END GAME MARATHON

CLASS-12TH

Physics

COMPLETE FORMULA REVISION

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B.Tech. HBTI, M.Tech. HBTI & M.Sc. Physics

Topics *to be covered*

- COMPLETE FORMULA REVISION


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NOTES

Electric Charges & Fields

Quantisation of charge

$Q = ne$

Coulomb's Law

$$F = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r^2}$$

Electric Field

$$E = \frac{1}{4\pi\varepsilon_0}\frac{q}{r^2}$$

$$E = \frac{F}{q_0} \Rightarrow \vec{F} = q_0\vec{E}$$

Electric Dipole

$-q$ ——— $2l$ ——— q

$$\vec{p} = q(2\vec{l})$$

EF at Axial Position

$$E_a = \frac{1}{4\pi\varepsilon_0}\frac{2p}{r^3}$$

EF at Equatorial Position

$$E_{eq.} = \frac{1}{4\pi\varepsilon_0}\frac{p}{r^3}$$

Torque on dipole in EF

Imp

$$\tau = pE\sin\theta$$

$$\vec{\tau} = \vec{p}\times\vec{E}$$

Electric Flux

$$\phi = \vec{E}\cdot\vec{A} = EA\cos\theta$$

$$\phi = \int \vec{E}\cdot d\vec{A}$$

Gauss' Law

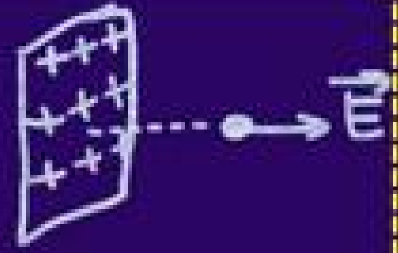
$$\phi_E = \int \vec{E}\cdot d\vec{A} = \frac{q_{in}}{\varepsilon_0}$$

Infinite Line Charge

$$E = \frac{\lambda}{2\pi\varepsilon_0 r}$$

Infinite Plane Sheet

$$E = \frac{\sigma}{2\varepsilon_0}$$



Thin Spherical Shell

$E_{inside} = 0$

$$E_{outside} = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r^2}$$

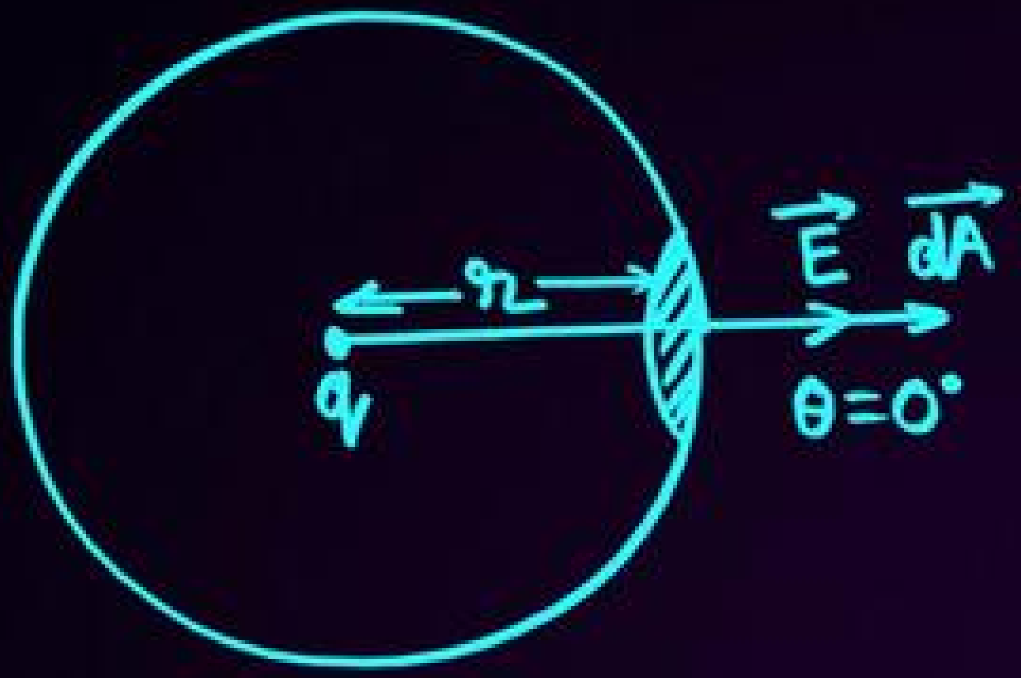
$$E_{surface} = \frac{1}{4\pi\varepsilon_0}\frac{Q}{R^2}$$

