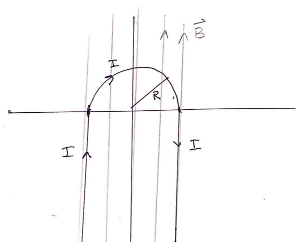
10/16–Tutorial: Current and Magnetic Fields

In class, I showed that $\vec{F} = Q\vec{v} \times \vec{B}$ becomes

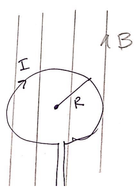
$$\vec{F} = \int I d\vec{\ell} \times \vec{B}$$

when there is a steady current.

1. Do Griffiths problem 5.4
2. A semi-circle of radius R is made of wire and carries a current I in the up-then-clockwise-then-down direction as shown. A magnetic field $\vec{B} = B\hat{z}$ (up) is in the same region. Find the net force on the wire.



3. Imagine now that a circle of wire carrying current I in the clockwise direction is in the same field as above. What is the net force on the circular wire?



Next, we defined volume current density, $\vec{J}$, such that

$$\vec{I} = \int \vec{J} da_\perp \quad \hookrightarrow \quad \vec{J} \equiv \frac{d\vec{I}}{da_\perp}$$

And similarly, a surface current density, $\vec{K}$, such that

$$\vec{I} = \int \vec{K} d\ell_\perp \quad \hookrightarrow \quad \vec{K} \equiv \frac{d\vec{I}}{d\ell_\perp}$$

4. A long straight wire of radius R carries a current I uniformly distributed throughout the volume. (Uniformly distributed means J is constant.) Show that integrating J over a wire of radius R gives I if

$$J = \frac{I}{\pi R^2}$$

5. Do Griffiths problem 5.5