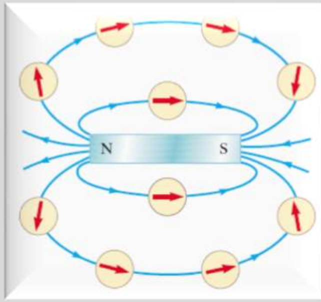
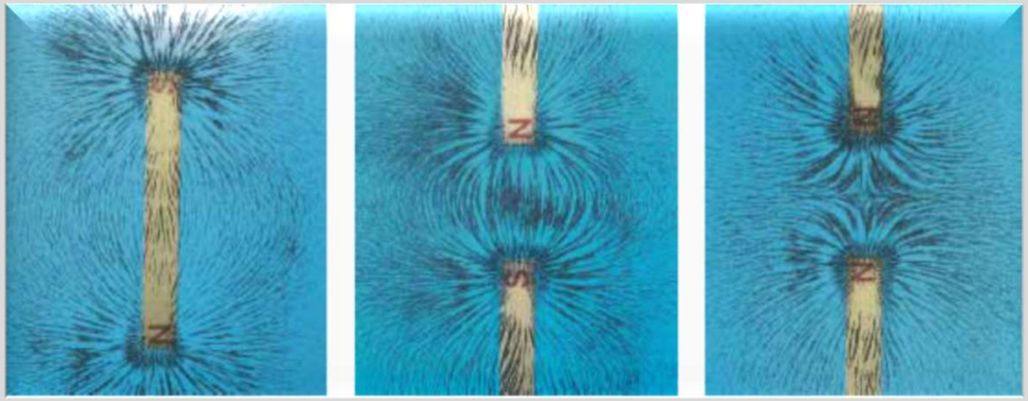


Hans Christian Oersted

Danish Physicist and Chemist (1777–1851)

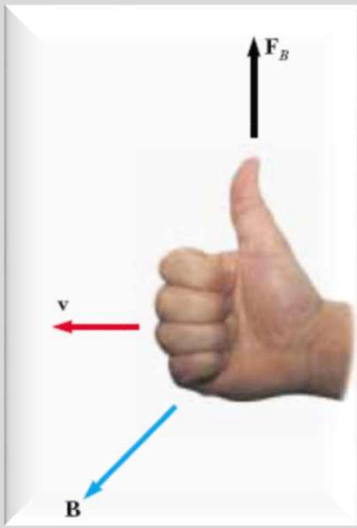


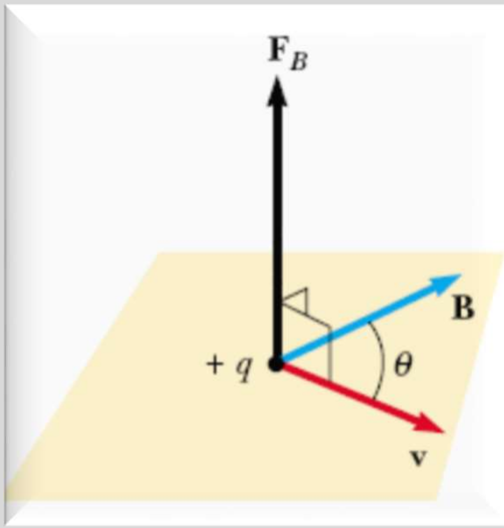
$$\mathbf{F}_B = I\,\mathbf{L} \times \mathbf{B}$$

$$1\ \mathrm{T} = 1\ \frac{\mathrm{N}}{\mathrm{C \cdot m/s}}$$

$$F_B = |q|vB\sin\theta$$

$$1\ \mathrm{T} = 10^4\ \mathrm{G}$$

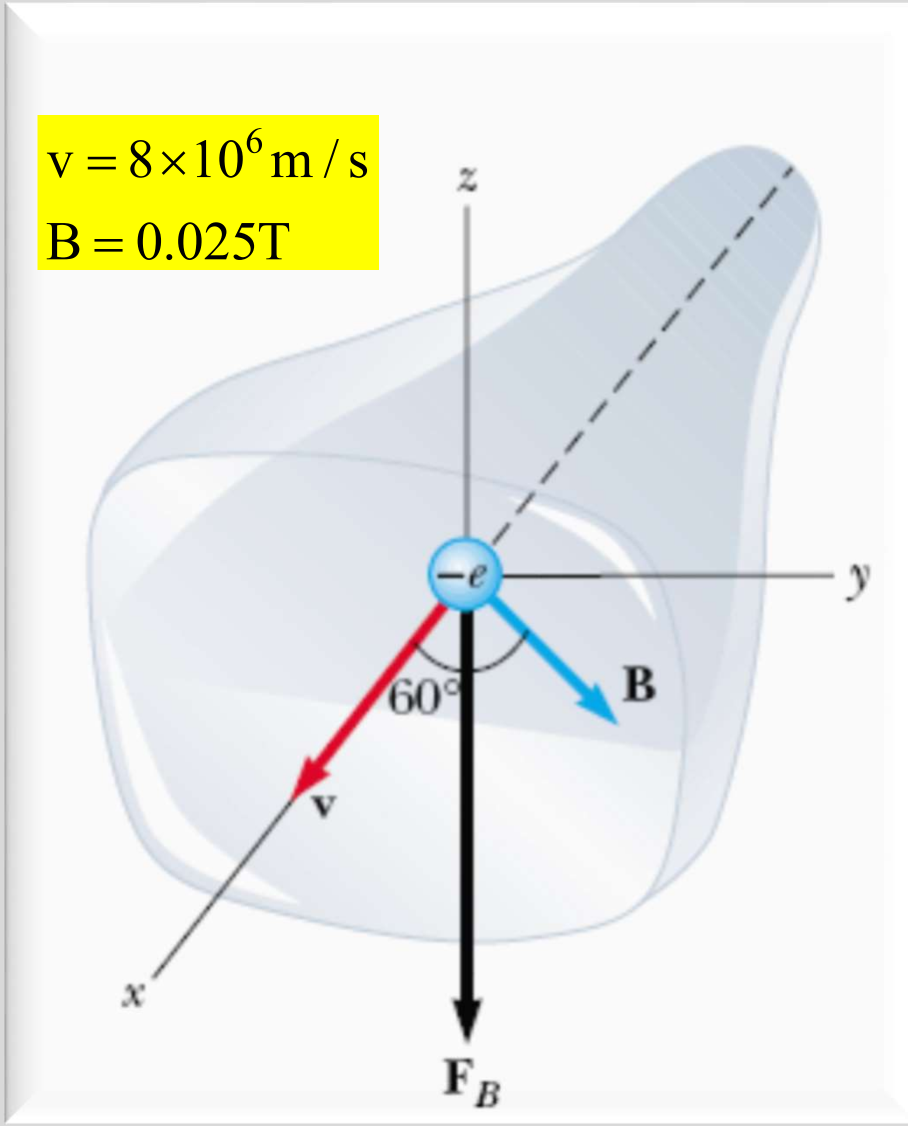




Some Approximate Magnetic Field Magnitudes

Source of Field	Field Magnitude (T)
Strong superconducting laboratory magnet	30
Strong conventional laboratory magnet	2
Medical MRI unit	1.5
Bar magnet	10^{-2}
Surface of the Sun	10^{-2}
Surface of the Earth	0.5×10^{-4}
Inside human brain (due to nerve impulses)	10^{-13}