Solid Sphere

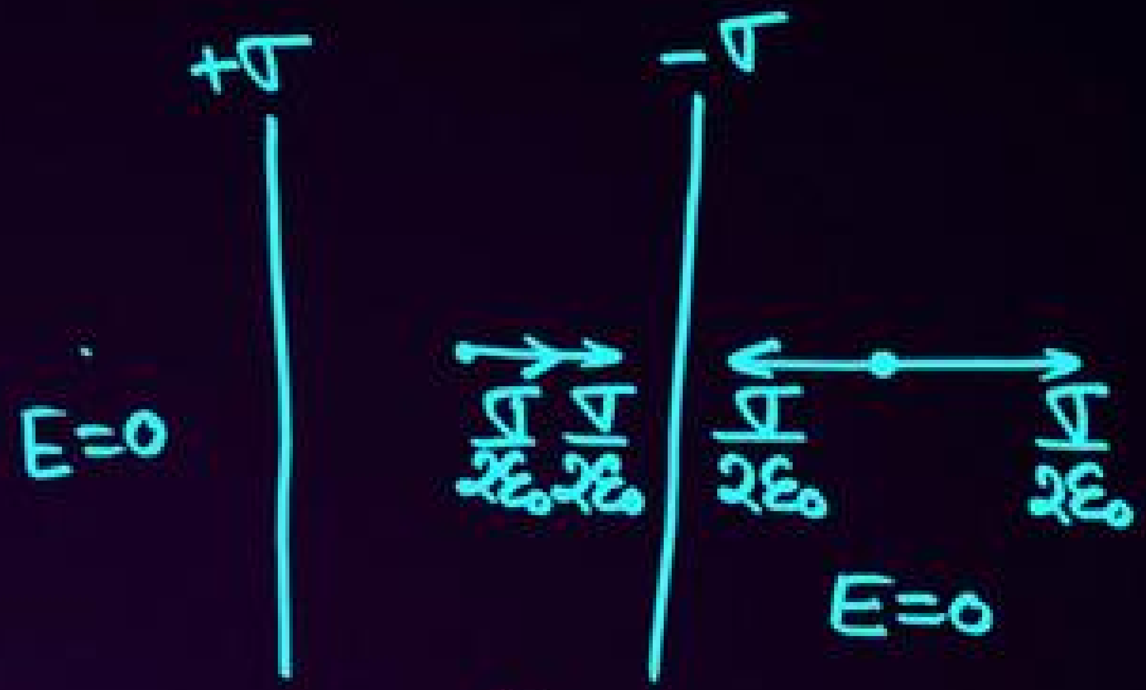
$$E_{inside} = \frac{1}{4\pi\varepsilon_0}\frac{Qr}{R^3}$$

$$E_{outside} = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r^2}$$

$$E_{surface} = \frac{1}{4\pi\varepsilon_0}\frac{Q}{R^2}$$



$$\phi_E = \int \vec{E}\cdot\vec{dA}$$
$$= \int E\,dA\cos 0^\circ$$
$$= \int \frac{1}{4\pi\varepsilon_0}\frac{q}{r^2}\,dA$$
$$= \frac{1}{4\pi\varepsilon_0}\frac{q}{r^2}\int dA$$
$$= \frac{1}{4\pi\varepsilon_0}\frac{q}{r^2}(4\pi r^2) = \frac{q}{\varepsilon_0}$$



$$E = \frac{q/A}{\varepsilon_0}$$

$$\vec{p} = 2\hat{i} + 3\hat{j} + 4\hat{k}$$
$$\vec{E} = \hat{i} - \hat{j} + \hat{k}$$

$$\hat{i} \times \hat{j} = \hat{k}$$
$$\hat{j} \times \hat{k} = \hat{i}$$
$$\hat{k} \times \hat{i} = \hat{j}$$

$$\vec{\tau} = \vec{p} \times \vec{E} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 2 & 3 & 4 \\ 1 & -1 & 1 \end{vmatrix}$$

$$= \hat{i} \begin{vmatrix} 3 & 4 \\ -1 & 1 \end{vmatrix} - \hat{j} \begin{vmatrix} 2 & 4 \\ 1 & 1 \end{vmatrix} + \hat{k} \begin{vmatrix} 2 & 3 \\ 1 & -1 \end{vmatrix}$$

