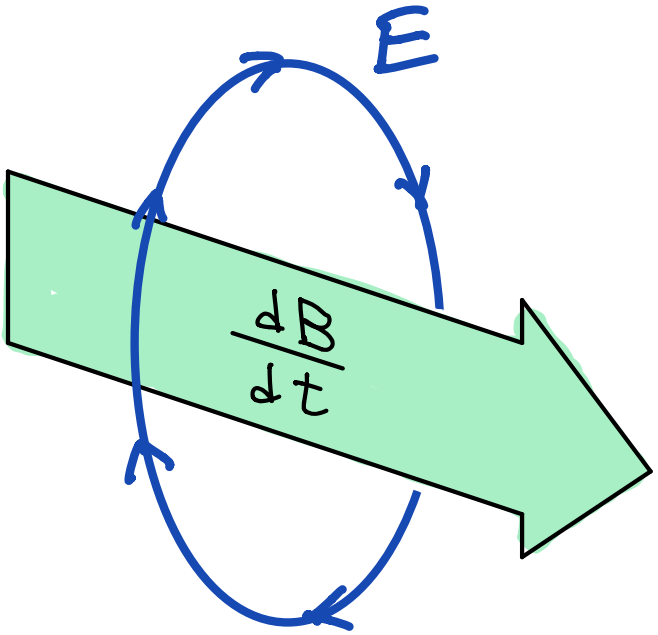
Review

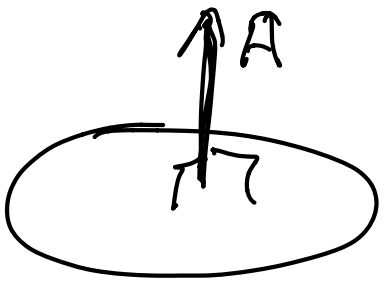


$$\oint \vec{E} \cdot \vec{dl} = -\frac{d}{dt}(\vec{B} \cdot \vec{A})$$

Define

$$\mathcal{E} = \oint \vec{E} \cdot \vec{dl}$$ induced EMF

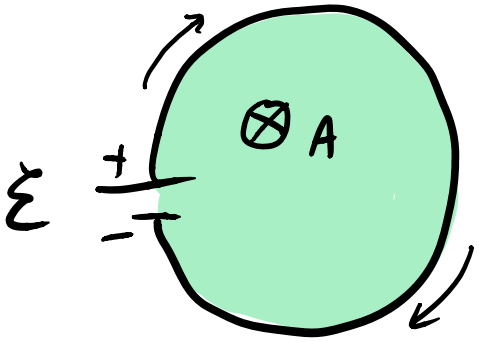
$$\Phi_B = \vec{B} \cdot \vec{A}$$ magnetic flux



