Class 38 Power generator, eddy current, and self inductance

Faraday's Law for motion emf: Example III

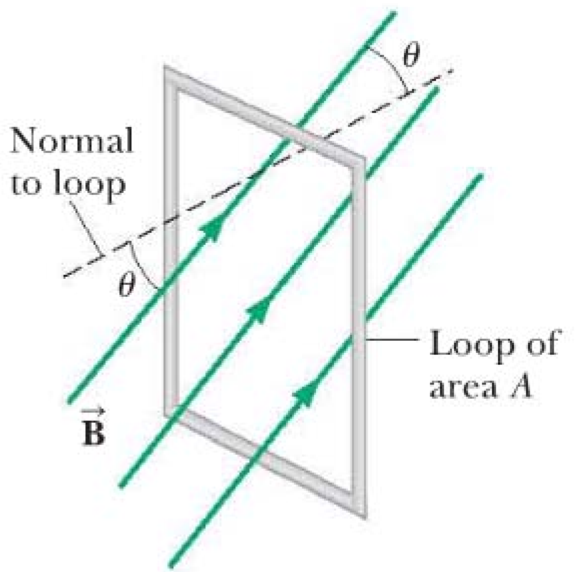


Figure 31.3 A conducting loop that encloses an area A in the presence of a uniform magnetic field $\vec{B}$. The angle between $\vec{B}$ and the normal to the loop is θ.

$$\varepsilon_{\text{loop}} = -\frac{d}{dt}\Phi_B$$

or

$$\oint_{\text{loop}} \vec{E}\cdot d\vec{s} = -\frac{d}{dt}\left(\int \vec{B}\cdot d\vec{A}\right)$$

Notes:

1. ε_{loop} does not equal to 0 any more if $d\Phi_B/dt \neq 0$
2. There are two ways to make $d\Phi_B/dt \neq 0$:
   (i) Changing B
   (ii) Changing A (loop shape)

Faraday's Law for changing θ: Generator

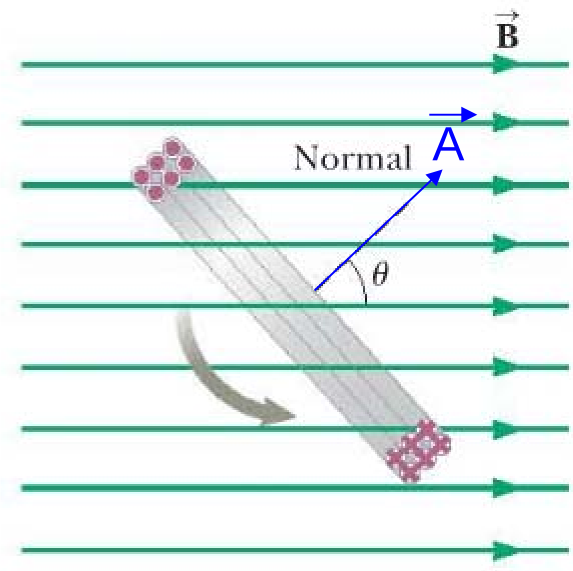


Figure 31.18 A cutaway view of a loop enclosing an area A and containing N turns, rotating with constant angular speed ω in a magnetic field. The emf induced in the loop varies sinusoidally in time.

$$\theta = \omega t$$

$$\theta = 0 \text{ at } t = 0$$

$$\oint_{\text{loop}} \vec{E} \cdot d\vec{s} = -\frac{d}{dt}\left(\int \vec{B} \cdot d\vec{A}\right)$$

$$= -\frac{d}{dt}\left(\int B \cdot NdA \cos \omega t\right)$$

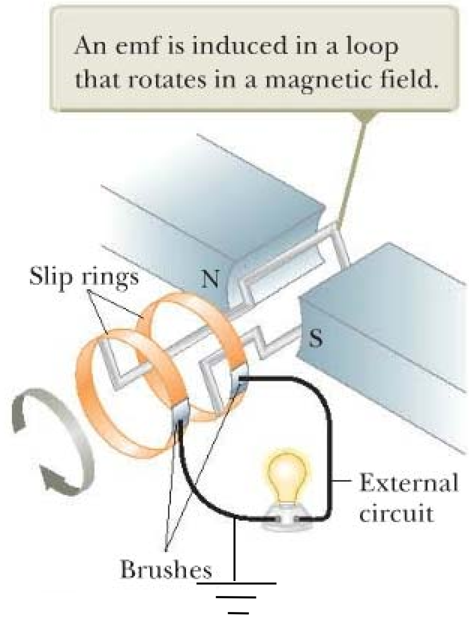
$$= -\frac{d}{dt}\left(NBA \cos \omega t\right)$$