$$= \hat{i}(7) - \hat{j}(-2) + \hat{k}(-5)$$

$$= 7\hat{i} + 2\hat{j} - 5\hat{k}$$

Electrostatic Potential & Capacitances

Electric Potential

$V = \frac{W}{q_0} = \frac{1}{4\pi\varepsilon_0}\frac{q}{r}$

Potential Difference

$V_B - V_A = \frac{W_{AB}}{q_0}$

Work Done on Charge

$W = q\Delta V$

Potential Gradient

$E = -\frac{dV}{dr}$

$V = -\int E \cdot dr$

Electric Potential Energy

$U = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r}$

Potential due to dipole

$V_{axial} = \frac{1}{4\pi\varepsilon_0}\frac{p}{r^2}$

$V_{eq.} = 0$

$V_{general} = \frac{1}{4\pi\varepsilon_0}\frac{p\cos\theta}{r^2}$

Potential Energy of Dipole

$U = -pE\cos\theta = -\vec{p}\cdot\vec{E}$

W.D. in rotating dipole

$W = pE(\cos\theta_1 - \cos\theta_2)$

Electrical Capacitance

$q \propto V \Rightarrow q = CV$

Spherical Conductor

$C = 4\pi\varepsilon_0 R$

Parallel Plate Capacitor

$C = \frac{\varepsilon_0 A}{d}$

Partially filled Capacitor

$C = \frac{\varepsilon_0 A}{d - t + \frac{t}{K}}$

Spherical Capacitor

$C = 4\pi\varepsilon_0 \frac{ab}{b-a}$

Cylindrical Capacitor

$C = 2\pi\varepsilon_0 \frac{l}{\ln\left(\frac{b}{a}\right)}$

Series Combination

$\frac{1}{C_s} = \frac{1}{C_1} + \frac{1}{C_2} + \cdots$

Parallel Combination

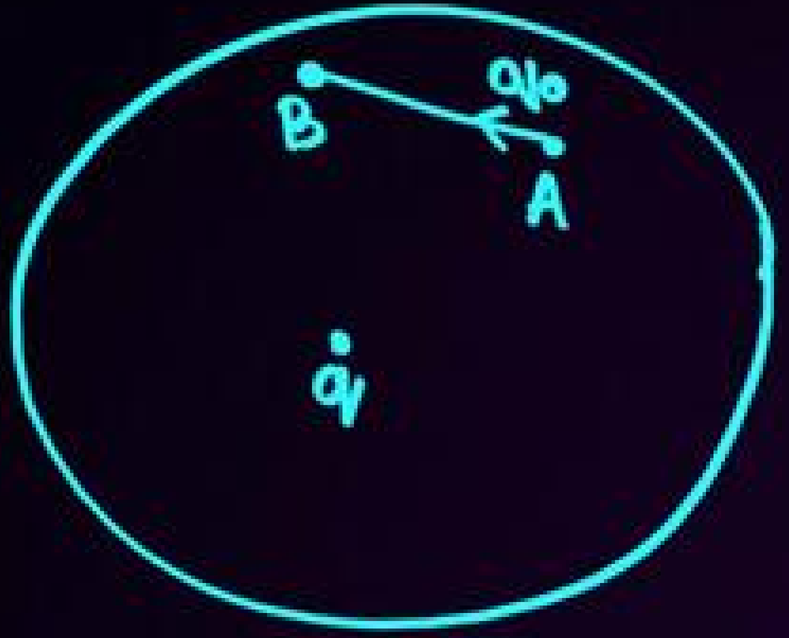
$C_p = C_1 + C_2 + \cdots$

Energy Stored

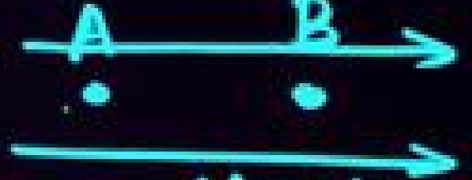
$U = \frac{1}{2}CV^2 = \frac{1}{2}\frac{q^2}{C} = \frac{1}{2}qV$

Energy Density

$u = \frac{U}{Vol} = \frac{1}{2}\varepsilon_0 E^2$



EF



$$V_B - V_A = \frac{W_{AB}}{q_0}$$

$$\boxed{W = q_0 \Delta V}$$

$$= 3 \times 7 = 21\,J.$$

$$\boxed{V = \frac{C_1V_1 + C_2V_2}{C_1 + C_2}}$$

$$\Delta U = U_i - U_f$$

$$= \left[\frac{1}{2}C_1V_1^2 - \left(\frac{1}{2}C_1V^2 + \frac{1}{2}C_2V^2\right)\right)$$

$$\boxed{E = -\frac{dV}{dr}}$$

$$V_A > V_B$$

$$V = 3x^2 + 2x - 3$$

$$E = -\frac{dV}{dx} = -\frac{d}{dx}(3x^2 + 2x - 3)$$

$$= -(6x + 2)$$

$$\Rightarrow E = \frac{a}{r^2}$$

$$-\frac{dV}{dr} = \frac{a}{r^2}$$

$$\int dV = -\int a r^{-2}\, dr$$

$$V = -a\frac{r^{-1}}{-1} \Rightarrow \boxed{V = \frac{a}{r}} ✓$$

Current Electricity

Electric Current

$I = \frac{q}{t} = \frac{ne}{t}$

Drift Vel. & Ohm's Law

$V_d = \frac{eE}{m}\tau$, $I = neAV_d$

$R = \frac{\rho l}{A} = \frac{ml}{ne^2\tau A}$, $\rho = \frac{m}{ne^2\tau}$

Current Density

$\vec{J} = \frac{I}{A} = neV_d = \sigma \vec{E}$

$\sigma = \frac{1}{\rho}$, $C = \frac{1}{R}$

Mobility

$\mu = \frac{V_d}{E} = \frac{e\tau}{m}$

Effect of Temp. on R

$R_T = R_0[1 + \alpha \Delta T]$

$\rho_T = \rho_0[1 + \alpha \Delta T]$

Heat Generated & Power

$H = VIt = I^2Rt = \frac{V^2}{R}t$

$P = \frac{H}{t} = VI = I^2R = \frac{V^2}{R}$

Combination of Resistors

$R_s = R_1 + R_2$, $\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2}$

* Conditions of Cell

$V = E - Ir$ (Discharging)

$V = E + Ir$ (Charging)

$V = 0 \Rightarrow E = Ir$ (Short-Circuit)

$V = E$ (Isolated) $I = 0$

Imp Kirchoff's Law

KCL $\sum_{node} I = 0$

KVL $\sum_{loop} V = 0$

Series Combination of Cell

$I = \frac{nE}{R + nr}$ $R_{ext} \gg r_{int}$

$E_{eq} = E_1 \pm E_2$, $r_{eq} = r_1 + r_2$

* Parallel Combination of cell

$I = \frac{nE}{nR + r}$ $R_{int} \gg R_{ext}$

$E_{eq} = \frac{\frac{E_1}{r_1} \pm \frac{E_2}{r_2}}{\frac{1}{r_1} + \frac{1}{r_2}}$, $\frac{1}{r_{eq}} = \frac{1}{r_1} + \frac{1}{r_2}$

