WORK & ENERGY

$W = \int \vec{F}\cdot\vec{ds}$

General

$W = \int_{x_i}^{x_f} F_x\,dx + \int_{y_i}^{y_f} F_y\,dy + \int_{z_i}^{z_f} F_z\,dz$

$\vec{F}$ = const

$W = \vec{F}\cdot\vec{\Delta s}$

$= F_x x + F_y y + F_z z$

Work- Energy Theorem

$W_{all} = \Delta K$

POTENTIAL EN

- +ve / -ve
- depends frame
- Property of system
- for Cons forces

$F_c = -\frac{\partial U}{\partial r}$

$F_c = -\left(\frac{\partial U}{\partial x} + \frac{\partial U}{\partial y} + \frac{\partial U}{\partial z}\right)$

EQUILIBRIUM

$F_{net} = 0$

UNSTABLE EQ

$-\frac{dU}{dx} = 0$

PE is max

$\frac{d^2U}{dx^2} = -ve$

STABLE

$-\frac{dU}{dx} = 0$

$\frac{d^2U}{dx^2} = +ve$ [U → minimum

POTENTIAL ENERGY

$\int dU = -\int_{r_i}^{r_f} \vec{F_c}\cdot dr$

$U_f - U_i = -\int \vec{F_c}\cdot dr = -W_{cF}$

(negative of work done by Cons. Force)

Electro. Pot. Energy

$U = \frac{1}{4\pi\epsilon_0}\frac{q_1 q_2}{r}$

GRA. POT En.

$U = -\frac{G m_1 m_2}{r}$

(Elastic)

EPE (U) = $\frac{1}{2}ky^2$

y → extension

CIRCULAR MOTION

$dS = r\,d\theta$

$v = r\omega$

$a_t = \frac{dv}{dt} = r\alpha$

Tangential acc^n

$a_r = \frac{v^2}{r} = \omega^2 r$

. UNIFORM RECT

$a_r = 0,\ a_t = 0$

ACCELARATED RECTI

$a_r = 0,\ a_t \neq 0$

UCM

$a_r \neq 0,\ a_t = 0$

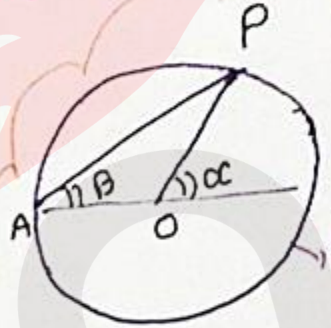
NUCM

$a_r \neq 0,\ a_t \neq 0$

$\vec{d\theta}$ is vector

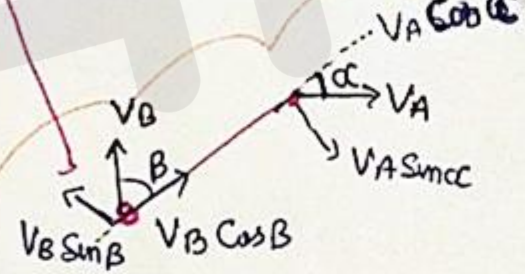
Angular displacement

$\omega = \frac{d\theta}{dt}$ (Ang. velocity)



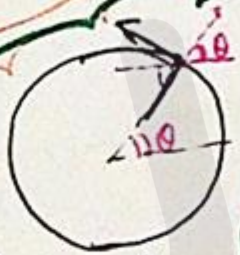
$\omega_{P/A} = \frac{d\beta}{dt}$

$\omega_{P/O} = \frac{d\alpha}{dt}$



$\omega_{A/B} = \omega_{B/A} = \frac{[\vec{V}_{A/B}] \perp \text{ to line joining}}{l_{AB}}$

