Lect. # 23

Magnetic Induction

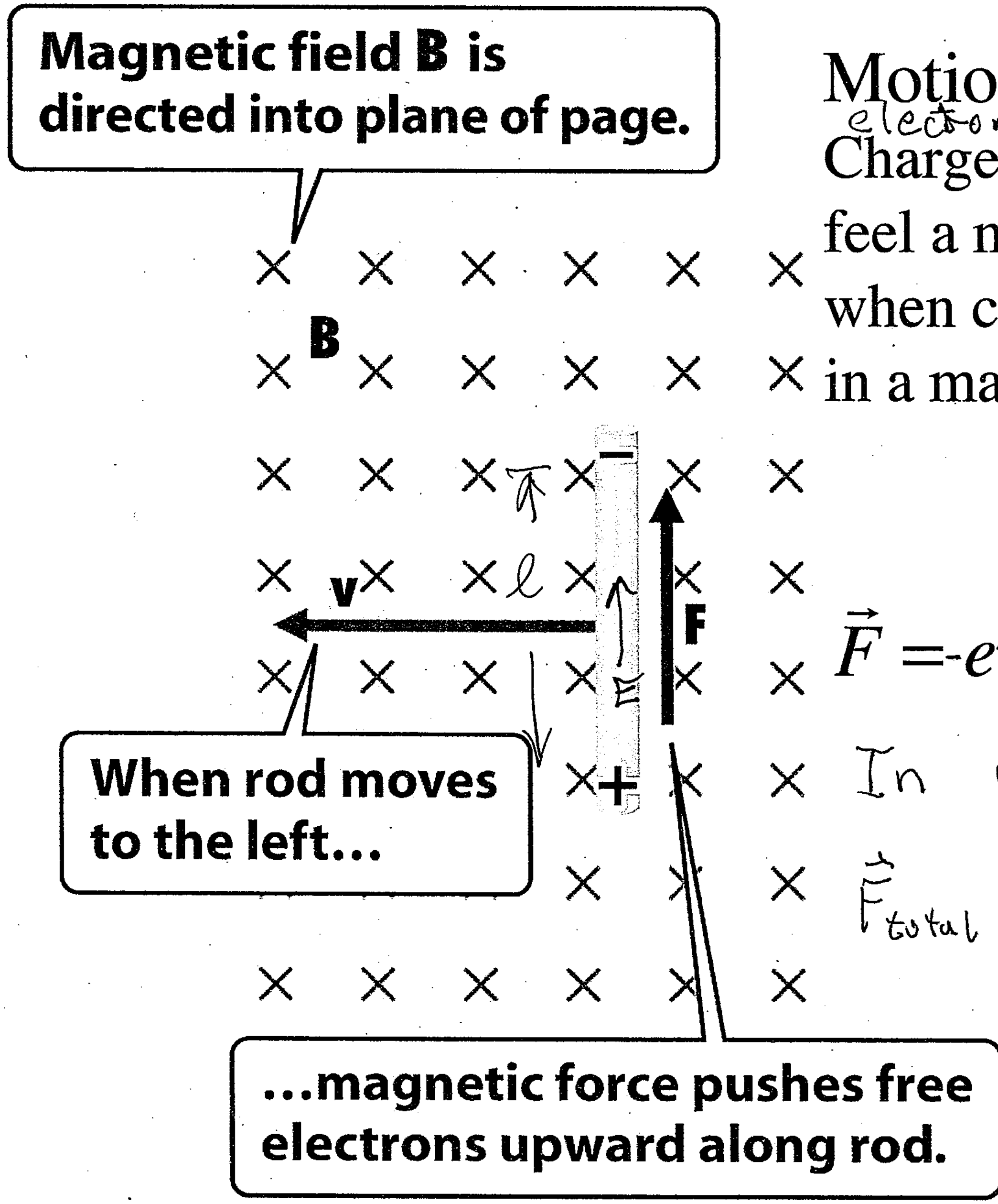

Figure 31-1 Physics for Engineers and Scientists 3/e

Motional EMF

Charges (electron) in a conductor feel a magnetic force when conductor moves in a magnetic field

