Phy-101

Wave & oscillations

Wave: A wave is a disturbance in a medium that carries energy without a net movement of particles.

* wave is formed by an oscillation electro-magnetically or mechanically.

Types of wave:

i) Mechanical or elastic wave
ii) electromagnetic wave
iii) Matter wave.

* mechanical wave produced in a material medium.
* mechanical waves governed by Newton's laws of motion. Exm: waves on water surface, waves on strings, sound wave.

(*) Electromagnetic waves: Micro-waves, X-ray, ultraviolet waves, Radio waves.

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* Matter waves:

- Its also called de Broglie wave
- It describe Relation betwein momentum & wavelength.
- wavelength $\propto \frac{1}{\text{momentum}}$

  momentum → mass × velocity

- Smaller the wavelength → fastest the particle move

Oscillations: A periodic ~~of the~~ motion of the system which can creat a wave is known as oscillation.

Wave motion

wave motion propagation of disturbances that is deviations from a state of rest or equilibrium from place to place in a regular & organized way.

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Characteristics of wave :

1. Amplitude <A>

⇒ Maximum displacement of a particle of the medium from its mean position.

2. Period (T)

⇒ The time in which a particle of the medium completes one oscillation.

3. Wave length (λ) page-442

⇒ It is the distance travelled by the wave in the time in which a particle of the medium completes one oscillation.

4. Frequency (f) page 442

⇒ It is the number of waves produced per second or the number of oscillations made by a particle of the medium per second.

5. Velocity (v)

⇒ The rate of change of the objects position with respect to a frame of reference & time.

(4)

Phase

→ Phase is a defination for the position of a point in time on a wave from cycle.

→ Phase can be measured in distance, time or degrees.

Angular frequency

The rate of change of phase with time.

Periodic motion

A motion that repeats itself after equal intervals of time is known as periodic motion.

Simple Harmonic motion:

Simple harmonic motion is motion where the force acting on a body & thereby accelaration of the body proportional to & opposite in direction to the displacement from its equilibrium position.

(*) Simple Harmonic motion is a periodic motion.

Amplitude : measure of the height of the wave

(5)

It is determined as $m\frac{d^2x}{dt^2} = -kx$

k = positive constant

m = mass of the body

x = displacement from mean position.

Characteristics of Simple Harmonic Motion (SHM)

(1) (i) In SHM the acceleration of the particle is directly proportional to ~~the~~ its displacement & directed towards its mean position.

(ii) The total energy of the particle exhibiting simple harmonic motion is conserved.

(iii) SHM is a periodic motion

(iv) SHM can be represented by a single harmonic function of sine or cosine.

(v) The motion is along a straight line about the mean or equilibrium position.

(6)

Harmonic Oscillator

A Harmonic oscillator is a system, when displaced from its equilibrium position experiences a restoring force F proportional to the displacement x according to ~~Hoo~~ Hooke's law.

$$F = -kx$$

k → positive constant.

(a) If F is the only force acting on the system, the system is called a simple harmonic ~~motion~~ oscillator.

(4a) (b) Damped oscillator: If a frictional force proportional to the velocity is also present the harmonic oscillator is described as a damped oscillator.

(*) Driven oscillator If an external time dependent force is present the harmonic oscillator is described as a driven oscillator.

Simple harmonic oscillator

(***) Differential equation of SHM

$$F = -kx$$

$$\Rightarrow F = ma = -kx$$

$$\Rightarrow m\frac{d^2x}{dt^2} = -kx$$

$$\Rightarrow m\frac{d^2x}{dt^2} + kx = 0$$

$$\Rightarrow \frac{d^2x}{dt^2} + \frac{k}{m} = 0$$

$$\Rightarrow \frac{k}{m} = \omega_0^2$$

$$\Rightarrow \frac{d^2x}{dt^2} + \omega_0^2 x = 0$$

(4)