$$v = 8\times10^6 \text{ m/s}$$
$$B = 0.025\text{T}$$



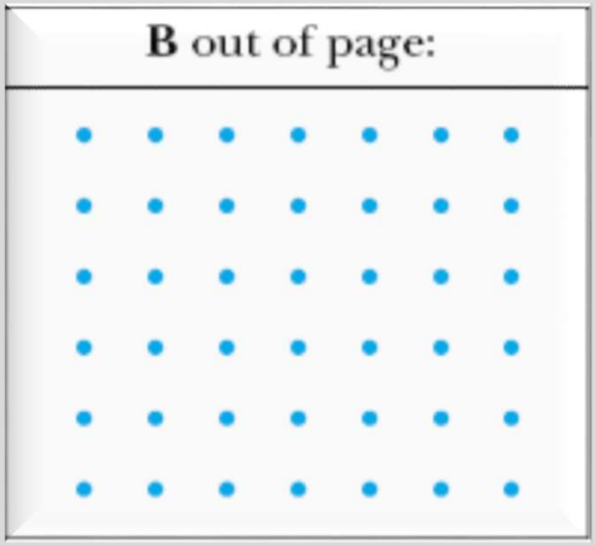
$$\mathbf{v} = (8.0 \times 10^6\,\hat{\mathbf{i}})\ \text{m/s}$$

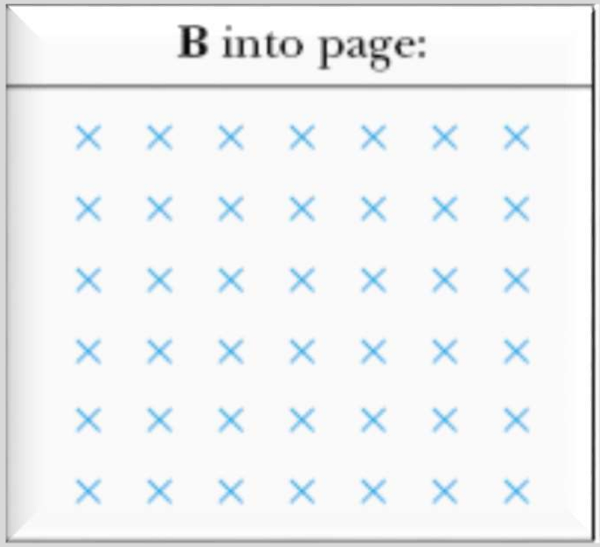
$$\begin{aligned}\mathbf{B} &= (0.025 \cos 60°\,\hat{\mathbf{i}} + 0.025 \sin 60°\,\hat{\mathbf{j}})\text{T} \\ &= (0.013\,\hat{\mathbf{i}} + 0.022\,\hat{\mathbf{j}})\text{T}\end{aligned}$$

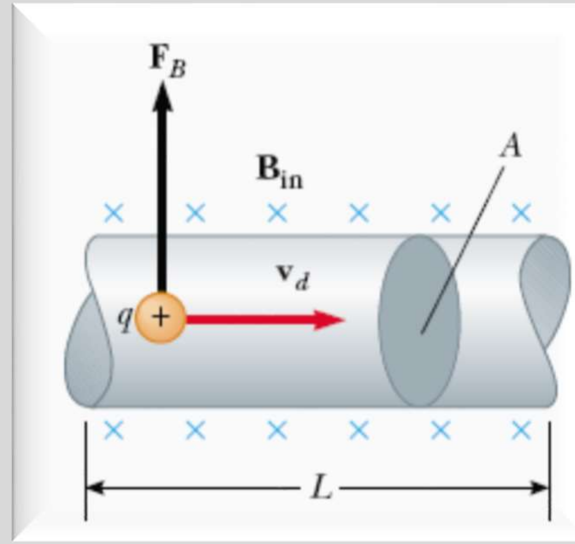
$$\begin{aligned}\mathbf{F}_B &= q\mathbf{v} \times \mathbf{B} \\ &= (-e)[(8.0 \times 10^6\,\hat{\mathbf{i}})\ \text{m/s}] \times [(0.013\,\hat{\mathbf{i}} + 0.022\,\hat{\mathbf{j}})\text{T}] \\ &= (-e)[(8.0 \times 10^6\,\hat{\mathbf{i}})\ \text{m/s}] \times [(0.013\,\hat{\mathbf{i}})\text{T}] \\ &\quad + (-e)[(8.0 \times 10^6\,\hat{\mathbf{i}})\ \text{m/s}] \times [(0.022\,\hat{\mathbf{j}})\text{T}] \\ &= (-e)(8.0 \times 10^6\ \text{m/s})(0.013\ \text{T})(\hat{\mathbf{i}} \times \hat{\mathbf{i}}) \\ &\quad + (-e)(8.0 \times 10^6\ \text{m/s})(0.022\ \text{T})(\hat{\mathbf{i}} \times \hat{\mathbf{j}}) \\ &= (-1.6 \times 10^{-19}\ \text{C})(8.0 \times 10^6\ \text{m/s})(0.022\ \text{T})\,\hat{\mathbf{k}}\end{aligned}$$

$$\begin{aligned}F_B &= |q|vB \sin\theta \\ &= (1.6 \times 10^{-19}\ \text{C})(8.0 \times 10^6\ \text{m/s})(0.025\ \text{T})(\sin 60°) \\ &= 2.8 \times 10^{-14}\ \text{N}\end{aligned}$$

