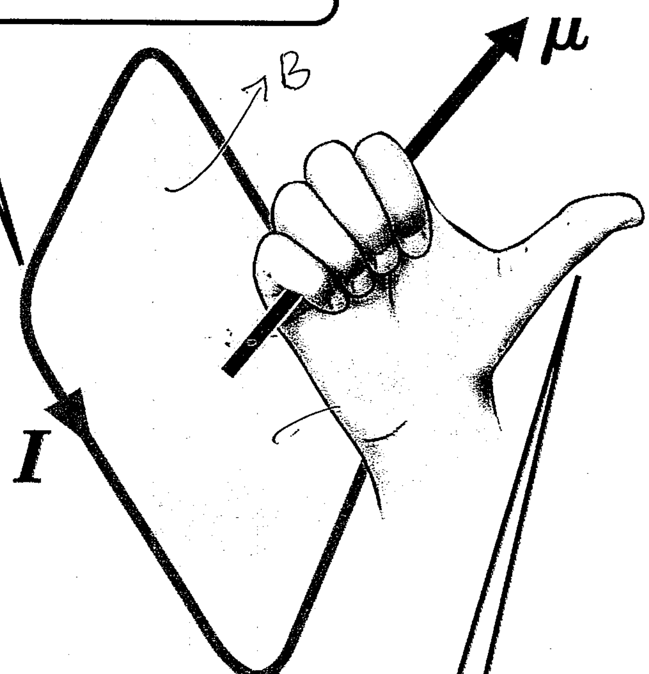
Lecture # 16

Faraday's Law

Direction of magnetic dipole



N-pole $\vec{B}$ comes out of loop in direction of thumb

1. $\vec{\mu} = I\vec{A}$; single loop
2. $\vec{\mu} = NI\vec{A}$; N-identical loops (coil)
3. $\vec{\mu} = NI\vec{A}(1+\chi)$

(if loops surround permeable material with susceptibility χ)

Figure 30-15 Physics for Engineers and Scientists 3/e

In which direction is the south pole of loop?