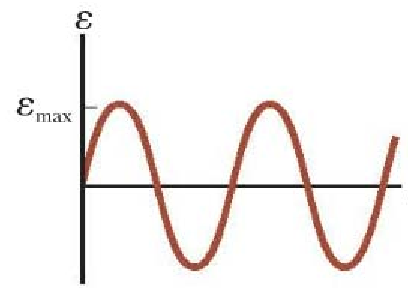
$$= NBA\omega \frac{d}{dt} \cos \omega t$$

$$\therefore \boxed{\varepsilon = NBA\omega \sin \omega t}$$

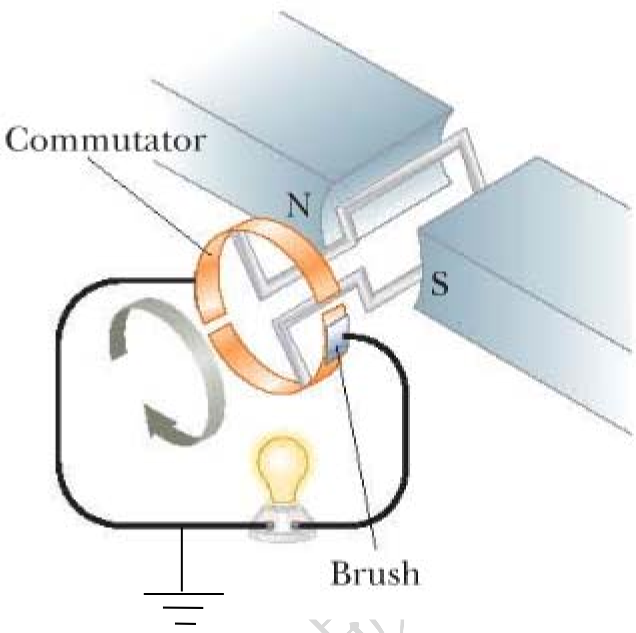
AC and DC Generators

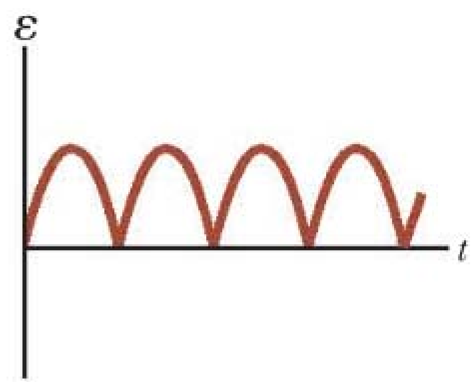
AC Generator



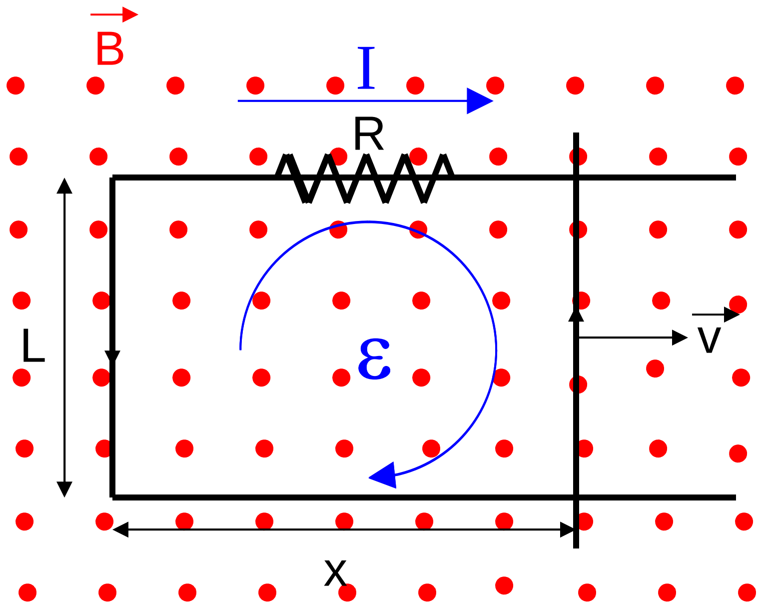


DC Generator



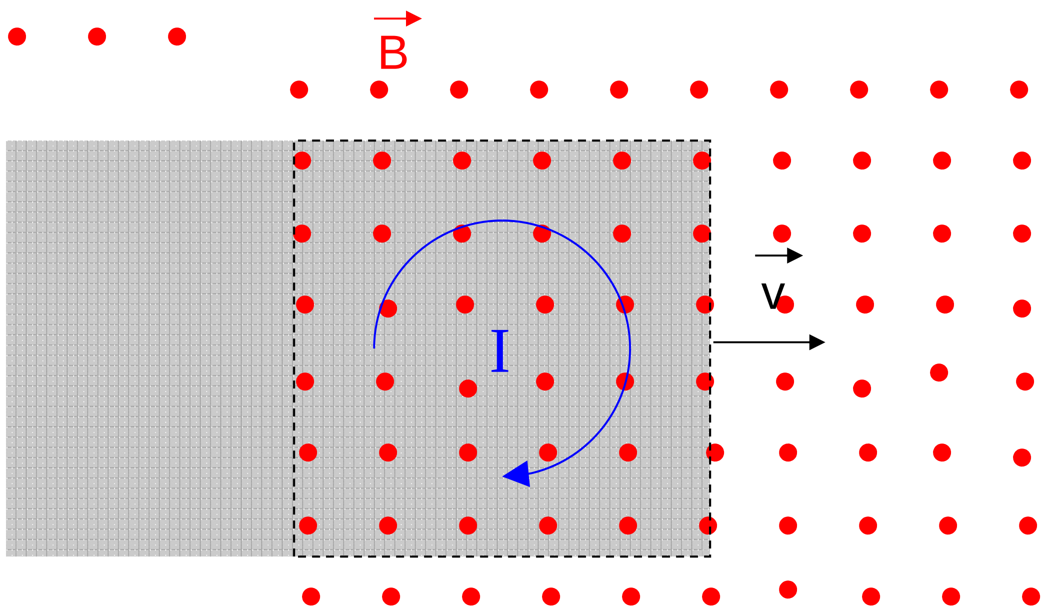


Eddy Current

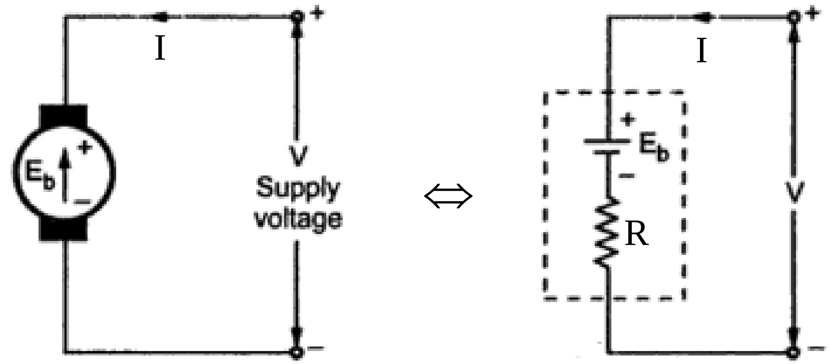


When a conductor moves in an inhomogeneous magnetic field, the induced emf will produce current flow in the conductor, called Eddy current.

Lenz's Law: The Eddy current will in turn produce a magnetic force in opposite direction to the velocity, like friction.



Electric motor and back emf



An electric motor behaves like a generator as it is rotating. This will generate an emf in opposite to the applied voltage, called back emf.

$$V = E_b + IR$$

Where R is the resistance of the windings. When the motor starts turning , E_b =0 and all power is dissipated as heat I_2R (wasted). When the motor is in full speed, mechanical power of the motor is IE_b and the power of the wasted heat will drop to $(V-E_b)^2/R$.