Total energy of SHM

Total energy = P.E + K.E

$$= \frac{1}{2} m\omega^2 a^2 \sin^2 \omega t + \frac{1}{2} m a^2 \omega^2 \cos^2 \omega t$$

$$= \frac{1}{2} m\omega^2 a^2$$

Ans

For exam

K.E

(2) (a)

$$y = a\sin(\omega t)$$

$$\Rightarrow v = \frac{dy}{dt} = \frac{d}{dt} a\sin(\omega t)$$

$$\Rightarrow v = a\omega\cos(\omega t)$$

$$\therefore K.E = \frac{1}{2} m v^2$$

$$= \frac{1}{2} m a^2 \omega^2 \cos^2 \omega t$$

Again,
Acceleration,

$$a = \frac{dv}{dt} = \frac{d}{dt}(a\omega\cos\omega t)$$

$$= -a\omega^2 \sin\omega t$$

$$= -\omega^2 y$$

$dw = -$ Force × displacement

$dw = m\omega^2 y\,dy$

$$dw = \int_0^y m\omega^2 y\,dy$$

$$\therefore w = \frac{1}{2} m\omega^2 y^2$$

$$P.E = \frac{1}{2} m\omega^2 y^2$$

$$= \frac{1}{2} m\omega^2 a^2 \sin^2 \omega t$$

~~P.E~~

Total energy $= P.E + K.E$

$$= \frac{1}{2} m\omega^2 a^2 \sin^2 \omega t + \frac{1}{2} m a^2 \omega^2 \cos^2 \omega t$$

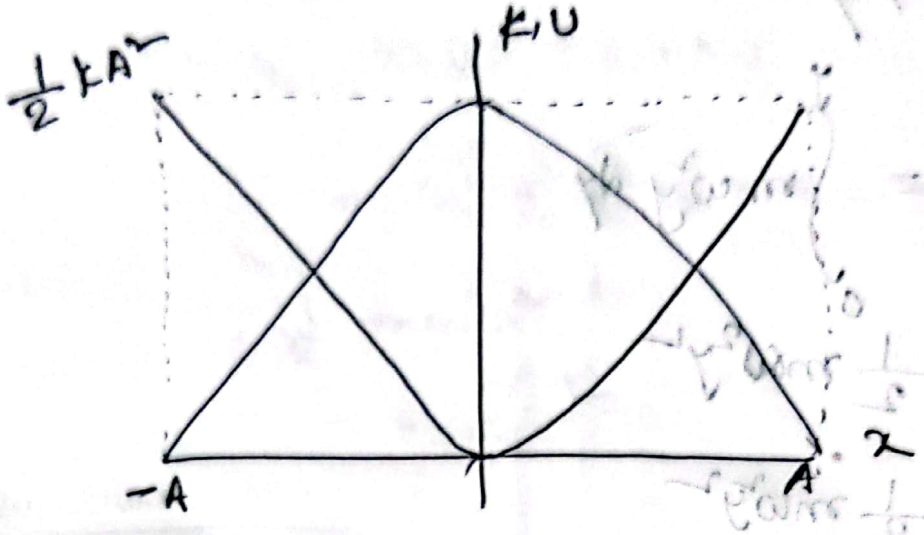
$$= \frac{1}{2} m\omega^2 a^2$$

Ans

(10)

(2) (6)

Total energy graph



Free oscillator:- If an oscillator is displaced & then released it will begin to vibrate. If no more external forces are applied to the system it is a free oscillator.

Force oscillator: If a force is continually or repeatedly applied to keep the oscillation going it is a forced oscillator.

Damped Harmonic motion:-

Example: Simple Pendulum

Types of damping:-

(i) Critical Damping
(ii) Under or light Damping
(iii) Heavy or over Damping

Under or light Damping:-

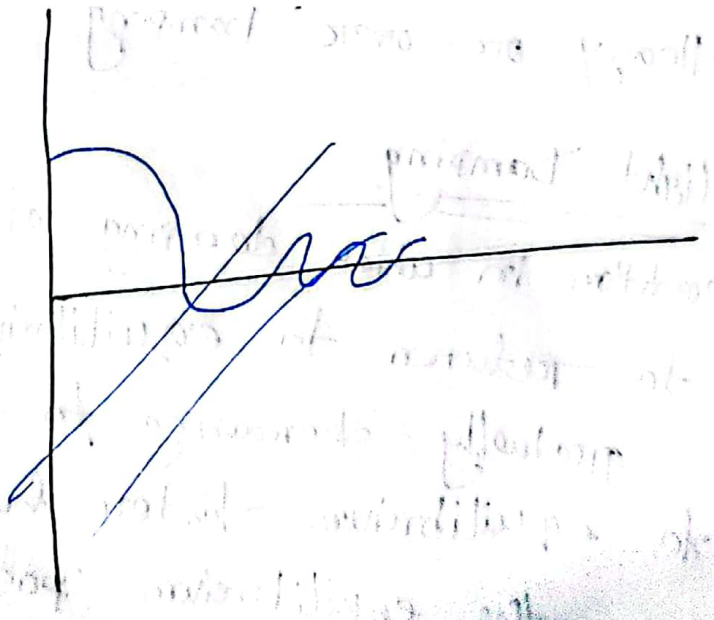
The condition in which damping of an oscillator causes it to return to equilibrium with the amplitude gradually decreasing to zero. system returns to equilibrium faster but overshoots & crosses the equilibrium position one or more times.

