NEET

THE ULTIMATE REVISION STOP

PYQ Tagged

E + M Question type covered

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1 Chapter- 2 Page Notes

MAGNETIC PHYSICS- Full

Moving Charges and Magnetism

Electric and Magnetic Lorentz force

1. Electric Lorentz Force

- $\vec{F_e} = q\vec{E}$ ★2011, 2010
- Acts on a charge
  - Charge at Rest
  - Charge is moving
- Direction of the force depends on the sign of the charge.

2. Magnetic Lorentz Force

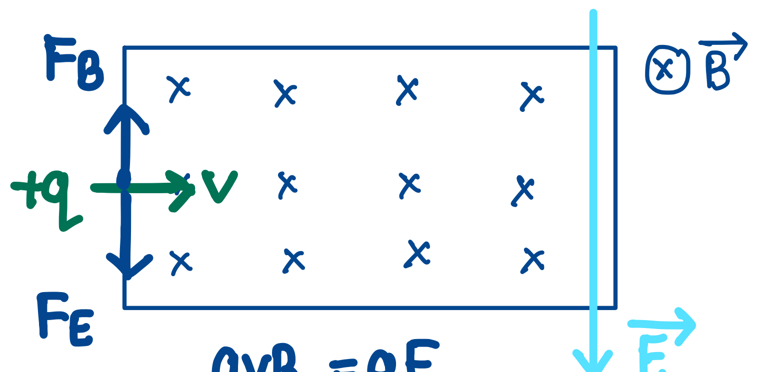
- $\vec{F_B} = q(\vec{v}\times\vec{B})$ ★2009
- Acts on a charge
  - when it is moving in $\vec{B}$ having $\vec{v}$ or component of $\vec{v}\perp\vec{B}$ ★2006
- Direction of force is decided by charge as well as the direction of $\vec{v}\times\vec{B}$.

Right Hand Rule

1. Point fingers in direction of $\vec{v}$.
2. Curl fingers in direction of $\vec{B}$.

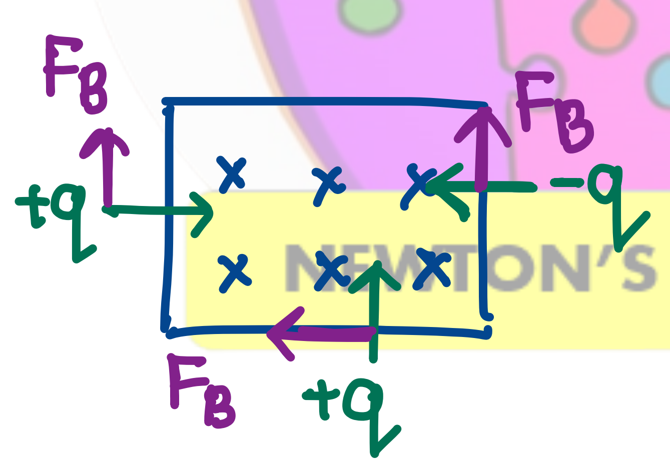
$\vec{F_B}$

- $+q$: In the direct^n of $\vec{v}\times\vec{B}$
- $-q$: Opposite to $\vec{v}\times\vec{B}$



$qvB = qE$

★2007 $v = \frac{E}{B}$ (Velocity selector)



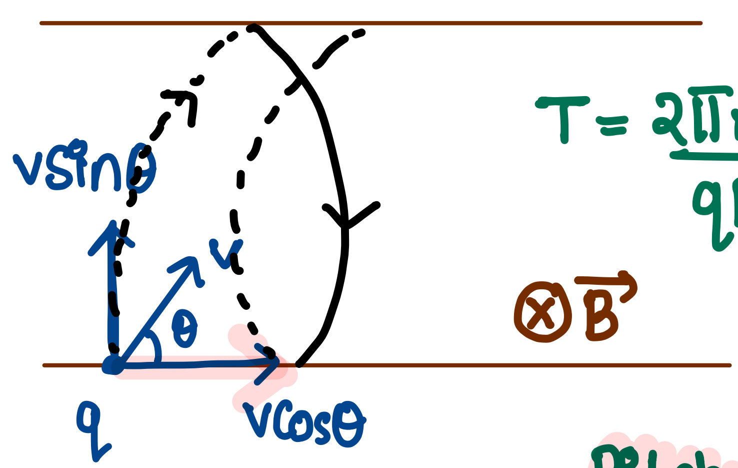
Important Equations

★2005 $R = \frac{mv}{qB}$ ★2007 $T = \frac{2\pi m}{qB}$

★2008 $KE = \frac{1}{2}mv^2 = \frac{q^2B^2R^2}{2m}$

$\omega = \frac{qB}{m}$ $\nu = \frac{qB}{2\pi m}$ ★2016

Charge moving in $\vec{B}$ such that $\vec{v}$ not $\perp$ to $\vec{B}$

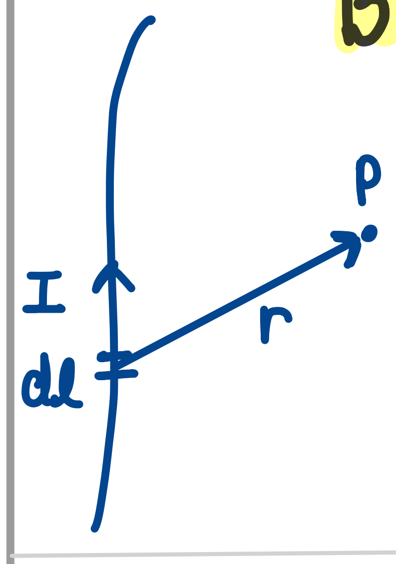


$T = \frac{2\pi m}{qB}$

$\otimes\vec{B}$

Pitch: $u_x . T = (v\cos\theta)\left(\frac{2\pi m}{qB}\right)$

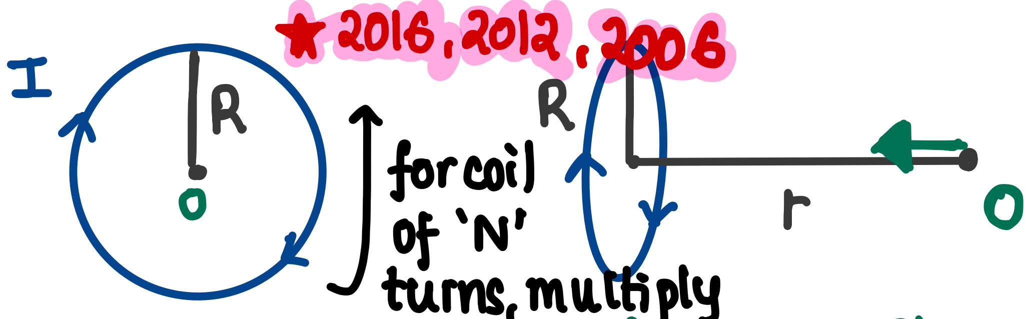
Biot-Savart's Law



$$d\vec{B_p} = \frac{\mu_0}{4\pi} \cdot \frac{I(\vec{dl}\times\hat{r})}{r^2} = \frac{\mu_0}{4\pi} \cdot \frac{I(\vec{dl}\times\vec{r})}{r^3}$$

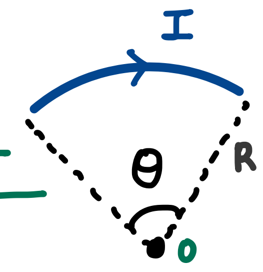
$\vec{B}$ Produced due to circular coil:

★2016, 2012, 2006



for coil of 'N' turns, multiply by N.

$\otimes \vec{B_0} = \frac{\mu_0 I}{2R}$ $\vec{B_0} = \frac{\mu_0 I}{2}\frac{(R^2)}{(R^2+r^2)^{3/2}}$

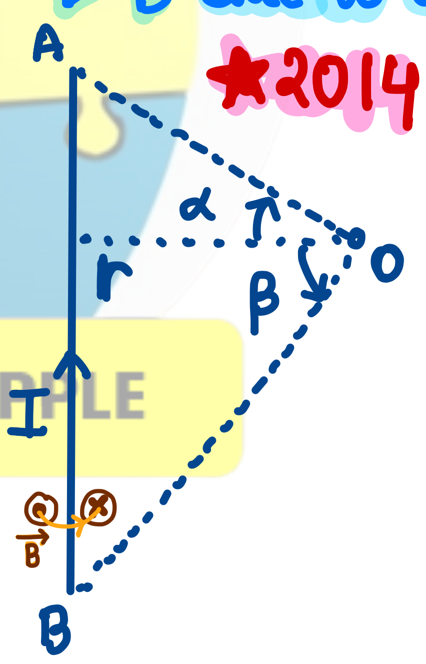


$\vec{B_0} = \frac{\mu_0 I}{12R} \xleftarrow{\theta=\frac{\pi}{3}}$ $\xrightarrow{\theta=\frac{\pi}{2}} \vec{B_0} = \frac{\mu_0 I}{8R}$

$\vec{B_0} = \frac{\mu_0 I}{2R}\cdot\frac{\theta}{2\pi}$

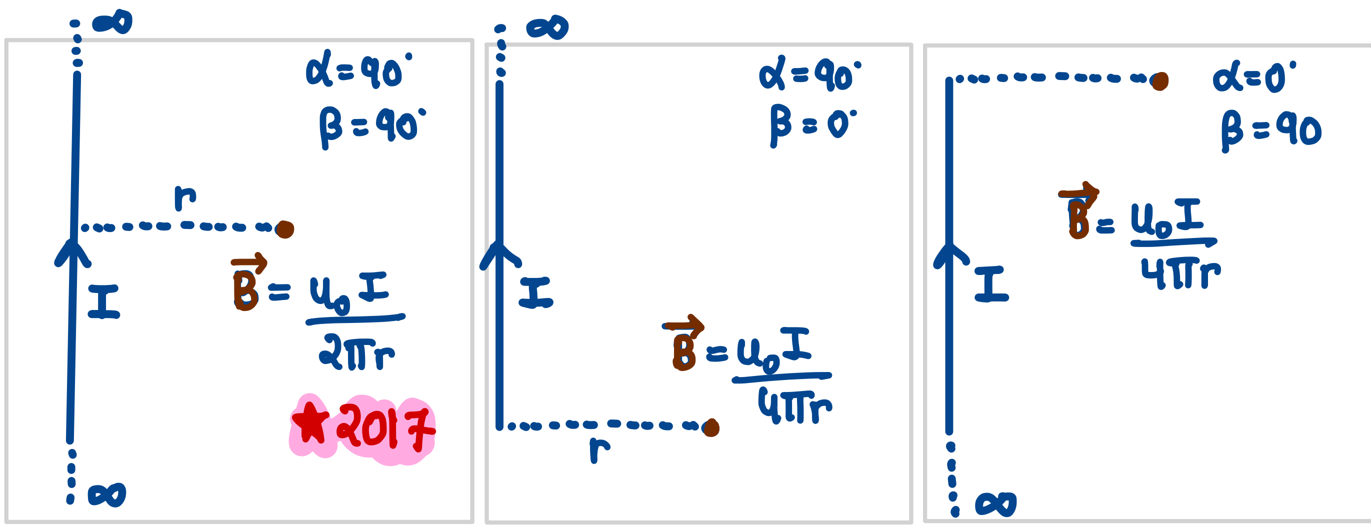
$\vec{B}$ due to a straight wire:

★2014

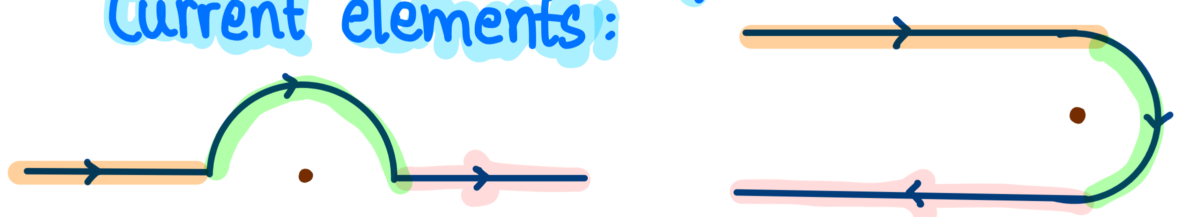


$$\vec{B_0} = \frac{\mu_0 I}{4\pi r}(\sin\alpha + \sin\beta)$$

- If A end is at infinity, $\alpha = 90^\circ$
  If B end is at infinity, $\beta = 90^\circ$
- If A end is at one of the ends, $\alpha = 0^\circ$
  If B end is at one of the ends, $\beta = 0^\circ$

