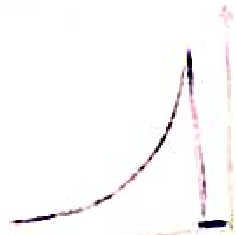
FUNDAMENTALS OF PHYSICS

* Concepts like mechanics, electrical, electronics, magnetics, thermodynamics, semiconductors and optics play a role of great importance in the process of innovation & development.
* Everything around us uses energy in one way or other. Search for new tech, to enhance by modifying properties like internal & external parameters like ext force, temp, chem, struct, ch
* Physics - natural science that involves study of matter and its motion and behavior thrgh space and time with related compounds like Energy and force

UNIT - 1



WAVES AND OSCILLATION

Depending on the system, force value changes

$$\boxed{F = ma}$$

$$\boxed{F = m\frac{d^2x}{dt^2}}$$

$$\int m\frac{d^2x}{dt^2} = \int \frac{1}{4\pi\varepsilon_0}\cdot\frac{q_1q_2}{r^2} = \int -kx$$

$$= \int \frac{GmM}{R^2} = \int$$

PERIODIC MOTION:

Periodic motion can cause disturbances that move thrgh a medium in the form of a wave

WAVE MOTION:

- Wave is a motion of a disturbance
- Mechanical waves require:
  - some source of disturbance
  - medium that can be disturbed
  - phy connection or mechanism through which adjacent positions of the medium influence each other
  - waves carry energy & momentum.

Waves → Transverse wave

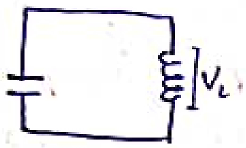
Waves → Logitudinal wave

• Transverse waves – each element ~~to the wave~~ that is disturbed moves in a direction ⊥r to wave motion.

• Logitudinal aka compression waves – the elements of medium undergo displacements parallel to the motion of the wave.

(Particular type of periodic motion)

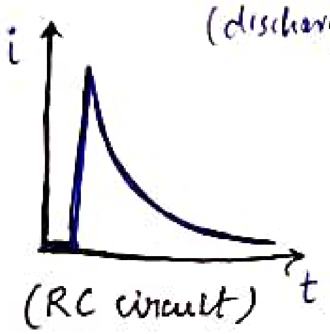
☆ SIMPLE HARMONIC MOTION:



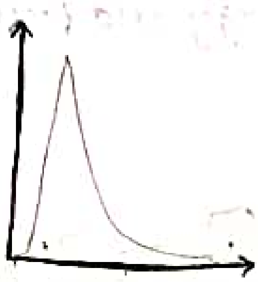
$$\boxed{V_L = -L\frac{di}{dt}}$$

LC oscillator

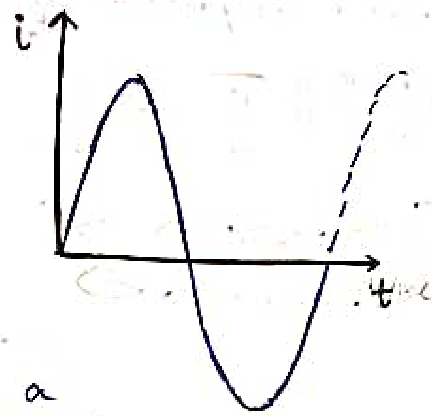
(discharge)



(RC circuit)



(LC circuit)



→ In a clock when current flows thrgh a quartz crystal which is given a force and vibrates. Vibration rate is controlled by a microchip which is connected to a motor that converts it to circulatory motion.

• Periodic motion is a motion that regularly returns to a given position after a fixed time interval.
• SHM occurs when the net force acting along obeys "Hookes law".
(ie) $F = -kx$
• In SHM, force acting on the object is proportional to the position of the object about some equilibrium position.

NOTE: [Force is always directed towards equilibrium position]

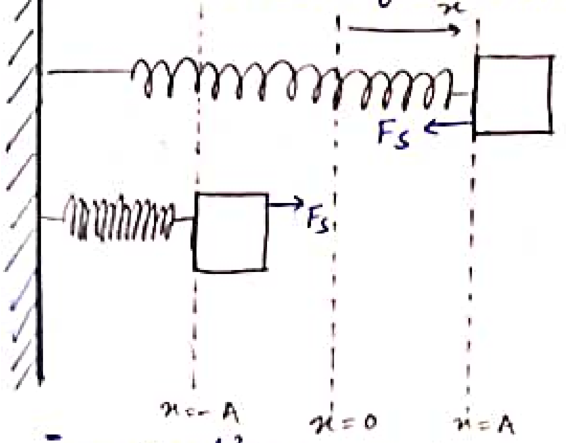
Ex: Spring mass system

• Clock – phisioelectric principle
(when F is applied – gives rise to V difference)

[voltage → quartz crystal → vibrates → microchip controls the vib
oscillate with same ν ← stepper motor ↵]

(Hooke's law) $\boxed{F_s = -kx}$ [k - spring constant defines spring stiffness]

$x=0 \Rightarrow$ equilibrium position



→ K affects the distance it moves given the force F

→ F is always directed opp to the displacement i.e. towards the eq. position aka "Restoring force"

$$\Rightarrow m\frac{d^2x}{dt^2} = F = -kx \qquad \boxed{\omega^2 = \frac{k}{m}}$$

$$\frac{d^2x}{dt^2} = -\omega^2 x \quad -①$$

$$\boxed{\frac{d^2x}{dt^2} + \omega^2 x = 0}$$ [Equation of motion for simple harmonic motion]

$$\boxed{x = c e^{\alpha t}} \text{ (solution)} \quad -②$$

$$\left[\begin{array}{l} D^2 = -\omega^2 x \\ D = \pm i\omega \end{array}\right]$$

$$\frac{dx}{dt} = c e^{\alpha t} \cdot \alpha$$

$$\frac{d^2x}{dt^2} = c e^{\alpha t} \cdot \alpha^2 \quad -③$$

$$c e^{\alpha t}\alpha^2 + \omega^2 c e^{\alpha t} = 0$$

$$c e^{\alpha t}(\alpha^2 + \omega^2) = 0$$

$$\alpha^2 + \omega^2 = 0$$

$$\boxed{\alpha = \pm i\omega}$$

$$\boxed{x = c e^{\pm i\omega t}} \quad \text{(or)} \quad \boxed{x = c_1 e^{i\omega t} + c_2 e^{-i\omega t}}$$

$$x = c_1(\cos\omega t + i\sin\omega t) + c_2(\cos\omega t - i\sin\omega t)$$

$$= (c_1 + c_2)\cos\omega t + i(c_1 - c_2)\sin\omega t$$

$$= a\sin\phi\cos\omega t + a\cos\phi\sin\omega t$$

$$\left[\begin{array}{l} c_1 + c_2 = a\sin\phi \\ c_1 - c_2 = a\cos\phi \end{array}\right]$$