$= \frac{V_A \sin\alpha + V_2 \sin\beta}{r}$



$\hat{e}_r = \cos\theta\,\hat{i} + \sin\theta\,\hat{j}$

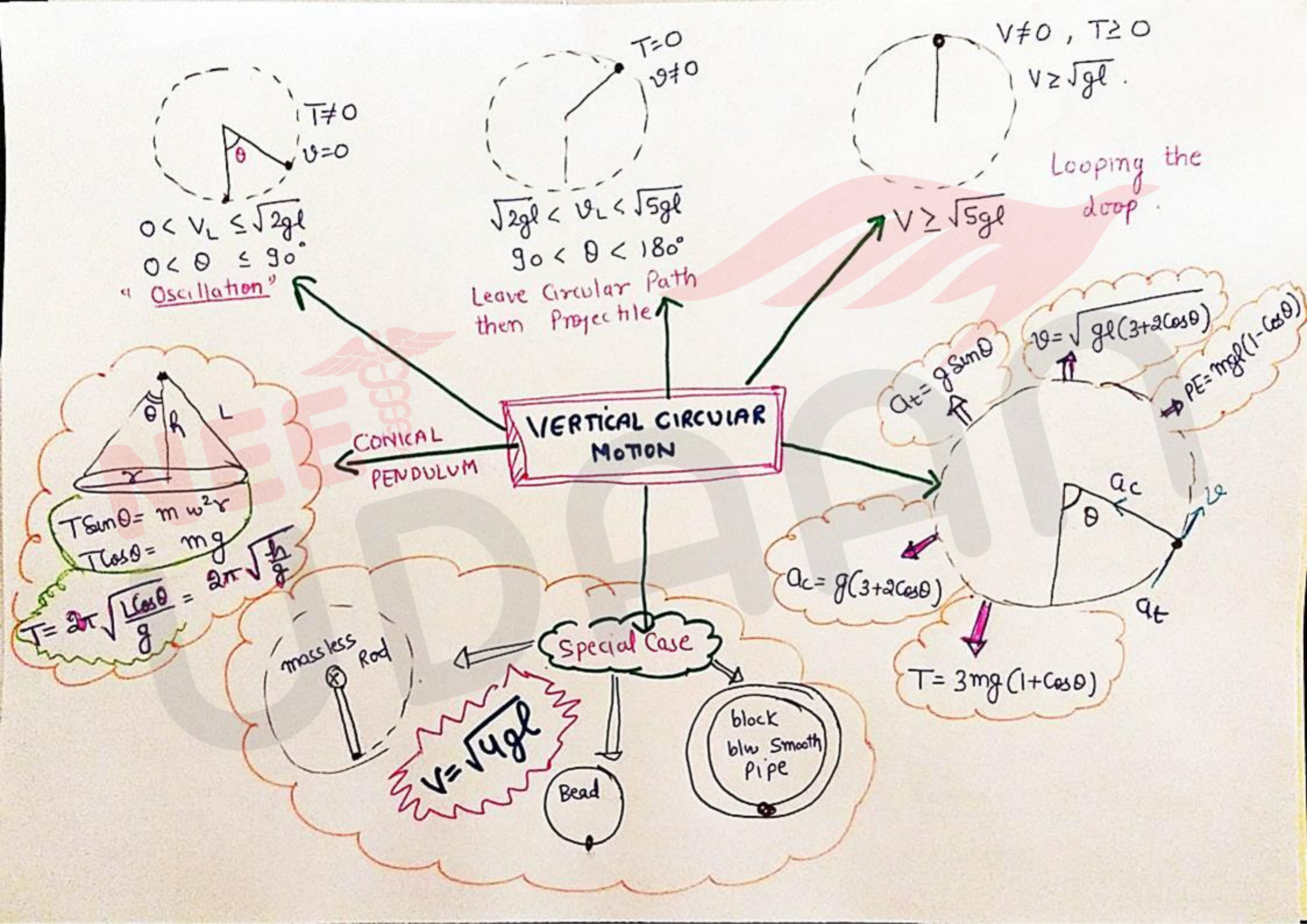
$\hat{e}_t = \sin\theta\,\hat{i} + \cos\theta\,\hat{j}$

Radial & Tang. Unit Vector

$\omega_f = \omega_i + \alpha t$

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

$\omega_f^2 = \omega_i^2 + 2\alpha(\theta_f - \theta_i)$


VERTICAL CIRCULAR MOTION
$T \neq 0$
$v = 0$
θ
$0 < V_L \leq \sqrt{2gl}$
$0 < \theta \leq 90^\circ$
" Oscillation"
$T = 0$
$v \neq 0$
$\sqrt{2gl} < v_L < \sqrt{5gl}$
$90 < \theta < 180^\circ$
Leave Circular Path then Projectile
$V \neq 0$, $T \geq 0$
$V \geq \sqrt{gl}$.
$V \geq \sqrt{5gl}$
Looping the loop .
CONICAL PENDULUM
θ
h
L
r
$T\sin\theta = m\omega^2 r$
$T\cos\theta = mg$
$T = 2\pi\sqrt{\frac{L\cos\theta}{g}} = 2\pi\sqrt{\frac{h}{g}}$
$a_t = g\sin\theta$
$v = \sqrt{gl(3+2\cos\theta)}$
$PE = mgl(1-\cos\theta)$
a_c
θ
v
a_t
$a_c = g(3+2\cos\theta)$
$T = 3mg(1+\cos\theta)$
Special Case
massless Rod
$V = \sqrt{4gl}$
Bead
block b/w Smooth Pipe

COLLISION

Inelastic Collisions

$$\vec{v}_1 = \left(\frac{m_1 - e m_2}{m_1 + m_2}\right)\vec{u}_1 + \left(\frac{m_2(1+e)}{m_1+m_2}\right)\vec{u}_2$$

$$\vec{v}_2 = \left(\frac{m_2 - e m_1}{m_2 + m_1}\right)\vec{u}_2 + \left(\frac{m_1(1+e)}{m_1+m_2}\right)\vec{u}_1$$

Loss of KE

$$\Delta K = \frac{1}{2}\frac{m_1 m_2}{(m_1+m_2)}(u_1-u_2)^2(1-e^2)$$

Perfectly Inelastic $e = 0$

$$\Delta K_{max} = \frac{1}{2}\frac{m_1 m_2}{m_1+m_2}(u_1-u_2)^2$$

(loss is maximum
May be 100%
* **Not must**

Elastic Collision

$$e = \frac{V_{sep}}{V_{app}} = 1$$

→ KE is **NOT** Conserved

→ KE(before) = KE(after)

→ $u_1 - u_2 = V_2 - V_1$
[$V_{app} = V_{sep}$]

$$V_1 = \left(\frac{m_1 - m_2}{m_1+m_2}\right)u_1 + \left(\frac{2m_2}{m_1+m_2}\right)u_2$$

$$V_2 = \left(\frac{m_2 - m_1}{m_1+m_2}\right)u_2 + \left(\frac{2m_1}{m_1+m_2}\right)u_1$$

[exchange 1→2 ☺]

Transfer of KE

$$\frac{\Delta K}{K} = \frac{4m_1 m_2}{(m_1-m_2)^2 + 4m_1 m_2}$$

maximum

$m_1 = m_2$
100% Transfer

If $m_1 = m_2$
$\vec{V}$ are exchanged.