(a) into the page (b) up (c) down (d) out of the page

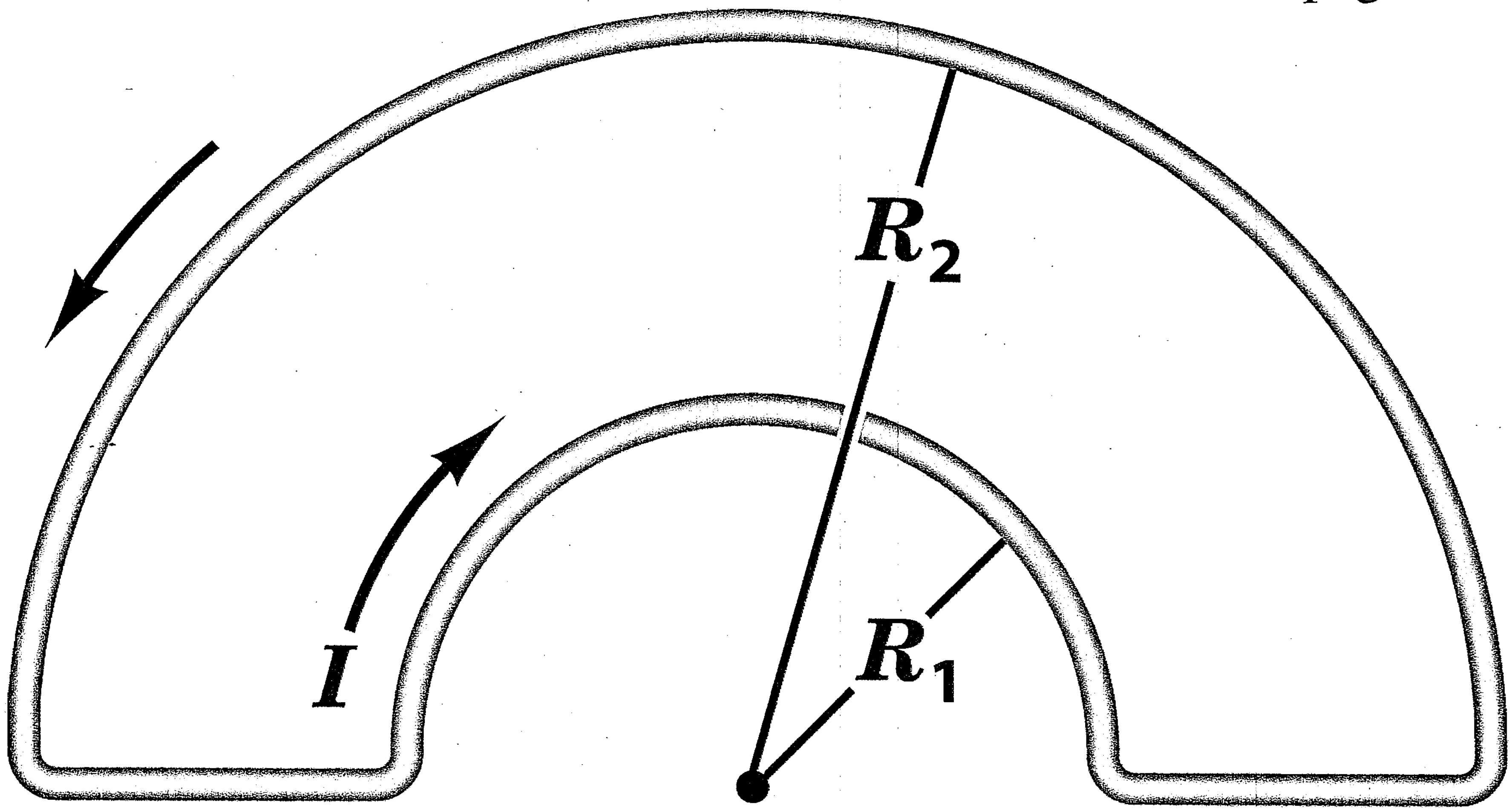


Figure 29-58 Physics for Engineers and Scientists 3/e

The magnitude of the magnetic moment is:

(a) $I\pi(R_2^2 - R_1^2)$ (b) $I\pi R_1 R_2$ (c) $I2\pi R_2^2$ (d) $I\pi(R_2^2 - R_1^2)/2$

(1)

True or False

The north pole of this loop is above and the south pole is below this figure.