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

→ Phase const.
→ Frequency
→ Amplitude

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

$$v = \frac{dx}{dt} = a\omega\cos(\omega t + \phi)$$

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

$$\begin{cases} \sin(\omega t + \phi) = \frac{x}{a} \\ \cos(\omega t + \phi) = \sqrt{1 - \frac{x^2}{a^2}} \end{cases}$$

$$\left[\cos\theta = \sqrt{1 - \sin^2\theta}\right]$$

$$v = a\omega\sqrt{\frac{a^2 - x^2}{a^2}}$$

$$v = \omega\sqrt{a^2 - x^2}$$

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

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

(To calculate Time period)

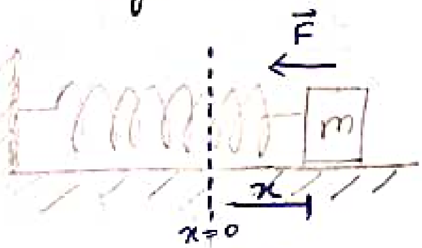
$$T = \frac{1}{\nu} = \frac{2\pi}{\omega}$$

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

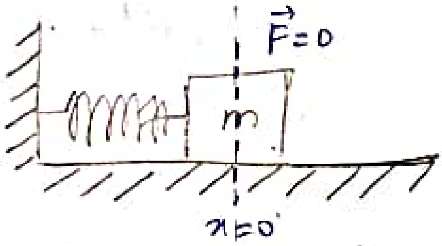
$$T = \frac{2\pi}{\sqrt{K/m}} \Rightarrow \boxed{T = 2\pi\sqrt{\frac{m}{K}}}$$

★ Restoring force and Spring mass system.

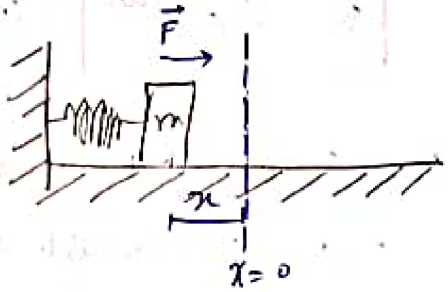
- Here the block is displaced to the right of $x = 0$. The restoring force exerted by the spring is directed to the left (negative)



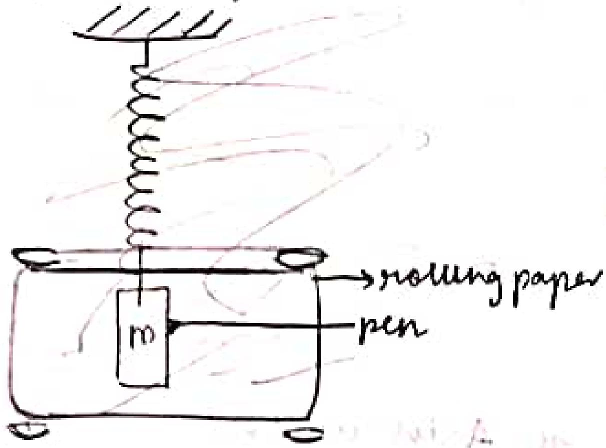
- Block is at eq. position ($x = 0$). Thus the spring is neither stretched nor compressed. $\vec{F}_s = 0$



- Block is displaced to the left of $x = 0$. (position is $-$ve) The restoring force is directed to the right (positive)



☆ Verification of Sinusoidal Nature:



BLAH
BLAH

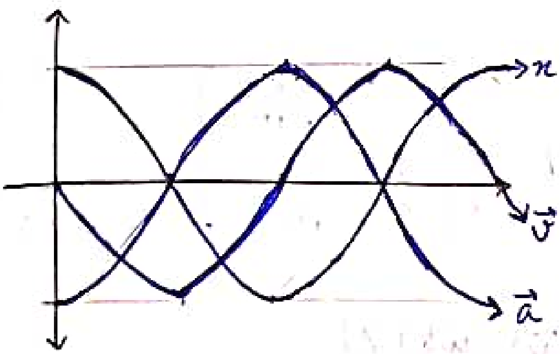
☆ Amplitude:

- Amplitude is the maximum position of the object from its equilibrium position.
- [Ideal SHM involves oscillation of m between $x = \pm A$]

☆ Period:

- The period is the time taken by object to complete one complete cycle of motion. [$x=A$ to $x=-A$ to $x=A$]
- Represented by 'T' (seconds)
- The frequency is the no of complete cycles per unit time

$$\boxed{f = 1/T} \text{ (Hertz)}$$



- velocity is 90° out of phase with displacement
- acceleration is 180° out of phase with displacement.

$x = Av$

- when $x = max$; $v = zero$
- when $x = 0$; $v = max$ and in negative direction
- when $x = +max$; $a = max$ and in $-ve$ direction

☆ Kinetic and Potential energies w.r.t Force.

$$F = -Kx$$

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

$$\int \frac{du}{dx} = \int Kx$$

$$U = \frac{1}{2}Kx^2 + C$$

$$\boxed{U = \frac{1}{2}Kx^2} \qquad x = A\sin(\omega t + \phi)$$

$$U = \frac{1}{2}KA^2\sin^2(\omega t + \phi) \qquad \boxed{U = \frac{1}{2}KA^2\sin^2(\omega t + \phi)}$$

$$\boxed{U_{max} = \frac{1}{2}KA^2}$$

$$K.E = \frac{1}{2}mv^2 = \frac{1}{2}m\left(\frac{dx}{dt}\right)^2 \qquad \boxed{K.E = \frac{1}{2}mv^2}$$

$$= \frac{1}{2}m[A\omega\cos(\omega t + \phi)]^2$$

$$\boxed{K.E = \frac{1}{2}m\omega^2A^2\cos^2(\omega t + \phi)} \qquad KE = \frac{1}{2}m\omega^2A^2\cos^2(\omega t + \phi)$$

$$K.E_{max} = \frac{1}{2}m\omega^2A^2$$

$$\boxed{K.E_{max} = \frac{1}{2}KA^2} \qquad \left[\begin{array}{l}\omega = \sqrt{\frac{K}{m}} \\ \omega^2 = \frac{K}{m}\end{array}\right]$$

$$T.E = \frac{1}{2}AK\sin^2(\omega t + \phi) + \frac{1}{2}AK\cos^2(\omega t + \phi)$$