$$R_{com} = \frac{\Sigma m_i r_i}{\Sigma m_i}$$

CENTRE of MASS

- Semi-Disc: $\frac{4R}{3\pi}$
- Semicirc Ring: $\frac{2R}{\pi}$
- System of 2 masses: $m_1 \leftarrow L \rightarrow m_2$; $\frac{m_2 L}{m_1+m_2}$, $\frac{m_1 L}{m_1+m_2}$
- Rectangular Plate: L, b; $x_c = \frac{b}{2}$, $y_c = \frac{l}{2}$
- Hemisph. Shell: $\frac{R}{2}$
- Solid Hemisphere: $\frac{3R}{8}$
- Hollow Cone: $\frac{h}{3}$
- Solid Cone: $\frac{h}{4}$

$$F_{ext} = M a_{com}.$$

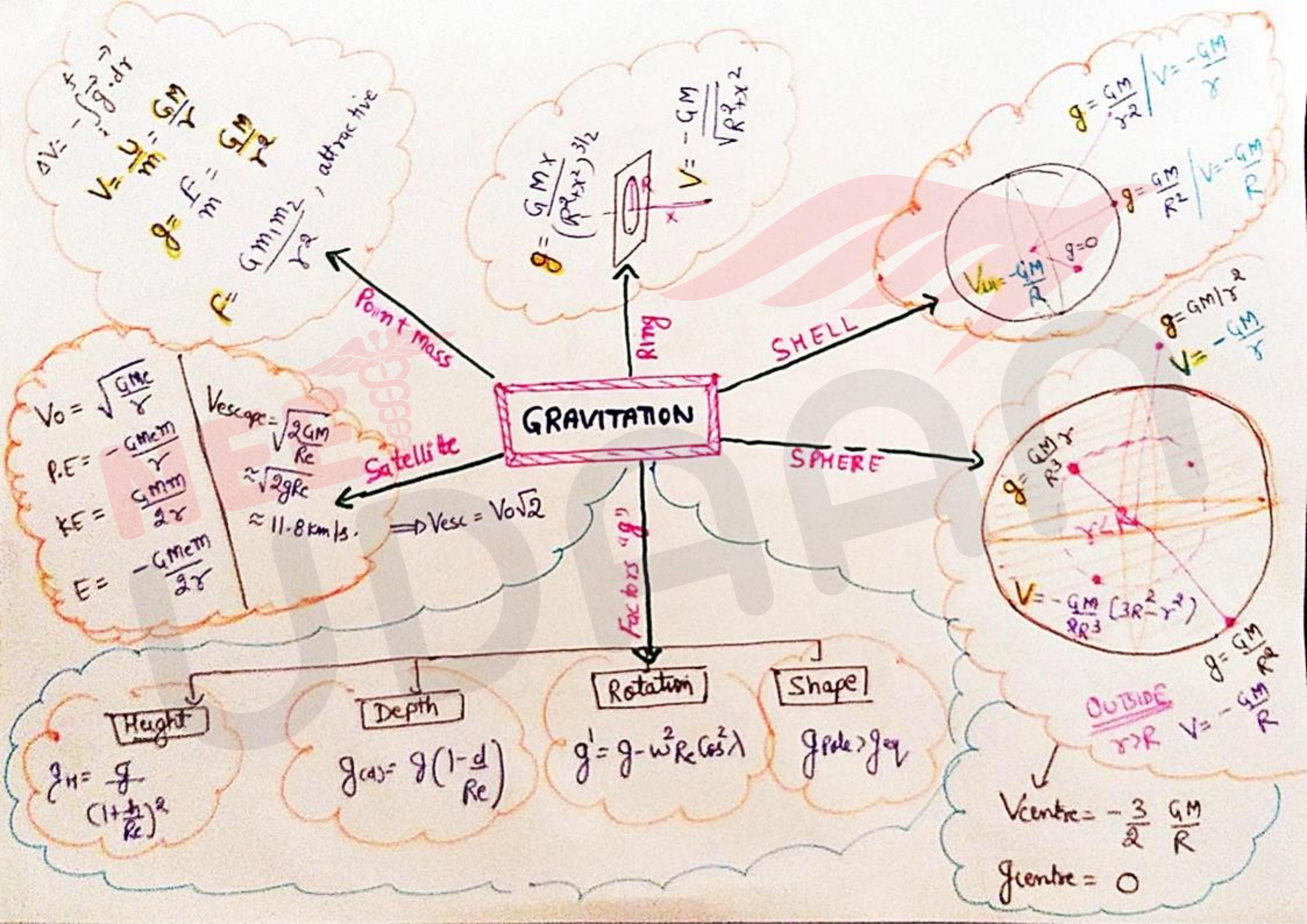
$$\vec{J} = \int F\,dt$$

$$\vec{V}_{com} = \frac{\Sigma m_i v_i}{\Sigma m_i}$$

$$\vec{P}_{system} = M\vec{V}_{com}.$$

* If some mass is removed (m_2 is removed)

$$R_{com} = \frac{m_1\vec{r_1} - m_2\vec{r_2}}{m_1 - m_2} = \frac{A_1 r_1 - A_2 r_2}{A_1 - A_2}$$ [Laminar body]


