Nancy Mokh

Physics:

Work & Energy:

* Work done by a cst force along rectilinear displacement: $W_{\vec{F}\,A\to B} = \vec{AB} \cdot \vec{F} = F_{(N)} \times AB_{(m)} \times \cos(\vec{F}; \vec{AB})$

* Work done by weight $= \pm mgh$; where h is the height between initial & final position:
* Note: If $W_{\vec{\omega}}$ is positive ; then weight is motive.
  If $W_{\vec{\omega}}$ is negative ; then weight is resistive.
* $W_{\vec{N}} = 0\,J$ ($\perp$ to displacement).
* $W_{\vec{f_r}\,A\to B} = -f_r \times AB$. $(\cos(\vec{f_r}, \vec{AB}) = -1)$.

* Energy: A system has energy if it does work, or it's able to do work.

i) Kinetic energy: Is the energy owned by system due to its motion. $KE = \frac{1}{2} m v^2$.

ii) Potential energy: Is the energy stored by the system due to its position:

a) PEg: Is the energy stored by the system due to its height from a certain position, where: *
$PEg = \pm mgh$; where h is the distance between the center of mass of the object & the chosen reference

Note: If the object is above reference $\Rightarrow PEg > 0$.
If the object is below reference $\Rightarrow PEg < 0$.

b) PEe: Is the energy stored in the spring due to its elongation or compression from its initial length.

$PEe = \frac{1}{2} k x^2$ where: k: stiffness constant (N/m)
x: elongation or compression of spring (m)

iii) **Mechanical energy:** is the sum of KE & PE.

$\Rightarrow$ $ME = KE + PE$.

- Conservation of ME: In case of no resistive forces (friction or air resistance), ME is conserved

$\Rightarrow$ ME is cst: $ME_i = ME_f = ME_{(t)}$.

- Non-conservation of ME: In case of resistive forces (friction or air resistance), ME is not conserved "it decreases with time".

$\Rightarrow \Delta ME_{A \to B} = W_{\vec{f_r}\, A \to B}$.

iv) **Work - Kinetic Energy Theorem:** $\Delta KE_{A \to B} = \Sigma W_{A \to B}$

Notes on the Chapter:

- friction $\Rightarrow$ object is on rough surface.
- velocity: is the speed with vector.
- the position is: - in translation: x.
  - in rotation: angle θ.
- reference must be always horizontal.
- PE_g is not affected with friction
- Thermal energy $= -\Delta ME$.
- Inextensible string: $\begin{cases} x_1 = x_2 = x. \\ V_1 = V_2 = V. \\ a_1 = a_2 = a. \end{cases}$

U.ARM: $a = cst$, trajectory st line.

- To prove that ME is conserved, we can prove that $\Delta KE = -\Delta PE_g$, where KE & PE_g have opp variations,
- jointed spring doesn't make compression.
- Put the units on each expression with unknowns or variables.
- ME_{system} = sum of ME of each object in that system.
- rod of mass "m" is uniformly distributed along its ~~mass~~ length $\Rightarrow \frac{m}{l} = c$

Chapter 2: Linear Momentum:

→ A particle having mass m & moving with velocity $\vec{v}$ has a linear momentum given by:

$$\underset{(kgm/s)}{\vec{P}} = \underset{kg}{m}\,\underset{(m/s)}{\vec{v}}$$

{ since $m>0$, then $\vec{P}$ & $\vec{v}$ have same direction.

* Linear momentum of a system of particles:

$\vec{P}_{system} = \sum m\vec{v}$ ⇒ we can bring it by 2 methods:

i) 1st method: graphically: $\vec{P}_{system} = \vec{P}_1 + \vec{P}_2$:

- draw $\vec{P}_1$ & $\vec{P}_2$ according to a chosen scale.
- draw $\vec{P}_{system}$ (4th vertex of a parm).
- measure $\vec{P}_{system}$ using a ruler
- put it under the chosen scale to get P_{syst} (kgm/s)

ii) 2nd method: By calculation:

$P_{system} = \sqrt{P_1^2 + P_2^2 + 2P_1P_2\cos(\vec{P}_1;\vec{P}_2)}$ /general rule of phythagorous).

* Linear momentum of center of inertia G:

$\vec{P}_G = \sum m\vec{v} = M_{system} \times \vec{V}_G = \vec{P}_{system}$.

→ Neuton's 2nd law:

By definition: $\sum \vec{F}_{ext} = \frac{d}{dt}\vec{P}$ (true anywhere).

→ 2 cases: 1- if m is constant, then,

$$\sum \vec{F}_{ext} = \frac{d}{dt}(m\vec{v})$$

$$\sum \vec{F}_{ext} = m\frac{d\vec{v}}{dt} = m\vec{a}.$$

2- If m is variable, then,

$$\sum \vec{F}_{ext} = \frac{d}{dt}(m\vec{v})$$

$$= m'\vec{v} + \vec{v}' \times m.$$

$$\sum \vec{F}_{ext} = m'\vec{v} + m\vec{a}$$

* Conservation of L.M:

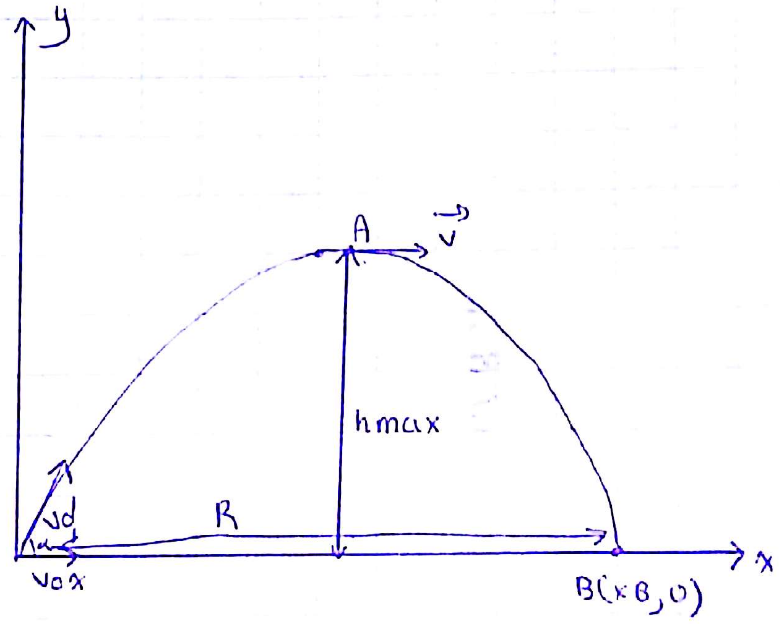
If $\sum \vec{F}_{ext} = \vec{0} \Rightarrow$ nystem is mechanical isolated;

$\Rightarrow \frac{d}{dt}\vec{P} = \vec{0} \Rightarrow \vec{P}$ is cst $\Rightarrow$ L.M is conserved.

* Center of inertia G:

$x_G = \frac{x_1 m_1 + x_2 m_2 + \dots}{m_1 + m_2 + \dots}$; $y_G = \frac{m_1 y_1 + m_2 y_2 + \dots}{m_1 + m_2 + \dots}$; $z_G = \frac{m_1 z_1 + m_2 z_2 + \dots}{m_1 + m_2 + \dots}$

* Projectile motion: The only force acting on the Projectile is its weight: (neglect air resistance)



i) Apply Neuton's 2nd law:

$$\sum \vec{F}_{ext} = \frac{d}{dt}\vec{P}.$$

$$\vec{w} = \frac{d}{dt}\vec{P},$$

$$w_x\vec{i} + w_y\vec{j} = \frac{d}{dt}P_x\vec{i} + \frac{d}{dt}P_y\vec{j},$$

$$-mg\vec{j} = \frac{d}{dt}P_x\vec{i} + \frac{d}{dt}P_y\vec{j}.$$

$$\Rightarrow \begin{cases} \frac{d}{dt} P_x = 0 \\ \frac{d}{dt} P_y = -mg \end{cases} \Rightarrow \begin{cases} P_x = P_{0x} = mV_{0x} = mV_0\cos\alpha \\ P_y = -mgt + P_{0y} = -mgt + mV_0\sin\alpha. \end{cases}$$

$$\vec{V} \begin{cases} V_x = \frac{P_x}{m} = V_0\cos\alpha. \\ V_y = \frac{P_y}{m} = -gt + V_0\sin\alpha \end{cases} \Rightarrow \vec{r} \begin{cases} x = V_0\cos\alpha t + x_0 \quad -① \\ y = -\frac{gt^2}{2} + V_0\sin\alpha t + y \quad -② \end{cases}$$

- equation of trajectory: from equation ①.

$t = \frac{x}{V_0\cos\alpha}$ (with $x_0 = 0$).

subistitute t in ② ⇒ we get:

$$y = -\frac{g}{2V_0^2\cos\alpha^2} x^2 + \frac{V_0\sin\alpha}{V_0\cos\alpha} \cancel{x}$$

$$y = \frac{-g}{2V_0^2\cos\alpha^2} x^2 + \cancel{V_0} \tan\alpha\, x.$$

- hmax: at hmax $V_y = 0$, $t = \frac{V_0\sin\alpha}{g}$

subistitute in ②: $y = -\frac{V_0^2\sin\alpha^2}{2g} + \frac{V_0^2\sin\alpha^2}{g}$

$$y = \frac{V_0^2\sin^2\alpha}{2g}.$$

- range: X max:

at Xmax: $y = 0$.

$$-\frac{gt^2}{2} + V_0\sin\alpha t + y_0 = 0.$$

$$t = \frac{2V_0\sin\alpha}{g},$$

subistitute in ①:

$$x_{max} = V_0\cos\alpha \frac{2V_0\sin\alpha}{g} = \frac{V_0^2\, 2\sin\alpha\cos\alpha}{g} = \frac{V_0^2\sin 2\alpha}{g}$$

Notes on Chapter 2:

* $\frac{dP}{dt} \simeq \frac{\Delta P}{\Delta t}$ if :- Δt is very small
  &- P is linear.
* Principle of Interaction: $\vec{F}_{S_1/S_2} = -\vec{F}_{S_2/S_1}$.
* Newton's 1st Law: - If $\Sigma \vec{F}ext = \vec{0}$,
then: i) If object is at rest; it remains at rest.
ii) If object was in motion; it remains URM.

* $\vec{V}cannon = \frac{-mshell}{Mcannon} \times \vec{v}shell$ { to reduce recoil of the cannon we can ↗s the mass of cannon

* during collision ⇒ L.Ms is conserved.
collision: - elastic collision (L.Msystem conserved; KEs conserved)
- inelastic collision (" " ; KEs not conserved)
* Finding 2 unknowns during Head-on collision:
(Collision is elastic):
i) During collision L.M(system) conserved: $S_1 \{ m_1, V_1$ $S_2 \{ m_2, V_2$

$\vec{P}_{system}$ Jb = $\vec{P}_{system}$ Ja.

Jb

$m_1\vec{V_1} + m_2\vec{V_2} = m_1\vec{V_3} + m_2\vec{V_4}$ $S_1 \{ m_1, V_3$ $S_2 \{ m_2, V_4$

$\boxed{m_1 (\vec{V_1} - \vec{V_3}) = m_2 (\vec{V_4} - \vec{V_2})}$ - ①

Ja

ii) Collision is elastic ⇒ KEs is conserved:

KEs Jb = KEs Ja.

$\frac{1}{2}$ $\frac{1}{2}m_1 v_1^2 + \frac{1}{2}m_2 v_2^2 = \frac{1}{2}m_1 v_3^2 + \frac{1}{2}m_2 v_4^2$.

$m_1 v_1^2 + m_2 v_2^2 = m_1 v_3^2 + m_2 v_4^2$,

$m_1 (v_1^2 - v_3^2) = m_2 (v_4^2 - v_2^2)$

$m_1 (\vec{V_1} + \vec{V_3})(\vec{V_1} - \vec{V_3}) = m_2 (\vec{V_4} + \vec{V_2})(\vec{V_4} - \vec{V_2})$ - ②

$\frac{eq\,2}{eq\,1}$ ⇒ $\vec{V_1} + \vec{V_3} = \vec{V_4} + \vec{V_2}$, - ③

$\vec{V_3} = \vec{V_4} + \vec{V_2} - \vec{V_1}$

subistitule $\vec{V_3}$ in equation ① ⇒ we get:

$m_1(\vec{V_1} - \vec{V_4} - \vec{V_2} + \vec{V_1}) = m_2(\vec{V_4} - \vec{V_2})$

$2m_1\vec{V_1} - m_1\vec{V_4} - m_1\vec{V_2} = m_2\vec{V_4} - m_2\vec{V_2}$.

