PHYS 115

Contemporary Physics - Spring '07

Rec. Assignment #4

Torque on a loop

The torque on a ring of steady current in a magnetic field is:

$$\vec{\tau} = \vec{\mu} \times \vec{B} \tag{1}$$

Where the magnetic moment $\vec{\mu} = IA$ with I as the current and A as the area of the loop. For convenience lets have the magnitude of $|\vec{\mu}| = 1$.

Draw a ring with a radius of .5 centered at the origin. Also draw an arrow representing $\vec{\mu}$ centered at the origin. Both of these figures will have $\vec{\mu}$ as their axis. For a refresher on drawing shapes in VPython, there is a link in the sidebar.

To make matters simple, there will only be a magnetic field that lies in the plane of $\vec{\mu}$, namely $\vec{B} =< 0, 1, 0 >$ As a consequence of this, we can drop the vector quantities and only take the only non-zero component (the one in the $\hat{z}$ direction):

$$\tau = (\vec{\mu} \times \vec{B})_z \tag{2}$$

A long time ago (ie, at the beginning of this year) you learned that rotational motion could be described as:

$$\sum \tau = I\alpha \tag{3}$$

Where 'I' is the moment of inertia of the system (we will set this to unity as well).

A naive implementation of motion in the magnetic field (and one that will be sufficient for our purposes is):

$$\theta(t + \Delta t) = \theta(t) + \omega(t)\Delta t \tag{4}$$

$$\omega(t + \Delta t) = \omega(t) + \alpha(t)\Delta t \tag{5}$$

These equations should look familiar.

Set as initial conditions, $\vec{\mu} = 1/\sqrt{2} < 1, 1, 0 >$, $\omega = 0$. You can use the polar coordinate transform to change r,theta coordinates into x,y. When r = 1, they have a particularly simple form:

$$x = \cos\theta \tag{6}$$

$$y = \sin\theta \tag{7}$$

Let your simulation run for at least 20 seconds (simulation time, not real time), with a time step $\Delta t = .01$.

Mandatory questions:

Describe what you see. That is, try to relate the motion to another system you've seen before. Calculate the frequency of the motion by hand (or if you are feeling particularly adventurous, see if you can let the computer do it for you and display it as an output).