$e > 0$

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

In equilibrium

$$\vec{F}_{total} = 0 = -e(\vec{v} \times \vec{B} + \vec{E})$$

$$\vec{E} = -\vec{v} \times \vec{B}$$

$$\equiv \vec{E}_{ind}$$

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

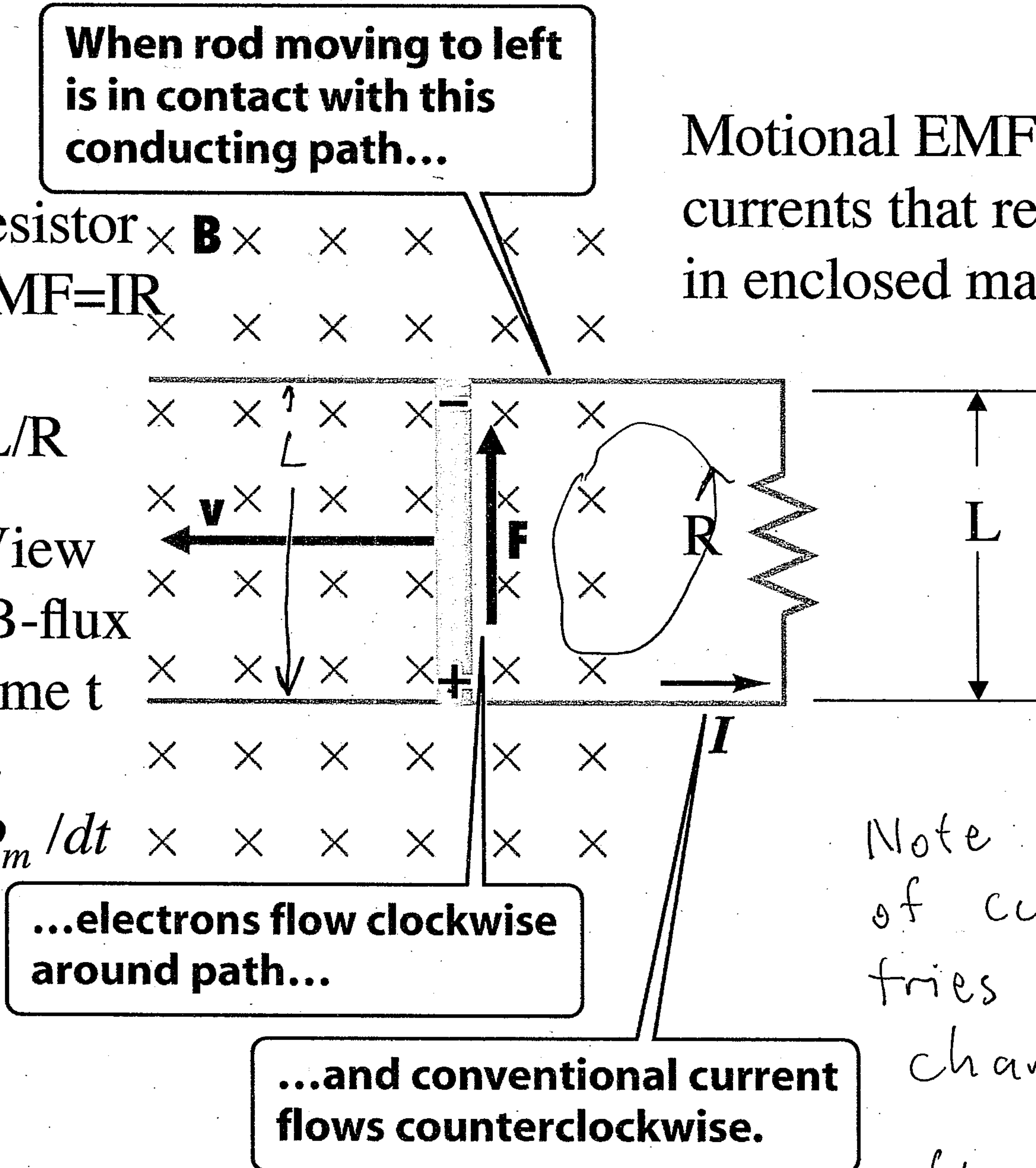

Figure 31-2 Physics for Engineers and Scientists 3/e

Note flow of current tries to resist change (Lenz's Law)

