$$B_{\text{loop}} = \frac{\mu_0}{2}\frac{IR^2}{(z^2+R^2)^{3/2}} \qquad B_{\text{dipole}} = \frac{\mu_0}{2}\frac{IR^2}{(z^2+R^2)^{3/2}} \approx \frac{\mu_0}{4\pi}\frac{2(\pi R^2)I}{z^3} = \frac{\mu_0}{4\pi}\frac{2AI}{z^3},$$

$\oint \vec{B}\cdot d\vec{s} = \mu_0 I_{\text{through}}$. η = charge density $\vec{F} = q\vec{v}\times\vec{B},$

(b) Cyclotron Motion

A charged particle moving in a magnetic field (but not parallel to the field) experiences a force that is perpendicular to the direction of motion and perpendicular to the field.

For a charge moving perpendicular to the field, the force provides centripetal acceleration and circular motion will result. Consider a charge q with speed v moving perpendicular to a magnetic field of strength B. The force on the charge is

$$F = qvB = ma_r = \frac{mv^2}{r} \quad \rightarrow \quad r_{\text{cyc}} = \frac{mv}{qB}$$

where m is the mass of the charge and r_{cyc} is the radius of the motion. Since the frequency of revolution is $f = v/2\pi r$, the cyclotron frequency is

$$f_{\text{cyc}} = \frac{qB}{2\pi m}$$

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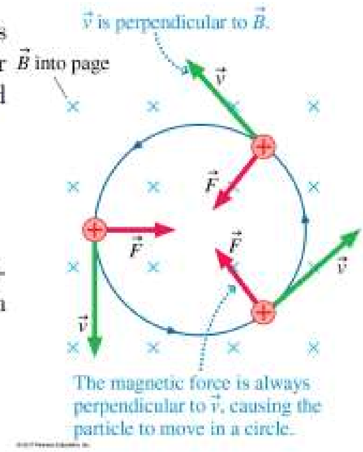

$$I = \frac{q}{\Delta t} \quad \rightarrow \quad q = I\Delta t = I\frac{l}{v} \quad \rightarrow \quad qv = Il$$

where Δt is the time required for the charge to flow through a segment of length l, and v is the speed of the charge. The force on a straight segment of wire carrying current I in direction $\vec{l}$ within a uniform magnetic field $\vec{B}$ can then be written

$$\vec{F}_{\text{wire}} = I\vec{l}\times\vec{B}. \qquad (3.2)$$