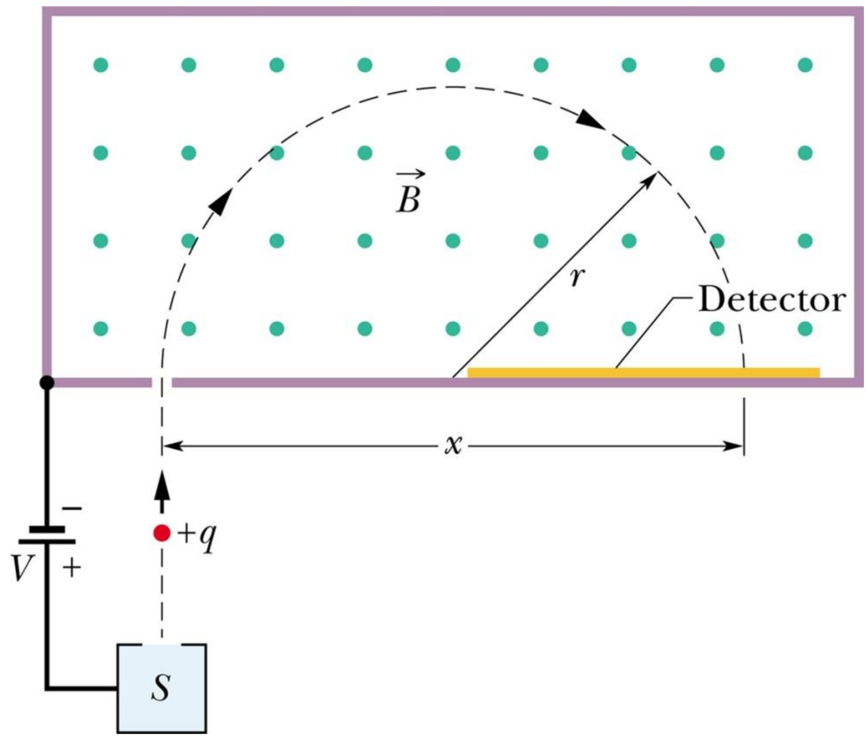
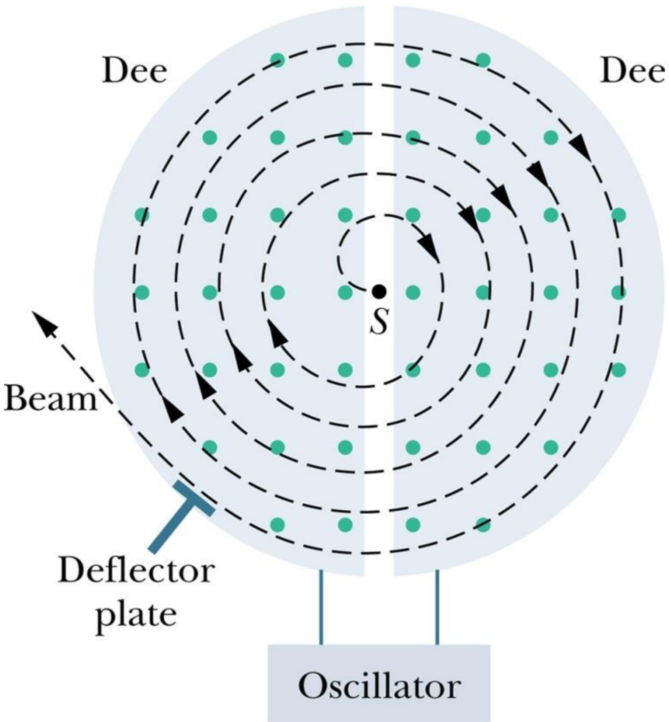
Copyright statement

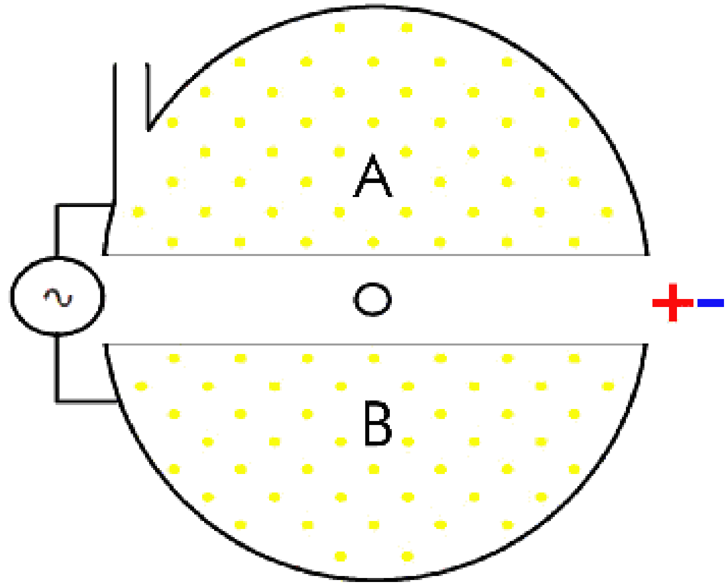
- The images and the pictures in this lecture are provided by the CDs accompanied by the books
  1. University Physics, Bauer and Westfall, McGraw-Hill, 2011.
  2. Principles of Physics, Halliday, Resnick, and Walker, Wiley, 8th and 9th Ed.
- The rest is made by me.

