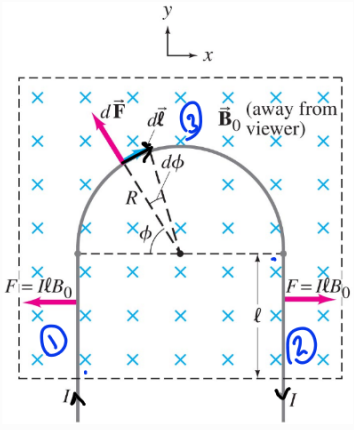
Chapter 27: Magnetism

Example 27.3



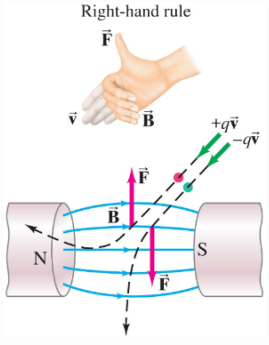
For ① and ②: $\vec{F} = I\vec{\ell} \times \vec{B} \Rightarrow F = I\ell B_0 \sin 90^\circ = I\ell B_0$

Thus, the force on straight portions cancel out!

For ③: $d\vec{F} = I\,d\vec{\ell} \times \vec{B}$, $dF = I B_0\, d\ell = I B_0 R\, d\phi$

$$F = \int_0^{\pi} (I B_0 R)\sin\phi\, d\phi = I B_0 R \int_0^{\pi} \sin\phi\, d\phi = I B_0 R \left[-\cos\phi\right]_0^{\pi} = 2 I B_0 R$$

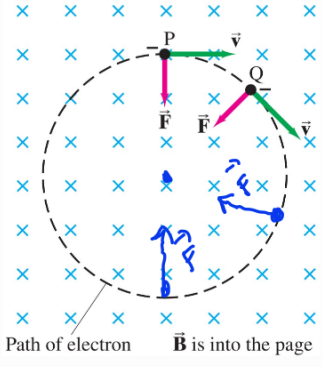
Force on a charge moving in a $\vec{B}$-field:



$$\vec{F} = q\vec{v} \times \vec{B}, \quad F = qvB\sin\theta$$

- q: charge
- v: velocity
- θ: angle between velocity and B vectors

moving charge in a perpendicular $\vec{B}$-field:



Newton's 2nd law: $\vec{F} = m\vec{a}$, $F = mv^2/R$

$$\Sigma F_R = qvB\sin 90^\circ = qvB = mv^2/R \Rightarrow R = \frac{mv}{qB}$$

Period: $T = 2\pi R/v \Rightarrow T = \frac{2\pi m}{qB}$

frequency: $f = 1/T = qB/2\pi m$ → cyclotron frequency

Example 27.4

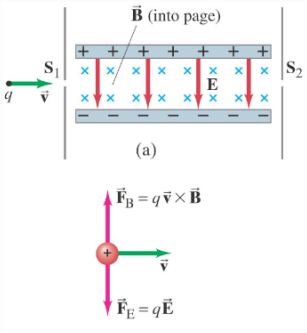
$$R = \frac{mv}{qB}$$

$B = 0.010\ T$, $m = 9.1 \times 10^{-31}\ kg$

$v = 2.0 \times 10^7\ m/s$, $q = 1.6 \times 10^{-19}\ C$

$$R = \frac{(9.1 \times 10^{-31}\ kg)(2.0 \times 10^7\ m/s)}{(1.6 \times 10^{-19}\ C)(0.010\ T)} = 1.1 \times 10^{-2}\ m$$

Example 27.10

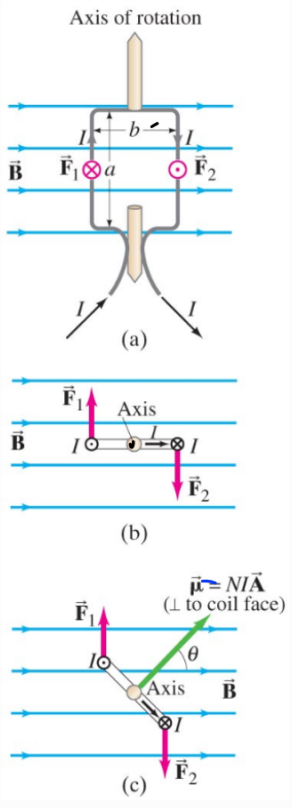


$\vec{F}_B = q\vec{v} \times \vec{B}$ and $\vec{F}_E = q\vec{E}$

$F_B = F_E \Rightarrow qvB = qE$

$v = \frac{E}{B}$ ✓

Torque on a Current Loop:



$\vec{F} = I\vec{\ell} \times \vec{B} = I\ell B \sin\theta$ and $\tau = \vec{r} \times \vec{F} = rF\sin\phi$

$\tau = \frac{b}{2} IaB + \frac{b}{2} IaB = \underbrace{Iab}_{A} B = IAB$

* If there are N loops of wire,

$\tau = NIAB$

* If the coil makes an angle θ with $\vec{B}$-field,

$\tau = NIAB\sin\theta$ define: $\vec{\mu} = NI\vec{A}$

$\vec{\tau} = \vec{\mu} \times \vec{B}$

↓

Torque on a magnetic dipole

Example 27.11

$\tau = NIAB\sin\theta$

$N = 10$

$A = \pi r^2 = \pi(0.100\,m)^2$

$A = 3.14 \times 10^{-2}\,m^2$

$I = 3.00\,A$

$B = 2.00\,T$

* Choose $\theta = 0 \Rightarrow \tau = 0$ (minimum torque) ✓

* Choose $\theta = 90^\circ \Rightarrow \tau = NIAB\underbrace{\sin 90^\circ}_{1}$ (maximum torque)

$\tau = 1.88\,N\,m$ ✓