$\times(-)$ $(-m_1 - m_2)\vec{V_4} = (-2m_1)\vec{V_1} + (-m_2 + m_1)\vec{V_2}$

$\div(m_1+m_2)$ $(m_1+m_2)\vec{V_4} = 2m_1\vec{V_1} + (m_2 - m_1)\vec{V_2}$.

$$\vec{V_4} = \frac{2m_1}{m_1+m_2}\vec{V_1} + \frac{m_2-m_1}{m_1+m_2}\vec{V_2}.$$

⇒ subistitute $\vec{V_4}$ in equation ③.

$$\vec{V_3} = \frac{2m_1}{m_1+m_2}\vec{V_1} + \frac{m_2-m_1}{m_1+m_2}\vec{V_2} + \vec{V_2} - \vec{V_1}$$

$$= \frac{2m_1 - m_1 - m_2}{m_1+m_2}\vec{V_1} + \frac{m_2 - m_1 + m_2 + m_1}{m_1+m_2}\vec{V_2}$$

$$\vec{V_3} = \frac{m_1 - m_2}{m_1+m_2}\vec{V_1} + \frac{2m_2}{m_1+m_2}\vec{V_2}$$

* If velocities are collinear we can remove vectors, but, V becomes the velocity in algebraic value (can be positive or negative).

* ME can be conserved before collision or after collision; but it can't be conserved during collisio

* In puck: - If object moves with URM (cst distance wit equal time) then: $V = \frac{d}{t}$.

- If object moves with U.V.RM, then $V = \frac{M_1M_2}{2\tau}$

* scale: - If we want to draw we multiply by scale.

- If we want to pick up information from the drawing, we multiply by the inverse of scale (÷ by scal

* ~~In URM: $x = x = \frac{d}{dt}V \Rightarrow V = \int x.\,dt =$~~

* In URM: $x = Vt + x_0$.

* In U.V.RM: $\begin{cases} x = \frac{1}{2}at^2 + V_0t + x_0. \\ V_f^2 - V_i^2 = 2ad. \\ V = at + V_0. \end{cases}$

Chapter 4: Mechanical Oscilation:

* **Oscilator:** Is a system that moves back & forth around its equilibrium position.

* **Characteristics of the oscilatory motion:**

i) Period T: is the time needed to complete one oscilation:

$$T = \frac{\Delta t \text{ (sec)}}{\text{nb. of oscilations}}$$

ii) frequency "f": is the nb. of oscilations per unit time:

$$f = \frac{\text{nb. of oscilations}}{\Delta t} \ (1/s) \ : Hz = \frac{1}{s} \cdot \left\{ \text{with } f = \frac{1}{T} \text{ & } T = \frac{1}{F} \right.$$

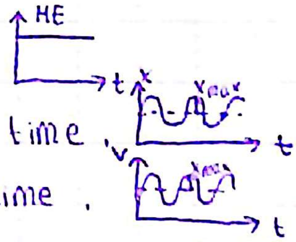
iii) Amplitude: max displacement measured from equil. position (midpt of 2 extremities); Amplitude is always >0.

iv) Angular frequency "ω": $\underset{(rad/s)}{\omega} = \frac{2\pi \text{ rad}}{T_s}$ or $\underset{(rad/s)}{\omega} = \underset{(rad)}{2\pi} \underset{(1/s)}{f}$

* **Free oscilation:** An oscilator undergoes free oscilation if it oscilates on its own (without external intervention during oscilation).

1) **Free undamped oscilation:** + nature of motion: simple harmonic

Characteristics: 1_ no friction.
2_ ME is conserved.
3_ Xmax is cst with time.
4_ Vmax is cst with time.



* Note: - period in this case is called proper period (T_0), frequ is proper frequency F_0, & ω is proper "ω_0".
- For same oscilator T_0 is the min possible period

* To determine X_m & φ we've to use I.C.;

* If we have a curve of $x = f(t)$, 3 methods to prove sign of v:
1) $v = \frac{d}{dt} x)_t$ = slope of tang$)_t$ = ...
2) $v = x'$; x is curve; if x ↗ing; $v>0$; If x ↘ing $\Rightarrow v<0$
3) from the oscilator (position).

* To draw a graph we must determine 4 characteristics of it:

i) type of motion (sinusoidal, ...)
ii) max value of variable (X_m; V_m ...)
iii) periodic or no & determine the period.
iv) I.C.; (x_0, v_0 ...).
v) sign of derivative of variable (to determine if it's ↗ or ↘).

scale: 1cm → $\frac{X_m}{2}$; 1cm → $\frac{T_0}{4}$

2) Free-damped oscilation:

i) Slightly damped:

- friction is very small.
- ME, X_m & V_m decrease slowly.
- nature of motion is pseudo periodic motion.
- period is called pseudo period "T", with $T \gtrsim T_0$ or $T \simeq T_0$.

ii) Large damped:

- friction is large.
- ME, X_m & V_m decrease with time.
- nature of motion is pseudo periodic motion.
- $T > T_0$.

* Driven oscilation:

to provide a damped oscilator with energy to compensate the loss in ME due to friction.

- friction $\neq 0$.
- ME is conserved.
- X_m & V_m are again constant.
- nature of motion: Simple Harmonic motion.
- period is again proper period.
- P_{av}(needed to compensate the loss) $= \frac{|\Delta ME|}{\Delta t}$
- P_{av} (friction) $= \frac{\Delta ME}{\Delta t}$.

- P_{inst} (operator) $= \frac{d}{dt} ME)_t$,

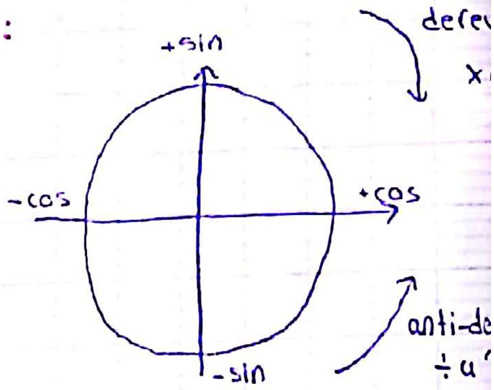
$P_{inst\ fr} = \frac{d}{dt} ME)_t$ = slope of tangent

Oscilation

- **free osc.**
  - **undamped**
    - $f_r = 0$.
    - To: proper period.
    - To is minimum T.
    - simple harmonic motion
    - ME, Xm & Vm are cst.
  - **damped**
    - **slightly**
      - f_r is very small
      - ME, Xm, Vm ↘ slowly
      - T: pseudo period.
      - $T \gtrsim T_0$.
      - pseudo periodic motion.
    - **large damped.**
      - f_r is large
      - ME, Xm, Vm ↘.
      - T: pseudo period.
      - $T > T_0$.
      - pseudo periodic motion.
- **driven osc.**
  - $f_r \neq 0$
  - ME is cst
  - Xm & Vm are again cst
  - simple harmonic motion
  - T is again To "proper

Notes on the Chapter: VVVI:

- $\cos \varphi = \ell$, $\varphi \to \cos^{-1}(\ell)$ or $\varphi \to -\cos^{-1}(\ell)$
- $\sin \varphi = \ell$, $\varphi \to \sin^{-1}(\ell)$ or $\varphi \to \pi - \sin^{-1}(\ell)$
- $\tan \varphi = \ell$, $\varphi \to \tan^{-1}(\ell)$ or $\varphi \to \pi + \tan^{-1}(\ell)$.



- Determine the time eq: we've to det Xm & φ.
- When we bring Xm & φ we write the time eq.
- Units in I.C. must be unique.
- Xm & Vm are always (+) ve.
- In osc. make the calculator in radian.
- $V_{max} = X_m \omega_0$.
- The absolute value of the quantity before sin or c... in an expression is the max value of quantity studied

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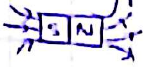
* If he said show that ME is conserved: we've to prove it (we can't say $f = 0\,N$). $V_{max} = cst$, $\frac{1}{2} m V_{max}^2 = c$
* $T\cos^2 = \frac{T\cos}{2}$.
$\Rightarrow$ ME conserved (cst)

* If we have graph $x = f(t)$ and we're asked to draw graph of V: we say:
$V = x'$, then if $x = \sim \sin(\sim)$ then $V = \sim \cos(\sim)$, so the difference between them is $\frac{\pi}{2}$, we move graph of x by $\frac{\pi}{2}$.
* I.C can be from the given or from the graph.
* speed is always positive
* velocity in algebraic value can be either >0 or $<$
* If we're solving on I.C, we can take φ without $+k\pi$, but if we substitute any value other than I.C we've to put $\varphi + k\pi$.
* $T = \ominus kx \rightarrow$ restoring force.
* We can bring d.E from: - conservation of ME
  - $\Sigma \vec{F}_{ext} = m\vec{a}$.
* Condition of equilibrium: $k\Delta l = mg$ $(\Sigma \vec{F}_{ext} = \vec{0})$.
  $\vec{f} = -h\vec{v} \rightarrow$ where h is roughness.

Chapter 18 : Electromagnetic induction:

* We know that: every magnet creates around it a magnetic field ($\vec{B}$).
* There are two types of magnets:

i) Bar magnet , where $\vec{B}$ isn't uniform (diverging).

ii) U-shaped magnet: , where $\vec{B}$ is uniform (same magnitude, same direction).

* When a solenoid is traversed by electric current, it creates a magnetic field. (solenoid where electricity passes acts as a magnetic field).

* Characteristics of $\vec{B}$ inside the solenoid:

- P.O.A: any pt inside the solenoid.
- L.O.A: axis of solenoid.
- direction: by right-hand rule.
- magnitude: $B = \frac{\mu_0 N i}{l}$ where:
  - B: magnetic field (T).
  - μ_0 = cst = $4\pi \times 10^{-7}$ SI.
  - N: nb of loops.
  - i: current (A).
  - l: length of solenoid (m)

- Laplace force or "electromagnetic force":

when a wire, is placed in a magnetic field & traversed by electric current, it's subjected to force called Laplace force or electromagnetic force.

- Characteristics of $\vec{F_L}$:

- P.O.A: center of mass of rod or wire,
- L.O.A: ⊥ to plane formed by $\vec{I}$ & $\vec{B}$,
- direction: By R.H.R (3 fingers),
- magnitude: $\underset{(N)}{F_L} = |i B L \sin(\vec{I}, \vec{B})|$ where
  - i: current "A"
  - B: magnetic fie
  - l: length of so

we put this amount in absolute value, in order to get ⊕ve nb (since i can be ⊖ve).

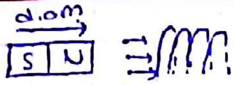
Magnetic flux: is the quantity of magnetic field that enters a surface area "S". symbol: ϕ.

$\underset{wb}{\phi} = NBS\cos\theta$ where: $\begin{cases} N: \text{nb of loops.} \\ B: \text{magnetic field (T).} \\ S: \text{surface area } (m^2) \\ \theta: (\vec{B}, \vec{n}), \text{ where } \vec{n} \text{ is the normal} \\ \text{vector to plane containing S.} \end{cases}$

- To specify the direction of $\vec{n}$ we must apply RHR to a chosen ⊕ve direction.
- Variation in magnetic flux:

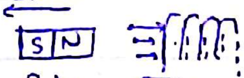
Variation in B:

d.o.m



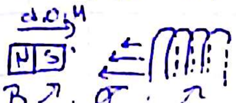
$B\nearrow$, $\phi\nearrow$.

d.o.m



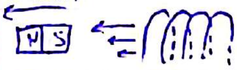
$B\searrow$, $\phi\searrow$.

d.o.m



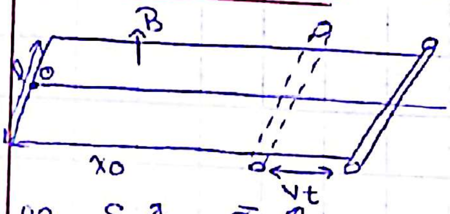
$B\nearrow$, $\phi\nearrow$.

d.o.m



$B\searrow$, $\phi\searrow$

variation in S:



as $S\nearrow$, $\phi\nearrow$.

for V=cst ⇒ URM; $x = Vt + x_0$

- $S = l \times w = l \times (Vt + x_0)$
$= lVt + lx_0$
$= S_0 + St.$

variation is θ:

- Loop rotates, θ varies ⇒ ϕ varies.

If $\theta' = \omega = cst$ ⇒ U.C.M

$\theta = \theta' t + \theta_0 = \omega t + \theta_0$

$\phi = \underbrace{NBS}_{\phi max}\cos(\omega t + \theta_0)$ } sinusoidal.

