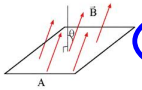
Chapter 22 - Electromagnetic Induction

Demo...loop in magnetic field and magnetic in solenoid

Magnetic Flux = "density" of B-field

Φ = BAcosφ

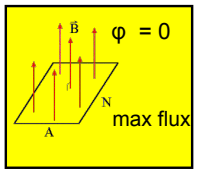


units = Tm² = Weber = Wb

φ = angle between normal to B-field and surface area of loop of wire

if φ = 90 = ⊥ to B-field = NO FLUX

if φ = 0 = // to B-field = MAX FLUX



emf = ε = electromotive force = "causing" a potential difference and "forcing" current to move (if there is a conductor with electrons)

Faraday's Law - A change in flux will INDUCE an emf

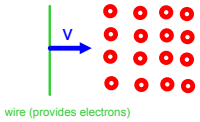
ε = - N(ΔΦ/t)

units for ε = v (like voltage)

- means induction is OPPOSITE change

3 ways to change Φ:

For a special case of a MOVING WIRE



$F_e = Eq$ & $E = V/d = \varepsilon/L$

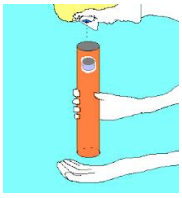
$F_e = \varepsilon q/L = qvB = F_B$

ε = vBL

******note v = velocity so to induce an emf in a wire you need MOTION********

Lenz's Law

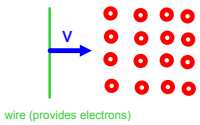
Demo ring toss and tubes



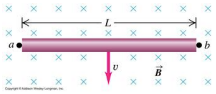
Lenz's Law explains polarity of induced emf

Induced emf ALWAYS OPPOSES MOTION

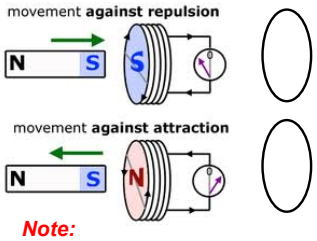
Use right hand rule to determine direction of current...remember F opposes v



Which way will current move?



What's at a higher potential, a or b?

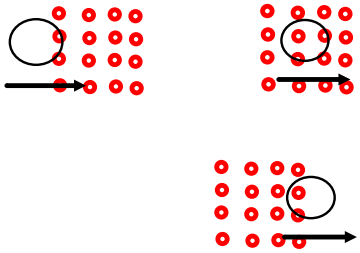


What is direction of current in the coils? Why?

Note:

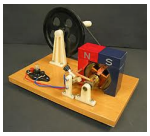
INCREASING B = induced B opposite direction

DECREASING B = induced B same direction



***Electrical generator* - converts mechanical energy into electrical energy (backwards motor)**

show generator



$\varepsilon = NAB\omega(\sin(\omega t))$

note ε changes with angle as coil turns with max at 90 deg and min at 0 deg = AC

"back emf" = due to induced emf by B field made by current...OPPOSES the current

$$I = (V - \varepsilon)/R$$

ε = back emf due to moving current

V = emf applied by external source

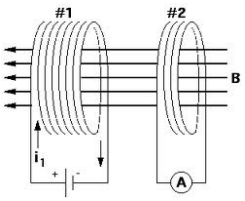
I = current needed to keep motor running at constant speed

***Mutual Induction* - when changing current in primary coil causes induction of emf in secondary coil**

$$N_2\Phi_2 = MI_1$$

$$\varepsilon_2 = -M(\Delta I_1/\Delta t)$$

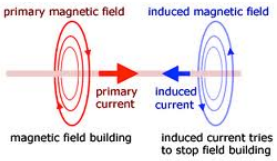
M = mutual inductance constant (units = Henries = H)



Self Induction **- when changing current in a coil causes induction of emf in the SAME coil**

$N\Phi = LI$

$\varepsilon = -L(\Delta I/\Delta t)$



L = self inductance constant (units = Henries = H)

Energy stored in magnetic field of inductors/ solenoids

Inductor Energy = $1/2(LI_2)$

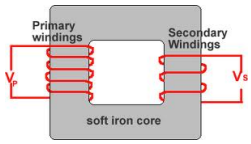
Solenoid Energy = $(1/2)\mu_o B2AL$

Energy density = energy/volume

= $B^2/(2\mu_o)$

Transformers -

device that steps V up or down



Uses AC current and induction

$\varepsilon_p/\varepsilon_s = N_p/N_s = I_s/I_p$

s = secondary
p = primary

step up transformer = more ε, more turns in secondary

step down transformer = less ε, less turns in secondary

POWER (VI) STAYS THE SAME
CONSERVATION OF ENERGY!!

Mutual and Self Inductance