PHYSICS NOTES

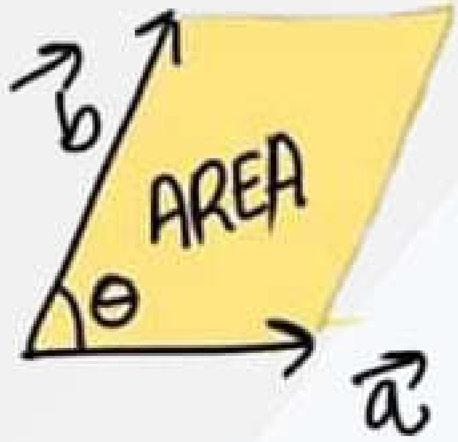
VECTORS

$$\vec{a} = a_x\hat{i} + a_y\hat{j} + a_z\hat{k} \qquad |\vec{a}| = \sqrt{a_x^2 + a_y^2 + a_z^2}$$

DOT PRODUCT $\vec{a}\cdot\vec{b} = a_x b_x + a_y b_y + a_z b_z$

$$= ab\cos\theta$$

CROSS PRODUCT $\vec{a}\times\vec{b} = ab\sin\theta$



$$\begin{array}{c} \\ \vec{a} \\ \vec{b} \end{array}\begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ a_x & a_y & a_z \\ b_x & b_y & b_z \end{vmatrix} = +(a_y b_z - b_y a_z) - (a_x b_z - b_x a_z) + (a_x b_y - b_x a_y)$$

DONT FORGET

PHYSICS NOTES

KINEMATICS

$\vec{V}_{inst} = d\vec{s}/dt$

$\vec{V}_{avg} = \Delta\vec{s}/\Delta t$

$\vec{a}_{inst} = d\vec{V}/dt$

$\vec{a}_{avg} = \Delta\vec{V}/\Delta t$

$s = ut + \frac{1}{2}at^2$

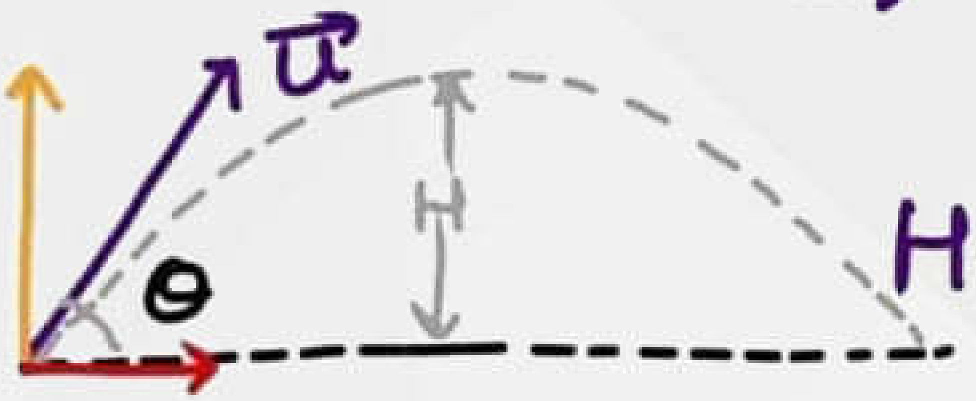
$v = u + at$

$v^2 = u^2 + 2as$

PROJECTILE MOTION

$u_x = u\cos\theta$

$u_y = u\sin\theta$



$H = u^2\sin^2\theta/2g$

Time of Flight $= 2u_y/g \Rightarrow T = 2u\sin\theta/g$

Range $= u_x \cdot T \Rightarrow R = u^2\sin 2\theta/g$

$y = \tan\theta \cdot x - \left(\frac{g}{2u^2\cos^2\theta}\right)\cdot x^2$

RELATIVE VELOCITY

$V_{A/B} = V_A - V_B$

PHYSICS NOTES

LAWS OF MOTION

INERTIA

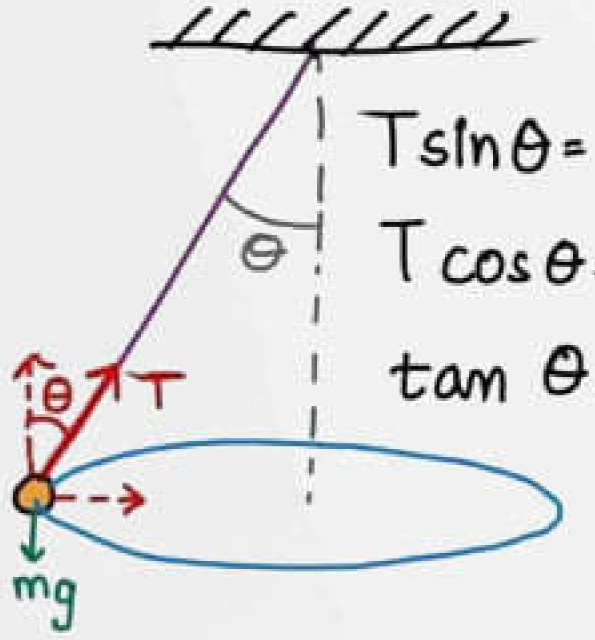
$$F = d\vec{P}/dt = ma$$

Action $\rightleftarrows$ Reaction

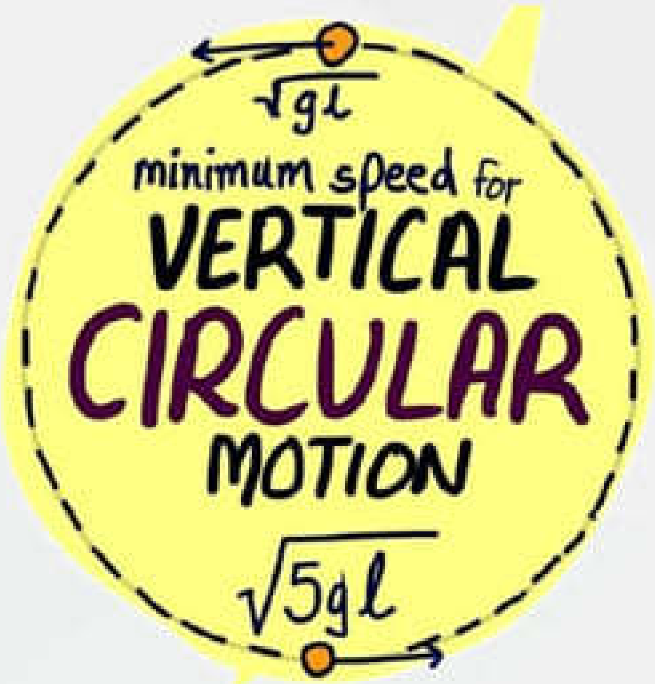
$$f = \mu_s N$$

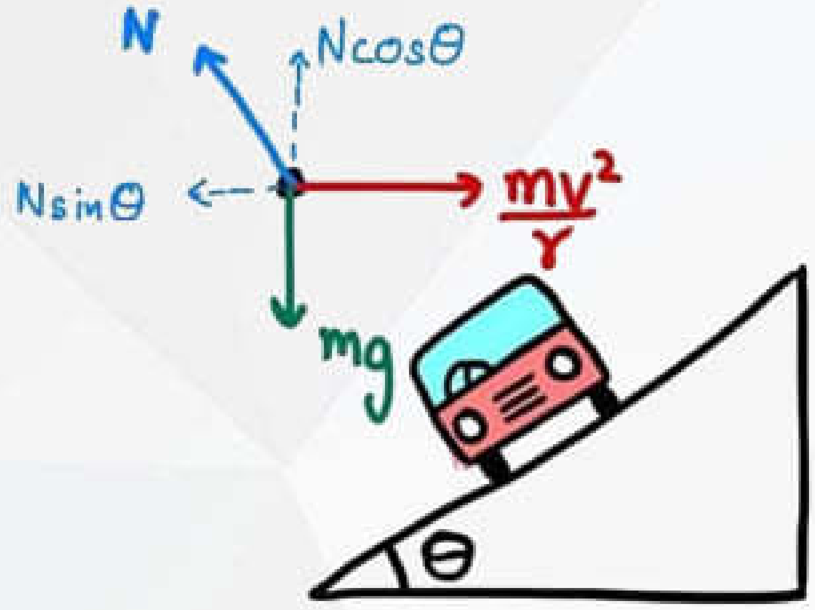
Centripetal force

$$\frac{mv^2}{r} = m\omega^2 r$$



$$T\sin\theta = mv^2/r$$
$$T\cos\theta = mg$$
$$\tan\theta = v^2/rg$$





CURVED BANKING

$$\frac{V^2}{rg} = \tan\theta \qquad \frac{V^2}{rg} = \frac{\mu \pm \tan\theta}{1 \mp \mu\tan\theta}$$

PHYSICS NOTES

WORK, POWER & ENERGY

$\text{Work} = \vec{F}.\vec{s} = \int \vec{F}.d\vec{s}$

$$\oint \vec{F}.d\vec{s} = 0$$

{Work by Conservative force in a closed path}

$\text{Power} = dW/dt = \vec{F}.\vec{v}$

$KE(K) = \frac{1}{2} mv^2$

POTENTIAL ENERGY (U)

$U_g = mgh$

$\vec{F} = \frac{-dU}{dx}$

$U_{spring} = \frac{1}{2} kx^2$

$K + U = \text{Conserved}$

FOR CONSERVATIVE FORCES

WORK-ENERGY THEOREM

$W_{net} = \Delta K$

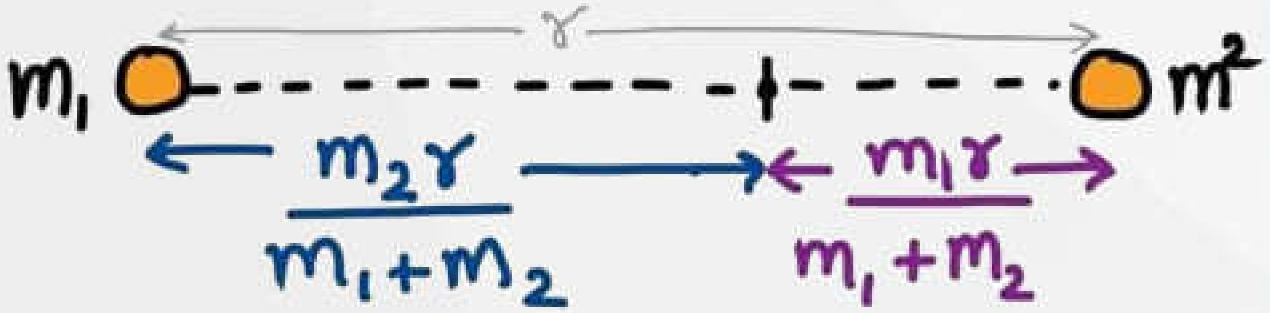
PHYSICS NOTES

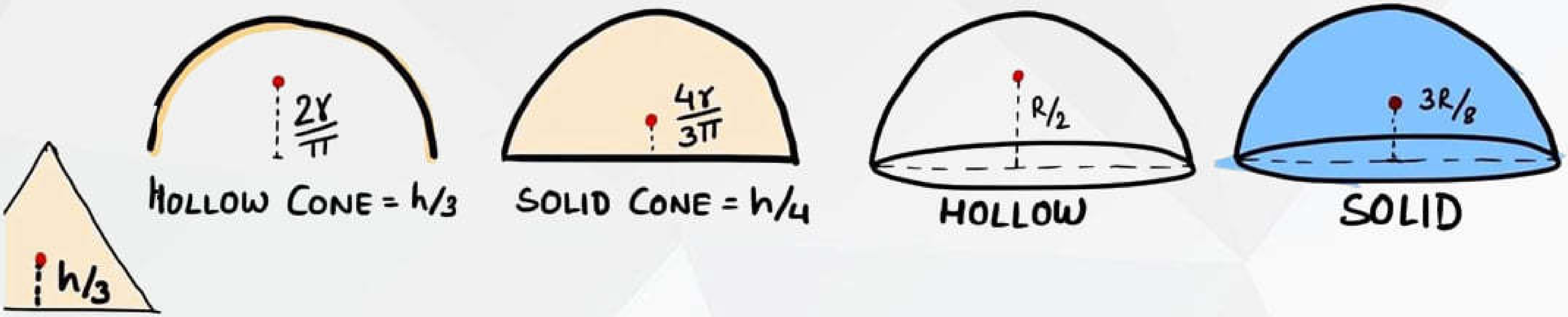
CENTER OF MASS

$$x_{cm} = \frac{\sum x_i m_i}{\sum m_i} = \frac{\int x\, dm}{\int dm}$$

$$\vec{V}_{cm} = \frac{\sum m_i \vec{v}_i}{\sum m_i}$$

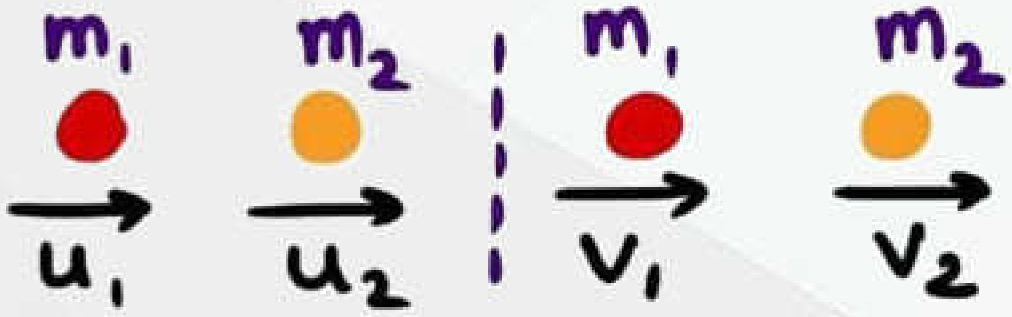
$$\vec{F} = m\vec{a}_{cm}$$





PHYSICS NOTES

COLLISION

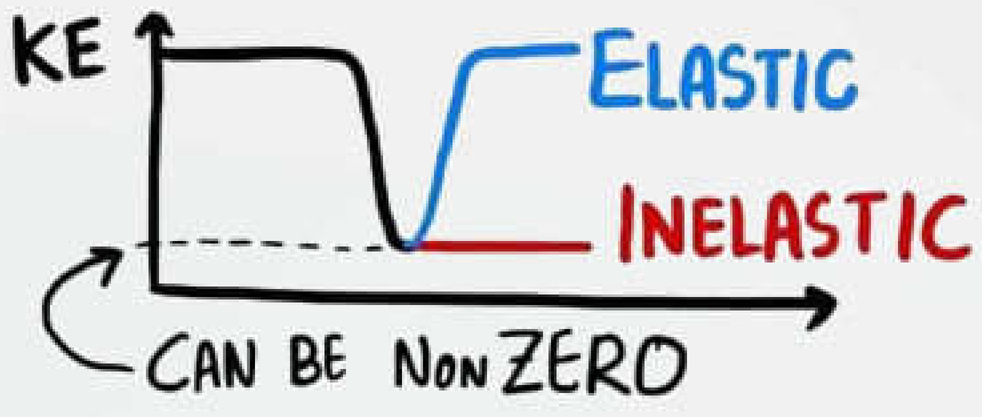


MOMENTUM CONSERVATION {Always}

$$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$$

ENERGY CONSERVATION {Elastic}

$$\frac{1}{2}m_1u_1^2 + \frac{1}{2}m_2u_2^2 = \frac{1}{2}m_1v_1^2 + \frac{1}{2}m_2v_2^2$$



$$CoR = e = \frac{V_{SEPARATION}}{V_{APPROACH}} = \frac{v_2 - v_1}{u_1 - u_2}$$

$m_1 >> m_2$

$m_1 \rightarrow$ undisturbed motion

Solve using CoR in m_1 Frame

$m_1 = m_2$

Velocity Exchange for Elastic

PHYSICS NOTES

RIGID BODY DYNAMICS

$$\omega = \frac{\Delta\theta}{\Delta t} = \frac{d\theta}{dt} \qquad \alpha = \frac{\Delta\omega}{\Delta t} = \frac{d\omega}{dt}$$

$$\vec{v} = \vec{\omega} \times \vec{r} \qquad \vec{a}_{tan} = \vec{\alpha} \times \vec{r} \qquad \vec{a}_{centri} = \omega^2 r$$