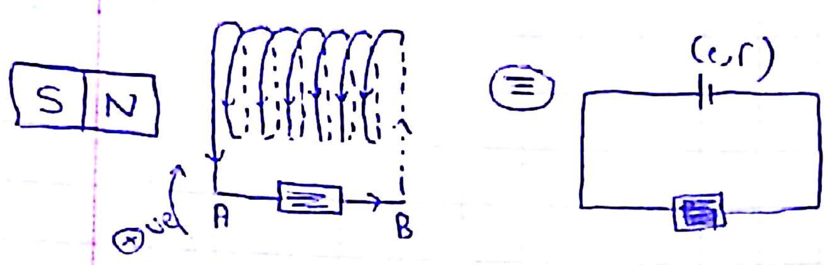
- Electromagnetic induction phenomenon: "creation of voltage": Is the establishment of electromotive force "max voltage when current is zero" across the terminals of coil when a <u>variable</u> flux crosses its surface.
- If circuit is closed ⇒ induced current.
- **Faraday's law:**

$$\underset{(v)}{e} = -\frac{d}{dt}\phi.$$

- Lenz's law: «Effects of induced current $(\vec{B}ind, \vec{F_L})$, oppo the causes producing it (variation in ϕ).

* $i_{ind} = \dfrac{e\ (V)}{R_{eq}\ (\Omega)}$

* Equivalent generator:

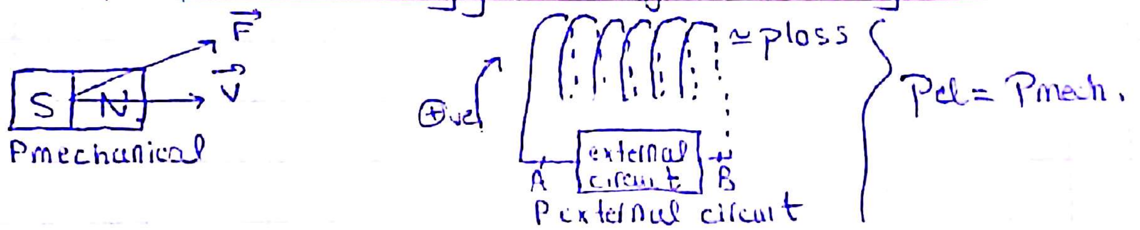


note: $V_{coil} = \pm(-e+ri)$ — signs depend on ⊕ve direction.
$V_R = \pm Ri$

V_{AB} through coil $= -e + ri$.
V_{AB} through resistor $= -Ri$.

V_{BA} through coil $= +e \mp ri$
V_{BA} through resistor $= Ri$.

* Electric power & energy in magnet-coil system:



$V_{AB} = -e + ri$

$\times i$ $\quad V_{AB} \times i = -ei + ri^2$

$ei = V_{BA} \times i + ri^2$.

$P_{t\,electric} = P_{ext\ circuit} + P_{loss}$ (due to Joule's effect).

$P_{mech} = \underset{N}{F} \times \underset{(m/s)}{V} \times \cos(\vec{F}, \vec{V})$.

$P_{el} = e \times i > 0$.

$P_{mech} = P_{el} \Rightarrow$ mechanical power is transformed totally into electric by induction $\Rightarrow$ energy is conserved.

* Voltmeter & oscilloscope play the role of open switch ($I=0A$), since they have very large resistance ($r \to +\infty$), where $I=\frac{V}{R}$ & $R \to +\infty$ then $I=0A$.
* Ammeter plays the role of closed switch (wire), $V=0v$, since it has very low resistance ($R \to 0$) ($V=Ri=0V$).

Notes: VVVV Imp:

* 1T is very large amount.
* Mercury is very good conductor.
* variable flux $\Rightarrow$ electricity.
* If we've a question on effect of B on ϕ, conclusion is $\phi \propto B$.
* If ϕ is $\propto$ BS cosθ, the $\phi = KBS\cos\theta$, where K is the cst of proportionality.
* If we don't have any given on nb of loops, then $N=1$.
* direction of B depends on polarity of magnet.
variation in B depends on ~~magnitude~~ d betw magnet & surface area (coil).
* Teslameter: instrument that measures B.
* for variation in ϕ 2 methods:

Variation in B in coil:

* B varies, ϕ varies, induction phenomenom appears (induced emf $\Rightarrow$ induced current), Bind to oppose variation in ϕ, Bind opp or support B, By RHR Iind as shown ....
* or we can depend on polarity of magnet depending ~~on direction~~ to bring polarity of coil (opp to that of magnet) & bring direction of Bind.

Variation is S:

* $S\nearrow$, $\phi\nearrow$, induced emf $\xrightarrow[\text{ckt}]{\text{closed}}$ induced current, Bind to oppose variation in ϕ Bind opp to B, by RHR direction of Iind.
* OR: rod moves to right, $\vec{F_L}$ is horizontal to left (to oppose the cause) "Lenz Law", By RHR we bring Iind (cause Bno Bind).

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- coil submitted to induction acts like a dry cell.
- Joule's effect: transforming electric power into heat power.
- orientation: +ve direction.
- Power of Fi is negative:
- Oscilloscope: channel or phone (+) ; ground (-).
- inductor: source of magnetic field.
- inducer: circuit where induction occurs.
- $V_{max} = S_v \times y_{max}$,
  $T = x \cdot S_h$.
- $R_{eq} = \text{perimeter} \times \lambda$.
- polarity: If $V_{PN} > 0$, $V_P - V_N > 0$, $V_P > V_N$, then
  P: positive pole.
  N: negative pole.
- to use $\theta = \theta' t + \theta_0$ we've to say: $\theta = \int \theta' \cdot dt$

Chapter 9: Self Induction.

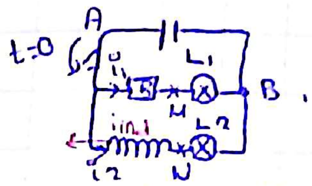
→ **Self induction phenomenon**: Is the establishment of self emf through the terminals of the coil when a variable self flux (proper flux) crosses its surface.

→ when a variable current traverses the coil, coil creates variable magnetic field ($B = \frac{\mu_0 N i}{\ell}$), this magnetic field enters the surface area of coil itself ⟹ variable self $\varnothing$ ⟹ self induced emf ⟹ closed iind to oppose variation in i.

→ In self induction: the coil is the inductor & inducer.

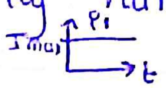
→ **Qualitative study of growth & decay of current:**

i) Growth of current:

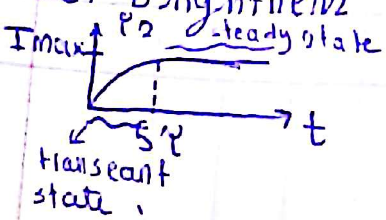


_ when we close the switch:

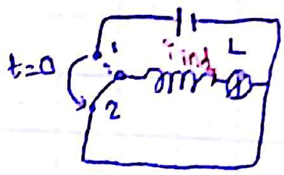
_ In branch AHB: current i_1 that traverses the resistor ↗s instantly & attains a cst value ⟹ L_1 glows instantly & attain cst brightness.



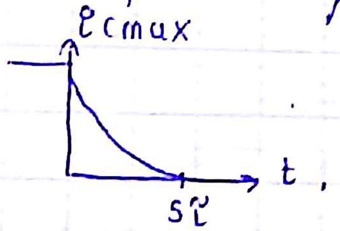
_ In branch ANB: i_2 that traverses the coil starts to increase, self induction ⟹ iind to oppose the ↗se in i, so iind delays the establishment of imax ⟹ i_2 ↗s progressively & attains cst value after a certain time (5τ), so L_2 glows progressively and attain cst brightness after 5τ.



ii) Decay (reduction of current).



at t = 0 sec, we move the switch from position 1 to position 2, so i starts to decrease (that traverse coil), then self induction occurs ⟹ iind to oppose variation in i ⟹ iind supports i ⟹ i ↘s progressively & reaches zero after certain time ⟹ Lamp turns off progressively.



Imp. * In this lesson: the current is always with ⊕ve direction.

→ Inductance of the coil "L":

$\phi = NBS\cos\theta \quad (\theta = 0)$

$= NBS$

$= NS \cdot \frac{\mu_0 N i}{l}$

$= \frac{N^2 S \mu_0}{l} i$

$\underset{wb}{\phi} = \underset{(H)\ \text{Henry}}{L} \underset{(A)}{i}$, where L is the inductance of the coil (H). $L = \frac{N^2 \mu_0 S}{l}$.

→ Faraday's law:

$\underset{(V)}{e} = -\frac{d}{dt}\phi$

$\underset{(V)}{e} = -L\frac{d}{dt} i \quad$ (If L is cst)

→ Ohm's Law for coil:

$V_{AB} = +(-e + ri)$

$= -e + ri$

$\boxed{V_L = L\frac{d}{dt} i + ri}$

→ Energy stored in coil:

$\underset{(J)}{W_{mag}} = \frac{1}{2} \underset{(H)}{L} \underset{(A)}{i^2}$ with $W_{mag\,max} = \frac{1}{2} L i_{max}^2$.

Notes on the Chapter:

→ Every coil is characterized by its inductance (L) + resistance

→ the coil stores energy in the form of magnetic energy.

→ Coil without iron core: has cst L.

→ Reostat resistor has a variable resistance.

→ $\Delta W_{el} = -\Delta W_{mag}$.

i

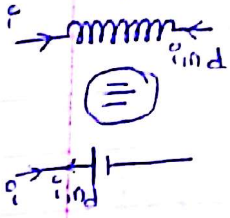
L

$i \nearrow$, $\frac{di}{dt} > 0$, $e_s < 0$, $e_s = -L\frac{di}{dt}$ ①, ②

$i_{ind} < 0$; electric energy ↗

coil recieves electric energy & converts it into magnetic

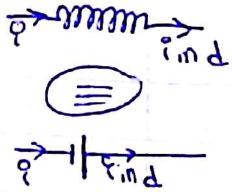
⇒ coil plays role of reciever



$$V_L = L\underbrace{\frac{d}{dt}i}_{>0} + ri.$$

$i \searrow$, $\frac{di}{dt} < 0$, $e_s > 0$, $i_{ind} > 0$,

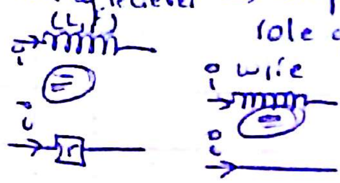
electric energy ↘, coil converts magnetic energy into electric ⇒ coil supplies electric energy ⇒ coil plays the role of generator



$$V_L = L\underbrace{\frac{d}{dt}i}_{<0} + ri$$

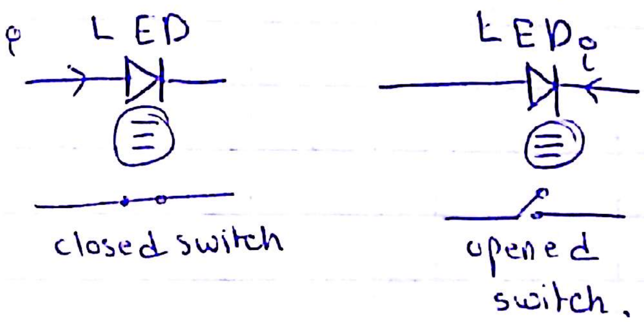
$i = cst$, $\frac{di}{dt} = 0$, $e_s = 0$.

- $r \neq 0$ (resistive coil): $V_L = L\frac{d}{dt}i + ri$, $V_L = ri = V_R$ ⇒ coil plays role of reciever (L, r)
- $r = 0$ (pure coil): $V_L = L\frac{d}{dt}i + ri$, $V_L = 0 = V_{wire}$ ⇒ coil plays role of wire



- e_s & $\frac{d}{dt}i$ have opp signs, if we're given them having same sign we've to put $\frac{d}{dt}i$ in a sign opp to that of e_s.

- If we've that i is increasing and we're given a cst value of i, in the time of increasing of i, then we can't bring V_L on the method of $V_L = L\frac{d}{dt}i + ri$, we've to bring it on summation of voltages.



- Oscilloscope reads from channel to ground.

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(VVImp) Chapter 10: AC voltage.

→ **Capacitor:** is formed of 2 // conducting plates separated by an insulator called dielectric.

→ Each capacitor is characterized by its capacitance "C"

where: $\underset{(\text{Farad})}{C} = \dfrac{\varepsilon \times S}{d}$ $\begin{cases} \varepsilon : \text{permittivity cst of dielectric used } (F/m) \\ S : \text{common surface area.} \\ d : \text{distance between 2 plates.} \end{cases}$

→ The quantity of charge of ⊕ve plate of capacitor is given by: $\underset{(\text{Coulomb})}{q} = \underset{(F)}{C}\underset{(V)}{U_c}$

→ The current that traverses the capacitor is given by:

$i = \dfrac{d}{dt} q$; where current is the rate of quantity of charge.

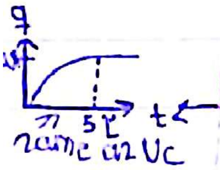
$i = C \dfrac{d}{dt} U_c$.

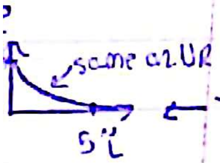
→ Capacitor stores energy in the form of electric energy.