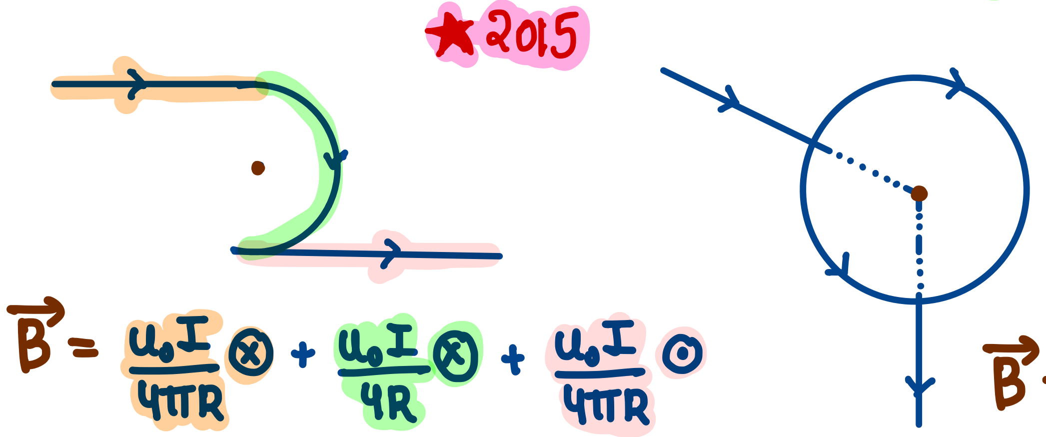


$\vec{B}$ due to combination of circular and linear Current elements:



$\vec{B} = 0 + \frac{\mu_0 I}{4R}\otimes + 0$ $\vec{B} = \frac{\mu_0 I}{4\pi R}\otimes + \frac{\mu_0 I}{4R}\otimes + \frac{\mu_0 I}{4\pi R}\otimes$

★2015

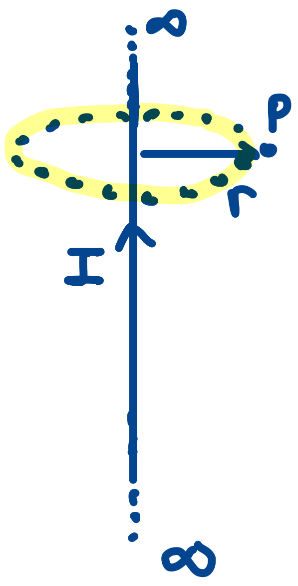


$\vec{B} = \frac{\mu_0 I}{4\pi R}\otimes + \frac{\mu_0 I}{4R}\otimes + \frac{\mu_0 I}{4\pi R}\odot$ $\vec{B} = 0$

Ampere's Circuital Law

$$\oint \vec{B}\cdot\vec{dl} = \mu_0 I_{enc}$$

→ $\vec{B}$ due to straight wire:

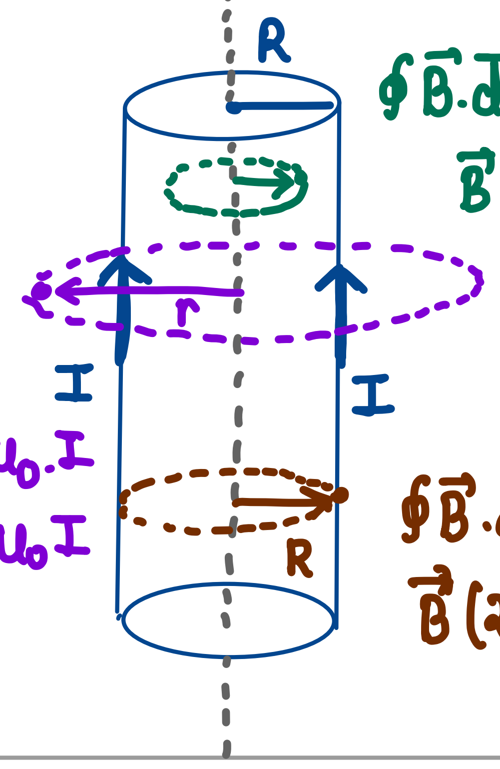


$\oint \vec{B_p}\cdot\vec{dl} = \mu_0 I_{enc}.$

$\vec{B_p}\cdot 2\pi r = \mu_0 . I$

$\vec{B_p} = \dfrac{\mu_0 I}{2\pi r}$

→ $\vec{B}$ due to a hollow wire:



$\oint \vec{B}\cdot\vec{dl} = \mu_0(0)$

$\vec{B} = 0$

$\oint \vec{B}\cdot\vec{dl} = \mu_0 . I$

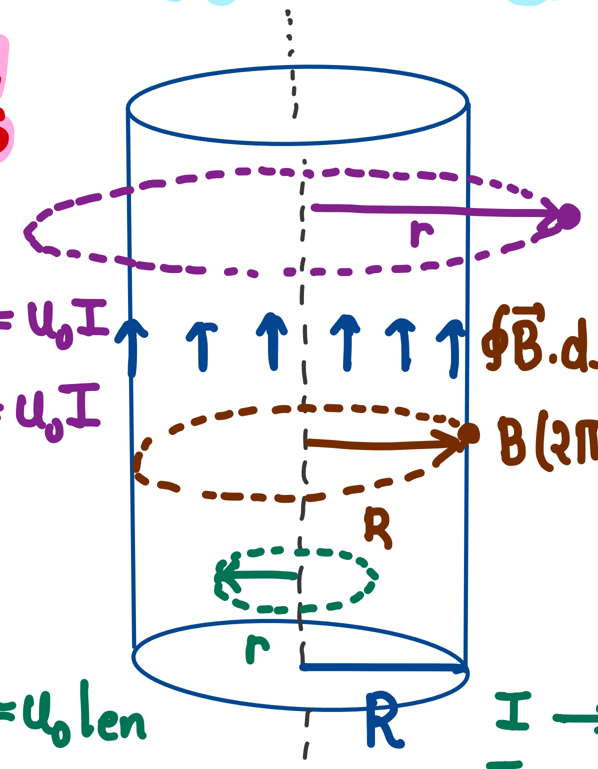
$B(2\pi r) = \mu_0 I$

$\oint \vec{B}\cdot\vec{dl} = \mu_0 . I$

$\vec{B}(2\pi R) = \mu_0 I$

→ $\vec{B}$ due to a solid wire:

★2019
2016



$\oint \vec{B}\cdot dl = \mu_0 I$

$B . 2\pi r = \mu_0 I$

$\oint \vec{B}\cdot dl = \mu_0 . I$

$B(2\pi R) = \mu_0 I$

$\oint \vec{B}\cdot\vec{dl} = \mu_0 I_{en}$

$B(2\pi r) = \dfrac{\mu_0 . I . r^2}{R^2}$

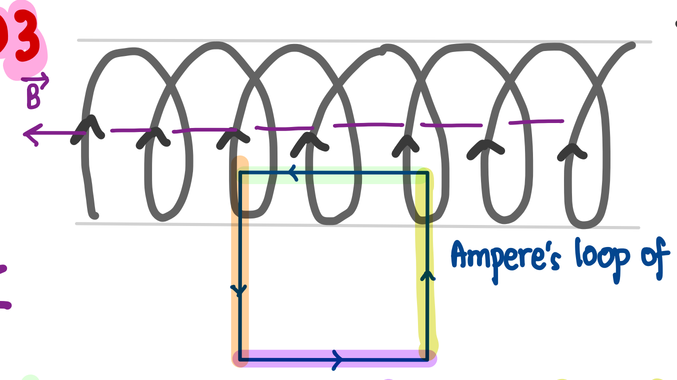
$I \rightarrow \pi R^2$

$I_{en} \rightarrow \pi r^2$

$\therefore I_{en} = \dfrac{I . r^2}{R^2}$

→ $\vec{B}$ due to a Solenoid

★2020, 2003



Total turns : N

length : L

$n = \dfrac{N}{L}$

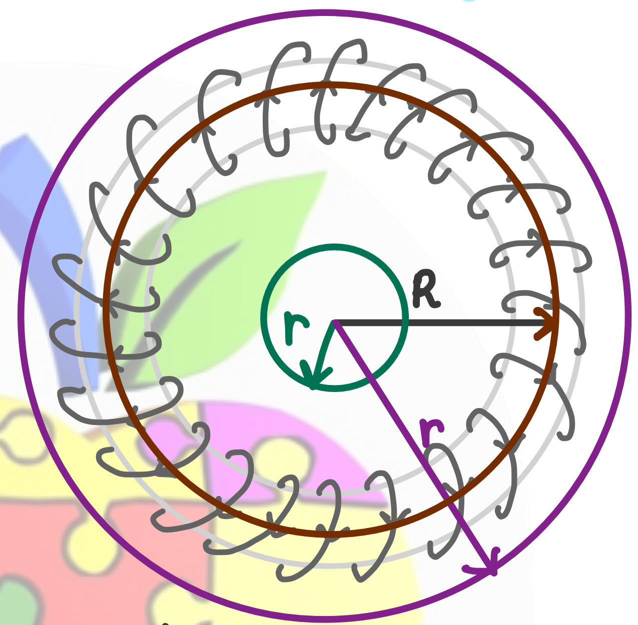
$I_{enclosed} = N_a . I = a . n . I$

$\mu_0 I_{enclosed} = \int \vec{B_1}\cdot\vec{dl_1} + \int \vec{B_2}\cdot\vec{dl_2} + \int \vec{B_3}\cdot\vec{dl_3} + \int \vec{B_4}\cdot\vec{dl_4}$

$= (Ba\cos 0^\circ) + B(a/2)\cos 90^\circ + (0)(a)\cos 180^\circ + B(a/2)\cos 90^\circ$