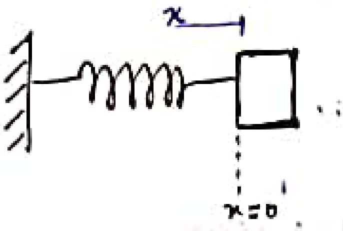
$$= \frac{1}{2}KA^2$$

$$\boxed{T.E = \frac{1}{2}KA^2}$$

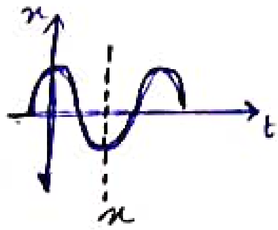
☆ Transfering of Energy of SHM:

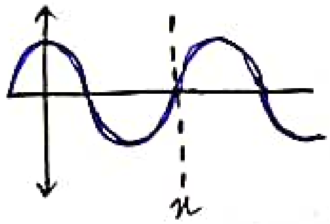
- Total energy is always constant. $E = \frac{1}{2}kA^2$
- Energy is continuously being transferred from P.E in the spring to K.E in the block

QUE :



Velocity is zero,
Force is to the left





Velocity is positive
Force is zero

QUE (i) Total distance travelled by m in SHM in T

$\Rightarrow 4A$

(ii) displacement after $T \Rightarrow 0$

(iii) At what point is $v = 0$ and $a = 0$ simultaneously

not possible. [v and a can not be zero at the same time]

QUE : In an SHM, when the m is doubled and A is unchanged, T.E = ?

$T.E \propto A^2$

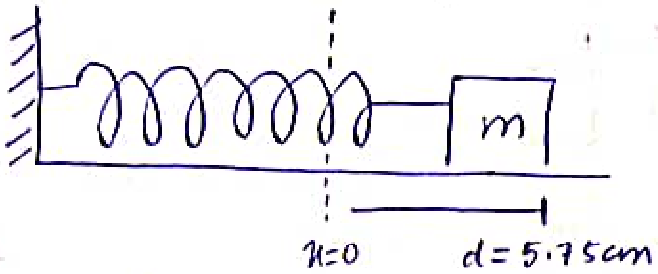
Total energy does not change coz it does not depend on mass. $\boxed{TE = \frac{1}{2}kA^2}$

QUE : mass oscillating on a vertical spring with T is taken to the moon.

Time period will not change

$\boxed{T = 2\pi\sqrt{\frac{m}{K}}}$ (does not depend on 'g')

Que: 1.55 Kg block sliding on a $\mu = 0$ plane is connected to a horizontal spring of $K = 2.55$ N/cm. Block is pulled to the right by $d = 5.75$ cm and released from rest. v after 1.5 s ?



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

$d = A \sin \phi$ — ① $(t=0)$

$v = \omega_0 A \cos(\omega t + \phi)$

$v = \omega_0 A \cos \phi$ $(t=0)$

[$v = 0$ at $t = 0$] (extreme end)

$\therefore \cos \phi = 0$

$\boxed{\phi = \pi/2}$ $d_{max} = A$

$[\cos(\omega t + \pi/2) = -\sin \omega t]$

$\Rightarrow \therefore v = -\omega_0 d \sin \omega t$

$= -\omega_0 d \sin(\sqrt{K/m}\, t)$ $\omega = \sqrt{\frac{K}{m}}$

$= -\sqrt{\frac{2.55}{1.55}}(0.0575) \sin[\omega_0 (1.5)]$

$\simeq \ldots$

Ans: $\boxed{v_{t=1.5s} = 6.92 \text{ cm/s}}$ //

QUE : If displacement of a moving particle at any time is $x = a\cos\omega t + b\sin\omega t$, show that the motion is SHM. If $a=3$, $b=4$, $\omega=2$, find period, v_{max}, a_{max}

$$x = a\cos\omega t + b\sin\omega t$$

$$\frac{dx}{dt} = -a\sin\omega t\,(\omega) + b\omega\cos\omega t$$

$$\frac{d^2x}{dt^2} = -a\omega^2\cos\omega t - b\omega^2\sin\omega t$$

$$= -\omega^2(a\cos\omega t + b\sin\omega t)$$

$$= -\omega^2 x \quad \therefore \text{SHM}$$

$$A_{max} = \sqrt{a^2+b^2} = \sqrt{9+16} = 5\text{ cm} \qquad \boxed{A = 5\text{ cm}}$$

$$T = \frac{2\pi}{\omega} = \frac{2\pi}{2} = \pi \qquad \boxed{T = \pi\text{ s}}$$

$$v_{max} = \omega A = 2\times 5 \qquad \boxed{v_{max} = 10\text{ cm/s}}$$

$$a_{max} = \omega^2 A = 4\times 5 \qquad \boxed{a_{max} = 20\text{ cm/s}}$$

QUE :

$A = 5$ cm $\qquad \nu = 1$ Hz

$$x = A\cos(\omega t + \alpha) \qquad \Rightarrow x = 5\cos(\omega t + \pi/2)$$

$$0 = 5\cos\alpha$$

$$\cos\alpha = 0$$

$$\boxed{\alpha = \pi/2}$$

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

$$\boxed{\omega = 2\pi}$$

(at $t = 8/3$ s)

$$\frac{dx}{dt} = 5\omega\cos(\omega t + \pi/2)$$

$$v = -5\omega\sin(8\omega/3 + \pi/2)$$

$$v = -10\pi\sin\left(\frac{16\pi}{3} + \frac{\pi}{2}\right)$$

$$= -10\pi\sin\left(\frac{35\pi}{6}\right) = -10\pi\sin\left(6\pi - \frac{\pi}{6}\right)$$

$$= -10\pi\sin(5.83\pi) = -10\pi\sin\left(-\frac{\pi}{6}\right)$$

$$= 10\pi\left[\sin\frac{\pi}{6}\right]$$

$$= 10\pi\left(\frac{1}{2}\right)$$

$$\Rightarrow 5\pi\text{ cm/s}$$

$$\Rightarrow 15.7\text{ cm/s}$$

QUE : $m = 10g$ is placed in a potential field.
$V = (50x^2 + 100)$ ergs/gm. $\vartheta = ?$

$U = mV = 10 \times 10^{-3} \times (50x^2 + 100)$

$\boxed{U = 0.5x^2 + 1}$

$F = -\frac{dU}{dx} = -\frac{d}{dx}(0.5x^2 + 1)$

$U = -F dx$

$F = -(0.5 \times 2)x$

$\boxed{F = -x}$

$F = kx = m\omega^2 x$

$m\omega^2 = 1$

$10^{-2} \times \omega^2 = 1$

$\omega^2 = 100$

$\boxed{\omega = 10}$

$T = \frac{\omega}{2\pi} = \frac{10}{2\pi}$

$\boxed{T = \frac{5}{\pi} s}$

QUE : write eqn of SHM
(i) $\phi_i = 0$ (ii) $\phi_i = \pi/2$ (iii) $A = 5cm$ $T = 8s$.