$$\theta = \omega_0 t + \frac{1}{2}\alpha t^2$$

$$\omega = \omega_0 + \alpha t$$

$$\omega^2 = \omega_0^2 + 2\alpha\theta$$

$$\vec{L} = \vec{r} \times \vec{p} = m v r_\perp$$

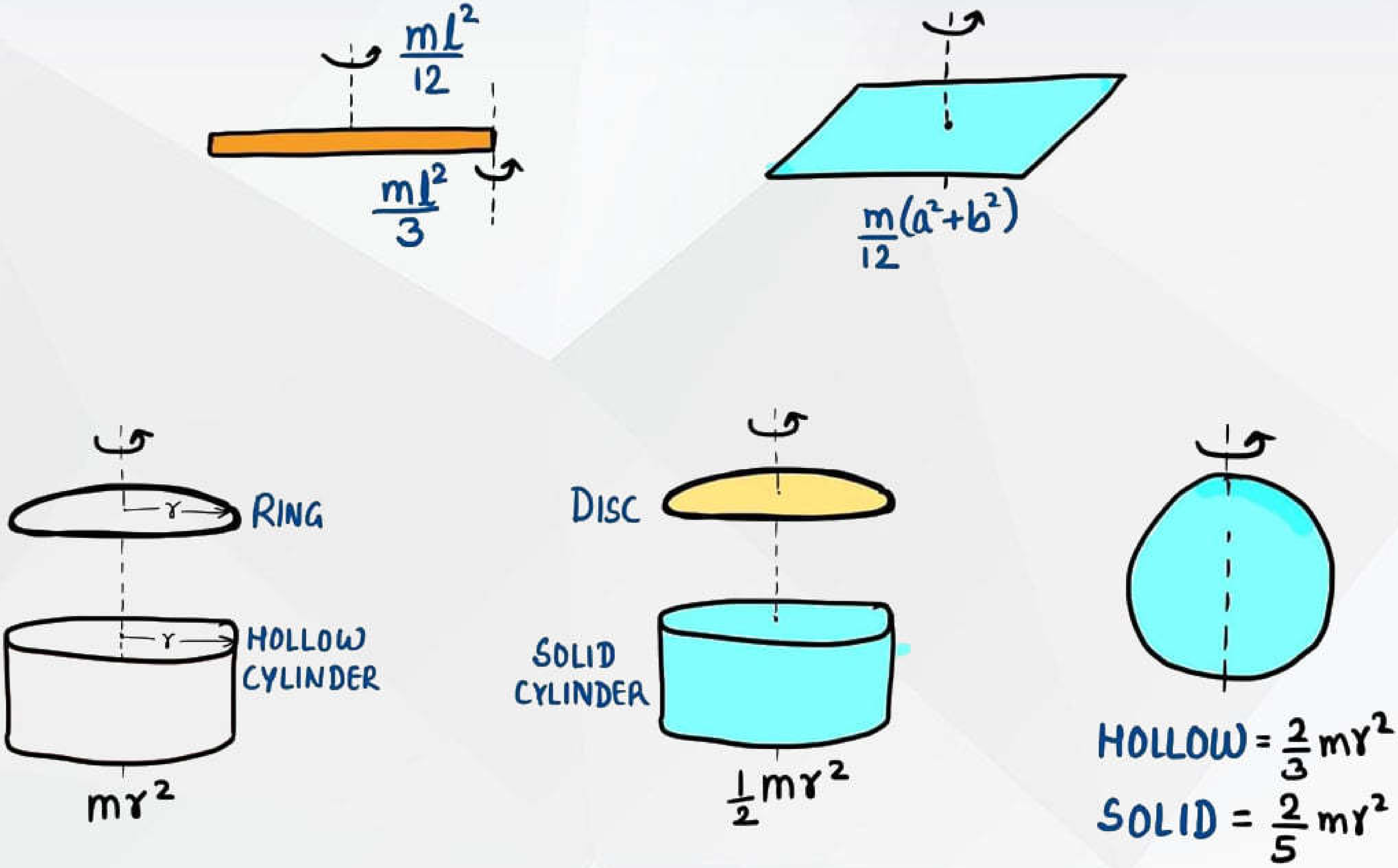
$$\tau = I\alpha = d\vec{L}/dt$$

$$\vec{\tau} = \vec{r} \times \vec{F} = r_\perp F = r F \sin\theta$$

EQUILIBRIUM : $F_{net} = 0 = \tau_{net}$

$$\omega = 2\pi f \qquad T = 1/f \qquad \omega = v_\perp / r$$

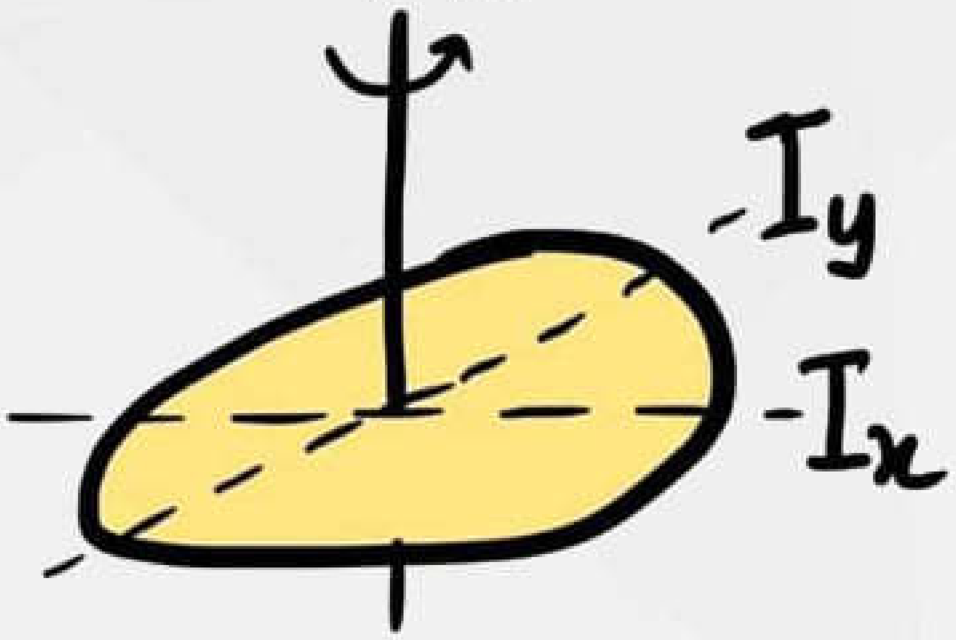
PHYSICS NOTES



PHYSICS NOTES

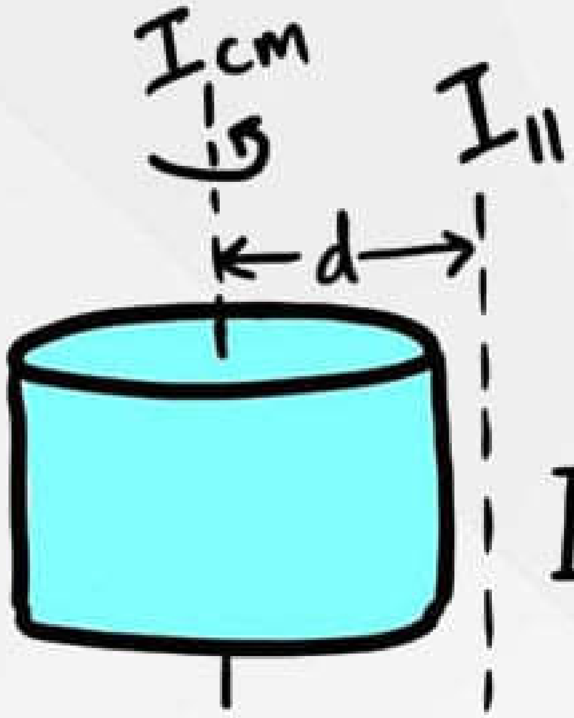
AXIS THEOREMS

$$I_z = I_x + I_y$$



PERPENDICULAR

PARALLEL



$$I_{\parallel} = I_{cm} + md^2$$

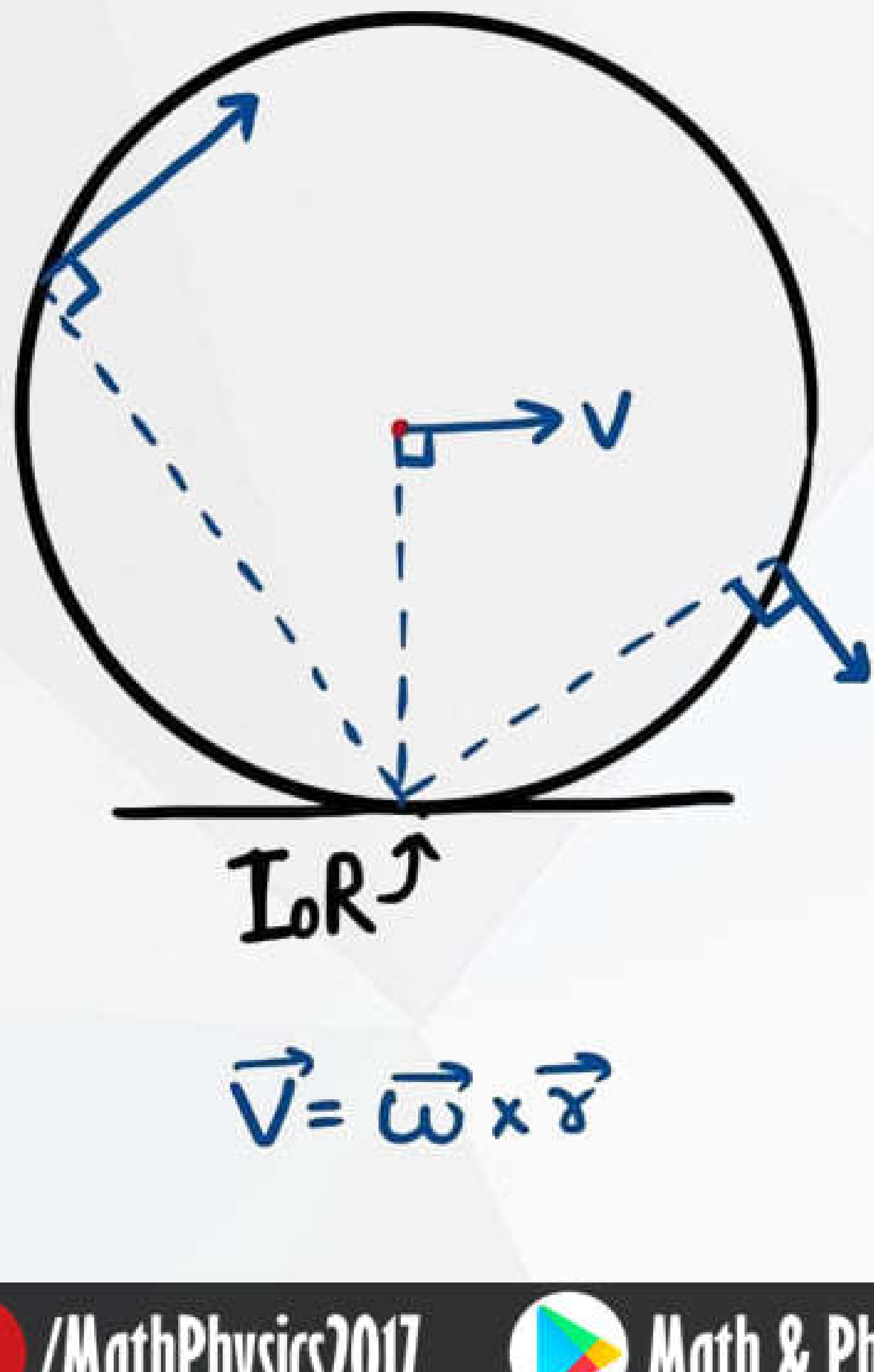
PHYSICS NOTES

IoR — INSTANTANEOUS AXIS OF ROTATION

KINETIC ENERGY

$$K = \frac{1}{2} m v_c^2 + \frac{1}{2} I_c \omega^2$$

$$K = \frac{1}{2} I_H \omega^2 \left\{ \begin{array}{l} \text{About Hinge} \\ \text{or IoR} \end{array} \right\}$$

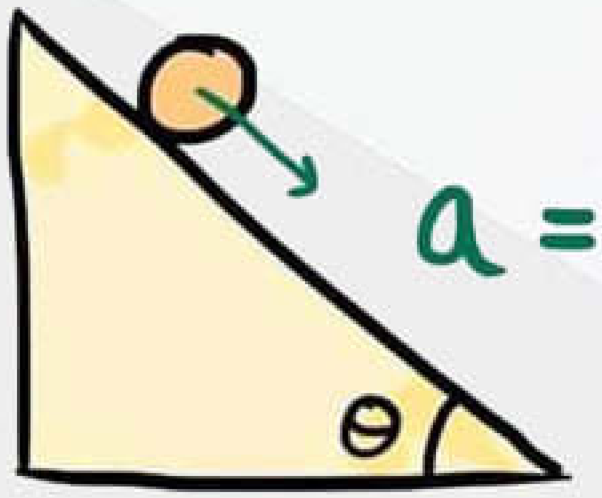


$\vec{V} = \vec{\omega} \times \vec{r}$

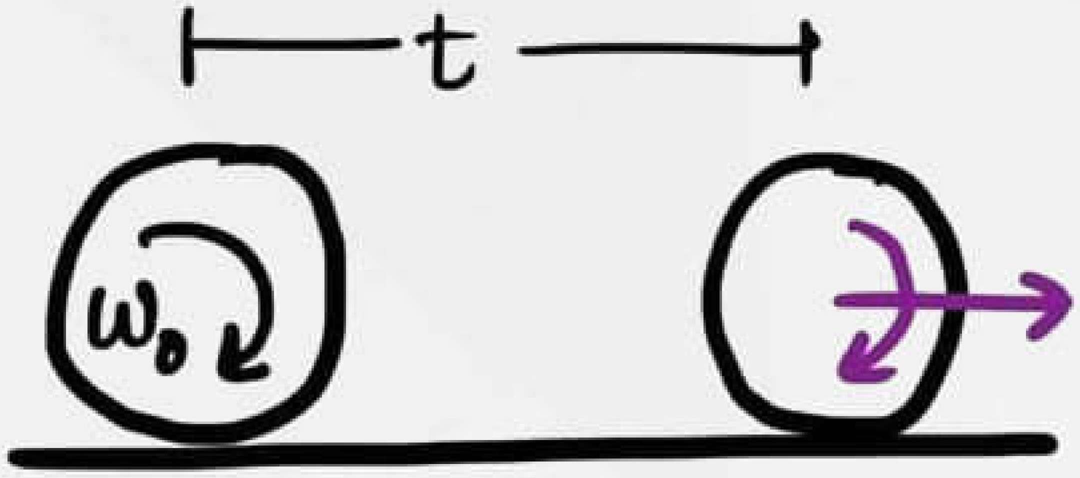
PHYSICS NOTES

ROLLING MOTION

$V = \omega r$ (no slip condition)



$$a = \frac{g \sin\theta}{\left[1 + \frac{I}{mr^2}\right]} \qquad V = \sqrt{\frac{2gH}{1 + \frac{I}{mr^2}}}$$



Initial

$$t = \frac{r\omega_0}{\mu g\left[1 + \frac{mr^2}{I}\right]}$$

$$t = \frac{V_0}{\mu g\left[1 + \frac{mr^2}{I}\right]}$$

PHYSICS NOTES

GRAVITATION

$$F = G\frac{Mm}{R^2}$$

Pot. Energy $(U) = -GMm/R$

$$V_{ORBITAL} = \sqrt{GM/R}$$

$$V_{escape} = \sqrt{2GM/R}$$

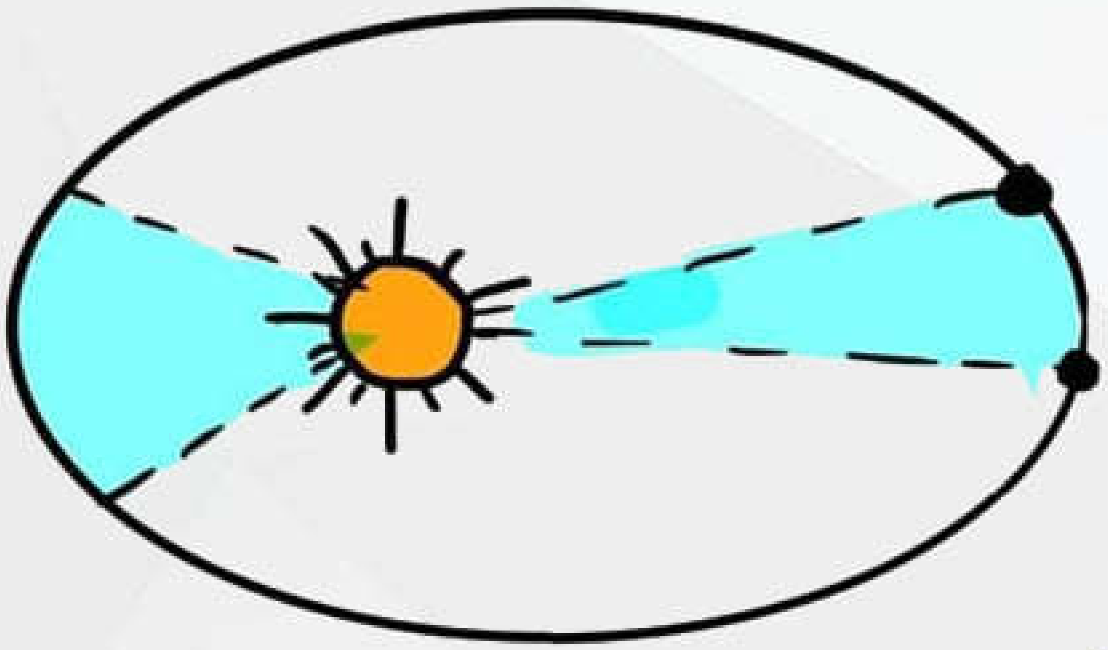
$$g = G\frac{M}{R^2} \qquad g' = g\left[1 - \frac{d}{R_e}\right] \qquad g' \approx g\left[1 - \frac{2h}{R_e}\right]$$

VARIATION OF g

$$g' = g - \omega^2 R_e \cos^2\theta$$

PHYSICS NOTES

KEPLER'S LAWS



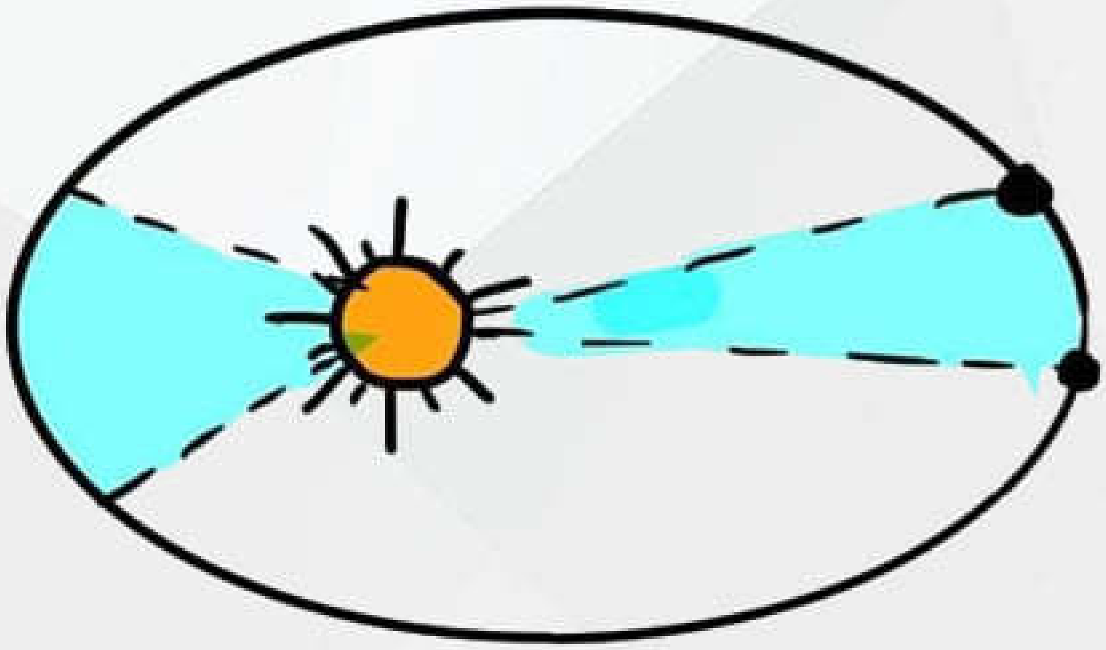
1st Elliptical Orbits, Sun @ foci

2nd Equal Area in Equal time ($\vec{L}$)

3rd $T^2 \propto a^3$ [semi major axis]

PHYSICS NOTES

KEPLER'S LAWS



1st Elliptical Orbits, Sun @ foci

2nd Equal Area in Equal time ($\vec{L}$)

3rd $T^2 \propto a^3$ [semi major axis]

PHYSICS NOTES

SHM

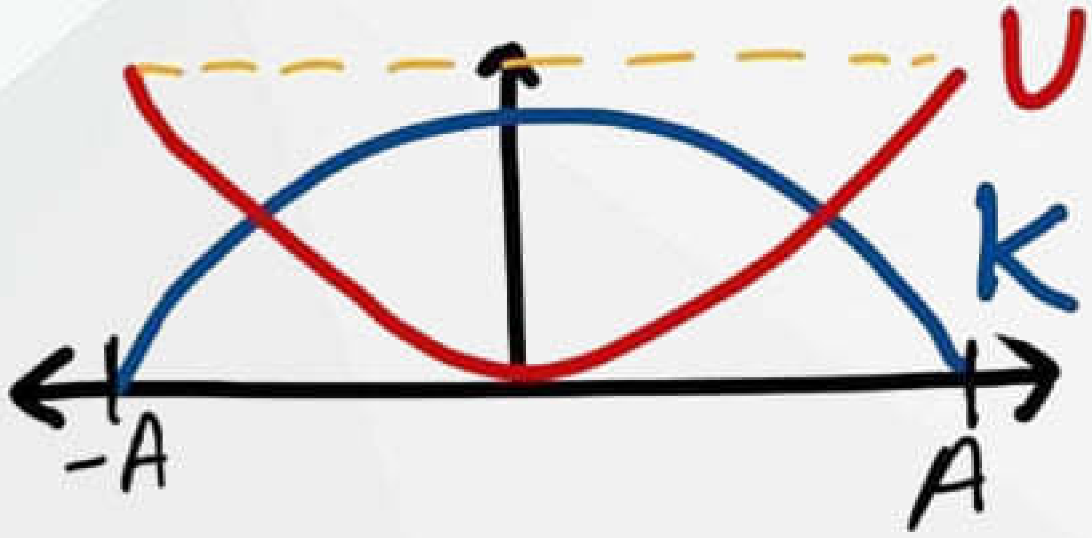
Hooke's Law $F = -kx$

$x = A\sin(\omega t + \phi)$

$v = A\omega\cos(\omega t + \phi)$

$a = -\omega^2 x = -k/m\, x$

$T = \frac{2\pi}{\omega} = 2\pi\sqrt{m/k}$

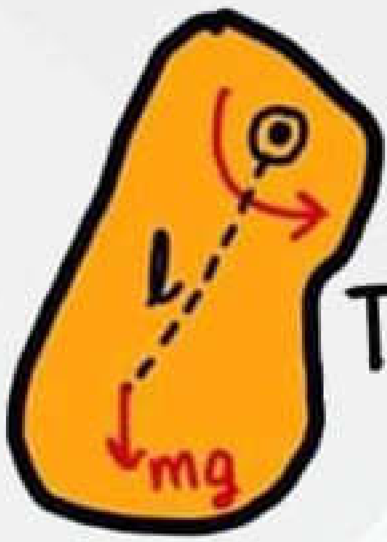


$K = \frac{1}{2}mv^2$

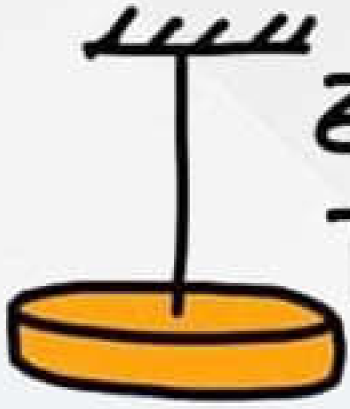
$U = \frac{1}{2}kx^2$

$E = K + U = \frac{1}{2}kA^2 = \frac{1}{2}m\omega^2 A^2$

$T = 2\pi\sqrt{l/g}$



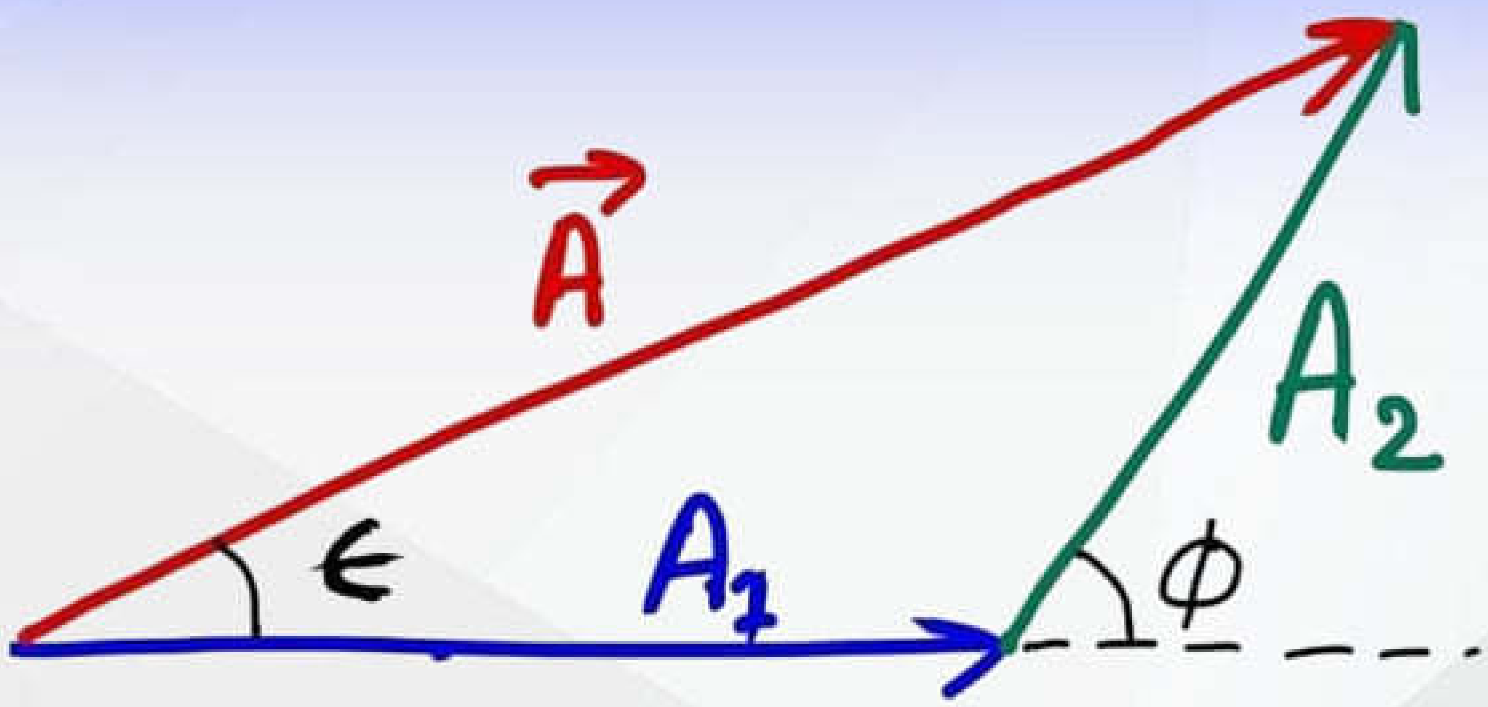
$T = 2\pi\sqrt{\frac{I}{mgl}}$



$\tau = k\theta$

$T = 2\pi\sqrt{\frac{I}{k}}$

PHYSICS NOTES



$$\tan\epsilon = \frac{A_2 \sin\phi}{A_1 + A_2 \cos\phi}$$

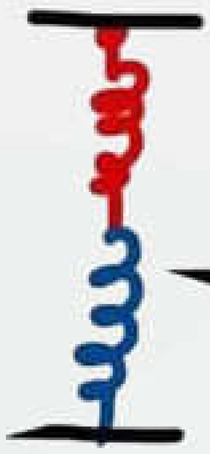
$$x_1 = A_1 \sin(\omega t)$$

$$x_2 = A_2 \sin(\omega t + \phi)$$

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

$$x = x_1 + x_2 = A\sin(\omega t + \epsilon)$$

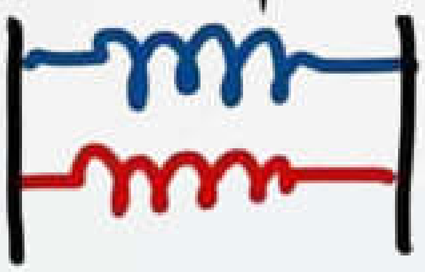
SPRINGS



SERIES

$$\frac{1}{K_{eq}} = \frac{1}{K_1} + \frac{1}{K_2}$$

PARALLEL



$$K_{eq} = K_1 + K_2$$

PHYSICS NOTES

PROPERTIES OF MATTER

Young's Modulus $(Y) = \frac{F/A}{\Delta l / l}$

Shear Modulus $(\eta) = \frac{F/A}{\tan\theta}$

Bulk Modulus $(B) = -V\frac{\Delta P}{\Delta V}$

Compres- -sibility $(K) = \frac{1}{B} = -\frac{1}{V}\frac{\Delta V}{\Delta P}$

Poisson's Ratio (σ)

$$\frac{\text{LATERAL STRAIN}}{\text{LONGITUDINAL STRAIN}} = \frac{\Delta D / D}{\Delta l / l}$$

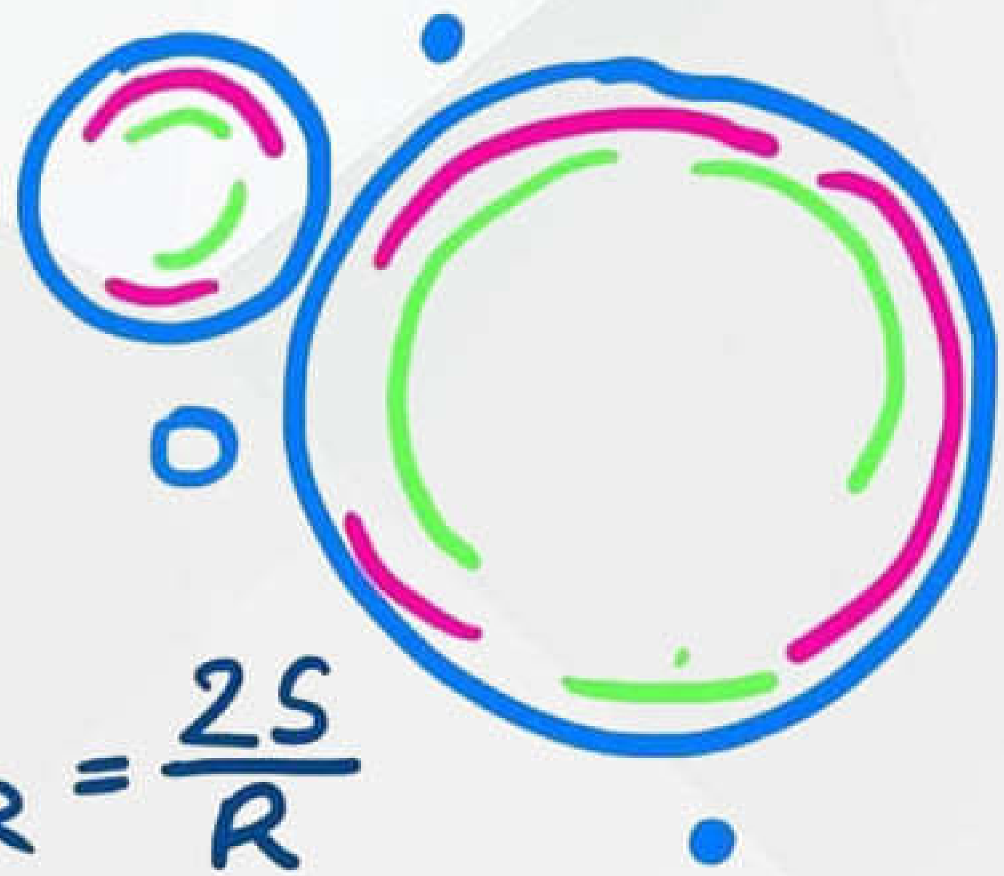
Elastic Energy (U)