GRAVITATION
Point mass
$\Delta V = -\int_{\infty}^{r} \vec{g}\cdot d\vec{r}$
$V = \frac{U}{m} = \frac{GM}{r}$
$g = \frac{F}{m} = \frac{GM}{r^2}$
$F = \frac{Gm_1m_2}{r^2}$, attractive
Ring
$g = \frac{GMx}{(R^2+x^2)^{3/2}}$
R
x
$V = -\frac{GM}{\sqrt{R^2+x^2}}$
SHELL
$g = \frac{GM}{r^2}$ | $V = -\frac{GM}{r}$
$g = \frac{GM}{R^2}$ | $V = -\frac{GM}{R}$
g=0
$V_{in} = -\frac{GM}{R}$
SPHERE
$g = GM/r^2$
$V = -\frac{GM}{r}$
$g = \frac{GM}{R^3}r$
r<R
$V = -\frac{GM}{2R^3}(3R^2-r^2)$
$g = \frac{GM}{R^2}$
OUTSIDE
r>R
$V = -\frac{GM}{R}$
$V_{centre} = -\frac{3}{2}\frac{GM}{R}$
$g_{centre} = 0$
Satellite
$V_0 = \sqrt{\frac{GM_e}{r}}$
$P.E = -\frac{GM_em}{r}$
$KE = \frac{GMm}{2r}$
$E = -\frac{GM_em}{2r}$
$V_{escape} = \sqrt{\frac{2GM}{R_e}}$
$\approx \sqrt{2gR_e}$
≈ 11.8 km/s.
$\Rightarrow V_{esc} = V_0\sqrt{2}$
Factors "g"
Height
$g_H = \frac{g}{(1+\frac{h}{R_e})^2}$
Depth
$g_{(d)} = g\left(1-\frac{d}{R_e}\right)$
Rotation
$g' = g-\omega^2R_e\cos^2\lambda$
Shape
$g_{pole} > g_{eq}$

S.H.M

$\vec{F} = k(-\vec{x})$

$\frac{d^2x}{dt^2} = \omega^2(-\vec{x})$

$a = -\omega^2(x)$

$a = -\omega^2 A \sin(\omega t+\phi)$

$\omega = \sqrt{\frac{K}{m}}$

$V = \omega\sqrt{A^2-x^2}$

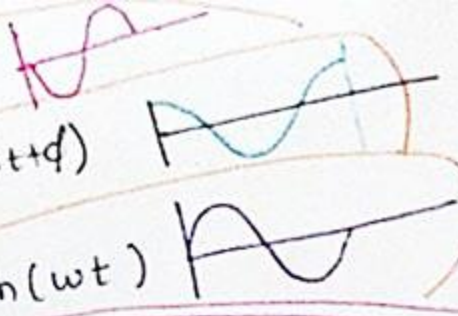
$V = \omega A \cos(\omega t+\phi)$

$X = A \sin(\underbrace{\omega t+\phi}_{\text{Phase}})$ → Phase const

$a = -\omega^2 A \sin(\omega t+\phi)$

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

$X = A \sin(\omega t)$

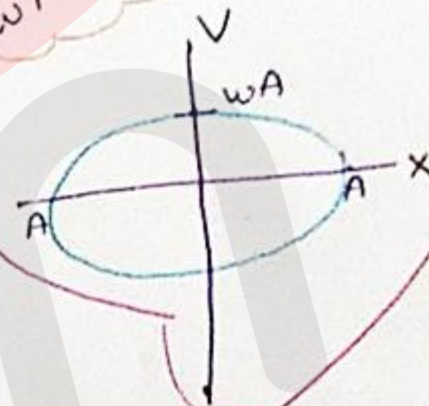


SPEED

$V = \omega\sqrt{A^2-x^2}$

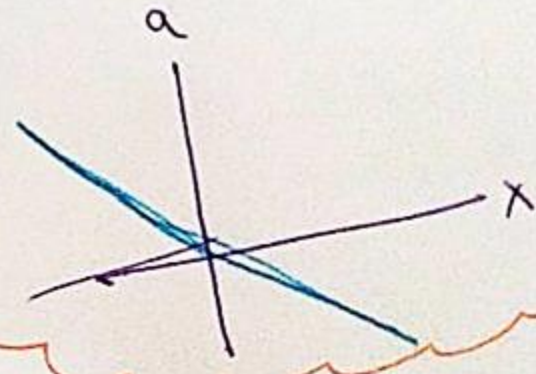
$V^2+\omega^2x^2 = \omega^2A^2$

$\frac{V^2}{\omega^2A^2} + \frac{x^2}{A^2} = 1$ → ellipse



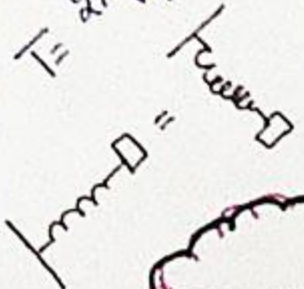
Accelaration

$a = -\omega^2 x$ / $a = -\omega^2 A \sin(\omega t+\phi)$



SPRING MASS

$T = 2\pi\sqrt{\frac{m}{K}} = 2\pi\sqrt{\frac{x_0}{g}}$



m_1 m_2

$T = 2\pi\sqrt{\frac{\mu}{g}}\left[\frac{1}{\mu} = \frac{1}{m_1}+\frac{1}{m_2}\right]$

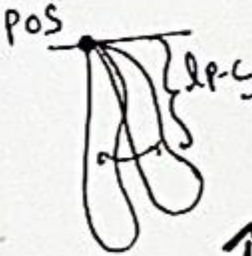
SIMPLE PENDULUM

$T = 2\pi\sqrt{\frac{l}{g_{eff}}}$

$T = 2\pi\sqrt{\frac{1}{g\left(\frac{1}{R}+\frac{1}{l}\right)}}$ R = Radius of earth

S.H.M

Compound Pendulum



$$T = 2\pi\sqrt{\frac{I_{POS}}{mg\,l_{(P\to COM)}}}$$

* POS

Forced Oscillation

$\omega = \omega_0$ (Resonance)