$W_{elec} = \frac{1}{2} C U_c^2 \longrightarrow W_{el} = \frac{1}{2} \frac{q}{U_c} \times U_c^2 = \frac{q U_c}{2}$

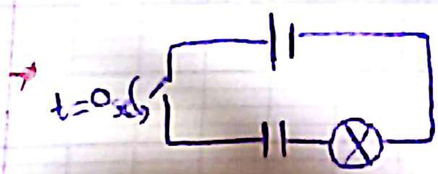
$W_{el} = \frac{1}{2} C \times \frac{q^2}{C^2} = \frac{q^2}{2C}$.

1) * Charging of capacitor:



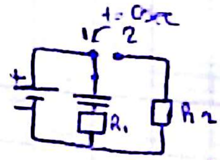


→ at $t = 0$ sec	as $t \nearrow$	at $t = 5\tau$
$q = 0$ C ⇒ $U_c = 0V$ but $E = U_c + U_R$, then $U_R = E = U_{max}$. ⇒ $i = I_{max} = \frac{E}{R}$	$q \nearrow$, $U_c \nearrow$. but $E = U_c + U_R$ & $U_c \nearrow$ so U_R will ↘ then i will ↘ $(U_R = Ri)$	$q = Q_{max}$, $U_c = U_{max} = $ but $E = U_c + U_R$ & U_c so $U_R = 0V$ ⇒ $i = 0A$.

→ 

Lamp glows instantly & turns off progressively.

* Derive 1st order D.E in terms of:

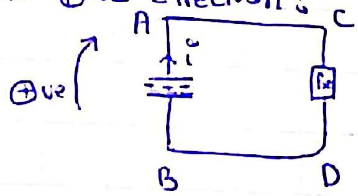


→ U_C:	→ q:	→ i:	→ U_R:
Apply law of add. of voltages: $E = U_C + U_R$. $E = U_C + Ri$ $E = U_C + R\frac{d}{dt}q$. $E = U_C + RC\frac{d}{dt}U_C$	Apply law of add. of voltages: $E = U_C + U_R$. $E = \frac{q}{C} + R\frac{d}{dt}q$.	Apply law of add of voltages: $E = U_C + U_R$. $E = \frac{q}{C} + Ri$ derive both sides w.r.t time: $0 = \frac{i}{C} + R\frac{d}{dt}i$.	Apply law of add of v: $E = U_C + U_R$ $E = \frac{q}{C} + U_R$ derive both sides w.r.t time: $0 = \frac{i}{C} \frac{d}{dt}U_R$ $0 = \frac{U_R}{RC} + \frac{d}{dt}U_R$.

* To draw graph $q = f(t)$, $i = f(t)$, $U_C = f(t)$; $U_R = f(t)$, we take 4 particular pts: $t = 0$, $t = \tau$, $t = 5\tau$, & $t = +\infty$.
* To bring t we've to know U_C (it can be given directly or indirectly)
* Capacitor is not affected with ⊕ve direction:

2) **Discharging of capacitor**

i) If i is in ⊕ve direction:



then $i = -\frac{d}{dt}q$ & not $\frac{d}{dt}q$, since $q \searrow$, $\frac{d}{dt}q < 0$, but $i > 0$ so $i = -\frac{d}{dt}q$.

* $U_{AB} + U_{BD} + U_{DC} + U_{CA} = U_{AA} = 0$

$U_C + 0 - U_R + 0 = 0$

$U_C = U_R$ (law of uniqueness of voltage)

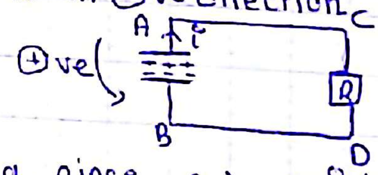
$U_C = Ri$

$U_C = R \times -\frac{d}{dt}q$.

$U_C = -RC\frac{d}{dt}U_C$

$\boxed{U_C + RC\frac{d}{dt}U_C = 0.}$ D.E.

ii) if i is in ⊖ve direction



$i = \frac{d}{dt}q$, since $q \searrow$ & $i < 0$, so $i = \frac{d}{dt}q$.

* $U_{AB} + U_{BD} + U_{DC} + U_{CA} = U_{AA} = 0$

$U_C + 0 + U_R + 0 = 0$

$U_C + U_R = 0$ (law of addition of voltages)

$U_C + Ri = 0$

$U_C + R\frac{d}{dt}q = 0$

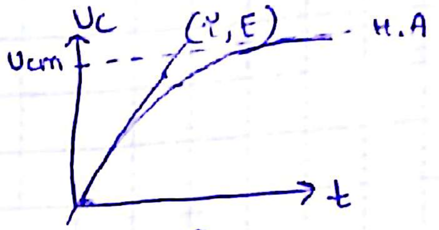
$\boxed{U_C + RC\frac{d}{dt}U_C = 0.}$ D.E.

Time cst of RC circuit: 'τ':

In charging: $U_C = E(1 - e^{-t/\tau})$

1) $\tau = R_t . C$, where R_t is the total resistance of charging circuit.
2) for $t = \tau$, $U_C = 0.63 E = k$, from graph, for $U_C = k$, $t = \tau = n$.
3) we draw tang to curve at $t = 0$ sec, it cuts HA in pt of abscissa τ.

i) 1st proof:



$U_C = E(1 - e^{-t/\tau})$.

$$\frac{d}{dt}U_C\Big)_{t=0} = \frac{E}{\tau}e^{-t/\tau} . = \frac{E}{\tau}.$$

$$\frac{d}{dt}U_C\Big)_{t=0} = \text{slope of tang}\Big)_{t=0} = \frac{\Delta U_C}{\Delta t} = \frac{E}{t_A}.$$

$$\frac{d}{dt}U_C{}_{t=0} = \frac{d}{dt}U_C{}_{t=0}.$$

$$\frac{E}{\tau} = \frac{E}{t_A} \Rightarrow \tau = t_A.$$

ii) 2nd proof:

eq of H.A: $U_{C} = E$.

eq of tangent $=$ ~~$\frac{E}{\tau}$~~ $U_C = at$.

$a = \text{slope} = \frac{d}{dt}U_C$ at $t = 0$ $= \frac{E}{\tau}$.

eq of tangent $= U_C = \frac{E}{\tau}t$.

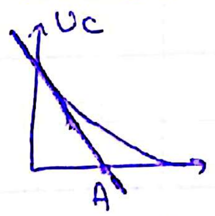
$U_C = U_C$,

$E = \frac{E}{\tau}t. \Rightarrow t = \tau$.

In discharging: $U_C = Ee^{-t/\tau}$

1) $\tau = R_t . C$ where R_t is the total resistance of discharging circuit.
2) for $t = \tau$, $U_C = 0.37 E = k$, for $U_C = k$, $t = n$ (from graph).
3) we draw tang to curve at $t = 0$ sec, it cuts H.A with pt of abscissa τ

i) 1st proof:



$$\frac{d}{dt}U_C\Big)_{t=0} = -\frac{E}{\tau}e^{-t/\tau} . = -\frac{E}{\tau}$$

$$\frac{d}{dt}U_C\Big)_{t=0} = \text{slope of tang}\Big)_{t=0} = \frac{\Delta U_C}{\Delta t} = \frac{E}{t_A}.$$

$$\frac{d}{dt} U_C\Big)_{t=0} = \frac{d}{dt} U_C\Big)_{t=0}$$

$$\frac{E}{\tau} = \frac{E}{t_A} \Rightarrow t_A = \tau.$$

2nd proof:

eq of HA: $U_C = 0$

eq of tang at $t=0$: $U_C = at + b$.

$$a = \frac{d}{dt} U_C\Big)_{t=0} = -\frac{E}{\tau}.$$

$b = E$.

$$U_C = -\frac{E}{\tau} t + E.$$

$U_C = U_C$.

$$-\frac{E}{\tau} t + E = 0.$$

$$\frac{E}{\tau} t = E \Rightarrow \tau = t.$$

→ Definition of τ: Is the time needed for U_C to ↗ or ↘ by 63% its max value.

→ $\frac{d}{dt} U_C$ → 1) DE
2) slope of tangent
3) solution for D.E.

IVVV Imp. → For charging:

We have: Power $= \frac{d}{dt}$ energy $=$ voltage × current.

→ G $P_G = U_G \times i = E \times I_m e^{-t/\tau} = E \times \frac{E}{R} e^{-t/\tau} = \frac{E^2}{R} e^{-t/\tau}$.

$$P_G = \frac{dW_G}{dt}, \quad W_{G\,0\to5\tau} = \int_0^{5\tau} P_G = \int_0^{5\tau} \frac{E^2}{R} e^{-t/\tau} = \left[\frac{E^2}{R(-\frac{1}{\tau})} e^{-t/\tau}\right]_0^{5\tau} = \left[-\frac{E^2}{R} \times \right.$$

$$= \left[-E^2 \times C e^{-t/\tau}\right]_0^{5\tau} = -E^2 C \times 0 + E^2 \times C$$

$$W_{G\,0\to5\tau} = E^2 \times C.$$

$$\rightarrow R \begin{cases} P_R = U_R \times i = Ri \times i = Ri^2 = RI_m^2 e^{-2t/\tau} \\ \underset{0\to5\tau}{W_R} = \int_0^{5\tau} P_R\, dt = \int_0^{5\tau} RI_m^2 e^{-2t/\tau} = \dfrac{RI_m^2}{(-\frac{2}{\tau})} e^{-2t/\tau} \\ = -\dfrac{RI_m^2 \times \tau}{2} e^{-2t/\tau} = \dfrac{-R \times \frac{E^2}{R^2} \times RC}{2} e^{-2t/\tau} \end{cases}$$

$$= \left[-\frac{E^2 \times C}{2} e^{-2t/\tau}\right]_0^{5\tau} = +\frac{1}{2} C E^2.$$

$$\rightarrow C \begin{cases} P_C = U_C \times i = E(1-e^{-t/\tau}) \times I_m e^{-t/\tau} = \dfrac{E^2}{R}(e^{-t/\tau} - e^{-2t/\tau}). \\ W_C = \int P_C\, dt = \dfrac{E^2}{R} \int e^{-t/\tau} - e^{-2t/\tau} = \dfrac{E^2}{R}\left[-RCe^{-t/\tau} + \dfrac{RC}{2} e^{-2t/\tau}\right] \\ = -\dfrac{E^2}{R} \times RC e^{-t/\tau} + \dfrac{RC}{2} \times \dfrac{E^2}{R} e^{-2t/\tau} \\ = -CE^2 e^{-t/\tau} + \dfrac{CE^2}{2} e^{-2t/\tau}. \\ = \left[CE^2 \left[-e^{-t/\tau} + \frac{1}{2} e^{-2t/\tau}\right]\right]_0^{5\tau} \end{cases}$$

$$\underset{0\to5\tau}{W_C} = \frac{1}{2} CE^2$$

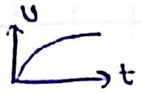
or, $C \begin{cases} P_C = U_C \times i = U_C \times C \dfrac{d}{dt} U_C = CU_C \times U_C' = \dfrac{d}{dt}\left(\frac{1}{2} C U_C^2\right) \\ W_C = \int \dfrac{d}{dt} \dfrac{1}{2} CU_C^2 = CU_C^2 = CE^2. \\ \qquad (\text{at } t = 5\tau,\ U_C \simeq E). \end{cases}$

<u>Notes:</u>

- to bring a cst from solution we use I.C → value = ~ (substitution); → value = ~ (given in circ

. Prove that $U_C + U_R = E$ (law of addition of voltages, prove U_C & U_R have opp variation.

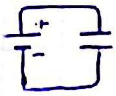
- Pay attention to I.C. when used in calculating cst.
- resistor produces energy in form of thermal one.
- current favors to pass through shortest circuit (less resistance) wire instead of resistor).
- If $U_C < E$, then for each existing U_C there's only 1 t.



{ at t=0sec, we close switch, it's graph of capacitor justify.
{ since time U increases from zero to max progressively w.r.t

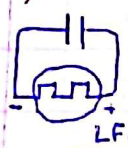
- watt = J/s.

I in worksheet

-  : time of charging = $5\tau = 5RC = 5 \times 0 \times C = 0$, so as we close switch, capacitor is fully charged.
- when we bring value of unknowns in time equation ($\frac{dq}{dt}$, Ucm, τ, D...etc) we write this time equation again.
- Pay attention to the scale on graph. Warning!!!

- 0.1A kills the person.
- ≠ : capacitor with adjustable capacitance (we can change value of C).
- $U_g = E - rI \Rightarrow$ ideal generator: $r=0$, then $U_g = E$.
- in square voltage: $i = \frac{d}{dt} q$.
- when capacitor is fully charged it, $U_C = f(t)$ becomes horizontal, since $i = C\frac{d}{dt}U_C$, but $i=0$, so $\frac{d}{dt}U_C$ must be zero.
- In square voltage, we can't change the ⊕ve direction,

⊕ve



: In charging i is with ⊕ve direction
In discharging i is with ⊖ve direction.