(a) true (b) false

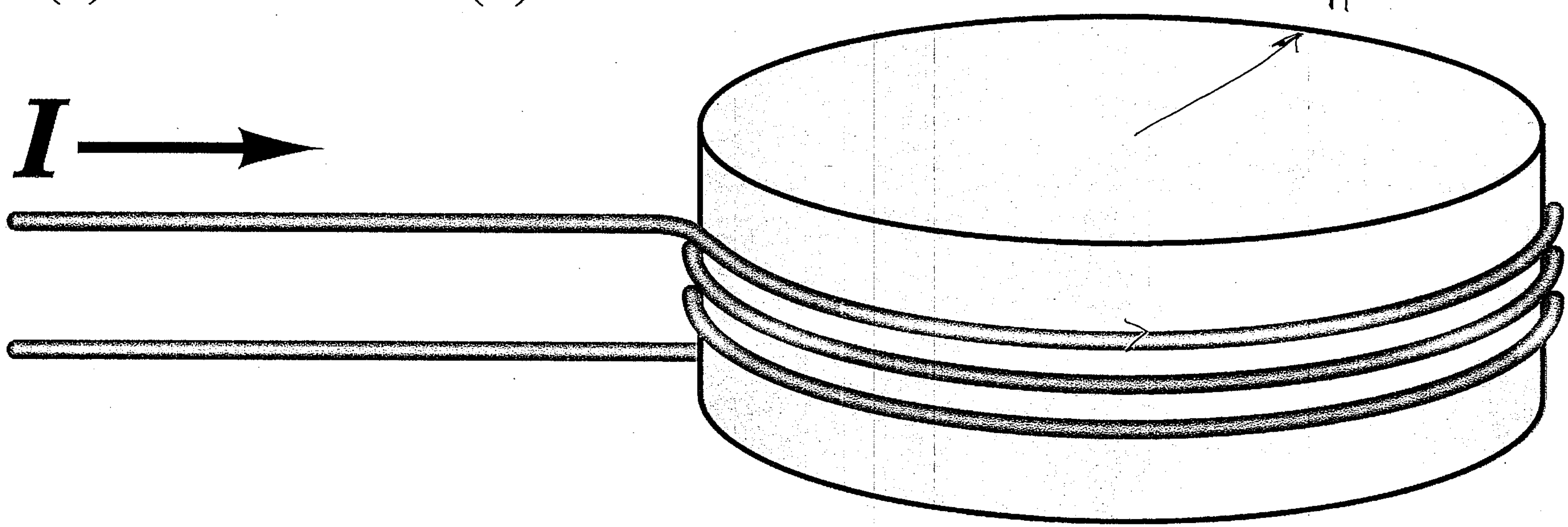


Figure 29-45 Physics for Engineers and Scientists 3/e

