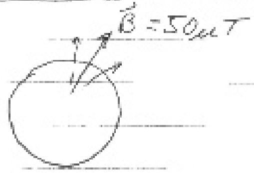
Problem 31.3



A coil, diameter 1m & co-axial with Earth B-field line.

turns, $n = 25$; In $\Delta t = 0.2s$, flip coil.

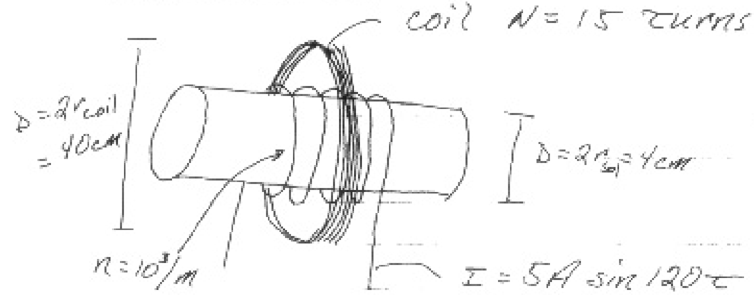
$\phi_B^{t=0s} = BA = (50\mu T)(\pi r^2)$
$= 3.93 \times 10^{-5} Tm^2$

$\phi_B^{t=0.2s} = -\phi_B^{t=0s}$

$\mathcal{E} = -n \dfrac{\Delta \phi_B}{\Delta t} = -(25)\dfrac{(7.86 \times 10^{-5} Tm^2)}{0.2s}$

$\boxed{\mathcal{E} = -983 mV}$

Problem 31.10



$r_{sol} < r_{coil}$

$B_{sol} = \mu_0 n I \Rightarrow \phi_B = B_{sol}(\pi r_{sol}^2)$
$= \mu_0 \pi n r_{sol}^2 I$

We can use Faraday's Law:

$\mathcal{E} = -N \dfrac{d}{dt}(\mu_0 \pi n r_{sol}^2 I)$

$= -N\mu_0 \pi n r_{sol}^2 \dfrac{dI}{dt}$

$= -(15)(4\pi \times 10^{-7} Tm/A)\pi(1000/m)(0.02m)^2 \times 600A/s \cos(120t)$

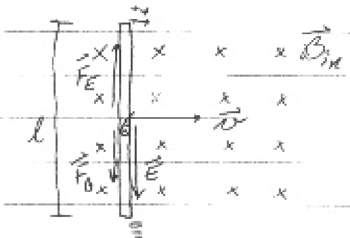
$= -(1.42 \times 10^5)(10^{-7}) Volt (\cos 120t)$

$= \boxed{-14.2 mV \cos(120t)}$

Motional Emf

1

$\vec{E}$ induced in a conductor moving thru a constant B field



straight conductor w/velocity, $\vec{v} \perp \vec{B}$

electrons feel force $\vec{F}_B = q_e \vec{v} \times \vec{B}$

$\vec{F}_B \rightarrow$ electrons to bottom

+ & - charges at opposite ends sets up $\vec{E}$ field

ΔV across ends of conductor

$\vec{F}_E = q\vec{E}$ upwards on electron

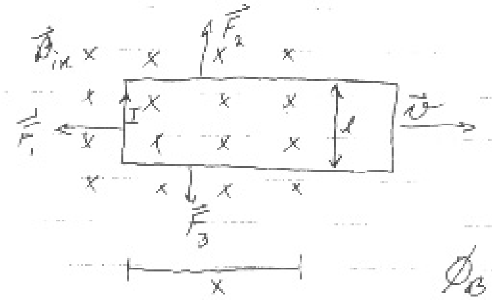
$\rightarrow$ charge accumulates until

$qvB = qE$

$\therefore$ $E = vB$ is equilibrium condition

Loop in a $\vec{B}$ field

2



A rectangular loop pulled out of a magnetic field with velocity, $\vec{v}$

Φ_B thru loop changes with time (since $x = x(t)$)

$\Phi_B = BA = Blx$

Using Faraday's Law

$$\mathcal{E} = -\frac{d\Phi_B}{dt} = -Bl\frac{dx}{dt} = \ominus Blv$$

$\hookrightarrow$ negative sign means induced I clockwise. This sets up a field // existing field (i.e. more Φ_B to slow its decrease)

Forces caused by loop in $\vec{B}$

$F_2 + F_3$ equal + opposite $\therefore$ cancel

F_1 counters our effort to move loop

$$F = I\vec{l} \times \vec{B} = IlB \sin 90^\circ (-\hat{i})$$

$$\vec{F}_1 = \boxed{-\frac{B^2 l^2 v}{R}\hat{i}}$$

1304/1404

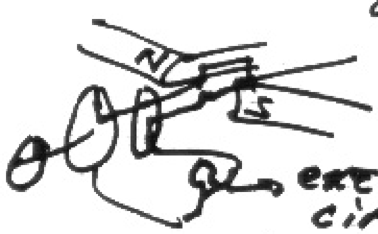
L15

2

Generators + Motors

Electric generators
→ energy by work transferred out by electrical transmission

AC generator
→ loop of wire rotated in a $\vec{B}$ field



Φ_B thru loop changes with time → $\mathcal{E}$

Let's say loop has N turns + rotates w/ freq. ω

$$\Phi_B = BA\cos\theta = BA\cos\omega t$$

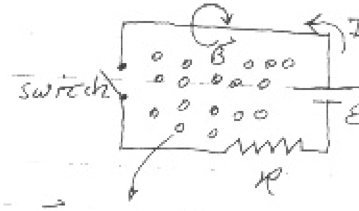
so $\mathcal{E} = -N\frac{d\Phi_B}{dt} = -NAB\frac{d}{dt}\cos\omega t$

$= NAB\omega \sin\omega t$ $\quad(\omega = 2\pi f)$

(1)

Self Induction:

→ Consider circuit with current + emf



$\vec{B}$ out of page inside of loop

– when throw switch
$I = 0 \Rightarrow I_{max}$
$\therefore B = 0 \Rightarrow B = B_{max}$
$\therefore \Delta\Phi_B > 0$

– this means we will have induced emf + current

From Lenz's Law, induced emf will try to keep $\Phi_B = 0$ + so an opposing emf results: "back emf"

$$I(t) < I_{max} = \mathcal{E}/R$$

{Note: this different than the RC circuit phenomenon which also causes $I(t) < I_{max}$}