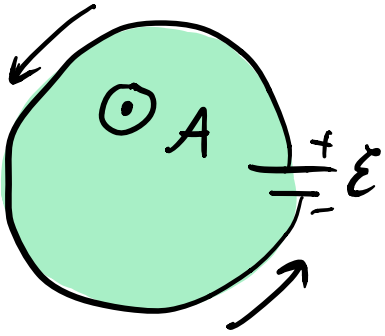
How to use

$$\mathcal{E} = -\frac{d}{dt}\left(\vec{B}\cdot\vec{A}\right)$$

Set direction

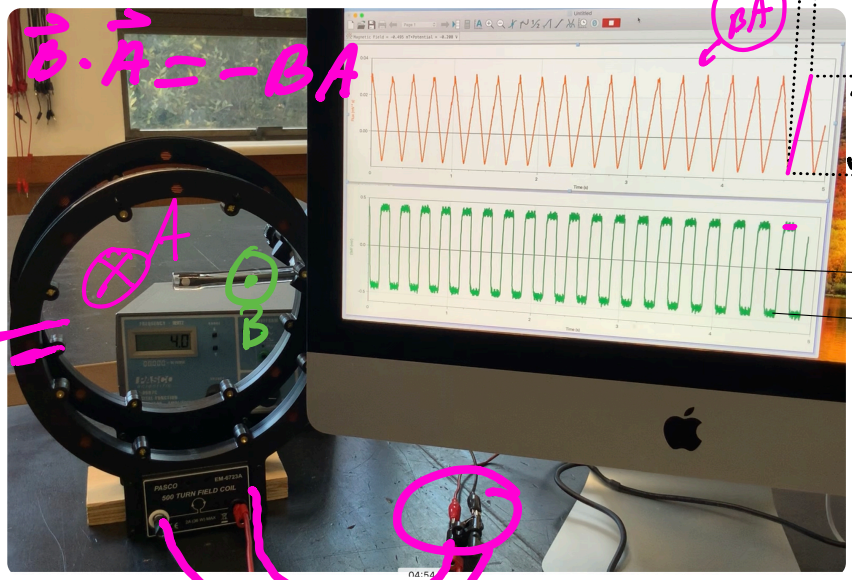


OR



Direction of $\vec{A}$ is the direction a bottle cap would move if the cap turned in the direction $\mathcal{E}$ is pushing

Example



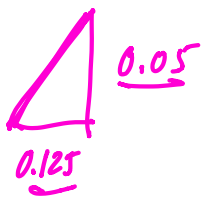
$\Delta t = 0.125\,s$

$\Delta(BA) = 0.05\,T\cdot m^2 = 0.05\,V\cdot s$

$\frac{\Delta BA}{\Delta t} = \frac{0.05\,V\cdot s}{0.125\,s} = 0.4\,V$

+0.4V

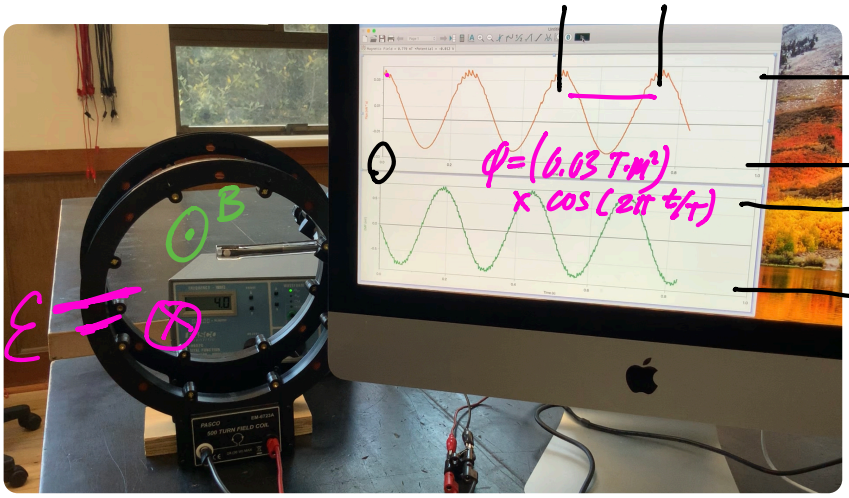
−0.4V



$$\mathcal{E} = -\frac{d}{dt}\left[\vec{B}\cdot\vec{A}\right] = -\frac{d}{dt}\left[-BA\right]$$