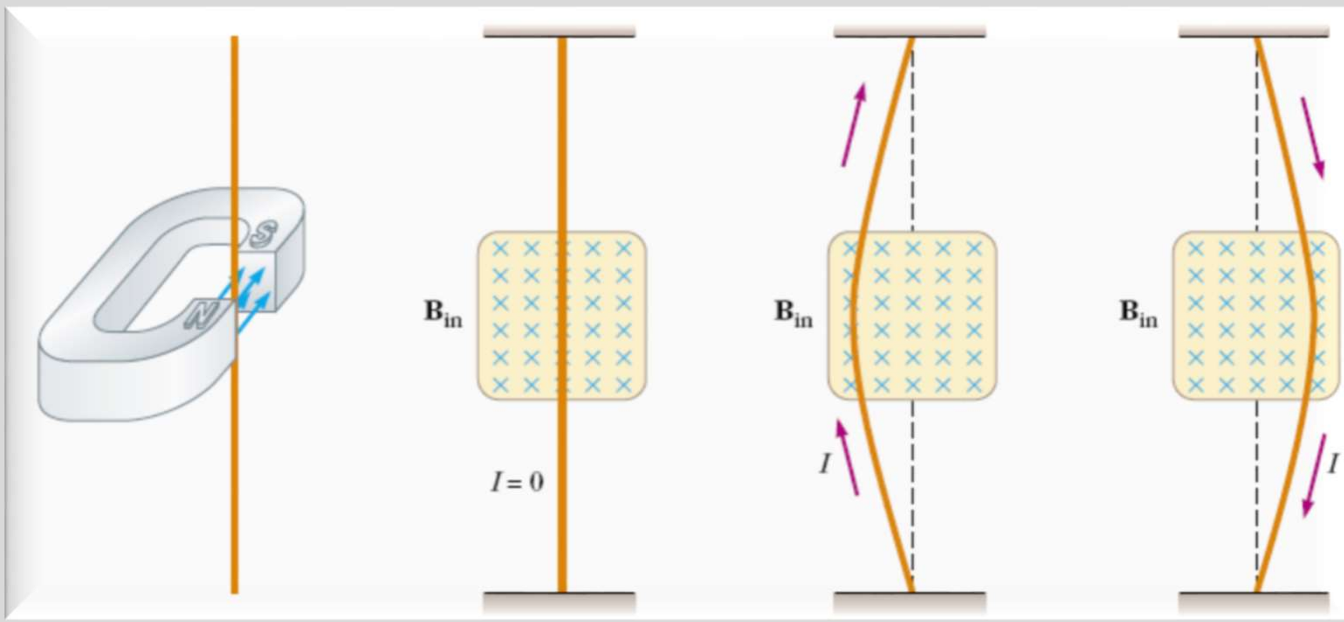
$$\mathbf{F}_B = (-2.8 \times 10^{-14}\ \text{N})\hat{\mathbf{k}}$$

