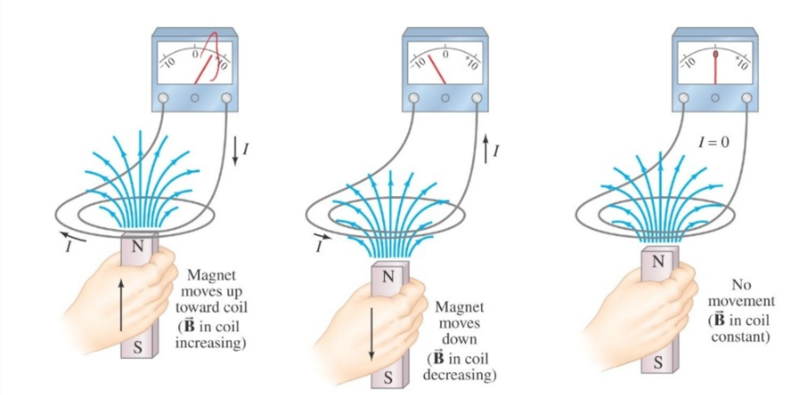
Chapter 29: Electromagnetic Induction

* A changing magnetic field induces an emf and thus a current.

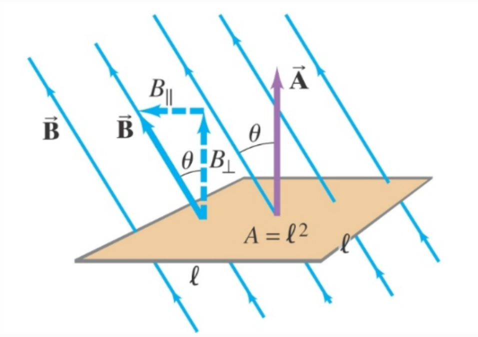


magnetic flux:

$$\Phi_B = \int \vec{B} \cdot d\vec{A}$$ If $\vec{B}$ is uniform, then we have $\Phi_B = \vec{B} \cdot \vec{A}$.

we measure magnetic flux in SI in weber (Wb): $1\,\text{Wb} = 1\,\text{T}\,\text{m}^2$.

+y



$\vec{A} = \ell^2 \hat{j}$ $\quad \Phi_B = BA\cos\theta = A\underbrace{B_\perp}_{B\cos\theta}$

* If $\vec{B} \perp \vec{A}$ then $\Phi_B = 0$
* If $\vec{B} \parallel \vec{A}$ then $\Phi_B = BA$ (maximum)

Faraday's Law of Induction:

$$\mathcal{E} = -\frac{d\Phi_B}{dt} = \frac{-d}{dt}(\vec{B} \cdot \vec{A})$$ ↳ assuming uniform magnetic field

* If there are N loops of wire then we have $\mathcal{E} = -N \dfrac{d\Phi_B}{dt}$

Example 29.2

a) $\Phi_B = \vec{B} \cdot \vec{A} = BA = \overbrace{(0.16\,\text{T})}^{B}\overbrace{(2.5 \times 10^{-3}\,\text{m}^2)}^{\ell^2} = 4.0 \times 10^{-4}\,\text{Wb}$

b) $\Phi_B = BA\cos 30^\circ = (0.16\,\text{T})(2.5 \times 10^{-3}\,\text{m}^2)\cos 30^\circ = 3.5 \times 10^{-4}\,\text{Wb}$

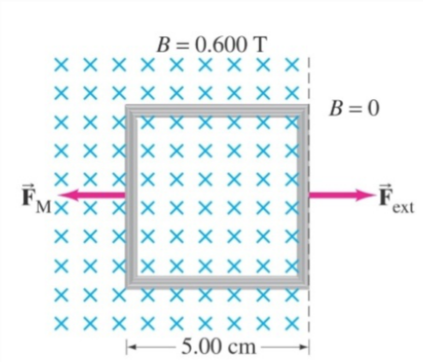
} flux decreases!

c) $\mathcal{E} = \dfrac{\Delta\Phi_B}{\Delta t} = \dfrac{(4.0 \times 10^{-4}\,\text{Wb}) - (3.5 \times 10^{-4}\,\text{Wb})}{0.14\,\text{s}} = 3.6 \times 10^{-4}\,\text{V} \Rightarrow$

$\mathcal{E} = IR$: $I = \dfrac{\mathcal{E}}{R}$

$I = \dfrac{3.6 \times 10^{-4}\,\text{V}}{0.012\,\Omega} = 0.030\,\text{A}$

Example 29.5



a) $\Delta\Phi_B = \overset{0}{\Phi_B^f} - \Phi_B^i = -\Phi_B^i = -BA = -(0.600T)(2.50\times10^{-3} m^2)$

$\Delta\Phi_B/\Delta t = -(0.600T)(2.50\times10^{-3} m^2)/(0.100s) = -1.50\times10^{-2}\ Wb/s$

b) $\varepsilon = -N\dfrac{\Delta\Phi_B}{\Delta t} = -(100)(-1.50\times10^{-2}\ Wb/s) = 1.50V$

$I = \varepsilon/R = (1.50V)/(100\Omega) = 1.50\times10^{-2} A$

c) $P = E/t \Rightarrow E = Pt = I^2Rt = (1.50\times10^{-2}A)^2(100\Omega)(0.100s) = 2.25\times10^{-3} J$

d) $W = Fd \Rightarrow F = W/d = (2.25\times10^{-3}J)/(5.00\times10^{-2}m) = 0.0450\ N$