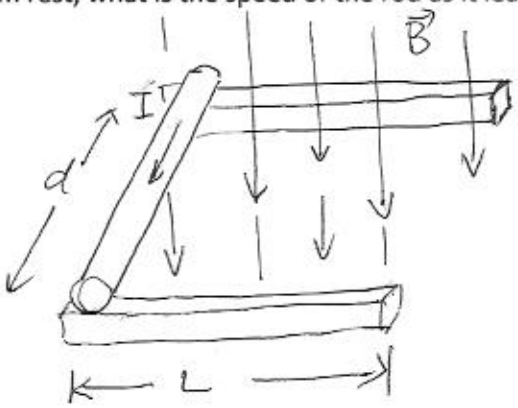
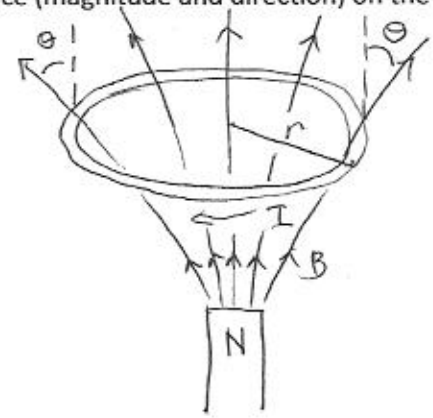
Homework Set 6 – Magnetic Force

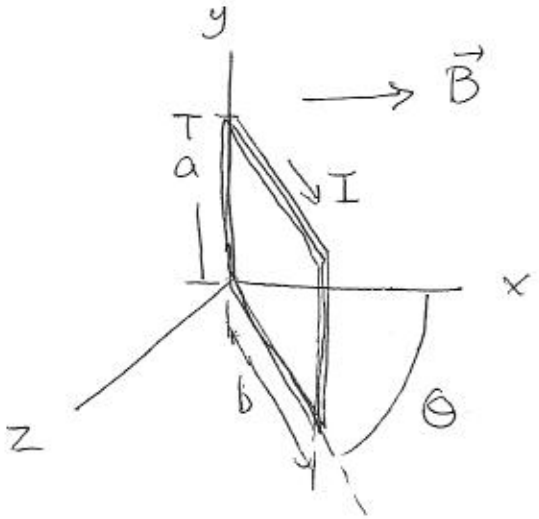
1. A rod of mass *m* and radius *r* rests on two parallel rails that are a distance *d* apart and of length *L*. The rod carries a current of $I$ in the direction shown and rolls along the rails without slipping. A uniform magnetic field *B* is directed perpendicular to the rod and the rails. If it starts from rest, what is the speed of the rod as it leaves the rails?




2. A strong magnet is placed under a horizontal conducting ring of radius *r* that carries current $I$ as shown in the figure. If the magnetic field *B* makes and angle θ with the vertical at the ring's location, what is the force (magnitude and direction) on the ring?



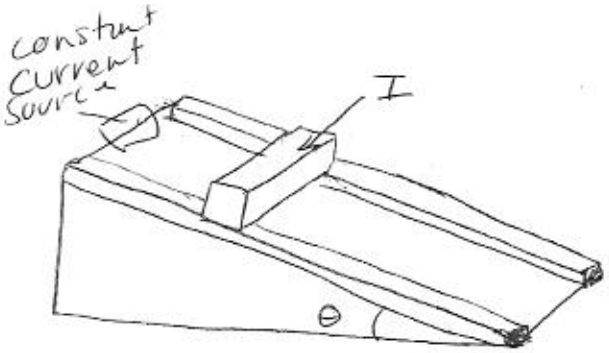

3. A rectangular coil of *N* turns has dimensions *a* and *b* as shown. The coil is hinged along the *y* axis, and its plane makes an angle θ with the *x*-axis. If the current in the wire is $I$ in the direction indicated and the magnetic field is given by $\boldsymbol{B} = B_o\boldsymbol{i\text{-}hat}$, find the torque exerted on the coil.



4. A rigid, circular loop of radius $R$ and mass $m$ lies in the $xy$ plane on a rough, flat table. The magnetic field is $\boldsymbol{B} = B_x\boldsymbol{i} + B_y\boldsymbol{j}$. How large must the current $I$ be before one edge of the loop will lift off the table?

5. A particle of mass $m$ and charge $q$ enters a region where there is a uniform magnetic field $B$ along the x axis. The initial velocity of the particle is $\boldsymbol{v} = v_{ox}\boldsymbol{i} + v_{oy}\boldsymbol{j}$, so that the particle moves in a helix. Show that the radius of the helix is $r = mv_{oy}/qB$. Show that the particle takes a time $t = 2\pi m/qB$ to make one orbit around the helix.

6. A metal crossbar of mass $M$ rides on a pair of long, frictionless conducting rails which make an angle $\theta$ with the horizontal and are separated by a distance $L$. The rails are connected to a device that supplies constant current $I$ to the circuit as shown. (a) What vertical magnetic field $B$ is need to keep the bar from sliding down the rails? (b) If the magnetic field $B$ is twice the value found in part a, what is the acceleration of the bar?




7. A circular loop of wire with mass $M$ carries a current $I$ in a uniform magnetic field. It is initially in equilibrium with its magnetic moment vector aligned with the magnetic field. The loop is given a small twist about a diameter and then released. What is the period of the motion? (Assume the only torque exerted on the loop is due to the magnetic field.)

8. A nonconducting disk of mass $M$ and radius $R$ has a surface charge density $\sigma$ and rotates with angular velocity $\omega$ about its axis. (a) Consider a ring of radius $r$ and thickness $dr$. Show that the total current in the is ring is $dI = (\omega/2\pi)dq = \omega\sigma r\,dr$. (b) Show that the magnetic moment of the ring is $dm = \pi\omega\sigma r^3\,dr$. (c) Integrate your result for part (b) to show that the total magnetic moment of the disk is $m = \frac{1}{4}\pi\omega\sigma R^4$ (d) Show that the magnetic moment $\mathbf{m}$ and angular momentum $\boldsymbol{L}$ are related by $\boldsymbol{m} = (Q/2M)\boldsymbol{L}$ where $Q$ is the total charge on the disk.