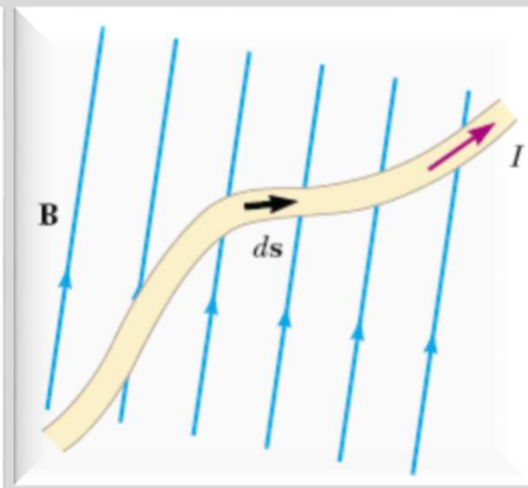




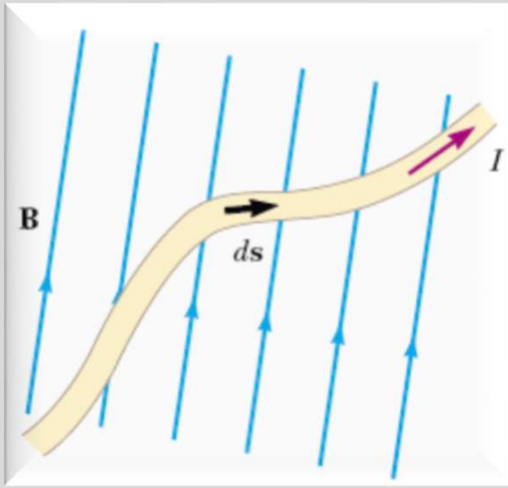


$$\mathbf{F}_B = (q\mathbf{v}_d \times \mathbf{B})\, nAL$$





$$d\mathbf{F}_B = I\, d\mathbf{s} \times \mathbf{B}$$

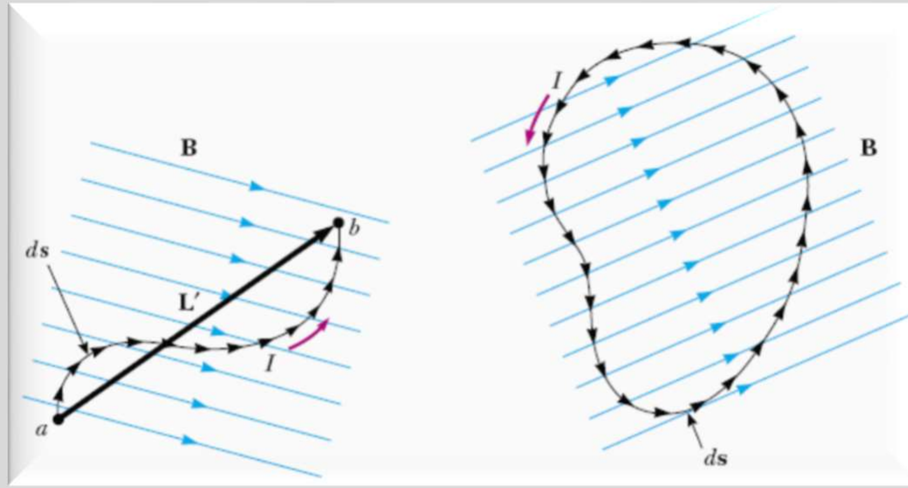


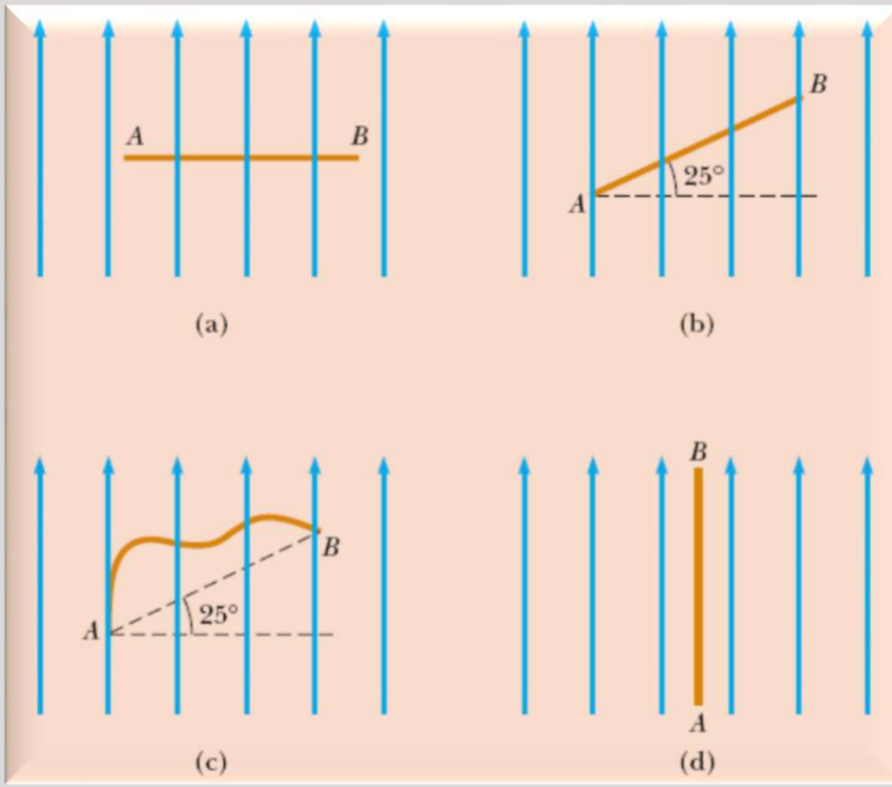
$$d\mathbf{F}_B = I\,d\mathbf{s} \times \mathbf{B}$$

$$\mathbf{F}_B = I\int_a^b d\mathbf{s} \times \mathbf{B}$$

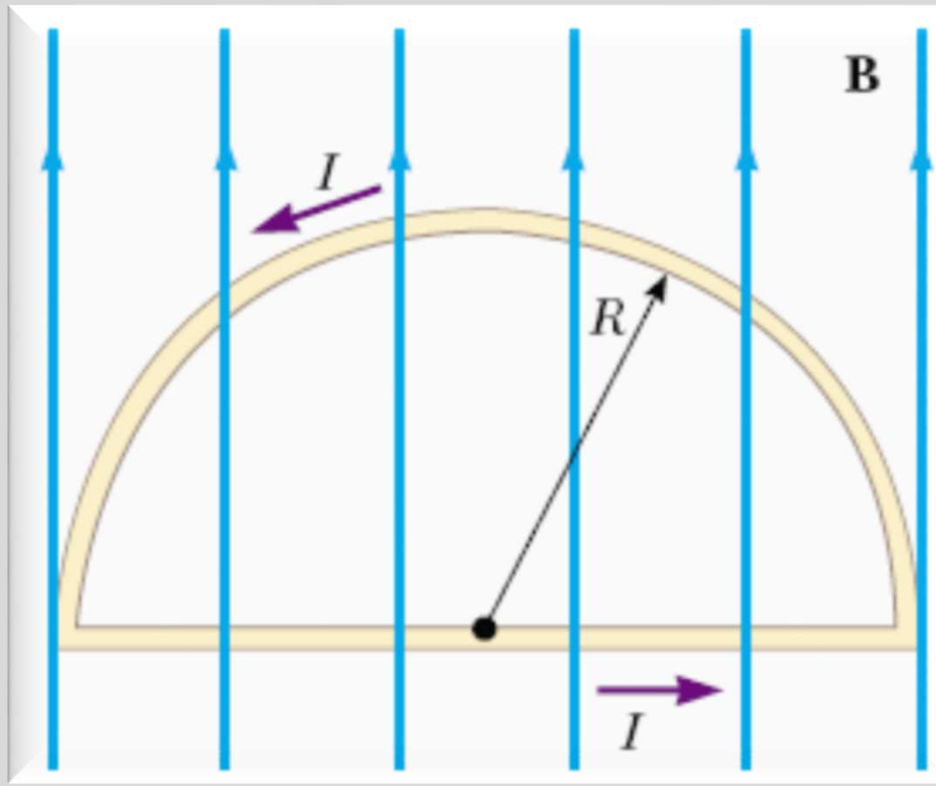
$$\mathbf{F}_B = I\left(\int_a^b d\mathbf{s}\right) \times \mathbf{B}$$

$$\mathbf{F}_B = I\,\mathbf{L}' \times \mathbf{B}$$

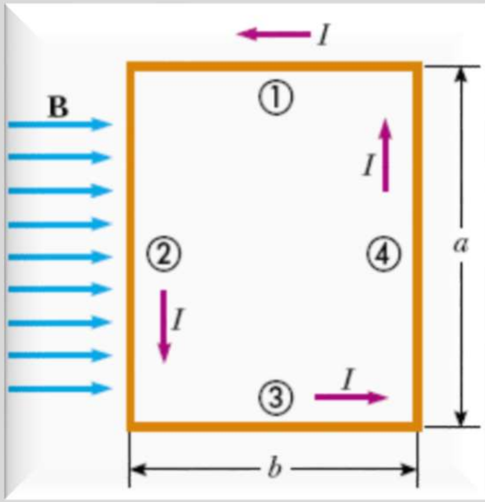


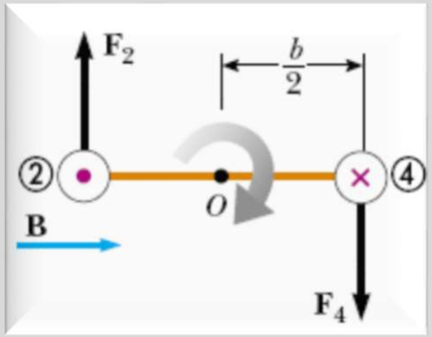


(a), (b) = (c), (d)



$$\sum \mathbf{F} = \mathbf{F}_1 + \mathbf{F}_2 = 2IRB\hat{\mathbf{k}} - 2IRB\hat{\mathbf{k}} = 0$$