Internal Resistance

$r = \left(\frac{E}{V} - 1\right)R$

Wheatstone Bridge

Balanced $I_g = 0$ $\frac{R_1}{R_2} = \frac{R_3}{R_4}$

Meter Bridge

$\frac{R_1}{R_2} = \frac{100 - l}{l}$

Potentiometer

$\frac{E_1}{E_2} = \frac{l_1}{l_2}$, $r = \left(\frac{l_1}{l_2} - 1\right)R$

Potential Gradient

$K = \frac{V}{l}$

$R = 10\Omega$

$t_1 = 20^\circ C$

$t_2 = 25^\circ C$

$R' = ?$

$V_A - V_B = ?$

$R' = R_0(1+\alpha\Delta t)$

$= 10(1 + 2\times10^{-5}\times5)$

$= 10(1+10^{-4})$

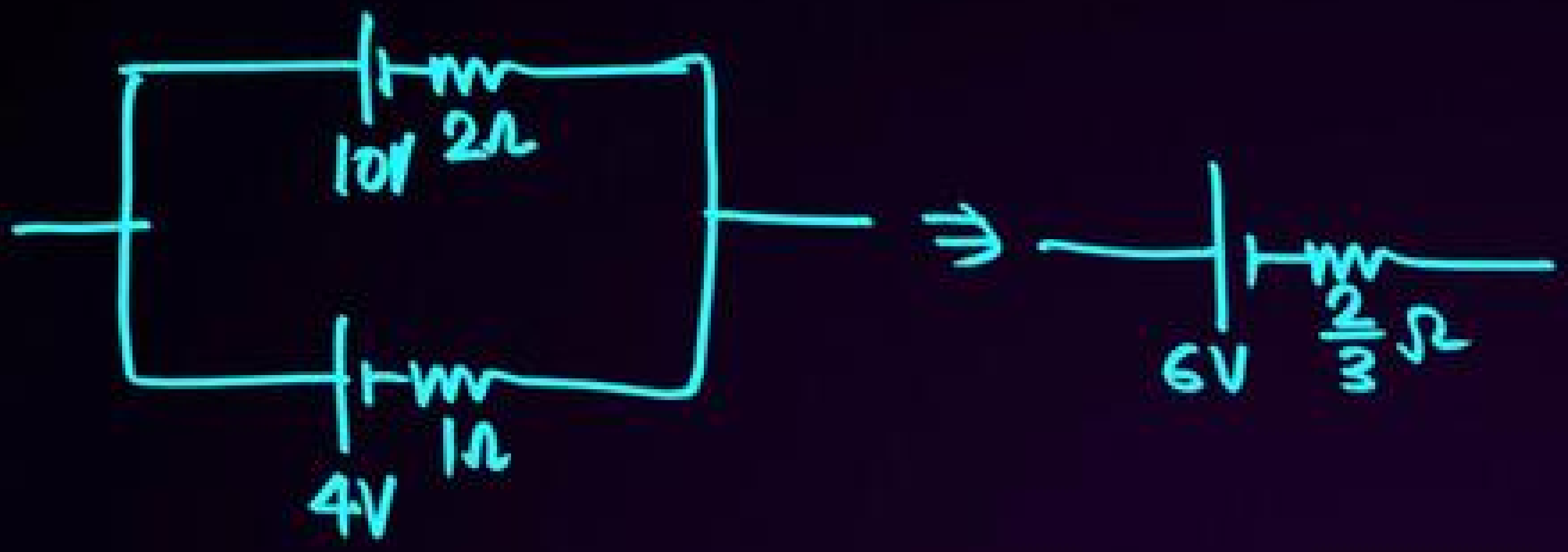
$\alpha < 0$

$T\uparrow R\downarrow$

$V_A - 10 + 4 + 2 + 5 = V_B$

$V_A + 1 = V_B$

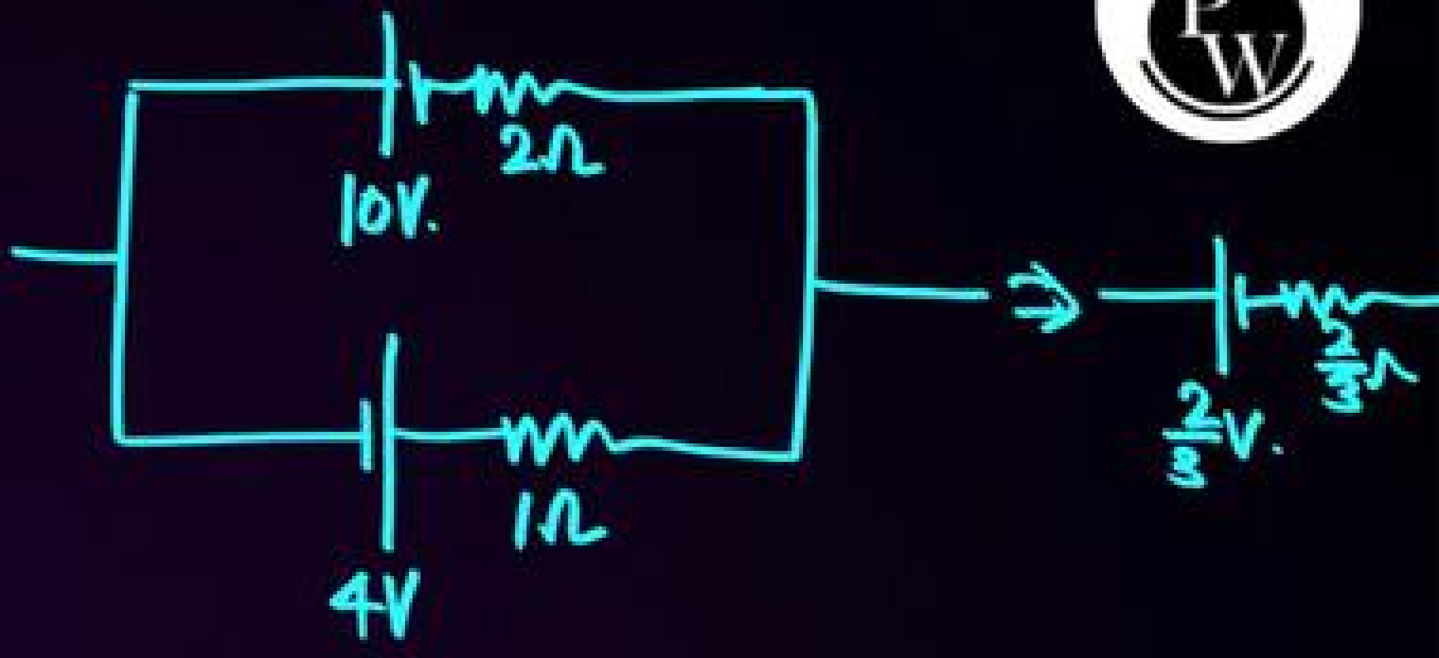
$\boxed{V_A - V_B = -1}$



$$\varepsilon_{eq} = \frac{\frac{\varepsilon_1}{r_1} + \frac{\varepsilon_2}{r_2}}{\frac{1}{r_1} + \frac{1}{r_2}} = \frac{5+4}{\frac{1}{2} + \frac{1}{1}} = \frac{9 \times 2}{3} = 6\,V.$$

$$\frac{1}{r_{eq}} = \frac{1}{2} + \frac{1}{1} = \frac{3}{2}$$

$$r_{eq} = \frac{2}{3}\,\Omega$$



$$\varepsilon_{eq} = \frac{5-4}{\frac{3}{2}} = \frac{2}{3}\,V.$$

$$\frac{1}{r_{eq}} = \frac{1}{2} + \frac{1}{1} \Rightarrow r_{eq} = \frac{2}{3}\,\Omega$$

