proprep

Workbook

Table of Contents

Lorentz Law and Force on Current Carrying Conductor

Lorentz Law and Force on Current Carrying Conductor

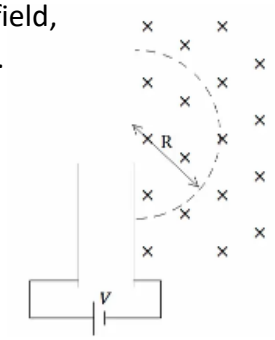
Questions

1) A charged particle with a charge q moves at a velocity $\vec{\mathrm{v}}$ in a region with a magnetic field of $\vec{\mathrm{B}} = -2\hat{\mathrm{x}} + 3\hat{\mathrm{y}}$ tesla. Calculate the magnetic force applied to the particle, given that:

a. $\vec{\mathrm{v}} = 2\hat{\mathrm{x}} + 3\hat{\mathrm{y}}$ m/s and $\mathrm{q} = 2\mathrm{C}$.

b. $\vec{\mathrm{v}} = -\hat{\mathrm{x}} + 2\hat{\mathrm{z}}$ m/s and $\mathrm{q} = -1\mu\mathrm{C}$.

2) The following system describes the Dempster Mass Spectrometer, whose purpose is to separate particles of different masses. Positive charged particles are released from a state of rest near the positive capacitor plate and accelerated by a voltage source V applied across the capacitor. The particles pass through the negative plate and enter a uniform magnetic field, going into the page. Find the radius of rotation as a function of particle mass. We are given the values for B, q, V.



3) A charge is in linear motion within a parallel plate capacitor. It has a constant velocity of v_0 and travels parallel to the capacitor plates.

Inside (and only inside) the capacitor a uniform known electric field, $\vec{E}$, is present.

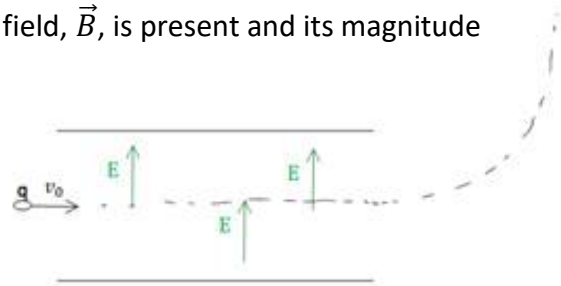
On exiting the capacitor, the charge travels in an upward circular direction.

Both inside and outside the capacitor a uniform magnetic field, $\vec{B}$, is present and its magnitude and direction are unknown.

Disregard the gravitational force acting on the charge.

a. What is the charge polarity?

b. Find the direction and magnitude of the magnetic field.

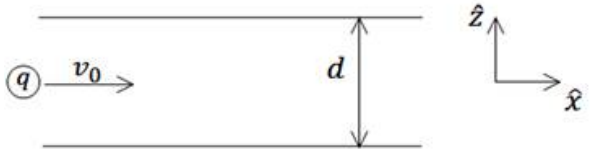


4) A particle with a mass m and charge $q > 0$ enters the centre of a parallel plate capacitor with a velocity of $\vec{v} = v_0\hat{x}$. The capacitor plates are parallel to the xy plane and their separation distance is d. The capacitor is connected to a voltage source, V, the upper plate being at the higher potential.

a. Find the distance, from the edge of the capacitor, where the charge will strike the plate.

b. Now assume that the capacitor is discharged and not connected to the voltage source. A uniform magnetic field $\vec{B} = B_0\hat{y}$ is present in the space. Find the distance, from the edge of the capacitor, where the charge will strike the plate.

c. In which direction will the charge be deflected if the capacitor is connected to the voltage source and a magnetic field is present?

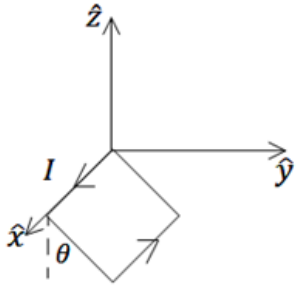


5) A proton enters a uniform magnetic field of intensity $0.15T$ at an angle of $30°$ to the field. Find the radius of rotation of the proton, given that the magnitude of its velocity is $v = 10^6 \frac{m}{s}$. The proton's charge and mass is $q_p = 1.6 \cdot 10^{-19}C$ and $m_p = 1.67 \cdot 10^{-27}kg$ respectively.

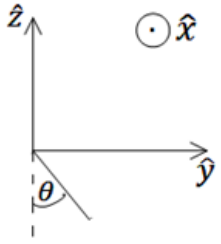
6) A suspended square loop with a side length of L and mass m is suspended from the *x*-axis and is free to rotate around it. The loop carries a current I such that the current flowing through side along the *x*-axis is positive.

a. Find the magnitude of the magnetic field required to act in the z-axis direction to bring the loop to rest at an angle of θ relative to the z-axis.

b. Find the magnitude of the magnetic field required to act in the y-axis direction to bring the loop to rest at an angle of θ relative to the y-axis.