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

$\omega = \frac{2\pi}{T} = \frac{\pi}{6}$

$x = 5\sin(0.785t)$ //

$\boxed{\omega = 0.785 \text{ rad/s}}$

(ii) $x = 5\sin(0.785t + \pi/2)$ //

QUE : $x = 2\sin\left(\frac{\pi t}{2} + \frac{\pi}{4}\right)$ cm. $T = ?$ $V_{max} = ?$

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

$\vartheta = \pi\cos(\omega t + \pi/4)$

$\vartheta = \pi\cos(\pi/2\, t + \pi/4)$

$\boxed{T = 4s}$ //

$\boxed{\vartheta_{max} = \pi \text{ cm/s}}$ //

$\boxed{\vartheta_{max} = \omega A = \frac{\pi}{2} \times 2 = \pi \text{ cm/s}}$ //

QUE $T = 31.4\,s$; $A = 5\,cm$ $v_{max} = ?$

$T = \frac{2\pi}{\omega}$ $\boxed{\omega = 0.2}$

$\boxed{v_{max} = \omega A \doteq 1\,cm/s}$

$\boxed{a_{max} = -\omega^2 A = 0.2\,cm/s^2}$

$\boxed{\begin{array}{l} v_{max} = \omega A \\ a_{max} = -\omega^2 A \end{array}}$

QUE : $T = 10\,s$; $A = 0.1\,m$

Write the equation. What are phase & displacement at $t = 5\,s$ after a passage of the particle through its extreme positive elongation. $v_{max} = ?$

$[\omega = \pi/5 \text{ rad/s}]$

$\boxed{v_{max} = \omega A = 2\pi\ m/s}$

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

$x = 0.1\sin(\pi/5\, t + \phi)$

2)

$t=0$ $A = 0.1\sin\phi$

[starts at extrem]

$0.1\sin\phi = 0.1$

$\sin\phi = 1$

$\boxed{\phi = \pi/2}$

* SUPER-POSITION OF WAVES

* HUYGEN'S PRINCIPLE :

- A wave is continuously repeating change or oscillation in matter or in a physical field. Light is also a wave
- Huygen's believed that light was made of waves vibrating up & down ⊥r to direction of motion (ie) transverse waves

$$\boxed{\nu = \frac{1}{\lambda}}$$

* Wave charactaristics :

Wavelength (λ) :

distance between 2 crests or 2 troughs is λ (lambda)

Frequency (ν)

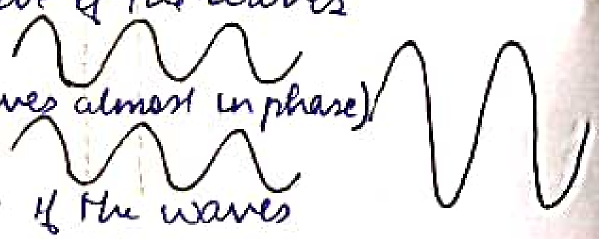
no of waves that pass a ⊥r point in one second.

Amplitude (A)

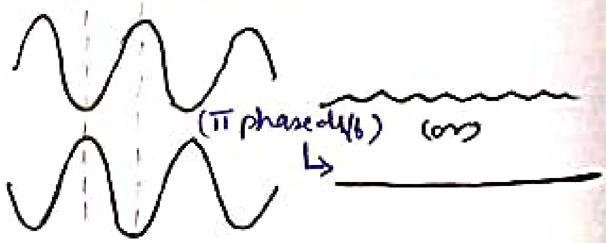
the vertical distance from midline of waves to the top of peak or bottom of troughs.

* Combination of waves :

- Composite wave = 2 waves combined is the algebraic sum of the 2 original waves point by point - (Superposition principle)
  - direction, Amplitude & Phase need to be taken into account while adding
  - phase difference should not be there.
- The interference is constructive if the waves reinforce each other



- The interference is destructive if the waves tend to cancell each other.
- If the phases are exactly opp (ie) π, then the result is nothing since the waves cancell each other completely



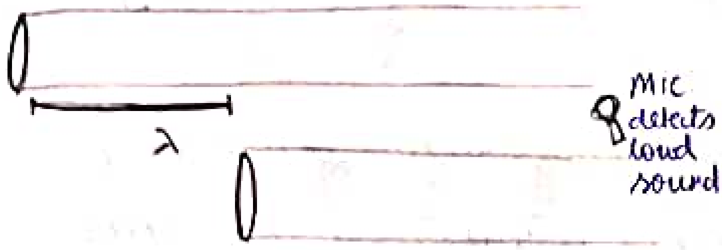
- The resultant Amplitude of the new wave depends on the phase differences of the 2 original waves.

* Coherence :

Coherent sources → same frequency
→ same phase values

[To keep the phase diff is alongthe length along the dir of propagation . the frequency ...

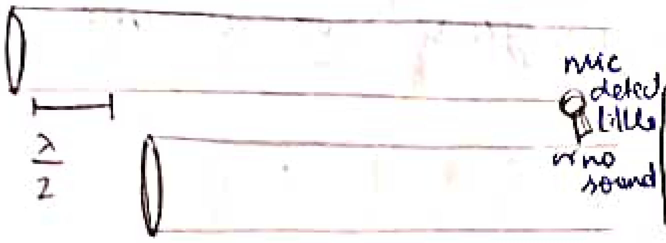
- In phase – peaks line up with peaks
  valleys line up with valleys } waves add up and $A_R = A_1 + A_2$
- Ex: sound amplifiers, surround sound



$\boxed{\text{Path diff} = n\lambda}$

constructive interference

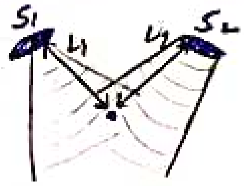
(m – odd integer – 2n+1)



$\boxed{\text{Path diff} = \frac{m\lambda}{2}}$

destructive interference

Noise cancellation headphones use destructive interferance.



