Electrodynamics-II

Muhammad Amer Mustafa (Lecturer)

UOS Sub Campus Bhakkar

Contents

- Example 5.1, Problem 5.1, Problem 5.2

Assignment

Problem 5.2

Example 5.1

- Cyclotron Motion

Motion of charge particles along circular path is called cyclotron motion.
If charge particle Q is inside the magnetic field which
Is into the page. The charge will move along
circular path because magnetic field is perpendicular
to velocity of charge particle and it provides
Necessary centripetal force. So

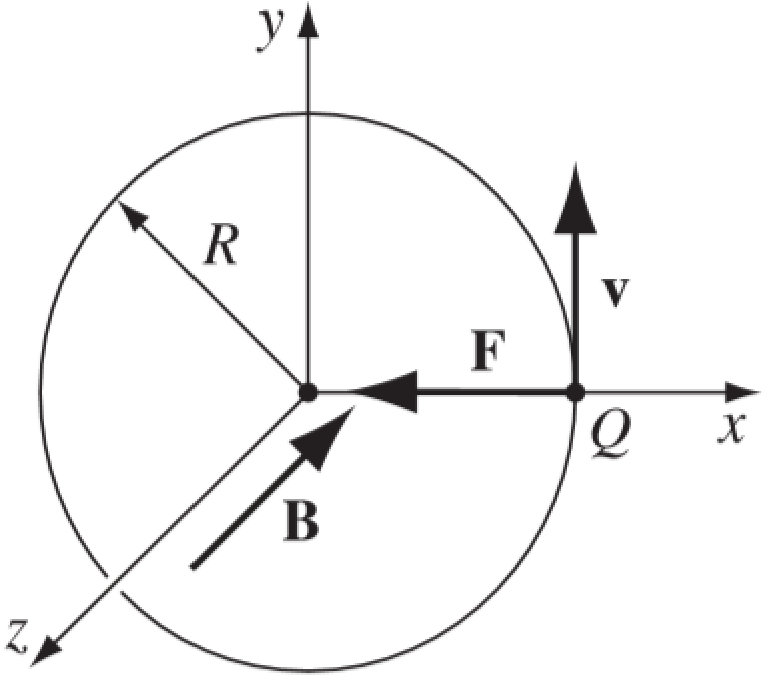


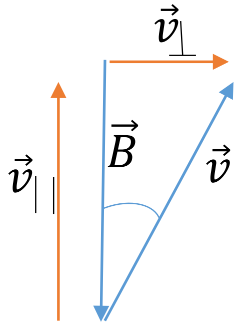
FIGURE 5.5

$$QvB = \frac{mv^2}{R}$$

$$\frac{QvB}{v} = \frac{mv^2}{vR}$$

$$p = mv = QBR$$

If charge particle does not move perpendicular to magnetic field
Then velocity of particle has two components : one is along magnetic field and other is along perpendicular to magnetic field



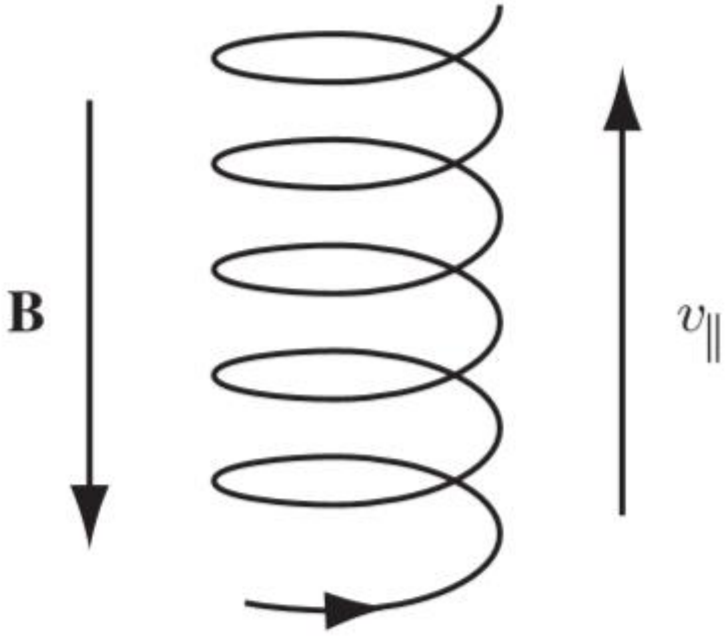


FIGURE 5.6

Problem 5.1 A particle of charge q enters a region of uniform magnetic field **B** (pointing *into* the page). The field deflects the particle a distance d above the original line of flight, as shown in Fig. 5.8. Is the charge positive or negative? In terms of a, d, B and q, find the momentum of the particle.