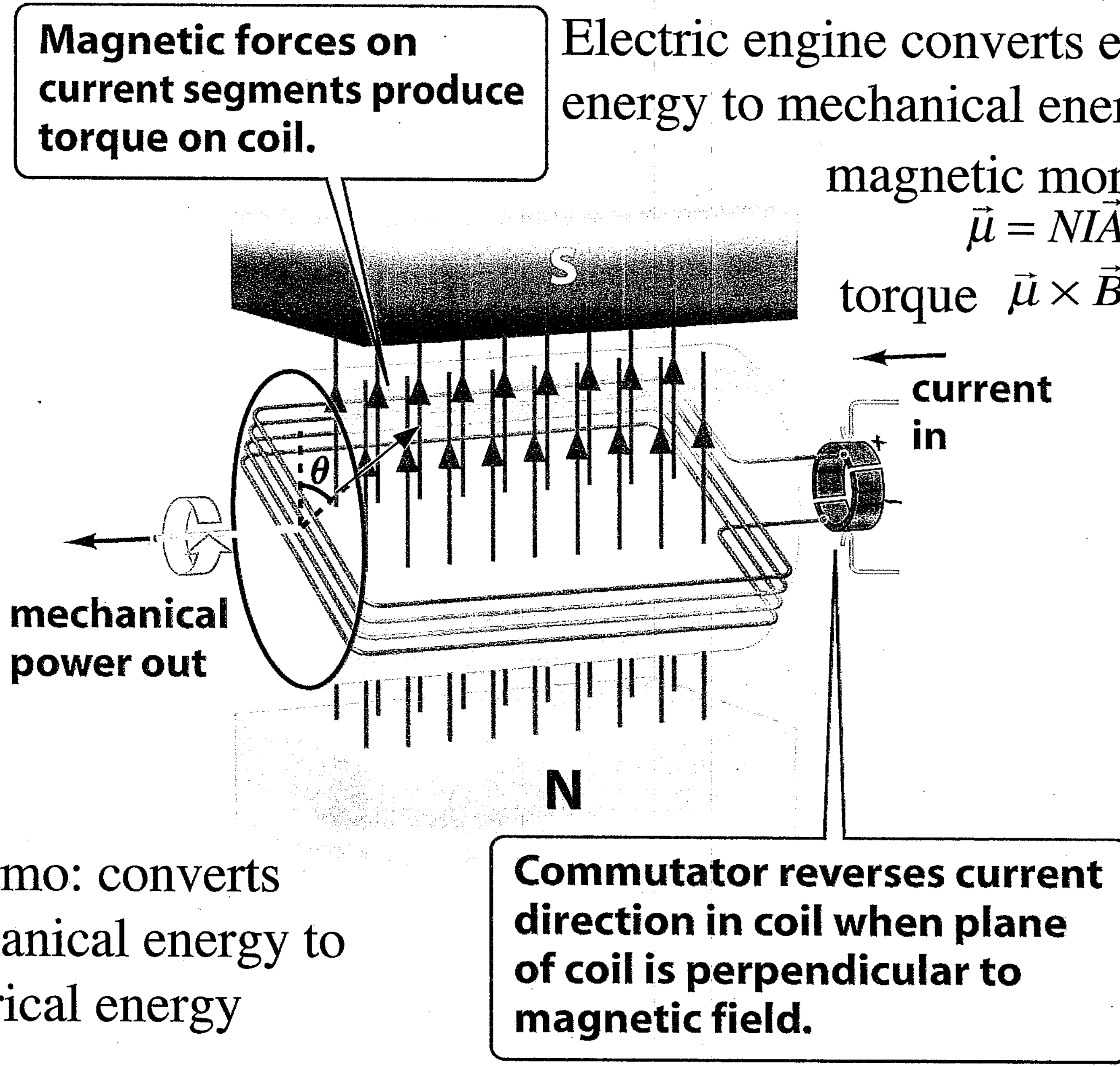
If R is the radius of this solenoid with a magnetic permeability μ, the magnitude of the magnetic moment is