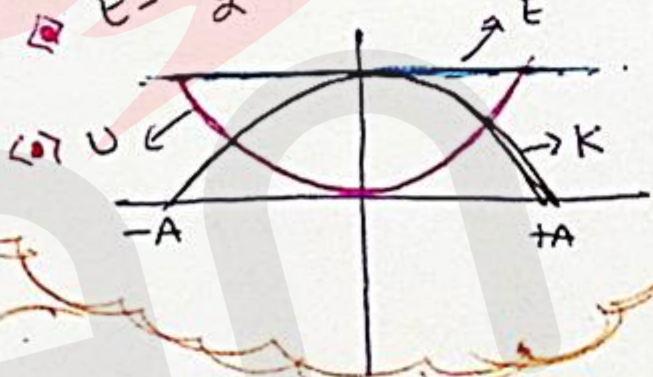
$$A = \frac{F_0/m}{\sqrt{(\omega^2-\omega_0^2)^2+\left(\frac{b\omega}{m}\right)^2}}$$

ENERGY SHM

$$K = \frac{1}{2}m\omega^2(A^2-x^2) = \frac{1}{2}k(A^2-x^2)$$

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

$$E = \frac{1}{2}kA^2.$$



Damped Oscillation

$$\frac{d^2y}{dt^2} = -\frac{k}{m}y - b\frac{dy}{dt}$$

b → damping const

$$y = A e^{-\frac{b}{2m}t}\sin(\omega_D t+\phi)$$

$$\omega_D = \sqrt{\omega_0^2 - \left(\frac{b}{2m}\right)^2}$$

SUPERPOSITION PERPENDICULAR SHM

$X = A\sin\omega t$

$Y = B\sin\omega t$

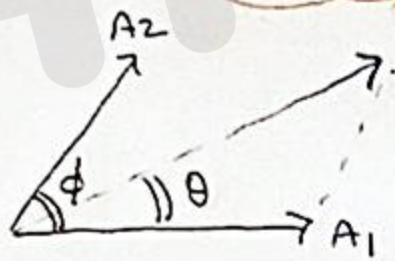
$\Rightarrow \theta = 0/\pi$ Path St line SHM ✓

$\Rightarrow \theta = \frac{\pi}{2}$, ellispse . SHM ✗.

SUPERPOSITION

$y_1 = A_1\sin\omega t$

$y_2 = A_2\sin(\omega t+\phi)$



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

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

KINETIC TH. GAS

ALWAYS $K = \frac{3}{2} PV$

$P = \frac{2}{3} \mu_K$

$PV = \frac{1}{3} mN (v_{rms})^2$

$K = \frac{1}{2} mN v_{rms}^2$

K. Density

$\mu_K = \frac{1}{2} \frac{mN v_{rms}^2}{V}$

Speed

$V_{rms} = \sqrt{\frac{3RT}{M}} = \sqrt{\frac{3PV}{W(\text{gas mass})}} = \sqrt{\frac{3KT}{m}}$

$V_{av} = \sqrt{\frac{8RT}{\pi M}}$

$V_{mp} = \sqrt{\frac{2RT}{M}}$

$V_{rms} > V_{av} > V_{mp}$

Gas Laws

Boyle's $PV = \text{const}$ $\quad \frac{m}{T} = \text{const}$

CHARLES $V \propto T_K$ $\quad m, P = \text{const}$

GAY. LUSSACS $P \propto T_K$ $\quad m, V = \text{const}$

IDEAL GAS EQ

$PV = \mu RT$

$PV = NKT$

$P = nKT$

$P = dRT/M$ — d = density

- P = Pressure
- V = Volume
- N = No. of particle
- N_A = Avagadro
- n = no. density $\left(\frac{N}{V}\right)$
- m = molecule mass
- M = Molecular mass
- W = mass sample
- K = Boltz. cons
- R = Uni. gas cons

THERMODYNAMICS

INT ENERGY

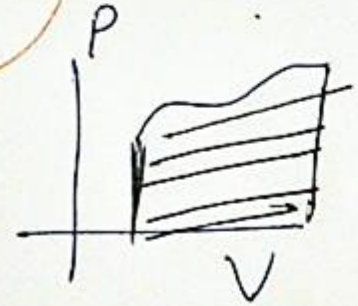
- Path Independent
- $\Delta U_{cyclic} = 0$
- $\Delta U = MC_v\Delta T$ — ALWAYS
- $U = U_K + \cancel{U_P}$ — Ideal Gas $U_P = 0$

HEAT

- $Q = MC_v\Delta T$ — V = const
- $Q = MC_p\Delta T$ — P = const
- $\boxed{Q = mL}$ — Change in state
- macroscopic
- Path dependent
- (+) Absorbed
- $Q = mc\Delta T = MC\Delta T$ — Change in Temp

WORK

- Energy transferred 1 → 2 owing to FORCE
- +ve → Expansion
- −ve → Compression
- Path dependent
- $W = \int_{V_i}^{V_f} P\,dV$ — Any Process
- Area P–V



$U = \frac{1}{2} \mu f R T$

$\Delta U = \frac{1}{2} \mu f R \Delta T$

$\Delta U = \mu C_V \Delta T$

$C_V = \frac{fR}{2}$ *** $= \frac{R}{\gamma - 1}$

$C_P = C_V + R$

$= \left(1 + \frac{f}{2}\right) R$

$\gamma^* = \frac{C_P}{C_V} = 1 + \frac{2}{F}$

Int Energy of Ideal gas is U_K (kinetic only)

General

DEGREE of FREEDOM

- Poly :) 3(T) + 3(R)
- Di + linear Poly :) 3(T) + 2(R)
- Mono = 3(T) + 0(R)

T = Translational

R = Rotational

LAW of EQUI PARTITION

Energy is equally divided among degree of freedom

Energy per molecule per degree $= \frac{1}{2} kT$ $= \frac{1}{2} RT =$ per mole per degree