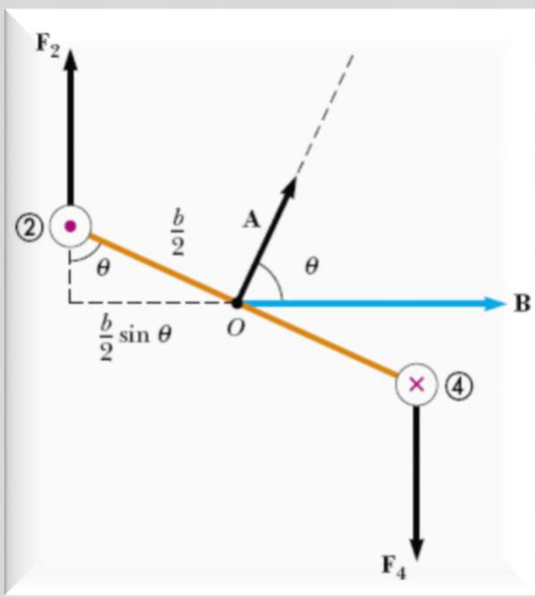


$$F_2 = F_4 = IaB$$

$$\tau_{\max} = F_2 \frac{b}{2} + F_4 \frac{b}{2} = (IaB)\frac{b}{2} + (IaB)\frac{b}{2} = IabB$$

$$\tau_{\max} = IAB$$

$$F_1 = F_3 = 0$$



$$\begin{aligned}\tau &= F_2 \frac{b}{2}\sin\theta + F_4 \frac{b}{2}\sin\theta \\ &= IaB\left(\frac{b}{2}\sin\theta\right) + IaB\left(\frac{b}{2}\sin\theta\right) = IabB\sin\theta \\ &= IAB\sin\theta\end{aligned}$$

$$\boldsymbol{\tau} = I\mathbf{A}\times\mathbf{B}$$

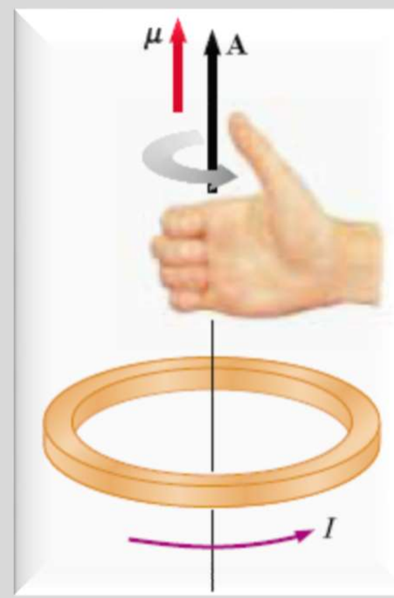
$$\boldsymbol{\tau} = N\boldsymbol{\mu}_{\text{loop}}\times\mathbf{B} = \boldsymbol{\mu}_{\text{coil}}\times\mathbf{B}$$