$\frac{1}{2}$ STRESS $\times$ STRAIN $\times$ VOLUME

PHYSICS NOTES

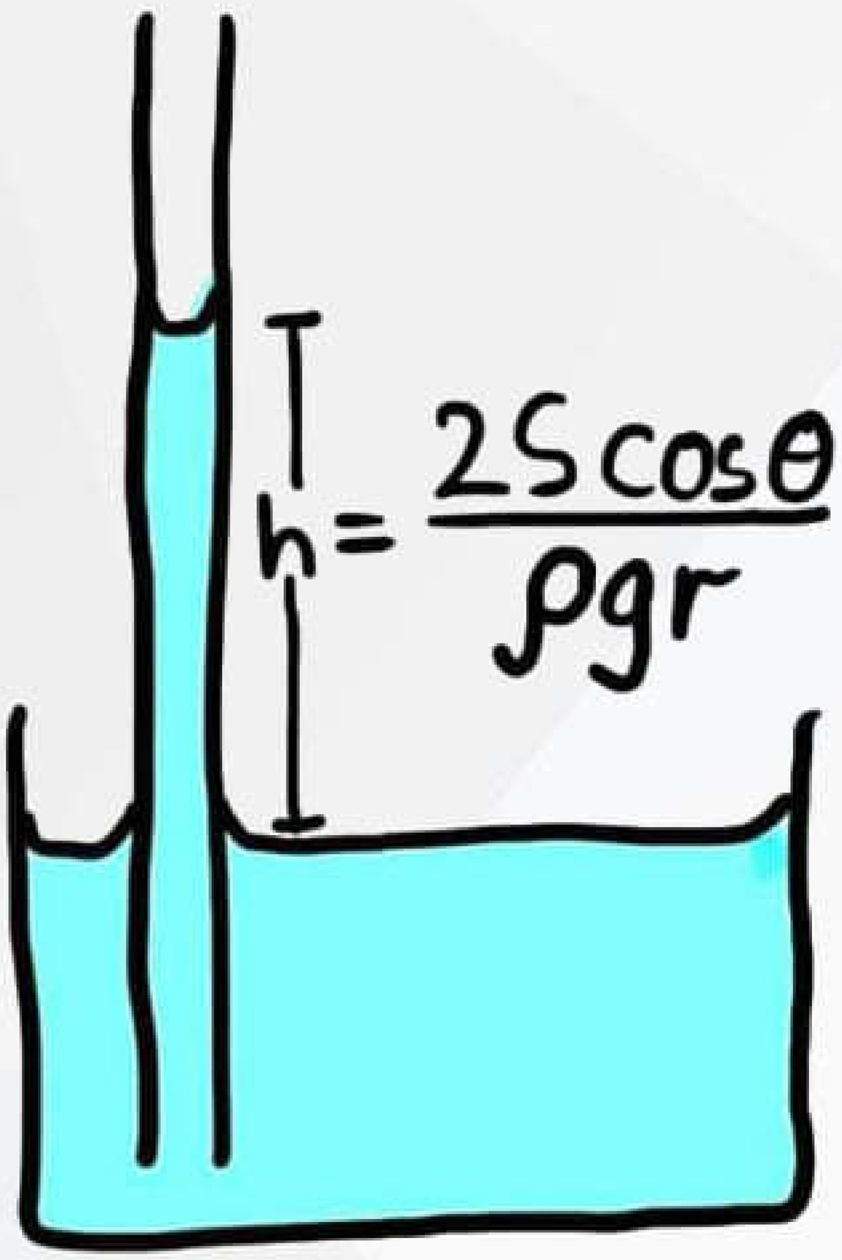
Surface Tension $(S) = F/\ell$

Surface Energy $(U) = S.\text{Area}$



$$\Delta P_{SOAP} = \frac{4S}{R}$$

$$P_{EXCESS} = \Delta P_{AIR} = \frac{2S}{R}$$



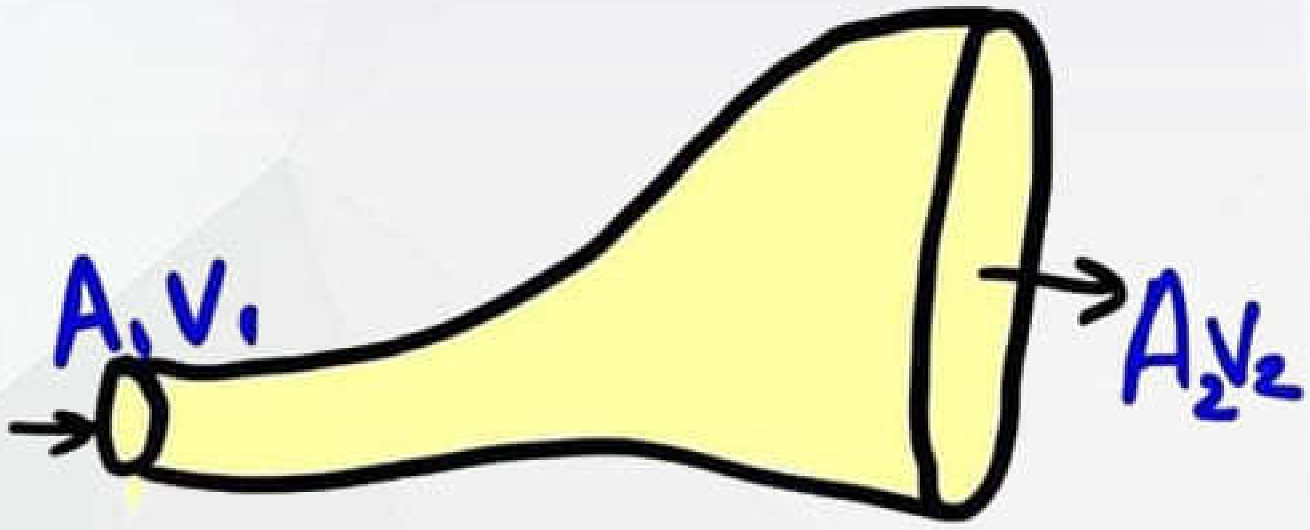
$$h = \frac{2S\cos\theta}{\rho g r}$$

PHYSICS NOTES

$P_{HYDROSTATIC} = \rho g h$

$F_{BUOYANT} = \rho g V$

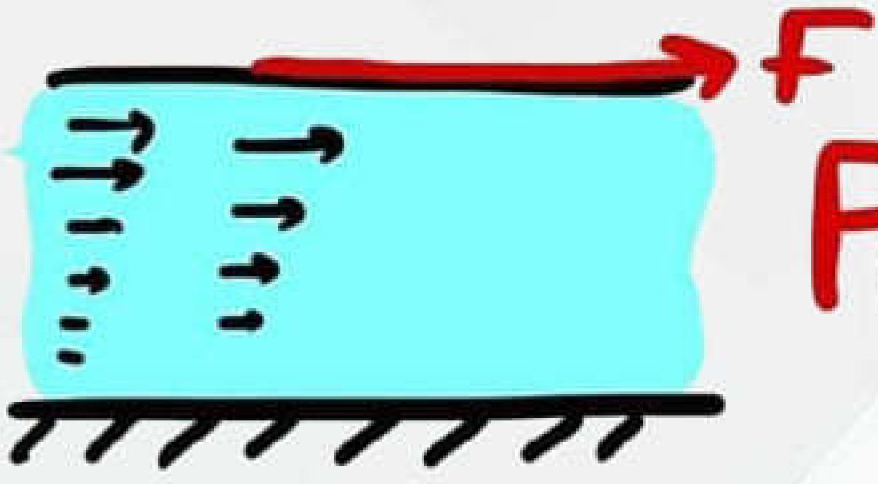
CONTINUITY



$A_1 v_1 = A_2 v_2$

BERNOULLI's

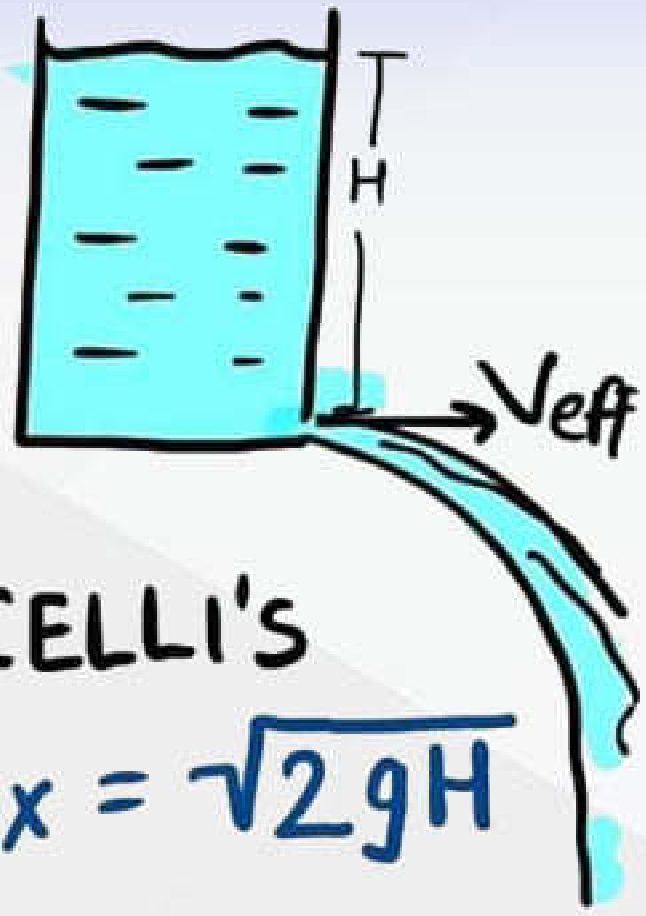
$P + \rho g h + \frac{1}{2}\rho v^2 = Const$



$F_{VISCOUS} = -\eta A \frac{dv}{dx}$

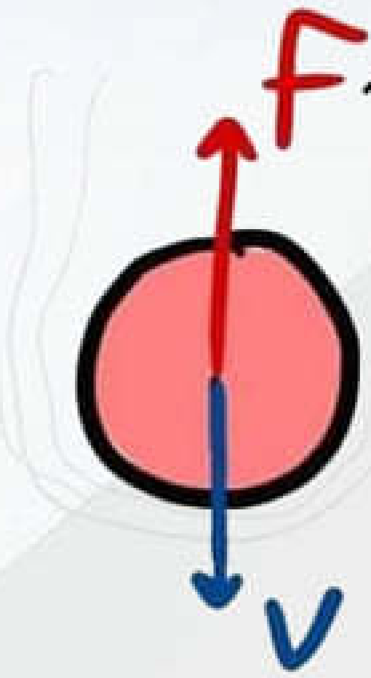
Area

PHYSICS NOTES



TORRICELLI'S

$V_{EFFLUX} = \sqrt{2gH}$



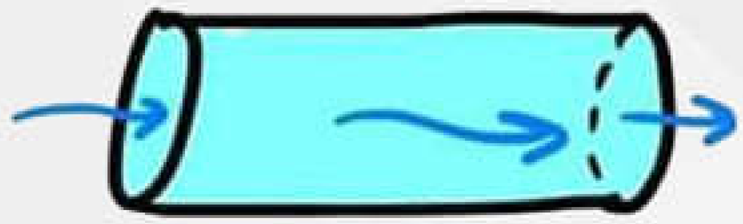
STOKE'S LAW

$F = 6\pi\eta r v$

$V_{TERMINAL}$

$\frac{2r^2(\rho-\sigma)g}{9\eta}$

POISEUILLI'S EQN

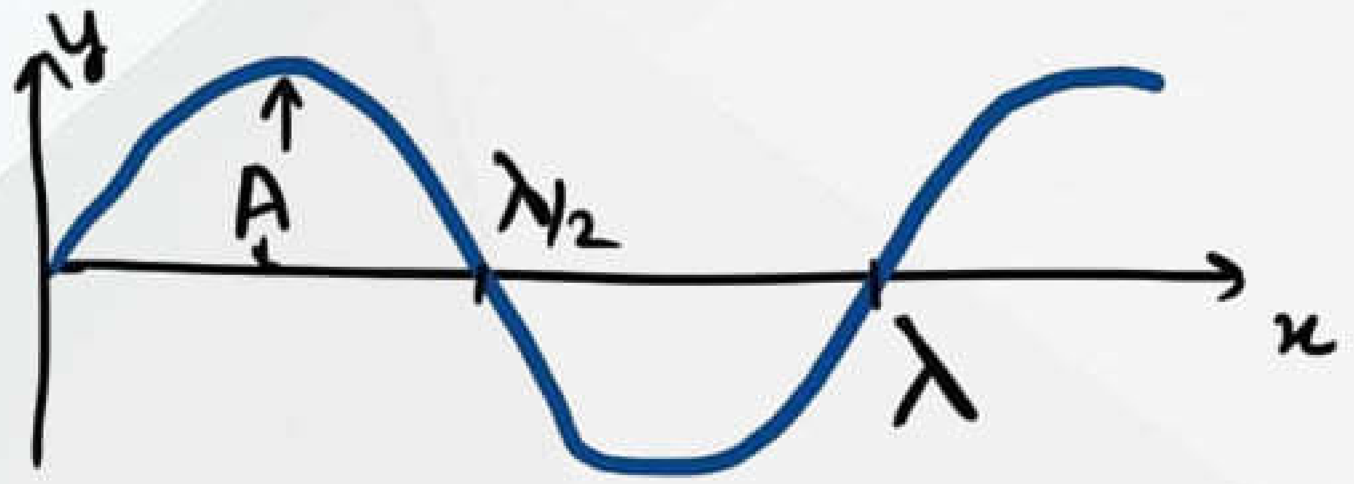


$$\frac{\text{VOLUME FLOW}}{\Delta t} = \frac{\pi \rho r^4}{8\eta L}$$

PHYSICS NOTES

WAVES

$$\frac{\partial^2 y}{\partial x^2} = \frac{1}{v^2}\frac{\partial^2 y}{\partial t^2}$$



$$Y = A \sin(kx - \omega t) = A \sin\left[2\pi\left(\frac{x}{\lambda} - \frac{t}{T}\right)\right]$$

Wave Number $(k) = \frac{2\pi}{\lambda}$

$$T = \frac{1}{\nu} = \frac{2\pi}{\omega}$$

$$v = \nu\lambda$$

PHYSICS NOTES

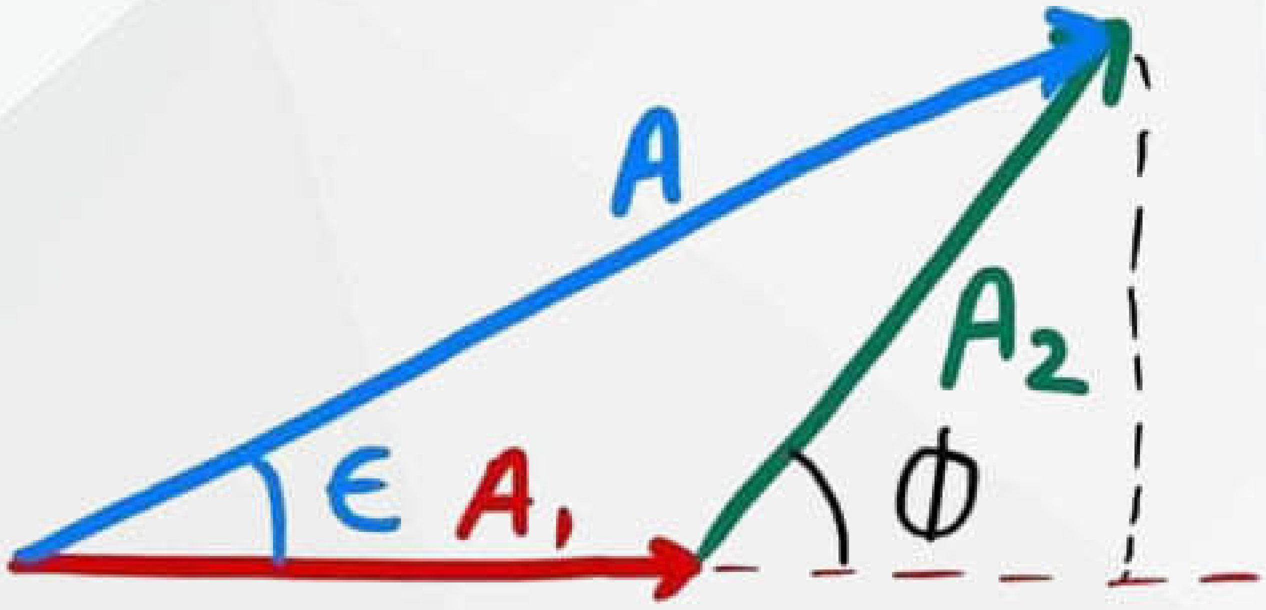
$$Y_1 = A_1 \sin(kx-\omega t)$$

$$Y_2 = A_2 \sin(kx-\omega t+\phi)$$

$$Y = A \sin(kx-\omega t+\epsilon)$$

$$A^2 = \sqrt{(A_1 + A_2\cos\phi)^2 + (A_2\sin\theta)^2}$$

$$\tan\epsilon = \frac{A_2\sin\phi}{A + A_2\cos\phi}$$



$\phi = 2n\pi$ (even) : constructive

$= (2n+1)\pi$ (odd) : destructive

$$V = \sqrt{\frac{T}{\mu}}$$

$$P_{AVG} = 2\pi^2 \mu \nu A v^2 \quad \text{(POWER)}$$

PHYSICS NOTES

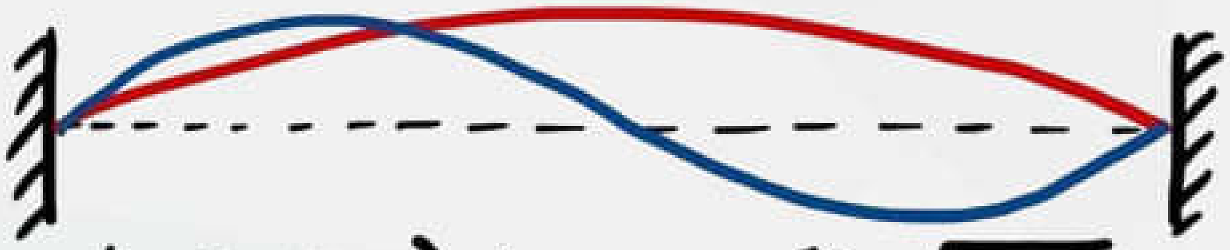
STANDING WAVES

$$y_1 = A\sin(kx - \omega t)$$

$$y_2 = A\sin(kx + \omega t)$$

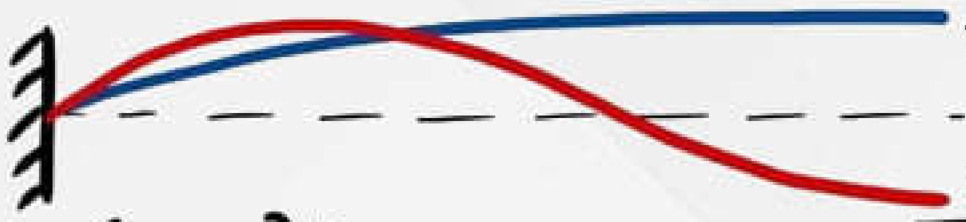
$$Y = 2A\cos kx \cdot \sin \omega t$$

Node if $\cos kx$ is zero $\Rightarrow x = (n + \frac{1}{2})\lambda$



$L = n \cdot \lambda/2 \quad \nu = \frac{n}{2L}\sqrt{\frac{T}{\mu}}$

SONOMETER



$L = (2n+1)\frac{\lambda}{4} \quad \nu = \frac{2n+1}{4L}\sqrt{\frac{T}{\mu}}$

PHYSICS NOTES

SOUND WAVES

$$S = S_0 \sin[\omega(t - x/v)]$$

$$P = P_0 \cos[\omega(t - x/v)]$$

$$P_0 = \left[\frac{B\omega}{v}\right] S_0$$

$$V_{solid} = \sqrt{Y/\rho}$$

$$V_{liq} = \sqrt{B/\rho}$$

$$V_{gas} = \sqrt{\gamma P/\rho}$$

$$I = \frac{2\pi^2 B}{v} S_0 \nu^2 = \frac{P_0^{\,2} v}{2B} = \frac{P_0}{2\rho v}$$

PHYSICS NOTES

STANDING LONGITUDINAL WAVES

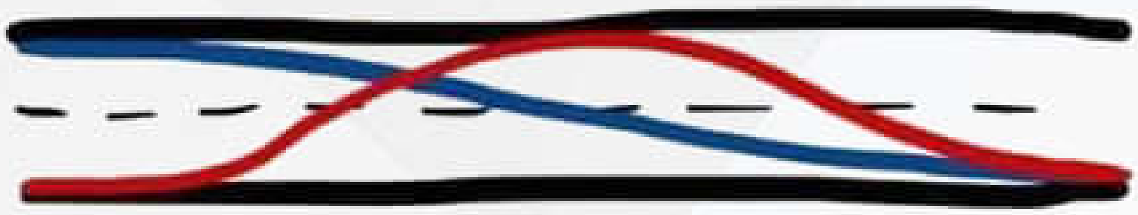
$P_1 = P_0 \sin[\omega(t - x/v)]$ $\quad$ $P_2 = \sin[\omega(t + x/v)]$

$P = P_1 + P_2 = 2P_0 \cos kx \sin \omega t$

CLOSED ORGAN PIPE

$L = (2n+1)\dfrac{\lambda}{4}$ $\quad$ $\nu = (2n+1)\dfrac{V}{4L}$

OPEN ORGAN PIPE



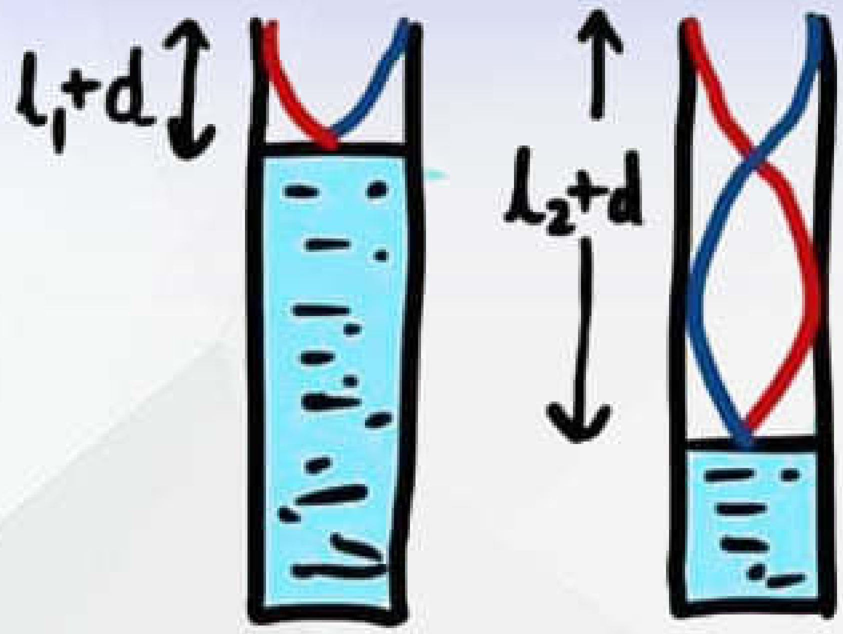
$L = n\dfrac{\lambda}{2}$ $\quad$ $\nu = n\dfrac{V}{2L}$

PHYSICS NOTES

Resonance Column

$l_1 + d = \frac{\lambda}{2}$ $l_2 + d = \frac{3\lambda}{2}$

$V = 2(l_2 - l_1)\nu$



Beats (if $\omega_1 \approx \omega_2$)

$P_1 = P_0 \sin \omega_1(t - x/v)$ $P_2 = P_0 \sin \omega_2(t - x/v)$

$P = 2P_0 \cos \Delta\omega(t - x/v) \sin \omega(t - x/v)$

$\omega = \left(\frac{\omega_1 + \omega_2}{2}\right)$ Beats $\rightarrow \Delta\omega = \omega_1 - \omega_2$

