Topics: Magnetic Fields: Force and Torque on a Current Loop
Related Reading:

Course Notes (Liao et al.)	Sections 8.3 – 8.4; 9.1 – 9.2
Serway and Jewett:	Sections 29.2 – 29.3; 30.1 – 30.2
Giancoli:	Sections 27.3 – 27.5; 28.1 – 28.3

Topic Introduction

In today's class we calculate the force and torque on a rectangular loop of wire. We then make a fundamental insight (that hopefully you had during the lab a couple of days ago) that a loop of current looks an awful lot like a magnetic dipole. We define the magnetic dipole moment μ and then do a calculation using that moment.

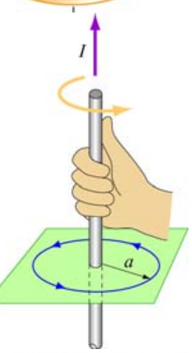
Lorenz Force on Currents

A piece of current carrying wire placed in a magnetic field will feel a force: $d\vec{\mathbf{F}} = Id\vec{\mathbf{s}}\times\vec{\mathbf{B}}$ (where **ds** is a small segment of wire carrying a current I). We can integrate this force along the length of any wire to determine the total force on that wire.

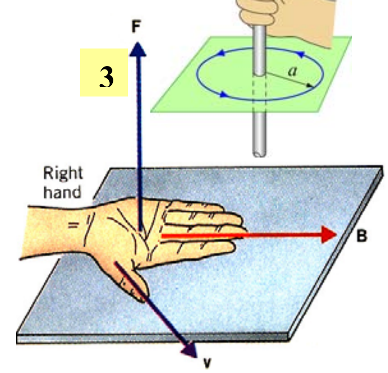
Right Hand Rules

Recall that there are three types of calculations we do that involve cross-products when working with magnetic fields: (1) the creation of a magnetic moment μ, (2) the creation of a magnetic field from a segment of wire (Biot-Savart) and (3) the force on a moving charge (or segment of current carrying wire). The directions of each of these can be determined using a right hand rule. I reproduce the three that I like here:

1) For determining the direction of the dipole moment of a coil of wire: wrap your fingers in the direction of current. Your thumb points in the direction of the North pole of the dipole (in the direction of the dipole moment μ of the coil).



2) For determining the direction of the magnetic field generated by a current: fields wrap around currents the same direction that your fingers wrap around your thumb. At any point the field points tangent to the circle your fingers will make as you twist your hand keeping your thumb along the current.



3) For determining the direction of the force of a field on a moving charge or current: open your hand perfectly flat. Put your thumb along v (or I for a current carrying wire) and your fingers along B. Your palm points along the direction of the force.

Torque Vector

I'll tack on one more right hand rule for those of you who don't remember what the direction of a torque τ means. If you put your thumb in the direction of the torque vector, the object being torque will want to rotate the direction your fingers wrap around your thumb (very similar to RHR #2 above).

Important Equations

Force on Current-Carrying Wire Segment: $d\vec{\mathbf{F}} = I d\vec{\mathbf{s}} \times \vec{\mathbf{B}}$

Magnetic Moment of Current Carrying Wire: $\vec{\boldsymbol{\mu}} = I\vec{\mathbf{A}}$ (direction for RHR #1 above)

Torque on Magnetic Moment: $\vec{\boldsymbol{\tau}} = \vec{\boldsymbol{\mu}} \times \vec{\mathbf{B}}$