Mass spectrometer



Cyclotron

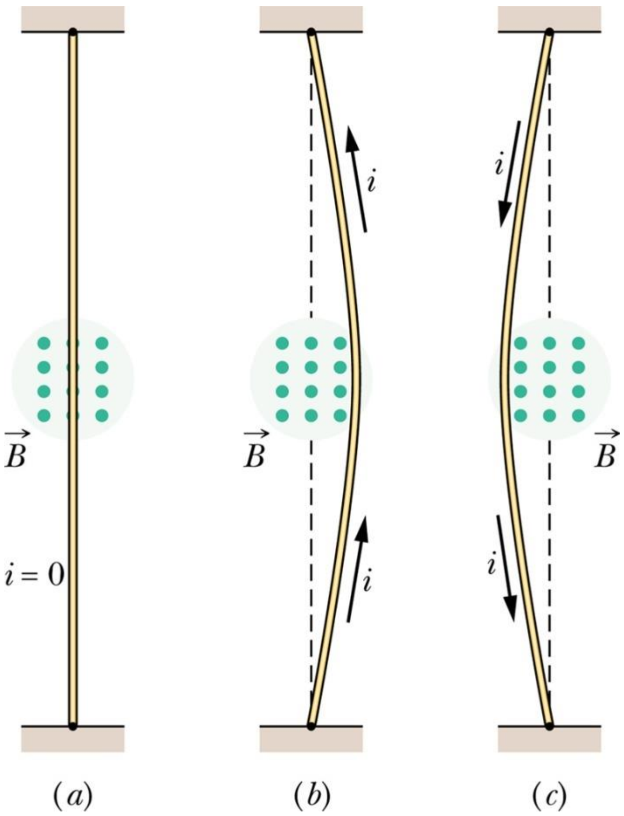


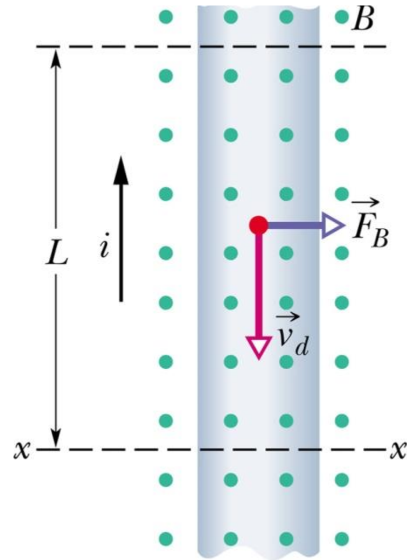


$$f = f_{\text{osc}}$$

$$|q|B = 2\pi m f_{\text{osc}}$$

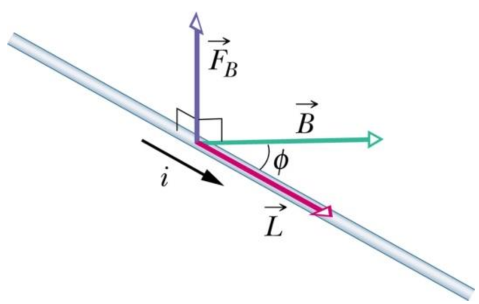
Magnetic force on a current-carrying wire





$$q = it = i\frac{L}{v_d}$$

$$\begin{aligned} F_B &= q v_d B \sin\phi \\ &= \frac{iL}{v_d} v_d B \\ &= iLB \end{aligned}$$

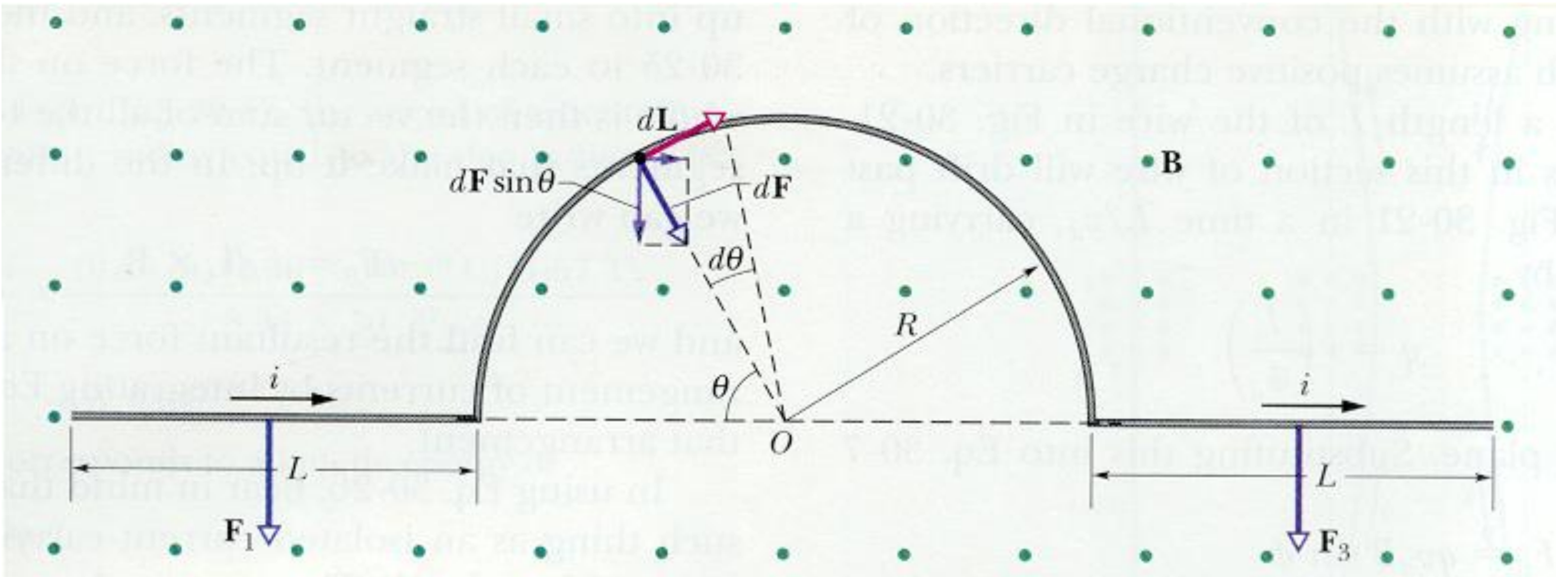


$$\vec{F}_B = i\vec{L} \times \vec{B}$$

$$F_B = iLB\sin\phi$$

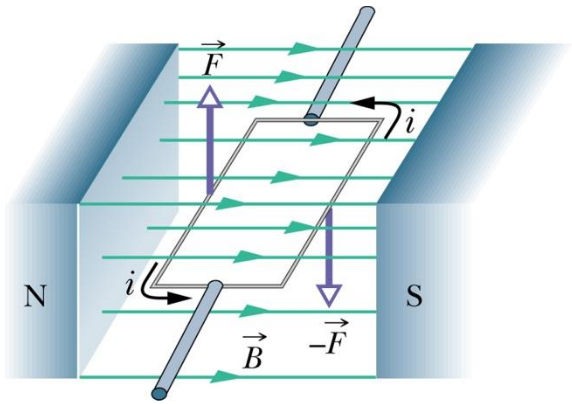
$$d\vec{F}_B = i d\vec{L} \times \vec{B}$$

Example



$d\mathbf{L}$
$d\mathbf{F} \sin\theta$
$d\mathbf{F}$
$d\theta$
θ
R
O
$\mathbf{B}$
i
i
L
L
$\mathbf{F}_1$
$\mathbf{F}_3$