DOPPLER

$\nu = \frac{V + V_0}{V - V_s} \nu_0$

PHYSICS NOTES

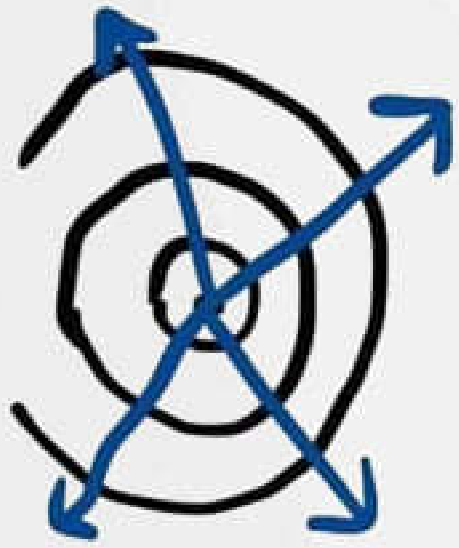
LIGHT WAVES

PLANE WAVES

$E = E_0 \sin\omega(t - x/v)\ ;\ I = I_0$

SPHERICAL WAVES

$E = \frac{aE_0}{r}\sin\omega(t - r/v)\ ;\ I = \frac{I_0}{r}$



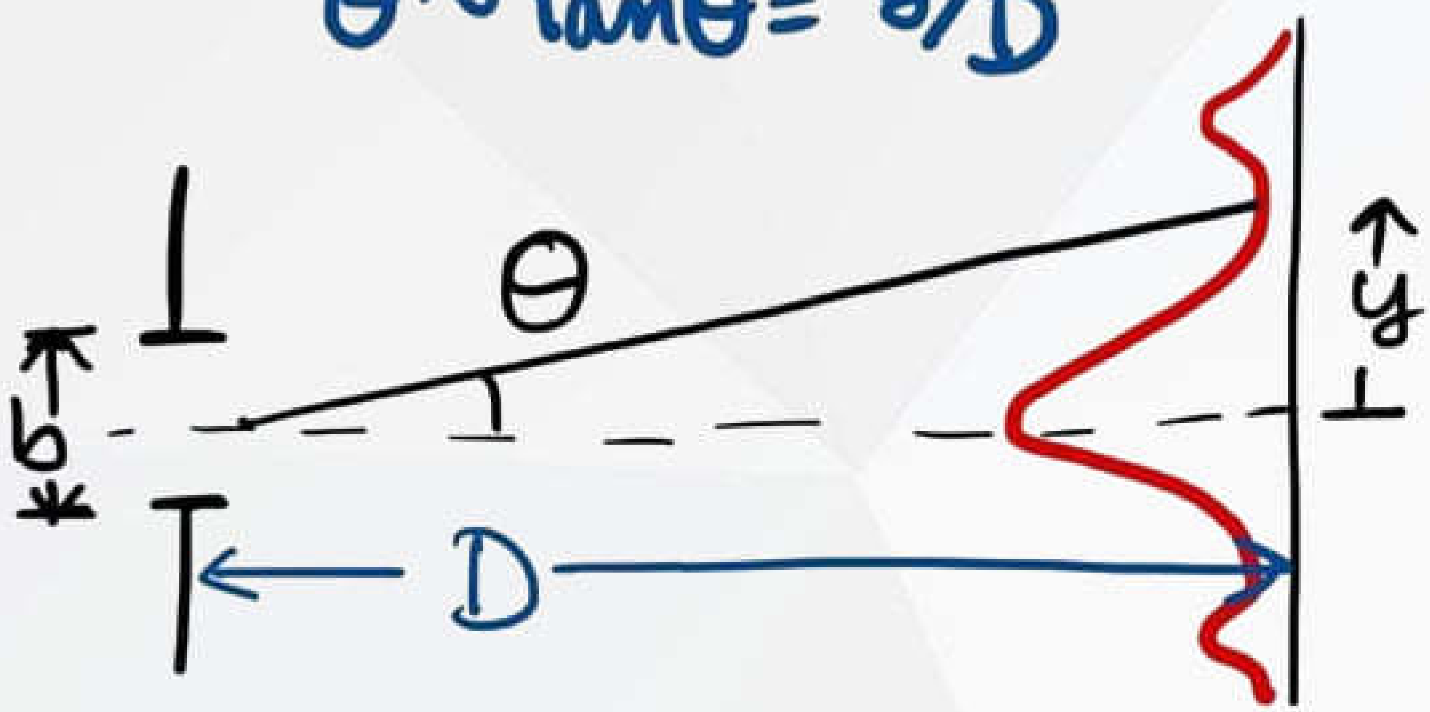
DIFFRACTION

$\theta \sim \tan\theta = y/D$

$\Delta x = b\sin\theta \simeq b\theta$

Minima $b\theta = n\lambda$

Resolution $\sin\theta = \frac{1.22\lambda}{b}$

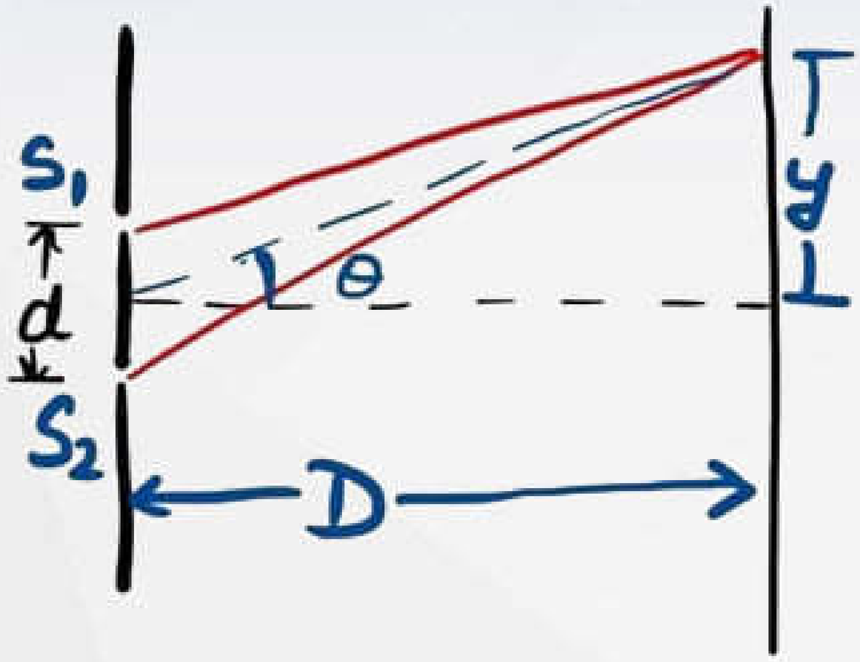


PHYSICS NOTES

YOUNG'S DOUBLE SLIT EXPERIMENT

Path diff: $\Delta x = y\frac{d}{D}$

Phase diff: $\delta = \frac{2\pi}{\lambda}\Delta x$



CONSTRUCTIVE

$\delta = 2n\pi$; $\Delta x = n\lambda$

DESTRUCTIVE

$\delta = (2n+1)\lambda$; $\Delta x = (n+1/2)\lambda$

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

$I_{max/min} = \left(\sqrt{I_1} \pm \sqrt{I_2}\right)^2$

Fringe Width $\omega = \lambda\frac{D}{d}$

Optical Path $\Delta x' = \mu\Delta x$

INTERFERENCE THROUGH THIN FILM

$\Delta x = 2\mu d = n\lambda \longrightarrow$ constructive

$(2n+1)\lambda/2 \longrightarrow$ destructive

PHYSICS NOTES

OPTICS

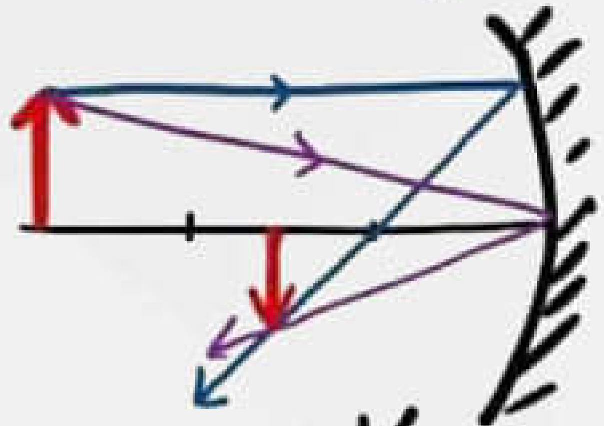
REFLECTION

(ii) $\angle i = \angle r$

(i) i, r & normal in same plane

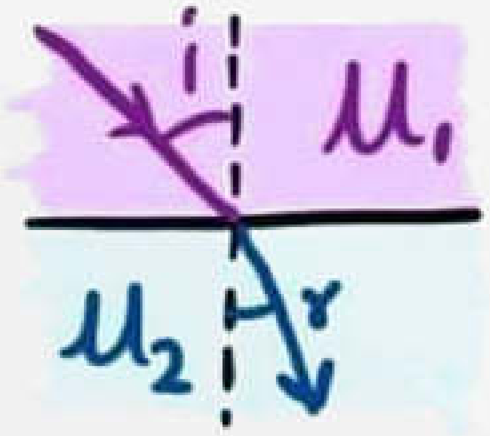
$f = R/2$

$\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$



Magnification $m = -\frac{v}{u}$

REFRACTION

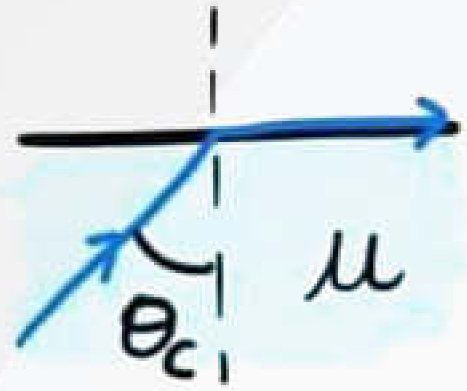


$\mu = \frac{c}{v} = \frac{(\text{vacuum})}{(\text{Medium})}$

Snail's Law $\mu_1 \sin i = \mu_2 \sin r$

Apparent Depth $d' = d/\mu$

TIR Critical Angle

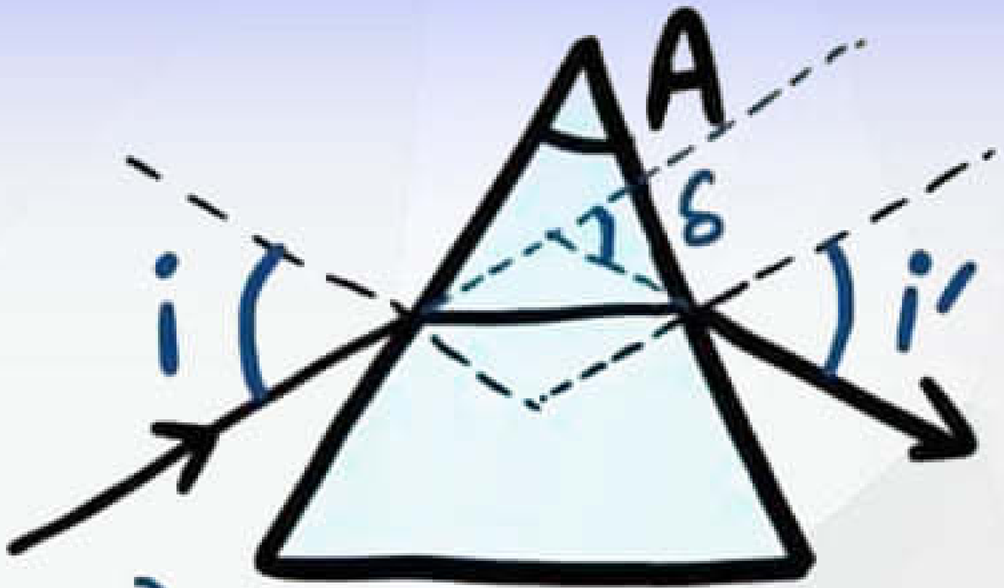


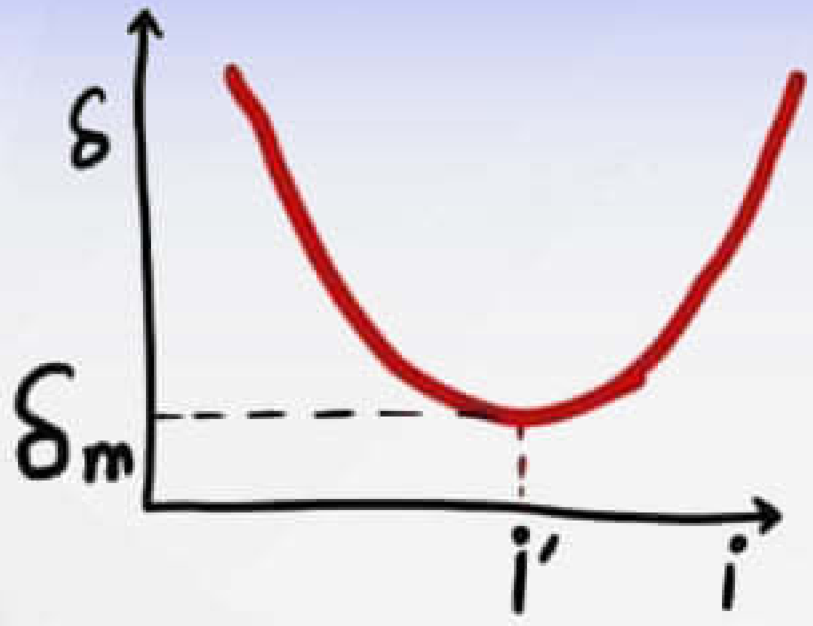
$\mu \sin\theta_c = \cancel{\sin 90^\circ} \; 1$

PHYSICS NOTES

PRISM

$\delta = i + i' - A$



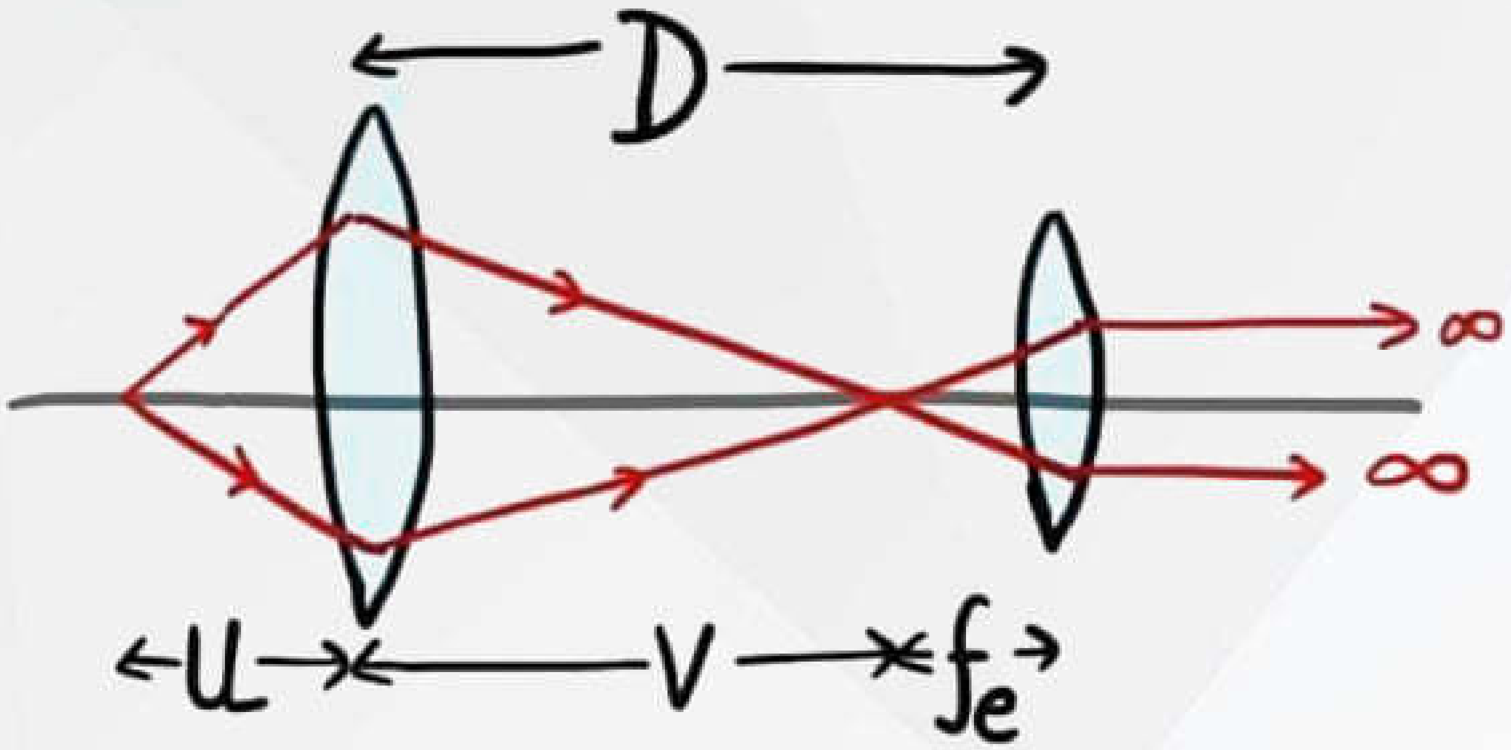


$$\mu = \frac{\sin\left(\frac{A+\delta_{min}}{2}\right)}{\sin\left(\frac{A}{2}\right)}$$

$\delta_{min} = (\mu - 1)A$

For small 'A'

MICROSCOPE



Simple $m = D/f$

Compound

$m = \frac{v}{u}\frac{D}{f_e}$

Resolving Pow $R = \frac{1}{\Delta d} = \frac{2\mu\sin\theta}{\lambda}$

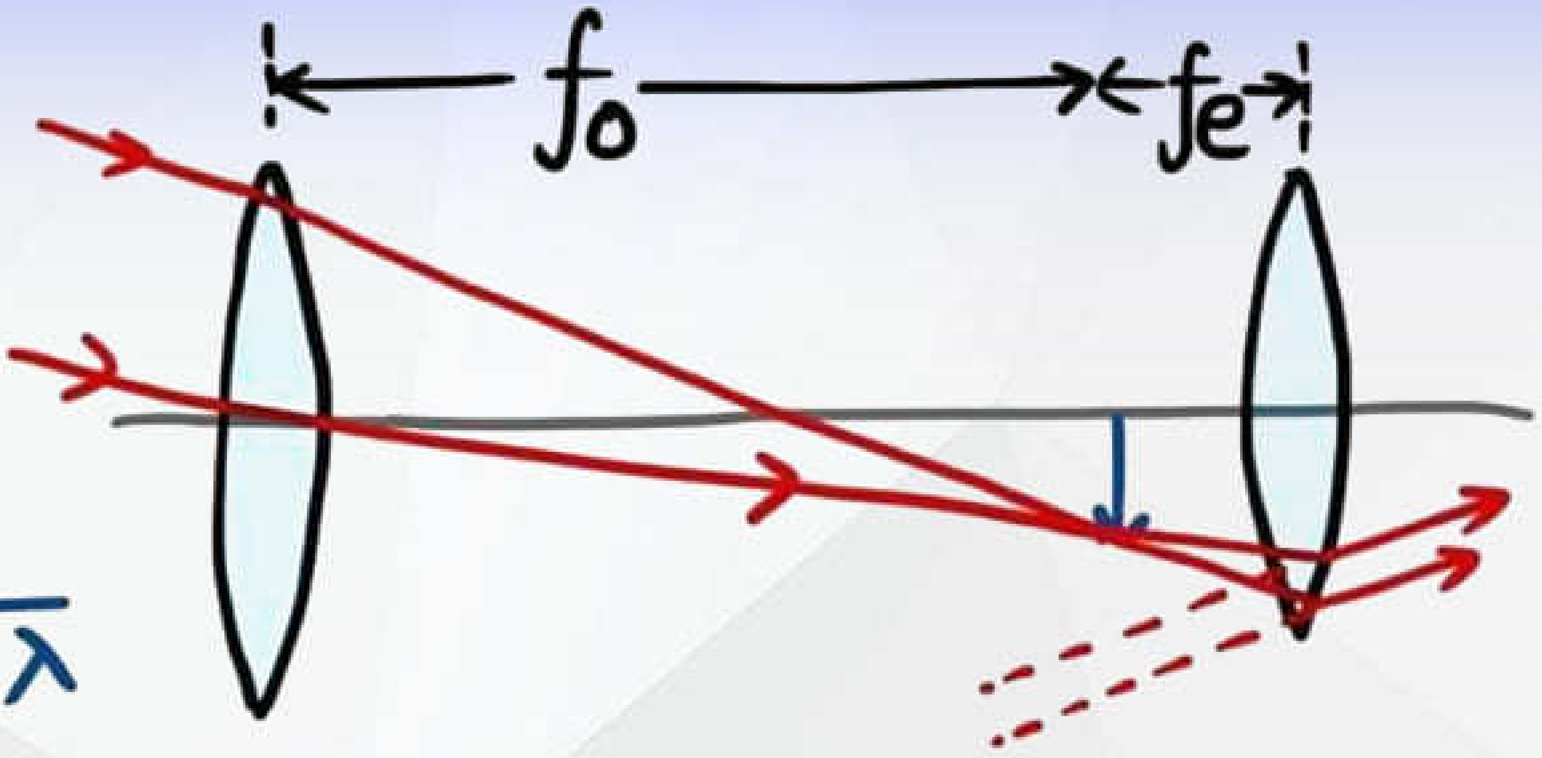
PHYSICS NOTES

TELESCOPE

$m = -f_o / f_e$

$L = f_o + f_e$

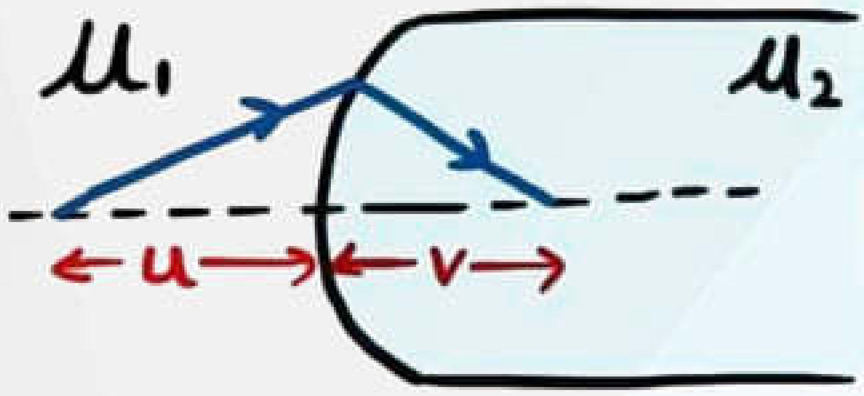
$R = \dfrac{1}{\Delta\theta} = \dfrac{1}{1.22\lambda}$



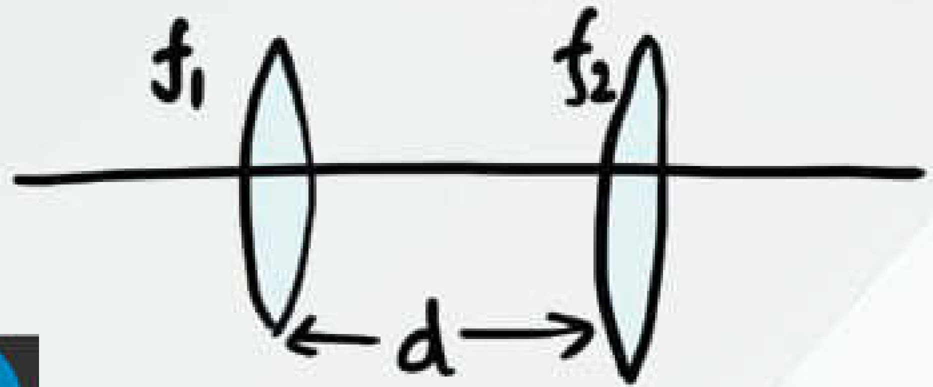
SPHERICAL SURFACE

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

$$m = \frac{\mu_1 v}{\mu_2 u}$$



THIN LENSES $\dfrac{1}{F} = \dfrac{1}{f_1} + \dfrac{1}{f_2} - \dfrac{d}{f_1 f_2}$



LENS MAKER'S $\dfrac{1}{f} = (\mu - 1)\left(\dfrac{1}{R_1} - \dfrac{1}{R_2}\right)$