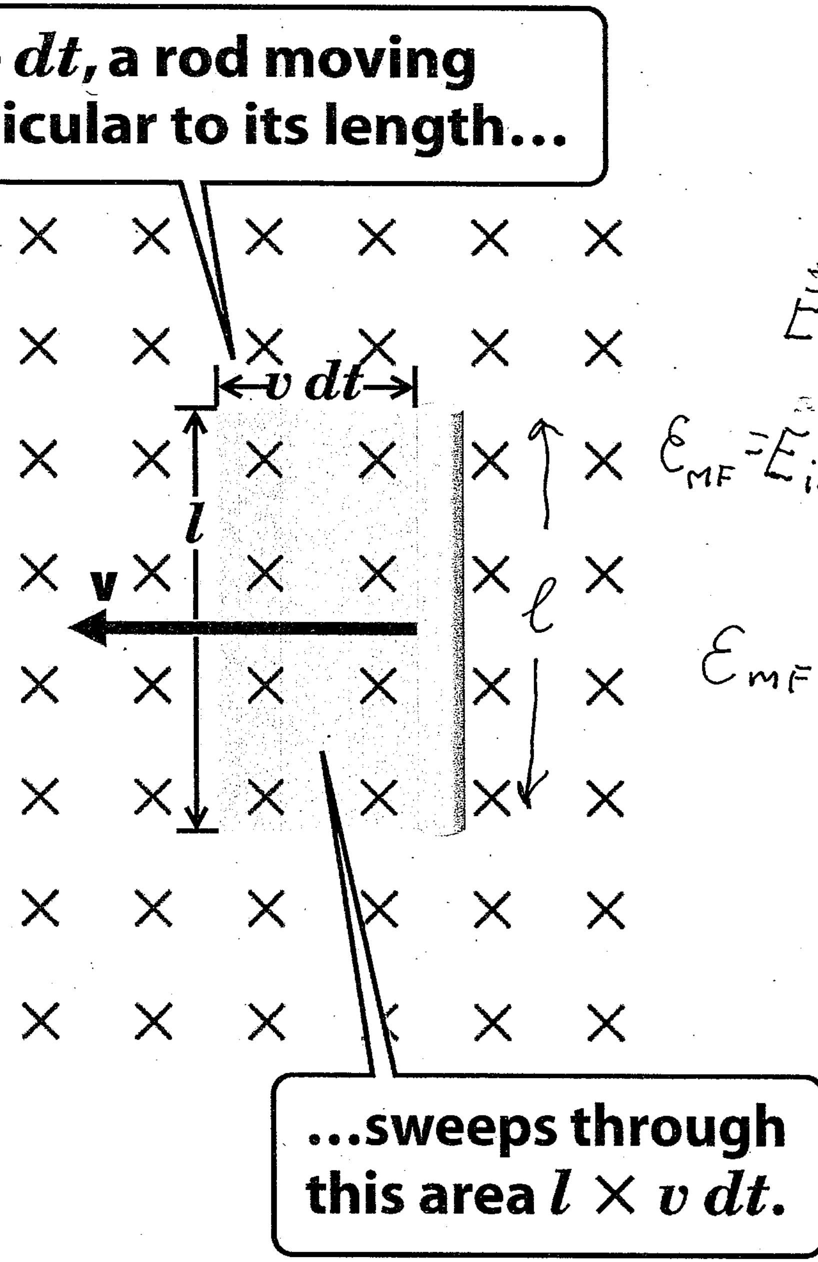

Figure 31-7 Physics for Engineers and Scientists 3/e

$\Delta A = l v \Delta t$

$\frac{\Delta A}{\Delta t} = l v = \frac{dA}{dt}$

$\vec{E}_{in} = -\vec{v} \times \vec{B}$

$\mathcal{E}_{MF} = \vec{E}_{in}\, l = -l v B \frac{d}{dt} dt$

$\mathcal{E}_{MF} = -B \frac{dA}{dt}$

Faraday's Law

even more generally

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

$\mathcal{E}_{MF} = -\frac{d}{dt}(BA)$

$= -\frac{d}{dt} \Phi_M$

3