" per molecule $= \frac{f kT}{2}$ $= \frac{fRT}{2}$ per mole

Energy of sample (N molecule) $= \frac{N f k T}{2}$ $= \frac{\mu f R T}{2}$

$Nk = N \frac{R}{N_A} = \mu R$

1= $PV^x = \text{const}$

Any Gen. Process

2. If $TV^x = \text{const}$

then $PV = \mu RT$

$T = \frac{PV}{\mu R}$

eliminate T and bring it in $PV^x = \text{const}$

3 $P_iV_i = \mu RT_i$

$P_fV_f = \mu RT_f$

$\therefore \boxed{P_fV_f - P_iV_i = \mu R\Delta T}$ ***

$Q = \Delta U + W$

$\mu C\Delta T = \mu C_v\Delta T + \frac{\mu R\Delta T}{1-x}$

Specific Heat

$C = C_v + \frac{R}{1-x}$

for any Process.

Isobaric $(x=1)$ $C_p = C_v + R$

Isothermal $(\Delta T = 0)$ $C = \frac{Q}{\mu\Delta T} = $ N.D

Adiabatic $C = 0$

$PV^x = \text{const}$

$W = \int PdV = \frac{P_fV_f - P_iV_i}{1-x} = \frac{\mu R\Delta T}{1-x}$

For all except $T = \text{const}$

$PV = \text{const}$

$x = 1$

$W_{isoth} = \mu RT \ln \frac{V_f}{V_i} = \mu RT \ln \frac{P_i}{P_f}$

$W_{(isobaric)} = P\Delta V = \mu R\Delta T$

$W_{(isocho)} = 0$

$PV^\gamma = \text{const}$

$W_{(adi)} \Rightarrow \frac{P_fV_f - P_iV_i}{1-\gamma} = \frac{\mu R\Delta T}{1-\gamma}$

WAVES

General

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

$$\downarrow$$

$y(x,t) = f(ax \pm bt)$

$(at - bx)$ = +ve X-axis

$(at + bx)$ = −ve X axis

$$\downarrow$$

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

$K = \frac{2\pi}{\lambda}$ [Propogation Constant]

$v_{wave} = \frac{\Delta x}{\Delta t} = \frac{\omega}{K}$

$v_{Pa} = \omega\sqrt{A^2 - y^2}$

$a_p = -\omega^2 y$

$V_{Pa} = (-\text{slope})\, v_{wave}$

STRING — speed of Trans wave

$v = \sqrt{\frac{T}{M}} = \sqrt{\frac{S}{\rho}}$

M → linear mass Density

S → stress

ρ → density

Reflection

From Denser → π Phase Change

From Rarer = no Phase change

f = same.

STANDING WAVES

Superposition Reflected & Incident wave

Amax

Nodes → Permanent Rest

N → AN = $\frac{\lambda}{4}$

N–N = $\frac{\lambda}{2}$

AN → AN = $\frac{\lambda}{2}$

Particles of same segment same phase

Energy not transmitted

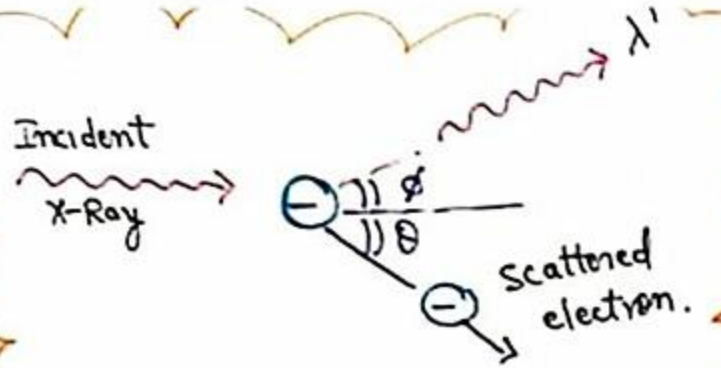
Power / Intensity

Power $= \frac{1}{2}\rho v \omega^2 A^2 S$

Intensity $= \frac{1}{2}\rho v \omega^2 A^2$

$I = \frac{P}{S} = \frac{P}{4\pi r^2}$

r



$\Delta\lambda = \lambda' - \lambda = \frac{h}{mc}[1-\cos\theta]$

Shift in wavelength

COMPTON EFFECT

- Scattering of elastic Photon (like particles) from electrons
- $\lambda_c = \frac{h}{m_e c}$ → compton wavelength (2.4×10^{-3} nm)
- in favour of Particle nature of Photon.
- Not seen with visible light

DUAL NATURE

PAIR ANNHILATION

Used in PET {Positron Emission Tomography}

$e^+ + e^- \rightarrow \gamma + \gamma$

PAIR PRODUCTION

$\lambda \rightarrow e^+ + e^-$ (Energy into positron & electron)

⇒ When Photon passes through matter

⇒ Possible with high Energy

MATTER WAVES

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

K → KE; V → Potential

For e^-

$\lambda = \frac{12.27}{\sqrt{V}}$ Å

For Protons

$\lambda = \frac{0.286}{\sqrt{V}}$ Å

Thermal Neutrons

$E = RT$

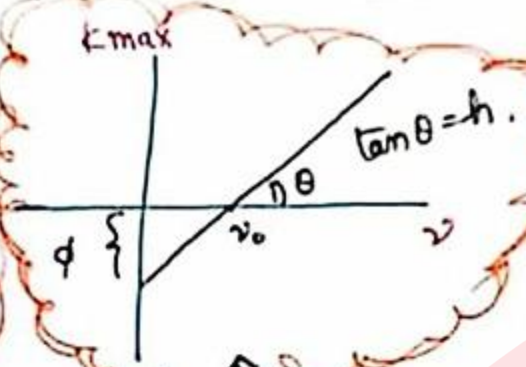
$\lambda = \frac{h}{\sqrt{2mRT}} = \frac{30.8}{\sqrt{T}}$ Å