$\mu_0 . (anI) = Ba \Rightarrow \boxed{B = \mu_0 n I}$

→ $\vec{B}$ due to a toroid



$\oint \vec{B}\cdot dl = \mu_0 . (0) \Rightarrow \vec{B_{in}} = 0$

$\oint \vec{B}\cdot dl = \mu_0(0) \Rightarrow \vec{B_{out}} = 0$

$\oint \vec{B}\cdot dl = \mu_0 I_{enc}$

$\vec{B}(2\pi R) = \mu_0 . N . I$

$\vec{B} = \mu_0 . I\left(\dfrac{N}{2\pi R}\right) = \mu_0 n I$

Total turns : N

length : $L = 2\pi R$

$n = \dfrac{N}{L} = \dfrac{N}{2\pi R}$

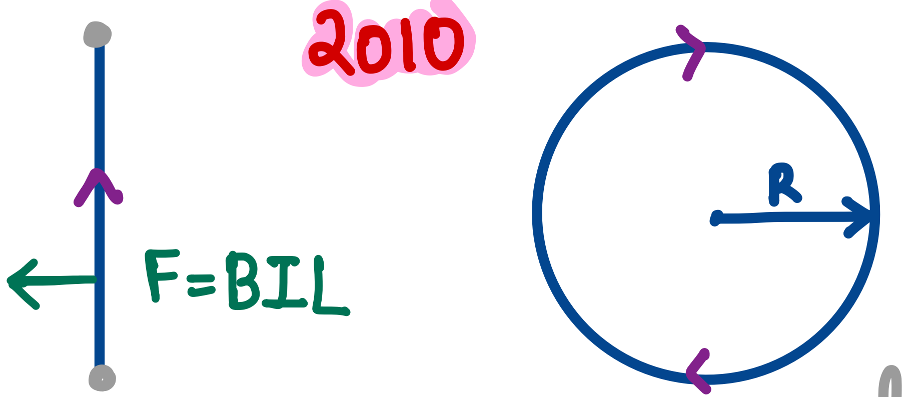
$\vec{F}$ on Current Carrying Wire

★2018

$\otimes \vec{B}$

$\vec{F} = I(\vec{l} \times \vec{B})$ → $l_{effective}$

★2011
2010

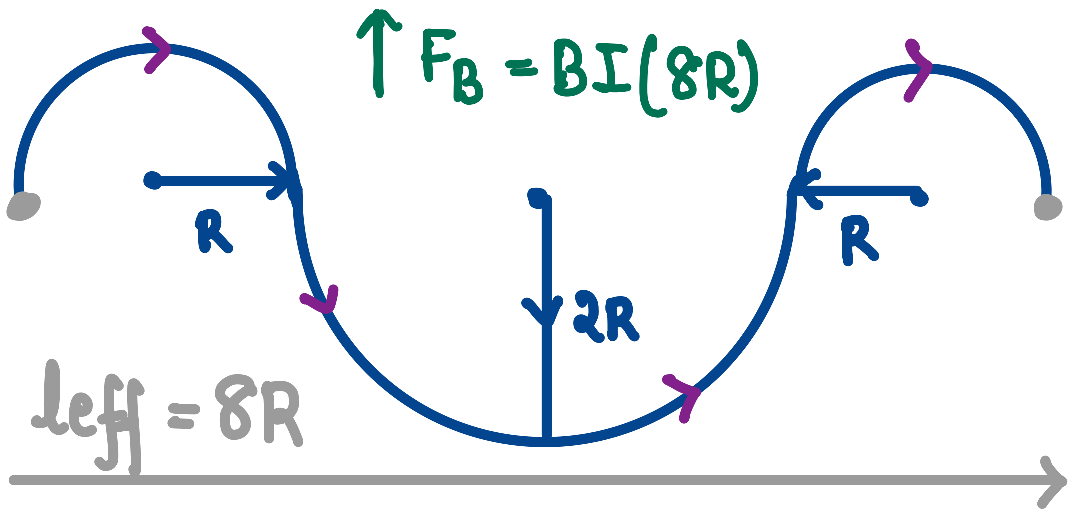


$F = BIL$

$l_{eff} = L$

$F = 0$

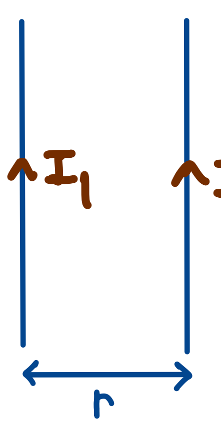
$l_{eff} = 0$



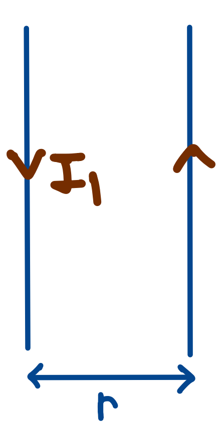
$\uparrow F_B = BI(8R)$

$l_{eff} = 8R$

Two Current Elements



$\left(\dfrac{F}{l}\right)_{attractive} = \dfrac{\mu_0 I_1 I_2}{2\pi r}$



$\left(\dfrac{F}{l}\right)_{repulsive} = \dfrac{\mu_0 I_1 I_2}{2\pi r}$

Moving Coil Galvanometer

$\vec{\tau}_{N coils} = \vec{M} \times \vec{B}$

$C\theta = (NIA)(B)$

Couple per unit twist.

$\theta = \dfrac{NIBA}{C}$

Per unit Ampere ★2018 → Current Sensitivity: $\theta_i = \dfrac{NBA}{C}$

Per unit Volt → Voltage Sensitivity: $\theta_v = \dfrac{NBA}{CR}$

Torque : $\vec{\tau} = \vec{M} \times \vec{B} = MB\sin\theta$

★2005
2016
★2017

Potential Energy : $PE = -\vec{M}\cdot\vec{B} = -MB\cos\theta$

Workdone $(\theta_1 \rightarrow \theta_2)$ ★2009 $= PE_{\theta_2} - PE_{\theta_1} = [MB\sin\theta_1 - MB\sin\theta_2]$

$\theta = 0^\circ$	$\tau = 0$	$PE_{min} = -MB$
$\theta = 90^\circ$	τ_{max}	$PE = 0$
$\theta = 180^\circ$	$\tau = 0$	$PE_{max} = MB$

$\theta = 0^\circ$ → Stable Equilibrium

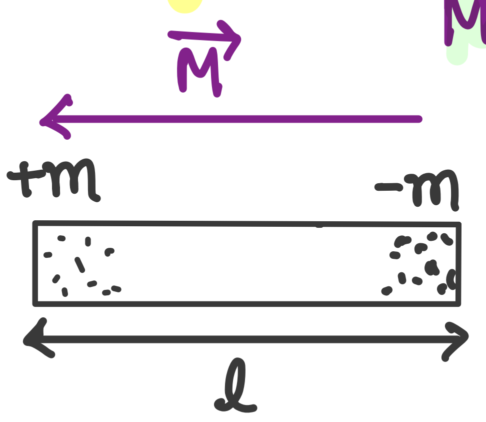
$\theta = 180^\circ$ → Unstable Equilibrium

Magnetism and Matter

Magnets

Two monopoles

North $(+m)$ South $(-m)$



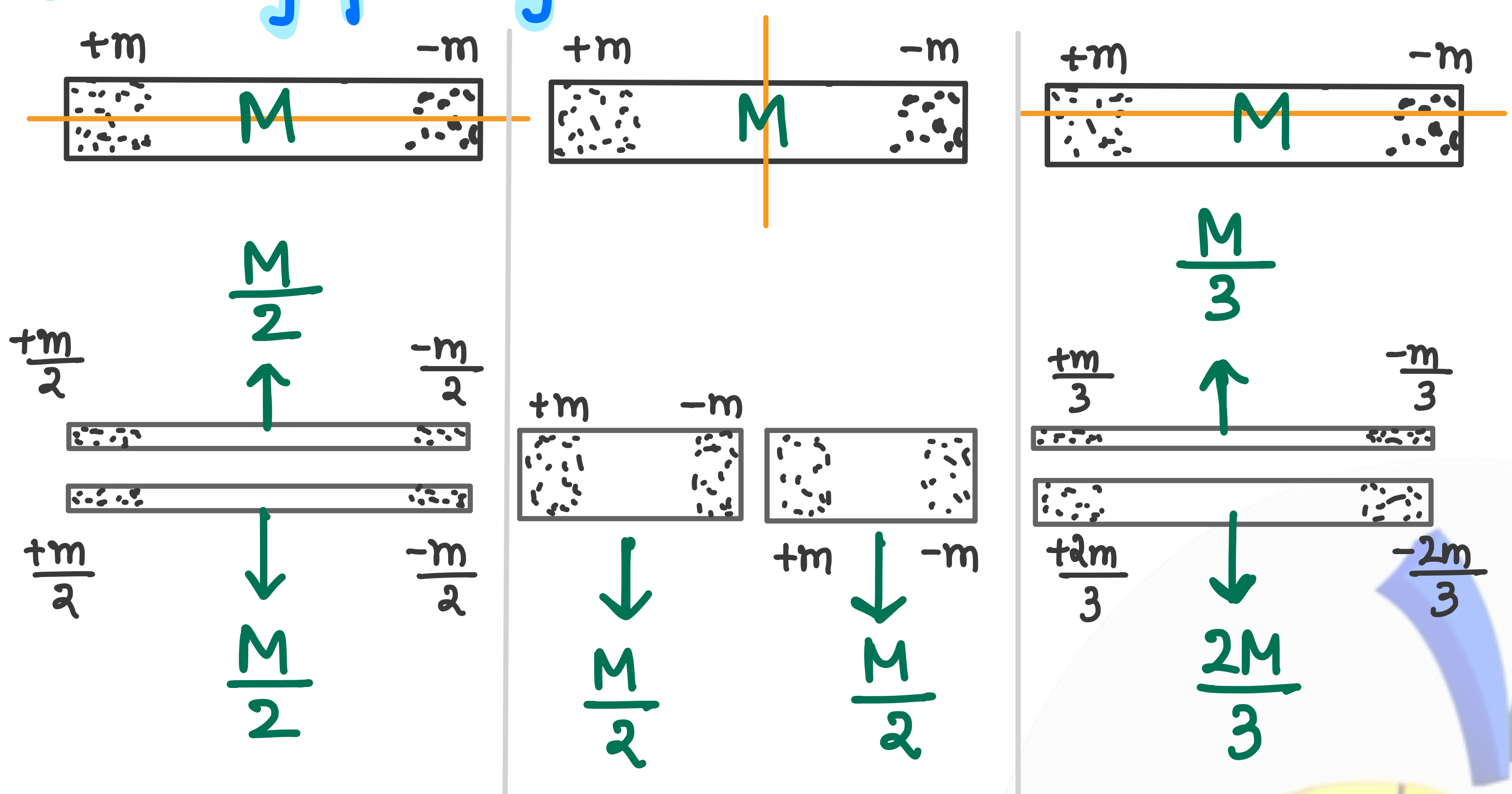
Magnetic Moment

$|\vec{M}| : (m)(l)$

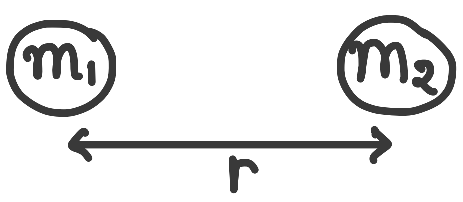
$\hat{M} : (S \to N)$ l_{eff}

★2014, 2013

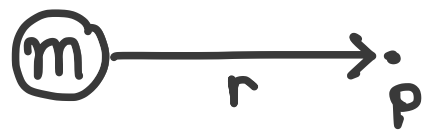
⇒ Cutting of a Magnet



⇒ Important Formulas related to Magnet

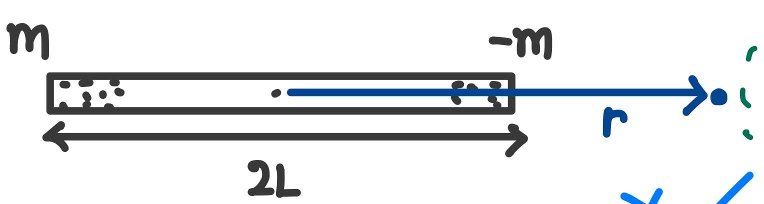


$$\vec{F}_{b/w} = \frac{\mu_m}{4\pi} \cdot \frac{m_1 m_2}{r^2}$$



$$\vec{B}_p = \frac{\mu_m}{4\pi} \cdot \frac{m}{r^3}$$

In the direction of $\vec{M}$



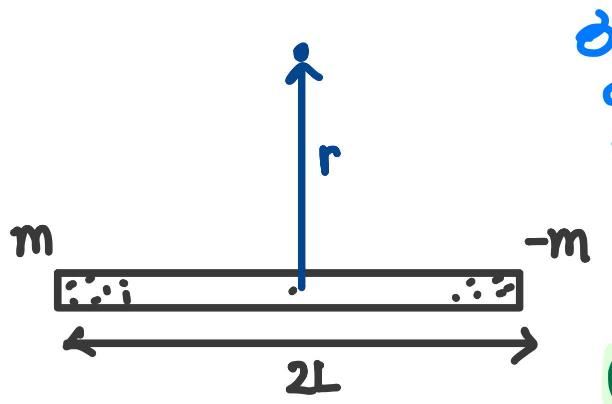
$$\vec{B}_{axial} = \frac{\mu_0}{4\pi} \cdot \frac{2Mr}{(r^2-L^2)^2}$$

