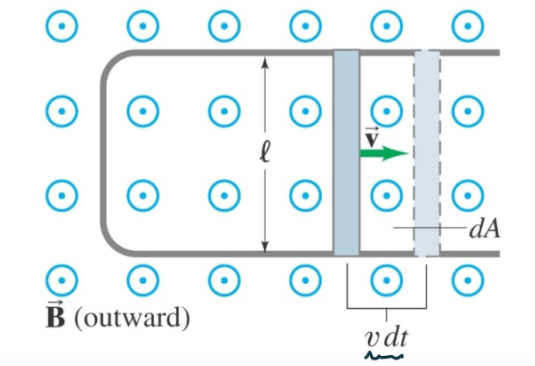
Chapter 29 : Electromagnetic Induction

Emf induced in a moving conductor :



$$\mathcal{E} = \frac{d\Phi_B}{dt} = \frac{B\,dA}{dt} = \frac{B\ell v\,dt}{dt} = B\ell v$$

* This is valid as long as B, ℓ and v are mutually perpendicular!

Example 29.6

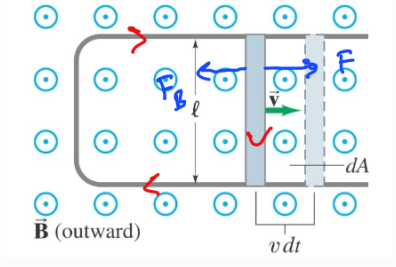
$\ell = 70\ m$

$v = 1000\ km/h \approx 280\ m/s$

$B = 5 \times 10^{-5}\ T$

$$\mathcal{E} = B\ell v = (5\times10^{-5}\,T)(280\ m/s)(70\ m) = 1\ V$$

Example 29.8



Ohm's Law

a) $\vec{F} = I\vec{\ell} \times \vec{B} \Rightarrow F = I\ell B = (\mathcal{E}/R)\,\ell B$

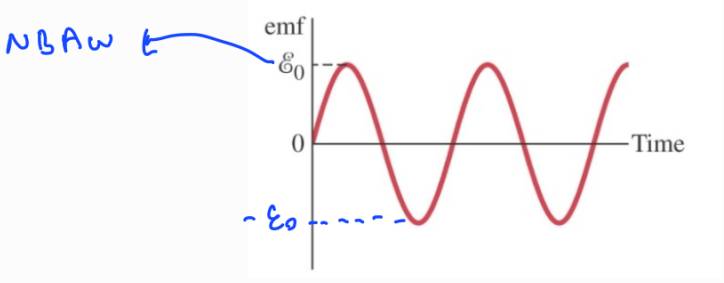
$\mathcal{E} = B\ell v$, $F = (B\ell v/R)\,\ell B = B^2\ell^2 v/R$

b) $P_{ext} = Fv = B^2\ell^2v^2/R$ $(\vec{F} \parallel \vec{v})$

Electric Generators :

$$\mathcal{E} = -\frac{d\Phi_B}{dt} = -\frac{d}{dt}(\vec{B}\cdot\vec{A}) = -\frac{d}{dt}(BA\cos\theta) = BA\,\frac{d}{dt}(\cos\omega t) = BA\omega\sin\omega t$$

If there are N loops in the coil : $\mathcal{E} = \underbrace{NBA\omega}_{\mathcal{E}_0}\sin\omega t = \mathcal{E}_0 \sin\omega t$

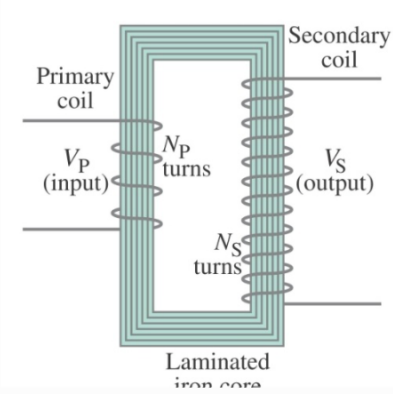


Example 29.9

$\mathcal{E}_0 = NBAw \Rightarrow N = \mathcal{E}_0/BAw$, $w = 2\pi f = (6.28)(60\,Hz) = 377\,s^{-1}$

$N = 170\,V / (0.15\,T)(2\times10^{-2}\,m^2)(377\,s^{-1}) = 150$ turns

Transformers and Transmission of Power:



$V_s = N_s \frac{d\Phi_B}{dt}$ and $V_p = N_p \frac{d\Phi_B}{dt}$

$\Rightarrow \frac{V_s}{V_p} = \frac{N_s}{N_p}$

* using conservation of energy, $P = IV \Rightarrow I_p V_p = I_s V_s$

$\Rightarrow \frac{I_s}{I_p} = \frac{N_p}{N_s}$

Example 29.12

a) $\frac{N_p}{N_s} = \frac{V_p}{V_s} \Rightarrow N_p = N_s \frac{V_p}{V_s} = (30)\frac{(120V)}{(5.0V)} \Rightarrow N_p = 720$ turns

b) $I_p = I_s \frac{N_s}{N_p} = (0.70A)\frac{(30)}{(720)} = 29\,mA$

c) $P = I_s V_s = (0.70A)(5.0V) = 3.5\,W$

Example 29.13

a) $I = \frac{P}{V} = \frac{1.2\times10^5\,W}{2.4\times10^2\,V} = 500\,A \Rightarrow P_L = I^2R = (500A)^2(0.40\Omega) = 100\,kW$

b) $I = \frac{P}{V} = \frac{1.2\times10^5\,W}{2.4\times10^4\,V} = 5\,A \Rightarrow P_L = (5A)^2(0.40\Omega) = 10\,W$