

e.g. 27-1. Magnetic force on a current-carrying wire. 16-1

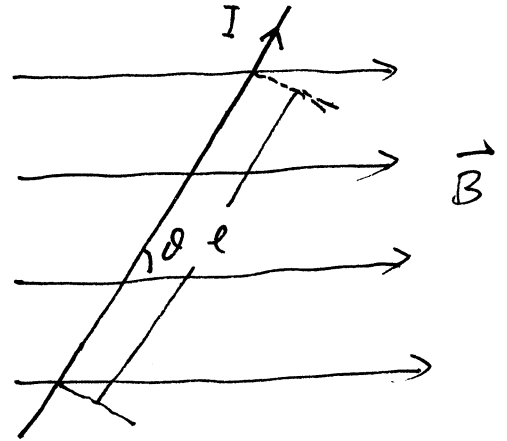
$$I = 30 \text{ A}.$$

$$l = 12 \text{ cm} = 0.12 \text{ m}.$$

$$\theta = 60^\circ.$$

$$B = 0.9 \text{ T}.$$

$$\vec{F} = I \vec{l} \times \vec{B}$$



Direction: RHR: into the page.

Magnitude: $F = I l B \sin \theta$.

$$= 30 \times 0.12 \times 0.9 \times \sin 60^\circ$$

$$= 2.8 \text{ N}$$

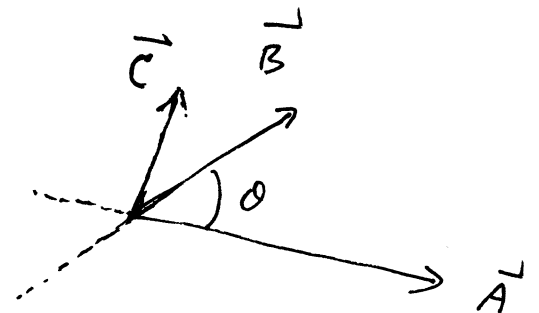
Cross product of 2 vectors. (vector product)

$$\vec{C} = \vec{A} \times \vec{B}.$$

Result: $\vec{C}$ — It's a vector.

Direction: Right-hand-rule

Magnitude: $AB \sin \theta$



θ — angle between $\vec{A}$ and $\vec{B}$.

3D view.

e.g. 27-2. Measuring a magnetic field.

$$l = 0.10 \text{ m} , \quad \theta = 90^\circ .$$

$$F = 3.48 \times 10^{-2} \text{ N} . \quad (\text{downward})$$

$$I = 0.245 \text{ A} .$$

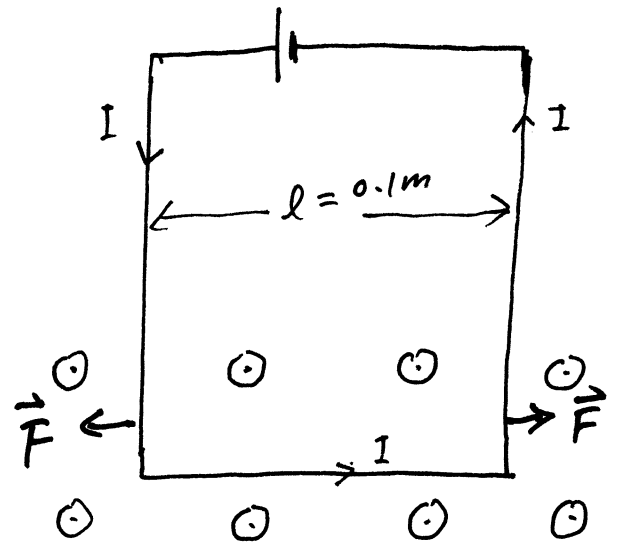
$$B = ?$$

$$F = I l B \sin \theta = I l B$$

$$B = \frac{F}{I l \sin \theta} = \frac{F}{I l} .$$

$$= \frac{3.48 \times 10^{-2}}{0.245 \times 0.10 \times \sin 90^\circ}$$

$$= 1.42 \text{ T} .$$



$\vec{B}$ — out of page .
uniform .

e.g. 27-5. force $F = 8 \times 10^{-14} \text{ N}$, $v = 5 \times 10^6 \text{ m/s}$ (6-3.

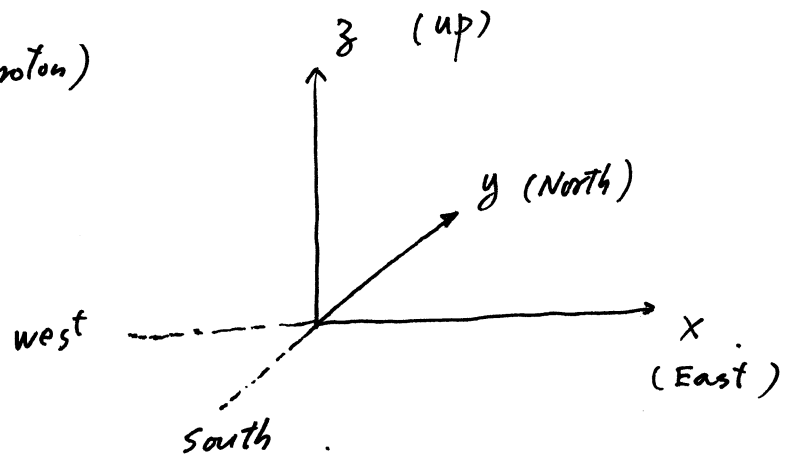
charge: $q = 1.6 \times 10^{-19} \text{ C}$. (proton)

① when $\vec{v} \parallel \hat{z}$ (upward).

$$\vec{F} \parallel (-\hat{x}).$$

② when $\vec{v} \parallel \hat{y}$.

$$\vec{F} = 0$$



$$\text{Since } |\vec{F}| = |q \vec{v} \times \vec{B}| = q v B \sin \theta$$

$$v \neq 0, B \neq 0. \text{ If } F = 0, \theta = 0^\circ \text{ or } 180^\circ.$$

$$\therefore \vec{B} \parallel \hat{y} \quad (\text{or } \vec{B} \parallel (-\hat{y}))$$

But from case ①, we know $\vec{B} \parallel \hat{y}$.