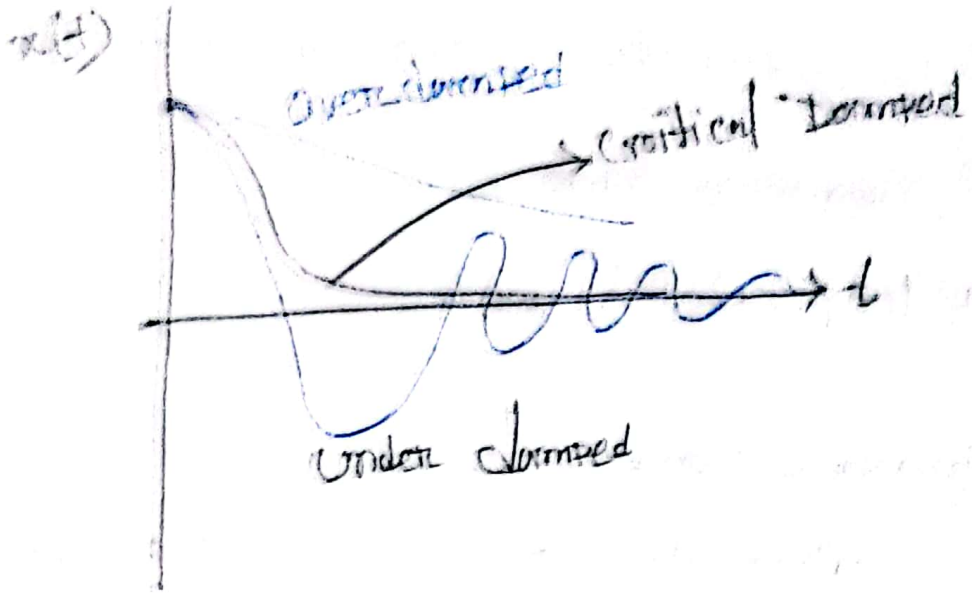
Critically Damped:

The condition in which the damping of an oscillator causes it to return as quickly as possible to its equilibrium position without oscillating back & forth about this position.

Over Damped.

The condition in which damping of an oscillator causes it to return to equilibrium without oscillating; oscillator moves more slowly toward equilibrium than in the critically damped system.





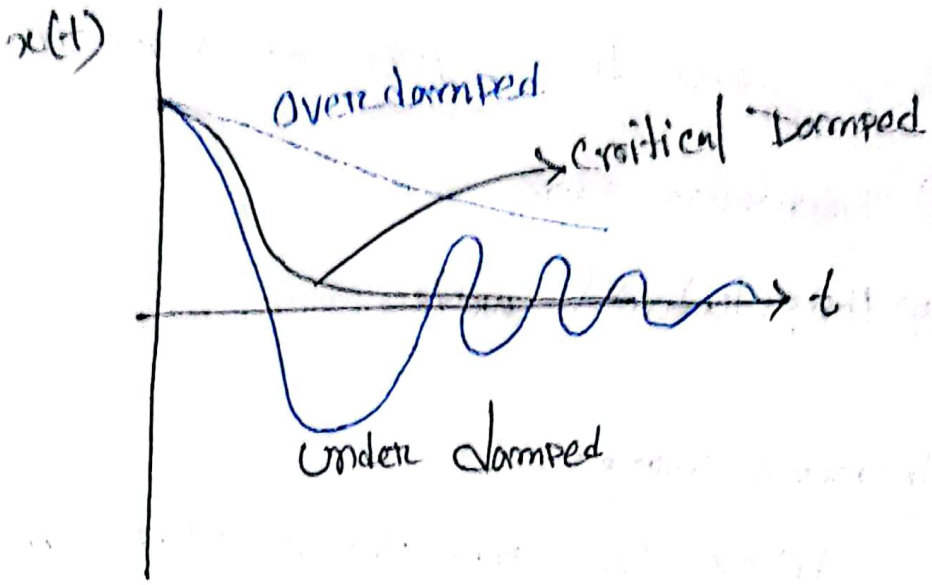
Resonance:

If the frequency is the same as the natural frequency the amplitude becomes quite large. This is called resonance.

(5) Sharpness of resonance peak is depend on damping.

(a) If the damping is small resonance is quite sharp

(b) If " " " large " " less sharp.



(1) (b) **Resonance:**

If the frequency is the same as the natural frequency the amplitude becomes quite large. This is called resonance.

(*) sharpness of resonance peak is depend on damping.

(a) If the damping is small resonance is quite sharp

(b) If " " " large " " less sharp.

Types of wave motion:

There are two types of wave motion.

(i) Transverse wave

(ii) longitudinal wave

Transverse wave:

When the particles of the medium vibrate at right angles to the direction of propagation of the wave, the wave is said to be a transverse wave.

longitudinal wave

When the particles of the medium vibrates parallel to the direction of propagation of the wave, the wave is called longitudinal wave.

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characteristics of progressive wave:

1. Every particle discribed simple harmonic motion along the direction of propagation of wave, there being a change of phase from point to point.

2. The wave velocity in a given medium is a constant determined by the density & the elastic constant of the medium.

3. Only the energy is carried by the advancement of the waveform in the direction of propagation of the wave.

4. The phase difference between two vibrating particles on the line of propagation is proportional to the path difference between the particles.

(16)

Equation of plane progressive wave

$$y = A\sin\omega t \quad \text{—— (I)}$$

$$\Rightarrow y = A\sin(\omega t - \phi) \quad \text{—— (II)}$$

$$\Rightarrow y = A\sin\left(\omega t - \frac{2\pi x}{\lambda}\right) \quad \text{—— (III)} \quad \left[\phi = \frac{2\pi x}{\lambda}\right]$$

$$\Rightarrow y = A\sin\left(\frac{2\pi t}{T} - \frac{2\pi x}{\lambda}\right) \quad \text{—— (IV)} \quad \left[\omega = \frac{2\pi}{T}\right]$$

$$\Rightarrow y = A\sin 2\pi\left(\frac{t}{T} - \frac{x}{\lambda}\right) \quad \text{—— (V)}$$

$$\Rightarrow y = A\sin 2\pi\left(\frac{vt}{\lambda} - \frac{x}{\lambda}\right) \quad \text{—— (VI)} \quad \boxed{v = \frac{\lambda}{T} \Rightarrow T = \frac{\lambda}{v}}$$

$$\Rightarrow y = A\sin\frac{2\pi}{\lambda}(vt - x) \quad \text{—— (VII)}$$

train
or
the
compression

$$\Rightarrow \boxed{\frac{dy}{dx}} = A \cdot \frac{2\pi}{\lambda}\cos\frac{2\pi}{\lambda}(vt - x) \quad \text{—— (VIII)}$$

$$\Rightarrow \frac{dy}{dt} = A\frac{2\pi v}{\lambda}\cos\frac{2\pi}{\lambda}(vt - x) \quad \text{—— (VIII)}$$

Comparing 7 & 8

$$\Rightarrow \frac{dy}{dt} = -v\frac{dy}{dx} \quad \text{—— (IX)}$$

diff eqn (VII)

$$\Rightarrow \frac{d^2y}{dt^2} = -A\frac{4\pi^2}{\lambda^2}\sin\frac{2\pi}{\lambda}(vt - x) \quad \text{—— (X)}$$

diff eqn (VIII)

$$\Rightarrow \frac{d^2y}{dt^2} = -A\frac{4\pi^2}{\lambda^2}v^2\sin\frac{2\pi}{\lambda}(vt - x) \quad \text{—— (XI)}$$

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Comparing (10) & (11)

$$\frac{d^2y}{dt^2} = v^2 \frac{d^2y}{dx^2}$$

This is the differential equation of wave motion.