Magnetic Effects of Current

Biot-Savart's Law

$dB = \frac{\mu_0}{4\pi}\frac{Idl\sin\theta}{r^2}$

MF due to finite wire

$B = \frac{\mu_0}{4\pi}\frac{I}{r}(\sin\phi_1 + \sin\phi_2)$

MF due to infinite length

$B = \frac{\mu_0}{2\pi}\frac{I}{r}$

MF due to ⊙ Loop

* $B_{center} = \frac{\mu_0}{2}\frac{NI}{a}$

✓ MF at Axis of ⊙ Loop

* $B_{axis} = \frac{\mu_0}{2}\frac{NIa^2}{(a^2+r^2)^{3/2}}$

Ampere's Circuital law

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

MF inside Solenoid

$B = \mu_0 n I$, $n = \frac{N}{l}$

MF at ends of Solenoid

$B = \frac{\mu_0 n I}{2}$

Force on Moving Charge

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

$F = qvB\sin\theta$

Lorentz Force

$\vec{F_l} = q\vec{E} + q(\vec{v}\times\vec{B})$

Force on C.C.C in MF

$\vec{F} = I(\vec{l}\times\vec{B})$, $F = IlB\sin\theta$

Velocity Selector or Filter

$V = \frac{E}{B}$

* Force on two Parallel Wires

$\frac{F}{l} = \frac{\mu_0}{2\pi}\frac{I_1 I_2}{r}$

Motion of Charge in MF.

$\theta = 0°$ or $180° \Rightarrow F = 0 \Rightarrow a = 0$

V = constant. (Str. line)

* $\theta = 90° \Rightarrow$ Circular Path

$r = \frac{mv}{qB}$, $T = \frac{2\pi m}{qB}$, $f = \frac{qB}{2\pi m}$

* $\theta \Rightarrow$ Helical Path

$r = \frac{mv\sin\theta}{qB}$, $T = \frac{2\pi m}{qB}$, $p = \frac{2\pi mv\cos\theta}{qB}$

Torque on coil in MF.

* $\tau = NIAB\sin\theta$, $\vec{m} = NI\vec{A}$

$\vec{\tau} = \vec{m}\times\vec{B}$

Galvanometer Constant

$G = \frac{K}{NBA}$ $NIAB = K\theta$

Sensitivity of Galvano.

* $I_S = \frac{NBA}{K} = \frac{\theta}{I}$, $V_S = \frac{NBA}{KR} = \frac{\theta}{V}$

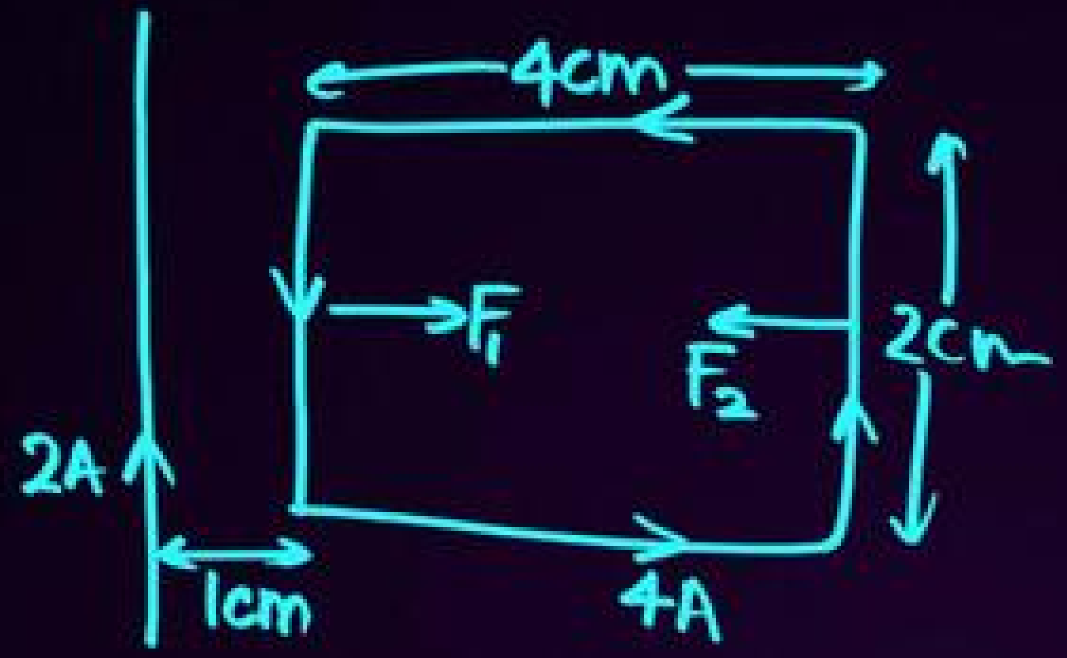
Ammeter

$I_g G = (I - I_g)S$

$\frac{1}{R_A} = \frac{1}{G} + \frac{1}{S}$

Voltmeter

$V = I_g(G + R)$, $R_V = G + R$



$$F_{net} = F_1 - F_2$$

$$\frac{F}{l} = \frac{\mu_0}{2\pi}\frac{I_1 I_2}{r}$$

Magnetism & Matter

Dipole Moment

$$\vec{m} = q(2\vec{l})$$

Coulomb's Law

$$F = \frac{\mu_0}{4\pi}\frac{q_{m_1} q_{m_2}}{r^2}$$

Magnetic Field

$$B = \frac{F}{q_m}$$

Magnetic Length

$$\frac{M.L.}{G.L} = \frac{5}{6} = 0.84$$

Magnetic Dipole

$$B_{axial} = \frac{\mu_0}{2\pi}\frac{2m}{r^3}$$

$$B_{eq.} = \frac{\mu_0}{4\pi}\frac{m}{r^3}$$

Gauss' Law

$$\oint \vec{B} \cdot \vec{ds} = 0$$

P.E. of dipole in MF.