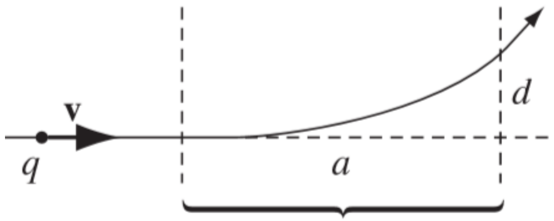


FIGURE 5.8

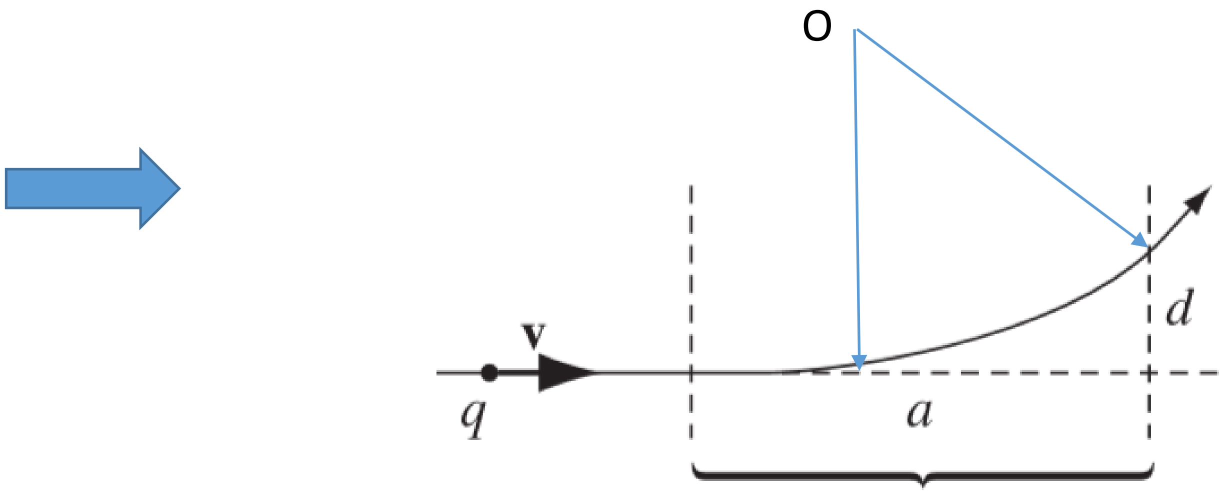
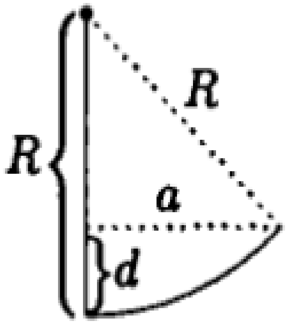


FIGURE 5.8

Problem 5.1

Since $\mathbf{v} \times \mathbf{B}$ points upward, and that is also the direction of the force, q must be $\boxed{\text{positive.}}$ To find R, in terms of a and d, use the pythagorean theorem:

$$(R-d)^2 + a^2 = R^2 \;\Rightarrow\; R^2 - 2Rd + d^2 + a^2 = R^2 \;\Rightarrow R = \frac{a^2+d^2}{2d}.$$



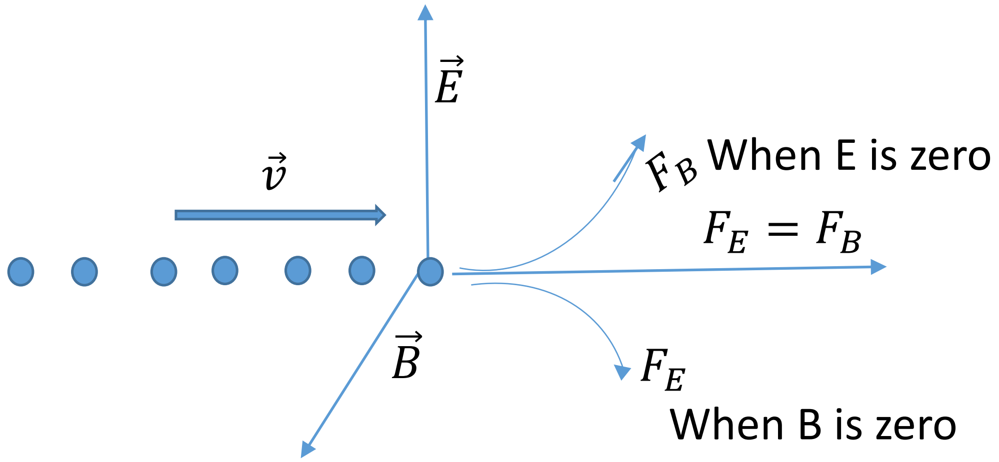
The cyclotron formula then gives

$$p = qBR = \boxed{qB\frac{(a^2+d^2)}{2d}.}$$

Problem 5.3 In 1897, J. J. Thomson "discovered" the electron by measuring the charge-to-mass ratio of "cathode rays" (actually, streams of electrons, with charge q and mass m) as follows:

(a) First he passed the beam through uniform crossed electric and magnetic fields **E** and **B** (mutually perpendicular, and both of them perpendicular to the beam), and adjusted the electric field until he got zero deflection. What, then, was the speed of the particles (in terms of E and B)?

(b) Then he turned off the electric field, and measured the radius of curvature, R, of the beam, as deflected by the magnetic field alone. In terms of E, B, and R, what is the charge-to-mass ratio (q/m) of the particles?



Problem 5.3(a)

From Eq. 5.2, $\vec{F} = q(\vec{E} + \vec{v} \times \vec{B}) = 0$

$\vec{E} = -\vec{v} \times \vec{B}$ $\qquad \theta = 90^0$

In magnitude $\quad E = vB$

$$v = \frac{E}{B}$$

Problem 5.3(b)

From Eq. 5.3, $mv = qBR$

$$\frac{q}{m} = \frac{v}{BR}$$

Put value of $v = \frac{E}{B}$ ⇨ $\frac{q}{m} = \frac{E}{B^2R}$