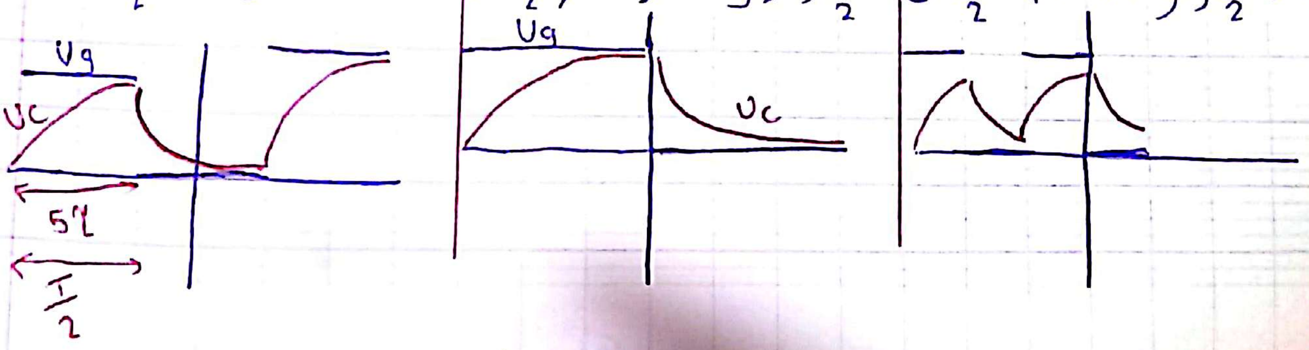
-  : for $t \in]0, \frac{T}{2}[$ L.F.G ⊜ generator.
$t \in]\frac{T}{2}, T[$ L.F.G ⊜ wire

3 cases:

1) if $\frac{T}{2} = 5\tau$,

2) $\frac{T}{2} > 5\tau$, $f_g \searrow$, $\frac{T}{2} \nearrow$

3) $\frac{T}{2} < 5\tau$. $f_g \nearrow$, $\frac{T}{2} \searrow$.



- If $\frac{T}{2} <<<< 5\tau$ (high freq): curve seen is almost triangular. prove that capacitor won't full
- from graph of u_C, at $t = u$ tang at $t = u$ has slope $\neq 0$, $\frac{d}{dt}u_C)_t \neq 0$ $i = C\frac{d}{dt}u_C$, $i \neq 0$ for $t \in]u, u[$.
- Deduce the variation of u from graph with time, we take its value at 1st time & how it varies with time, & its value at last time.

In charging: we use law of addition of voltages.
In discharging: we use law of uniqueness of voltage.

$P = \frac{d}{dt}W = \frac{\Delta W}{\Delta t}$. for power = cst. $P = \frac{W}{t}$.

~~for~~
$W = \int P.dt$.
for $P = cst$ (special case).
$W = P \times t$.

$P_{av} = \frac{\Delta W}{\Delta t}$.

$P_{inst} = \frac{d}{dt}W$.

Alternating sinusoidal voltage:

- $T = x.Sh$; $F = \frac{1}{T}$; $\omega = \frac{2\pi}{T}$; $\omega = 2\pi f$.

- $U_{max} = y \times S_v$, $U_{eff} = \frac{U_{max}}{\sqrt{2}}$.

Phase diff: ~~of a~~

- $\varphi_{a/b} = \pm \frac{2\pi \alpha}{\alpha'}$ horizontal distance between 2 curves if both are going up
no. of div for 1 period. or both are going down.

"a" leads "b" : a reaches max. before "b":

If a leads b: then $\varphi_{a/b} > 0$
If a lags behind b: then $\varphi_{a/b} < 0$.
$\varphi_{a/b} = \varphi_a - \varphi_b$.

- $U_b = U_{mb} \sin(\omega t + \varphi_b)$ $\varphi_b = \frac{\pi}{4}$ we've (a) leads (b): $\varphi_{a/b} = \frac{\pi}{3}$,

write expression of $U_a = f(t)$:

- take Ub as reference:

(a) leads (b) by $\frac{\pi}{3}$ lead.

then $U_a = U_{ma} \sin(\omega t + \frac{\pi}{4} + \frac{\pi}{3})$.

If $\varphi_{a/b} = -\frac{\pi}{3}$ & a lags behind (b); then $U_a = U_{ma} \sin(\omega t + \frac{\pi}{4} - \frac{\pi}{3})$ lags behind

- U_R is the image of i: since: $U_R = Ri$, but $R = cst > 0$, so U_R & i are directly proportional $\Rightarrow$ U_R & i are inphase $(\varphi_{U_R/i}) = 0$.

- $U_L = L\frac{d}{dt}i + ri$.

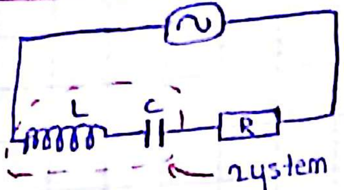
- $U_{Lmax} = I_m \sqrt{L^2\omega^2 + r^2}$

- for $r = 0$, $\tan \varphi_{U_L/i} = \frac{L\omega}{r}$ ~~$= \frac{L}{}$~~ $\Rightarrow \varphi_{U_L/i} = \tan^{-1} \frac{L\omega}{r} = \tan^{-1} + \infty = \frac{\pi}{2}$.

for $r \neq 0$, $\tan \varphi_{U_L i} = \frac{L\omega}{r} \Rightarrow \varphi_{U_L/i} = \tan^{-1} \frac{L\omega}{r}$, then $0 < \varphi_{U_L/i} < \frac{\pi}{2}$.

- $U_C = \frac{1}{C}\int i.dt$ (needs proof when we want to use it).
- $U_{Cm} = \frac{I_m}{C\omega}$. $\varphi_{U_C/i} = \frac{\pi}{2}$.

RLC circuit under sinusoidal voltage:



system resonator has freq $f_0 = \frac{1}{2\pi\sqrt{LC}}$

- we have 3 cases:

1st case: $f_g < f_0$ (low freq), then capacitor dominates on coil:
U_R or i leads U_g (capacitive circuit).

2nd case: $f_g > f_0$ (high freq), then coil dominates on capacitor.
U_g leads U_R or i $\Rightarrow$ (inductive circuit).

3rd case: $f_g = f_0 \Rightarrow$ effect of coil cancels effect of capacitor ($U_C = U_L$), $\Rightarrow$ circuit becomes U_g & i only where U_g & i are inphase $\varphi_{u_g/i} = 0 \Rightarrow$ current resonance phenomenon

C i v i l

$f_g < f_0$
i leads U_g

$f_g > f_0$.
U_g leads i.

- we have:

$$\varphi_{u_g/i} = \tan^{-1}\left[\frac{L\omega - \frac{1}{C\omega}}{R+r}\right]$$

$$U_{gm} = I_m\sqrt{\left[L\omega - \frac{1}{C\omega}\right]^2 + [R+r]^2}$$

- At current resonance:

- $\varphi_{u_g/i} = 0$, U_g & i are inphase.
- $L\omega = \frac{1}{C\omega}$, $LC\omega^2 = 1$ $\quad f_g = f_0 = \frac{1}{2\pi\sqrt{LC}}$.
- I_{eff} in the circuit reaches its max value at current resonance

$I_{eff} = \frac{U_{geff}}{R_t}$, $I_{eff} = \frac{U_{Reff}}{R}$, $I_m = \frac{U_{gm}}{R_t}$; $I_m = \frac{U_{Rm}}{R}$.

$\varphi_{ug/i}$ at R-L-C circuit $= \tan^{-1}\left(\dfrac{L\omega - \frac{1}{C\omega}}{R+r}\right)$

1) If $L\omega < \frac{1}{C\omega}$ $f_g < f_o$ "$\omega = 2\pi f$".

Then $L\omega - \frac{1}{C\omega} < 0$.

$\varphi_{ug/i} < 0$

$\Rightarrow$ i leads U_g

$\Rightarrow$ Capacitor dominates on coil.

(capacitive circuit)

2) If $L\omega > \frac{1}{C\omega}$ "$f_g > f_o$"

Then $L\omega - \frac{1}{C\omega} > 0$

$\varphi_{ug/i} > 0$

$\Rightarrow$ U_g leads i

$\Rightarrow$ coil dominates on capacitor

(inductive circuit)

3) If $L\omega = \frac{1}{C\omega}$ ($f_g = f_o$)

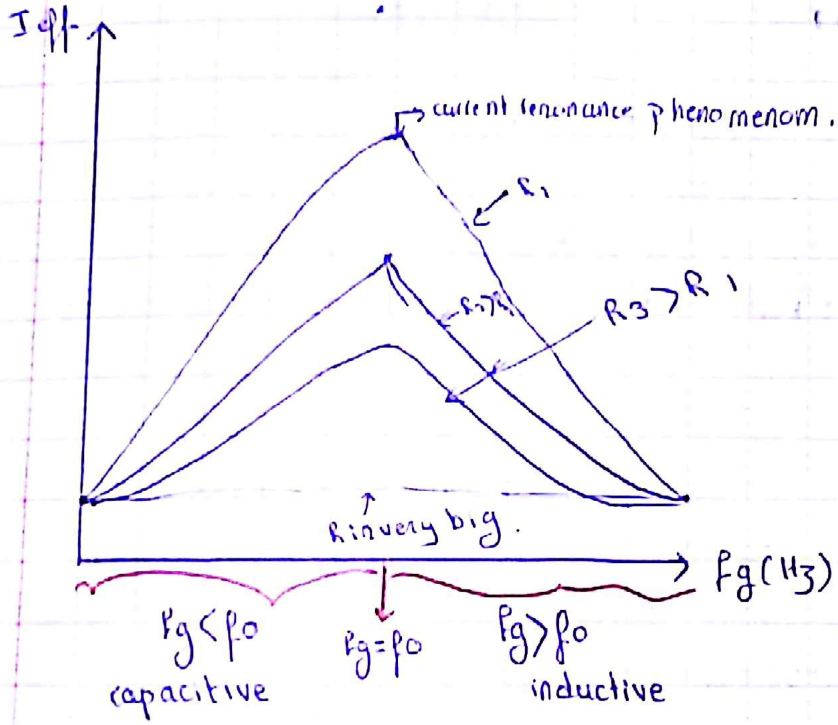
Then $L\omega - \frac{1}{C\omega} = 0$.

Then $\varphi_{ug/i} = 0$

$\Rightarrow$ U_g & i are inphase

$\Rightarrow$ effect of coil cancel effect of capacitor

$\Rightarrow$ current resonance phe[nomenon]



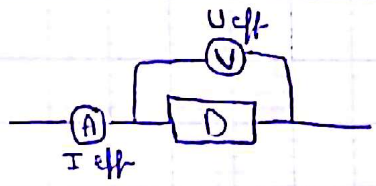
since $I_{eff} = \frac{U_R}{R}$,

$\Rightarrow$ for R is very sma[ll] I_{eff} is large $\Rightarrow$ sharp curve.

$\Rightarrow$ for R is very large $\Rightarrow$ I_{eff} is small $\Rightarrow$ broad curve.

non 2 wires

Electric power of a dipole:



$$P_D = U_{eff(V)} \times I_{eff(A)} \times \cos(\varphi_{uD/i}).$$

special cases:

$P_R = R\, I_{eff} \times I_{eff} \times \cos(\underbrace{\varphi_{uR/i}}_{=0})$; $\cos = 1$

$P_R = R\, I_{eff}^2$.

$P_C = U_{C\,eff} \times I_{eff} \times \cos(\underbrace{U_C/i}_{=\frac{\pi}{2}})$; $\cos = 0$

$P_C = 0$ W.

P_L → if $r=0$ (pure inductive) : $P_L = U_{eff\,L} \times I_{eff\,L} \times \cancel{\cos}(\varphi_{U_L/i})$, with $(\varphi_{U_L/i}) = \frac{\pi}{2}$ and $\cos(\varphi_{U_L/i}) = 0$

$P_L = 0\,W$

→ for resistive coil : $P_L = U_{eff\,L} \times I_{eff\,L} \times \cos(\varphi_{U_L/i})$

$P_{resistive\ coil} = P_{pure} + P_r$

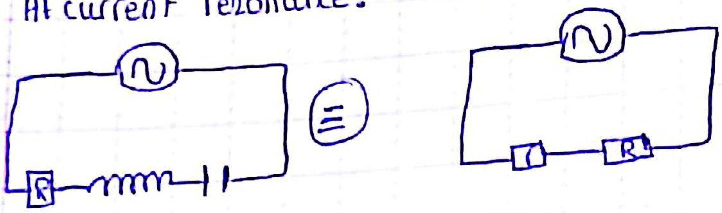
$= 0\,W + P_r$

$P_{resistive\ coil} = r\,I_{eff}^2$.

→ for current resonance:

P consumed in the circuit = $\boxed{R_t I_{eff}^2 \text{ is max}}$

At current resonance: the circuit :



→ $P_G = U_{g\,eff} \times I_{g\,eff} \times \cos(\varphi_{u_g/i})$

$P_G = P_L + P_C + P_R$

$= r I_{eff}^2 + 0\,W + R I_{eff}^2$

$= R_t I_{eff}^2 = P_G$ = P consumed by the circuit.