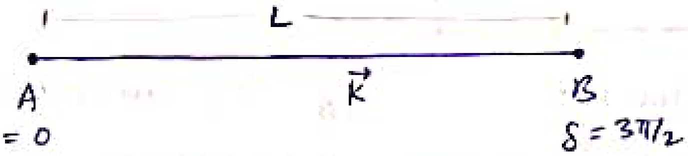
★ Path difference (ΔL):

- Path difference ΔL is the absolute value of the difference ~~between~~ in the distances from each source to a point being considered.

$$\boxed{\Delta L = |L_1 - L_2|}$$

- We express the path difference in terms of number of wavelengths. Ex: $3\frac{1}{2}\lambda$, 5λ, etc

★ Theory of Super-position:



- Let light travell from A to B and travells a distance L, its phase changes from 0 to 3π/2.

$$\boxed{\delta = nKL}$$

$$\boxed{\delta = \frac{n\,2\pi L}{\lambda}}$$

$$\boxed{K = \frac{2\pi}{\lambda}}$$

K – wave vector

λ – wavelength

$\delta \propto n$

$\delta \propto 1/\lambda$

$\delta \propto L$

- Consider a constructive interference situation where Amplitudes of original waves are A & A resp.

$$\Rightarrow A_R = A + A = 2A$$

$$\boxed{A_R = A_1 + A_2} \qquad I \propto |A_R|^2$$

$$\Rightarrow I_R = (2A)^2 = 4I$$

$$\boxed{I_R > I_1 + I_2} \rightarrow \text{constructive interference}$$

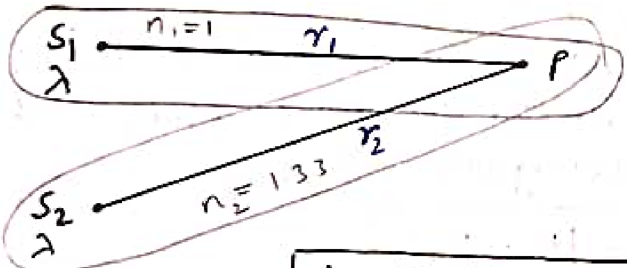
- Consider a destructive interference situation where amplitudes of original waves are A & A resp.

$$\Rightarrow A_R = A - A = 0$$

$$\Rightarrow I_R = (0)^2 = 0$$

$$\boxed{A_R = A_1 + A_2}$$

$$\boxed{I_R < I_1 + I_2} \rightarrow \text{destructive interference}$$



- Consider 2 coherent sources but in 2 different media of refractive indexes n_1 & n_2 resp.

$$\boxed{\Delta = n_2 r_2 - n_1 r_1}$$

$$\boxed{\Delta = n\lambda} \rightarrow \text{Constructive}$$

$$\boxed{\Delta = \frac{(2n+1)\lambda}{2}} \rightarrow \text{Destructive}$$

- $E_A = E_1 \sin \omega t \qquad E_B = E_2 \sin(\omega t + \delta)$

2 waves of same freq but diff phase

$$E_R = E_1 + E_2 = E_1 \sin \omega t + E_2 \sin(\omega t + \delta)$$

$$= E_1 \sin \omega t + E_2 (\sin \omega t \cos \delta + \cos \omega t \sin \delta)$$

$$= \underbrace{(E_1 + E_2 \cos \delta)}_{E \cos \phi} \sin \omega t + (E_2 \sin \delta) \cos \omega t$$

$$\left[\text{Let } \begin{array}{ll} E_1 + E_2 \cos \delta = E \cos \phi & \text{— ①} \\ E_1 \sin \delta = E \sin \phi & \text{— ②} \end{array}\right.$$

$$= E \cos \phi \sin \omega t + E \sin \phi \cos \omega t$$

$$①^2 + ②^2 \Rightarrow (E_1 + E_2 \cos \delta)^2 + (E_1 \sin \delta)^2 = E^2 \cos^2 \phi + E^2 \sin^2 \phi$$

$$= E_1^2 + E_2^2 \cos^2 \delta + 2 E_1 E_2 \cos \delta + E_2^2 \sin^2 \delta = E^2$$

$$\Rightarrow E_1^2 + E_2^2 + 2 E_1 E_2 \cos \delta = E^2$$

$$\boxed{I_R = I_1 + I_2 + 2\sqrt{I_1 I_2} \cos \delta}$$

$$\boxed{E_R^2 = E_1^2 + E_2^2 + 2E_1E_2 \cos \delta}$$

- $\boxed{\delta = \frac{2\pi n L}{\lambda}}$ $\boxed{K = \frac{2\pi}{\lambda}}$

- Constructive:

  $\boxed{\Delta = n\lambda}$

  $A_R = A_1 + A_2$

  $I_R > I_1 + I_2$

  Destructive:

  $\boxed{\Delta = \frac{(2n+1)\lambda}{2}}$

  $A_R = A_1 + A_2$

  $I_R < I_1 + I_2$

- $\boxed{E_R^2 = E_1^2 + E_2^2 + 2E_1E_2\cos\delta}$

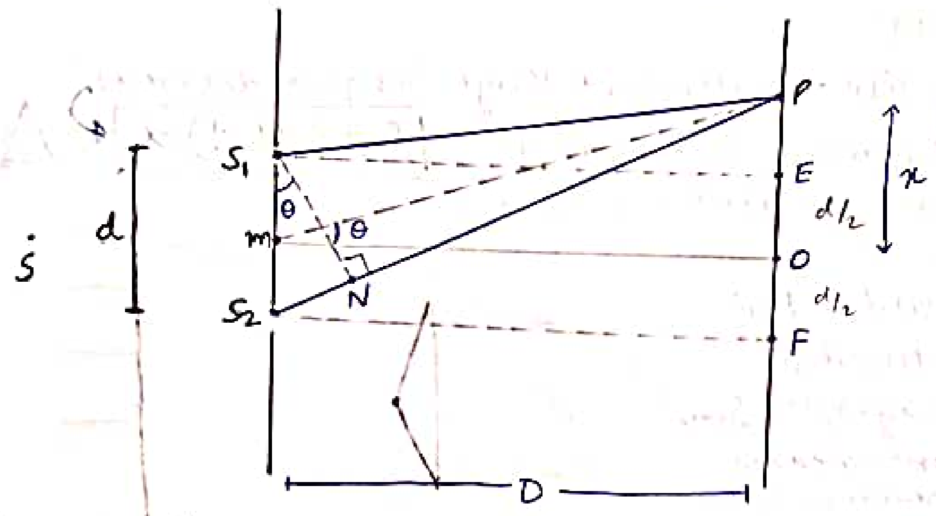
- $\boxed{I_R = I_1 + I_2 + 2\sqrt{I_1 I_2}\cos\delta}$

$\boxed{I_{max} = 4I}$ $\boxed{I_{min} = 0}$

☆ YOUNG'S DOUBLE SLIT EXPERIMENT:

Describes the wave nature of light and demonstrates the interference of light.