Torque on a current-carrying loop



$$F_2 = ibB\sin(90^\circ - \theta) = ibB\cos\theta$$

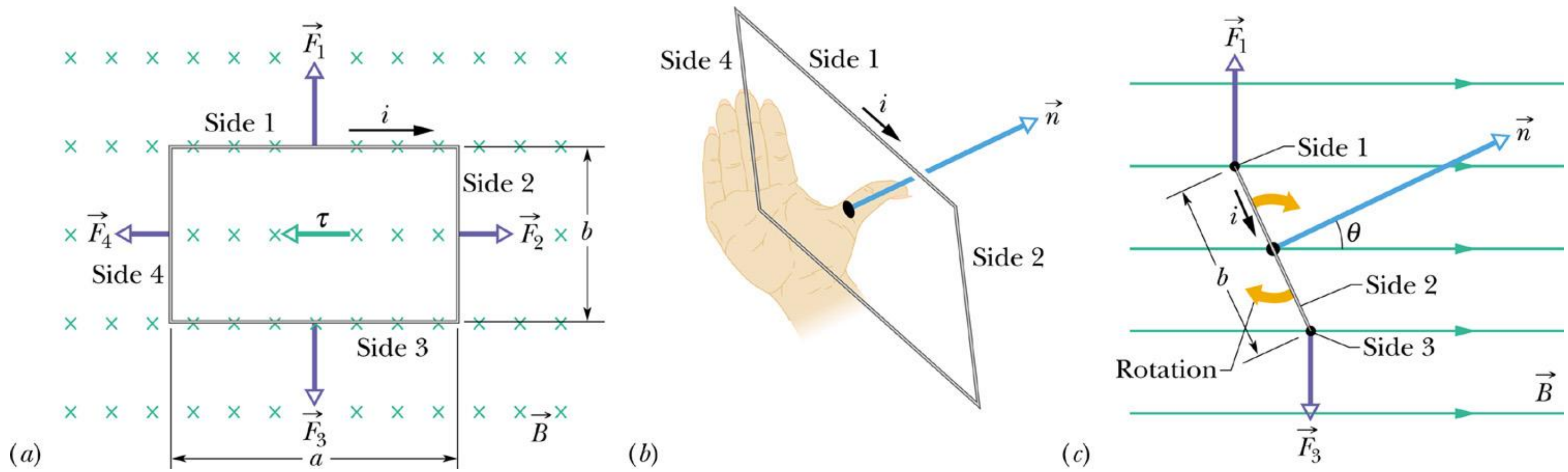
F_2, F_4 는 서로 상쇄됨.

$$\tau' = iaB\frac{b}{2}\sin\theta \times 2 = iabB\sin\theta$$

$$\tau = N\tau' = NiabB\sin\theta = (NiA)B\sin\theta$$

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

$$\vec{\mu} = Ni\vec{A}$$ Magnetic dipole moment



Magnetic dipole moment

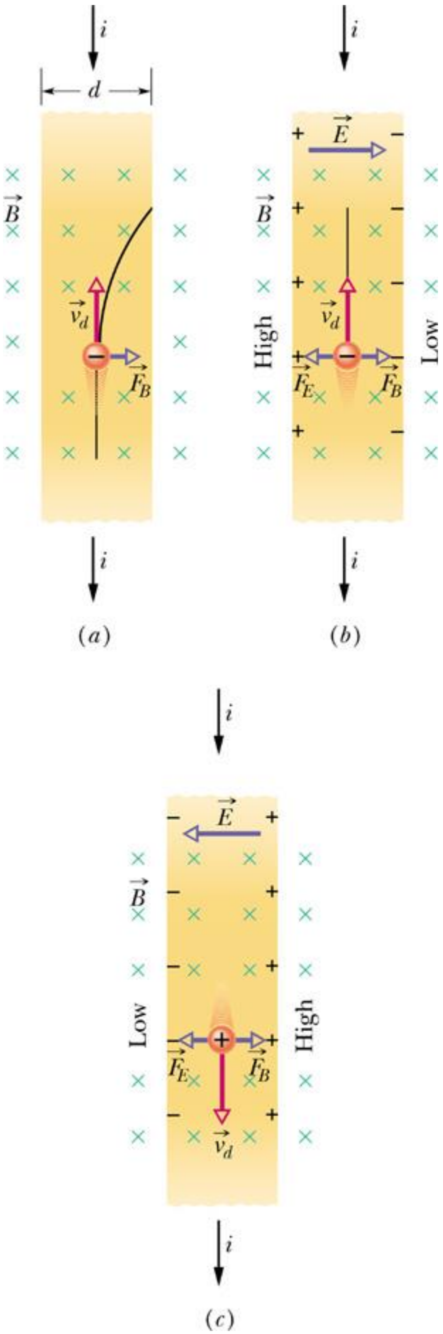
Magnetic dipole moment $\mu = NiA$

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

Magnetic potential energy $U(\theta) = -\vec{\mu} \cdot \vec{B}$

- Electric potential energy of an electric dipole $U(\theta) = -\vec{p} \cdot \vec{E}$