LENS FORMULA $\dfrac{1}{v} - \dfrac{1}{u} = \dfrac{1}{f}$; $m = \dfrac{v}{u}$

POWER $P = 1/f$

PHYSICS NOTES

DISPERSION

Cauchy's $\mu = \mu_0 + A/\lambda^2 \quad A > 0$

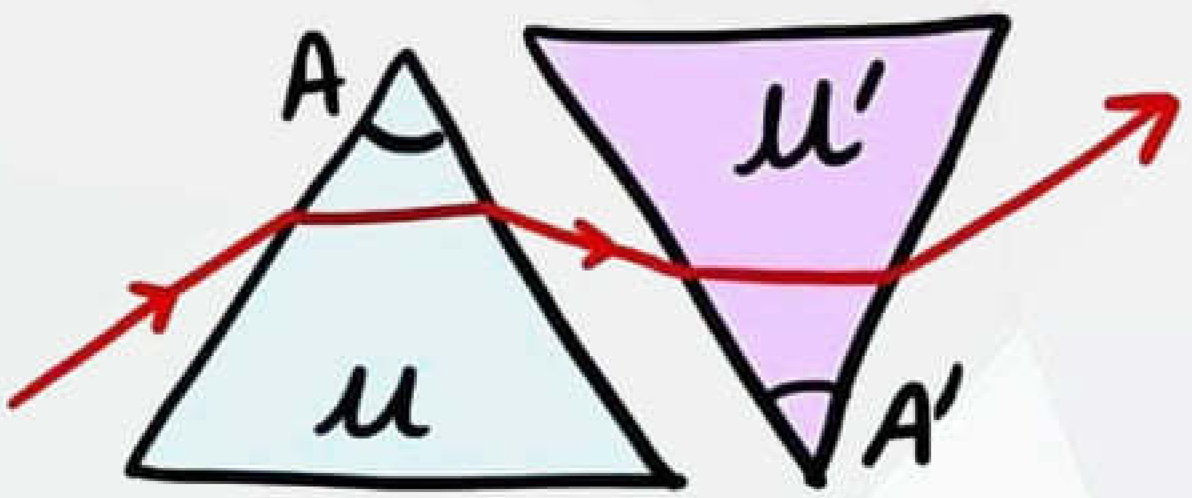
For small A & i

mean deviation $\delta_y = (\mu_y - 1)A$

Angular dispersion $\theta = (\mu_y - \mu_r)A$

Dispersive Power

$$\omega = \frac{\mu_v - \mu_r}{\mu_y - 1} \approx \frac{\theta}{\delta_y}$$



DISPERSION only

$(\mu_y - 1)A + (\mu'_y - 1)A' = 0$

DEVIATION only

$(\mu_v - \mu_r)A = (\mu'_v - \mu'_r)A'$

PHYSICS NOTES

HEAT AND TEMP

$F = 32 + \frac{9}{5}C$

$K = C + 273.16$

Ideal Gas → $PV = nRT$

van der Waals

$\left(p + \frac{a}{V^2}\right)(V - b) = nRT$

$L = L_0(1 + \alpha \Delta T)$

$A = A_0(1 + 2\alpha \Delta T)$

$V = V_0(1 + 3\alpha \Delta T)$

THERMAL STRESS

$\frac{F}{A} = Y\frac{\Delta L}{L}$

PHYSICS NOTES

KINETIC THEORY

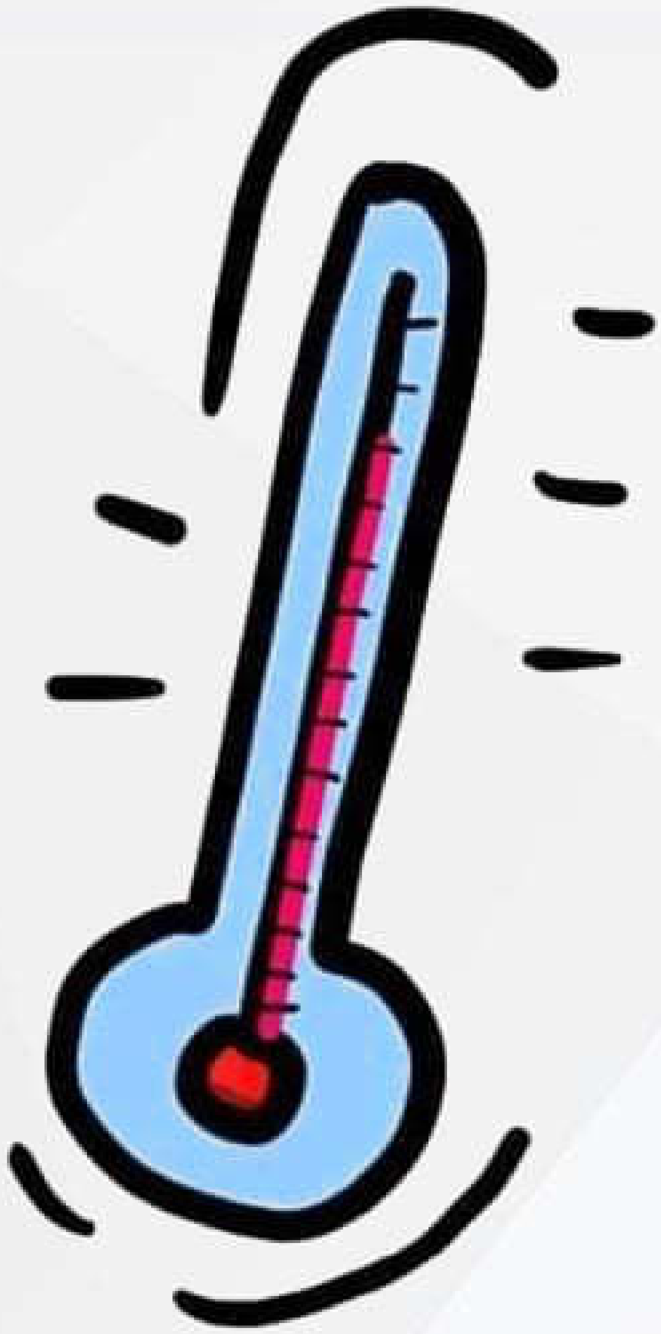
EQUIPARTITION OF ENERGY

$K = \frac{1}{2}kT$ for each DoF

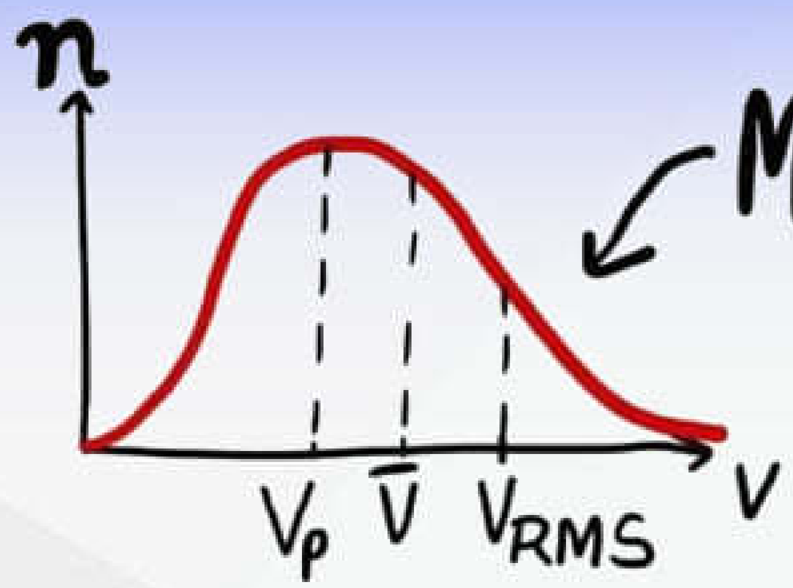
$K = \frac{f}{2}kT$ for f Degrees of freedom

Internal Energy $U = \frac{f}{2}nRT$

$f = 3$ (monatomic) ; 5 (diatomic)



PHYSICS NOTES



MAXWELL DISTRIBUTION

$$V_{RMS} = \sqrt{\frac{3kT}{m}} = \sqrt{\frac{3RT}{M}}$$

$$V_{avg} = \bar{V} = \sqrt{\frac{8kT}{\pi m}} = \sqrt{\frac{8RT}{\pi M}}$$

$$P = \frac{1}{3} \rho V_{RMS}^2$$

$$V_{most\ probable} = \sqrt{\frac{2kT}{m}} = \sqrt{\frac{2RT}{M}}$$

SPECIFIC HEAT

Specific heat $S = \frac{Q}{m \Delta T}$

Latent heat $L = Q/m$

$$C_v = \frac{f}{2} R \qquad C_p = C_v + R \qquad r = C_p / C_v$$

$$C_v = \frac{n_1 C_{v1} + n_2 C_{v2}}{n_1 + n_2} \qquad r = \frac{n_1 C_{p1} + n_2 C_{p2}}{n_1 C_{v1} + n_2 C_{v2}}$$

PHYSICS NOTES

THERMODYNAMICS

IST LAW $\Delta Q = \Delta U + W$ $\quad W = \int p \cdot dV$

ADIABATIC $W = \dfrac{p_1 V_1 - p_2 V_2}{\gamma - 1}$

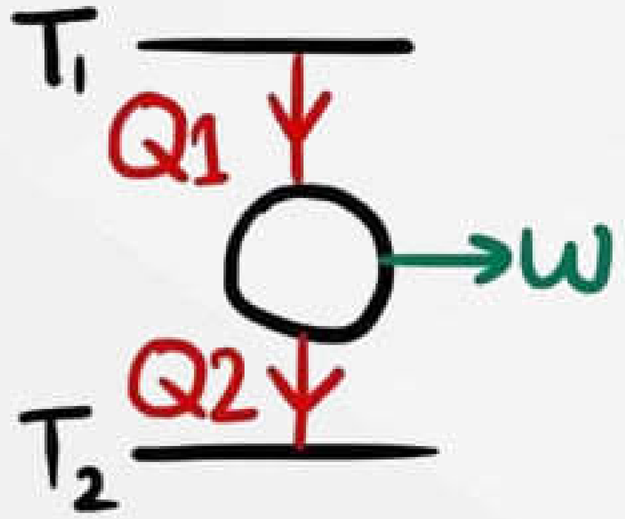
ISOTHERMAL $W = nRT \ln\left(\dfrac{V_2}{V_1}\right)$

ISOBARIC $W = p(V_2 - V_1)$

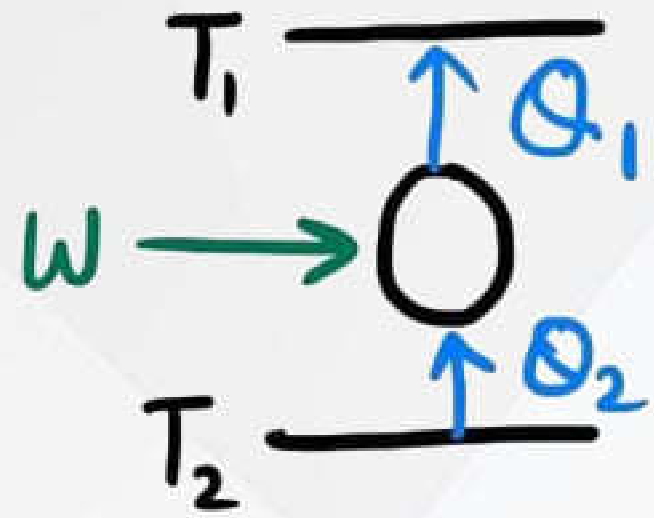
ADIABATIC: $\Delta Q = 0$; $PV^{\gamma} = \text{Const}$

IIND LAW ENTROPY $dS = \dfrac{dQ}{T}$

IIIRD LAW ENTROYY @ $T = 0K$ $= 0$



$$\eta = \frac{W}{Q_1} = 1 - \frac{Q_2}{Q_1} = 1 - \frac{T_2}{T_1}$$



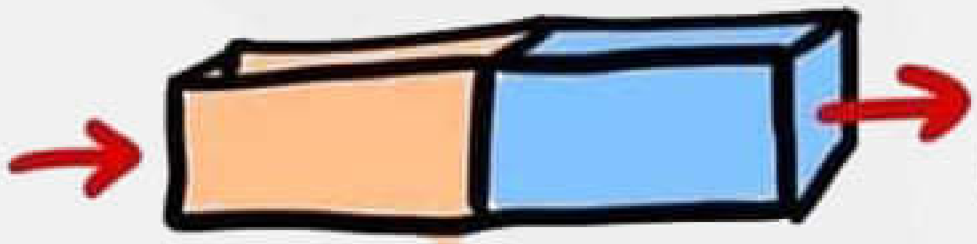
$$CoP = \frac{Q_2}{W} = \frac{T_{cold}}{\Delta T}$$

PHYSICS NOTES

HEAT TRANSFER

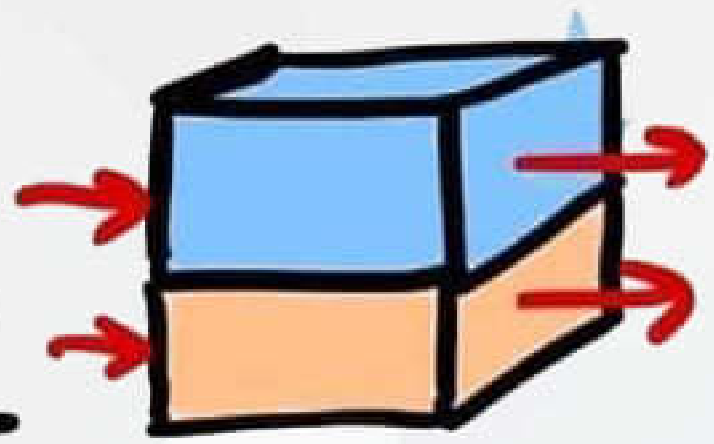
CONDUCTION $\frac{\Delta Q}{\Delta t} = -KA\frac{\Delta T}{x}$

Thermal Resistance $= \frac{x}{KA}$



SERIES

$R = R_1 + R_2 = \frac{x_1}{K_1 A_1} + \frac{x_2}{K_2 A_2}$

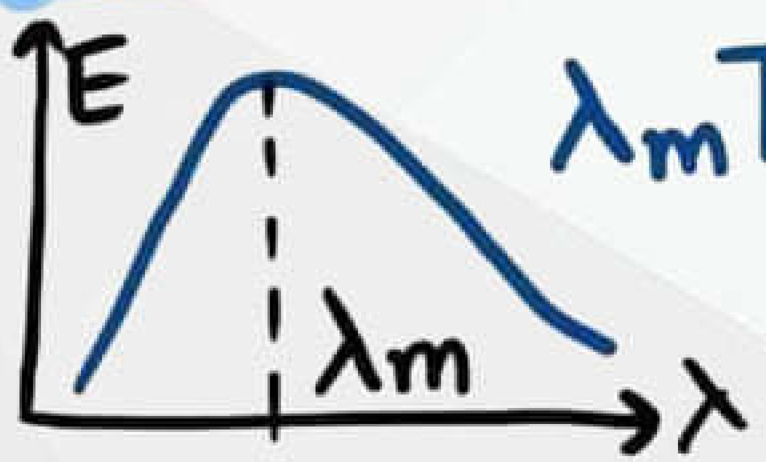


PARALLEL

$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$

PHYSICS NOTES

WIEN's DISPLACEMENT



$$\lambda_m T = b$$

STEFAN-BOLTZMANN

$$\Delta\theta / \Delta t = \sigma e A T^4$$

NEWTON'S COOLING

$$\frac{dT}{dt} = -bA(T - T_0)$$

KIRCHHOF's LAW

$$\frac{\text{Emmisive Power}}{\text{Absorptive Power}} = \frac{E_{body}}{a_{body}} = E_{blackbody}$$

PHYSICS NOTES

ELECTROSTATICS

COULOMB'S LAW $F = \frac{1}{4\pi\epsilon_0}\frac{q_1 q_2}{r^2}\hat{r}$

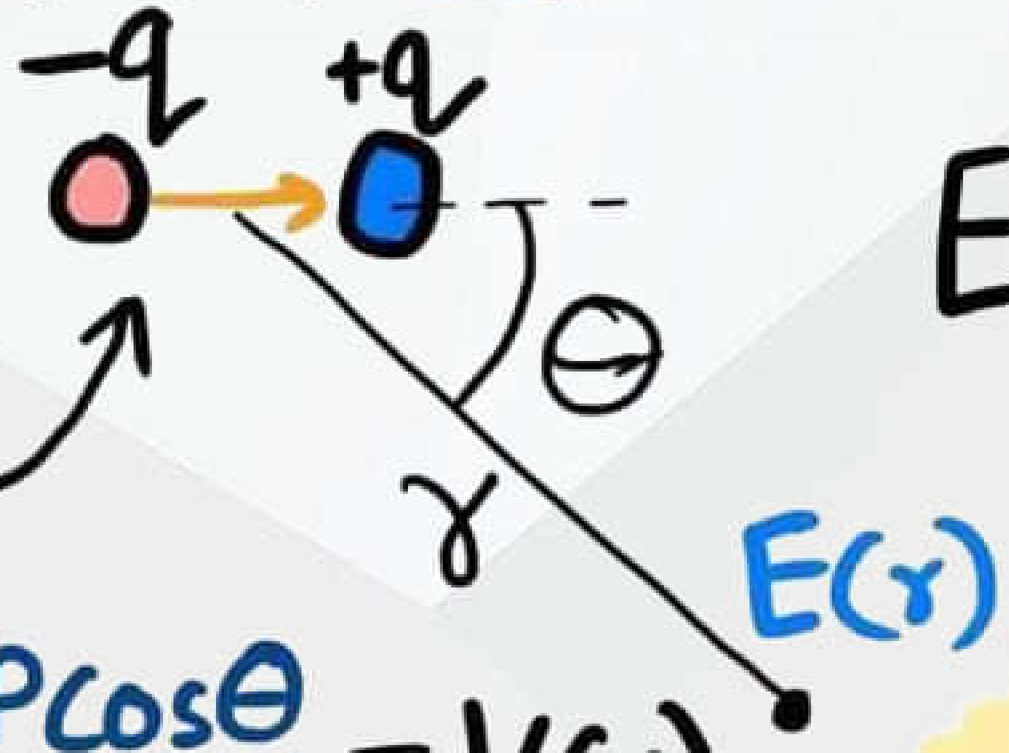
$\vec{E} = \vec{F}/q = \frac{1}{4\pi\epsilon_0}\frac{q}{r^2}$

POTENTIAL $(V) = \frac{1}{4\pi\epsilon_0}\frac{q}{r}$

PE $(U) = \frac{-1}{4\pi\epsilon_0}\frac{q_1 q_2}{r}$ $\quad \vec{E} = -\frac{dV}{dr}$

PHYSICS NOTES

DIAPOLE MOMENT



$$\vec{P} = q\vec{d}$$

$$\frac{1}{4\pi\epsilon_0}\cdot\frac{P\cos\theta}{r^2} = V(r)$$

$$E_r = \frac{1}{4\pi\epsilon_0}\cdot\frac{2P\cos\theta}{r^3}$$

$$E_\theta = \frac{1}{4\pi\epsilon_0}\cdot\frac{P\sin\theta}{r^3}$$

DIAPOLE IN FIELD

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

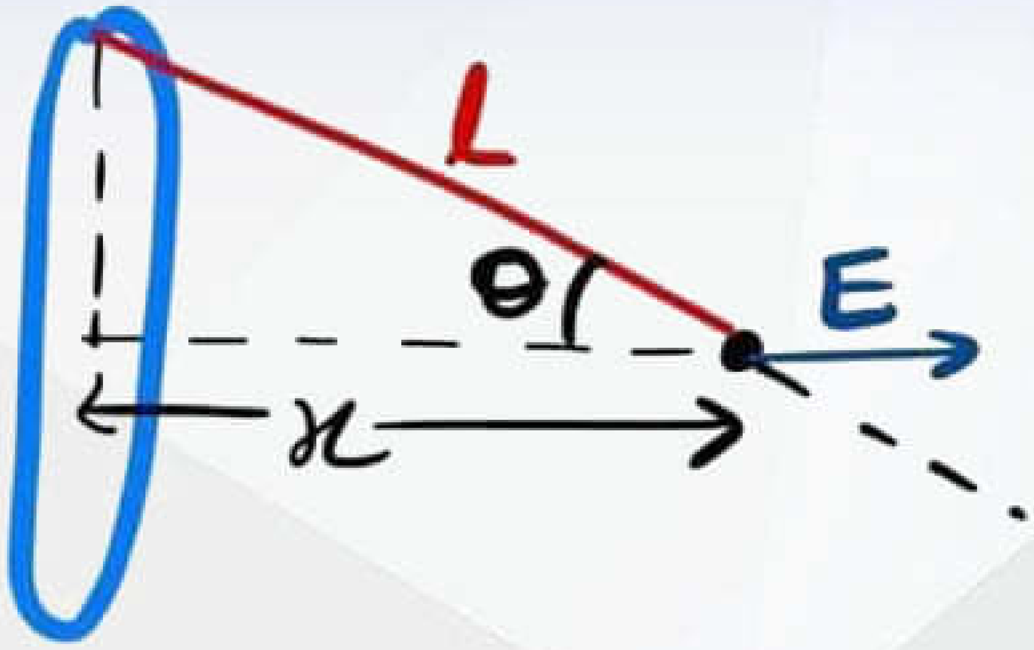
$$U = -\vec{p}\cdot E$$

GAUSS'S LAW

$$\phi = q_{in}/\epsilon_0$$

FLUX $\phi = \oint \vec{E}\cdot d\vec{s}$

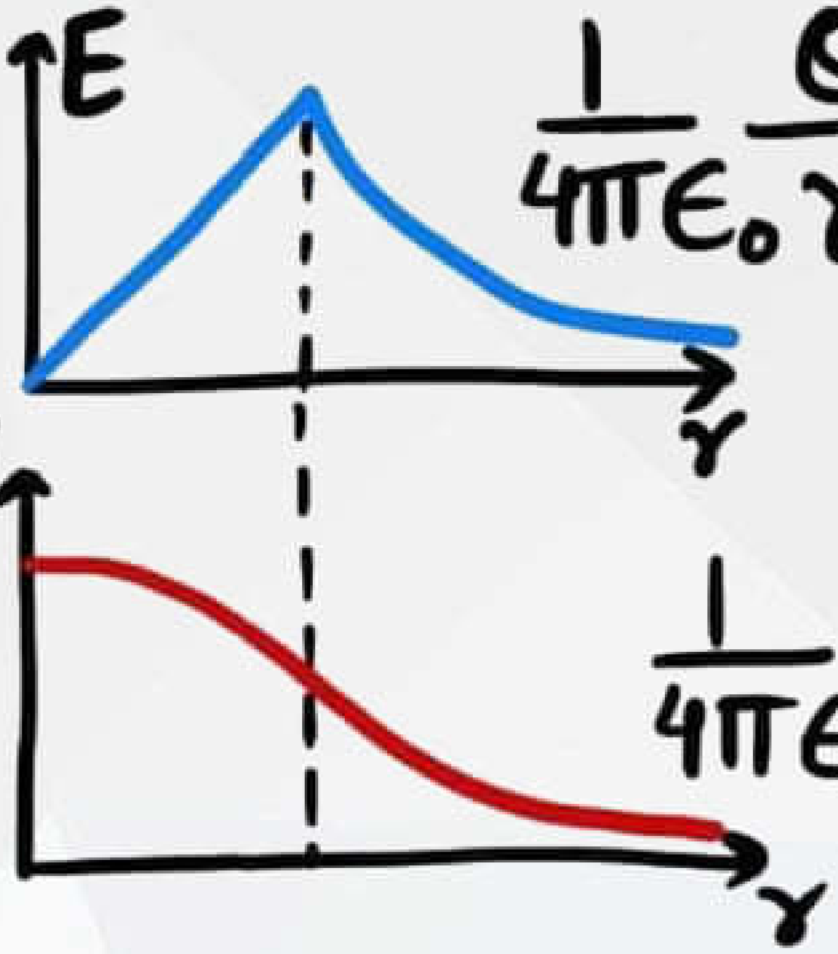
PHYSICS NOTES



$$E = \frac{1}{4\pi\epsilon_0}\frac{q}{l^2}\cos\theta$$

UNIFORMLY CHARGED SPHERE

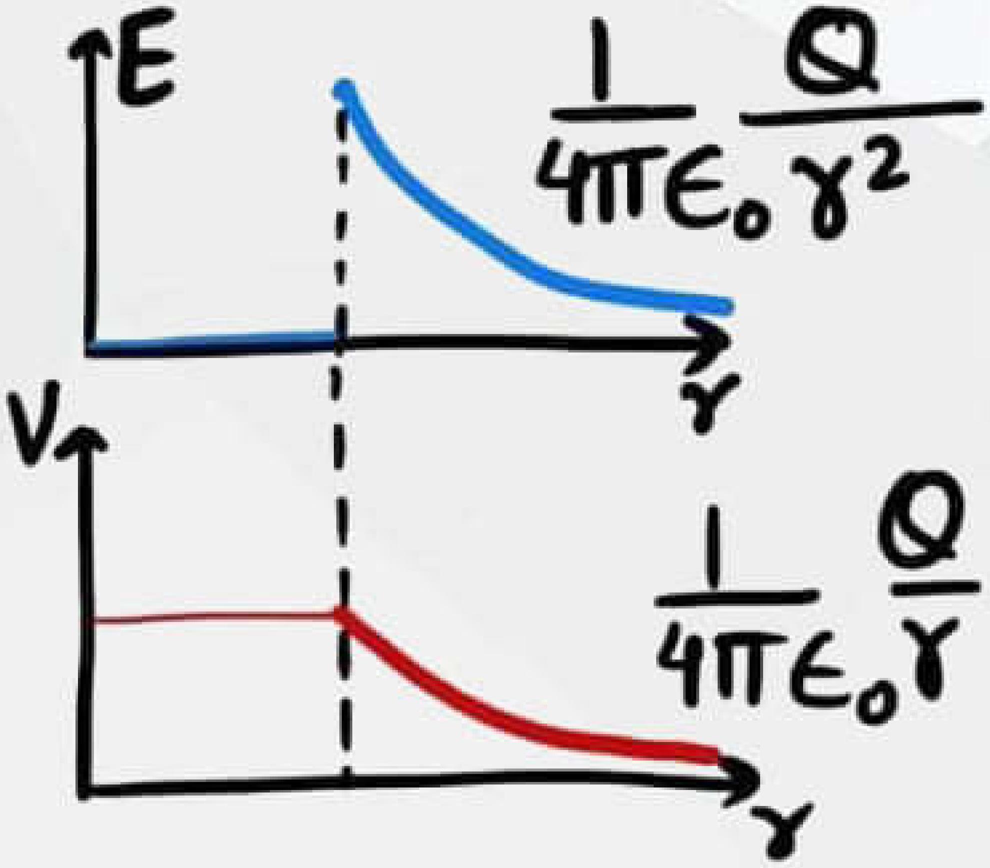
$$\frac{1}{4\pi\epsilon_0}\frac{Q}{R^3}\cdot r \qquad \frac{1}{4\pi\epsilon_0}\frac{Q}{r^2}$$



$$\frac{1}{4\pi\epsilon_0}\cdot\frac{1}{2R}\cdot\left[3-\frac{r^2}{R^2}\right] \qquad \frac{1}{4\pi\epsilon_0}\frac{Q}{r}$$

