbf{A}(x, y) = 4x^2\mathbf{a}_x + 2xy\mathbf{a}_y$. Find

(1) the unit vectors of **A** at (1, –1) and (–2, 3)

(2) plot A_x versus x for x from –1 to 1 using MATLAB

(3) plot A_y versus x and y for $-1 \le x \le 1$ and $-1 \le y \le 1$ using MATLAB function *surf*

(4) plot **A** using MATLAB function *quiver* for $-1 \le x \le 1$ and $-1 \le y \le 1$

We can use MATLAB symbolic operations to express a vector field. The symbolic operation is easy for students to understand and the student version of MATLAB has the symbolic toolbox. Firstly, we define *x*, *y* and *z* as symbolic variables using MATLAB command syms as

```
syms x y
```

And then we can write down vector field **A** as

A = [4*x^2, 2*x*y]

For the values of A at specific points, we can use MATLAB command subs to obtain.

```
A_point1 = subs(A,{x,y},{1,-1})
A_point2 = subs(A,{x,y},{-2,3})
```

And the unit vectors can be obtained as

```
a_A1 = A_point1/norm(A_point1)
a_A2 = A_point2/norm(A_point2)
```

(2) We can get the x component of A from

```
Ax = A(1);
```

To plot Ax using MATLAB function *plot* for *x* from –1 to 1, we need to calculate numerical values of Ax as follows

```
xx = –1:0.1:1;
Axx = subs(Ax,{x},{xx});
```

And then, we can simply plot as follows

```
plot(xx,Axx);
```

(3) We can get Ay from

```
Ay = A(2) ;
```

To plot using surf, we need to build a mesh using MATLAB function meshgrid.

```
[X, Y] = meshgrid(-1:0.1:1, -1:0.1;1)
```

And then, we calculate numerical values of Ay on this mesh using subs

```
Ay_num = subs (Ay, {x,y},{X,Y})
```

After that, we can plot Ay using 3D MATLAB plot function *surf*

```
surf(X,Y,Ay_num)
```

We can also calculate Ax on the mesh although it only depends on *x*. That is,

Ax_num = subs (Ax, {x,y},{X,Y})

And then, the vector field **A**(x,y) can be plotted using *quiver*.

quiver(X,Y,Ax_num,Ay_num)

In quiver plot, the magnitude and direction of the vector field at any point are

indicated by the length and orientation of the arrows. In all the figures plotted,

we can add labels for all the axes and title for each figure.

4(B)

- Plot vector magnetic field Intensity in Cartesian co-ordinates on xy plane caused by a current filament of 1 A in the z direction and extending from z=-1 to 1.

```
syms x y z_prime real
syms a I PI mu0 positive
a_z = [0 0 1];
r = [x y 0];
r_prime = [0 0 z_prime];
R = r-r_prime;
norm_R = sqrt(R(1)^2+R(2)^2+R(3)^2);
a_R = R/norm_R;
dH = cross(a_z,a_R)/norm_R^2

disp('Magnetic field Intensity in Cartesian system')
HH = int(dH,z_prime); I = 1;

H = (subs(HH,z_prime,1) - subs(HH,z_prime,-1))*I/4/pi
ezsurf(H);
```

Assignment

- Find the vector magnetic field intensity in cartesian co-ordinates at P(1.5,2,3) caused by current filament of 24A in the az direction on the z axis and extending from: z=0 to z=6.

- Ans: -0.939ax + 0.704 ay A/m