Notes:

→ i is the key of solving the ques.

→ We press ⊕inv buttom when we're recording voltages of 2 components (capacitor, coil, resistor, etc..).

→ There's no need to press ⊕inv when we're reading volt of generator with component.

→ If we're obliged with ⊕ve direction we press ⊕inv to component that is with ⊖ve direction.

→ when we write $U_R = Ri$ we've to say it's Ohm's L

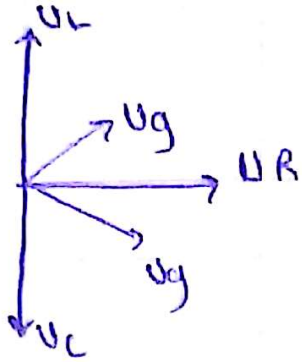
→ Ammeter reads I_{eff}, voltmeter reads U_{eff}.

→ i: expression of I.

I: I_{eff}.

Im: Imax,

* coil + capacitor : resonator.
generator : excitor.



ω can be given in the expression of U_g.

Chapter 13: Diffraction of light

- In air: $C = \lambda \nu$.
  In medium: $V = \lambda' \nu$
  $\left\} \frac{C}{V} = \frac{\lambda}{\lambda'} = n. \right.$

- In air ~ vaccum $400nm \leq \lambda_{visible} \leq 800nm$.
- In any other medium $\frac{400nm}{n_{medium}} \leq \lambda_{visible} \leq \frac{800nm}{n_{medium}}$

- frequency depends on color not on medium, so $3.75\times10^{14} \leq \nu_{visible} \leq 7.5\times10^{14}$ for all mediums.
- If we mix all colors with same %, we obtain white color.

- Diffraction: Is the spread out of light when it passes through relatively narrow slit or relatively sharp edge.
- Conditions of diffraction:
1) The width of the slit (a) must be near to the wavelength λ of light used (for visible $a \leq 1mm$).
2) The distance between plane of slit & screen must be order of meters (to obtain well seen D+BF)
- Description of diffraction figure:
- Alternating + sym dark & bright fringes w.r.t C.BF.
- The width of C.BF is double the width of other b.Fs
- fringes are aligned ⊥ to direction of slit.
- Intensity of BFs ↘ as order ↗.

- Diffraction shows wave aspect of light since:
BFs are due to constructive superposition of inphase waves. ($\varphi = 0$ rad.)
DFs are due to destructive superposition of ant waves. ($\varphi = \pi$ rad)

- According to Hygen's Principle: each pt of the slit plays the role of 2ndary source.
- Using a narrow slit we can't isolate a Light ray (it diffracts.

- monochromatic Light: a Light with single freq (1 color) such as laser.
- polychromatic Light: a Light with more than 1 freq. more than one main color.

- Rules.

$\sin \theta_n = \frac{n\lambda}{a}$. $\Rightarrow$ but, since θ_n is very small $(D \ggg x_n^d)$

$\tan \theta_n = \frac{x_n^d}{D}$ "$\theta_n < 0.17\,rad \simeq 10°$), so $\sin \theta_n = \tan \theta_n = \theta_n$

$\sin \theta_n = \tan \theta_n = \theta_n$.

$\frac{x_n^d}{D} = \frac{n\lambda}{a}$.

$x_n^d = \frac{n\lambda D}{a}$.

x_n^d: position of d.f. of order n.
n: order of d.F., a: width of slit.
λ: wave length of light used.
D: distance between plane of slit & scree

- Linear width: (L): of C.B.F:

$L = 2x_1^d = \frac{2\lambda D}{a}$.

- Angular width (α) of C.B.F:

$\alpha = 2\theta_1 = \frac{2\lambda}{a}$.

$\alpha = 2\theta_1 = \frac{2x_1^d}{D} = \frac{L}{D}$ (D isn't affected with α, since as D change L change to keep on α

- (Every rule except θ_n needs proof.)

→ If we have 2 exps in the ques, we write the rule in every exp & divide them to iliminate csts.

→ Detector detects:

same as observation of diffraction.

→ If we illuminate a slit with white light, we observe that:

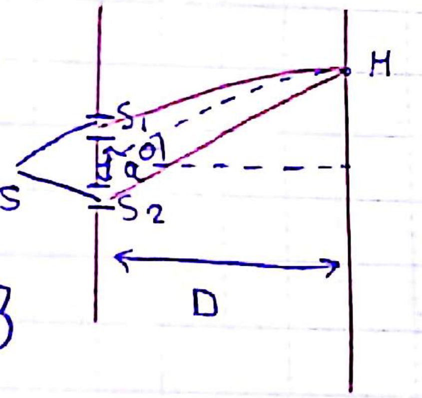
- The centers of all C.BFs coincide with common width = to that of violet (Lv is smallest, "it has smallest λ").
- colors superpose
- We observe at O white light with width = Lv.

Chapter 14: Interference.

- **Interference phenomenom "kind of superposition:**
Is due to superposition of 2 synchronous & coherent waves:
synchronous: same frequency "color".
coherent: cst phase difference.
- **Conditions of Interference:**
The 2 sources must be synchronous & coherent ⇒ to satisfy such condition we illuminate 2 narrow + close slits from a single same source.
- **Discription of interference:** Fringes are:
- Rectilinear.
- Equidistant.
- Alternating + sym bright & dark w.r.t. C.BF.
- parallel to each other and to the slit.
- **Interference shows the wave aspect of Light**, since:
- Bright fr, are due to constructive superposition of inphase waves
- DFs are due to destructive superposition of antiphase waves

- **Study of interference:**

expression of optical path diff:



$$\delta = (SS_2 + S_2M) - (SS_1 + S_1M)$$
$$= \underbrace{SS_2 - SS_1}_{=0,\ S \text{ on } \perp \text{ of } (S_1S_2)} + S_2M - S_1M$$
$$= S_2M - S_1M$$

$\boxed{\delta_g = \frac{ax}{D}}$ {it satisfies D & BFs.}

order of b.F - $\delta b = k\lambda$ ⇒ center of b.F.(inphase), where k is a multiple of λ.
- $\delta d = (2k+1)\frac{\lambda}{2}$ ⇒ center of d.F(antiphase), k in odd multiple of $\frac{\lambda}{2}$.
- x_k^b & x_k^d: we bring them from $\delta = \delta$:

$$\delta b = \delta g.$$
$$k\lambda = \frac{a x_k^b}{D}$$
$$x_k^b = \frac{k\lambda D}{a}$$

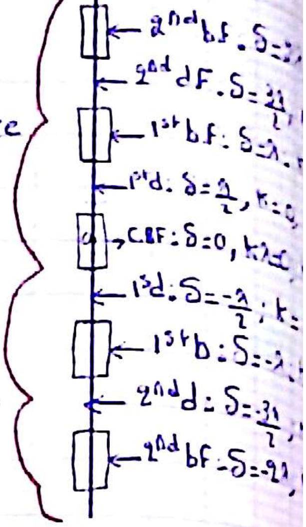
$$\delta d = \delta g.$$
$$(2k+1)\frac{\lambda}{2} = \frac{a x_k^d}{D}$$
$$x_k^d = (2k+1)\frac{\lambda D}{2a}$$

Scanned by CamScanner

- for $\delta_{wr} = 0$: then P is the center of C.B.F.

- To check if a pt is center of b or d.F:
- if $\frac{\delta}{\lambda} \in \mathbb{Z}$ $\{0, \pm 1, \pm 2 \ldots\} \Rightarrow$ C. of b.F.

Interference zone



- $\frac{\delta}{\frac{\lambda}{2}} \in$ odd in $\mathbb{Z}$ $\{\pm 1; \pm 3 \ldots\} \Rightarrow$ C. of d.F.

neither $\frac{\delta}{\lambda} \in \mathbb{Z}$ nor $\frac{\delta}{\frac{\lambda}{2}} \in$ odd in $\mathbb{Z}$ then pt is neither center of b.F nor center of d.F.

- In general:

In bright ; k = order.

In dark : above O: k = order − 1.

order = k + 1.

below O : k = order.

- interfringe distance "i": Is the distance separating the ce[nters] of 2 consecutive fringes of same nature (bright − bright) or (dark − dark) ; (d betw 2 consec. fringes $= \frac{i}{2}$).

- For bright bright:

$$i = x_b^{k+1} - x_b^{k}$$

$$= (k+1)\frac{\lambda D}{a} - \frac{k\lambda D}{a}$$

$$i = \frac{\lambda D}{a}$$

For dark − dark :

$$i = x_d^{k+1} - x_d^{k}$$

$$= 2(k+1)+1\,\frac{\lambda D}{2a} - (2k+1)\frac{\lambda D}{2a}$$

$$= \frac{2\lambda D}{2a}$$

$$i = \frac{\lambda D}{a}$$

1) - Displacement of source (S):

- If S moves on ~~the~~ ⊥ of $[S_1S_2]$: $\delta = \frac{ax}{D}$, ⇒ no chan[ge] in δ, no change in x ⇒ no change in interference figure.

- Spectroscope: device used to separate superposed colors.

- If (S) moves on axis ∥ to plane of slit, CBF is no more at O ($\delta_0 \neq 0$).

$$\delta_{new\,C.BF} = 0$$
$$(SS_2 + S_2O') - (SS_1 + S_1O') = 0.$$
$$SS_2 - SS_1 + S_2O' - S_1O' = 0.$$
$$SS_2 - SS_1 = S_1O' - S_2O'.$$
but $SS_2 - SS_1 > 0$

$S_1O' > S_2O' \Rightarrow O'$ below $O \Rightarrow$ C.BF is shifted downward

→ new $\delta g = SS_2 - SS_1 + S_2P - S_1P$

$$\delta g = \frac{a\overbrace{y}^{\text{position of source}}}{d} + \frac{a\overbrace{x}^{\text{position of pt } P}}{D}.$$

→ Position of O':

$$\frac{a x_0}{D} + \frac{ay}{d} = 0.$$

$$x_0 = \ominus \frac{yD}{d}$$ x_{CBF} & y have opp signs, If S shifted up, C.BF is shifted down.

→ x_b^k & x_d^k:

$\delta_b = \delta g$

$$k\lambda = \frac{ax}{D} + \frac{ay}{d}.$$

$$\boxed{x_k^b = \frac{k\lambda D}{a} - \frac{\cancel{a}yD}{d}}$$

$\delta_d = \delta g.$

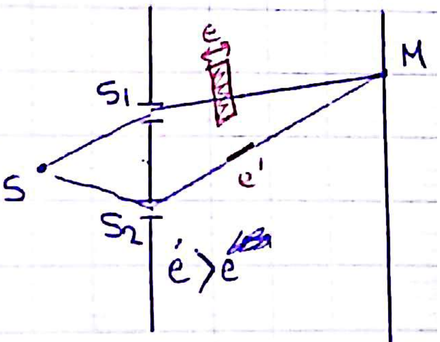
$$(2k+1)\frac{\lambda}{2} = \frac{ax}{D} + \frac{ay}{d}.$$

$$\boxed{x_k^d = (2k+1)\frac{\lambda D}{2a} - \frac{yD}{d}.}$$

→ $i = cst$, for displacement of source.

2) → Glass plate of index (n):

→ $\delta_M = S_2M - S_1M.$



In glass: $v = \frac{d}{t} = \frac{e}{t} \Rightarrow t = \frac{e}{v}.$

In air: $C = \frac{d}{t} = \frac{e'}{t} \Rightarrow e' = C \times t \Rightarrow e' = \frac{C}{v} \times e$

$\Rightarrow e' = ne.$

→ path diff due to glass plate: $e' - e = ne - e = e(n-1).$

$$\delta = S_2M - S_1M = S_2M - (S_1M + e(n-1)).$$

$$= \cancel{\frac{ax}{D} \pm (}$$

$$\delta g = \cancel{\delta x}\ \frac{ax}{D} \pm e(n-1).$$

$S_{ggg} = \frac{ax}{D} + \frac{ay}{d} \mp e(n-1)$.

- new position of C.B.F:

$S_{C.B.F} = 0$.

$\frac{ax}{D} - e(n-1) = 0$.

$x_{C.B.F} = \frac{e(n-1) \times D}{a} > 0$ & C.BF is shifted upward.

- When we put 1glass and we want for the C.BF that's shifted up to return back to 0 we can:
- display the source upward.
- put another glass sym to that we put.
- remove glass.

- Emission of white light:

What do you observe at O: $S_O = 0 \; \forall \lambda$, C.BF of all radiations coincide at O $\Rightarrow$ colors superpose to obtain white color.

1) If he said x_H = value (white light), find λs superpos inphase at it: we bring ~~$\lambda = f(x)$. substitute at~~ $\lambda = f(K)$, substitute K in $400 \leq \lambda \leq 800$, then bring value of K & bring λ.