The results can be proved only by taking light as wave.



$S_1P = NP$
(S_2N is path diff)

In ΔS_1PE;

$PE = x - d/2$

$(S_1P)^2 = D^2 + (x - d/2)^2$

In ΔS_2PF;

$PF = x + d/2$

$(S_2P)^2 = D^2 + (x + d/2)^2$

$$(S_2P)^2 - (S_1P)^2 = D^2 - D^2 + x^2 + \left(\frac{d}{2}\right)^2 + xd - x^2 - \left(\frac{d}{2}\right)^2 + xd$$

$$(S_2P)^2 - (S_1P)^2 = 2dx$$

$$(S_2P - S_1P)(S_2P + S_1P) = 2xd$$

$$S_2P - S_1P = \frac{2xd}{S_2P + S_1P}$$

$$S_2P - S_1P = \frac{2xd}{D + D} = \frac{xd}{D}$$

$$S_2P - S_1P = \frac{xd}{D}$$

$$x_m = \frac{m\lambda D}{d} \qquad x_{m+1} = \frac{(m+1)\lambda D}{d}$$

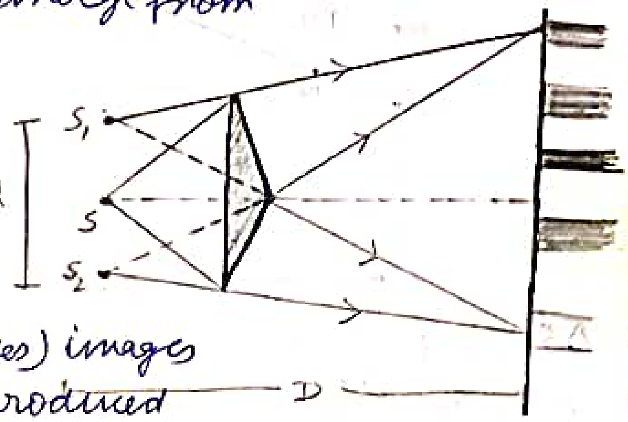
(Fringe width) $\boxed{\beta = \frac{\lambda D}{d}}$

$d\sin\theta = m\lambda$	→ constructive (maxima)
$d\sin\theta = \frac{2m+1}{2}\lambda$	→ Destructive (minima)

Light can hold coherent only for a limit and thus intensity gradually fades to zero.

✯ FRESNEL'S BIPRISM:

- Biprism consists of 2 prisms of very small refractive angles joined base to base
  - Usually 2 side angles are 30′ (0.5°) and other angle is 179°
  - ordinary prism – ray is bent through 'angle of deviation'. $\boxed{\delta = (\mu - 1)\alpha}$
  - But in a Biprism; the ray coming out of prism, appears to emerge from a source S
  - Then it is said to that prism produced a virtual image of the Source
  - Then biprism creates 2 virtual sources S_1, S_2
  - S_1 & S_2 are (virtual sources) images of the same source S produced by 'Refraction'. They are coherent



$$\boxed{\frac{xd}{D} = m\lambda}$$

(Bright fringe)

$$\boxed{\frac{xd}{D} = (2m+1)\frac{\lambda}{2}}$$

Dark fringe

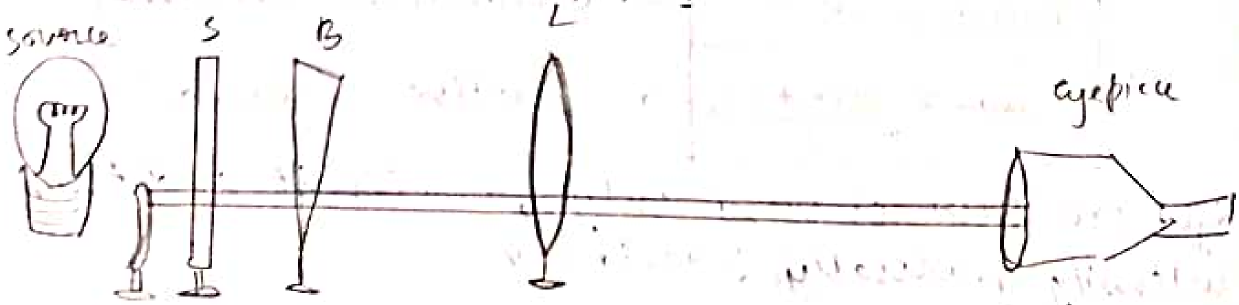
$$x_m = \frac{m\lambda D}{d} \qquad x_{m+1} = \frac{(m+1)\lambda D}{d}$$

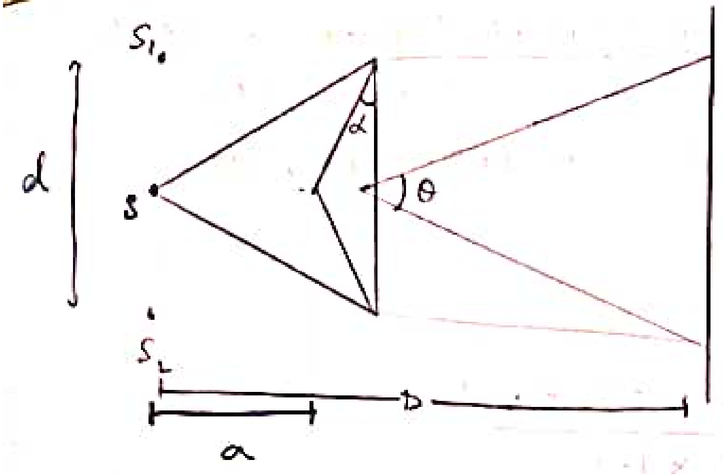
$$\beta = x_m - x_{m+1} = \frac{\lambda D}{d}$$

$$\boxed{\beta = \frac{\lambda D}{d}}$$ ⇒ Fringe width.

~~Expt~~ (Experimental arrangement)

- Biprism mounted on an optical bench – (2 horizontal ∥el rods)
- (Blah)





$\boxed{\delta = \frac{\theta}{2}}$ $\boxed{\theta = \frac{d}{a}}$

$\delta = (\mu - 1)\alpha$

$\theta/2 = (\mu-1)\alpha = \frac{d}{2a} = (\mu-1)\alpha$

$d = 2a(\mu-1)\alpha$

$\boxed{d = 2a(\mu-1)\alpha}$ (a → source to prism)

$\boxed{t = \frac{xd}{D(\mu-1)}}$ (thickness of glass sheet)

$\boxed{d = \sqrt{d_1 d_2} = 2a(\mu-1)\alpha}$

QUE: Viewing screen is ~~pt~~ separated from a double slit by 1.2m. d = 0.030 nm. second order brlength fringe (m=2) is 4.5cm from center line.