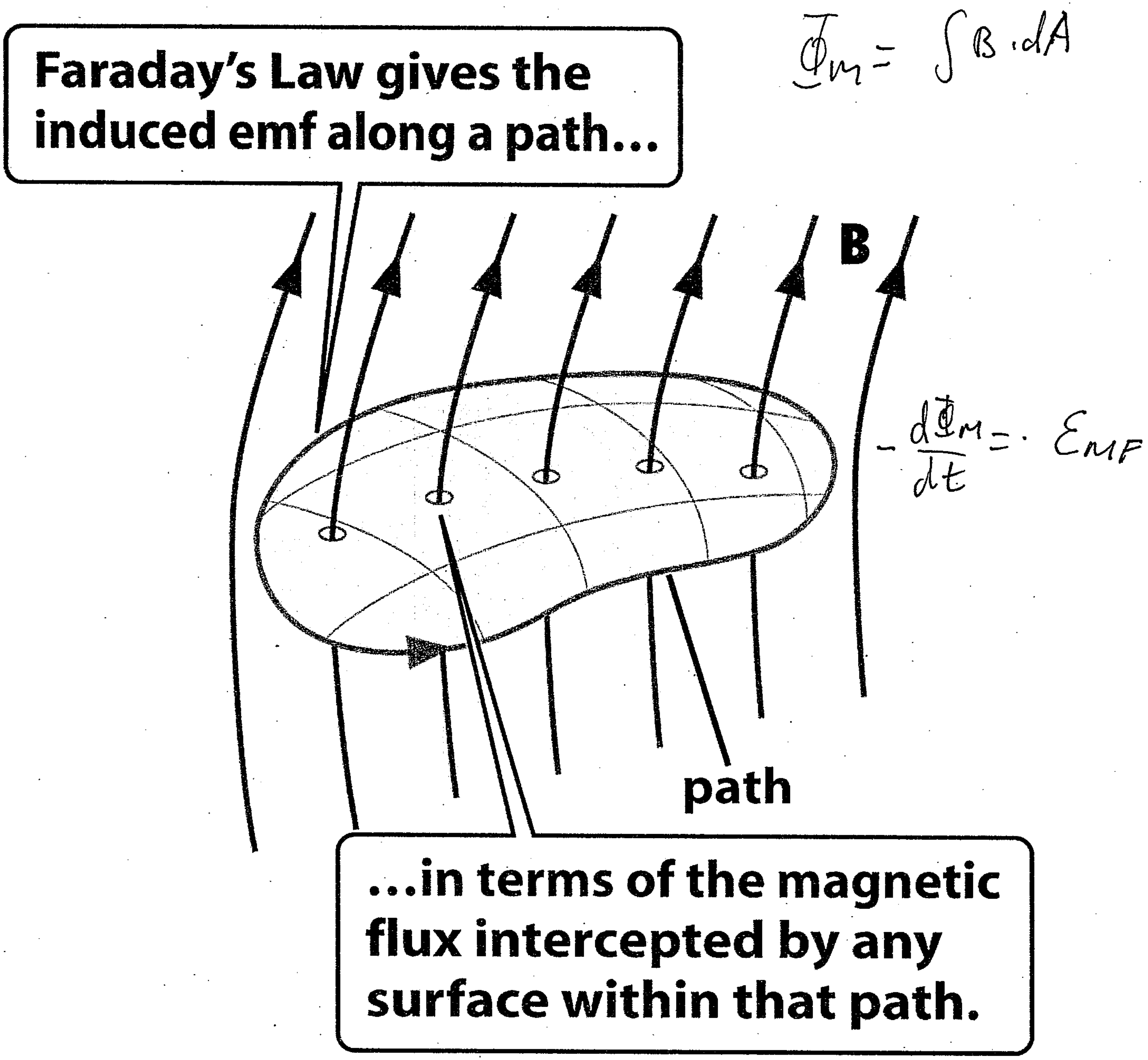

Figure 31-9 Physics for Engineers and Scientists 3/e

One can change magnetic flux through a surface by rotating surface

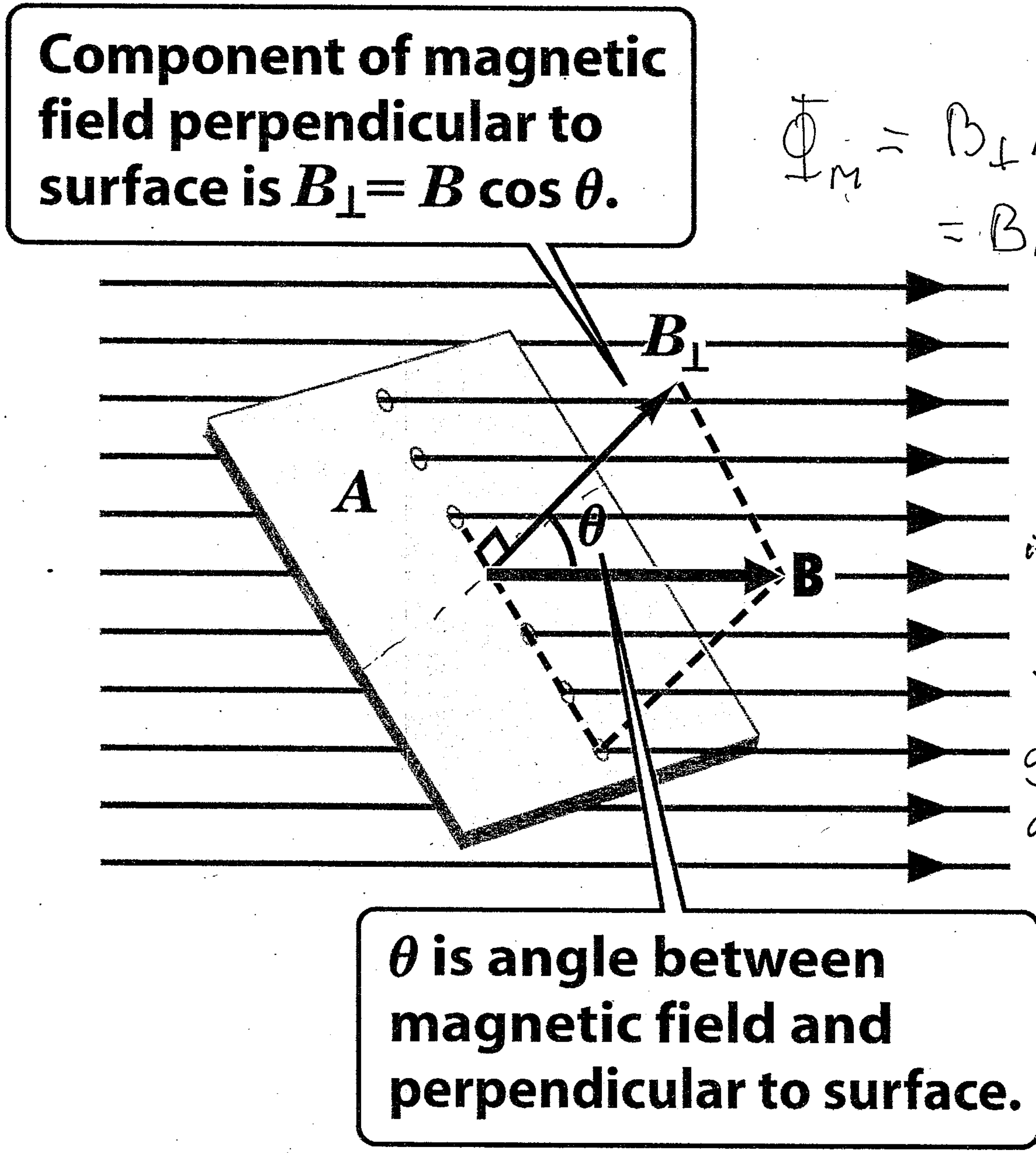

Figure 31-6 Physics for Engineers and Scientists 3/e

$\Phi_M = B_\perp A$

$= BA\cos\theta$

$\theta = \theta(t)$

$\frac{d\Phi_M}{dt} = -BA\sin\theta\frac{d\theta}{dt}$

if $B(t)$

$\Phi_M = B(t)A\cos\theta$

$\frac{d\Phi_M}{dt} = \frac{dB}{dt}A\cos\theta$

$= -\mathcal{E}_{MF}$