For a short magnet

$$|\vec{B}_a| = \frac{\mu_0}{4\pi} \cdot \frac{2M}{r^3}$$

$$\rightarrow |\vec{B}_a| = 2|\vec{B}_e|$$

$$|\vec{B}_e| = \frac{\mu_0}{4\pi} \cdot \frac{M}{r^3}$$



$$\vec{B}_{equi} = \frac{\mu_0}{4\pi} \cdot \frac{M}{(r^2+L^2)^{3/2}}$$

Opposite to $\vec{M}$

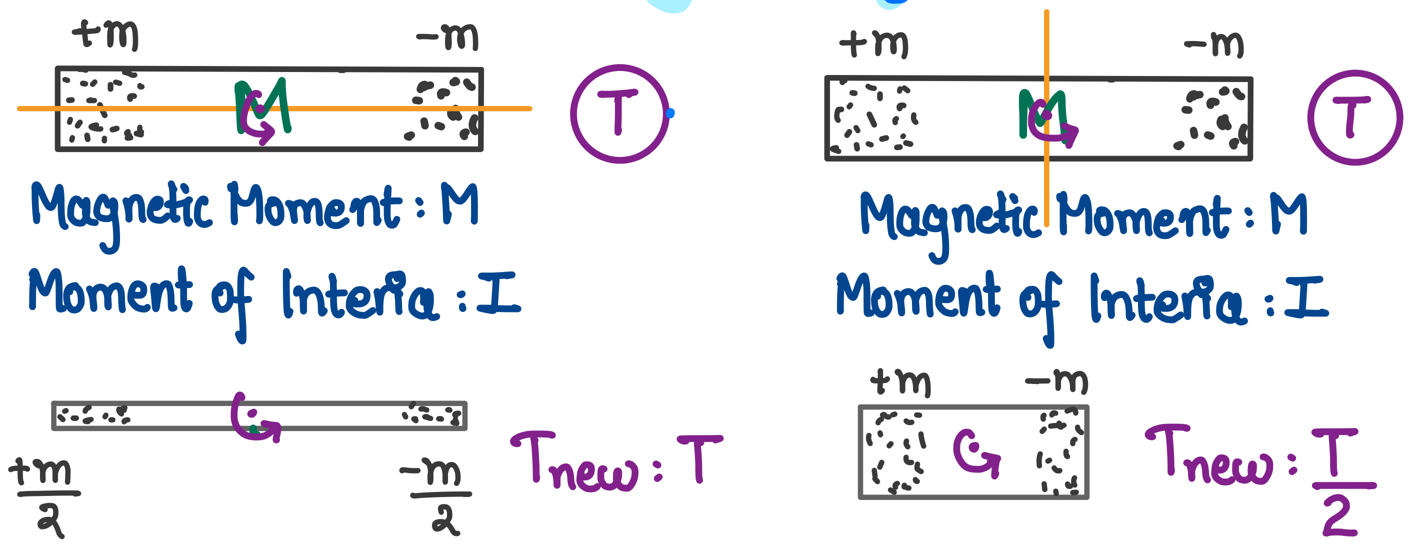
⇒ Oscillation of a magnet in $\vec{B}_{ext}$:

$$\tau = MB\sin\theta = I.\alpha \rightarrow \alpha = \frac{MB}{I}.\theta$$

$$\therefore \omega = \sqrt{\frac{MB}{I}} \quad \text{or} \quad T = \frac{2\pi}{\omega} = 2\pi\sqrt{\frac{I}{MB}}$$

Time period of Oscillation

⇒ Variation on cutting a magnet



Magnetic Moment : M
Moment of Interia : I

T_{new} : T

Magnetic Moment : $\frac{M}{2}$
Moment of Interia : $\frac{I}{2}$

Magnetic Moment : M
Moment of Interia : I

T_{new} : $\frac{T}{2}$

Magnetic Moment : $\frac{M}{2}$
Moment of Interia : $\frac{I}{8}$

⇒ Combining two bar magnets

$$T_1 = \frac{1}{2\pi}\sqrt{\frac{(I_1+I_2)}{B(M_2+M_1)}} \qquad T_2 = \frac{1}{2\pi}\sqrt{\frac{(I_1+I_2)}{B(M_1-M_2)}}$$

$$\frac{M_1}{M_2} = \frac{T_2^2+T_1^2}{T_2^2-T_1^2} \quad ; \quad \frac{T_1}{T_2} = \sqrt{\frac{M_1-M_2}{M_1+M_2}}$$

⇓

Oscillation Magnetometer ★2010

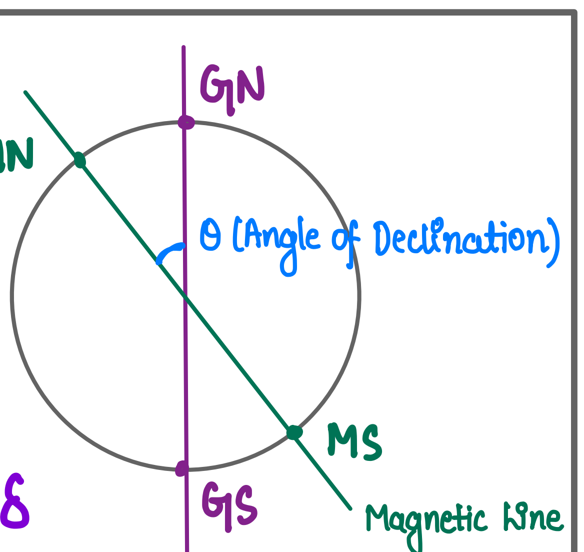
1. Device in which magnet is placed, which is then free to oscillate in $\vec{B}_{ext}$.
2. The above method in which two magnets are placed simultaneously ⇒ Sum/Difference Method
3. Method in which one magnet is substituted by other → Substitution Method

Magnetic Field Lines

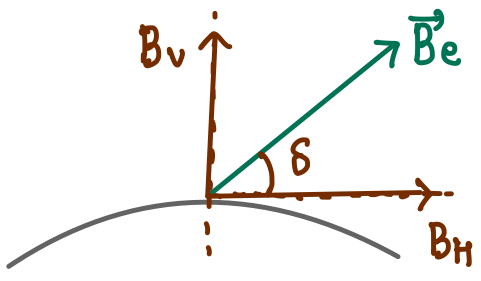
1. Continous Closed curves.
2. $(N \to S)$ outside the magnet
   $(S \to N)$ inside the magnet
3. Never Intersect
4. Magnetic field lines
   - Crowded → Strong $\vec{B}$
   - Spaced → Weak $\vec{B}$.
   - Equally Spaced: $\vec{B}$ uniform
   - Not Equally Spaced: $\vec{B}$ non-uniform

Earth's Magnetism

➡ Basics



- $B_H = B_e . \cos\delta$
- $B_V = B_e . \sin\delta$

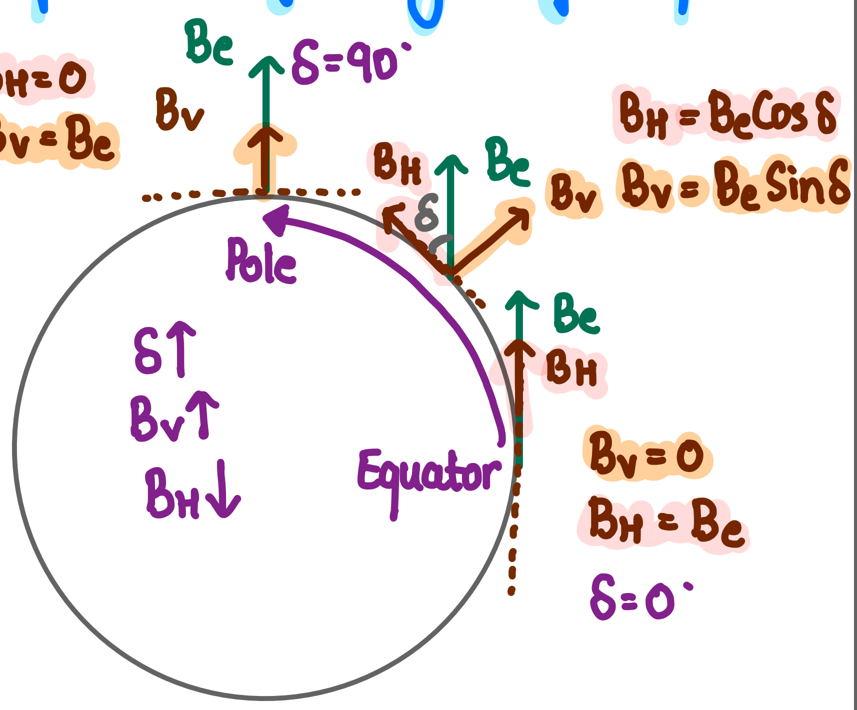


$B_e = \sqrt{B_H^2 + B_V^2}$

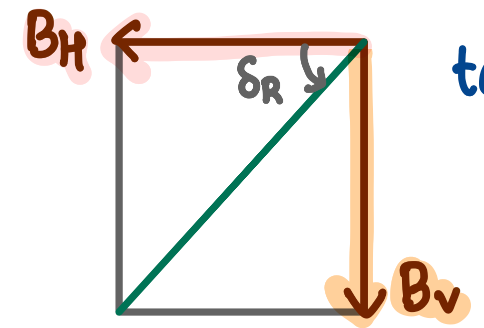
δ → Angle of Dip
δ → Angle of Inclination

➡ Depiction of Angle of Dip

★2019

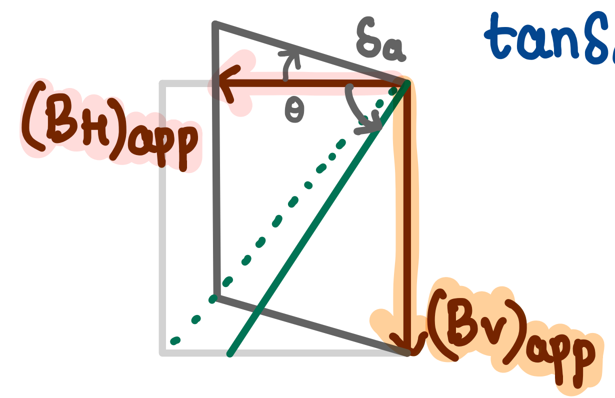


➡ δReal and δapp



$\tan\delta_R = \frac{B_V}{B_H}$

★2017 Magnetic Needle deflected by θ from Magnetic plane



$\tan\delta_a = \frac{B_V}{B_H . \cos\theta}$

$= \frac{\tan\delta_R}{\cos\theta}$

Important Rules to solve Q on oscillation of magnet in Earth's Magnetic field

$T \propto \frac{1}{\sqrt{B}}$

Magnet is Oscillating in

Magnetic Plane	Horizontal Plane	Vertical Plane
$B = B_e$	$B = B_H = B_e \cos\delta$	$B = B_V = B_V \sin\delta$

→ In most devices, like Deflection and Tangent Galvanometer

➡ Tangent Galvanometer

Initially

Magnetic needle points towards $\vec{B}_H$ ⟶ B_H

↓

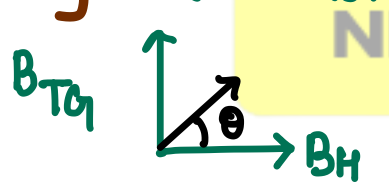
When no current is flowing through the Galvanometer

↓

$\vec{B}_{TG} = 0$

Finally

When the current flows through N Circular coils.



Deflection by θ

$\tan\theta = \frac{B_{TG}}{B_H}$

$\tan\theta . B_H = \mu_0 . \frac{NI}{2R}$

$\therefore I = \frac{2RB_H}{\mu_0 . NI} . \tan\theta$

Reduction factor

➡ Deflection Magnetometer

Initially

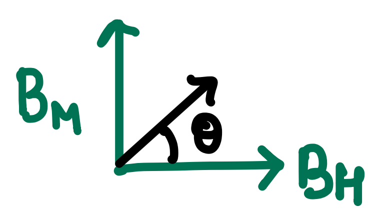
Magnetic needle points towards $\vec{B}_H$ ⟶ B_H

↓

No external magnet Present

Finally

External magnet brought



Deflection by θ

$\tan\theta = \frac{B_M}{B_H}$

$B_M = B_H . \tan\theta$

Tan A | Tan B

Tan A: Short Magnet Produces $\vec{B}_{axial}$ on the Magnetic Needle

↓

$\frac{\mu_0}{4\pi} . \frac{2M}{r^3} = B_H . \tan\theta$

Tan B: Short Magnet Produces $\vec{B}_{equitorial}$ on the Magnetic Needle

↓

$\frac{\mu_0}{4\pi} . \frac{M}{r^3} = B_H . \tan\theta$

Magnetic Properties

1. Magnetic Intensity, H : $\frac{M \text{ due to } \vec{B}_{ext}}{\text{Volume}}$
2. Intensity of Magnetisation, I : $\frac{M \text{ due to } \vec{B}_{ind}}{\text{Volume}}$
3. Magnetic Susceptibility, χ_m : $\frac{\vec{I}}{\vec{H}}$
   - χ_m ⊕ → $\vec{B}_{ind}$ and $\vec{B}_{ext}$ in same direction
   - χ_m ⊖ → $\vec{B}_{ind}$ and $\vec{B}_{ext}$ in Opposite direction
4. Magnetic Permeability, μ_m : $\frac{\vec{H}}{\vec{B}}$

Magnetic Materials ★2011

★2018

Diamagnetic	Paramagnetic	Ferromagnetic
• Weakly repels MFL.	• Weakly attracts MFL.	• Strongly attracts MFL.
$\mu_r < 1$ ★2016	$\mu_r > 1$	$\mu_r >> 1$
• χ_m : Small and ⊖	• χ_m : Small and ⊕	• χ_m : Large and ⊕
Doesnt obey Curie's Law	$\chi_m \propto \frac{B}{T_c}$	$\chi_m \propto \frac{B}{T - T_c}$