(a) $\lambda = ?$ (b)

$$x = \frac{m\lambda D}{d}$$

$$\lambda = \frac{xd}{mD} = \frac{0.045 \times 0.030 \times 10^{-9}}{2 \times 1.2}$$

$$= \frac{4.5 \times 3 \times 10^{-13}}{2 \times 1.2}$$

$$= 5.625 \times 10^{-13}$$

$\Rightarrow$

QUE: Screen placed 13.7 m apart. 3rd order fringe is seen 2.50 cm from central. d = 0.960 cm. $\lambda = ?$

$D = 13.7\ m$ $\qquad x = 2.50\,cm = 0.025\,m$

$d = 0.0096\ m$

$$x = \frac{3\lambda D}{d} = \frac{3\lambda(13.7)}{96 \times 10^{-4}} = 25 \times 10^{-3}$$

$$\lambda = \frac{25 \times 96 \times 10^{-7}}{13.7 \times 3}$$

$$\lambda = 5.84 \times 10^{-7} m$$

$$\boxed{\lambda = 584\ nm}$$

QUE: How far ~~will~~ from the central fringe the first order violet (λ = 350 nm) & Red (λ = 700 nm)

$D = 10\ m$ $\qquad d = 0.50\ cm$

$$x_V = \frac{\lambda m D}{d} = \frac{350 \times 10^{-9} \times 1 \times 10}{0.05 \times 10^{-2}} \Rightarrow 0.007\ m$$

$$x_R = \frac{\lambda m D}{d} = \frac{700 \times 10^{-9} \times 1 \times 10}{0.05 \times 10^{-2}} \Rightarrow 0.014\ m$$

QUE : If yellow light with $\lambda = 540\ nm$ shines on a double slit ; $d = 0.01\ mm$ $\theta = ?$ $n = 2$

$\boxed{\sin\theta = \frac{x}{D}}$

$$\left[\sin\theta = \frac{x}{D}\right] \qquad x = \frac{\lambda m D}{d} = \frac{540 \times 2 \times D \times 10^{-9}}{1 \times 10^{-}}$$

$$\lambda = \frac{d}{m} \times \frac{x}{D} = \frac{d}{m}\sin\theta$$

$$\sin\theta = \frac{2 \times 540 \times 10^{-9}}{10^{-5}} = 1080 \times 10^{-4}$$

$$\sin\theta \approx \frac{1}{10}$$

$$\boxed{\theta = \sin^{-1}(1/10)} \qquad \boxed{\theta \approx 6.20}$$

QUE : Distance between adjacent dark spots from a double slit ; $\lambda = 500\ nm$; $d = 1\ mm$; $D = 2\ m$

$\theta = ?$ $\quad$ distance $= \frac{2\lambda D}{d} - \frac{\lambda D}{d} = \frac{\lambda D}{d}$

$$\boxed{\beta = \frac{\lambda D}{d}} \Rightarrow \quad = \frac{500 \times 2 \times 10^{-9}}{10^{-3}}$$

$$= 1000 \times 10^{-6}$$

$$\boxed{y = 10^{-3}\ m}$$

$$\sin\theta_1 = \frac{x}{D} = \frac{\lambda D}{d D} = \frac{\lambda}{d} = \frac{500}{10^{-3}} \times 10^{-9} = 500 \times 10^{-6}$$

$$\sin\theta_1 = 5 \times 10^{-4}$$

Ans : $\boxed{\theta_1 = \sin^{-1}(5 \times 10^{-4}) \Rightarrow 0.0286}$ //

$$m\lambda = d\sin\theta$$

$$\theta = \sin^{-1}\left(\frac{m\lambda}{d}\right)$$

$$\sin\theta = \frac{1 \times 500 \times 10^{-9}}{10^{-3}}$$

$$\sin\theta = 5 \times 10^{-4}$$

$$\boxed{\theta = 0.0286^\circ}$$ //

QUE: Biprism exp; refrating angles ⇒ 1.5 ; $\mu = 1.5$
with single slit of 5cm from biprism; $\lambda = 580\,nm$;
fringes were formed 1m from the slit. fringe width = ?

$\mu = 1.5$ $a = 5cm$

$\boxed{d = \sqrt{d_1 d_2}}$

$\alpha = 1.5 \times \frac{\pi}{180}$

$d = 2 \times 5 \times 10^{-2}\ (1.5 - 1)\left(\frac{1.5 \times \pi}{180}\right)$

$\boxed{d = 0.13 \times 10^{-2}\,m}$ //

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

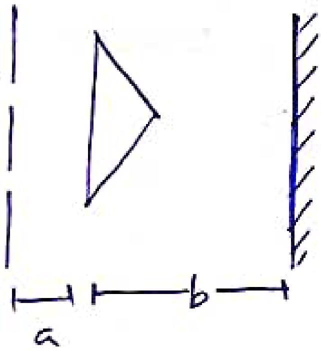
$\beta = \frac{\lambda D}{d} = \frac{580 \times 1}{0.13 \times 10^{-2}}$

$\boxed{d = 2a(\mu - 1)\alpha}$

$\boxed{\beta = 4461.5 \times 10^{-7}\,m}$ //

QUE: $a = 25cm$ (biprism to slit) $b = 100cm$ (slit to screen) $\alpha = 20'$

$\beta = 0.55mm$



$\rightarrow \Delta x = \frac{l\lambda}{d}$ $[l = a + b = 125cm]$

$\Delta x = \frac{125 \times \lambda}{d}$

$\rightarrow \boxed{d = 2a(\mu - 1)\alpha}$

$= 2 \times 0.25\ (1.5 - 1)\ 20 \times \pi/180$

$= 0.25 \times \pi/9$

$\boxed{\Delta x = \beta = \frac{D\lambda}{d}}$

$\rightarrow \Delta x = \frac{l\lambda}{d} = \frac{1.25 \times \lambda}{0.25 \times \pi/9} = \beta$

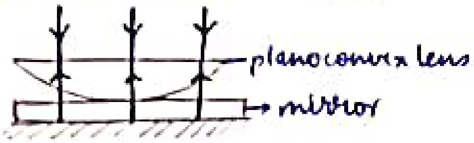
$\lambda = \frac{0.25 \times \frac{\pi}{9} \times \beta}{1.25}$

