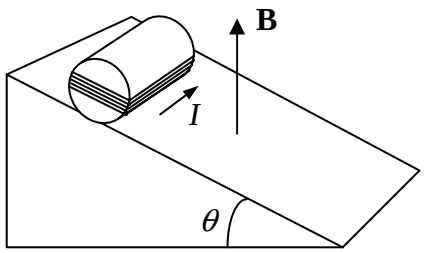
Physics 1215
Group Problem

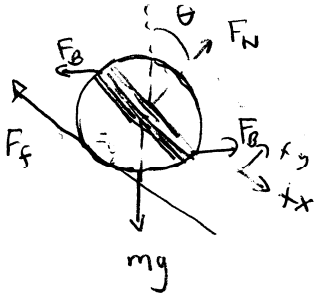
In the last two days we have introduced a new force: the magnetic force that affects current-carrying wires and moving charged particles. The following two problems use skills that are necessary to solve problems involving this force. You may only have time to solve the first one. If you have time, the second one can be solved for extra credit.

1. A wooden cylinder has a mass of 0.250 kg and length 0.100 m, with 10 turns of wire wrapped around it longitudinally, so that the plane of the wire coil contains the axis of the cylinder. What is the least current, I through the coil that will prevent the cylinder from rolling down an inclined plane at an angle of θ to the horizontal, in the presence of a vertical, uniform magnetic field of 0.500 T, if the plane of the windings is parallel to the inclined plane. (Hint: consider the sum of the torques around the center of mass of the cylinder. Don't forget static friction.)



2. A long rigid conductor, lying along the x axis carries a current of 5.0 A in the negative direction. A magnetic field **B** is present, given by $\mathbf{B} = 2.0\mathbf{i} + 8.0x^2\mathbf{j}$, with x in meters and **B** in milliteslas. Calculate the force on the 2.0 m segment of the conductor that lies between x=1.0 and x=3.0 m. (Hint: consider the force $d\mathbf{F} = I\, d\mathbf{L}\times\mathbf{B}$ and integrate.)

GROUP PROBLEM

1) 

$\vec{\tau}_B = \vec{\mu} \times \vec{B} = NI\vec{A} \times \vec{B}$

$\Sigma F_x = 0 \Rightarrow F_f = mg \sin\theta$

Around c.m

$\Sigma \tau = 0$

$\tau_B + \tau_f = 0$

$NI\vec{A} \times \vec{B} + F_f R = 0$ R = radius

$NI\ 2RL\ B \sin\theta + mg \sin\theta\ R = 0$

$$I = \frac{mg}{2NLB} = \frac{(0.250\ kg)(9.8\ m/s^2)}{2(10)(0.100m)(0.500T)} = \boxed{2.45\ A}$$

2) $dF = \int_1^3 I\, d\vec{L} \times \vec{B}$ $\vec{L} = -x\hat{i}$ $d\vec{L} = -dx\hat{i}$

$= I\int_1^3 (-dx\hat{i}) \times (2.0\hat{i} + 8.0x^2\hat{j})$

$= I\int_1^3 -8.0x^2\, dx\ \hat{k}$

$= -I\ \frac{x^3}{3}\ 8.0\Big]_1^3 \hat{k} = -8.0I\left[\frac{27}{3} - \frac{1}{3}\right]\hat{k}$

$= (-8.0)(5.0A)\left(\frac{26}{3}\right)\hat{k} \times 10^{-3}\ T/mT$

$= \boxed{-.347\ N\ \hat{k}}$