$$= \frac{d}{dt}\left[BA\right]$$

Example



$+0.03\,T\cdot m^2 = +0.03\,V\cdot s$

$-0.03\,T\cdot m^2 = -0.03\,V\cdot s$

+0.7V

−0.7V

$$BA = (0.03\,V\cdot s)\cos(2\pi t/T)$$

$$\phi = \vec{B}\cdot\vec{A} = -BA$$

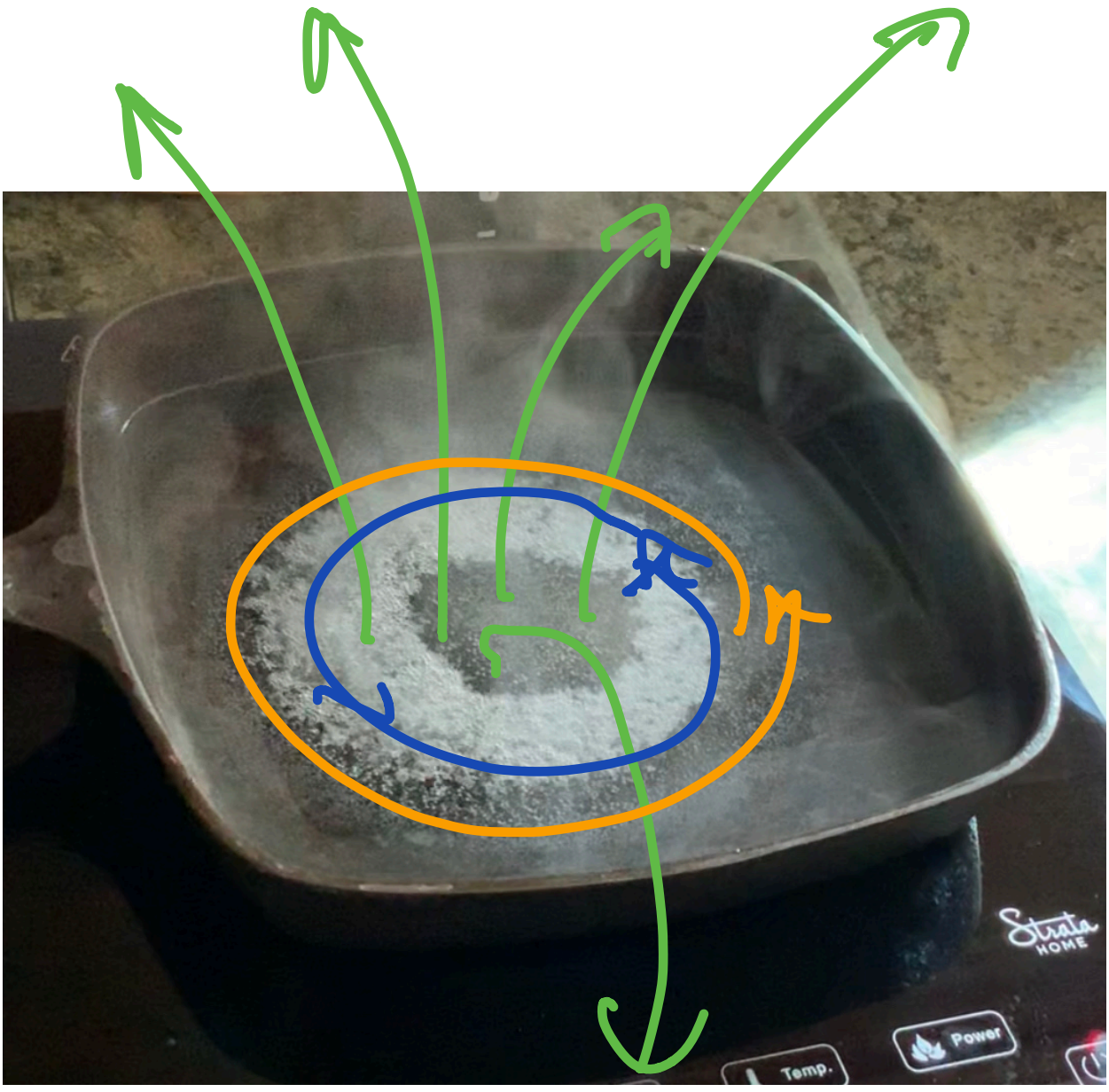
$$\mathcal{E} = -\frac{d\phi}{dt} = \frac{d}{dt}\left[BA\right]$$

$$= -(0.03\,V\cdot s)\sin(2\pi t/T)\,\frac{2\pi}{T}$$

$$= -\left[(0.03\,V\cdot s)\,\frac{2\pi}{1.25\,s} \right] \sin\left(2\pi \frac{t}{T}\right)$$