2) If he said: source emits 2 radiations λ_1 & λ_2, find x where 2 λs superpose antiphase.

we solve: $x_d^k = x_d^k$.

$$(2k_1+1)\frac{\lambda_1 D}{a} = 2k_2+1 \frac{\lambda_2 D}{a}.$$

$$\frac{(2k_1+1)}{(2k_2+1)} = \frac{\lambda_2}{\lambda_1} = nb_{//}.$$

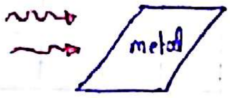
we try values of k_1, the value that gives us $k_2 \in \mathbb{Z}$ then we substitute k_1 or k_2 & bring x.

- when we move ~~source~~ source by distance d, position of pt H of abscissa $x = x + d$.

Chapter 16 : Photoelectric effect.

Photoelectric effect: Is the extraction or emission of electron from the surface of metal when it's illuminated by suitable radiation.

radiation (light carry energy)



: electrons emitted are called photoelectrons.

- each metal is characterized by: W_0: work function, extraction energy, ionization energy.
  ν_0: threshold frequency.
  λ_0: " wavelength, wh

W_0: is the min energy needed to extract e^- from metal.
ν_0: " " freq " " " " " "
λ_0 is the max wavelength " " " " " "
since $\lambda max = \frac{C}{\nu_0 min}$

- ev: electron volt new unit of energy. $ev \xrightarrow{\times 1.6\times10^{-19}} J$, $J \xrightarrow{\div 1.6\times10^{-19}} ev$.

- Photo electric effect shows corpuscular aspect of light:

since: 1) wave theory states that light is formed of continuous radiations, so it gives continuous energy, then we can extract ~~any~~ electron from any metal with any radiation by long illumination, but it contradicts with real exp.

2) Planck - Einshtien Hypothesis:

Light is an electromagnetic radiation formed of small particles ~~called~~ corpuscular called photons & charact by:

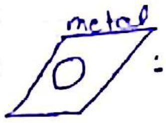
photon:
- massless
- chargeless
- propagates in vaccum with speed C.
- E: carry energy: $E ph = \frac{hc}{\lambda} = h\nu = \frac{hV}{\lambda'}$

$\frac{hc}{\lambda}$ in vaccum; $\frac{hV}{\lambda'}$ in medium of index n other than air

h: Plancks cst: 6.62×10^{-34} J.s.
ν: 1/.

- Energy of monochromatic light is quantized; discrete, has well det value, discontin. E
- Energy light = $k h\nu = k \times E_{ph}$, where $k \in \mathbb{N}$ is nb of photons
- Law of one to one where energy of 2 photons can't be added → energy of photon can't be separated.
- simple exp:

photon | $E_{ph} = \frac{hc}{\lambda_{ph}}$
λ_{ph}
ν_{ph}



: $W_0 = h\nu_0 = \frac{hc}{\lambda_0}$.
λ_0
ν_0

- for $E_{ph} < W_0$, $\lambda_{ph} > \lambda_0$, $\nu_{ph} < \nu_0$ ⇒ no extraction of e^- no ph.e.e.
- for $E_{ph} = W_0$, $\lambda_{ph} = \lambda_0$, $\nu_{ph} = \nu_0$ ⇒ extraction of e^- with zero speed ($KE_{e^-} = 0$) "rest e^-" ⇒ phee.
- for $E_{ph} > W_0$, $\lambda_{ph} < \lambda_0$, $\nu_{ph} > \nu_0$ ⇒ extraction of e^- with $V \neq 0$ ⇒ ph.e.e.

- Einshtien's Relation: $KE_{e^-} = E_{ph} - W_0$.
- We have: $KE_{max} = E_{ph} - W_0$ ∴ for $KE_{max} = 0$, $\lambda_{ph} = \lambda_0$.
$0 = \frac{hc}{\lambda_0} - W_0 \Rightarrow W_0 = \frac{hc}{\lambda_0} = h\nu_0$.
- $KE = h\nu - W_0$ (graph).

~~If we~~

- **Photocell**: it converts radiant energy into electric one.

- N_r = nº of recieved photons.
- E_r (energy rec.) $= N_r . E_{ph} = N_r . h\nu = \frac{N_r hc}{\lambda}$.
- P_r (power ″) $= \frac{E_r}{t} = \frac{N_r . E_{ph}}{t} = \frac{N_r h\nu}{t}$

- N_{eff} : nº of eff photons (that act
- $E_{eff} = N_{eff} . E_{ph} = N_{eff} h\nu = N_{eff}$
- $P_{eff} = \frac{E_{eff}}{t} = \frac{E_{eff} h\nu}{t} = \frac{E_{eff}}{\lambda}$

- Efficiency of photocell:

$\eta = \frac{N_{eff}}{N_r} = \frac{E_{eff}}{E_r} = \frac{P_{eff}}{P_r}$

$\%\eta = \frac{N_{eff}}{N_r} \times 100$.

- $I = \frac{|Q|}{t} = \frac{|N_{e^-} \times e_{e^-}|}{t} = \frac{N_{e^-} \times |-e|}{t} = \frac{N_{e^-} \times e}{t}$. $\begin{cases} N_{e^-} = N_{eff} : \text{nb of emitted } e^- \\ e : \text{elementary charge of } e^- = 1.6 \times 10^{-19} C \\ I : \text{electric current (A).} \end{cases}$

- <u>Planck's ~~law~~ theory</u> exchange of energy between radiations & metal is quantized, which means metal takes energy from light which descrete.

- <u>Notes:</u> vvvImp.
- to ↗I, we've to ↗N_{e^-} ⇒ ↑N_{eff} ⇒ ↗N_r ⇒ ↗P_r. $I = \frac{N_{e^-} \times e}{t}$.
- I is independet of frequency: If we ↗ frequency: E_{ph} will ↗, so KE_{e^-} ↗ ($KE = E_{ph} - W_0$), so speed of e^- will ↗ ($KE_{e^-} = \frac{1}{2}mv^2$) but nb of emitted e^-s is cst ⇒ I is cst.
- Condition of phee:

$E_{ph} \geq W_0$

$\nu_{ph} \geq \nu_0$

$\lambda_p \leq \lambda_0$.

- If we have graph $KE = f(\nu)$: $KE = h\nu - W_0$, & he said that this graph's for cesium ion, draw on same graph $KE = f(\nu)$ of Zn ion: We draw a line having same slope (h) (// to graph) since h is Planck's <u>cst</u>.
- $KE = f(\lambda)$: graph  ~~to bring~~ $KE = \frac{hc}{\lambda} - W_0$, to bring W_0 & h we take 2 pts on graph, substitute, solve system.
- <u>White light:</u> is a set of visible electromagnetic radiations whose wavelength is vaccum is between 400 & 800nm.
- To use $E_{ph} = \frac{h\nu}{\lambda'}$, we've to prove it;

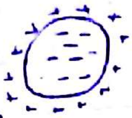
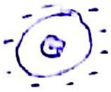
where $E_{ph} = \frac{hc}{\lambda}$ but $C = n \times V$, $\lambda = n \times \lambda'$, then $E_{ph} = \frac{hV}{\lambda'}$.
- Interaction with matter needs few eVs.
- area sphere $= 4\pi R^2$.
- ~~as~~ pt source considered sphere given ligh in all directions:

$P_{emitted} \longrightarrow$ area sphere $= 4\pi R^2$

$P_{recieved} \longrightarrow$ area given
- Don't take particular pts on the limits of graph (asymptotes).
- $q = \frac{\Delta KE}{\Delta u}$.

Chapter 17: The atom:

History of Atom:

- **Thomson's Model:**  with diameter 10^{-10} m, where the mass is associated with ⊕ve.
- **Rutherford's Model.**  : positive charges embedded in nucleus where e-'s move around it similar to planets around sun.
- **Bohr's Model:** Each atom has its own set of allowed energy levels in which e's can be found.

- Any intermediate energy is strictly forbidden.
- Energy of atom is quantized, descrete, discontin, well-det...

- When e- move from energy level E_i to lower energy level E_f, ($E_f < E_i$) atom lose energy in form of photon. then atom emits photon of energy = $E_{ph} = \Delta E = E_i - E_{ph}$.
- When e- moves from energy level E_f to higher energy level E_{ph}, it absorbs photon with energy: $E_{ph} = \Delta E = E_f - E_i$.

Emission Spectrum:

- Is obtained by exciting an atom to emit photon.
- Emission spectrum is formed of descrete colored lines on black font.

Absorption Spectrum:

- Obtained by introducing absorbing atom (gas) in trajectory of white
- It's formed of descrete black lines in a rainbow font
- Using Absorbtion spectrum show energy ~~levels~~ of atom is descrete

λs descrete $\Rightarrow$ Eph decrete ($E_{ph} = \frac{hc}{\lambda}$); ΔE descrete $\Rightarrow$ E descr

Hydrogen atom:

Energy in hydrogen atom: $E_n = \frac{-13.6}{n^2}$ (ev) $n \in \mathbb{N}^*$.

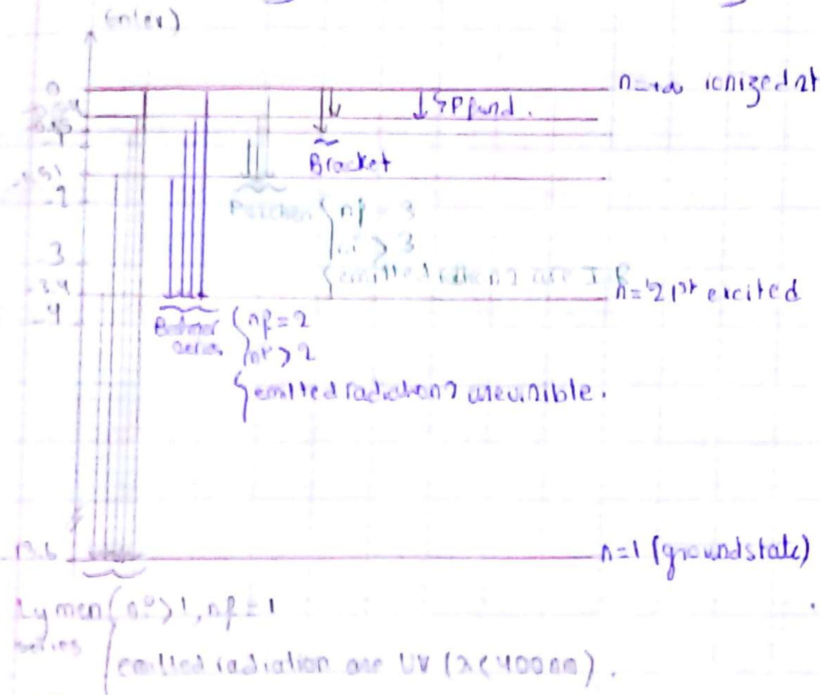
$n=1$ $E_1 = -13.6$ ev (ground or fundemental state).

$n=2$ $E_2 = -3.4$ ev (1^{st} excited state).

⋮

$n=+\infty$ $E_{+\infty} = 0$ (ionized state).

- Using relation $E_n = \frac{-13.6}{n^2}$, show energy of atom is quantized: we bring E_1, E_2 & E_3 & say E is discret $\Rightarrow$ E is quantized.



Lymen → Balmer
Parchen → Bracket
Pfund.

- **Interaction photon - atom:**

$E_{atom\,i} + E_{ph} = K$.

1) $K<0$, ∉ energy levels, no interaction ....
2) $K<0$, E energy level, interaction with $E_f = K$
3) $K \geq 0$, interaction, atom is ionized, $KE_{e^-} = K$, Phee.

- **Interaction electron - atom.**

$E_{atom\,i} + KE_{e^-} = K$.

1) $K<0$, $K<E_{i+1}$, no interaction..
2) $K<0$, $K>E_{i+1}$, interaction, where atom absorb energy from e^- & become in new excited state, e^- leaves with $KE_{e^-} = E_{pul} K - E_f$
3) $K>0$, Interaction (atom takes either part or all energy).

Notes VVVVImp:

- E_{atom} is ⊖ve since e^- is bound to nucleus.
- Atom can't stay in excited state for a long time.
- If a photon of $\lambda = $ nm is absorbed by atom in n state: In hydrogen we say $\Delta E_{m \to n} = E_{ph}$. & bring E_m then bring n if $n \in \mathbb{N}^*$: ✓, $n \notin \mathbb{N}^*$: ✗

- Emission spectrum ⇒ downward transition.
Absorption spectrum ⇒ upward transition.
- Energy of atom depends on position of e^-s on energy levels.
- ground state: level that has lowest energy.

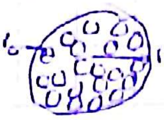
2006 1st G.S - For same atom: Emission spect, Absorption spectrum = full spectrum
2006 2nd L.S - For same atom: Emission spect, nb of dark lines in absorbtion spectrum = nb
2009 1st GS - " " " nb of dark lines in absorbtion spectrum = nb of colored lines in emission one.

