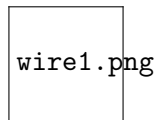


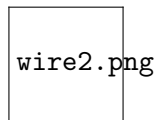
17 Ampere's Law

$$\begin{array}{llll}
 \text{Wire:} & d\vec{F} = I d\vec{l} \times \vec{B} & \tau = N_{\text{loops}} I A \hat{n} \times \vec{B} & \vec{\mu} = I A \hat{n} \\
 \text{Dipole:} & \vec{\tau} = \vec{\mu} \times \vec{B} & U = -\vec{\mu} \cdot \vec{B} & F_z = -\frac{dU}{dz} = \mu_z \frac{dB}{dz}
 \end{array}$$

1. (RHK Exercise 32.32) A metal wire of mass m slides without friction on two horizontal rails spaced a distance c apart, as shown below. The track lies in a vertical uniform magnetic field \vec{B} . A constant current I flows from the generator along one rail, across the wire, and back down the other rail. Find the velocity of the wire as a function of time, assuming it to be at rest at $t = 0$.



2. (RHK Problem 32.18) The figure below shows a wire ring of radius a at right angles to the general direction of a radially symmetric diverging magnetic field. The magnetic field at the ring is everywhere of the same magnitude B , and its direction at the ring is everywhere at an angle θ with a normal to the plane of the ring. Find the magnitude and direction of the force the field exerts on the ring if the ring carries a current I as shown. (The twisted wire leads have no effect on this problem.)



3. (RHK Exercise 35.11) A charge q is uniformly distributed around a thin ring of radius r . The ring is rotating about an axis through its center and perpendicular to its plane at angular frequency ω . (a) Show that the magnetic moment due to the rotating charge is $\mu = (1/2)q\omega r^2$. (b) If L is the angular momentum of the ring, show that $\mu/L = q/2m$.

4. (RHK Problem 35.1) A thin, plastic disk of radius R has a charge q uniformly distributed over its surface. If the disk rotates at an angular frequency ω about its axis, show that magnetic dipole moment of the disk is

$$\mu = \frac{\omega q R^2}{2} \tag{17.1}$$

5. A circular loop of wire with radius r and mass m is centered on the z -axis. A current I flows counterclockwise through the wire. An external, *non-uniform* magnetic field $\vec{B} = B_0 z^2 \hat{z}$ is applied. (a) What is the magnetic moment of the loop? (b) What is the potential energy of the loop, as a function of its height along the z -axis? (c) What is the corresponding force on the loop? (d) If the loop initially is stationary at height h_0 , find its height $h(t)$ as a function of time.