$$U = -mB\cos\theta = -\vec{m} \cdot \vec{B}$$

Magnetic Moment

$$\vec{m} = NI\vec{A}$$

Gyromagnetic Ratio

$$\frac{m}{L} = \frac{e}{2m} = 8.8 \times 10^{20}\ C/kg$$

Magnetic Permeability

$$\mu = \frac{B}{H}$$

Magnetising Field Intensity

$$H = \frac{B}{\mu_0} = nI$$

Intensity of Magnetisation

$$M = \frac{m}{Vol.}$$

Magnetic Susceptibility

$$\chi_m = \frac{M}{H}$$

Relative Permeability

$$\mu_r = \frac{\mu}{\mu_0} = 1 + \chi_m$$

Diamagnetic Substance

$$-1 \le \chi_m < 0, \quad 0 \le \mu_r < 1$$

Paramagnetic Substance

$$0 < \chi_m < \eta, \quad 1 < \mu_r < 1 + \eta$$

Curie's Law

$$\chi_m \propto \frac{1}{T}$$

Ferromagnetic Substance

$$\chi_m \gg 1, \quad \mu_r \gg 1$$

Curie Temperature

$$\chi_m = \frac{C}{T - T_c}$$

Electromagnetic Induction

Magnetic Flux

$\phi_B = BA\cos\theta = \vec{B}\cdot\vec{A}$

Wb or Mx

Faraday's Law

* $\varepsilon_{in} = -N\frac{d\phi_B}{dt}$

Induced Current

$I_{in} = \frac{\varepsilon}{R} = -\frac{N}{R}\frac{d\phi_B}{dt}$

Induced Charge

$q_{in} = I\cdot\Delta t = -\frac{N\Delta\phi_B}{R}$

Motional EMF

$\varepsilon = Bvl$

$I = \frac{Bvl}{R}$

$F = \frac{B^2l^2v}{R}$

$P = \frac{B^2l^2v^2}{R}$

* Rotating Rod in MF

$\varepsilon = \frac{1}{2}Bl^2\omega$

Self Induction

$N\phi = LI$

$\varepsilon = -L\frac{\Delta I}{\Delta t}$

Self Inductance of Solenoid

$L = \frac{\mu_0 N^2 A}{l}\mu_r$

Mutual Induction

$N_s\phi_s = MI_p$

$\varepsilon_s = -M\frac{\Delta I_p}{\Delta t}$

* Mutual Inductance of Solenoid

$M = \frac{\mu_0 N_p N_s A_s}{l_p}$

Coefficient of Coupling

$K = \frac{M}{\sqrt{L_1L_2}}$

Series Combination

$L_s = L_1 + L_2 \pm 2M$

Parallel Combination

$L_p = \frac{L_1L_2 - M^2}{L_1 + L_2 \pm M}$

Alternating Current

Alternating Current

$V = V_0 \sin\omega t$

$I = I_0 \sin\omega t$

Mean Value of AC

$(I_{mean})_{full\ cycle} = 0$

$(I_{mean})_{Half} = \frac{2}{\pi} I_0 = 0.636 I_0$

RMS. Value of AC

$(I_{rms})_{full} = \frac{I_0}{\sqrt{2}} = 0.707 I_0$

Purely Resistive Circuit

$V = V_0 \sin\omega t$, $I = I_0 \sin\omega t$

$I_0 = \frac{V_0}{R}$, $Z = R$

Purely Inductive Circuit

$V = V_0 \sin\omega t$, $I = I_0 \sin(\omega t - \frac{\pi}{2})$

$I_0 = \frac{V_0}{X_L}$, $X_L = \omega L$

Purely Capacitive Circuit

$V = V_0 \sin\omega t$, $I = I_0 \sin(\omega t + \frac{\pi}{2})$

$I_0 = \frac{V_0}{X_C}$, $X_C = \frac{1}{\omega C}$

Series LCR Circuit

$V = V_0 \sin\omega t$, $I = I_0 \sin(\omega t - \phi)$

$I_0 = \frac{V_0}{Z}$, $Z = \sqrt{R^2 + (X_L - X_C)^2}$

$\tan\phi = \frac{X_L - X_C}{R}$

$V_0 = \sqrt{V_R^2 + (V_L - V_C)^2}$

Condition of Resonance

$X_L = X_C \Rightarrow \omega L = \frac{1}{\omega C}$

Resonant Frequency.

$\omega_r = \frac{1}{\sqrt{LC}}$, $f_r = \frac{1}{2\pi\sqrt{LC}}$

At $\omega_r \Rightarrow \phi = 0$, $V = V_R$

Quality Factor

$Q = \frac{\omega_r}{\omega_2 - \omega_1} = \frac{\omega_r L}{R} = \frac{1}{R}\sqrt{\frac{L}{C}}$

Power Dissipation

$P_{avg} = \varepsilon_{rms} I_{rms} \cos\phi$

Wattless Current

$I_{wattless} = I_0 \sin\phi$

A.C Generator

$\varepsilon = NBA\omega \sin\omega t$ ($\varepsilon_0 = NBA\omega$)