(By RHR)

(NOT $\vec{B} \parallel (-\hat{y})$)

i.e. $\vec{B}$ is pointing to the North.

$$F = q v B \sin 90^\circ \text{ for case ①. } \sin 90^\circ = 1.$$

$$= q v B.$$

$$B = \frac{F}{q v} = \frac{8 \times 10^{-14}}{1.6 \times 10^{-19} \times 5 \times 10^6} = 0.10 \text{ T}.$$

e.g. 27-7.

16-4.

$$\vec{v} \perp \vec{B}$$

$$v = 2 \times 10^7 \text{ m/s}$$

$$B = 0.01 \text{ T (uniform)}$$

$$q = -e = -1.6 \times 10^{-19} \text{ C}$$

path: circular. (uniform circular motion)

on a plane $\perp \vec{B}$

Radius:

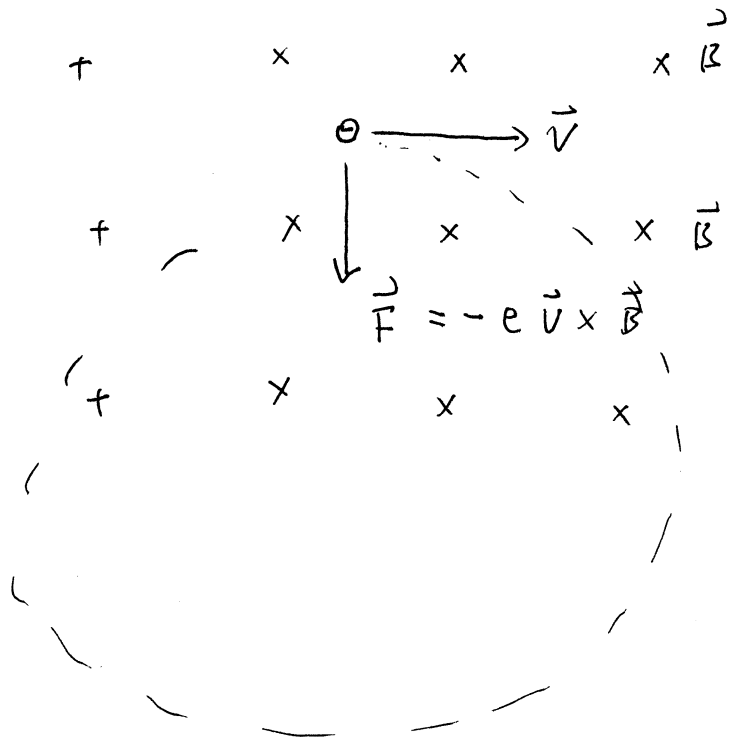
$$F = ma$$

$$q v B = m \frac{v^2}{R}$$

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

$$= 1.1 \times 10^{-2} \text{ m}$$

$$= 1.1 \text{ cm}$$



$$R \propto \frac{m}{q} \quad (\text{mass spectrometer})$$

e.g. 27-11. Torque on a coil.

16-5.

$$\tau = NIA \cdot B \sin \theta \quad (\text{magnitude})$$

$$A = \pi r^2 = \pi \left(\frac{0.2}{2}\right)^2 = 0.0314 \text{ m}^2 \quad \otimes$$

$$\tau = 10 \times 3 \times 0.0314 \times 2 \cdot \sin \theta = 1.88 \sin \theta$$

max: When $\sin \theta = 1$. $\theta = 90^\circ$.

$$\tau_{\max} = 1.88 \text{ N}.$$

min: When $\sin \theta = 0$

$$\tau_{\min} = 0.$$

e.g. 27-12. magnetic moment of a hydrogen atom.

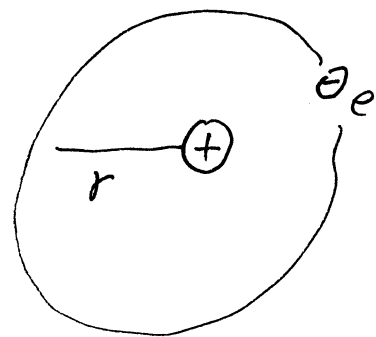
$$r = 0.529 \times 10^{-10} \text{ m}.$$

$$F = ma$$

$$I = \frac{e}{T}$$

$$T = \frac{2\pi r}{v}$$

T - period.



$$v: F = ma: \quad \frac{e^2}{4\pi\epsilon_0 r^2} = m \frac{v^2}{r} \quad (a = \frac{v^2}{r})$$

$$\text{Solve for } v: \quad v = \sqrt{\frac{e^2}{4\pi\epsilon_0 m r}} = 2.19 \times 10^6 \text{ m/s}.$$

$$\mu = IA = \frac{e}{T} \cdot \pi r^2 = \frac{e v}{2\pi r} \pi r^2$$

$$\mu = \frac{e v r}{2} = 9.27 \times 10^{-24} \text{ A} \cdot \text{m}^2$$

$$\mu = IA = \frac{e v}{2\pi r} \cdot \pi r^2$$

Lorentz
equation:

$$\vec{F} = q\vec{E} + q\vec{v} \times \vec{B}$$

$$e v B' = m \frac{v^2}{r}$$

$$m = \frac{e B' r}{v}$$