Hall effect



Potential difference: $V = Ed$

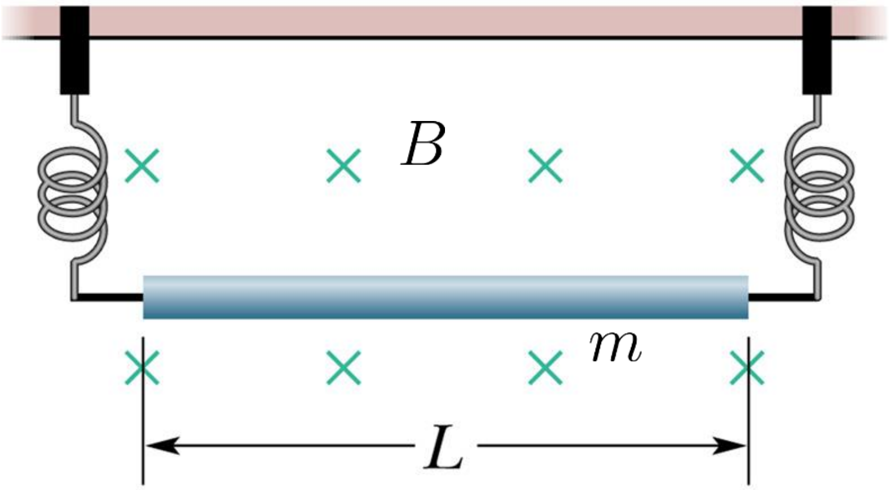
$$eE = ev_d B$$

$$v_d = \frac{J}{ne} = \frac{i}{neA}$$

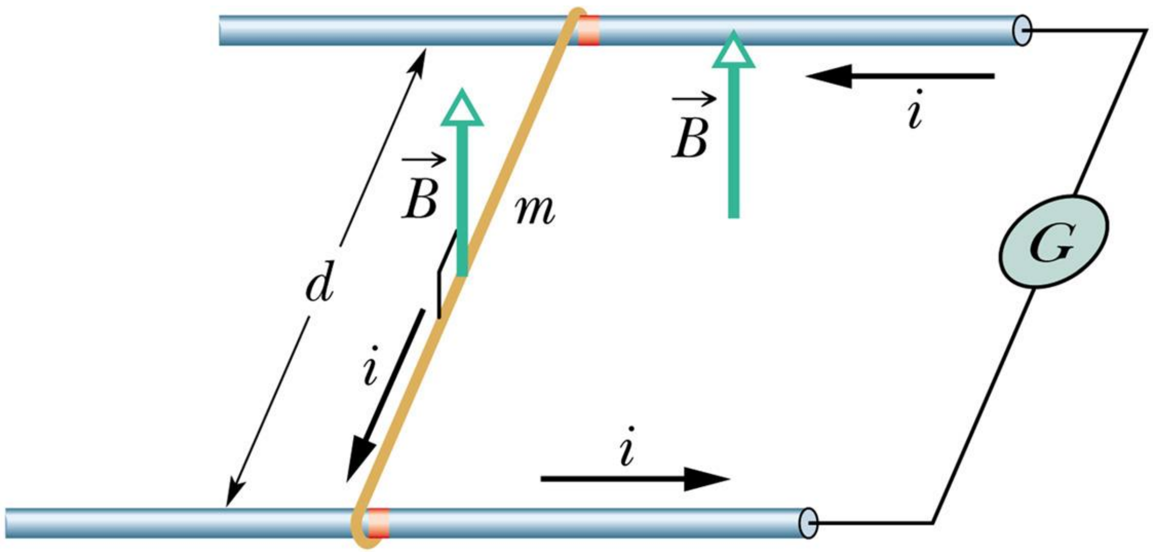
$$n = \frac{Bi}{Vle}$$

$$l = \frac{A}{d}$$

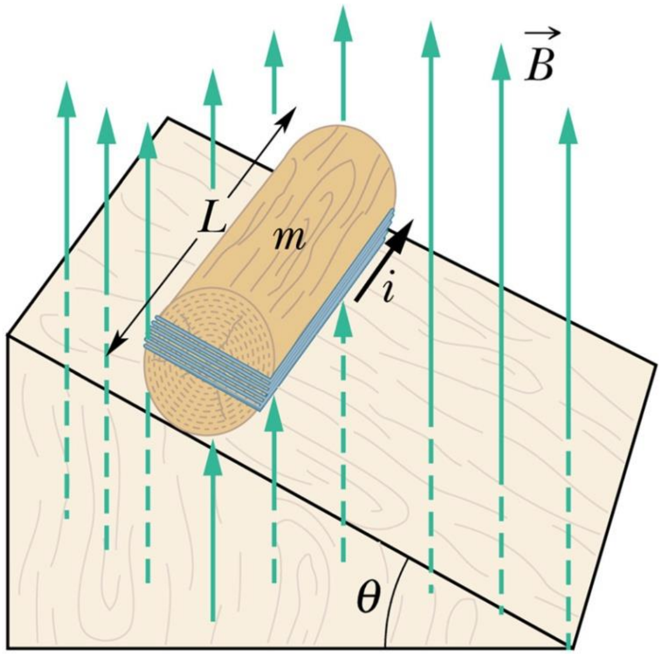
Problem 1



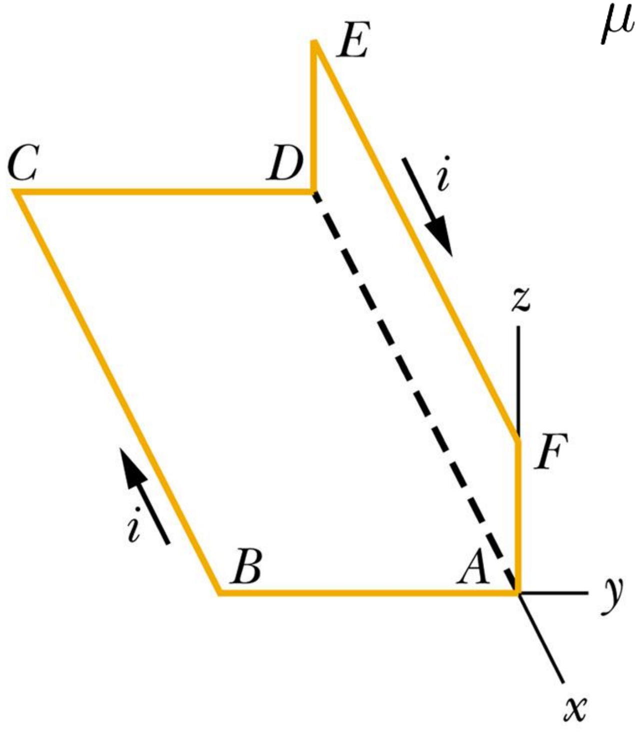
Problem 2