$(a)\ I\pi R^2$ (b) $3I\pi R^2$ (c) $3I\pi R^2\mu / \mu_0$ $(d)\ I\pi R^2\mu / \mu_0$

Electric engine converts electrical energy to mechanical energy

magnetic moment
$\vec{\mu} = NI\vec{A}$

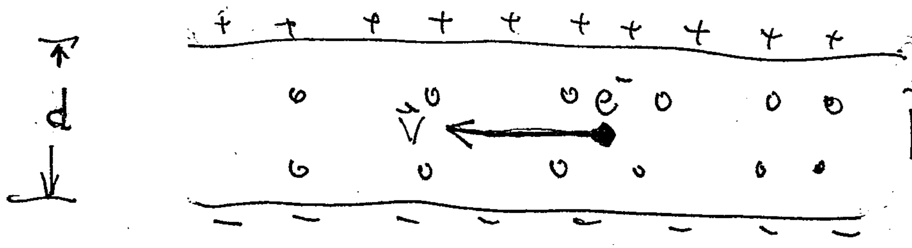
torque $\vec{\mu} \times \vec{B}$



Dynamo: converts mechanical energy to electrical energy

Figure 30-16 Physics for Engineers and Scientists 3/e

In terms of $\vec{v}$, $\vec{B}$ and d, what voltage is required for electron to pass through?



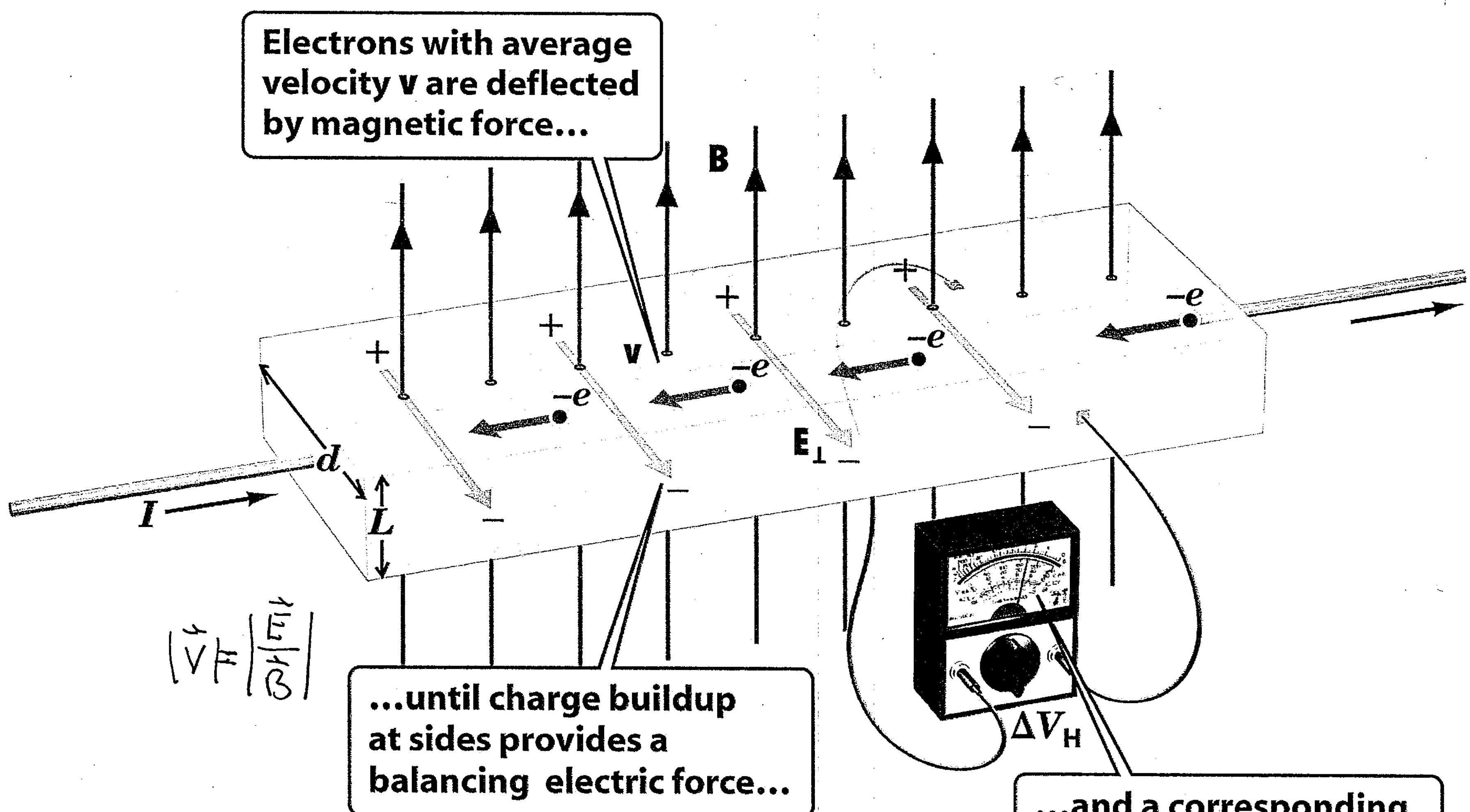
$\vec{B}$ (out of plane)