Motional EMF and Stationary Loop EMF combine together in one compact Law

Faraday's Law $\oint \vec{E} \cdot d\vec{s} = -\frac{d\Phi_m}{dt}$

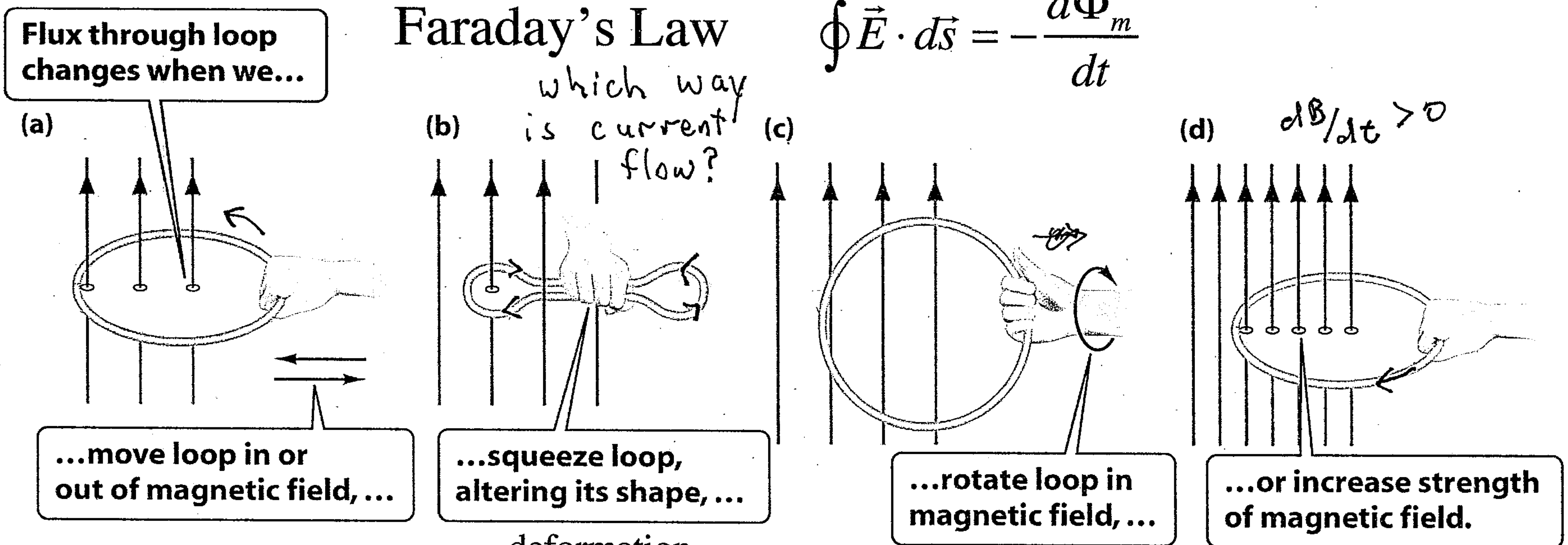

Figure 31-10 Physics for Engineers and Scientists 3/e

Translation through non-uniform field

deformation

rotation

time varying field

This Law is true whether the loop moves through a non-uniform magnetic field, deforms, rotates, and B-field changes in time.

In (a), Does the current flow is the clockwise or anti-clockwise direction?