Problem 3

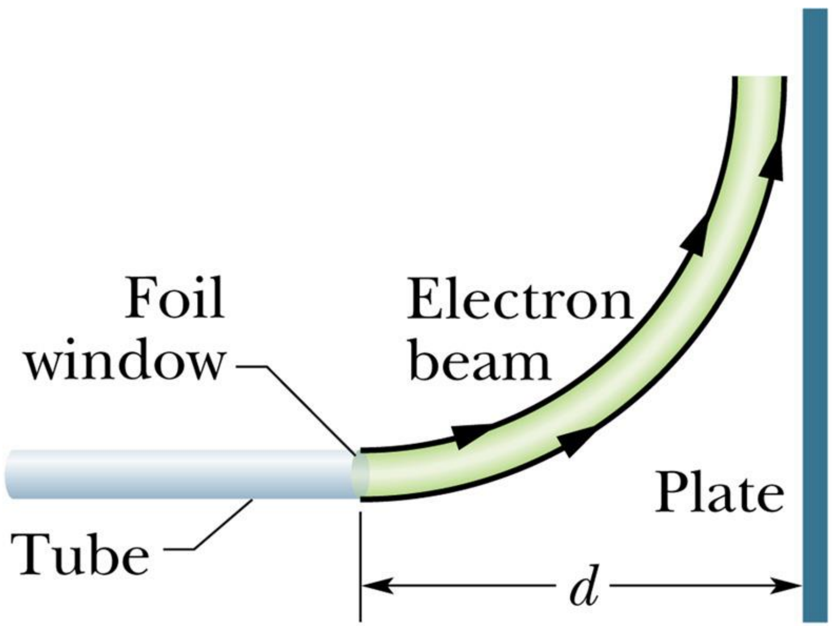


Problem 4



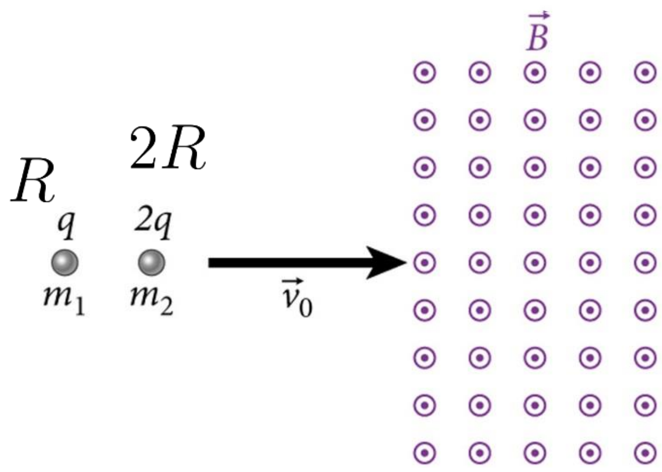
$\vec{\mu} = ?$

Problem 5



$$B \geq \sqrt{\frac{2mK}{e^2 d^2}}$$

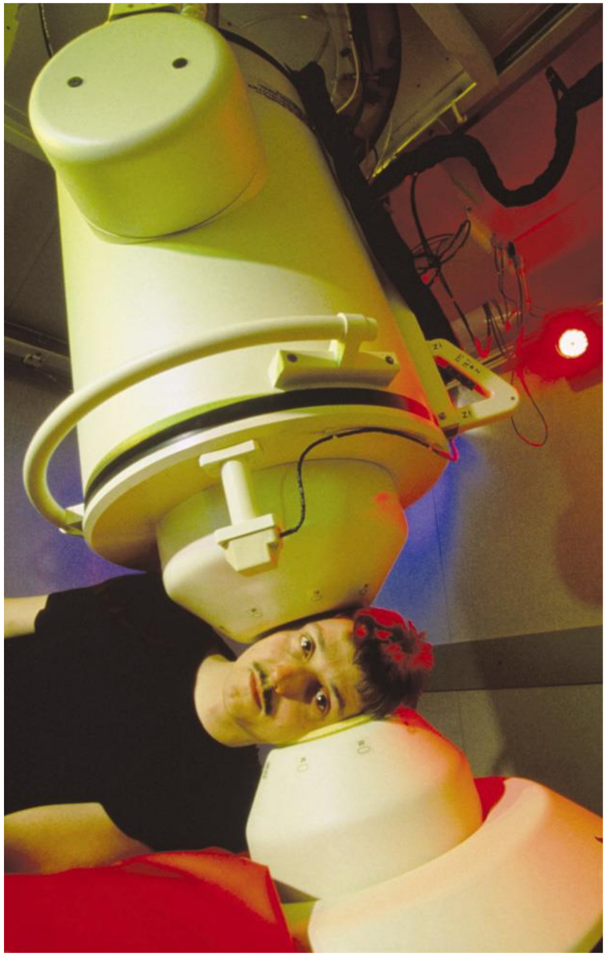
Problem 6



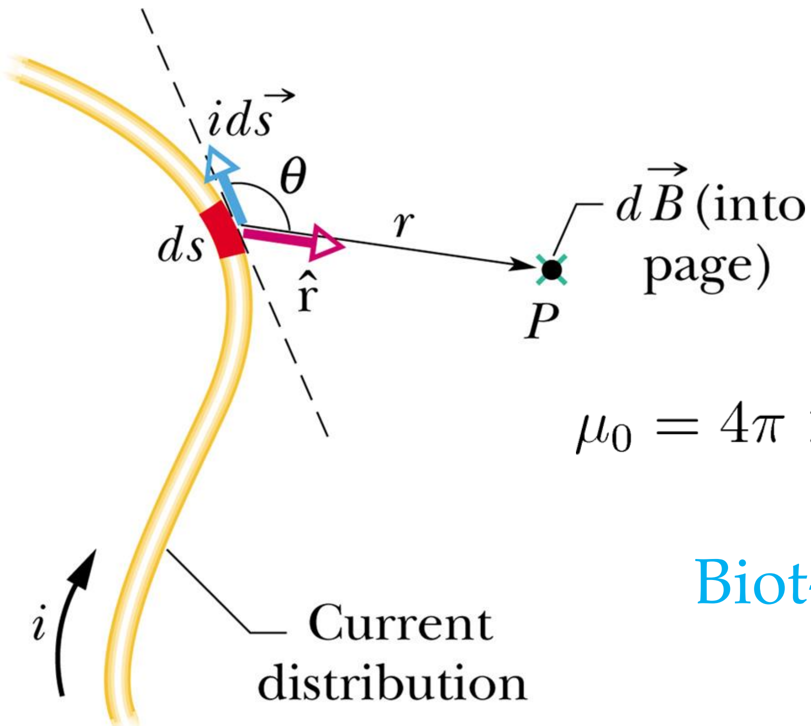
(1) m_1/m_2

(2) Common electric field to make them Move in straight lines?