Gas molecules

$E = \frac{3}{2}RT$

PHOTOELECTRIC EFFECT

- PEE takes place only $\bar{e}$ is lightly bound
- * PEE Never takes place with FREE ELECTRONS
- Emitted Photoelectrons have KE from $0 \to K_{max}$
- K_{max} depends → ν (frequency) ↳ Nature of material



$K_{max} = h\nu - \phi$

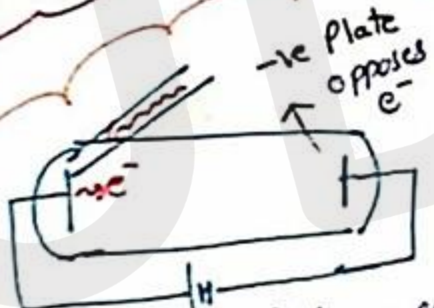
K_{max} linearly with ν

If $\nu \to$ increased by 'n' times K_{max} more than 'n' times

Energy of Photon localized so Immediate effect. "No Time delay"

Result of 1 to 1 Inelastic collision b/w photon & electron.

STOPPING POTENTIAL



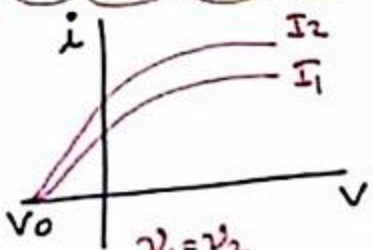
minimum negative Potential sufficient to Stop most energetic Photons.

$K_{max} = |V_s| e$ {e}

→ more ν, ↑K_{max}, ↑V_s

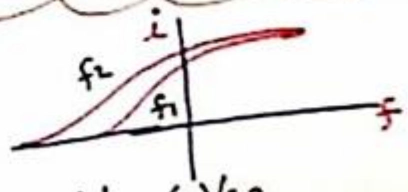
→ V_s linearly with ν

* not directly Proportional



$\nu_1 = \nu_2$

$I_1 < I_2$



$V_{s1} < V_{s2}$

$\therefore f_1 < f_2$.

SPECTRUM

(a) $E_H - E_f = \frac{hc}{\lambda}$

(c) $\frac{1}{\lambda} = RZ^2\left[\frac{1}{n_l^2} - \frac{1}{n_h^2}\right]$

LYMAN

- UV region
- both abs^n & emission
- Transitions start or end at $n=1$
- $\frac{1}{\lambda} = R\left[\frac{1}{1^2} - \frac{1}{n^2}\right]$
- $n=2$, λ_{max}

  $\frac{1}{\lambda} = R\left[\frac{1}{1} - \frac{1}{4}\right]$

  $\lambda_{max} = 1212\ \mathring{A}$
- $n \to \infty$, $\lambda_{min} = 912\ \mathring{A}$

Balmer

- visible
- mainly emission
- $\frac{1}{\lambda_m} = R\left[\frac{1}{2^2} - \frac{1}{n^2}\right]$
- $n=3$, $\lambda_{max} = 6666$

  $n=\infty$, $\lambda_{min} = 3636$

Paschen

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

$\lambda_{max} = 18888\ \mathring{A}$

$\lambda_{min} = 820\ \mathring{A}$

Infra Red.

BRACKET

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

- $\lambda_{max} \to n=5$

  $\lambda_{min} \to n \to \infty$

PFUND.

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

- λ_{max}, $n=6$

  λ_{min}. $n=\infty$

Bohr's Model

Formula's

Radius

$$r_n = \frac{n^2}{Z}\left(\frac{h^2\epsilon_0}{\pi m e^2}\right) = \left(r_0 \cdot \frac{n^2}{Z}\right)$$

$$r_0 = 0.53\,\mathring{A}$$

SPEED

$$V = \left(\frac{e^2}{2\epsilon_0 h}\right)\frac{Z}{n} = \frac{Z}{n}V_0$$

$$V_0 = 2.2\times10^6\ \text{m/s}$$

Time Period

$$T = \frac{2\pi r}{v} = \left(\frac{n^3}{Z^2}\right)T_0 \rightarrow f = \frac{Z^2}{n^3}$$

Mag field

$$B = \left(\frac{Z^3}{n^5}\right)B_0 \quad \left[B = \frac{\mu_0 i}{2r}\right]$$

Current

$$I = e\nu_n = \frac{Z^2}{n^3}$$

Mag Moment

$$M = L\left(\frac{q}{2m}\right) \propto n$$

$$\boxed{L \propto n}$$

Energy

- $$U = \left(\frac{-me^4}{4\epsilon_0^2 h^2}\right)\frac{Z^2}{n^2} = \left(U_0\frac{Z^2}{n^2}\right)$$

  $$U_0 = -27.2\ \text{eV}$$

- $$K = \left(+\frac{me^4}{8\epsilon_0 h^2}\right)\frac{Z^2}{n^2}$$

- $$E = \left(-\frac{me^4}{8\epsilon_0 h^2}\right)\frac{Z^2}{n^2}$$

$$KE = |\vec{E}| = \frac{|U|}{2}$$

$$E = -\left(\frac{me^4}{8\epsilon_0 h^3 c}\right)ch\left(\frac{Z^2}{n^2}\right)$$