(1) clockwise (2) counter-clockwise

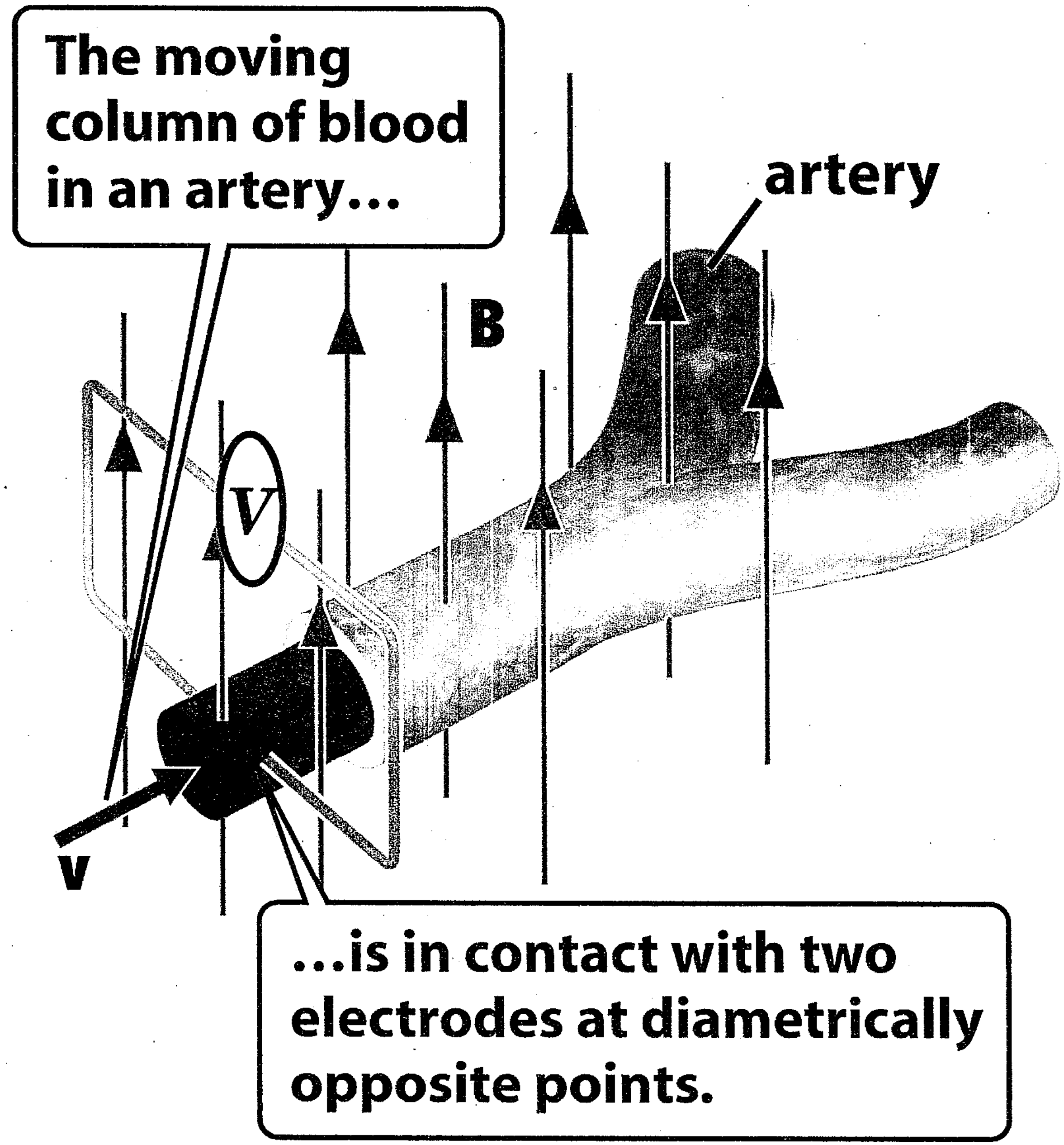

Figure 31-4 Physics for Engineers and Scientists 3/e

Dynamo is used to generate electrical currents from mechanical input power

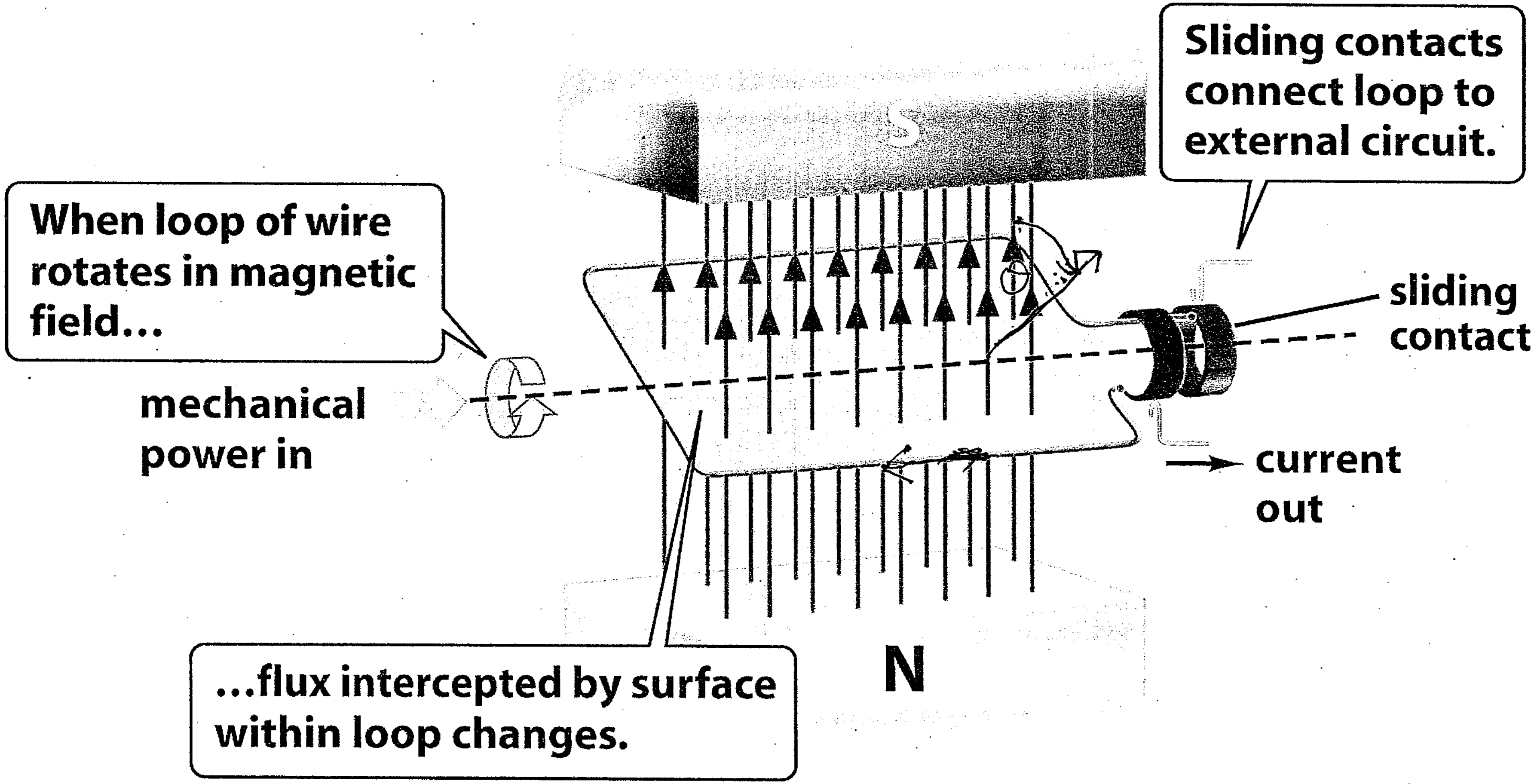

Figure 31-11 Physics for Engineers and Scientists 3/e

$\Phi_M = A B_0 \cos\theta$, $\theta = -\omega t + \theta_0$

Induced electromagnetic torque is opposite applied torque (Lenz's law).

$\mathcal{E} = \omega A B_0 \sin(\theta_0 - \omega t)$

$\mathcal{E} = \dot{\Phi}_m = AB \frac{d}{dt} \cos(\theta_0 - \omega t) = \omega A B_0 \sin(\theta)$