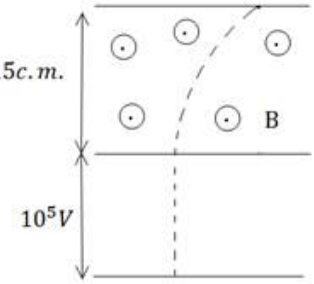
THREE-DIMENSIONAL VIEW



TWO-DIMENSIONAL VIEW

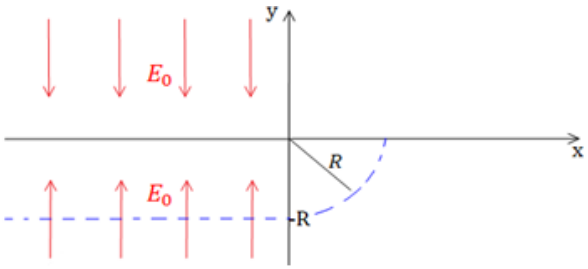
7) A proton is accelerated within a capacitor subject to a voltage of $10^5 V$.
It then passes through a uniform magnetic field before striking a screen located at a distance of $15cm$ from the capacitor. The magnetic field intensity is $0.2T$.

a. Find the horizontal distance traversed by the proton before striking the screen.
b. Find the time that elapsed until the screen was stricken.
c. What is the minimum voltage required for the proton to strike the screen?



8) An electric field is present where $x < 0$ such that above the x-axis ($y > 0$) the field is $\vec{E} = -E_0\hat{y}$ and below the x-axis ($y < 0$) the field is $\vec{E} = E_0\hat{y}$. A uniform magnetic field of unknown magnitude and direction is also present in the entire space.
A particle of mass m and charge $|q|$ arrives from $x = -\infty$ and moves in a straight line at a constant velocity. The height of the particle's trajectory is $y = -R$. When the particle crosses over the y-axis it travels along the parameter of a quarter circle of radius R (see diagram).

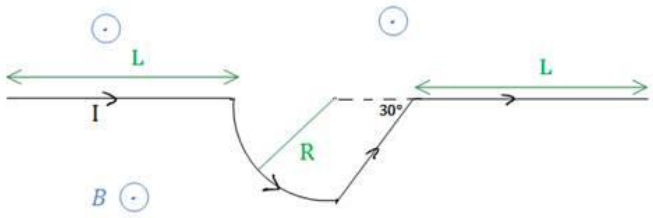
a. Sketch the rest of the particle's trajectory.
b. What is the charge's polarity?
c. Determine the charge velocity and magnetic field.
d. Given the same conditions, but a magnetic field three times as strong, determine the particle's required mass for the same trajectory to be followed.



9) Show that the magnetic force acting on a square current loop in a uniform field:

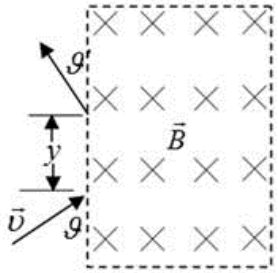
a. perpendicular to the loop's plane cancels out.
b. parallel to the loop's plane cancels out.
c. cancels out.
d. The magnetic force acting on a closed current loop of any shape in a uniform field cancels out.

10) A conducting wire is bent as shown in the diagram, the rounded section forming a quadrant of radius R. A uniform magnetic field is present coming out of the page and a current, I, flows through the wire. Length L, B, I and R are given. Find the resultant force acting on the wire.



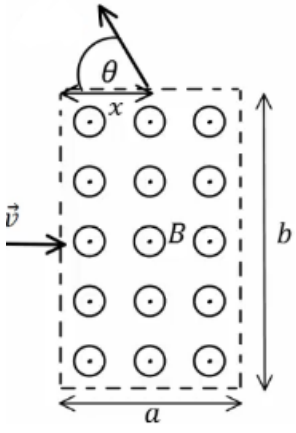
11) A particle beam with a mass of m and a charge of q encounters a region where a uniform magnetic field $\vec{B}$ is present. The magnetic field is perpendicular to the plane of the page and going inwards. The particles possess kinetic energy, E_k, and they enter the magnetised zone at an angle of θ, as shown in the diagram.

a. Determine the vertical distance, y, traversed by the particles from their entry point into the magnetised zone until they exit it.
b. Determine the exit angle θ' (see left-hand side of diagram).



12) A uniform magnetic field B is present in a rectangular area $a \times b$, its direction is out of the page. Outside of this region the field is zero. Charge $|q|$ enters the middle of the region with a velocity of magnitude v, and direction that is perpendicular to the side of the rectangle. The charge then exits the rectangle via its upper edge.

a. What is the charge's polarity? What is the magnitude of its velocity as it exits the rectangle?
b. What is the distance, x, between the upper left corner of the rectangle and the charge's exit point along the upper edge?
c. What is the angle θ of the charge's exiting velocity relative to the upper edge of the rectangle?



*For the solutions go see the videos