Transformer

$\frac{\varepsilon_s}{\varepsilon_p} = \frac{N_s}{N_p} = \frac{I_p}{I_s}$

Ideal Transformer

$P_{in} = P_{out} \Rightarrow \varepsilon_p I_p = \varepsilon_s I_s$

Real Transformer

$\eta = \frac{\varepsilon_s I_s}{\varepsilon_p I_p} \times 100\%$

Step-up

$\varepsilon_s > \varepsilon_p \Rightarrow N_s > N_p$

Step-down

$\varepsilon_p > \varepsilon_s \Rightarrow N_s < N_p$

$\vec{E} \times \vec{B} \Rightarrow \vec{V}$

E M Waves

Displacement Current

$$I_D = \varepsilon_0 \frac{d\phi_E}{dt}$$

Modified Ampere's law

$$\oint \vec{B} \cdot \vec{dl} = \mu_0 (I_c + I_D)$$

Frequency of EM Wave

$$f = \frac{1}{2\pi\sqrt{LC}}$$

Electric & Mag. Field

$$E = E_0 \sin(\omega t - Kx)$$

$$B = B_0 \sin(\omega t - Kx)$$

$$\omega = \frac{2\pi}{T} \quad K = \frac{2\pi}{\lambda}$$

Speed of E-M Wave

$$C = \frac{E_0}{B_0} = \frac{1}{\sqrt{\mu_0 \varepsilon_0}}$$

Speed of light in medium

$$V = \frac{C}{\sqrt{\mu_r \varepsilon_r}} = \frac{C}{\mu}$$

Energy Density

For Static Field

$$u = \frac{1}{2}\varepsilon_0 E^2 + \frac{1}{2\mu_0} B^2$$

For Sinusoidal Field

$$u = \frac{1}{2}\varepsilon_0 E_{rms}^2 + \frac{1}{2\mu_0} B_{rms}^2$$

In EM Wave,

$$u_E = u_B$$

Intensity of EM wave

$$I = \frac{1}{2}\varepsilon_0 E_0^2 C = \varepsilon_0 E_{rms}^2 C$$

Radiation Pressure

$$P_r = \frac{I}{c}$$

Electromagnetic Spectrum

1. Gamma Ray → λ_{min} f_{max}
2. X-Ray
3. U.V. Ray
4. Visible light
5. I.R. light
6. Microwaves
7. Radio waves → λ_{max} f_{min}

Visible Spectrum

1. Violet → λ_{min}
2. Indigo
3. Blue
4. Green
5. Yellow
6. Orange
7. Red → λ_{max}

Ray Optics

Reflection of Light

$\angle i = \angle r$

Mirror Formula

$\frac{1}{f}=\frac{1}{v}+\frac{1}{u}$, $m=\frac{h_i}{h_o}=\frac{-v}{u}$

Focal Length

$f=\frac{R}{2}$

Refraction of Light

$\frac{\sin i}{\sin r} = {}_1\mu_2 = \frac{\mu_2}{\mu_1} = \frac{v_1}{v_2}$

Shift

Lateral $d=\frac{t\sin(i_1-r_1)}{\cos r_1}$

Normal $N.S. = R.D.\left(1-\frac{1}{{}_r\mu_d}\right)$

Critical Angle

$\sin i_c = \frac{1}{{}_r\mu_d}$

Refraction at Spherical Surface

$\frac{\mu_2}{v}-\frac{\mu_1}{u}=\frac{\mu_2-\mu_1}{R}$

Len's Makers Formula

$\frac{1}{f}=(\mu-1)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$

Thin Lens Formula

$\frac{1}{f}=\frac{1}{v}-\frac{1}{u}$, $P=\frac{1}{f}$

$m=\frac{h_i}{h_o}=\frac{v}{u}=\frac{f}{u+f}=\frac{f-v}{f}$

Combination of lens

$\frac{1}{F}=\frac{1}{f_1}+\frac{1}{f_2}$, $m=m_1\times m_2$

Refraction through prism

$\mu=\frac{\sin\frac{A+\delta_m}{2}}{\sin\frac{A}{2}}$

$A+\delta=i+e$

$\delta_m=(\mu-1)A$

$\delta_m \propto \mu \propto \frac{1}{\lambda}$

Simple Microscope

Case I Image at 25cm.

$M=1+\frac{D}{f}$

Case II Image at ∞

$M=\frac{D}{f}$

Compound Microscope

Case I Image at 25cm.

$M=\frac{v_o}{u_o}\left(1+\frac{D}{f_e}\right)$

Case II Image at ∞

$M=\frac{v_o}{u_o}\left(\frac{D}{f_e}\right)$

Telescope

Case I Image at 25cm.

$M=-\frac{f_o}{f_e}\left(1+\frac{f_e}{D}\right)$

Case II Image at ∞

$M=-\frac{f_o}{f_e}$

Magnifying Power

$M=\beta/\alpha$

Wave Optics

Interference of Light

$y = y_1 + y_2$

$A^2 = A_1^2 + A_2^2 + 2A_1A_2\cos\phi$

$I = KA^2$

$I = I_1 + I_2 + 2\sqrt{I_1 I_2}\cos\phi$

If $I_1 = I_2 = I_0$

* $I = 4I_0\cos^2\frac{\phi}{2}$

Phase Difference

$\Delta\phi = \frac{2\pi}{\lambda}\Delta p$

Constructive Interference

* $\Delta\phi = 2n\pi$. $n = 0, 1, 2 \ldots$

$\Delta p = n\lambda$

$I_{max} = (\sqrt{I_1} + \sqrt{I_2})^2$

Destructive Interference

$\Delta\phi = (2n-1)\pi$, $n = 1, 2, 3 \ldots$

$\Delta p = (2n-1)\frac{\lambda}{2}$

$I_{min} = (\sqrt{I_1} - \sqrt{I_2})^2$

Intensity Ratio

$\frac{I_{max}}{I_{min}} = \left(\frac{A_1 + A_2}{A_1 - A_2}\right)^2 = \left(\frac{r+1}{r-1}\right)^2$