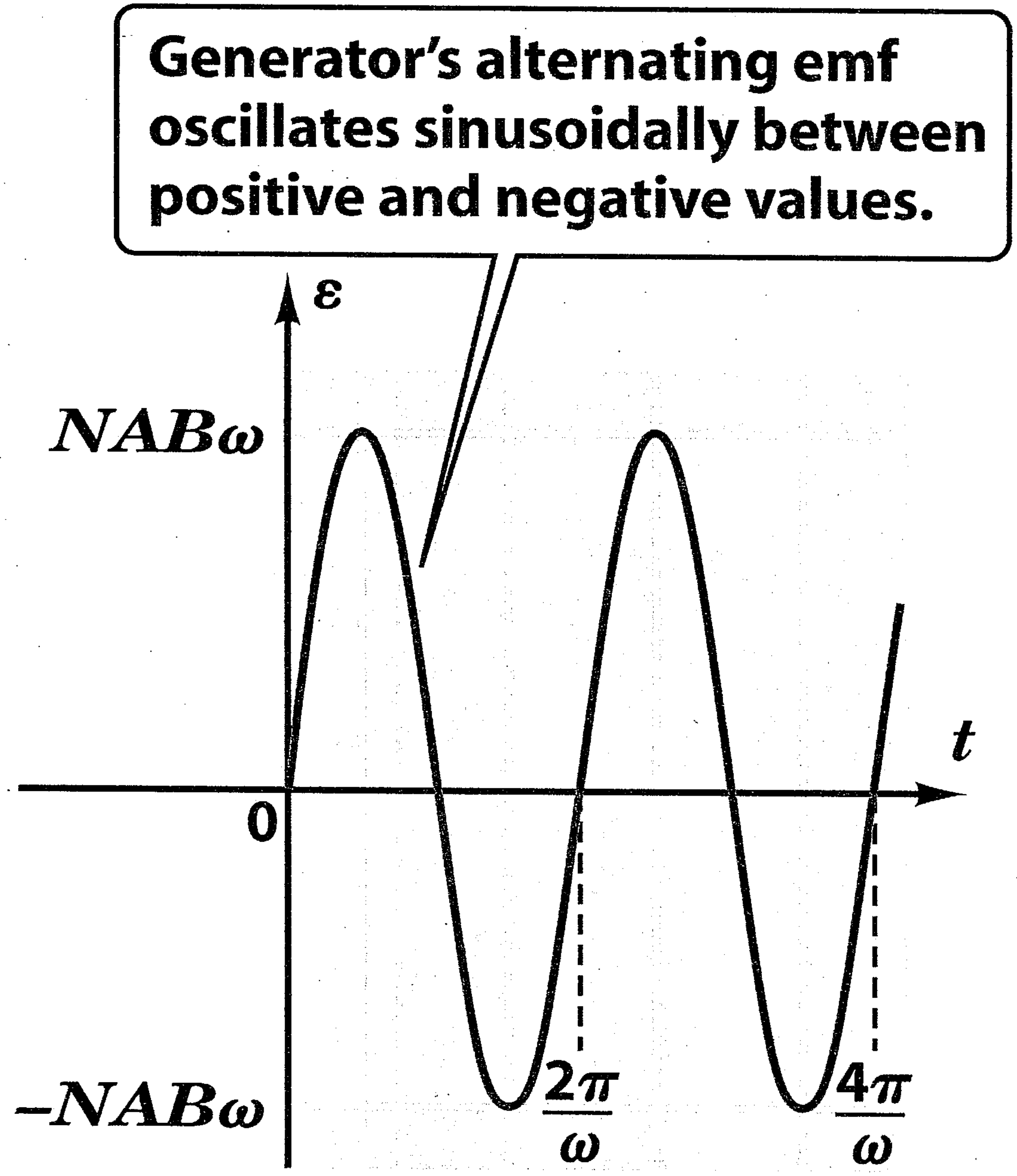

Figure 31-17 Physics for Engineers and Scientists 3/e

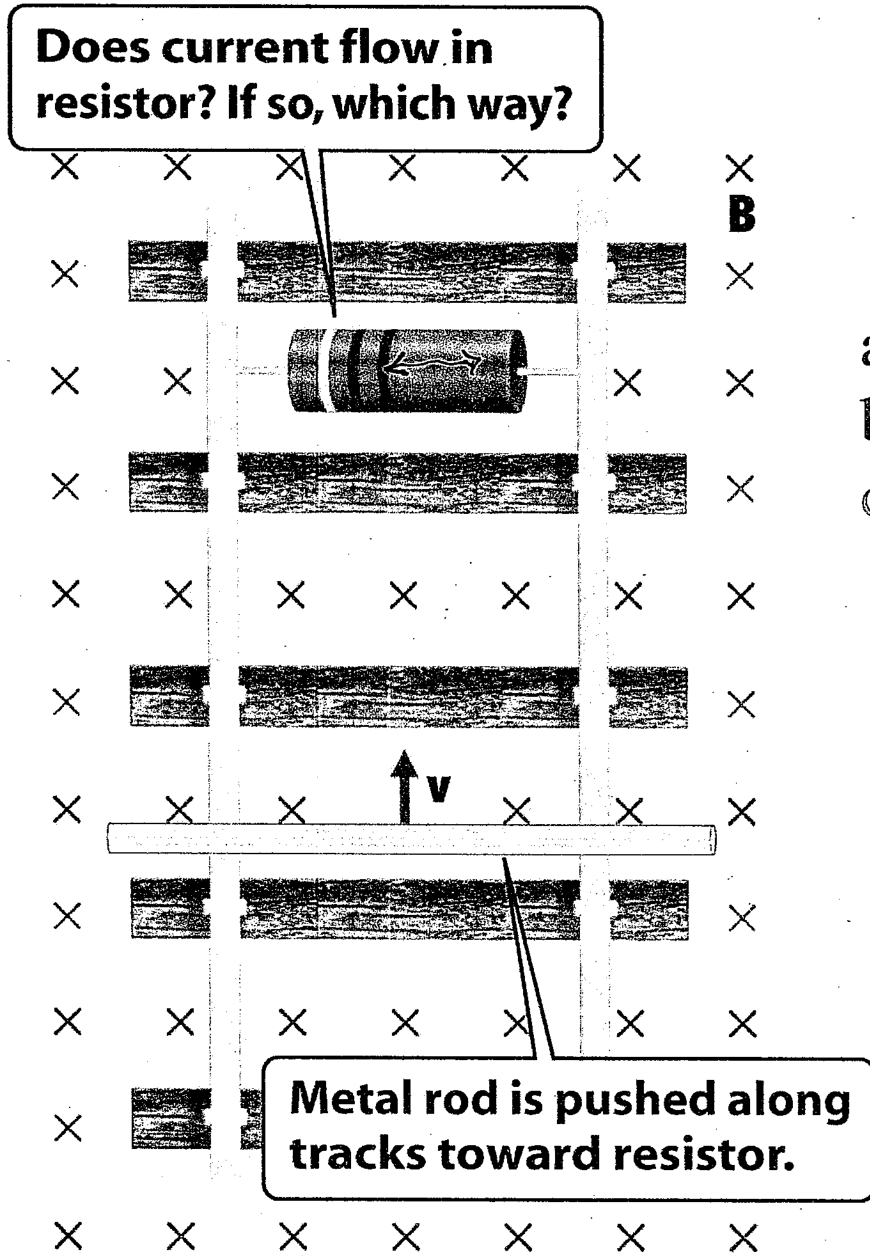

Figure 31-20 Physics for Engineers and Scientists 3/e

a. Left to right
b. Right to left
c. Does not flow