$$\approx 0.75\,V$$

Induction Stove Demo

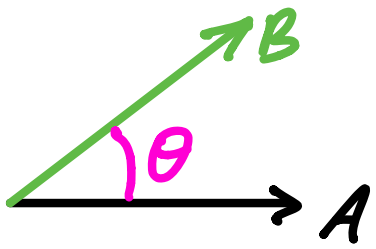


Field Directions

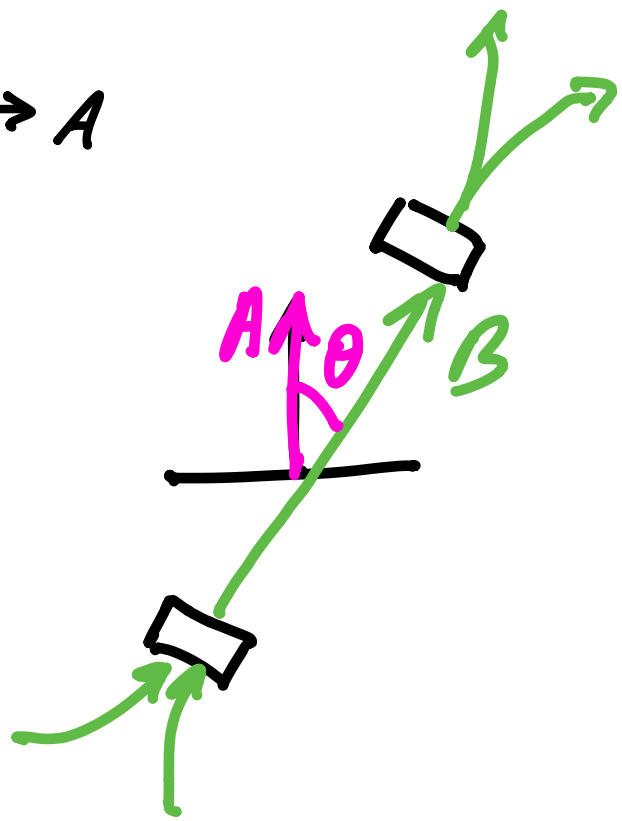
$$\Phi_B = \vec{B} \cdot \vec{A} = B_{\parallel} A = BA\cos\theta$$

note:

Only parallel component of B contributes to flux.



Drill Demo



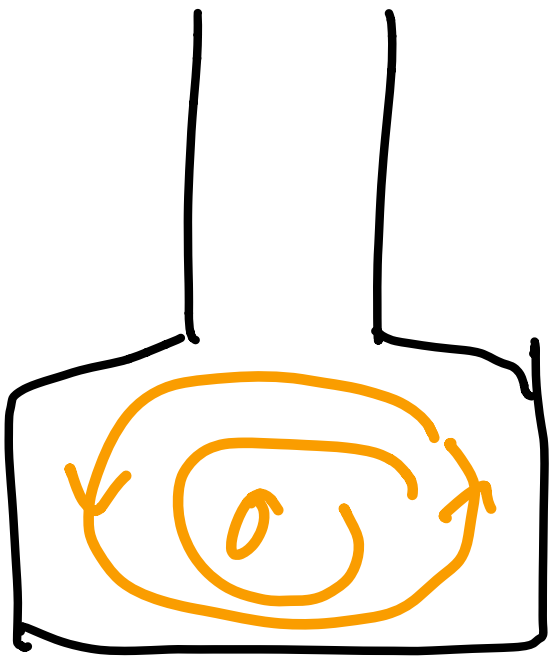
$$\theta = \omega t$$

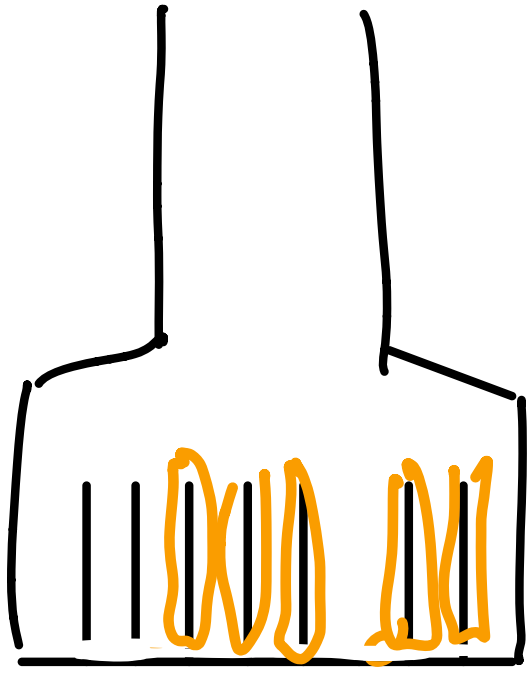
$$\mathcal{E} = -\frac{d}{dt}\left[\vec{B} \cdot \vec{A}\right]$$

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

$$= BA\sin(\omega t)\,\omega$$

Demo Eddy Currents





$\Phi \propto r^2$

$R \propto r$

$I \propto \frac{\Phi}{R} = r$

$F = r^4$

$R = 2r$

$F = 1(2r)^4$

$= 16r^4$

$F = 4r^4$