Chap. 28 Magnetic fields of moving charges



Biot-Savart law



$$dB = \frac{\mu_0}{4\pi}\frac{i\,ds\sin\theta}{r^2}$$

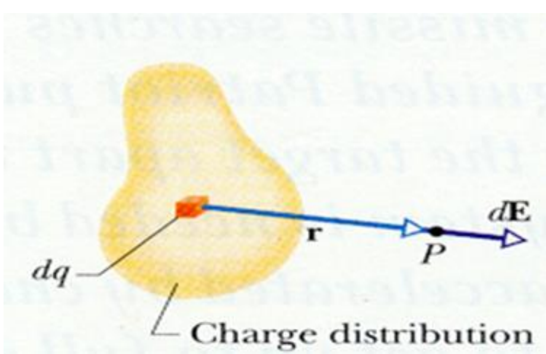
Magnetic permeability

$$\mu_0 = 4\pi \times 10^{-7}\ \mathrm{T\cdot m/A} = 1.26 \times 10^{-6}\ \mathrm{T\cdot m/A}$$

Biot-Savart law

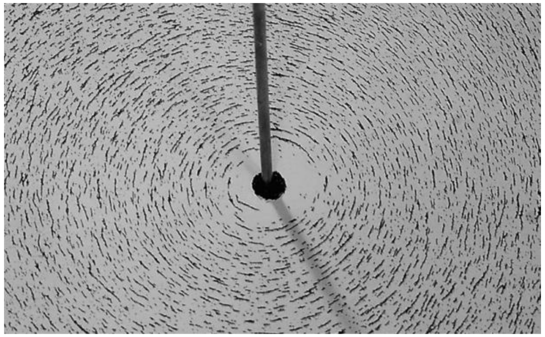
$$d\vec{B} = \frac{\mu_0}{4\pi}\frac{i\,d\vec{s}\times\vec{r}}{r^3}$$

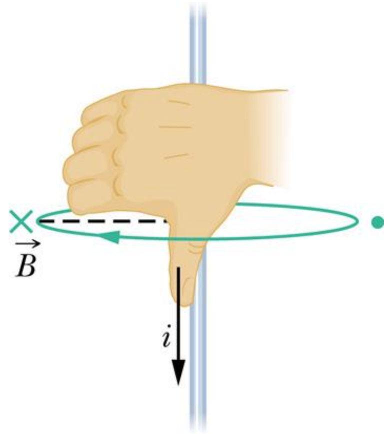
* Electric fields



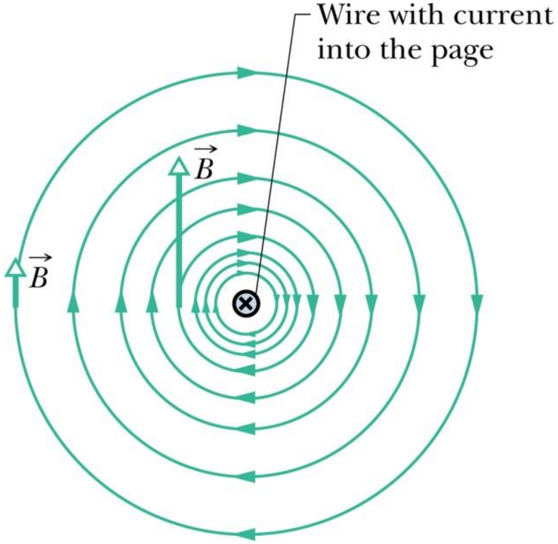
$$d\vec{E} = \frac{1}{4\pi\epsilon_0}\frac{dq\ \vec{r}}{r^3}$$

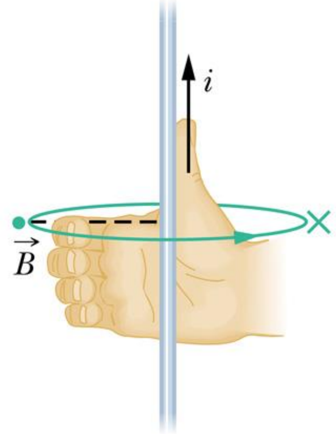
Magnetic field from a long, straight wire



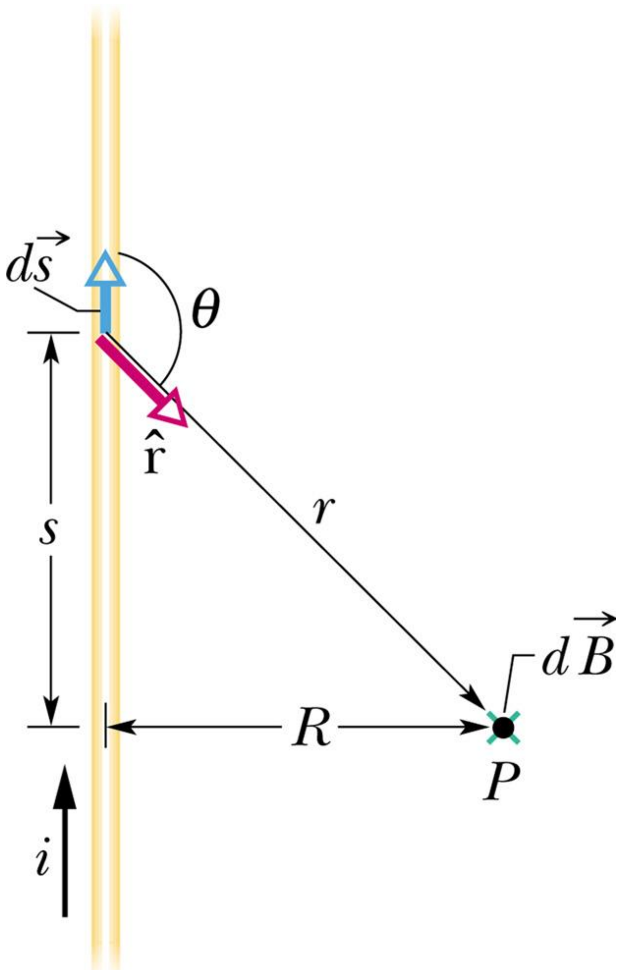


(a)





(b)