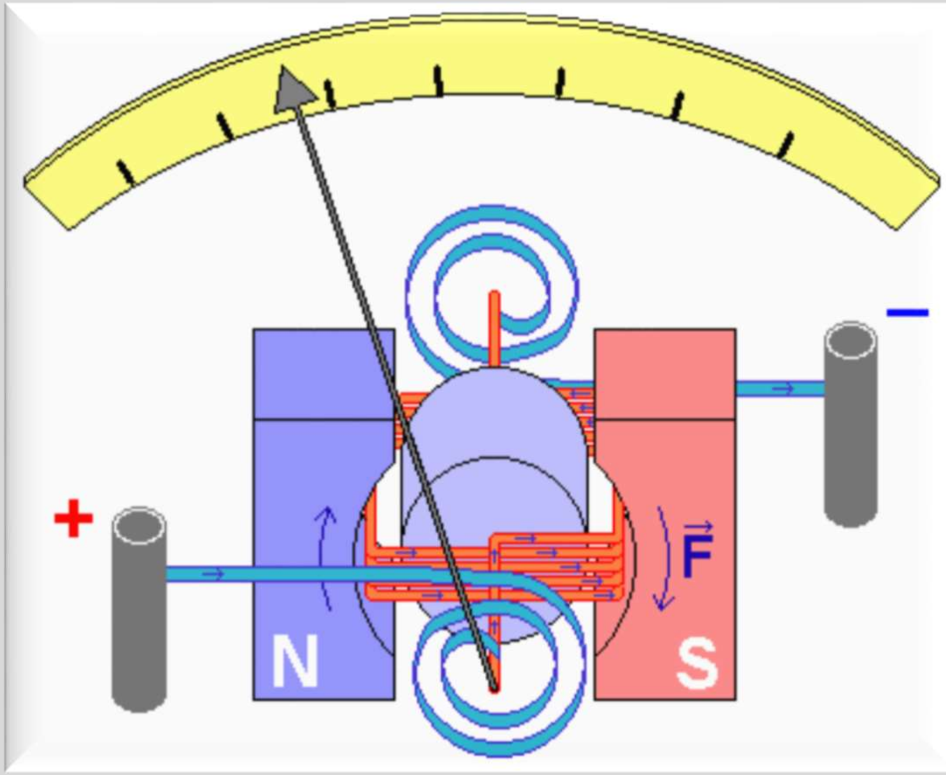
$$\boldsymbol{\mu} = I\mathbf{A}$$

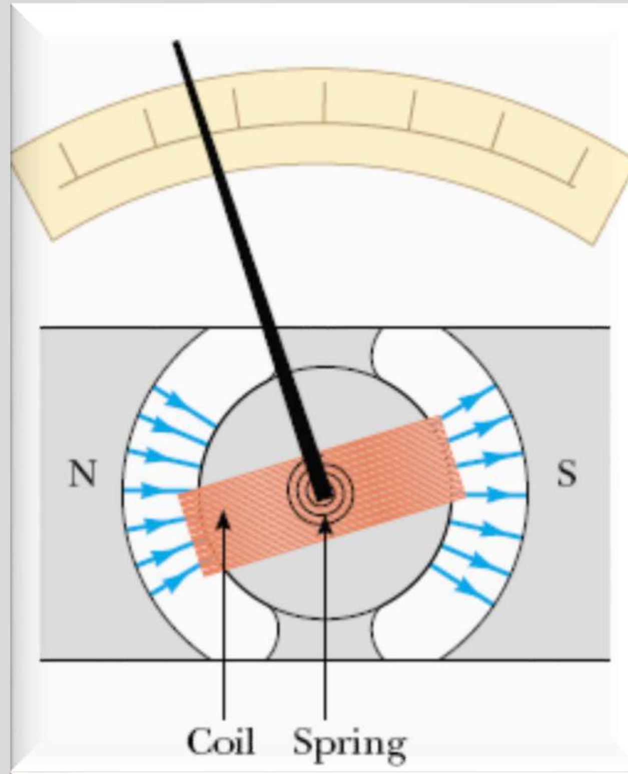
$$U = -\mathbf{p}\cdot\mathbf{E}$$

$$U = -\boldsymbol{\mu}\cdot\mathbf{B}$$

$$\boldsymbol{\tau} = \boldsymbol{\mu}\times\mathbf{B}$$







$$\tau_m = \mu B$$

$$\tau_m + \tau_s = \mu B - \kappa\phi = 0$$

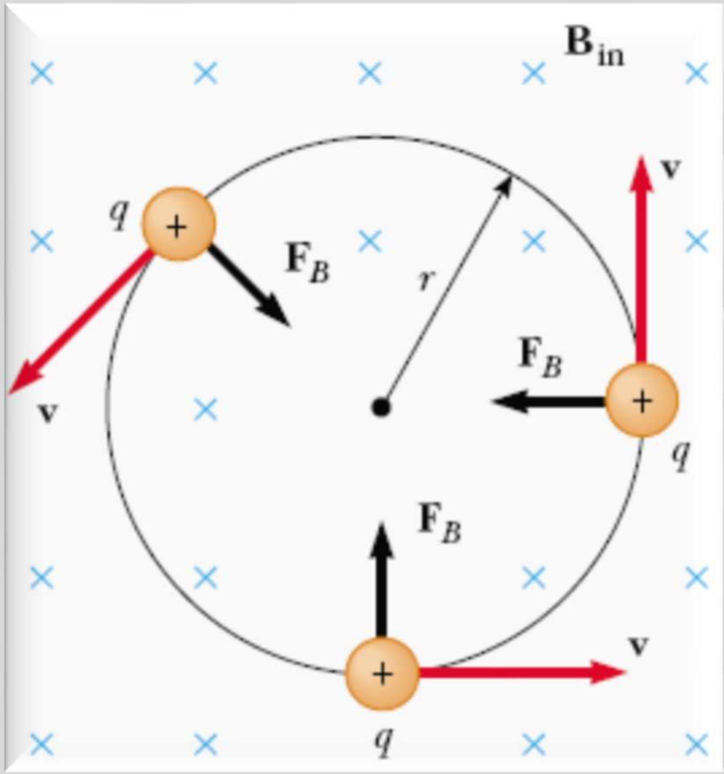
$$\mu = NIA$$

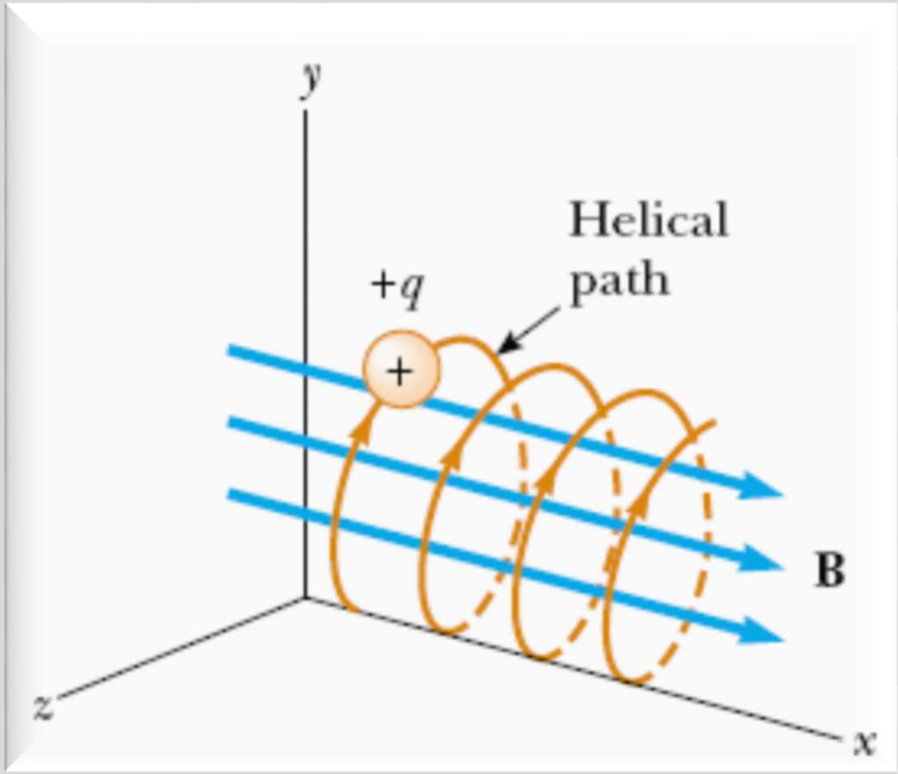
$$(NIA)B - \kappa\phi = 0$$