PHYSICS NOTES

Uniform Shell



Line Charge $E = \frac{\lambda}{2\pi\epsilon_0 r}$

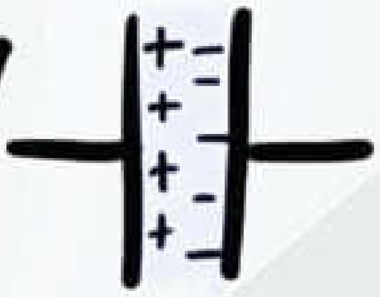
∞-sheet $E = \frac{\sigma}{2\epsilon_0}$

$\vec{E}$ near Conducting Surface $E = \frac{\sigma}{\epsilon_0}$

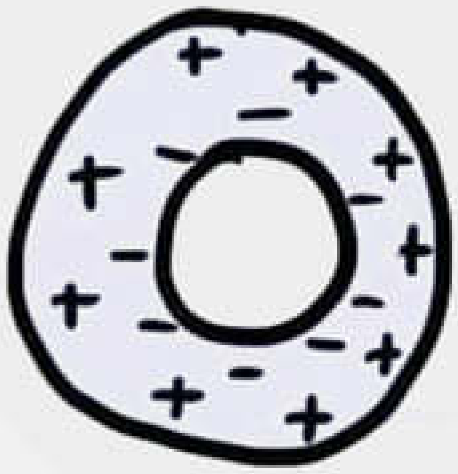
PHYSICS NOTES

CAPACITORS

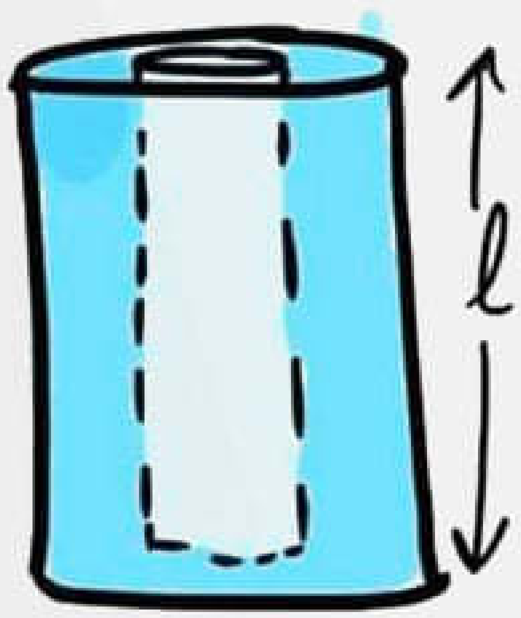
$C = q/V$



$C = \epsilon_0 A/d$



$$C = \frac{2\pi\epsilon_0 l}{\ln(r_2/r_1)}$$



$$C = 4\pi\epsilon_0 \frac{r_1 r_2}{r_2 - r_1}$$

SPHERE

WITH DIELECTRIC $C = \frac{\epsilon_0 K A}{d}$

PARALLEL $C_{eq} = C_1 + C_2$

SERIES $\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2}$

Force b/w plates $= \frac{Q^2}{2A\epsilon_0}$

$U = \frac{1}{2} C V^2 = \frac{Q^2}{2C} = \frac{1}{2} Q V$

PHYSICS NOTES

CURRENT ELECTRICITY

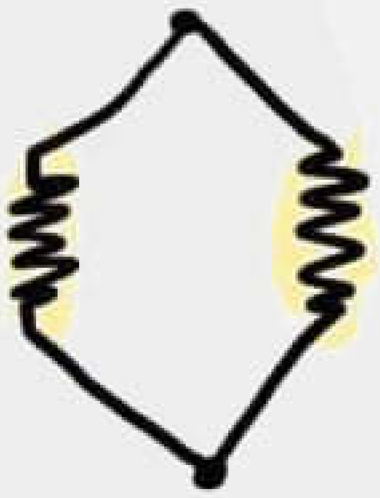
DENSITY $j = i/A = \sigma E$

$V_{drift} = \frac{1}{2}\frac{eE\tau}{m} = \frac{i}{neA}$

$R_{WIRE} = \rho\, l/A \quad \rho = 1/\sigma$

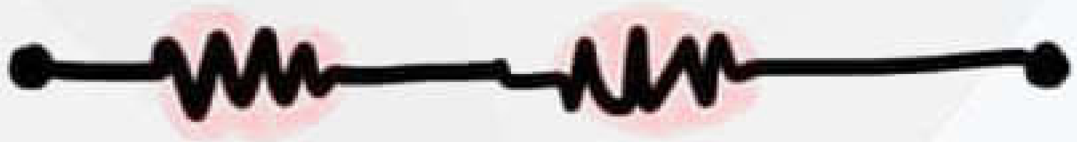
$R = R_0(1 + \alpha\Delta T)$

OHM'S LAW $V = iR$



PARALLEL

$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2}$



SERIES

$R_{eq} = R_1 + R_2$

PHYSICS NOTES

KIRCHHOF'S LAWS

*** JUNCTION LAW** $\sum I_i = 0$

Sum of all i towards a node = 0

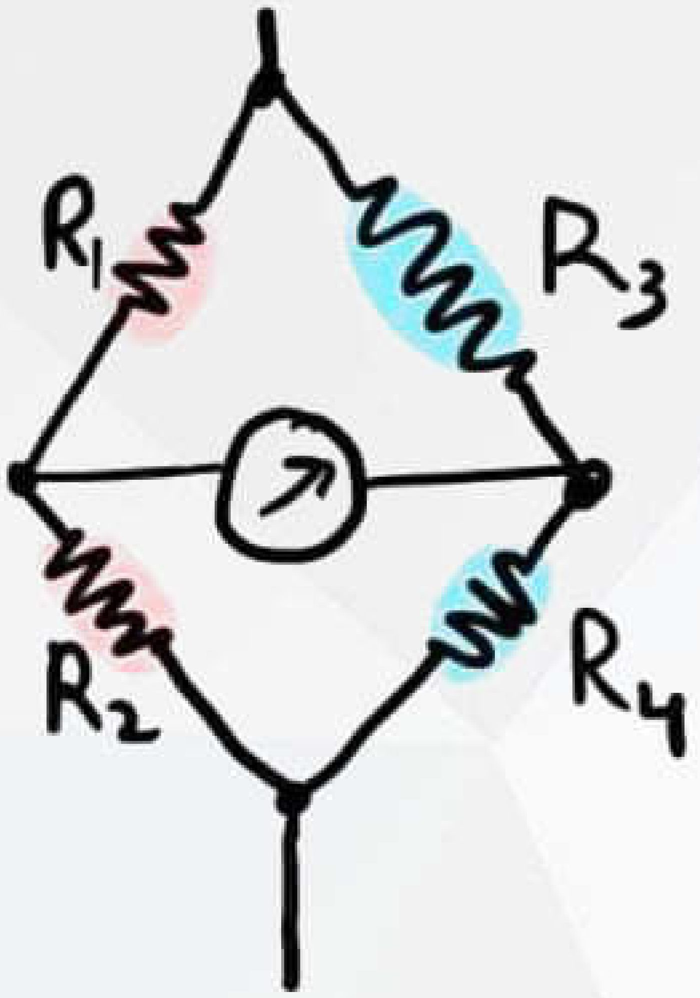
*** LOOP LAW** $\sum \Delta V = 0$

Sum of all ΔV in closed loop = 0

POWER $= i^2R = V^2/R = iV$

BALANCED WHEATSTONE BRIDGE

$$\frac{R_1}{R_2} = \frac{R_3}{R_4}$$

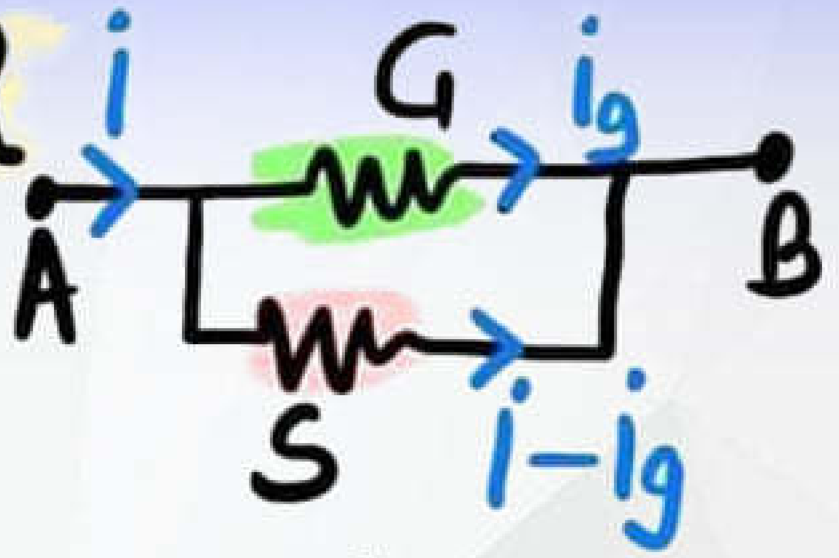


PHYSICS NOTES

GALVANOMETER

→ Ammeter

$i_g G = (i - i_g) S$



→ Voltmeter

$V_{AB} = i_g (R + G)$

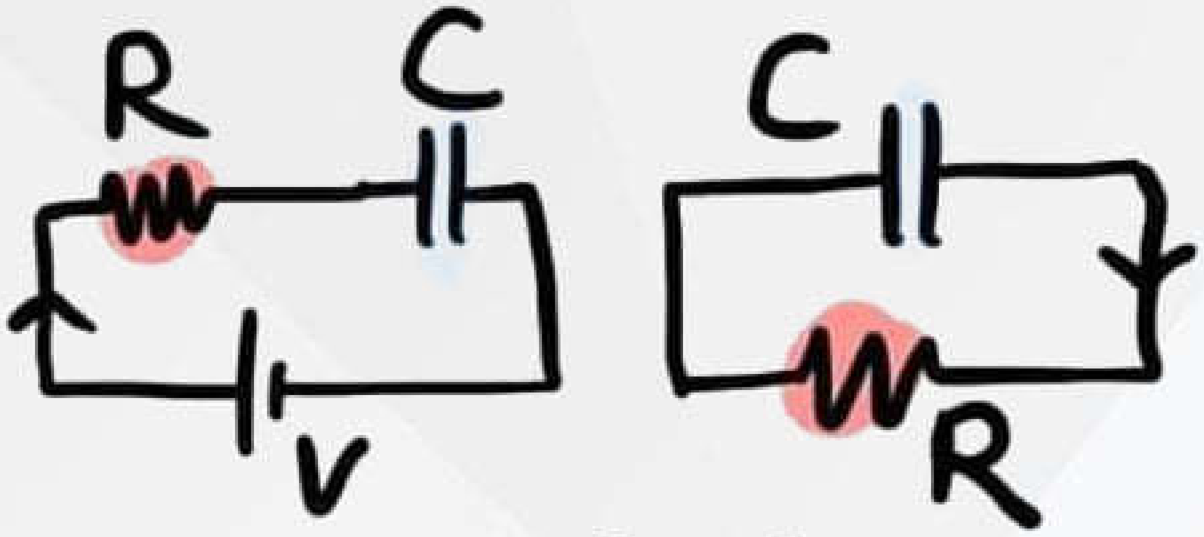
CAPACITOR

Charging

$q(t) = CV\left(1 - e^{-\frac{t}{RC}}\right)$

Discharging

$q(t) = q_0 e^{-(t/RC)}$



Time Constant $\tau = RC$

PHYSICS NOTES

THOMSON EFFECT

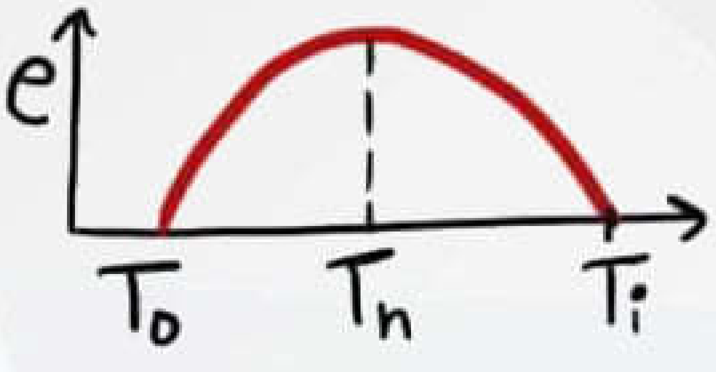
emf $e = \frac{\Delta H}{\Delta \theta} = \sigma \Delta T$

