Induced EMFs screencast notes

March 30, 2020 10:06 PM

Induced EMFs...

INDUCED EMFs (ELECTROMOTIVE FORCES)

March 24, 2020 7:33 AM

$$EMF = -N\frac{d\phi}{dt}$$ (N = number of turns) → Response to a change in flux

$$\phi = \iint_S \bar{B}\cdot\hat{n}\,dS$$

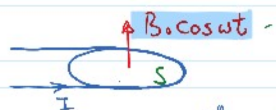
Ways to create an EMF:

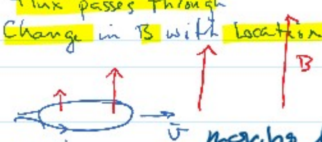
i) Change in B with time → $B(t) = B_0\cos\omega t$

ii) Change in S - surface that flux passes through

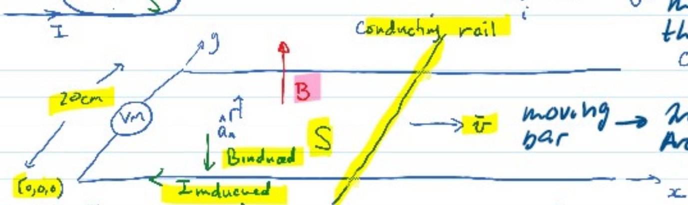
iii) Change in B with location

or, a combination of these effects.





moving loop through diff. B



Conducting rails

moving bar → inc. Area ∴ inc. $\bar{B}$

$\bar{B} = 0.8x^2\hat{a}_z$ $x = 5t + 2t^3$ → bar position x wrt time t

→ System opposes change in flux
∴ current generated in loop, creating $\vec{B}$ field opposing the change in $\vec{B}$ field

→ Find I_{emf} using RHR

What is the voltmeter reading @ 0.4s?

$$EMF = -N\frac{d\phi}{dt} \qquad \phi = \iint_S \bar{B}\cdot\hat{n}\,dS \qquad N = 1$$

$$\phi = \int_0^{0.2}\int_0^{x}(0.8)(x')^2\,\hat{a}_z\cdot\hat{a}_z\,dx'dy$$

$$= (0.2)(0.8)\frac{x^3}{3} = \frac{(0.2)(0.8)(5t+2t^3)^3}{3} \text{ Wb}$$

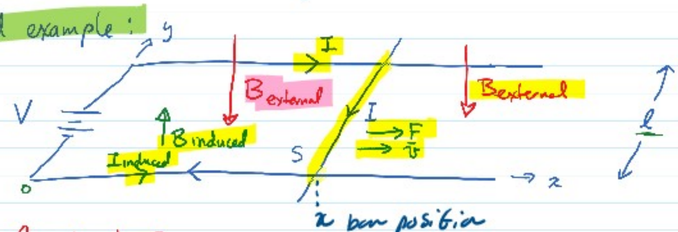
↳ sub in bar position

$$EMF = -\frac{d\phi}{dt} = -\frac{(0.2)(0.8)(3)(5t+2t^3)(5+6t^2)}{3}$$

@ t = 0.4 = −4.32 V.

Rail gun

2nd example :



Constant B

Connect Source V, current will flow

Force on the bar $\quad F = \int I d\ell \times B = I\ell B$ → For straight line segment in uniform field

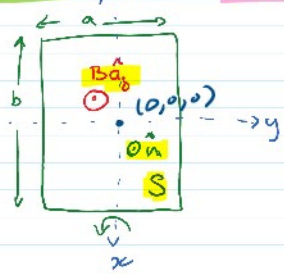
If Force is big, the bar could move

↳ ↑ S

$$\phi = BS = B\ell x$$

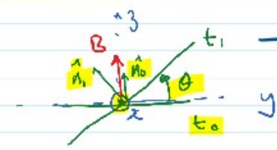
$$\text{Emf} = -\frac{d\phi}{dt} = -B\ell\frac{dx}{dt} = -B\ell v \longrightarrow \Delta x$$

3rd example - rotating loop



view from side

view from side



→ loop rotates w.r.t. t

$$\phi = \iint_S \vec{B}\cdot\hat{n}\, ds$$

$$ds = \hat{n}\, dx dy$$

$$\hat{n} = \cos\omega t\, \hat{a}_z - \sin\omega t\, \hat{a}_y$$ → normal $\hat{n}$ $\hat{a}_z$ & $\hat{a}_y$ components changes as loop rotates

$$\phi = \int_{-b/2}^{b/2}\int_{-a/2}^{a/2} B\hat{a}_z \cdot \left(\cos\omega t\, \hat{a}_z - \cancel{\sin\omega t\, \hat{a}_y}\right) dy dx$$

this component goes to zero due to dot product.

↳ $\because \hat{a}_z \cdot \hat{a}_y = 0$

$$= B ab \cos\omega t \quad \text{Wb}$$

$$\mathcal{E}_{MF} = -N\frac{d\Phi}{dt} = NB\underbrace{ab}_{S}\omega\sin\omega t \quad V$$

$$|\mathcal{E}_{MF}| \propto \underbrace{\overset{\#turns}{N}, B, S, \overset{\text{speed of rotation}}{\omega}}$$

↳ Emf depends on