$$|\vec{v}| = \frac{E}{B}, \quad V = Ed$$

$$= B|\vec{v}|.d$$

Magnetic Field 'Forces' Electron down

Electric Field 'Forces" electron up



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

Figure 30-23 Physics for Engineers and Scientists 3/e

$$R_H = \frac{V}{I} = \frac{E\,d}{nveA} = \frac{E\,d}{n\frac{E}{B}eLd} = \frac{B}{neL} \equiv R_H$$

Magnetic Flux

$$\Phi_m = \int \vec{B} \cdot d\vec{A}$$

$$= B A \cos\theta$$

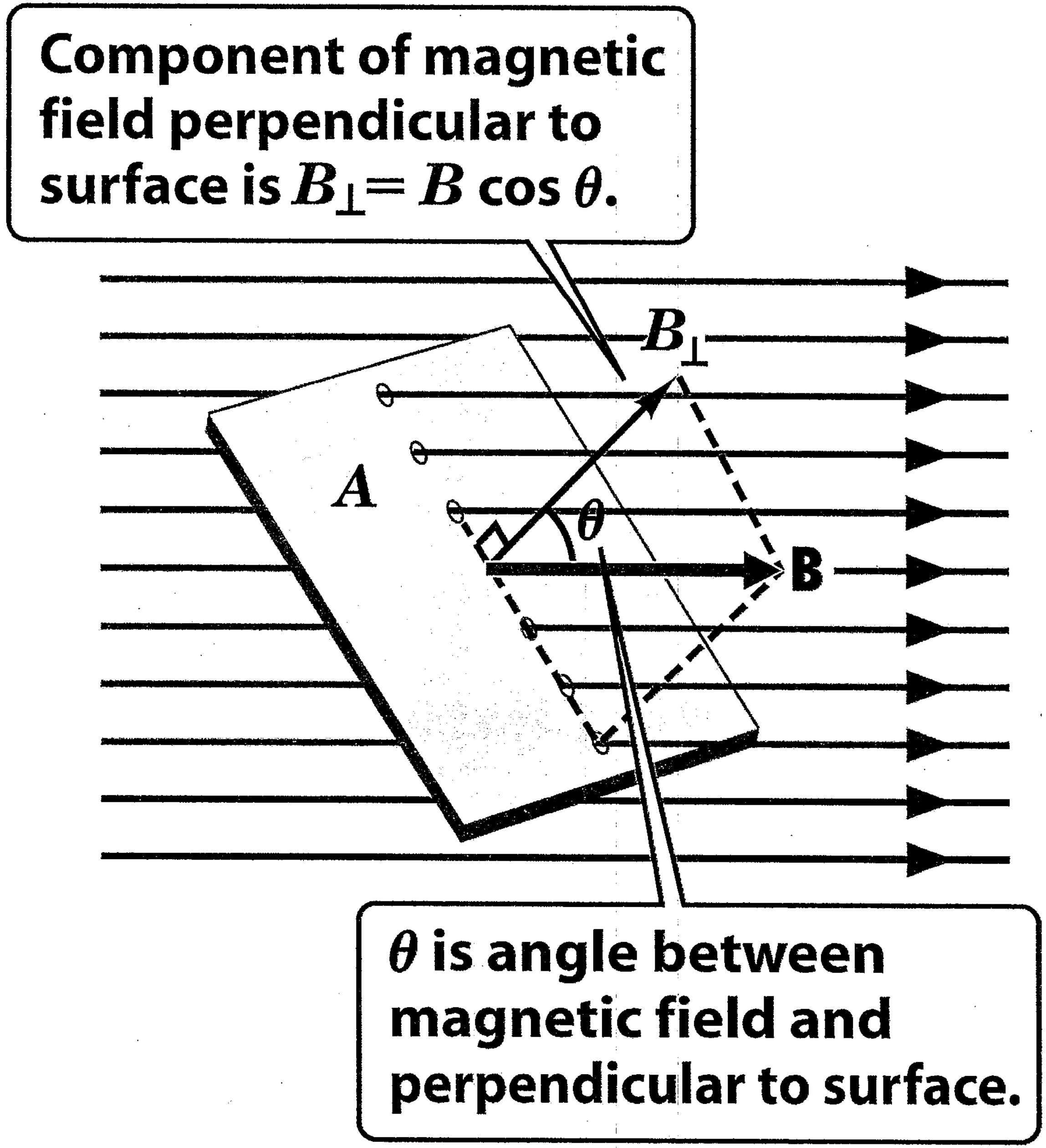


Figure 31-6 Physics for Engineers and Scientists 3/e

Faraday's Law

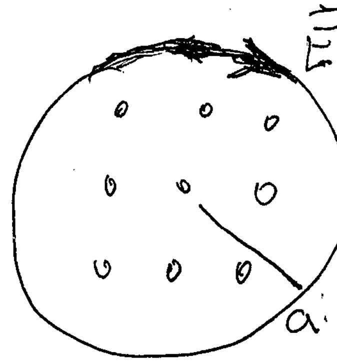
Magnetic Fields changing in time induce electric fields!

magnetic flux $\equiv \Phi_m = \int \vec{B} \cdot d\vec{A}$

$$\text{EMF} \equiv \oint d\vec{s} \cdot \vec{E} = -\frac{\partial \Phi_m}{\partial t}$$

↑ loop integral

$$B = B_0 + B_1\, t/T$$



$$\text{EMF} = \left| 2\pi a E_{ind} \right| = \frac{\partial \Phi_m}{\partial t}$$

$$= \frac{\partial}{\partial t}\left(B_0 + \frac{B_1 t}{T}\right)\pi a^2$$

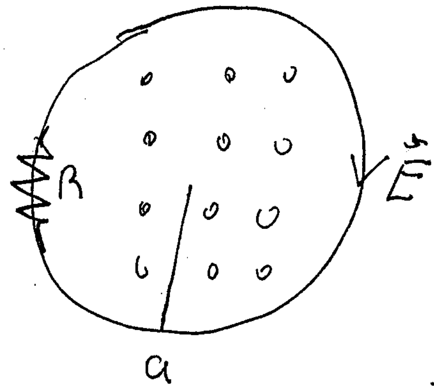
$$2\pi a E_{ind} = \pi B_1 a^2/T$$

$$2\pi E_{ind} = \frac{\pi B_1 a^2}{T}$$

$$E_{ind} = \frac{B_1 a}{2T}$$

Lenz's Law:

Induced Response resists change



Rising B-Field $B = B_0 + B_1 t/T$

Induced Electric Field attempts to prevent B-field from rising

Let loop at radius a have a resistance R.