$$\phi = \frac{NAB}{\kappa} I$$

GALVANOMETER

Motion of a Charged Particle in a Uniform Magnetic Field



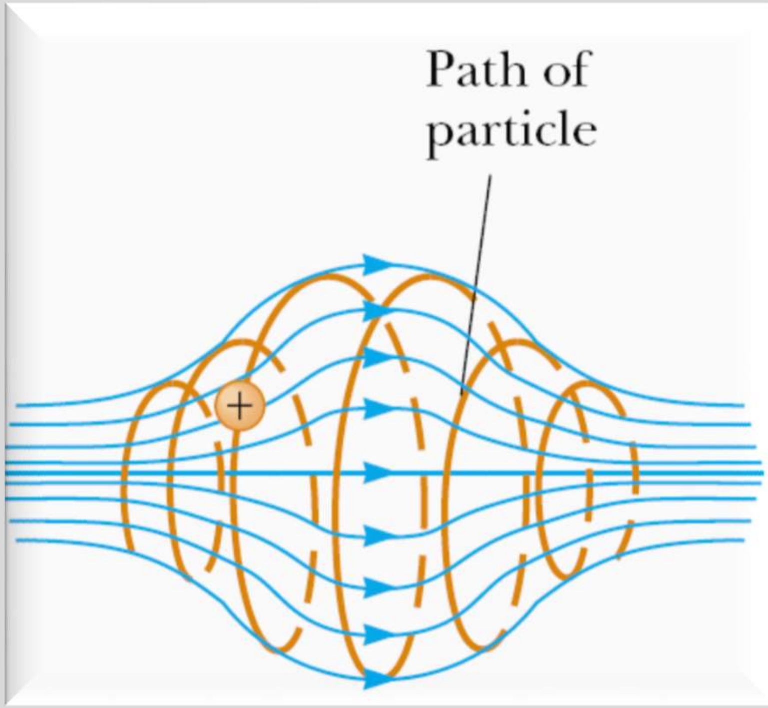


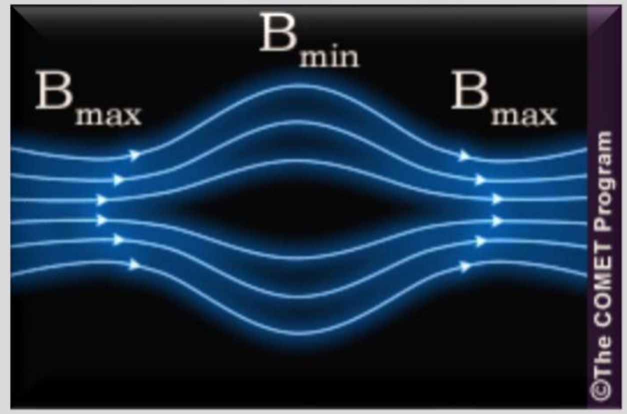
$$F_B = qvB = \frac{mv^2}{r}$$

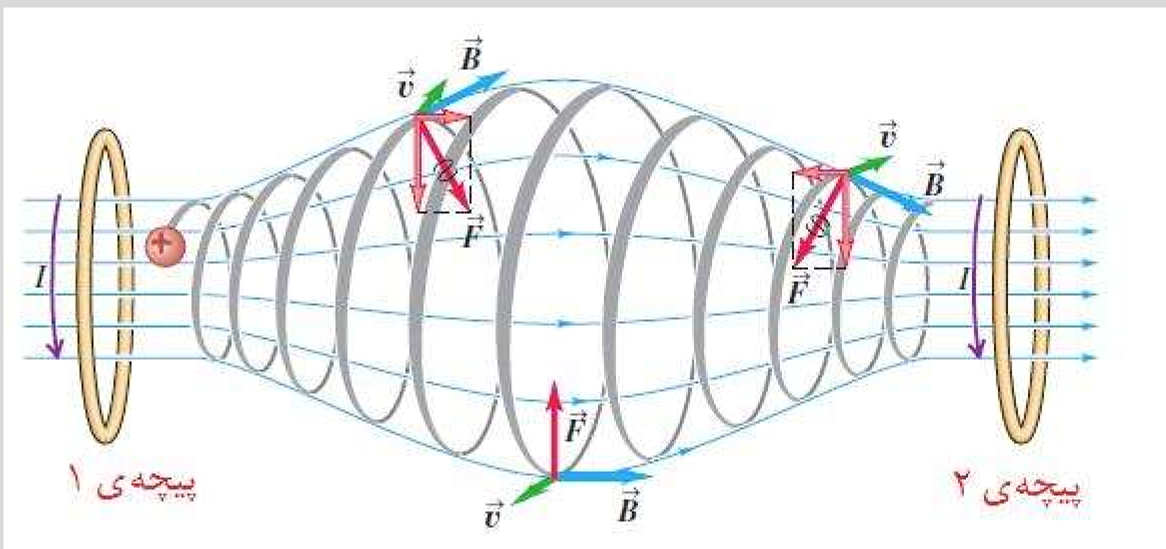
$$\omega = \frac{v}{r} = \frac{qB}{m}$$

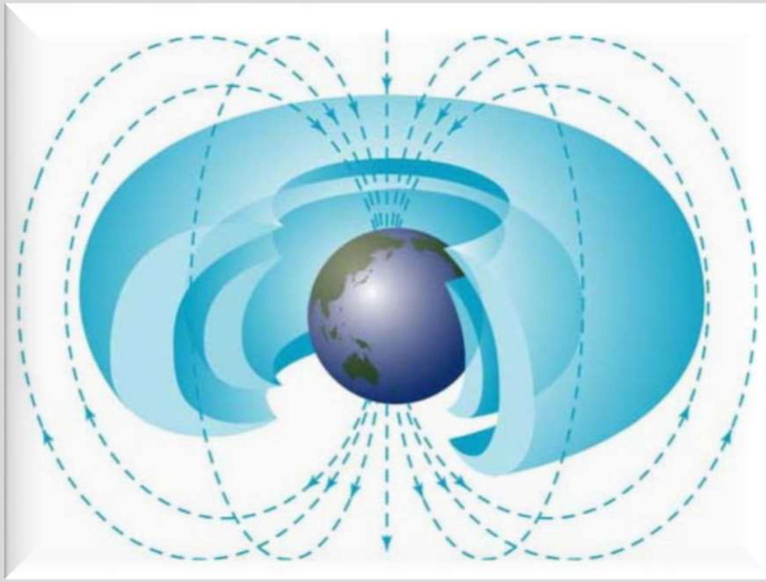
$$r = \frac{mv}{qB}$$

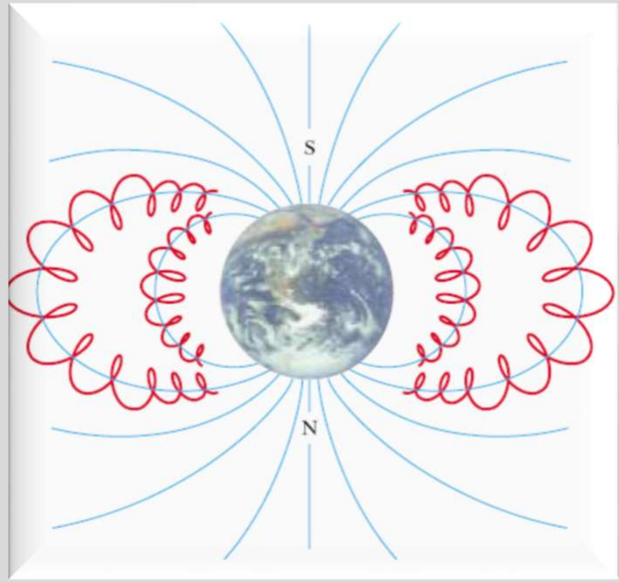
$$T = \frac{2\pi r}{v} = \frac{2\pi}{\omega} = \frac{2\pi m}{qB}$$