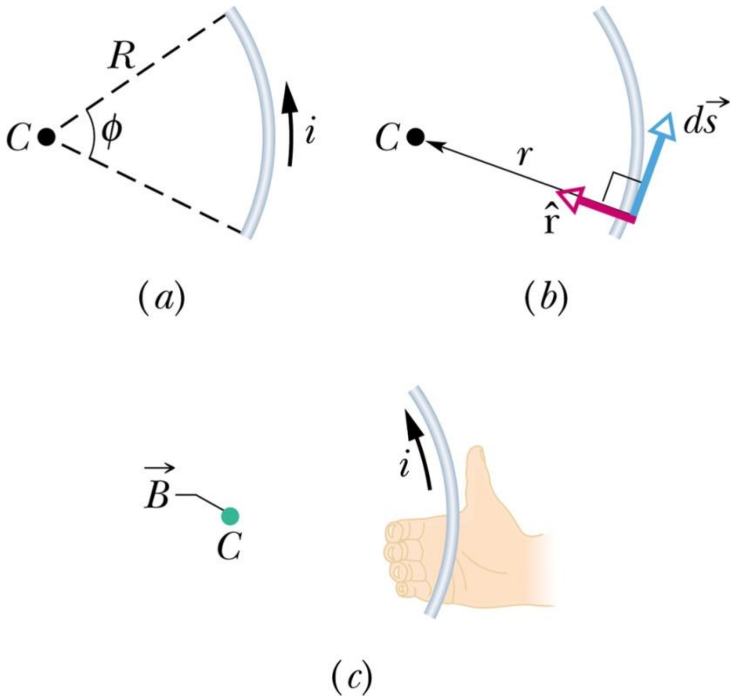
$$dB = \frac{\mu_0}{4\pi} \frac{i\, ds \sin\theta}{r^2}$$

$$B = 2\int_0^\infty dB = \frac{\mu_0 i}{2\pi} \int_0^\infty \frac{\sin\theta ds}{r^2}$$

$$= \frac{\mu_0 i}{2\pi} \int_0^\infty \frac{R\, ds}{(s^2 + R^2)^{3/2}}$$

$$= \frac{\mu_0 i}{2\pi} \left[\frac{s}{(s^2 + R^2)^{1/2}} \right]_0^\infty = \frac{\mu_0 i}{2\pi R}$$

Magnetic field due to current through an arc



(a) (b) (c)

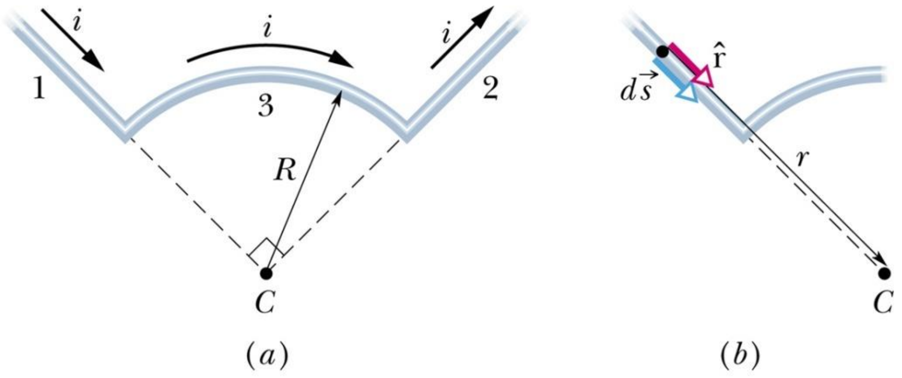
$$dB = \frac{\mu_0}{4\pi}\frac{i\,ds\sin 90^\circ}{R^2} = \frac{\mu_0}{4\pi}\frac{i\,ds}{R^2}$$

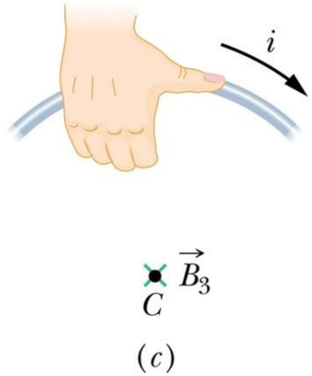
$$B = \int dB = \int_0^\phi \frac{\mu_0}{4\pi}\frac{iRd\phi}{R^2} = \frac{\mu_0 i}{4\pi R}\int_0^\phi d\phi = \frac{\mu_0 i\phi}{4\pi R}$$