Current is induced in the loop to produce magnetic field to 'buck' changing [illegible] rising magnetic fields

$$EMF = 2\pi a E = \pi a^2 B_1 / T$$

$$IR = \pi a^2 B_1/T$$

$$\boxed{I = \frac{\pi a^2 B_1}{TR}}$$

Motional EMF produces currents that resist change in enclosed magnetic flux

current in resistor

Motional EMF=IR

EMF=vBL

Thus I=vBL/R

Faraday's View

Change of B-flux

In loop in time t

$\Delta\Phi_m$ =vBtL

EMF=$d\,\Delta\Phi_m/dt$

=vBL

same EMF as motional EMF

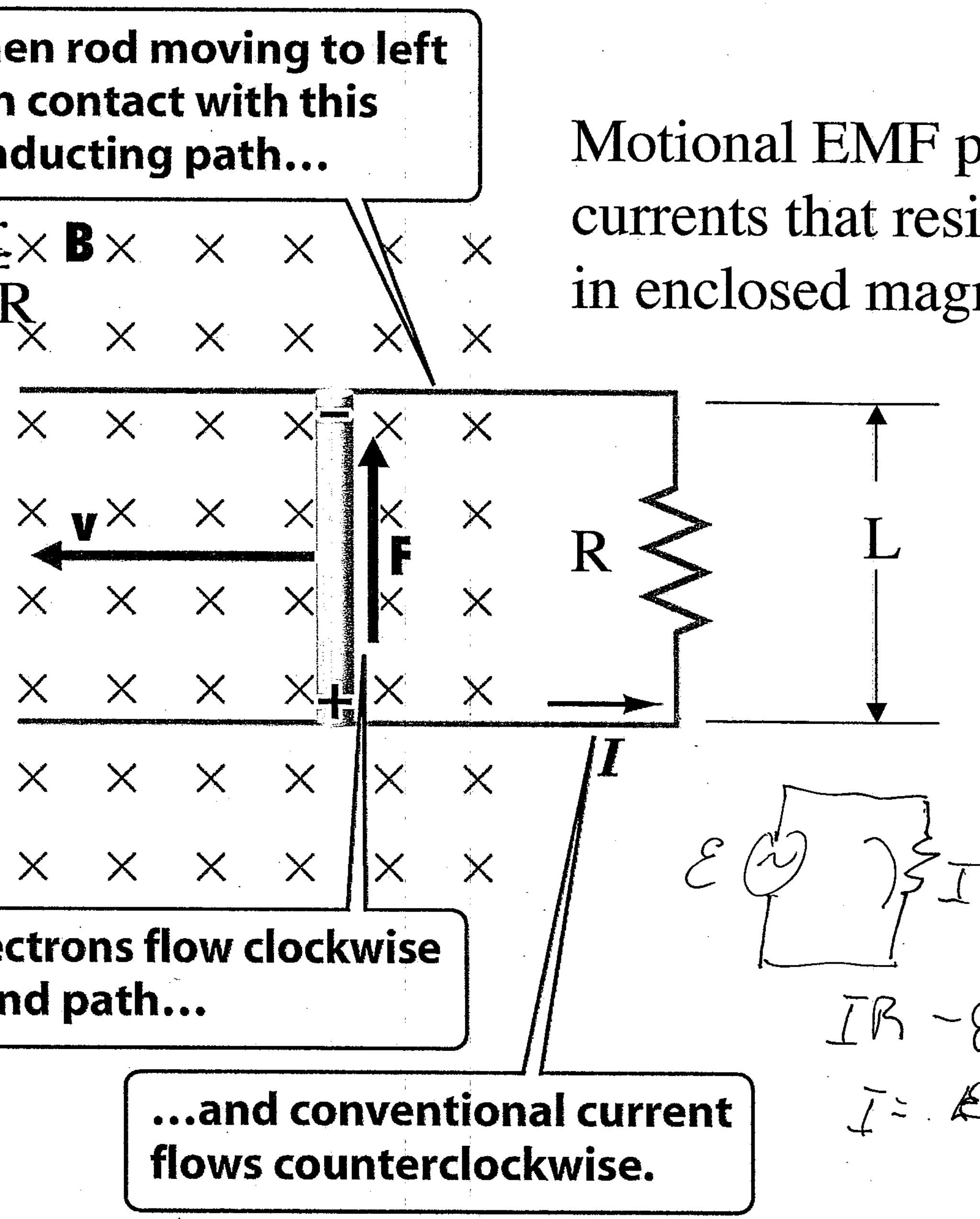


Figure 31-2 Physics for Engineers and Scientists 3/e

$IR - \mathcal{E} = 0$

$I = \mathcal{E}/R$

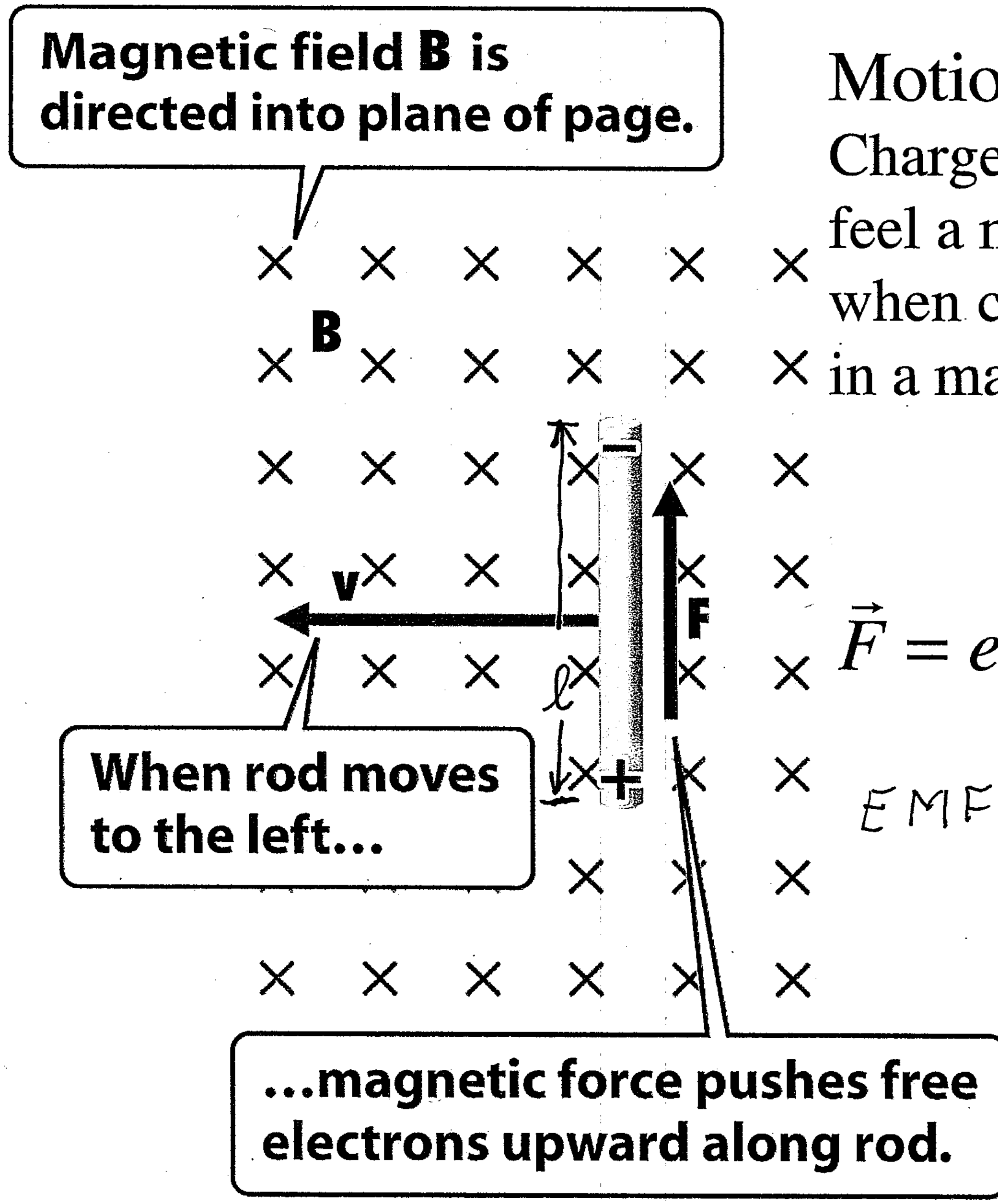


Figure 31-1 Physics for Engineers and Scientists 3/e

Motional EMF

Charges in a conductor feel a magnetic force when conductor moves in a magnetic field

$$\vec{F} = e\vec{v} \times \vec{B}$$

$$EMF = \frac{F}{e}\ell$$
$$= vB\ell$$