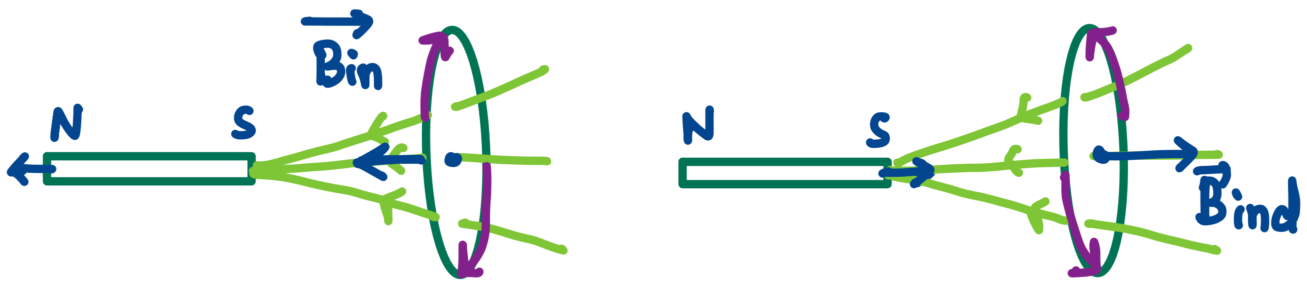
★2007, 2006, 2003

Electromagnetic Induction

Lenz's law

$(\phi_B)_{coil} \uparrow \Rightarrow$ EMF is induced to ↑ it

$(\phi_B)_{coil} \downarrow \Rightarrow$ EMF is induced to ↓ it



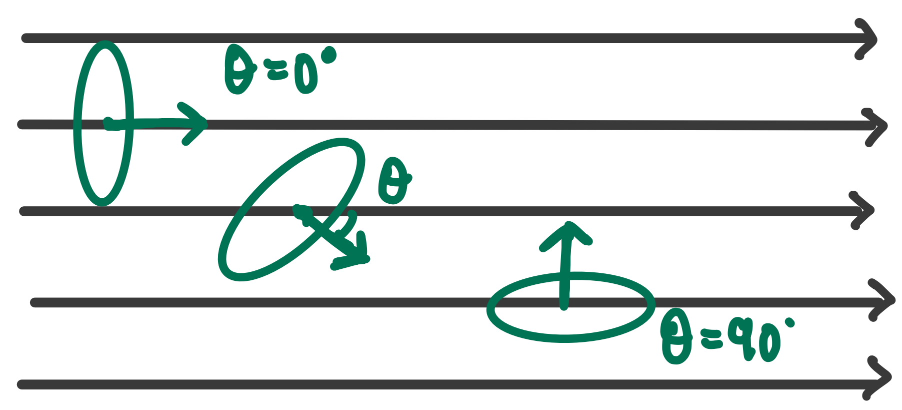
$\phi_B \downarrow$ — $\vec{B}_{ind}$ in the directⁿ of $\vec{B}_{ext}$

$\phi_B \uparrow$ — $\vec{B}_{ind}$ opposite to $\vec{B}_{ext}$

Induced due to EMF induced

- $\phi_B \uparrow$: EMF induced ⊖ ★2015
- $\phi_B \downarrow$: EMF induced ⊕

Magnetic flux and Induction ★2019



$\phi_B = \vec{B}.\vec{A}$ ★2008 → SI Unit : Weber

$= BA\cos\theta$

★2010, 2009 ★2016

$$\frac{d\phi_B}{dt} = B\left(\frac{dA}{dt}\right) = B.2\pi R_t.\left(\frac{dR}{dt}\right) = A.\left(\frac{dB}{dt}\right)$$

$$EMF_{induced} = -\frac{d\phi_B}{dt}$$

★2012, 2011

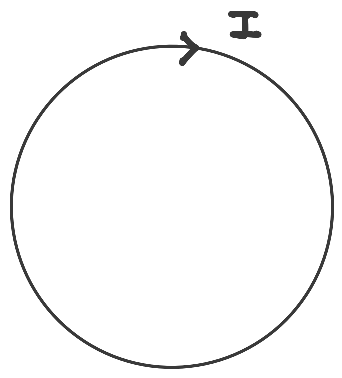
$$I_{induced} = -\frac{d\phi_B}{dt}.\frac{1}{R_{coil}}$$

$$Q_{induced} = -\frac{\Delta\phi_B}{R_{coil}}$$

- If flux through a coil changes at high Rate, EMF is induced of greater magnitude.

Self and Mutual Inductance

⇒ Circular Coil



Radius – R

$B_{coil} = \frac{\mu_0 I}{2R}$

$A_{coil} = \pi R^2$

$\phi_B = B_{coil}.A_{coil}$
$= \frac{\mu_0 I}{2R}.\pi R^2$

$L_{coil} = \frac{\phi_B}{I} = \frac{\mu_0 \pi R}{2}$

⇒ Solenoid

No. of Coils : N
Length : L

$B_{solenoid} = \mu_0 n I$
$= \frac{\mu_0 N I}{L}$

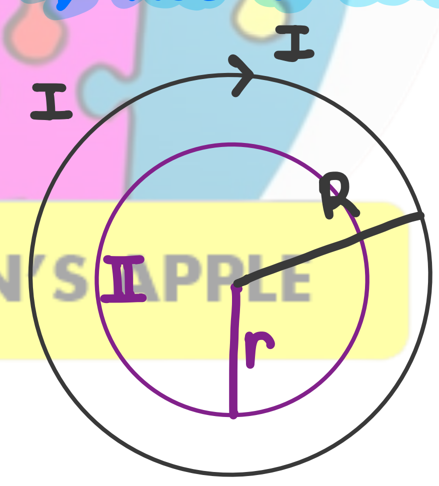
$A_{solenoid} = NA$

$\phi_B = \frac{\mu_0 . N^2 A I}{L}$

★2016, 2008, 2020

$L_{solenoid} = \frac{\phi_B}{I} = \frac{\mu_0 N^2 A}{L}$

⇒ Two co-axial, co-centric circular coils

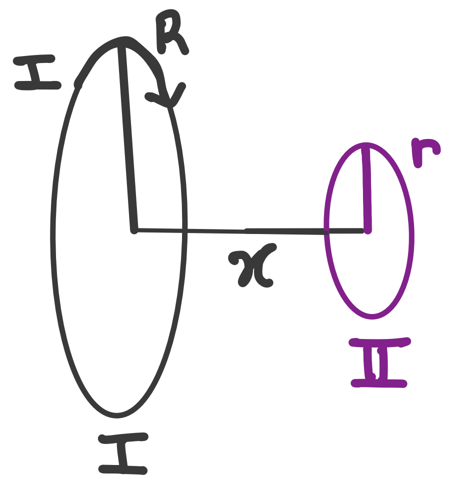


$\vec{B}_1 = \frac{\mu_0 I}{2R}$; $A_2 = \pi r^2$

$\phi_{21} = B_1 A_2 = \frac{\mu_0 I \pi r^2}{2R}$

$M_{21} = \frac{\phi_{21}}{I} = \frac{\mu_0 \pi r^2}{2R}$

⇒ Two co-axial, circular coils



$\vec{B}_1 = \frac{\mu_0 I}{2}.\frac{R^2}{(R^2+x^2)^{3/2}}$

$A_2 = \pi r^2$

$\phi_{21} = B_1 A_2 = \frac{\mu_0 I . R^2 . \pi r^2}{2(R^2+r^2)^{3/2}}$

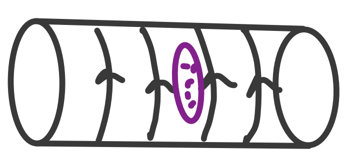
$M_{21} = \frac{\mu_0 \pi R^2 r^2}{2(R^2+r^2)^{3/2}}$

★ $\phi_{11} = L_1 I_1$
$\phi_{22} = L_2 I_2$
$\phi_{12} = M_{12} I_2$
$\phi_{21} = M_{21} I_1$

★ $EMF_{ind} = -L.\frac{dI}{dt}$
$= -M.\frac{dI}{dt}$

⇒ Circular coil in Solenoid

Current, I



Total coils : N
Length : L
Area of coils : A

Inside coil of Radius, r.

$\vec{B}_{solenoid} : \frac{\mu_0 . N . I}{L}$ $A_{coil} = \pi r^2$

$\phi_{cs} = A_c . B_s = \mu_0 n I . \pi r^2$; $M_{cs} = \mu_0 n \pi r^2$

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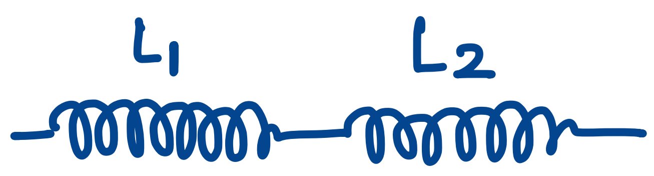
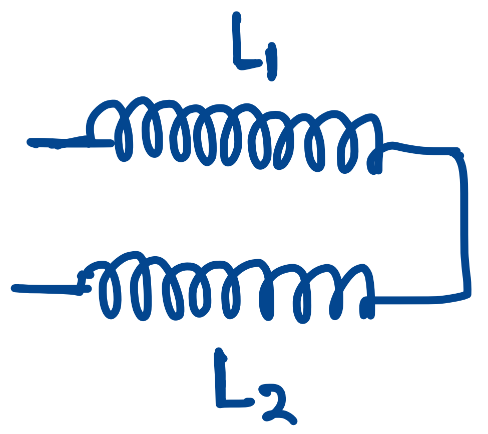
Combination of Inductors

Series

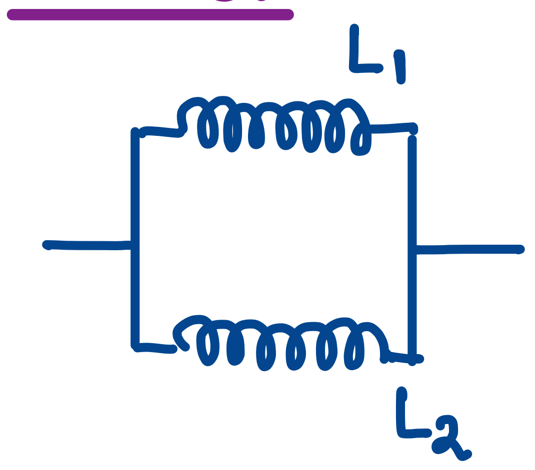




$L_s = L_1 + L_2 + 2M$

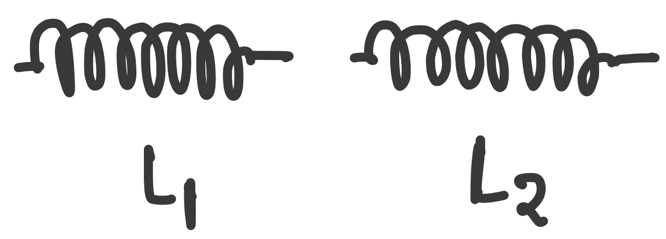
$L_s = L_1 + L_2 - 2M$

Parallel



$\frac{1}{L_p} = \frac{1}{L_1} + \frac{1}{L_2}$

Coupling of Inductors

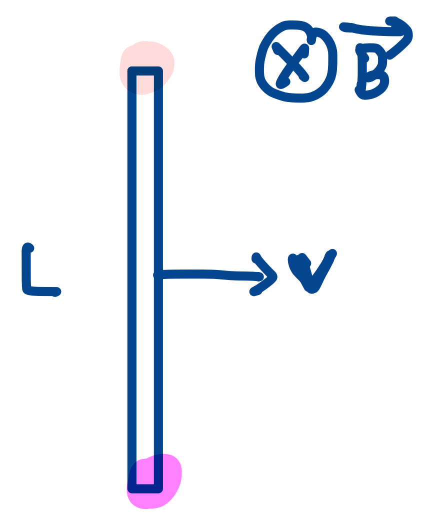


⇒ Maximum Mutual Inductance, M_{max}

$M_{max} = \sqrt{L_1 L_2}$ ★2006

⇒ Coupling factor, $k = \frac{M}{M_{max}}$

Motional EMF ★2014



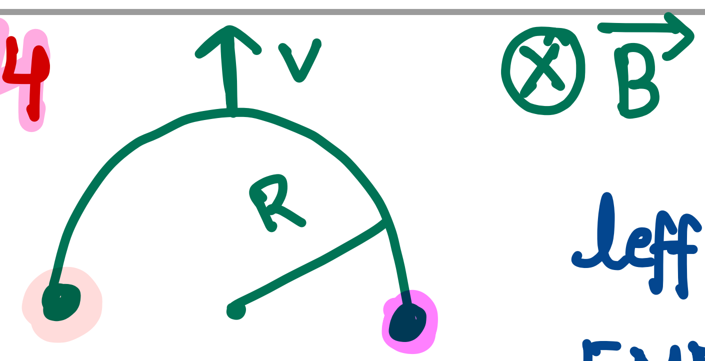
$(\vec{B} \perp \ell \perp \vec{v})$

- EMFinduced $= B l v$. ★2015
- Right Hand Rule · Point your fingers in the direction of $\vec{v}$ and curl in the direction of $\vec{B}$