- If he said prove that all λs in Lymen series are U.V: we bring λmax & prove it < 400nm.
- To see if photon is absorbed if K<0 & energy levels, we say $E_n < K < E_{n+1}$ ⇒ intermidiate Energy level is strictly forbidden.
- Justify ejection of e^-: we prove Eph > Eionization.
- Ionizing an atom: extract from it e^-.
- limits of spectrum λmax & λmin.
- Due to what is the cause of emission spectral lines:
1) λ has well def value (E is descrete)
2) downward transition of e^-.
- Relation between 2 csts: we divide them.
- Show that KEe^- is quantized:
$KEe^- = \frac{hc}{\lambda} - \frac{hc}{\lambda_0}$ but λ is desrete ⇒ KE is descrete

- Definition of emission spectrum: group of rays that can be emitted by atom.
- index of medium varies from radiation to other since: $n = \frac{c}{V}$, but $V = \lambda\nu$, λ & ν differ from 1 radiation to o
- $E_n = -\frac{hcR}{n^2}$.

Chapter 18 : Atomic nucleus:

- protons + neutrons are identical in shape.
- Isotopes : nuclei having same Z diff A (N).
- Hydrogen (^1_1H) has no neutron in its nucleus (it's a proton).
- Dimension of nucleus:



$V_{nucleus} = A \times V_{nucleon}$.

$\frac{4}{3}\pi r^3 = A \times \frac{4}{3}\pi r_0^3$.

$r_{nucleus} = r_0 A^{1/3}$. r_0 : radius of nucleon $= 1.2 fm = 1.2 \times 10^{-15} m = cst$

$\Rightarrow$ radius of nucleus depends on its mass nb (A).

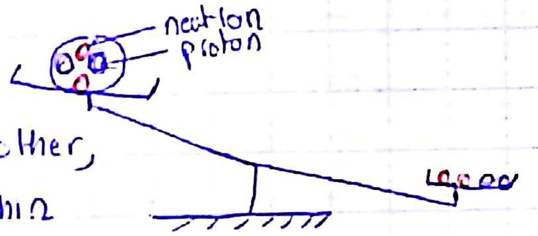
- $\rho_{nucleus} = \frac{m_{nucleus}}{V_{nucleus}} = \frac{A \times m_{nucleon}}{A \times V_{nucleon}} = \frac{m_{nucleon}}{V_{nucleon}} = \frac{1.66 \times 10^{-27} kg}{4\pi (1.2 \times 10^{-15})^3}$

$\rho_{nucleus} = 2.3 \times 10^{17} kg/m^3$ >>>>> $\rho_{atom} = \frac{m_{atom}}{V_{atom}} = \frac{m_{nucleus}}{V_{atom}}$,

where $V_{nucleus} <<< V_{atom}$; $\rho_{nucleus} >>> \rho_{atom}$.

$\Rightarrow$ $\rho_{nucleus}$ is indp of A; cst for all nuclei.

- Mass defect: Δm :



nucleons loses part of its ~~energy~~ mass in order to bind to eachother, + become binding to 1 nucleus, this mass lost is transformed into energy ($E = mc^2$) "since E is neither created nor destroyed".

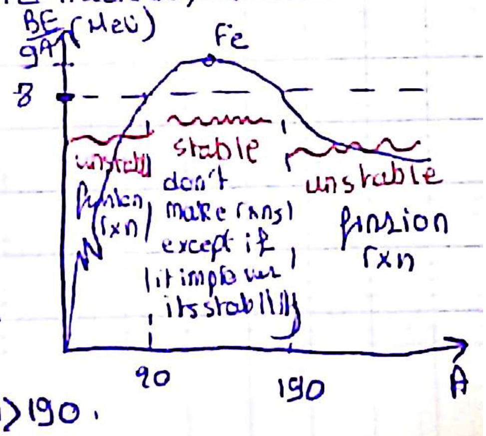
$\Delta m = (Z \times m_{p^+} + N \times m_{n^0}) - m(^A_Z X)$.

- BE ~~per nucleon~~: min energy needed to break down a rest nucleus into its rest constituents (or to bind nucleus).

- $BE = \Delta m . c^2$
  (J) (kg) $(m/s)^2$
  (Mev) $Mev/c^2 \times c^2$.

- BE per nucleon $= \frac{BE}{A} = \frac{\Delta m c^2}{A}$.

- Aston's curve:



Stable nucleus: $\frac{BE}{A} > 8$ Mev + $20 \leq A \leq 190$.

Unstable nucleus: $\frac{BE}{A} < 8$ Mev + $A < 20$ + $A > 190$.

Chapter 19: Radioactivity:

* **Radioactivity:** is a spontaneous nucleus rxn during which unstable mother nucleus is transformed (disintegr...) into more stable daughter one with the emission of radioactive radiations (α, β, γ).
* Conservation of mass nb + atomic nb & energy

$\Sigma A_{bef} = \Sigma A_{after}$, $\Sigma Z_{bef} = \Sigma Z_{after}$, $\Sigma E_{bef} = \Sigma E_{after}$.

* A particle (not photon) of mass m moving with speed v has energy $E = \underbrace{mc^2}_{rest\ energy} + \frac{1}{2}mv^2$, a particle of $v=0$ has $E = mc^2$.

Simply: Each object that has mass has energy.

* $^0_0\gamma$ - decay:

a) eq: $^A_ZX^* \longrightarrow {}^A_ZX + {}^0_0\gamma$

b) Characteristics of $^0_0\gamma$:

* nature: electromagnetic radiation (photon)
* massless
* chargeless
* move in vacuum with $C = 3\times10^8$.
* has energy $E_\gamma = \frac{hc}{\lambda} = h\nu$ very high ν $^{-13}$
* very high penetrating power (12cm in lead)
* can interact with matter
* very dangerous.

c) Conservation of energy:

$\therefore E_{lib} = \Delta m C^2 = E(\gamma)$ with $\Delta m = m_b - m_a$

for $KE_{^A_ZX^*} = KE_{^A_ZX} = 0$.

*

* α - decay: for nuclei with $A > 200$

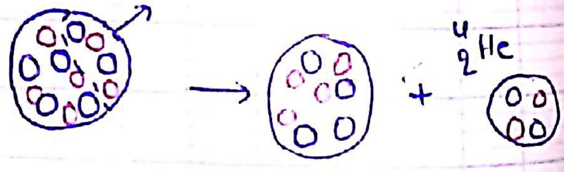
a) eq: $^A_ZX \longrightarrow {}^{A'=A-4}_{Z'=Z-2}Y + {}^4_2\alpha + {}^0_0\gamma$ (e-β exci...)

b) Characteristics of $^4_2\alpha$:

* name: Helium nucleus.
* nature: particle
* has mass.
* has ⊕ve charge.
* has low speed compared to c
* has energy.
* very low penetrating power (stopped by of paper)
* can interact with matter
* very dangerous.

c) Conservation of energy:

$E_{lib} = \Delta m C^2 = E(\gamma) + KE_\alpha$. for KE



* Due to what is the emission of $^0_0\gamma$;

Due to de-excitation of excited mother nucleus.

β^- decay: for nuclie of excess neutron

a) eg: ${}^{A}_{Z}X \longrightarrow {}^{A'}_{Z'}Y + {}^{0}_{-1}e + {}^{0}_{0}\bar{\nu} + {}^{0}_{0}\gamma$.

b) Characteristics of β^-:

- name: electron (${}^{0}_{-1}e$).
- nature: particle.
- has very low mass $\neq 0$
- ⊖vely charged.
- has high KE.
- has very high speed $\sim 0.9C$
- high penetrating power (7mm in AL)
- can interact with matter
- very dangerous.

c) Conservation of energy:

$E_{lib} = \Delta mc^2 = KE({}^{0}_{-1}e) + E(\gamma) + E({}^{0}_{0}\bar{\nu})$

- What happens inside nucleus:

${}^{1}_{0}n \longrightarrow {}^{1}_{1}p + {}^{0}_{-1}e + {}^{0}_{0}\bar{\nu}$

$KE_X = KE_Y = 0$ (heavy nucleus compared to ${}^{0}_{-1}e$) proved on L.M.

β^+-decay: for nuclie with excess protons

a) eg: ${}^{A}_{Z}X \longrightarrow {}^{A'}_{Z'}Y + {}^{0}_{+1}e + {}^{0}_{0}\nu + {}^{0}_{0}\gamma$

b) Characteristics of β^+:

- name: positron (${}^{0}_{+1}e$)
- nature: particle
- has very low mass $\neq 0$
- has ⊕ve charge.
- has high KE.
- very high speed $\sim 0.9C$.
- " " penetrating power (7mm in AL
- interacts with matter
- very dangerous.

c) Conservation of energy:

$E_{lib} = \Delta mc^2 = KE_{{}^{0}_{+1}e} + E(\gamma) + E(\nu)$

- What hapens inside the nucleus

${}^{1}_{1}p \longrightarrow {}^{0}_{+1}e + {}^{1}_{0}n + {}^{0}_{0}\nu$

$KE_X = KE_Y = 0$ (heavy nucleus compared to ${}^{0}_{+1}e$), proved on L.M.

- Characteristics of ${}^{0}_{0}\bar{\nu}$ or ${}^{0}_{0}\nu$:
- name: neutrino or antineutrino
- nature particle
- massless
- chargeless
- has energy
- move in vaccum with C
- very high penetrating power (+s)
- don't interacts with matter
- not dangerous.
- very very hard to detect.

- Laws of decay:

- $N_t = N_0 e^{-\lambda t}$,
- $N_d = N_0 - N_t$.
- $N_d = N_0(1 - e^{-\lambda t})$.
- $\lambda = \frac{\ln 2}{T}$, $T = \frac{\ln 2}{\lambda}$.
- $N_t = \frac{N_0}{2^n}$ ($n = \frac{t}{T}$) (nb of periods).

(Bq) = dis/sec.

- $A_t = \frac{-\Delta N_t}{\Delta t}$

$\boxed{A_t = \frac{N_d}{\Delta t}}$ for $t \lll T$.

- $P = A(t) \times E_{lib}$
- Age $= t = \frac{T}{\ln 2} \ln\left(\frac{N}{N}\right.$

- $A_t = -\frac{d}{dt}N_t = \frac{d}{dt}N_d$. – $N = \frac{m}{M} \times N_A$.
- $A_t = \lambda N_t$.

$A_t = \underbrace{A_0}_{\lambda N_0} e^{-\lambda t}$

→ Notes.

- Gieger counter is the instrument used to measure Activity
- we've to define the thing 1st.

Impppp. — In every determine, we've to define the thing 1st.

- for $N = \frac{m}{M} \times N_A$: N α m are directly prop: rules of N can be name as rules of m.
- for $A_t = \lambda N_t$; , N_t α A_t are α , rules of N can be name as that of A_t.
- $\frac{5}{\lambda}$: time needed for nucli to decay.

- If he said knowing that activity during this time remains cst, then $t <<< T$; $A_t = \frac{N_d}{\Delta t}$.

Imp — E_{lib} = BEproducts - BEreactants .

→ Role of Moderator. slow down speed of neutrons.
→ fissile isotope: is the isotope that leads to fission.
→ Provoked. hapens with external intervention & we name it.
→ If we bring A & Z & we've no name to that atom, we say it's an isotope of another atom in question
→ Calc. Elib per nucleon of rxn: $\frac{E_{lib}}{\text{sum of } A}$.

→ Uniformly distributed ⟹ we can use proportionality.
→ rxn having more Elib is more profitable.

Chapter 20 : Nuclear Rxns

* Fission: Is a stimulated nuclear rxn during which a heavy nucleus is divided into 2 lighter nuclei under the impact of neutron. $E_{lib \text{ by 1 nucleus}} = \Delta mc^2 = \sim 200$ Mev.
* Condition of Fission: KE of projected neutron must be order of 0.01ev, In this case neutron is called slow or thermal.
* Condition of Chain rxn: to have chain rxn, the rxn must produce more than 1 neutron.
* Fusion: Is a provoked nuclear rxn during which 2 light nuclei are combined to form 1 heavy nucleus.
* Condition of Fusion: KE of light nuclei must be order of 0.01 Mev, to overcome electrostatic repulsion of 2 ⊕ve nuclei. To satisfy such conditions, temperature of medium must be $\sim 10^8$K, so fusion can take place in Sun, stars
* Effect of radiations on living things:
* Absorbed dose: Is the energy absorbed / unit time.

$$D\,(Gy) = \frac{\text{Energy absorbed (J)}}{\text{mass (kg)}}.$$

1 rad $= 10^{-2}$ Gy.

* Quality factor: (effect):

$\alpha \rightarrow 20$; ${}_0^1n \rightarrow 10$; $\gamma \rightarrow 1$.

Physiological equivalent dose: ED = D × QF.

ED > 10 → death, ED < 0.05 → no effect, 0.05 < ED < 10 → diseases

بالتوفيق للجميع