EMI

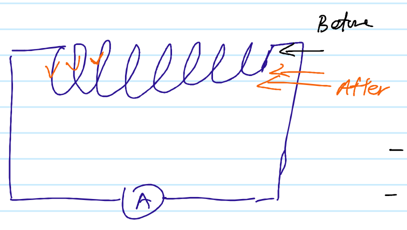
21 February 2025 08:28

Electromagnetic induction

Change in magnetic flux $\Rightarrow$ voltage

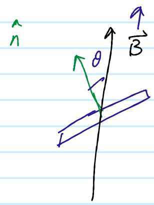
$$\mathcal{E} = -\frac{\partial \phi}{\partial t}$$

Lenz Law : Induced voltage (current) opposes change in ϕ $(\Delta\phi)$

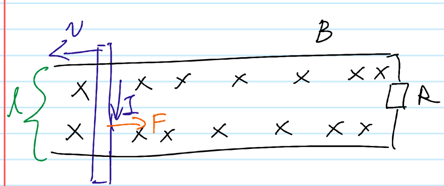


To produce
- Change in ϕ ✓
- Closed loop ✓

$\phi = NBA\cos\theta$ (in the direction of B)



Moving rod in $\vec{B}$.



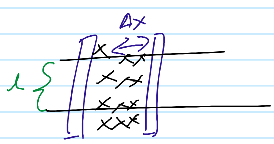
$\vec{F} = I\,\vec{L}\times\vec{B}$

right hand grip rule

When rod moves left, ϕ increases into page. (A increase)

To oppose $\Delta\phi$, the induced flows in ACW direction to produce $\vec{B}$ pointing out of the page.

$$\Delta\phi = Bl\Delta x$$



$$\Delta t = \Delta t$$

$$\mathcal{E} = -Blv$$

$$I = -\frac{Blv}{R}$$

on the rod

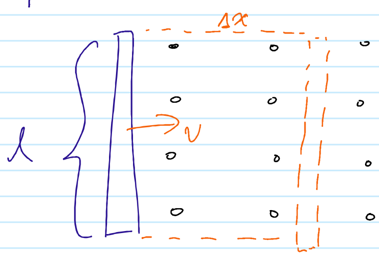
$$F = BIL = -\frac{B^2l^2v}{R} \quad (\text{to the right}).$$

$$m\frac{dv}{dt} = -\frac{B^2l^2v}{R} \longrightarrow \int \frac{1}{v}\,dv = \int -\frac{B^2l^2}{Rm}\,dt$$

$$v \sim v_0 \exp\left(\frac{-B^2l^2}{Rm}t\right).$$

Open circuit version

Open circuit version

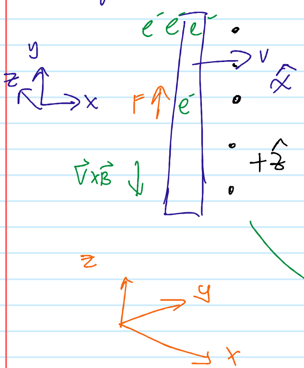


$\Delta\phi = Bl\Delta x$

$\mathcal{E} = -Blv$

No current flowing ∵ Not a closed loop.

Charge distrubution



$\vec{F} = q\vec{v}\times\vec{B}$

here $\vec{v}\times\vec{B}$

$\hat{x}\times(+\hat{z})$

$= +(\hat{x}\times\hat{z})$

$= -\hat{y}$

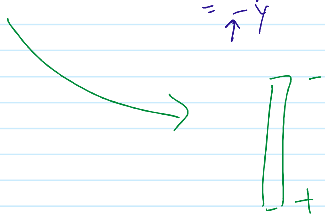
$\hat{a}\times\hat{b} = \epsilon_{abc}\hat{c}$

xzy

xyz → 順序 (+1)

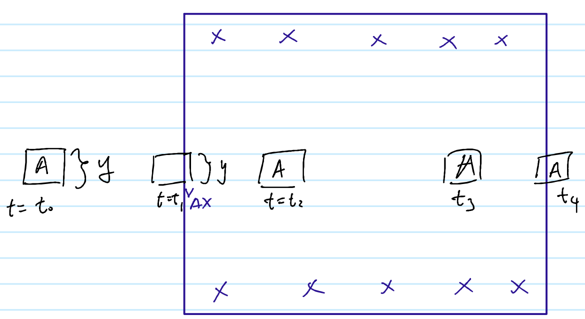
yxz → 倒序 (−1)

xxz → ??? 至少兩個一樣 (0)



