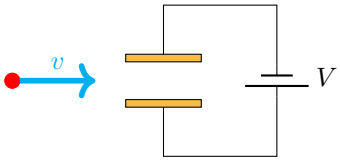
Chapter 27 - The Magnetic Field and Magnetic Forces

Physics 207

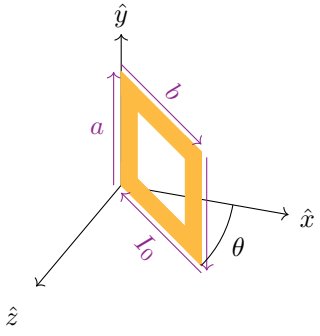
1. A straight piece of conducting wire with mass M and length L is placed on a frictionless incline tilted at an angle θ from the horizontal. There is a uniform magnetic field $\vec{B}$ at all points (produced by an arrangement of magnets not shown) in the figure. To keep the wire from sliding down the incline, a voltage source is attached to the ends of the wire. When just the right amount of current flows through the wire, the wire remains at rest.
a) Draw a free-body diagram of all the forces that act on the wire.
b) Determine the magnitude and direction of the current in the wire that will cause the wire to remain at rest.

Side View of Plane Front View of Plane

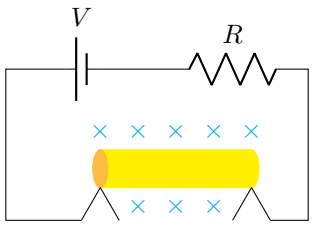
2. A battery with voltage V is connected across two parallel metal plates with area A and separation d. A beam of alpha particles (charge $+2e$ and mass m) is accelerated from rest through a potential difference of $100V$ and enters the region between the plates perpendicular to the electric field. What magnitude and direction of magnetic field are needed so that the alpha particles emerge undeflected from between the plates?



3. A rectangular loop is pivoted about the y-axis and carries a current I_0 in the direction indicated.
a) If the loop is in a uniform magnetic field with magnitude B in the $+x$-direction, find the magnitude and direction of the torque required to hold the loop in the position show.
b) Repeat part a) for the case in which the field is in the $-z$-direction.
c) For each of the above magnetic fields, what torque would be required if the loop were pivoted about an axis through its center, parallel to the y-axis?



4. A thin metal bar with length ℓ and mass m rests on but is not attached to, two metallic supports in a uniform magnetic field, $\vec{B}$ which points into the page as shown in the figure below. A battery and a resistor, R, are connected in series to the supports.
a) What is the highest voltage the battery can have without breaking the circuit at the supports?
b) When the battery voltage has the maximum value calculated in part a, the resistor suddenly gets partially short-circuited decreasing the resistance to $\frac{R}{10}$, find the initial acceleration of the bar. What is the direction of this acceleration?



5. Isotopes (different masses) of single ionized neon atoms (neon atoms that have lost one electron) enter a uniform magnetic field B. All of the atoms have the same velocity v, which is perpendicular to B.
a) The radius of the circular path of the atoms with mass m_1 is r_1 and for those with mass m_2 it is r_2. What is the ratio of m_2 to m_1?
b) You want to use this concept to create a velocity selector followed by a mass spectrometer to measure the radius of singly ionized ^{30}Ne which has 10 protons and 20 neutrons. The electric field in the velocity selector is 5000 N/C, the magnetic field in both the selector and the spectrometer is 50.0 mT. How big does your spectrometer need to be to let the atom complete half of a complete circle in the spectrometer? These isotopes only exist for an average of around 7.22 ms. If the particles are created at the start of the velocity selector which is 2.50 m long, will they reach the end of the spectrometer?

6. The following loop carries a constant current of I_0 and is in the presence of an external magnetic field. What is the net force vector acting on the loop if the magnetic field is $\vec{B}(x, y, z) = B_0\hat{k}$? What if it was $\vec{B}(x, y, z) = (B_0xy)\hat{k}$ instead?