Physics 115: Contemporary Physics III

Spring 2013

Programming Assignment 1

Due April 17, 2013

Drawing Magnetic Field Lines

The Biot-Savart law is for constant current is:

$$\mathbf{B} = \frac{\mu_0 I}{4\pi} \int \frac{d\mathbf{l} \times \hat{\mathbf{r}}}{r^2},$$

where the vector $\mathbf{r}$ runs from a point on the loop to the field point. In general this is an integral, for every field point, around the loop of current. Set

$$\frac{\mu_0 I}{4\pi} = 1$$

for these problems.

(a) In the case of a wire running perpendicular to a plane, the lines of constant magnetic field will curl around the wire according to the right-hand rule (i.e. they will have no component out of the plane). Start by creating a grid of points on the intervals $-1 \leq x \leq 1, -1 \leq y \leq 1$. with spacing $\Delta x = \Delta y = 0.1$. For each point on the grid, calculate the magnetic field using the Biot-Savart law. Save its components in arrays `Bx` and `By`. You can then plot these vector field lines with:

```
from pylab import *
quiver(x, y, Bx, By, scale=150)
show()
```

If the wire is coming out of the xy-plane, then $d\mathbf{l} = (0, 0, 1)$. You do not need to consider the other sections of the wire because they do not contribute to the magnetic field (why?). Plot the magnetic field for the following configurations:

1. A single wire coming out of the page at the origin.

2. Two wires separated by a distance of 1, with parallel currents.

3. Two wires separated by a distance of 1, with anti-parallel currents.

Look at the magnetic field lines from far away (or equivalently, when the wires are close together). What do they field lines look like when the currents are parallel? Anti-parallel?

(b) Now consider a square loop consisting of four segments of unit length lying in the x-y plane. The center of the square is at the origin of coordinates. Calculate and draw (in three dimensions, for $r = \sqrt{x^2 + y^2 + z^2} < 5$) the magnetic field lines passing through the following points in the x-y plane with $x = 0, \pm 0.5$, $y = 0, \pm 0.5$.