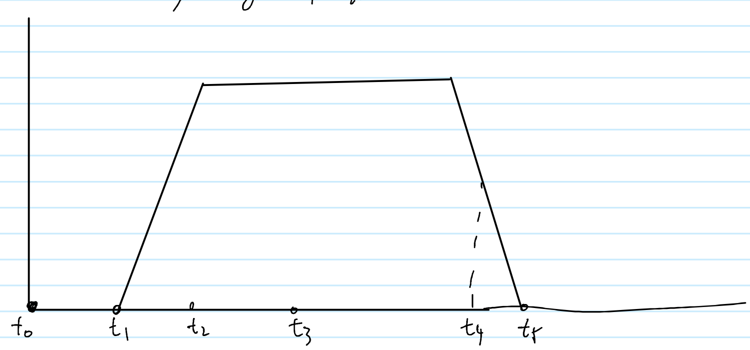
← higher voltage

Loop in $\vec{B}$.

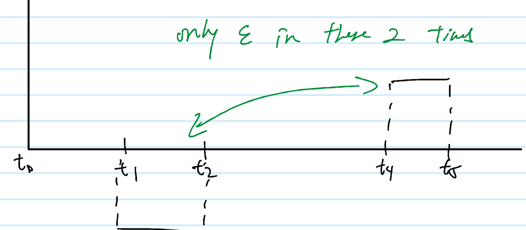


$\phi = By\Delta x = Bvy\Delta t$

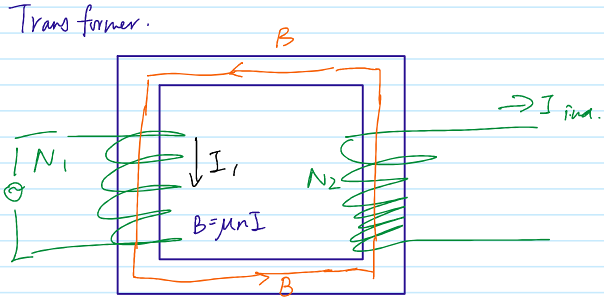
φ against time



$\mathcal{E}/I$ ~~ag~~ against time $\mathcal{E} = -\frac{\partial\phi}{\partial t}$ $I = -\frac{1}{R}\frac{\partial\phi}{\partial t}$



Transformer.



Soft iron core

$B = \mu_0 n I$ (increase μ_0)

$\mu_0 \to \mu_r \mu_0$

$\mu_r \sim 5000$

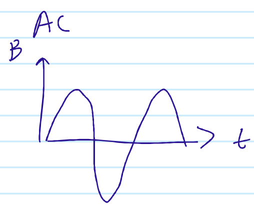
AC current only

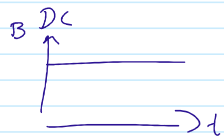
∵ AC current (not DC) can provide charging current

So $\vec{B}$ changes with time

and secondary coil experience $\Delta\phi$

→ induced current.





Coil 1:

$\Phi = N_1 B(t) A$

$V_1 = N_1 A \frac{\partial B}{\partial t}$

Coil 2:

$\Phi = N_2 B(t) A$

$V_2 = N_2 A \frac{\partial B}{\partial t}$

$$\boxed{\frac{V_1}{V_2} = \frac{N_1}{N_2}}$$

In a perfect transformer → Power is conserved.

$P_1 = P_2$

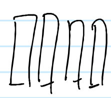
$e V_1 I_1 = V_2 I_{ind}$

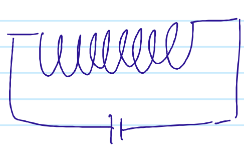
↑ efficiency

How to make efficiency

- Soft iron core
- Laminated iron core

↑ Fins





$B = \mu_0 I n$ → $\mu \to \mu_0 \mu_r$

increase B:
① Increase I
② Increase n
③ Insert soft iron core.