↓

Thumb will point towards V_{higher}

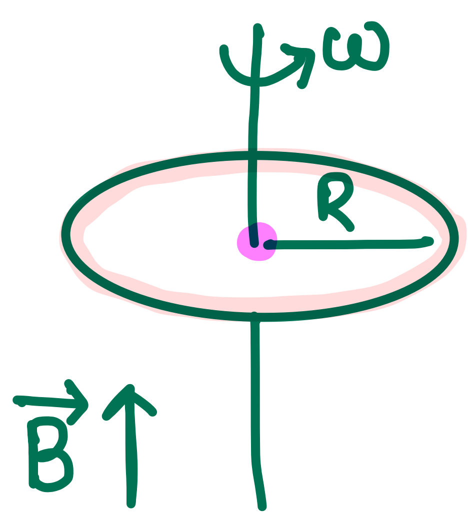
★



$l_{eff} = 2R$

$EMF = BI(2R)$

★

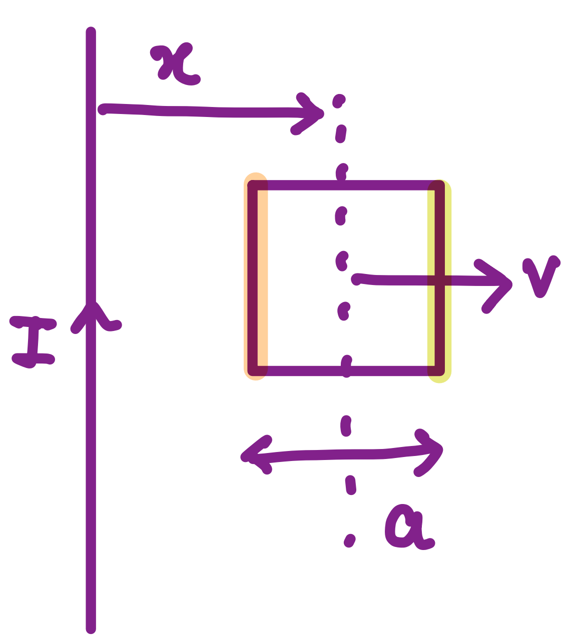


$EMF = \frac{1}{2} B \omega R^2$

★2018

⇒ Energy stored in Inductor $= \frac{1}{2} L I^2$

★2015



Induced EMF ?

$E_{ind} = E_1 - E_2$

$= B_1 a v - B_2 a v$

$= \left(\frac{\mu_0 I}{2\pi (x - \frac{a}{2})} - \frac{\mu_0 I}{2\pi (x + \frac{a}{2})} \right) a v$

$E_{ind} \propto \frac{1}{(2x - a)(2x + a)}$

AC Generator

'N' Coils of area A placed in $\vec{B}$ and rotated with 'ω'

$\phi_B = NBA \cos\theta$

$= NBA \cos \omega t$

$EMF_{ind} = -\frac{d\phi}{dt} = -NBA\omega . \sin \omega t$

↓

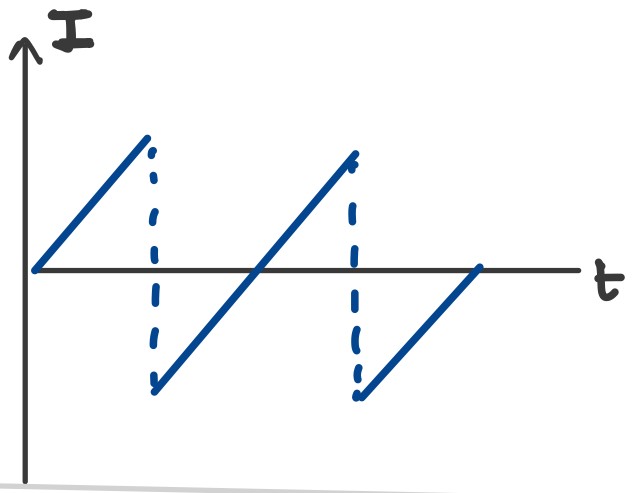
$(EMF)_{max}$

★2013

→ frequency of change in direction of E_{ind} is twice per revolution

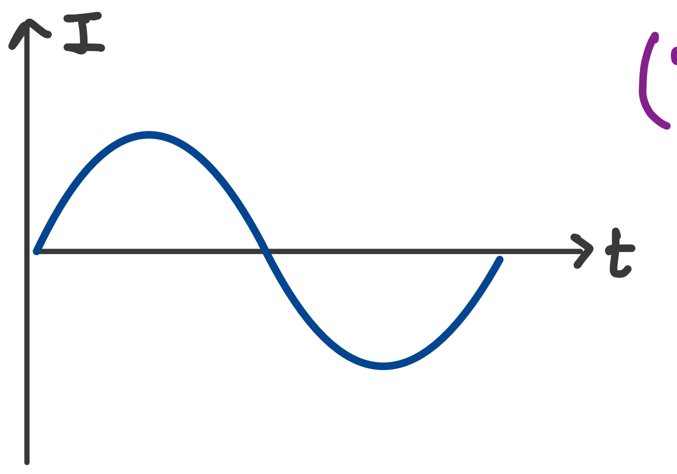
Alternating Current

Important types of Current Circuits



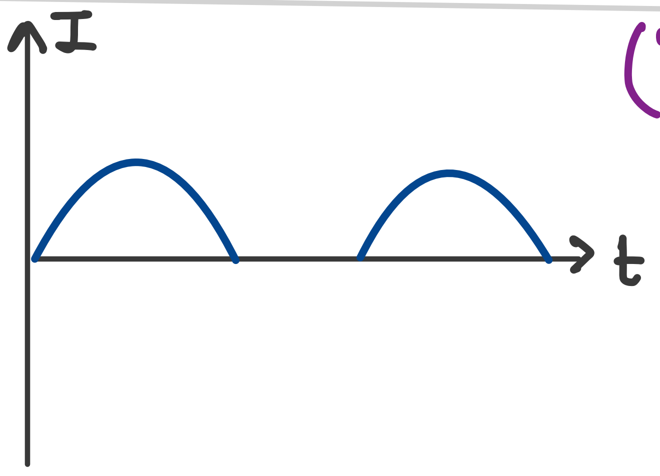
$(i_{mean})_{1/2} : \dfrac{\frac{1}{2} I_0 \times \frac{T}{2}}{\frac{T}{2}} = \dfrac{I_0}{2}$

$i_{rms} : \dfrac{I_0}{\sqrt{3}}$



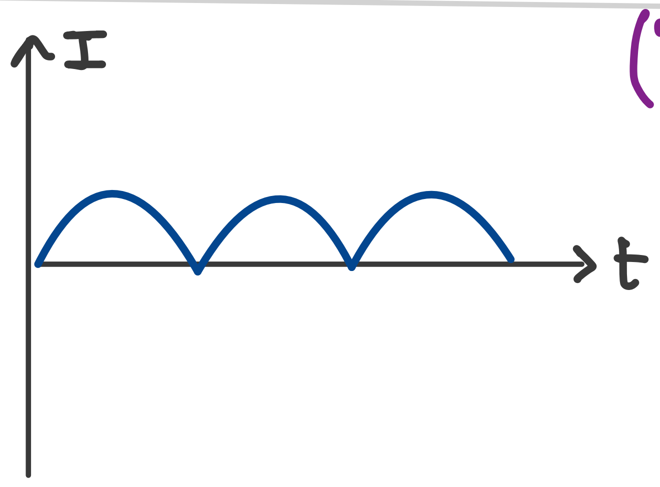
$(i_{mean})_{1/2} : \dfrac{\frac{2I_0}{\omega}}{\frac{T}{2}} = \dfrac{2I_0}{\pi}$

$i_{rms} : \dfrac{I_0}{\sqrt{2}}$ ★2011



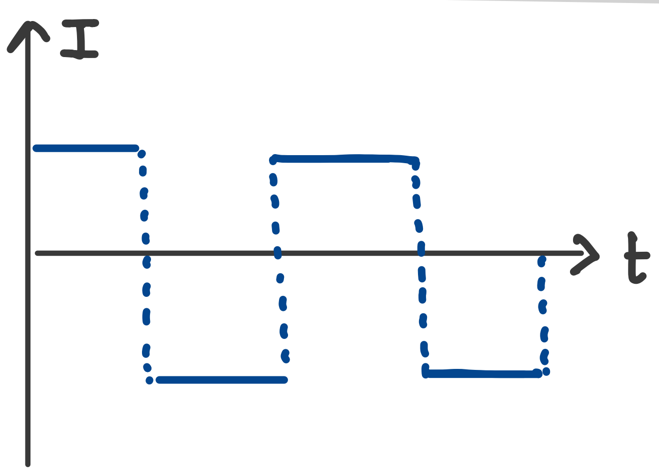
$(i_{mean})_{1/2} : \dfrac{\frac{2I_0}{\omega}}{\frac{T}{2}} = \dfrac{2I_0}{\pi}$

$i_{rms} : \dfrac{I_0}{2}$



$(i_{mean})_{1/2} : \dfrac{\frac{2I_0}{\omega}}{\frac{T}{2}} = \dfrac{2I_0}{\pi}$