PELTIER EFFECT

emf $e = \frac{\Delta H}{\Delta \theta}$

SEEBACK EFFECT

$e = aT + \frac{1}{2} bT^2$



$T_{neutral} = -a/b$

$T_{inversion} = -2a/b$

FARADAY'S LAW OF ELECTROLYSIS

$m = Zit = \frac{1}{F} Eit$

E = Chem equivalent

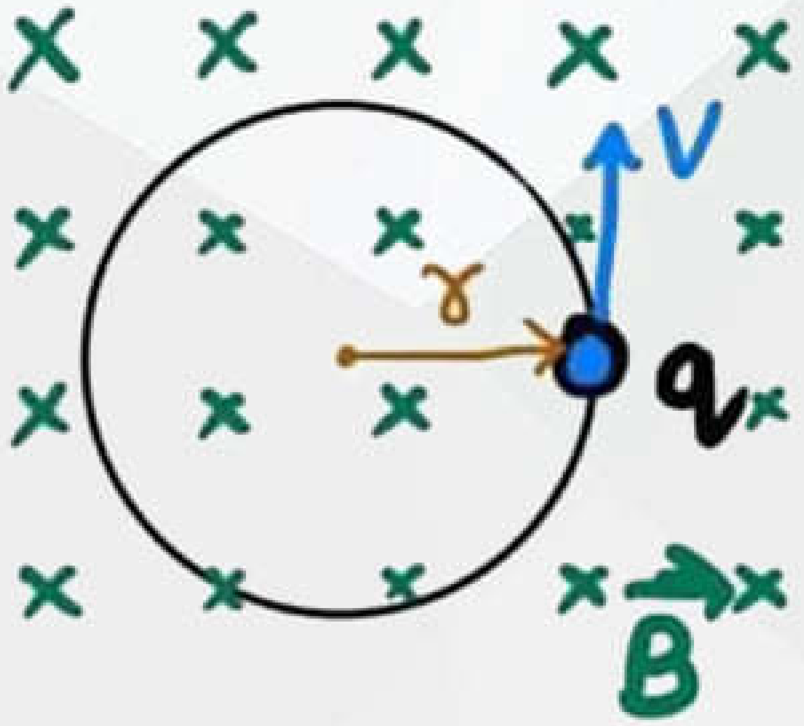
Z = Electro Chem eq

F = 96 485 C/g

PHYSICS NOTES

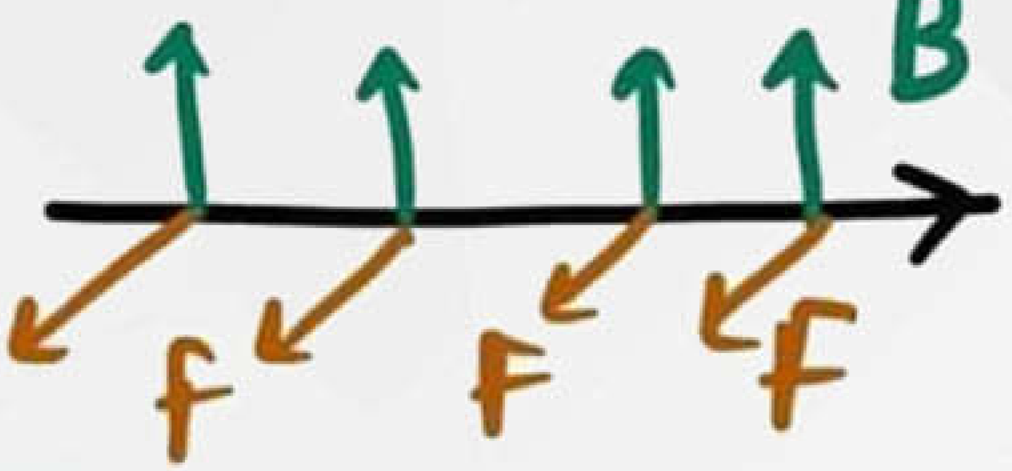
MAGNETISM

$$\vec{F}_{LORENTZ} = q\vec{v} \times \vec{B} + q\vec{E}$$



$$qvB = mv^2/r$$

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

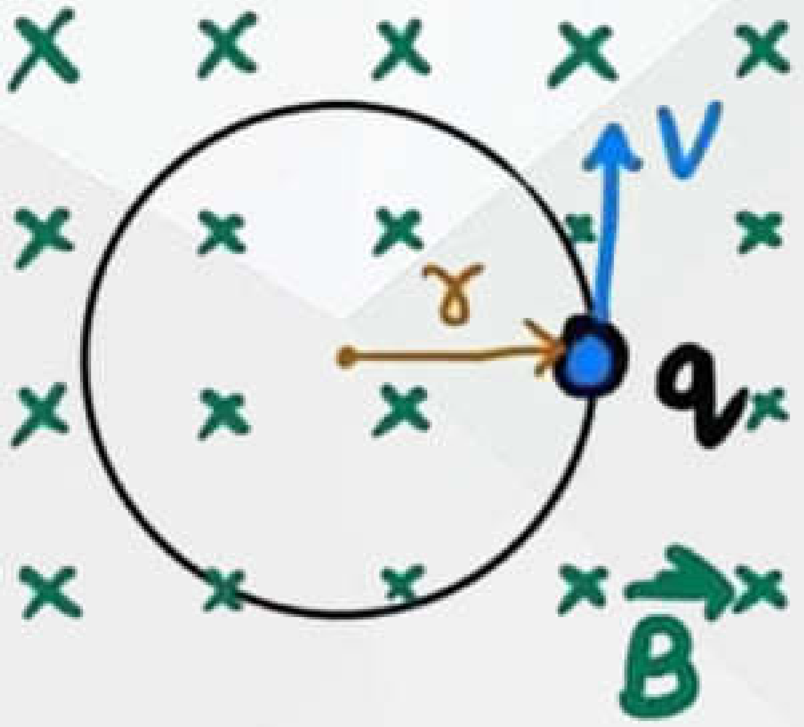


$$F = i\vec{L} \times \vec{B}$$

PHYSICS NOTES

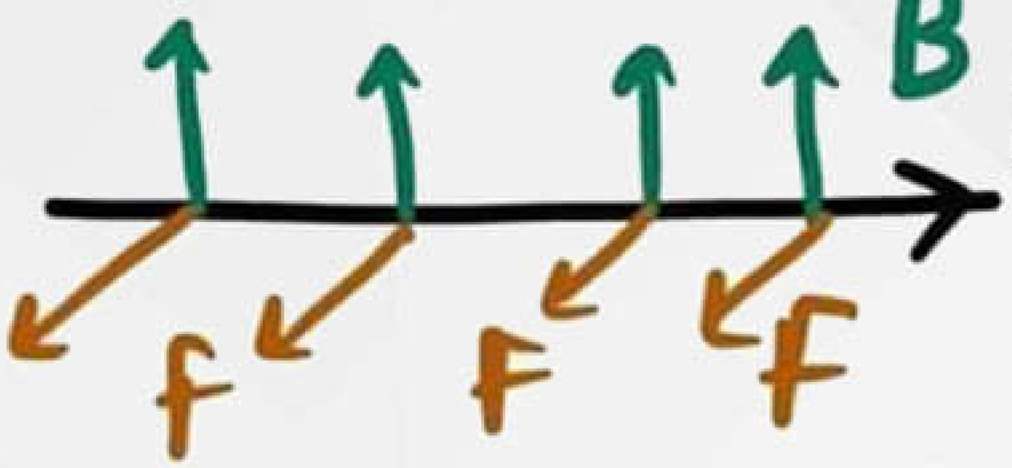
MAGNETISM

$$\vec{F}_{LORENTZ} = q\vec{v} \times \vec{B} + q\vec{E}$$



$$qvB = mv^2/r$$

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

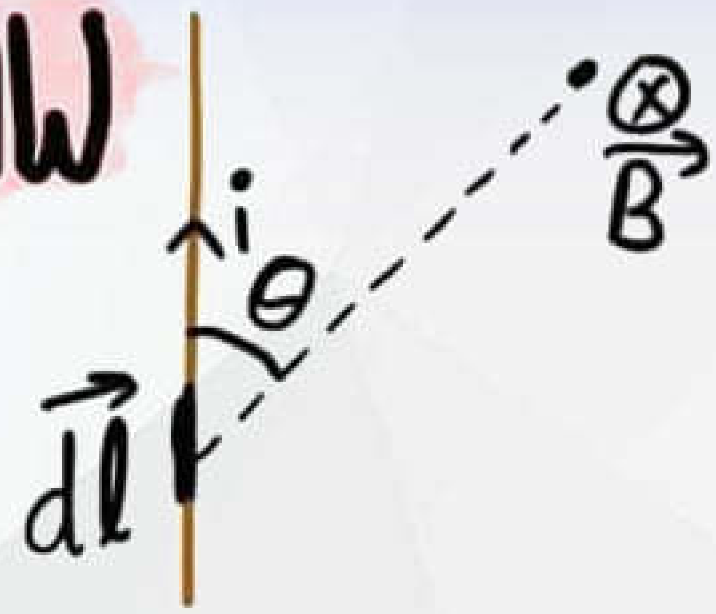


$$F = i\vec{L} \times \vec{B}$$

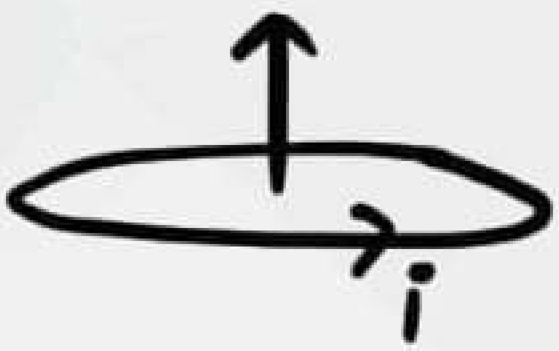
PHYSICS NOTES

BIOT-SAWART LAW

$$d\vec{B} = \frac{\mu_0}{4\pi}\,\frac{i\,d\vec{l}\times\vec{r}}{r^3}$$



MAGNETIC DIPOLE

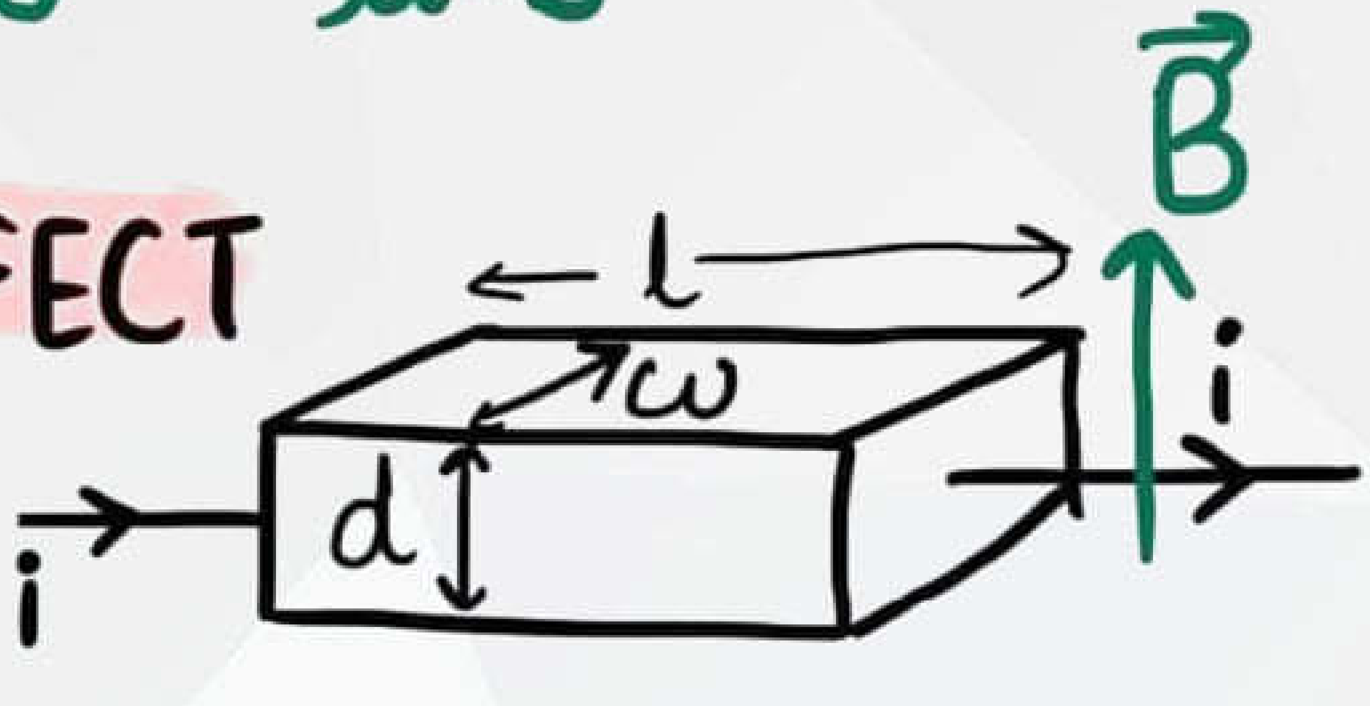


$$\vec{\mu} = i\,Area \qquad \vec{\tau} = \vec{\mu}\times\vec{B}$$

$$U = -\vec{\mu}\cdot\vec{B}$$

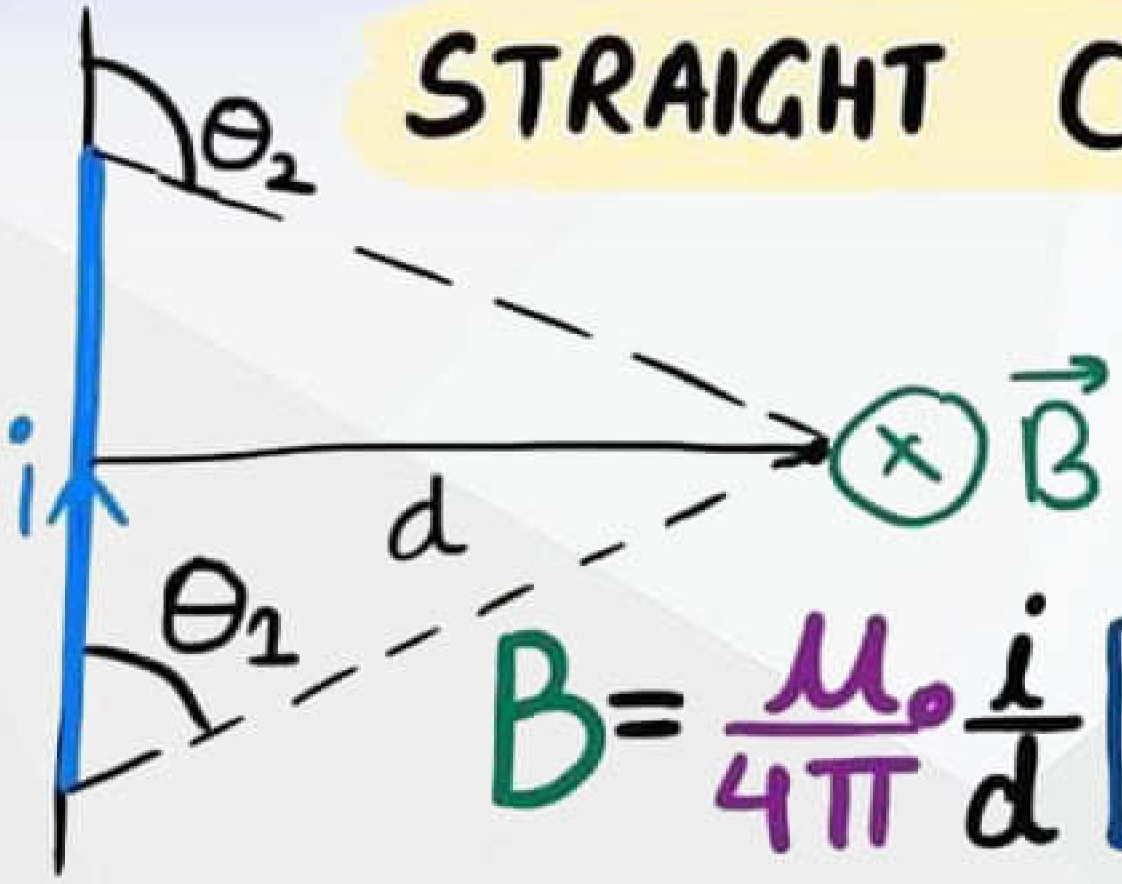
HALL EFFECT

$$V_w = \frac{Bi}{ned}$$



PHYSICS NOTES

STRAIGHT CONDUCTOR



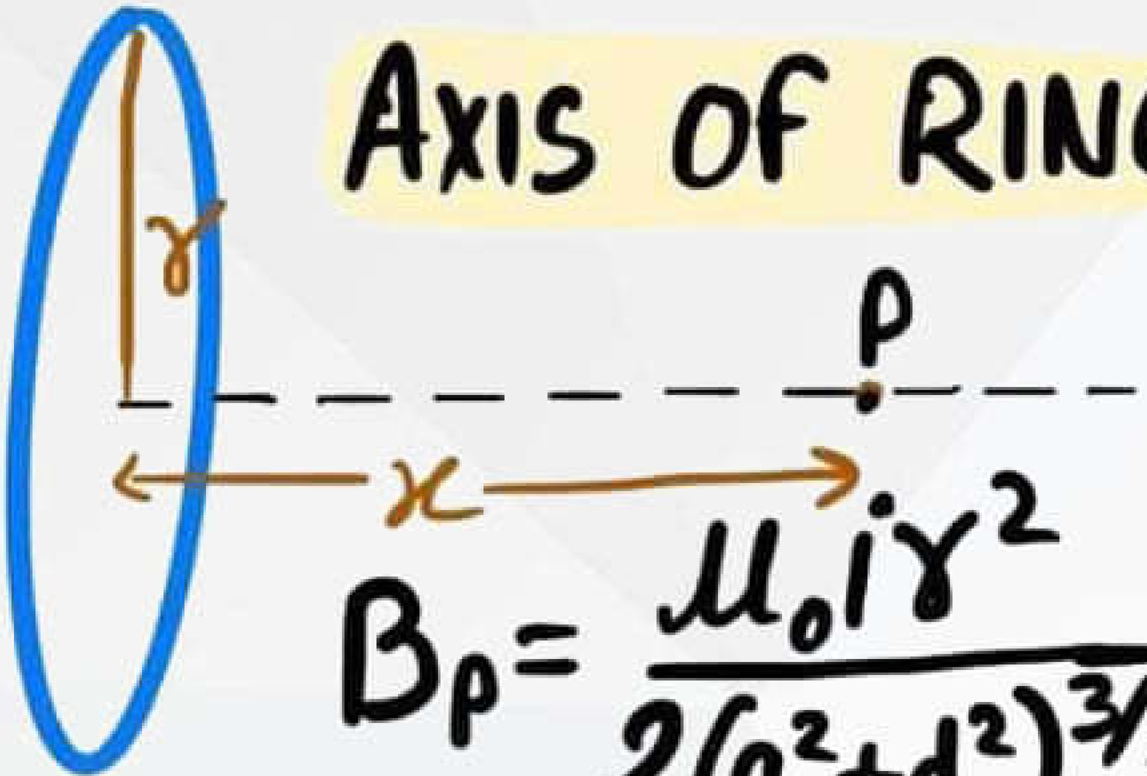
$$B_{\infty} = \frac{\mu_0 i}{2\pi d}$$

$$B = \frac{\mu_0}{4\pi}\frac{i}{d}\left[\cos\theta_1 - \cos\theta_2\right]$$

∞ WIRES

$$\frac{dF}{dl} = \frac{\mu_0 i_1 i_2}{2\pi d}$$

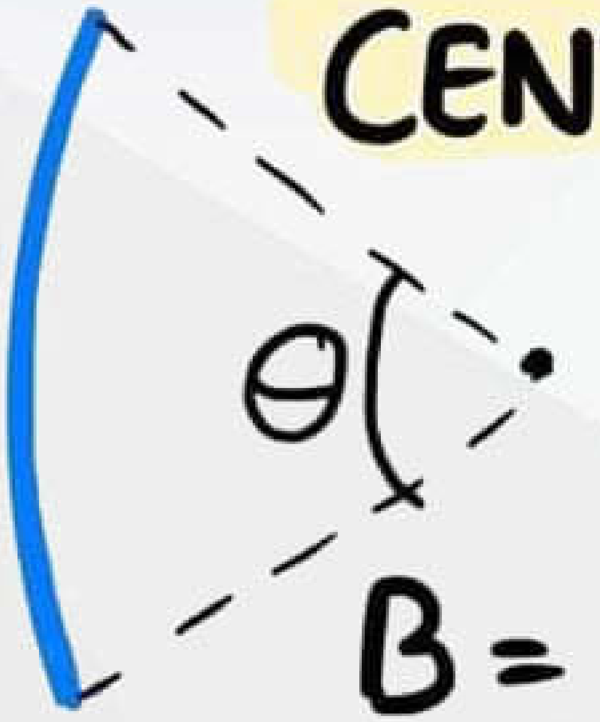
AXIS OF RING



$$B_P = \frac{\mu_0 i r^2}{2(a^2+d^2)^{3/2}}$$

PHYSICS NOTES

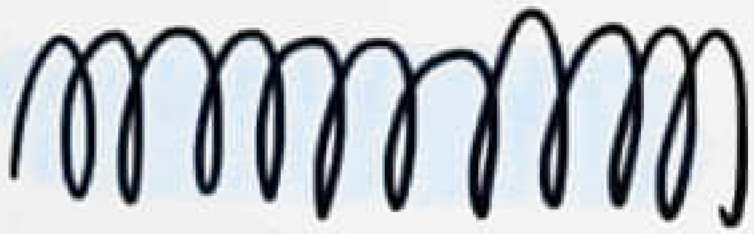
CENTER OF ARC



$$B = \frac{\mu_0 i \theta}{4\pi r}$$

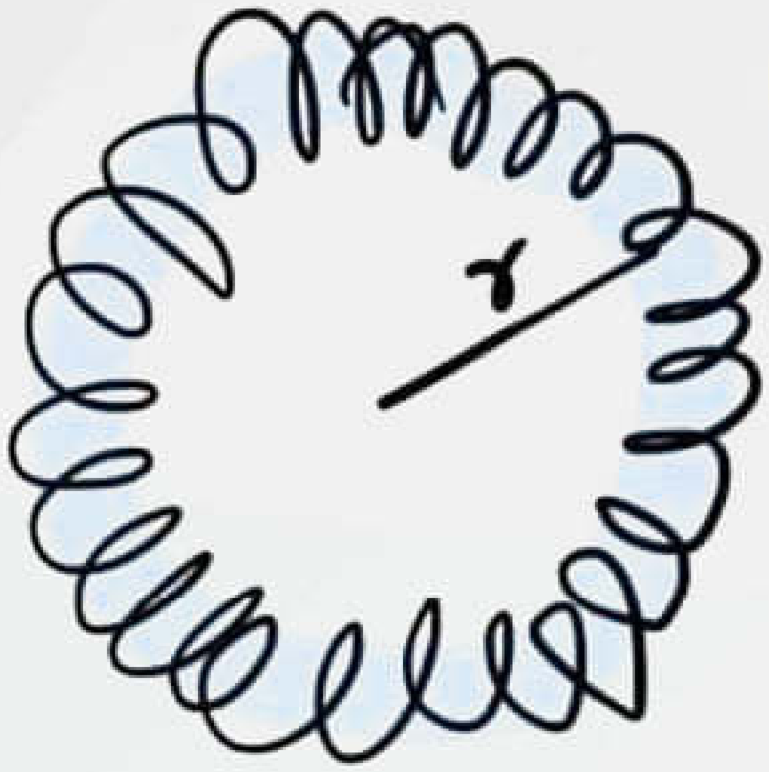
$$B = \mu_0 i / 2r \text{ (ring)}$$

SOLENOID



$$B = \mu_0 n i \quad n = N/l$$

TOROID



$$B = \mu_0 n i$$

$$n = N/2\pi r$$

AMPERE'S LAW

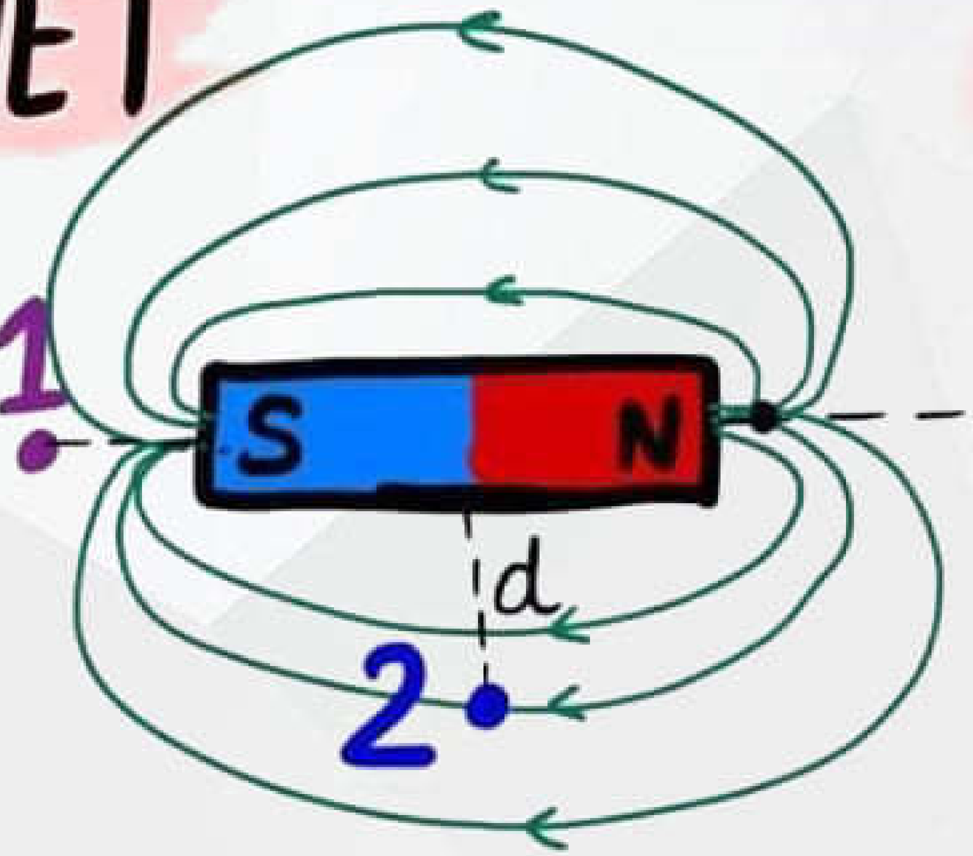
$$\oint \vec{B} \cdot d\vec{l} = \mu_0 I_{in}$$

PHYSICS NOTES

BAR MAGNET

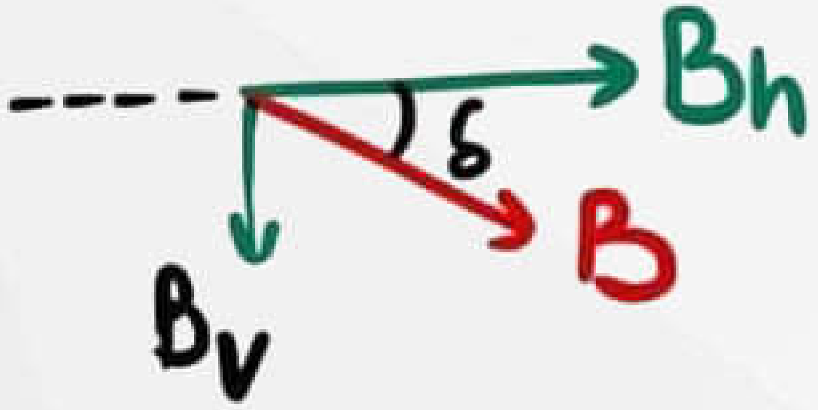
$$B_1 = \frac{\mu_0}{4\pi}\frac{2M}{d^3}$$