$\lambda = \frac{25 \times \pi \times 0.55 \times 10^{-3}}{9 \times 125}$

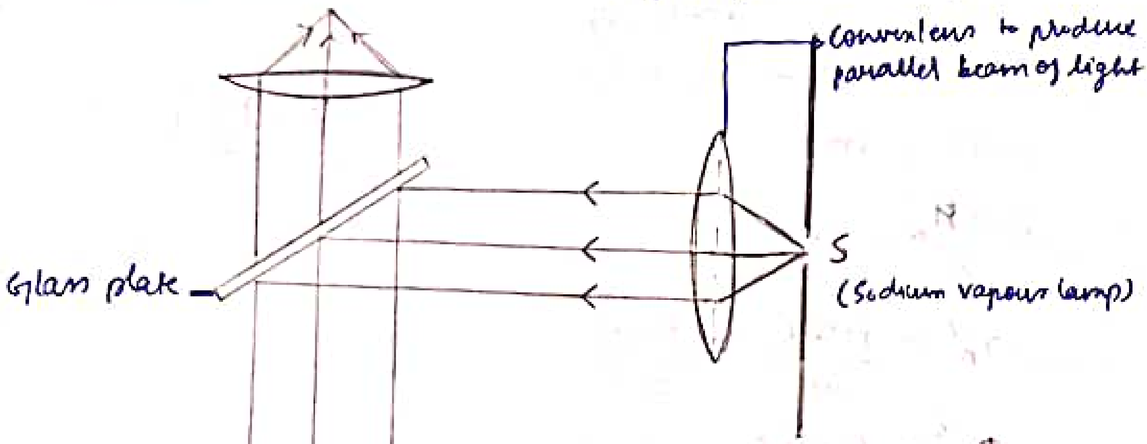
Ans: $\boxed{\lambda = 0.64 \times 10^{-6}\,m}$ //

* NEWTON'S RING:

- Used to calculate the refractive index of the given material.
- Works based on superposition principle of wave.



[partially the light will pass thrugh the lens and partially get reflected back by the mirror]



$$\boxed{\Delta = 2\mu t \cos(r+\theta) - \lambda/2}$$

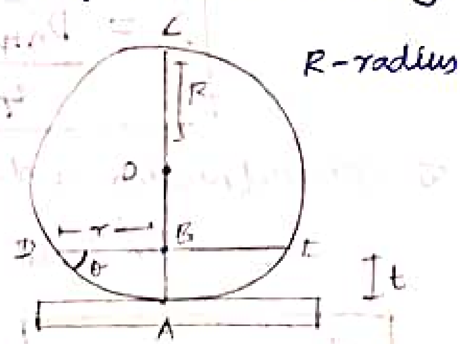
$$\boxed{\Delta = 2\mu t - \lambda/2}$$

Constructive $\Rightarrow$ $\boxed{2\mu t - \lambda/2 = m\lambda}$

Destructive $\Rightarrow$ $\boxed{2\mu t = (2m+1)\lambda/2}$

Conclusion: The central fringe will be dark for Newton's ring

☆ For constructive interference;



$$r \times r = t(2R-t)$$

$$r^2 = 2Rt - t^2 \qquad t^2 \simeq 0$$

$$r^2 = 2Rt$$

$$\boxed{t = \frac{r^2}{2R}} \quad -①$$

DB × BE = AB × BC

$$\Delta = \frac{2\mu r_n^2}{2R} = \frac{(2n+1)\lambda}{2}$$

$$r_n^2 = \frac{(2n+1)\lambda R}{2\mu} = \frac{D_n^2}{4}$$

$$D_n^2 = \frac{4(2n+1)\lambda R}{2\mu} = \frac{2(2n+1)\lambda R}{\mu}$$

$$\boxed{D_n = \sqrt{\frac{2(2n+1)\lambda R}{\mu}}} \quad \text{—②} \qquad [n^{th} \text{ Bright fringe}]$$

☆ For destructive interference;

$$2\mu t + \lambda/2 = (2n+1)\lambda/2$$

$$2\mu t = n\lambda + \lambda/2 \pm \lambda/2$$

$$2\mu t = n\lambda \qquad \left[t = \frac{r^2}{2R}\right]$$

$$\frac{2\mu r_n^2}{2R} = n\lambda$$

$$r_n^2 = \frac{n\lambda R}{\mu} = \left(\frac{D_n}{2}\right)^2$$

$$D_n^2 = \frac{4n\lambda R}{\mu}$$

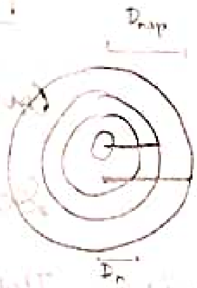
$$\boxed{D_n = \sqrt{\frac{4n\lambda R}{\mu}}} \qquad [n^{th} \text{ Dark fringe}]$$

☆ For wavelength;

$$D_n^2 = \frac{4n\lambda R}{\mu} \quad ; \quad D_{n+p}^2 = \frac{4(n+p)\lambda R}{\mu}$$

$$D_{n+p}^2 - D_n^2 = \frac{4p\lambda R}{\mu}$$

$$\lambda = \frac{D_{n+p}^2 - D_n^2}{4pR} \qquad [\mu = 1]$$



$$\boxed{\lambda = \frac{D_{n+p}^2 - D_n^2}{4pR}}$$

☆ For refractive index;

$$(D_n^2)_{med} = \frac{4n\lambda R}{\mu} \quad ; \quad (D_n^2)_{air} = 4n\lambda R$$

$$\boxed{\frac{(D_n^2)_{air}}{(D_n^2)_{med}} = \mu}$$

* DIFFRACTION :

(Bending of light)

- For a single slit diffraction, when the slit width decreases the number of observable fringes
Lesser width of slit → more fast drop on intensities

[single slit] $\Rightarrow$ $\boxed{I = I_0 \left(\frac{\sin\alpha}{\alpha}\right)^2}$ $\left[\alpha = \pi \frac{a \sin\theta}{\lambda}\right]$

mth minima when $\Rightarrow$ $\boxed{\sin\theta = \frac{m\lambda}{a}}$ [d – dist btw 2 slits]

[multi slit] $\boxed{I = I_0 \left(\frac{\sin\beta}{\beta}\right)^2 \cos^2\gamma}$ $\left[\beta = \frac{\pi}{\lambda} b \sin\theta\right]$

$\left[\gamma = \frac{\pi}{\lambda} d \sin\theta\right]$ $(N>1)$ ↓ no. slit

$\boxed{\text{phase diff } \Delta\phi = 2\pi \frac{\text{path diff}}{\lambda}}$

- When no. of slits is increased, the θ – diffraction angle also increases.

$$\boxed{\frac{\Delta\theta}{\Delta\lambda} = \frac{m}{d\cos\theta}}$$