University Physics II

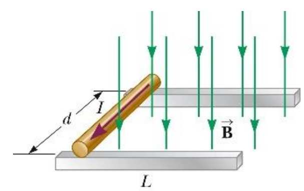
Homework Set 8

1. A conductor carrying a current I = 15.0 A is directed along the positive x axis and perpendicular to a uniform magnetic field. A magnetic force per unit length of 0.120 N/m acts on the conductor in the negative y direction. Determine the magnetic field $\vec{\mathbf{B}}$ in the region through which the current passes.

2. A wire carries a steady current of 2.40 A. A straight section of the wire is 0.750 m long and lies along the x axis within a uniform magnetic field $\vec{\mathbf{B}} = 1.60\ \hat{\mathbf{z}}$ T. If the current is in the positive x direction, what is the magnetic force $\vec{\mathbf{F}}_{\mathbf{B}}$ on the section of wire?

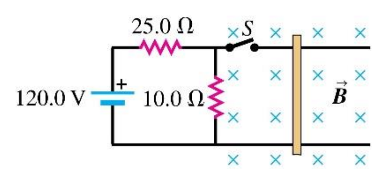
3. A wire 2.80 m in length carries a current of 5.00 A in a region where the uniform magnetic field has a magnitude of 0.390 T. Calculate the magnitude of the magnetic force on the wire assuming the angle between the magnetic field and the current is:
   a. 60°
   b. 90°
   c. 120°

4. A rod of mass 0.720 kg and radius 6.00 cm rests on two parallel rails as shown in the figure at right. The rails are a distance d = 12.0 cm apart and L = 45.0 cm long. The rod carries a current of I = 48.0 A in the direction shown and rolls along the rails without slipping. A uniform magnetic field of magnitude 0.240 T 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?

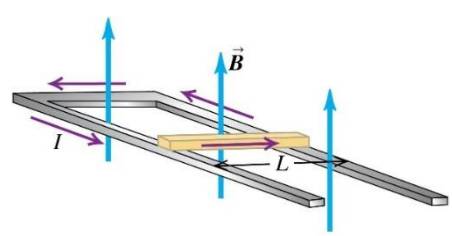


Hint: Use the work energy relation and be sure to include the rotational kinetic energy of the rod

5. A 2.60 N metal bar, 0.850 m long and having a resistance of 10.0 Ω, rests horizontally on conducting wires connecting it to the circuit shown at right. The bar is in a uniform, horizontal, 1.60 T magnetic field and is not attached to the wires in the circuit. What is the magnitude and direction of the acceleration of the bar just after the switch S is closed?



6. **An **electromagnetic rail gun** is constructed used a conducting bar with mass m and length L that slides over horizontal rails that are connected to a voltage source. The voltage source maintains a constant current I in the rails and bar. A constant, uniform, vertical magnetic field $\vec{\mathbf{B}}$ fills the region between the rails as shown in the figure at right.

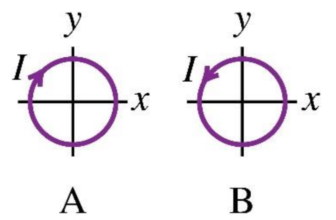


   a. Find an expression for the magnitude of the magnetic force on the conducting bar. (*We will ignore friction, air resistance, and electrical resistance*)

   b. Building on the result from part (a), if the bar has mass m and starts from rest, find an expression for the distance d that the bar must travel along the rails to attain speed v.

   c. It has been suggested that rail guns based on this principle could accelerate payloads into earth orbit or beyond. Use the expression found in part (b) to find the distance (*in km*) the bar must travel along the rails if it is to reach a speed equal to the escape velocity for the earth (11.2 km/s). Let B = 0.80 T, I = 2000 A, m = 25 kg and L = 50 cm. Does this seem practical as a launch method? Explain.

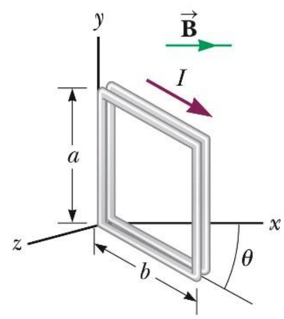
7. **Both circular coils A and B shown at right have an area A and N turns. They are free to rotate about the x axis. Current I circulates in each coil in the direction shown. There is a uniform magnetic field $\vec{\mathbf{B}}$ in the $+z$ direction (*out of the page*).



   a. What is the direction of the magnetic moment $\vec{\boldsymbol{\mu}}$ for each coil?
   b. What is the torque on each coil?
   c. Calculate an expression for the potential energy for each coil.

8. A current of 17.0 mA is maintained in a single circular loop of 2.00 m circumference. A magnetic field of 0.800 T is directed parallel to the plane of the loop.
   a. Calculate the magnetic moment of the loop
   b. What is the magnitude of the torque exerted by the magnetic field on the loop?

9. A rectangular coil consists of $N = 100$ closely wrapped turns and has dimensions $a = 0.400$ m and $b = 0.300$ m. The coil is hinged along the y axis, and its plan makes an angle $\theta = 30.0^{o}$ with the x axis as shown in the figure at right. A uniform magnetic field $B = 0.800$ T is directed along the positive x axis.



   a. What is the magnitude of the torque exerted on the coil by the magnetic field if the current is 1.20 A in the direction shown?
   b. What is the expected direction of rotation?

10. A wire is formed into a circle having a diameter of 10.0 cm and is placed in a uniform magnetic field of 3.00 mT. The wire carries a current of 5.00 A. Find:
    a. The maximum torque on the wire
    b. The range of potential energies of the wire-field system for different orientations of the circle.

11. A particle with positive charge $q = 3.20 \; x \; 10^{-19}$ C move with a velocity $\vec{\mathbf{v}} = (2\,\hat{\mathbf{x}} + 3\,\hat{\mathbf{y}} - \hat{\mathbf{z}})$ m/s through a region where both a uniform magnetic field and a uniform electric field exist. If $\vec{\mathbf{B}} = (2\,\hat{\mathbf{x}} + 4\,\hat{\mathbf{y}} + \hat{\mathbf{z}})$ T and $\vec{\mathbf{E}} = (4\,\hat{\mathbf{x}} - \hat{\mathbf{y}} - 2\,\hat{\mathbf{z}})$ V/m:
    a. Calculate the Lorentz force acting on the charge
    b. What angle does the force vector in part (*a*) make with the positive x axis?

12. **A metal rod having a mass per unit length λ carries a current I. The rod hangs from two wires in a uniform vertical magnetic field as shown in the figure at right. The wires make an angle θ with the vertical when in equilibrium. Determine an expression for the magnitude of the magnetic field.