$$B_2 = \frac{\mu_0}{4\pi}\frac{M}{d^3}$$



ANGLE OF DIP

$$B_h = B\cos\delta$$



TANGENT GALVANOMETER

$$B_h \tan\theta = \mu_0 n i / 2r \;\Big|\; i = K\tan\theta$$

PHYSICS NOTES

MOVING COIL GALVANOMETER

$$niAB = k\theta \; ; \; i = \frac{k}{nAB}\theta$$

PERMEABILITY

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

MAGNETOMETER

$$T = 2\pi\sqrt{I/MB_h}$$

PHYSICS NOTES

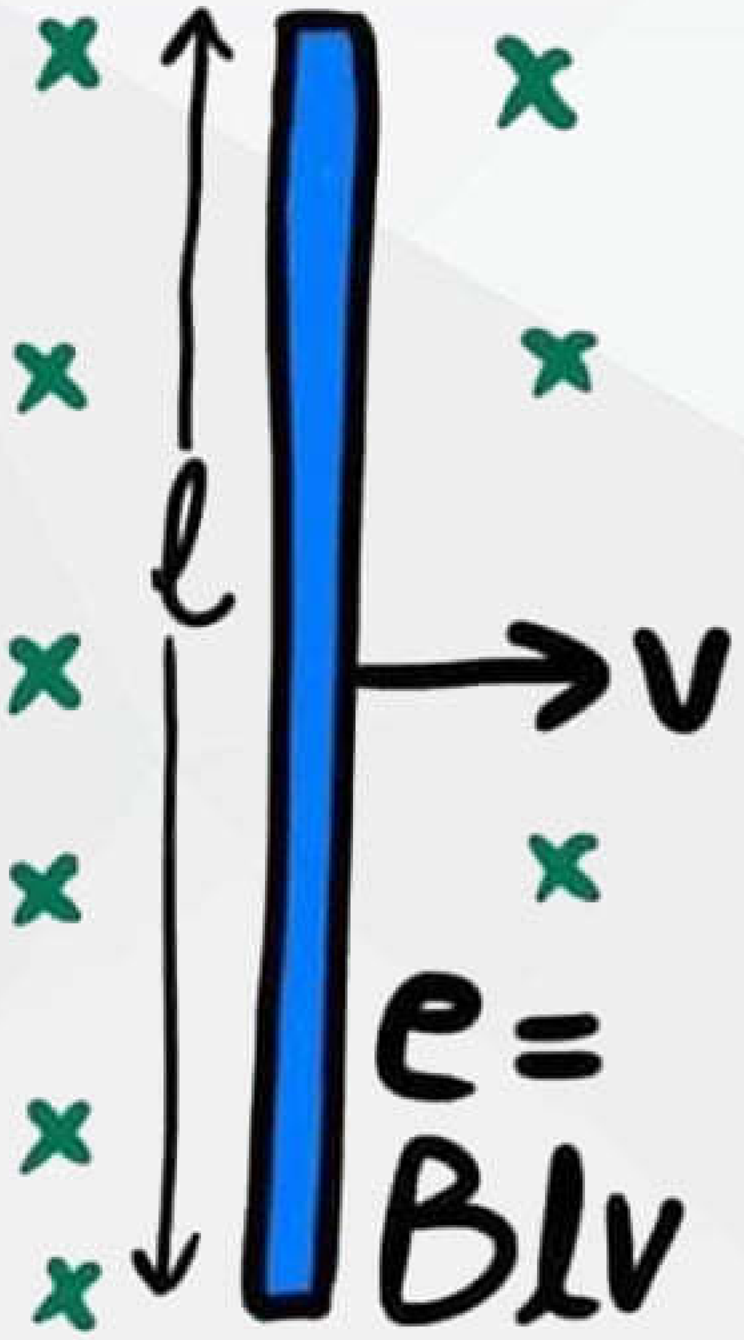
ELECTROMGNETIC INDUCTION

MAGNETIC FLUX $\Phi = \oint \vec{B} \cdot d\vec{s}$

FARADAY'S LAW $e = -\frac{d\phi}{dt}$

LENZ'S LAW: Induced current produces $\vec{B}$ that opposes change in ϕ

PHYSICS NOTES



SELF INDUCTANCE

$\phi = Li \quad e = -L\frac{di}{dt}$

SOLENOID $L = \mu_0 n^2 \pi r^2 l$

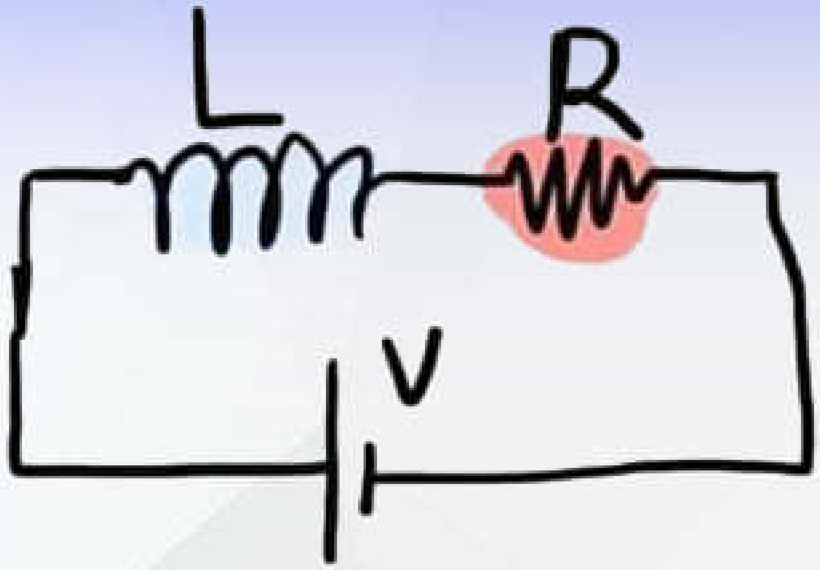
MUTUAL INDUCTANCE

$\phi = Mi \, , \quad e = -M\, di/dt$

PHYSICS NOTES

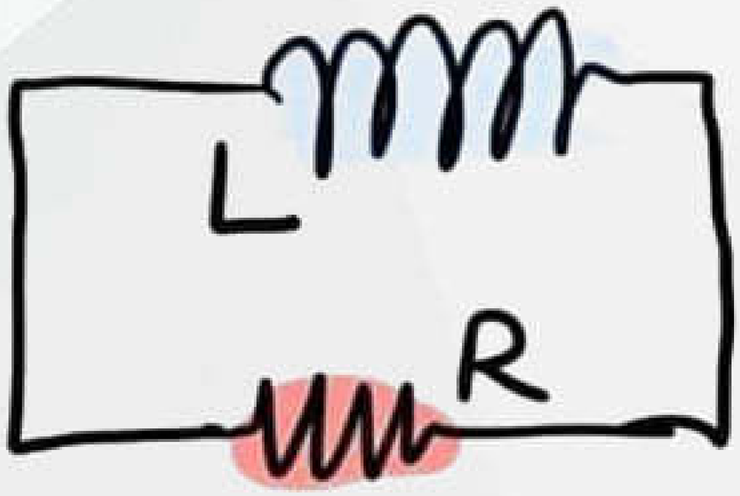
GROWTH

$$i = \frac{V}{R}\left[1 - e^{-\frac{t}{L/R}}\right]$$



DECAY

$$i = i_0 e^{-\frac{t}{L/R}}$$



Time Const. $\tau = L/R$

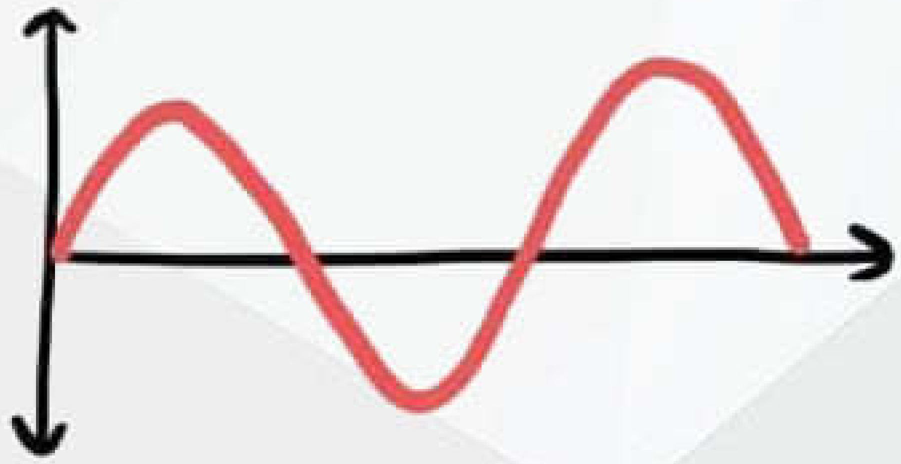
ENERGY $U = \frac{1}{2} L i^2$

ENERGY DENSITY OF B-FIELD

$$u = \frac{U}{V} = \frac{B^2}{2\mu_0}$$

PHYSICS NOTES

ALTERNATING CURRENT



$$i = i_0 \sin(\omega t + \phi)$$

$$i_{rms} = i_0/\sqrt{2}$$

$$\text{POWER} = i_{rms}^2 \cdot R$$

REACTANCE

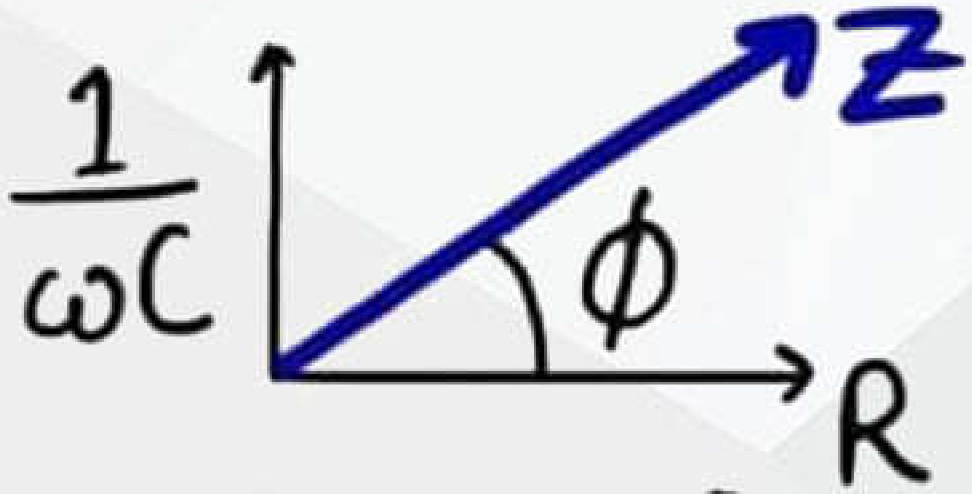
CAPACITIVE $X_C = 1/\omega C$

INDUCTIVE $X_L = \omega L$

IMPEDANCE $Z = e_0/i_0$

PHYSICS NOTES

RC-CIRCUIT

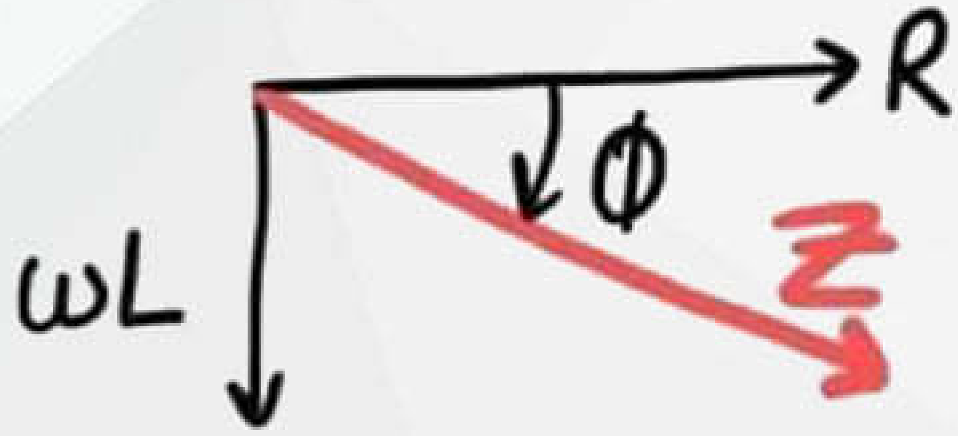


$$\tan\phi = \frac{1}{\omega C R}$$

$$Z = \sqrt{R^2 + X_c}$$

$$X_c = \frac{1}{\omega R}$$

LR-CIRCUIT



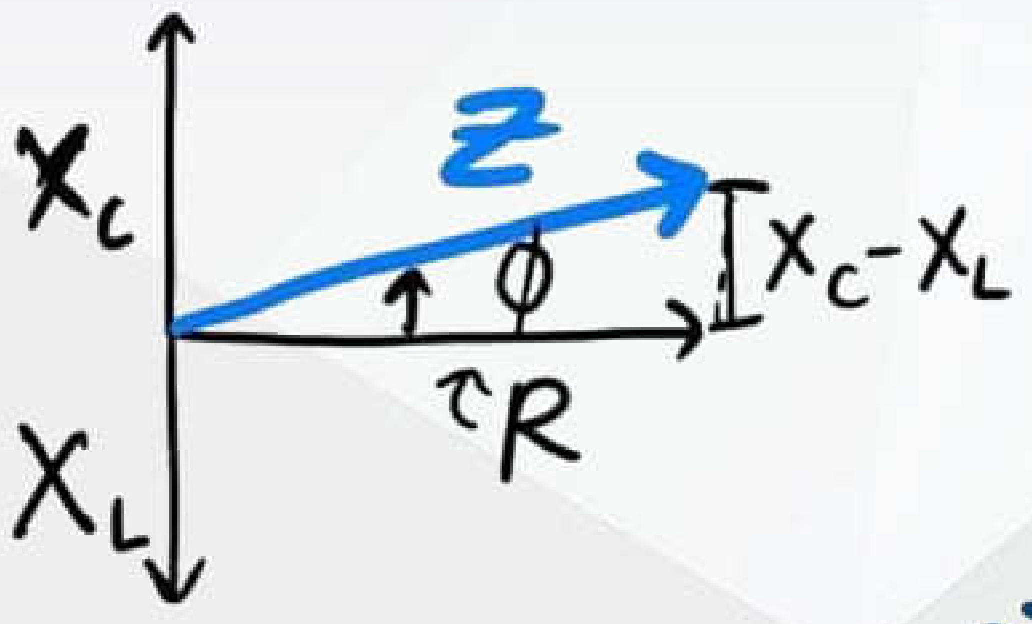
$$\tan\phi = \frac{\omega L}{R}$$

$$Z = \sqrt{R^2 + X_L^2}$$

$$X_L = \omega L$$

PHYSICS NOTES

LCR-CIRCUIT



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

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

$$P = e_{rms}\, i_{rms} \cos\phi$$

POWER FACTOR

$$\nu_{RESONANCE} = \frac{1}{2\pi\sqrt{LC}}$$

$(X_C = X_L)$

ROTATING COIL $e = NAB\omega \sin\omega t$

TRANSFORMER $\frac{N_1}{N_2} = \frac{e_1}{e_2}$

$$c = \frac{1}{\sqrt{\mu_0 \epsilon_0}}$$

PHYSICS NOTES

MODERN PHYSICS

$E = h\nu = hc/\lambda$ $p = h/\lambda = E/c$ $E = mc^2$

Ejected photo-electron $K_{max} = h\nu - \phi$

THRESHOLD $\nu_0 = \phi/h$

STOPPING $V_0 = \frac{hc}{e}\left(\frac{1}{\lambda}\right) - \frac{\phi}{e}$

de Broglie $\lambda = h/p$

PHYSICS NOTES

BOHR'S ATOM

$$E_n = -\frac{mZ^2e^4}{8\epsilon_0^2h^2n^2} = -\frac{13.6Z^2}{n^2}eV$$

$$\gamma_n = \frac{\epsilon_0 h^2 n^2}{\pi m Z e^2} = \frac{0.529\,n^2}{Z}A^\circ$$

QUNTIZATION OF ANGULAR MOMENTUM

$$l = \frac{nh}{2\pi}$$

$$E_{TRANSITION} = 13.6Z^2\left(\frac{1}{n^2} - \frac{1}{m^2}\right)A^\circ$$

HEISENBERG

$$\Delta x \Delta p \geq h/2\pi \qquad \Delta E \cdot \Delta t \geq h/2\pi$$

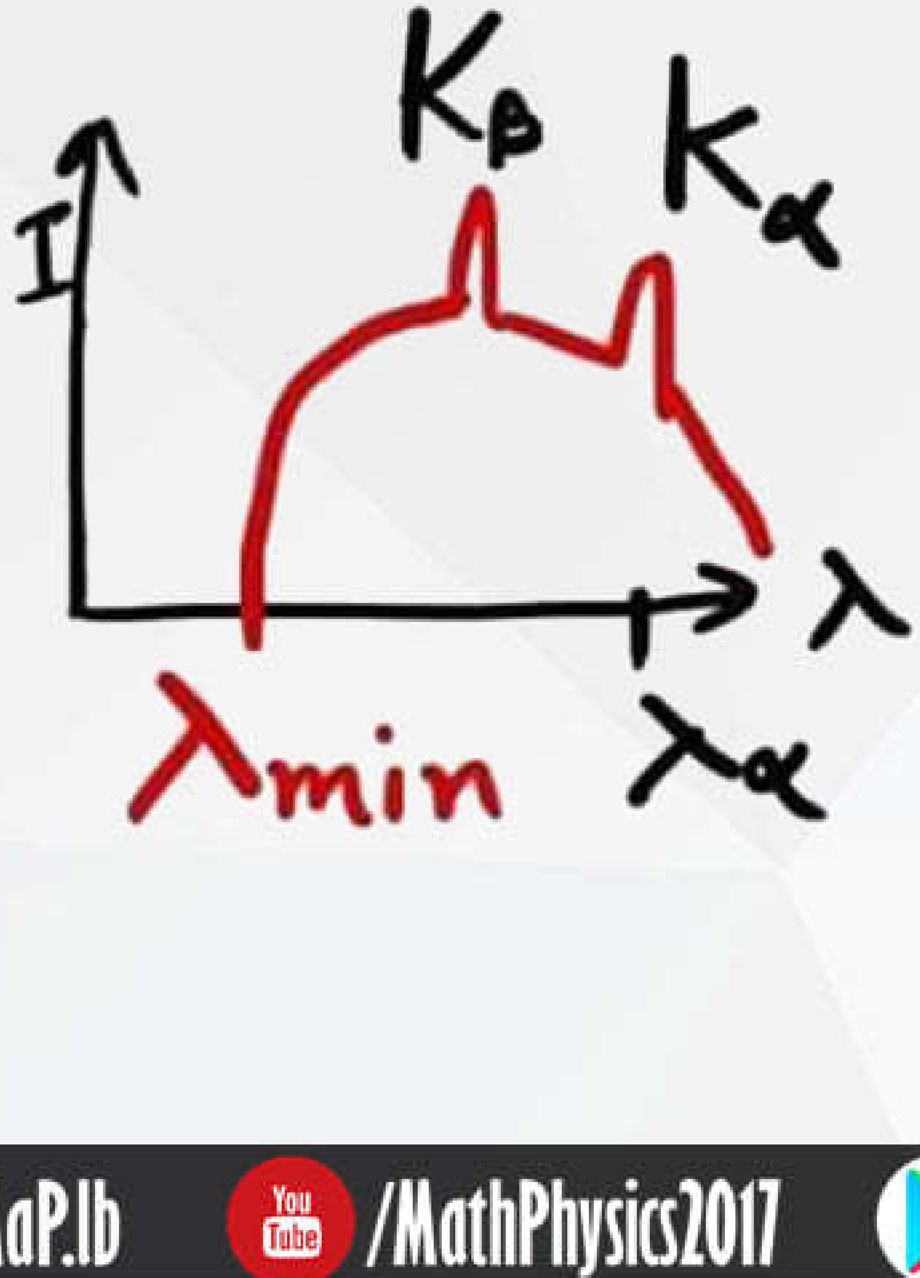
PHYSICS NOTES

MOSLEY'S LAW $\sqrt{\nu} = a(z-b)$

X-RAY DIFFRACTION $2d\sin\theta = n\lambda$

X-Ray SPE^{M}

$$\lambda_{min} = \frac{hc}{eV}$$



PHYSICS NOTES

NUCLEUS

$$R = R_0 A^{1/3} ; R_0 = 1.1 \times 10^{-15} m$$

RADIOACTIVE DECAY

$$\frac{dN}{dt} = -\lambda N \qquad N = N_0 e^{-\lambda t}$$

HALF LIFE $t_{1/2} = 0.693/\lambda$

Avg LIFE $t_{avg} = 1/\lambda$

Mass DEFECT

$$\Delta m = [Z m_p + (A-Z) m_n] - M$$

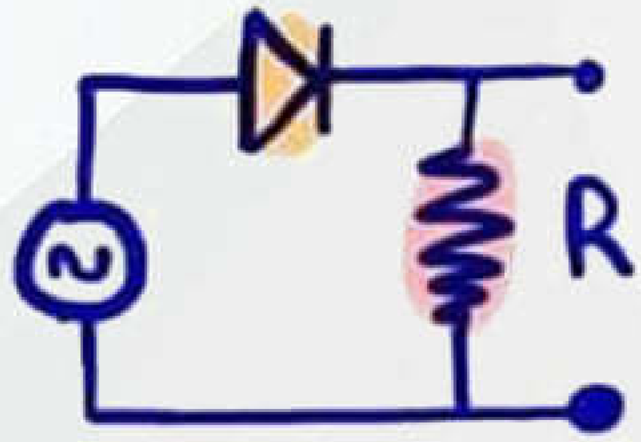
BINDING E $= \Delta m . C^2$

Q-VALUE $Q = U_i - U_f$

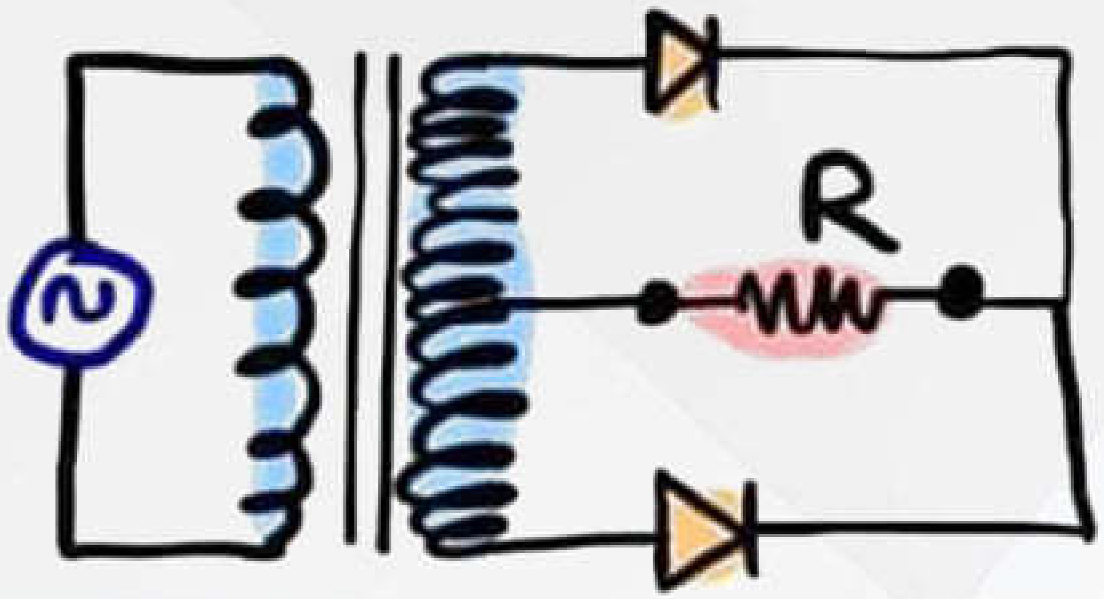
PHYSICS NOTES

SEMICONDUCTORS

HALF WAVE RECTIFIER

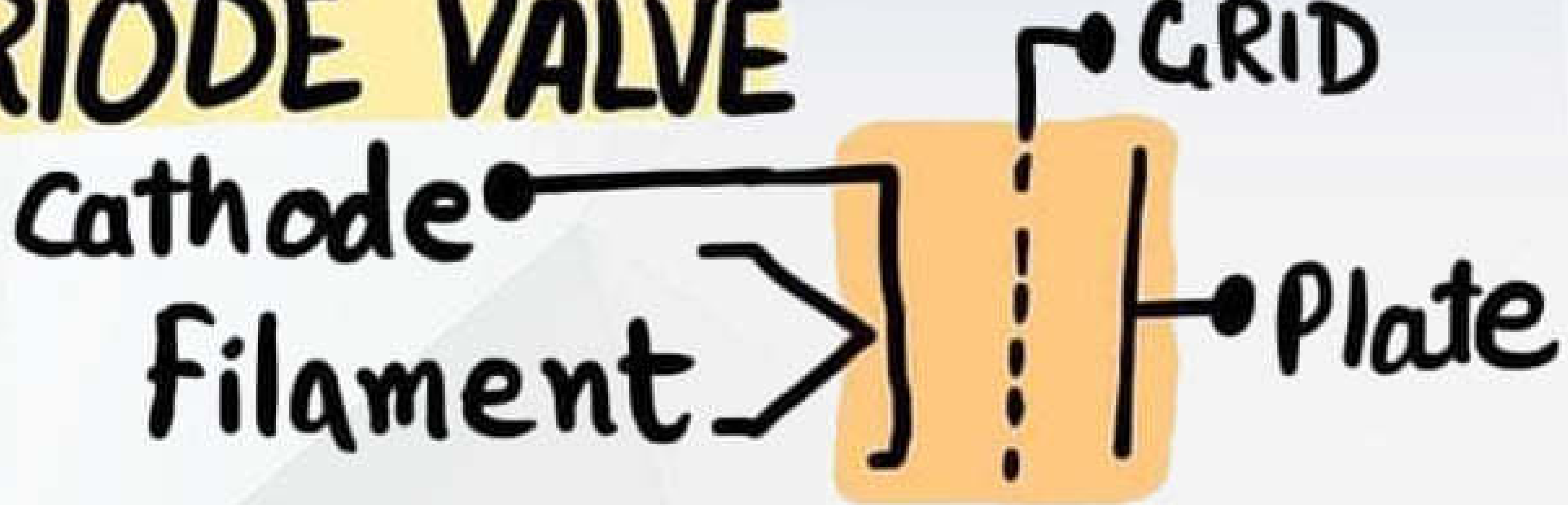


FULL WAVE RECTIFIER



PHYSICS NOTES

TRIODE VALVE



TRIODE

Plate Resistance $r_p = \dfrac{\Delta V_p}{\Delta i_p}\Big|_{\Delta V_g = 0}$

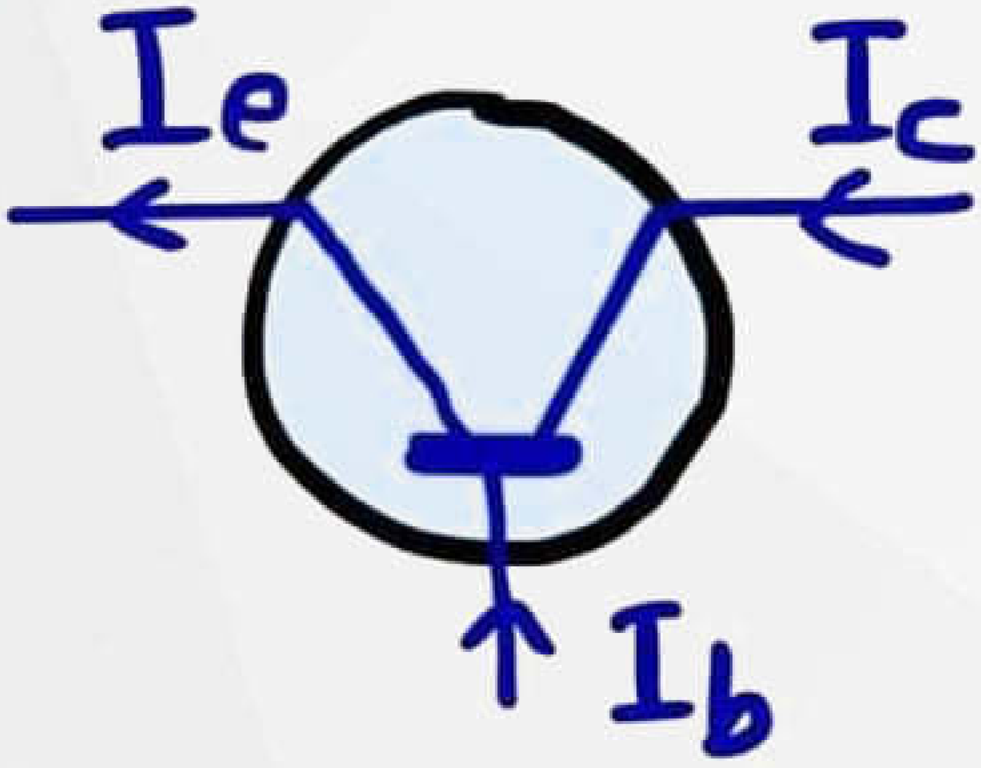
Trans-conductance $g_m = \dfrac{\Delta i_p}{\Delta V_g}\Big|_{\Delta V_p = 0}$

Amplification $\mu = -\dfrac{\Delta V_p}{\Delta V_g}\Big|_{\Delta i_p = 0}$

$\mu = r_p \times g_m$

PHYSICS NOTES

TRANSISTOR



$$I_e = I_b + I_c$$

$$\alpha = \frac{I_c}{I_e} \qquad \beta = \frac{I_c}{I_b} \qquad \beta = \frac{\alpha}{1-\alpha}$$

Transconductance $g_m = \dfrac{\Delta I_c}{\Delta V_{be}}$

PHYSICS NOTES

LOGIC GATES

A	B	AB	$A+B$	$\overline{AB}$	$\overline{A+B}$	$A\bar{B}+\bar{A}B$
0	0	0	0	1	1	0
0	1	0	1	1	0	1
1	0	0	1	1	0	1
1	1	1	1	0	0	0