

Physics 1C Discussion (Week 1)

Problem 1

What is the direction of the magnetic force on a positive charge that moves as shown in Fig 1.

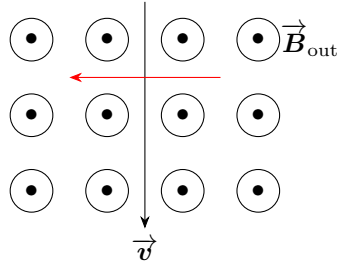


Figure 1: Illustration of the problem 1

The magnetic force on a positive charge is given by

$$\vec{F} = q\vec{v} \times \vec{B}, \quad (1)$$

where $q > 0$ (*i.e.* the sign of the charge does not flip the direction of $\vec{v} \times \vec{B}$). Then the direction of $\vec{F}$ is the same as $\vec{v} \times \vec{B}$.

Problem 2

What is the direction of the velocity of a negative charge that experiences the magnetic force shown in Fig 1, assuming it moves perpendicular to $\vec{B}_{\text{out}}$.

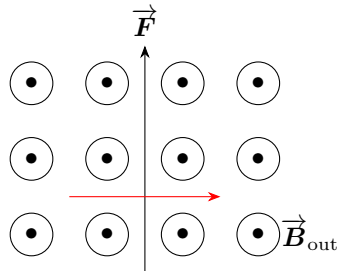


Figure 2: Illustration of the problem 2

Problem 3

An alpha-particle ($m = 6.64 \times 10^{-27}$ kg, $q = 3.2 \times 10^{-19}$ C) travels in a circular path of radius 35.2 cm in a uniform magnetic field of magnitude 1.01 T. What is the speed of the particle?
Equation of motion for circular motion reads

$$m \frac{v^2}{r} = qvB \quad (2)$$

If you arrange this relation in terms of $v \neq 0$, you get

$$v = \frac{qBr}{m}. \quad (3)$$

By substituting the known quantities, you get

$$\begin{aligned} v &= \frac{qBr}{m} \\ &= \frac{(3.2 \times 10^{-19} \text{ C})(1.01 \text{ T})(35.2 \times 10^{-2} \text{ m})}{6.64 \times 10^{-27} \text{ kg}} \\ &\simeq 1.7 \times 10^7 \text{ m/s}. \end{aligned} \quad (4)$$

Problem 4

An electron moving with a velocity $\vec{v} = (4.0\hat{i} + 3.0\hat{j} + 2.0\hat{k}) \times 10^6$ m/s enters a region where there is a uniform electric field and a uniform magnetic field. The magnetic field is given by $\vec{B} = (1.0\hat{i} - 2.0\hat{j} + 4.0\hat{k}) \times 10^{-2}$ T. If the electron travels through the region at constant velocity, what is the electric field?
In the component expression, velocity vector $\vec{v}$ and magnetic field vector $\vec{B}$ are given by

$$\vec{v} = \begin{pmatrix} 4.0 \times 10^6 \text{ m/s} \\ 3.0 \times 10^6 \text{ m/s} \\ 2.0 \times 10^6 \text{ m/s} \end{pmatrix}, \quad \vec{B} = \begin{pmatrix} 1.0 \times 10^{-2} \text{ T} \\ -2.0 \times 10^{-2} \text{ T} \\ 4.0 \times 10^{-2} \text{ T} \end{pmatrix}. \quad (5)$$

The Lorentz force in general is given by

$$\begin{aligned} \vec{F} &= (\text{electric force}) + (\text{magnetic force}) \\ &= q(\vec{E} + \vec{v} \times \vec{B}), \end{aligned} \quad (6)$$

where q is the charge of the electron, $\vec{E}$ is the electric field.

To make the electron travel at the constant velocity, the electric force must cancel the whole component of the magnetic force. That is

$$\begin{aligned} \vec{E} &= -\vec{v} \times \vec{B} \\ &= - \begin{pmatrix} 1.6 \times 10^5 \text{ N/C} \\ -1.4 \times 10^5 \text{ N/C} \\ -1.1 \times 10^5 \text{ N/C} \end{pmatrix} \\ &= \begin{pmatrix} -1.6 \times 10^5 \text{ N/C} \\ 1.4 \times 10^5 \text{ N/C} \\ 1.1 \times 10^5 \text{ N/C} \end{pmatrix}. \end{aligned} \quad (7)$$