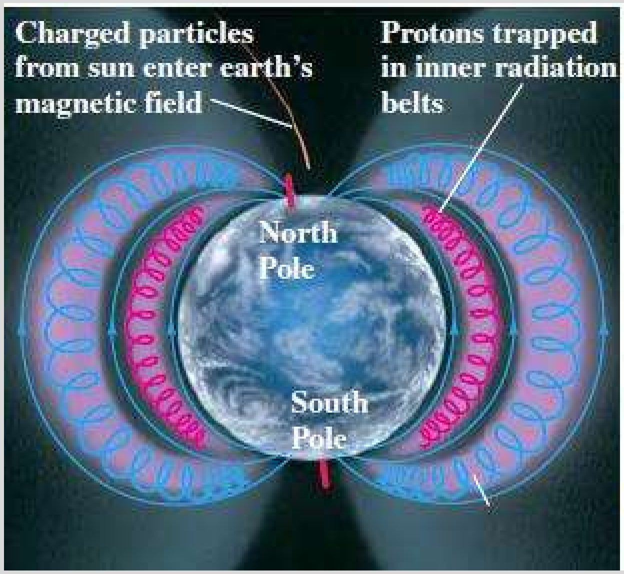

Path of
particle


B_{max}
B_{min}
B_{max}
©The COMET Program

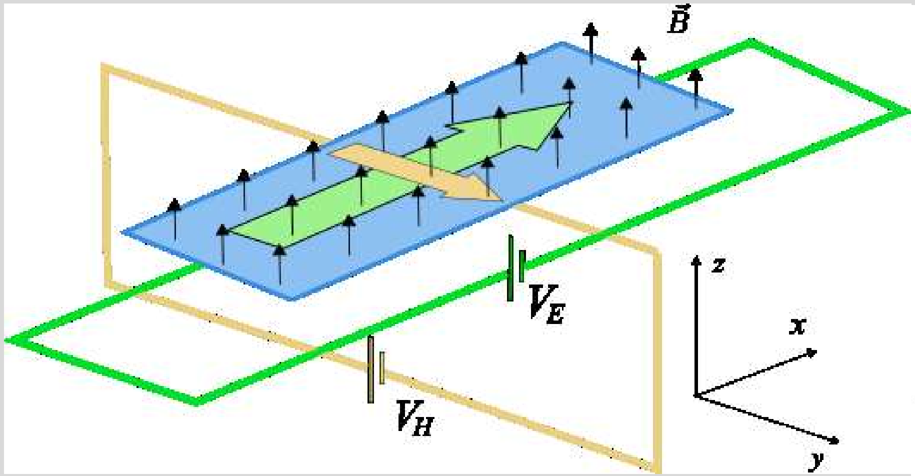

$\vec{B}$
$\vec{v}$
$\vec{F}$
I
پیچه‌ی ۱
پیچه‌ی ۲

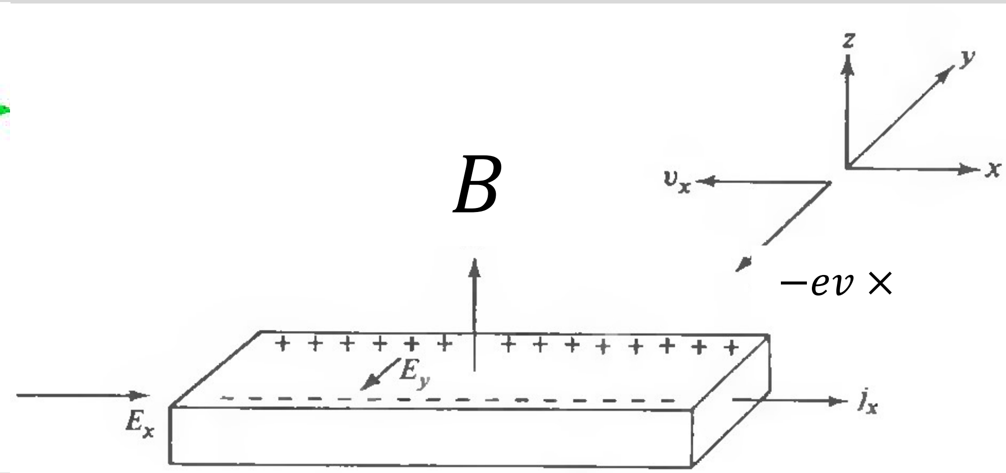



S
N


Charged particles from sun enter earth's magnetic field
Protons trapped in inner radiation belts
North Pole
South Pole

اثر هال کلاسیکی





$$\mathbf{B} = B\hat{\mathbf{k}}$$

$$E_y \propto BJ_x$$

$$\boxed{E_y = R_H B J_x}$$

$$\mathbf{J} = J_x\hat{\mathbf{i}}$$

$$\mathbf{F} = e\mathbf{V} \times \mathbf{B}$$

$$J_x = \sigma E_x$$

$$\frac{d\mathbf{P}}{dt} = \mathbf{F} - \frac{m}{\tau}\mathbf{V}$$

معادله حرکت ذره در داخل فلز:

$$\frac{d\mathbf{P}}{dt} = e\mathbf{E} + e\mathbf{V}\times\mathbf{B} - \frac{m}{\tau}\mathbf{V}$$

$$\frac{d\mathbf{P}}{dt} = e\left(E_x\hat{\mathbf{i}} + E_y\hat{\mathbf{j}}\right) + e\left(V_x\hat{\mathbf{i}}\right)\times B\hat{\mathbf{k}} - \frac{m}{\tau}V_x\hat{\mathbf{i}}$$

$$\mathbf{J} = J_x\hat{\mathbf{i}}$$

$$J_x = \rho V_x = enV_x$$

$$V_x = J_x / en$$

$$\frac{d\mathbf{P}}{dt} = 0$$

در حالت تعادل داریم که:

$$0 = e\left(E_x\hat{\mathbf{i}} + E_y\hat{\mathbf{j}}\right) + e\left(\frac{J_x}{en}\right)B(-\hat{\mathbf{j}}) - \frac{m}{en\tau}J_x\hat{\mathbf{i}}$$

$$eE_x = \frac{m}{en\tau}J_x$$

$$eE_y = \frac{J_xB}{n}$$

$$eE_x = \frac{m}{en\tau} J_x$$

$$J_x = \frac{ne^2\tau}{m} E_x$$

$$J_x = \sigma_L E_x$$

$$\sigma_L = \frac{ne^2\tau}{m}$$

$$\rho_L = \frac{m}{ne^2\tau}$$

$$eE_y = \frac{J_x B}{n}$$

$$E_y = \frac{1}{en} J_x B$$

$$E_y = R_H B J_x$$

$$R_H = \frac{1}{en}$$

$$J_x = \frac{1}{R_H B} E_y = \sigma_T E_y$$

$$\rho_T = \frac{B}{en}$$

چون ضریب هال به بار حامل جریان بستگی دارد، هال به طور تجربی نتیجه گرفت که حاملها باید الکترون باشند، زیرا:

چون میدان عرضی هال و در نتیجه اختلاف پتانسیل هال (که به طور تجربی قابل اندازه گیری است) به این ضریب وابسته به بار بستگی دارند

$$E_y = R_H B J_x$$