원형 도선의 경우 중심에서는

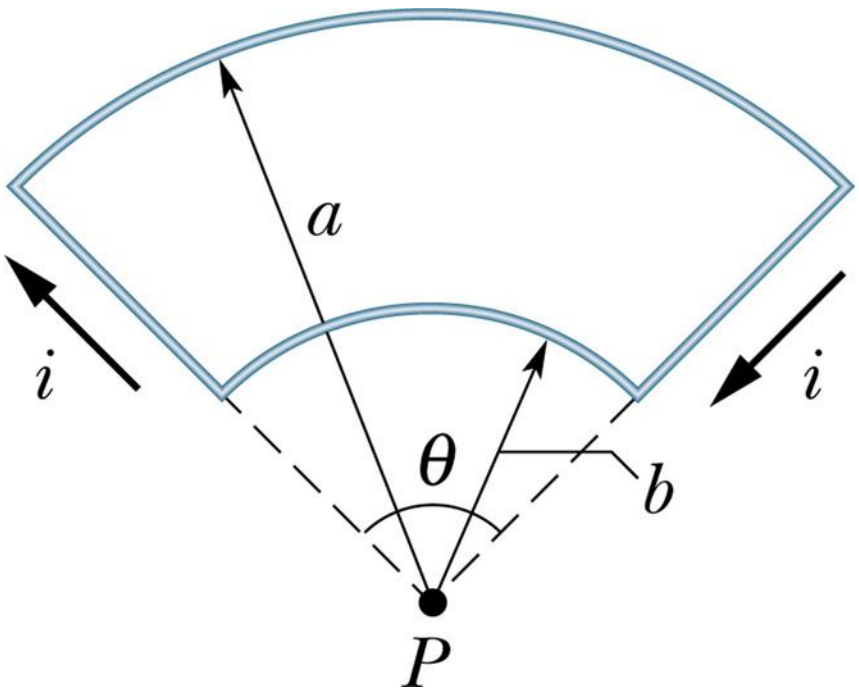
$$B = \frac{\mu_0 i}{2R}$$

Example

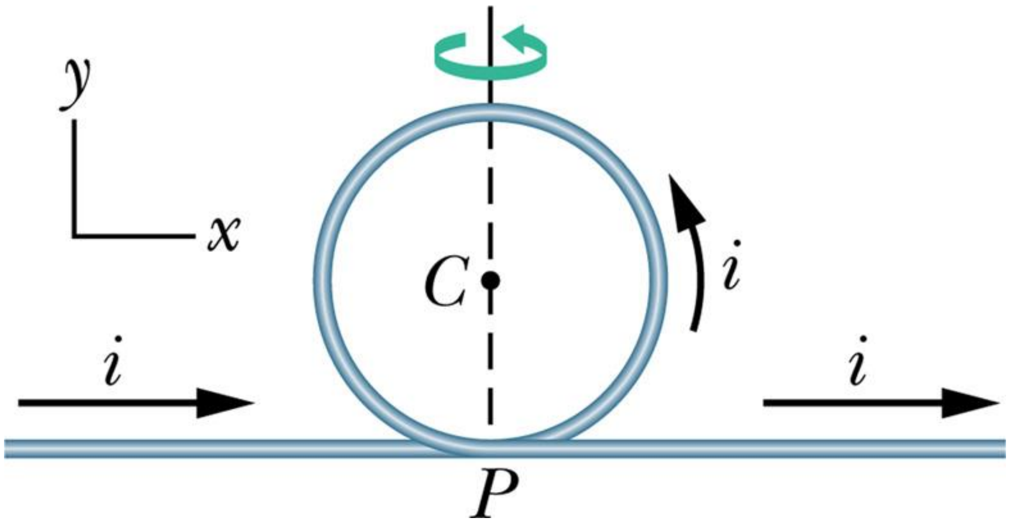




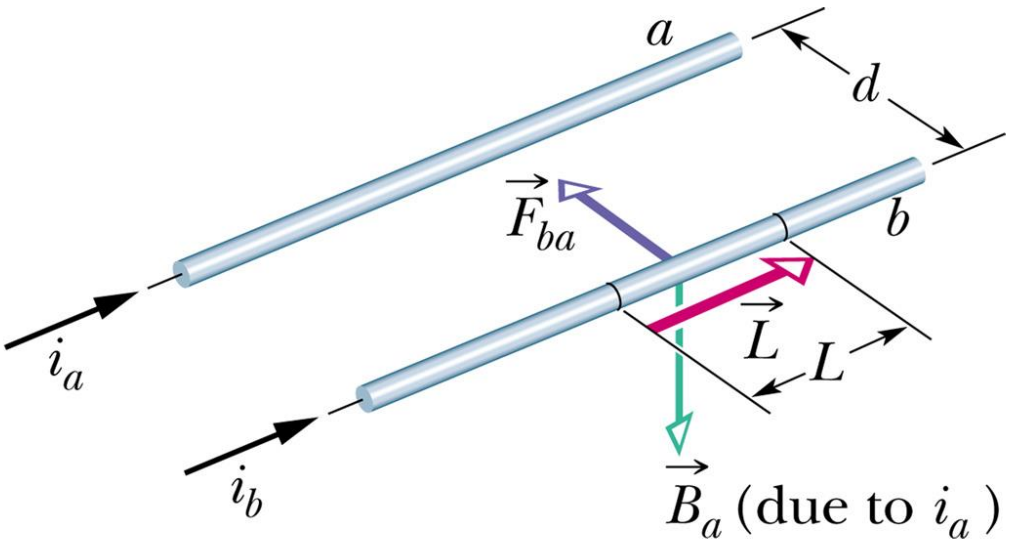
Problem



Problem



Force between two parallel wires

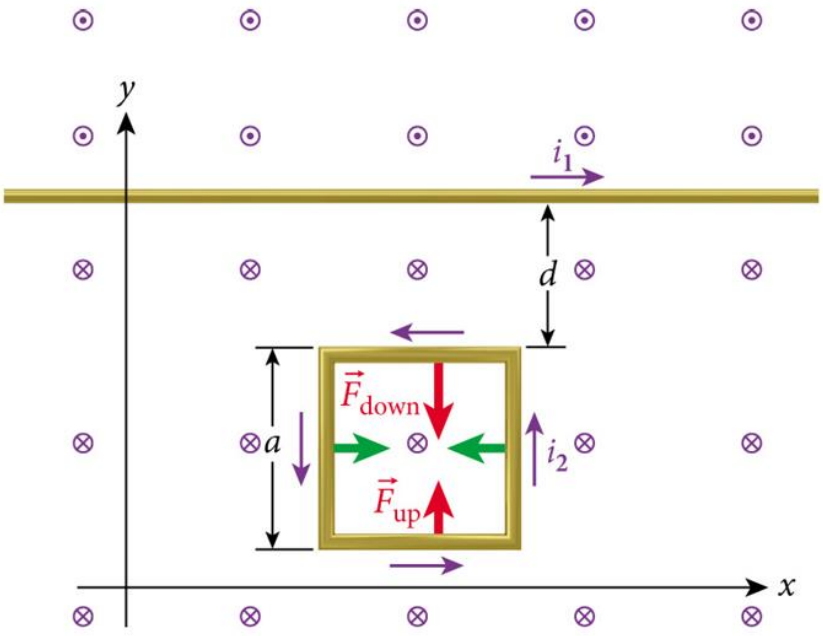


$$B_a = \frac{\mu_0 i_a}{2\pi d}$$

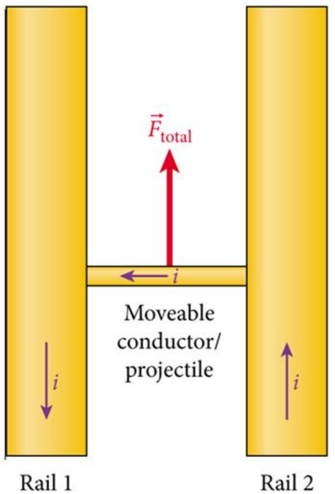
$$\vec{F}_{ba} = i_b \vec{L} \times \vec{B}_a \qquad F_{ba} = i_b B_a \sin 90^\circ = \frac{\mu_0 L i_a i_b}{2\pi d} = F_{ab}$$

전류 방향이 같으면 잡아당기고, 다르면 밀어낸다.

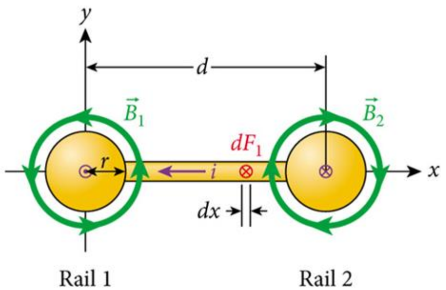
Example 28.1 Force on a loop



S.P. 28.1 Electromagnetic rail accelerator



(a)



(b)

$$K = \frac{\mu_0 L i^2}{\pi} \ln \frac{d-r}{r}$$