Relation with Slit Width

$\frac{W_1}{W_2} = \frac{I_1}{I_2} = \frac{A_1^2}{A_2^2}$

* Position of Bright Fringe

$y = \frac{nD\lambda}{d}$ $n = 1, 2, 3 \ldots$

* Position of Dark Fringe

$y = (2n-1)\frac{D\lambda}{2d}$ $n = 1, 2 \ldots$

Fringe Width

$\beta = \frac{D\lambda}{d}$, $\theta = \frac{\lambda}{d}$

Diffraction of Light

$\Delta p = d\sin\theta$

* Position of ~~secondary~~ Minima

$d\sin\theta = n\lambda$ $n = 1, 2 \ldots$

* Position of Secondary Maxima

$d\sin\theta = (2n+1)\frac{\lambda}{2}$, $n = 1, 2 \ldots$

Width of Central Maxima

$\beta_0 = \frac{2D\lambda}{d}$

$\theta_0 = \frac{2\lambda}{d}$

Width of Sec. Maxima

$\beta = \frac{D\lambda}{d}$

$\theta = \frac{\lambda}{d}$

Fresnel's Distance

$D_F = \frac{a^2}{\lambda}$

Dual Nature of Radiation & Matter

Work Function

$W_0 = h\nu_0 = \frac{hc}{\lambda_0}$

Momentum of Photon

$p = \frac{h\nu}{c} = \frac{h}{\lambda}$

Rest Mass of Photon

$m = 0$

Kinetic Mass of Photon

$m = \frac{h\nu}{c^2} = \frac{h}{c\lambda}$

Einstein's Equation

$h\nu = h\nu_0 + K_{max}$

$\frac{hc}{\lambda} = W_0 + eV_0$

Max. Kinetic Energy

$K_{max} = \frac{1}{2} m v_{max}^2 = eV_0$

Energy of Photon

$E = h\nu = \frac{hc}{\lambda} = \frac{1240}{\lambda} eV$

de-Broglie Wavelength

$\lambda = \frac{h}{p} = \frac{h}{mv} = \frac{h}{\sqrt{2mK}}$

de-Broglie λ of electron

* $\lambda_e = \frac{h}{\sqrt{2meV}} = \sqrt{\frac{150}{V}}\ A^\circ$

$\lambda_e = \frac{12.27}{\sqrt{V}} A^\circ$

$\lambda = \frac{h}{\sqrt{3mkT}}$

$hc = 1240\ eV$

Atoms

Impact Parameter

$b = \frac{1}{4\pi\varepsilon_0}\frac{Ze^2}{K.E.}\cot\frac{\theta}{2}$

Distance of Closest Approach

$r_0 = \frac{1}{4\pi\varepsilon_0}\frac{2Ze^2}{K.E.}$

Bohr's Quantisation

$mvr = n\left(\frac{h}{2\pi}\right)$

$\frac{mv^2}{r} = \frac{KZe^2}{r^2}$

Speed of Electron

$V = \frac{2\pi KZe^2}{nh} = \frac{c}{137}\frac{Z}{n}$

Radius of Orbit

$r = \frac{n^2h^2}{4\pi^2e^2mKZ} = 0.53\text{Å}\,\frac{n^2}{Z}$

Kinetic Energy of electron

$KE = \frac{me^2}{8\varepsilon_0^2h^2n^2} = \frac{kZe^2}{2r}$

Potential Energy of electron

$PE = -\frac{kZe^2}{r}$

Total Energy of electron

$TE = -\frac{KZe^2}{2r} = -\frac{mZ^2e^4}{8\varepsilon_0^2h^2n^2}$

$E = -13.6\,eV\left(\frac{Z^2}{n^2}\right)$

Hydrogen Spectrum

$\frac{1}{\lambda} = R\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$ $n_2 \to n_1$

Rydberg's Constant

$R = \frac{2\pi^2mk^2e^4}{ch^3}$

$= 1.0973 \times 10^7\ m^{-1}$

Lyman Series

$\frac{1}{\lambda} = R\left[\frac{1}{1^2} - \frac{1}{n^2}\right]$ $n = 2, 3 \ldots$

Balmer Series

$\frac{1}{\lambda} = R\left[\frac{1}{2^2} - \frac{1}{n^2}\right]$ $n = 3, 4 \ldots$

Paschen Series

$\frac{1}{\lambda} = R\left[\frac{1}{3^2} - \frac{1}{n^2}\right]$ $n = 4, 5 \ldots$

Brackett Series

$\frac{1}{\lambda} = R\left[\frac{1}{4^2} - \frac{1}{n^2}\right]$ $n = 5, 6 \ldots$

P-Fund Series

$\frac{1}{\lambda} = R\left[\frac{1}{5^2} - \frac{1}{n^2}\right]$ $n = 6, 7 \ldots$

For max λ
n = minimum

For min λ
$n = \infty$

Nuclei and Semiconductor Electronics

Nuclear Composition

For nuclide $_ZX^A$

$n_p = Z$

$n_e = Z$

$n_n = A - Z$

$n_{nucleons} = A$

Radius of Nucleus

$R = R_0 A^{1/3}$, $R_0 = 1.2$ fm.

Density of Nucleus

$\rho = \frac{m}{\frac{4}{3}\pi R_0^3} = 2.38 \times 10^{17}$ kg/m^3

Atomic Mass Unit

$1\, a.m.u = \frac{1}{12} m_{c\text{-atom}}$

$1\, amu = 1.66 \times 10^{-27}$ Kg.

Mass Defect

$\Delta m = Zm_p + (A-Z)m_n - m_N$

Binding Energy

$E_B = \Delta m \cdot c^2$

$1\, amu \approx 931$ MeV.

Energy of Reaction

$Q = (m_{reactant} - m_{product})c^2$

Thermodynamic Relation

$n_e \cdot n_h = n_i^2$

Dynamic Resistance

$r = \frac{\Delta V}{\Delta I}$

Conductivity of Semiconductor

$\sigma = e(n_e \mu_e + n_h \mu_h)$

Resistivity of Semiconductor

$\rho = \frac{1}{e(n_e \mu_e + n_h \mu_h)}$

Half Wave Rectifier

$I_{DC} = \frac{I_0}{\pi}$

Full Wave Rectifier

$I_{AC} = \frac{2 I_0}{\pi}$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