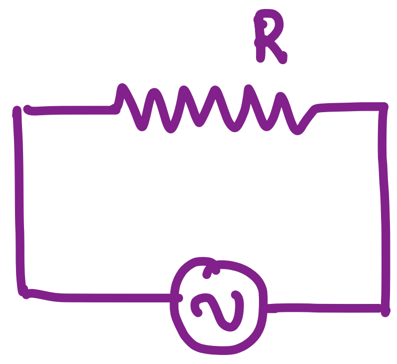
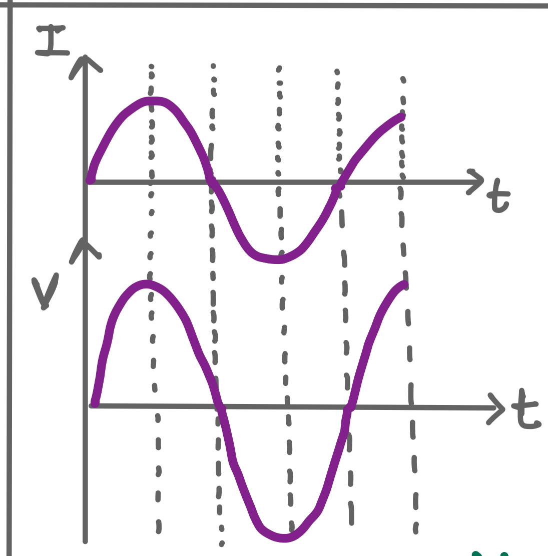
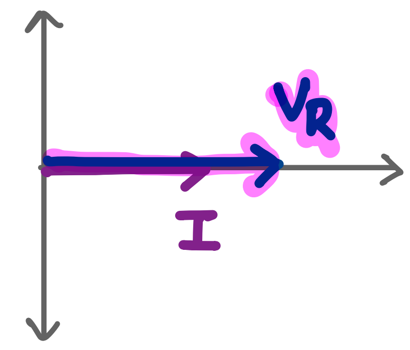
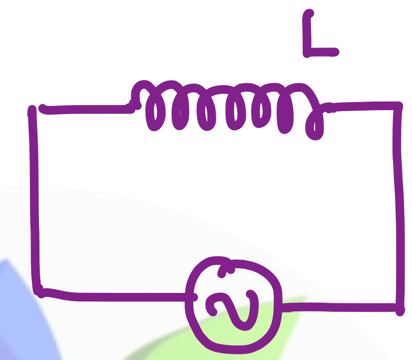
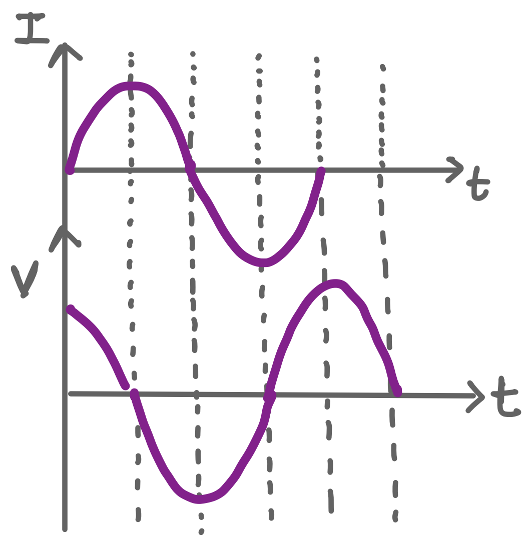
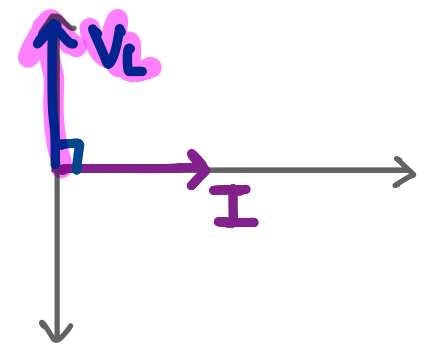
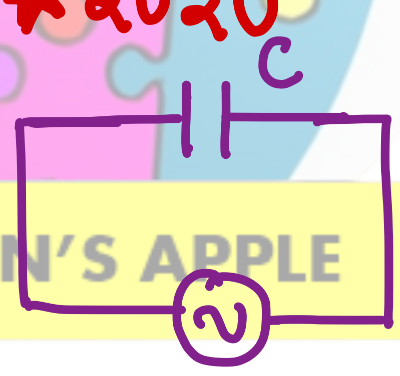
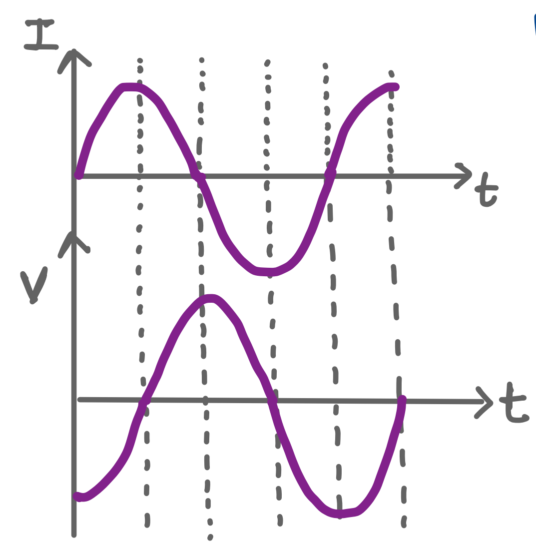
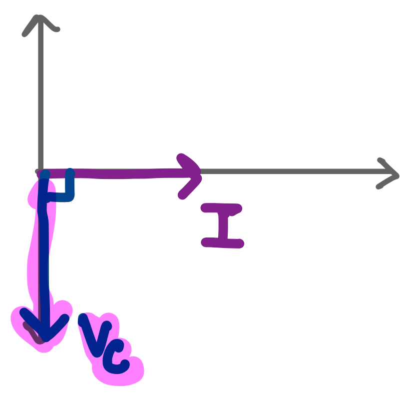
$i_{rms} : \dfrac{I_0}{\sqrt{2}}$



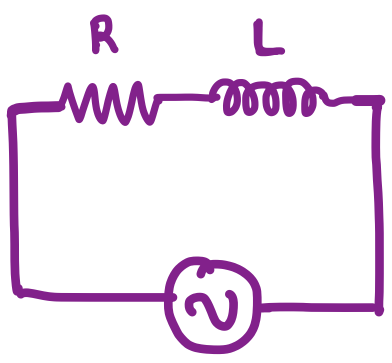
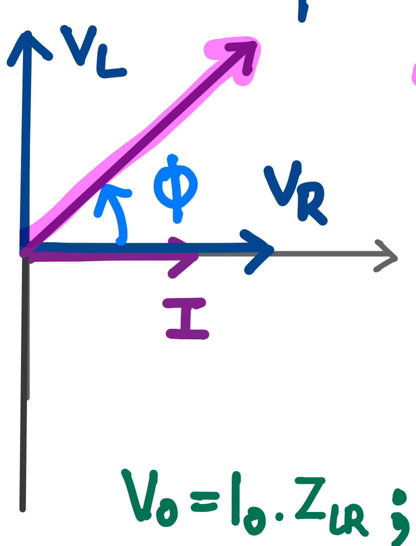
$(i_{mean})_{1/2} : I_0$

$i_{rms} : I_0$

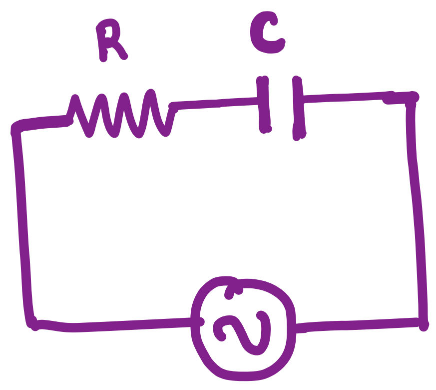
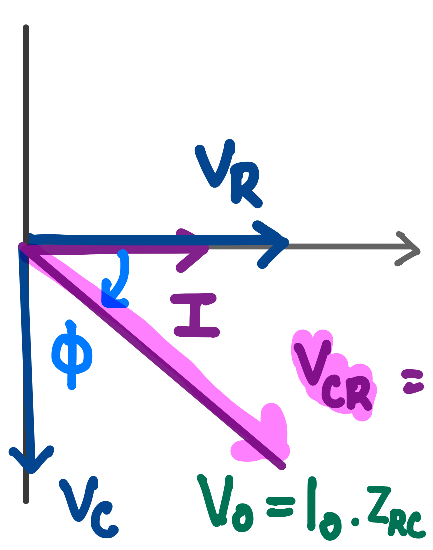
AC Circuits

Circuit	About
 $I = I_0 \sin \omega t$ $V = V_0 \sin \omega t$	 $\Delta\phi = 0°$ Impedence : R  $V_0 = I_0 \cdot R$; $V_{rms} = I_{rms} \cdot R$
 $I = I_0 \sin \omega t$ $V = V_0 \sin(\omega t + 90°)$	Impedence : $X_L : \omega L$  V leads by 90°  $V_0 = I_0 . X_L$; $V_{rms} = I_{rms} . X_L$
★2020  $I = I_0 \sin \omega t$ $V = V_0 \sin(\omega t - 90°)$	Impedence : $X_C : \dfrac{1}{\omega C}$  I leads by 90°  $V_0 = I_0 . X_C$; $V_{rms} = I_{rms} . X_C$

LR Circuit

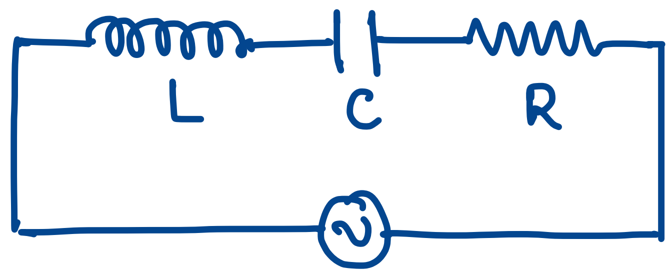
Circuit	About
 $I = I_0 \sin \omega t$ $V = V_0 \sin(\omega t + \phi)$	Impedence : $\sqrt{R^2 + X_L^2} : Z_{LR}$  $V_{LR} = \sqrt{V_L^2 + V_R^2}$ $\cos\phi : \dfrac{V_R}{V_{LR}} : \dfrac{R}{X_{LR}}$ $\tan\phi : \dfrac{V_L}{V_R} : \dfrac{X_L}{R}$ ★2011 $V_0 = I_0 . Z_{LR}$; $V_{rms} = I_{rms} . Z_{LR}$ ↓ ★2011

RC Circuit ★2015

Circuit	About
 $I = I_0 \sin \omega t$ $V = V_0 \sin(\omega t - \phi)$	Impedence : $\sqrt{R^2 + X_C^2} : Z_{RC}$ $\cos\phi : \dfrac{V_R}{V_{RC}} : \dfrac{R}{X_C}$ $\tan\phi : \dfrac{V_C}{V_R} : \dfrac{X_C}{R}$  $V_{CR} = \sqrt{V_C^2 + V_R^2}$ $V_0 = I_0 . Z_{RC}$; $V_{rms} = I_{rms} . Z_{RC}$

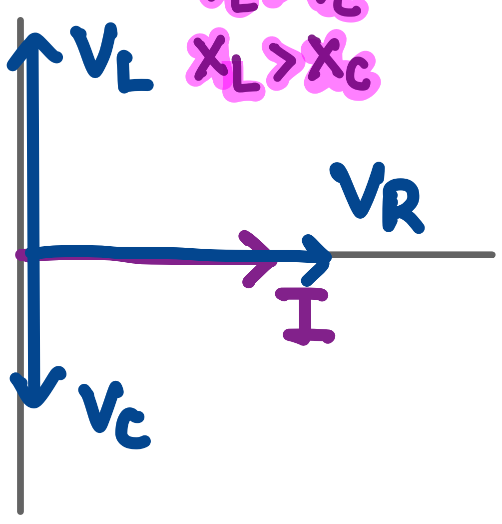
LCR Circuit

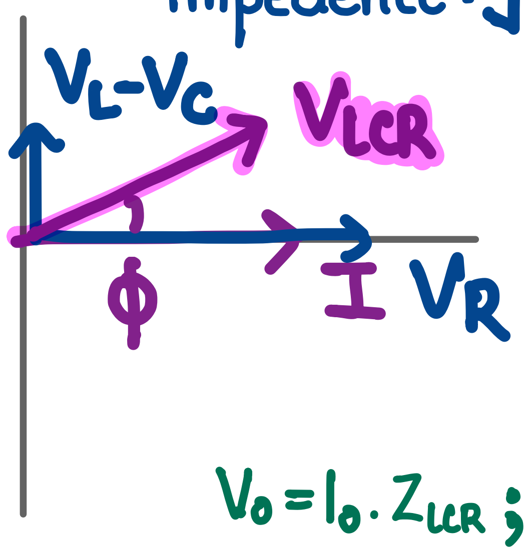
- Capacitive
- Inductive
- Resonance



Inductive LCR

Circuit	About
$V_L > V_C$, $X_L > X_C$	Impedence : $\sqrt{R^2 + (X_L - X_C)^2}$





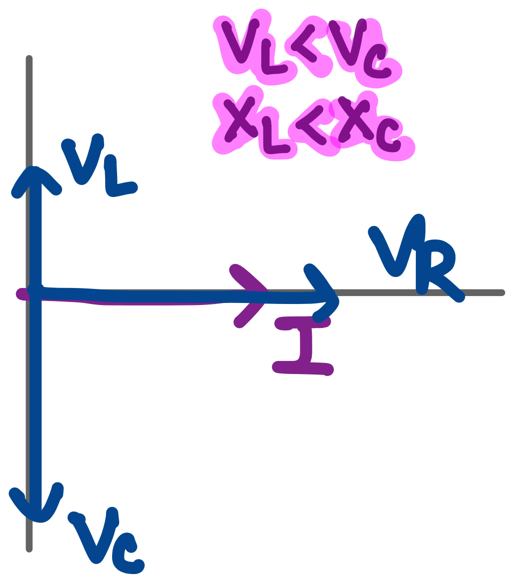
$\cos\phi : \frac{V_R}{V_{LCR}} : \frac{R}{Z_{LCR}}$