↳ Rydberg constant

$$E = -R(hc)\frac{Z^2}{n^2}$$

$$R = 1.09\times10^7\ \text{m}^{-1}$$

$$\frac{1}{R} = 912\,\mathring{A}$$

$$E = \frac{hc}{\lambda} = \frac{12400}{\lambda(\mathring{A})}\ \text{eV}$$

ATOMIC STRUCTURE

Rutherford Model

$N \propto \frac{1}{\sin^4\left(\frac{\theta}{2}\right)}$ → scattering angle

(no. of Particle)

$r_0 = \frac{2e^2}{2\pi \epsilon_0 K}$

↳ closest Approach (∝ size of Nucleus)

Failure

⇒ Stability → × explain
acc^n e^- radiate energy
∴ ultimately falls

⇒ line spectrum × explain

Bohr's Model

Postulates

- $\frac{mv^2}{R} = \frac{1}{4\pi\epsilon_0}\frac{(ze)e}{r^2}$
- $mvr = \frac{nh}{2\pi}$ → Stationary ORBITS

Imp Points.

- When Photon strikes atom. Loses Either ALL or None of energy
- After absorbing e^- jumps (l)→(h) energy state
- In case of H atom. E > 13.6 eV All photons will be absorbed as e^- will be taken to infinity the region of continuous Energy level.

Failure

- single e^- species
- No justification for quantization of angular momentum
- Fine splitting of spectrum
- Violation of Heisenberg-Uncertainty Principle

- **Work Function**
  minimum energy to liberate electrons from metal surface
  $\phi = h\nu_0 = \frac{hc}{\lambda_0}$
- **Threshold frequency**
  minimum frequency needed
- **Threshold Wavelength**
  maximum wavelength above which No PEE
- for PEE
  $\nu \geq \nu_0$ & $\lambda \leq \lambda_0$

***

- $I = \frac{P}{A} = \frac{E}{At} = \frac{nh\nu}{At}$

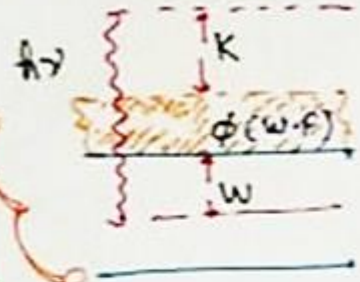
So for A = const, t = const

$I \propto n\nu$

I depends — no. of Photons striking
— frequency of Photon.

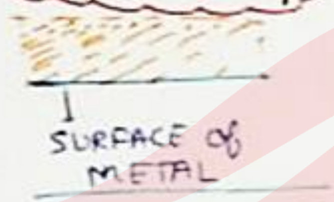
$K = h\nu - w - \phi$

w = different for diff electrons



$K_{max} = h\nu - \phi$ → Einstein's PEE

→ for surface electrons w = 0



PHOTOELECTRIC EFFECT

General

$K_{max} = h\nu - \phi$ (PE Equation)

(•) i (Photo current) $\propto$ Intensity (I) [if ν = constant]

$\because I = nh\nu$

here $I \propto n$

for constant "ν" I is a function of "n"

(•) for I = constant

$I = n(h\nu)$

If ν is ↑ed, lesser will be n

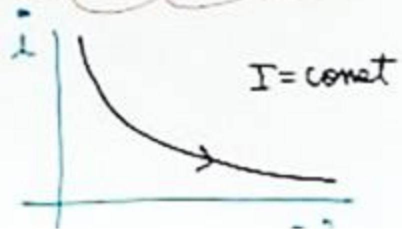
$\therefore$ for I = constant

$n \propto \frac{1}{\nu}$

$\therefore i \propto n \propto \frac{1}{\nu}$

Remember

- PhotoCurrent (i) $\propto n_{eff}$
  ↓
  n_{eff} :- no. of Photons $\nu > \nu_0$



MODERN PHYSICS

CATHODE RAYS

$\frac{e}{m} = \frac{v^2}{2V} = \frac{(E/B)^2}{2V}$

$\Uparrow$

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

$\approx 1.76 \times 10^{11}$ C/kg

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

LIGHT (General)

Photoelectric, Compton → Particle nature "Photon"

Polarization, diffraction, Interference → Wave nature

Relativity Theory

$E^2 = (m_0c^2)^2 + p^2c^2$

m_0 = Rest mass (for photon $m_0 = 0$)

p = momentum

c = speed of light

For "Photon"

$E^2 = p^2c^2$

$E = pC$ — (I)

$E = \frac{hc}{\lambda}$ — (II)

$\therefore P = \frac{h}{\lambda}$

PHOTON

- Small energy Packet
- $E = hf$ → frequency
  $= \frac{hc}{\lambda}$ → wavelength
- Energy Particle in motion
  "no meaning at Rest"
  Rest mass = 0
- Kinetic mass $(m) = \frac{E}{c^2}$ → Energy
- $P = \frac{E}{c} = \frac{h}{\lambda}$
  ↙ momentum.

Force & Pressure d/t Radiation

(complete absorbtion)

$F = \frac{IA}{c}$, $P = \frac{I}{c}$

Reflection $(r=1, a=0)$

$F = \frac{2IA}{c}$, $P = \frac{2I}{c}$

Both $[a+r=1]$

$F = \frac{IA}{c}(1+r)$, $P = \frac{I}{c}(1+r)$

$F = \frac{IA\cos\theta}{c}$, $P = \frac{F\cos\theta}{A} = \frac{I}{c}\cos^2\theta$

$F = 2\frac{IA\cos\theta}{c}$, $P = \frac{2I\cos^2\theta}{c}$

$P = \frac{I\cos^2\theta}{c}(1+r)$