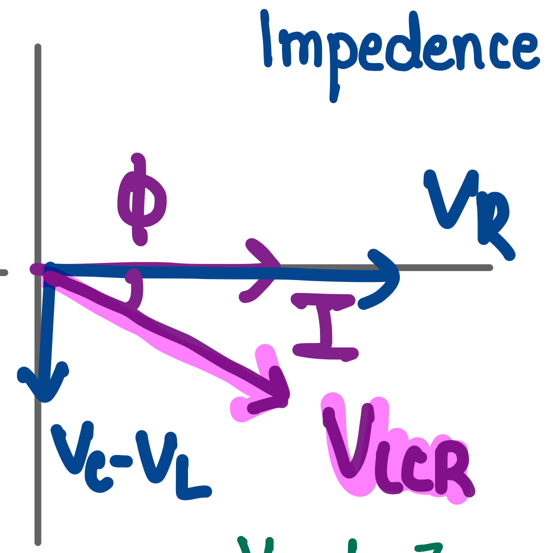
$\tan\phi : \frac{V_L - V_C}{V_R} : \frac{X_L - X_C}{R}$

$V_0 = I_0 . Z_{LCR}$; $V_{rms} = I_{rms} . Z_{LCR}$

Capacitive LCR

Circuit	About
$V_L < V_C$, $X_L < X_C$	Impedence : $\sqrt{R^2 + (X_C - X_L)^2}$





★2016, 2006

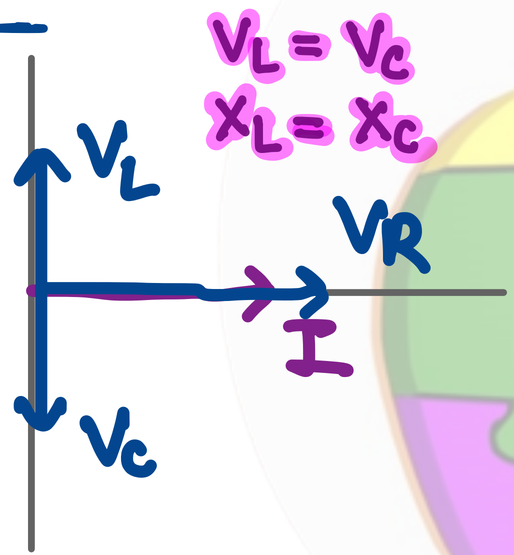
$\cos\phi : \frac{V_R}{V_{LCR}} : \frac{R}{Z_{LCR}}$

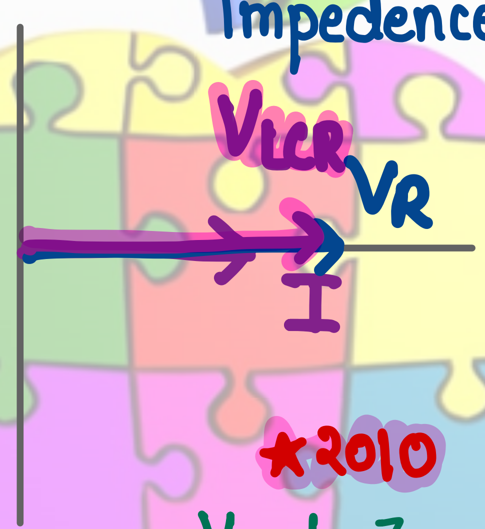
$\tan\phi : \frac{V_C - V_L}{V_R} : \frac{X_C - X_L}{R}$

$V_0 = I_0 . Z_{LCR}$; $V_{rms} = I_{rms} . Z_{LCR}$

LCR in Resonance

Circuit	About
$V_L = V_C$, $X_L = X_C$	Impedence : $\sqrt{R^2 + (X_L - X_C)^2}$: R





$\cos\phi : \cos 0°$

$\tan\phi : \tan 0°$

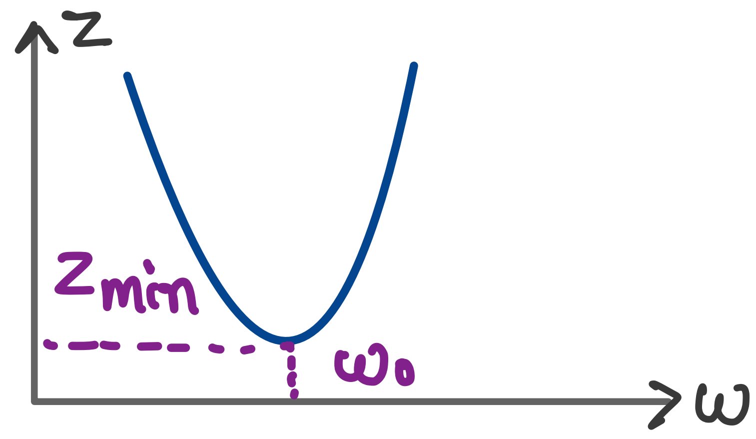
★2010

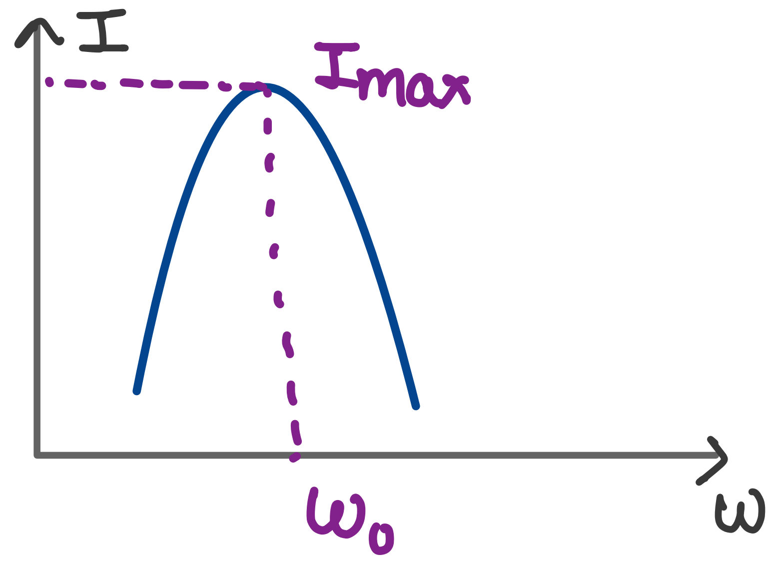
$V_0 = I_0 . Z_{LCR}$; $V_{rms} = I_{rms} . Z_{LCR}$

$X_L = X_C$

$\omega_0 L = \frac{1}{\omega_0 C}$

$\Rightarrow \omega_0 = \frac{1}{\sqrt{LC}}$ ★2006





Power and Power factor

2020 ★2018 ★2012

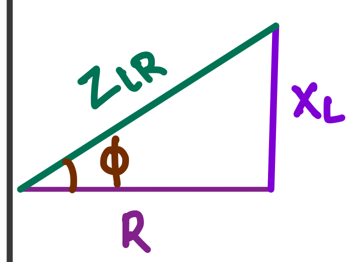
Power = $V_{rms} . I_{rms} . \cos\phi$ = $\frac{V_{rms}^2}{Z} . \cos\phi$ = $I_{rms}^2 . Z . \cos\phi$

★2016 2009 2008

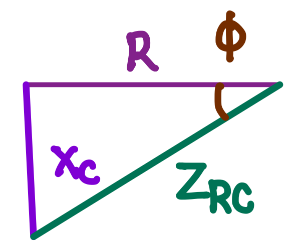
Powerfactor

- Maximum → 1 → R, LCR (Resonance)
- Minimum → 0 → L, C ★2016

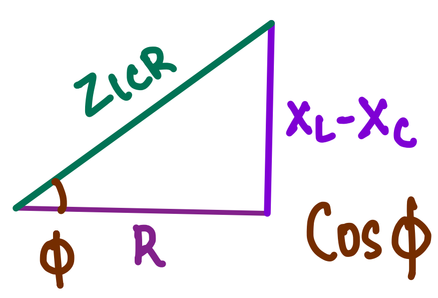
Impedence Triangle



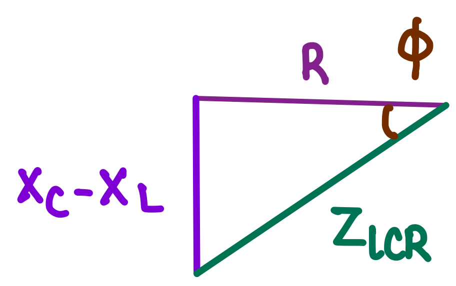
$\cos\phi = \frac{R}{Z_{LR}}$



$\cos\phi = \frac{R}{Z_{RC}}$



$\cos\phi = \frac{R}{Z_{LRC}}$



$\cos\phi = \frac{R}{Z_{LRC}}$

Transformer

$\frac{N_p}{N_s} = \frac{V_p}{V_s}$; Efficiency = $\frac{P_o}{P_i} = \frac{V_s I_s}{V_p I_p}$

- Step-up $\Rightarrow N_s > N_p$
- Step-down $\Rightarrow N_p > N_s$

In 100% efficient transformer → $P_i = P_o$; $V_p I_p = V_s I_s$

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Electromagnetic Waves

Displacement Current

Current developed due to $\Delta\phi_E$. Example: B/w the plates of the capacitor

$$I_d = -\varepsilon_0 \cdot \frac{d\phi_E}{dt} = -\varepsilon_0 \cdot E \cdot \frac{dA}{dt} = -\varepsilon_0 \cdot E \cdot 2\pi R \cdot \frac{dR}{dt}$$

$$= -\varepsilon_0 \cdot A \cdot \frac{dE}{dt}$$

$$= \frac{dQ}{dt}$$

$$= C \cdot \frac{dv}{dt} = V \cdot \frac{dc}{dt}$$

★2019

Properties of Electromagnetic Waves

★2010
- $\vec{E} \perp \vec{B} \perp$ velocity of wave $\Rightarrow \hat{E} \times \hat{B} = \hat{V}$

★2011 2018
- Speed on an EMW

In Vaccum: ★2012 2008 $\frac{E_0}{B_0} = \frac{1}{\sqrt{\mu_0 \varepsilon_0}}$

In Medium: $\frac{E_m}{B_m} = \frac{1}{\sqrt{\mu_m \varepsilon_m}}$

- Equation of a wave: ★2012, 2009

$\vec{E}_z = E_0 \sin(kx - \omega t)$ $E \rightarrow (+\hat{k})$, $V \rightarrow (+\hat{i})$

$\vec{B}_{-y} = B_0 \sin(kx - \omega t)$

- Energy density: $\frac{1}{2}\varepsilon_0 E_0^2 = \frac{1}{2} \cdot \frac{B_0^2}{\mu_0}$

: $\varepsilon_0 E_{rms}^2 = \frac{B_{rms}^2}{\mu_0}$

- Intensity = (ED)c
- Momentum $= \frac{E}{c}$

★2015
- Radiation Pressure

★2014

$\frac{I}{c}$ Perfectly Absorbing Surface

$\frac{2I}{c}$ Perfectly Reflecting Surface

Electromagnetic Spectrum

Gamma Rays
- Produced in Nuclear Reactions.
- Used in medicine to kill cancer cells.

X-Rays
- Generated by bombarding metal surface with high KEe⁻.
- Diagnistic tool in medicine
- Treatement : Cancer

UV Rays
- Produced by special lamps and very hot bodies.
- Production of more melanin
- Absorbed by Glass Windows
- Used in LASIK Eye surgery, Eye Surgery and UV lamps to kill germs.

Visible Region
- λ (400 to 700 nm)
- Eyes sensitive to this range.
- Snake : Infrared.

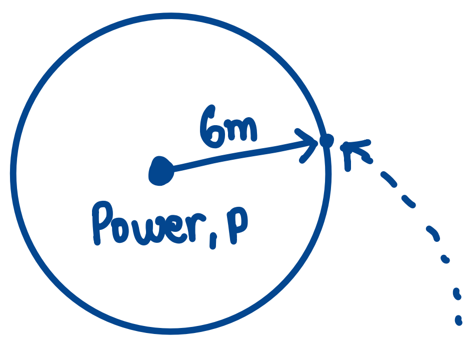
Infrared
- known as heat waves
- Infrared lamps used in Physical therapy.
- Important role in maintaining Earth's T.
- Infrared Detectors used in Earth Satellites
- Used in Remote Switches

★2013
Microwaves
- Produced in special vaccum tubes.
- Suitable for Radar System used in Aircraft Navigation
- Microwave Ovens

Radiowaves
Used in Radio and TV Communication Systems

Important Question Type:

★2020



What is E_{rms} at this point?

Step-I : $I_p = \frac{P}{4\pi(6)^2}$

Step-II $ED_p = \frac{I_p}{c}$

$\varepsilon_0 E_{rms}^2 = \frac{I_p}{c}$