Progressive wave

1. The disturbance travels onward, it being handed over from one particle to the adjoining particle.
2. Energy is transferred in the medium along the waves.
3. The amplitude of vibration of each particle is the same.
4. No particle of the medium is permanently at rest.
5. The equation of a progressive wave is

$$y = a\sin\frac{2\pi}{\lambda}(vt - x)$$

(18).

(11) (C)

Stationary waves

1. The disturbance is confined to a perticular region & there is no onward motion.

2. There is no transference of energy in the medium.

3. The amplitude of vibration of the particles changes from zero at nodes to maximum at antinodes.

4. The particles of the medium at nodes are permanently at rest.

5. The equation of a stationary wave is $y = A\sin\frac{2\pi}{\lambda}(vt)$

Wavelength:

The distance between two successive crest of a wave, especially points in a sound wave or electromagnetic wave.

$$\lambda = \frac{v}{f}$$

$v \rightarrow$ velocity, $f \rightarrow$ Frequency, $\lambda \rightarrow$ wave length

Frequency

The number of occurrence of repeating event per unit time is called frequency.

$$f = \frac{v}{\lambda} \quad [\text{unit } Hz]$$

Doppler effect:

Doppler effect is a phenomenon that is observed whenever the source of waves is moving with respect to an observer.

(H) Doppler effect is defined as the increase or decrease in the frequency of ~~the~~ sound, light or other waves as the source & observer move towards ~~or~~ or away from each other.

Doppler effect formula:

$$f' = \frac{(v \pm v_o)}{(v \pm v_s)} f$$

f' = observed frequency
f = actual frequency
v = velocity of sound waves
v_o = " " observer
v_s = " " the source

(a) source moving towards the observer at rest:

$$f' = \frac{v}{(v - v_s)} f$$

f' = observer frequency
f = actual frequency
v = velocity of sound waves
v_s = velocity of the source

(b) Source moving away from the observer at rest.

$$f' = \frac{V}{(V-(-V_s))} f$$

(c) observer moving towards a stationary source:

$$f' = \left(\frac{V+V_o}{V}\right) f$$

(d) observer moving away from a stationary source:

$$f' = \frac{(V-V_o)}{V} f$$

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Maths

Two trains A & B are moving towards each other with a speed of 432 km/h. If the frequency of the ~~wis~~ whistle emitted by A is 800 Hz, then what is the apparent frequency of the whistle heard by the passenger sitting in train B. (The velocity of sound in air is 360 m/s)

Ans

The source & the observer are moving towards each other, hence

$$f = f_0 \left(\frac{v + v_0}{v - v_s} \right)$$

Converting 432 km/h into m/s we get 120 m/s

Substituting the values in the equation we get

$$f = 800 \left(\frac{360 + 120}{360 - 120} \right)$$

$$= 1600 \text{ Hz}$$

Ans

Problem

Harmonic motion:-

1. A Harmonic motion is represented by

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

where y is measured in meters, T in seconds & the phase angle in radians.

Calculate:

(i) the time period

(ii) the maximum displacement.

(iii) the maximum velocity

(iv) the maximum accelaration

Here,

(i) Frequency, $\omega = 10$

But,

$$\omega = 2\pi n$$

$$\Rightarrow n = \frac{\omega}{2\pi}$$

$$= \frac{10}{2\times 3.1416} = 1.6 \text{ Hz}$$

(ii) $T = \frac{1}{n} = \frac{1}{1.6} = 0.63$ sec

(iii) Maximum displacement, $a = 10$m

(iv) Maximum velocity, $\frac{dy}{dt} = a\omega = 10\times 10 = 100$m/sec

(v) Maximum accelaration, $\frac{d^2y}{dt^2} = -a\omega^2 =$

$-10\times(10)^2 = -1000$ m/sec^2 Ans.

(2)

A particle executes simple harmonic motion given by the equation.

$$y = 12 \sin\left(\frac{2\pi t}{10} + \frac{\pi}{4}\right)$$

Calculate (i) Amplitude

(ii) Frequency

(iii) Displacement at $t = 1.25$ sec

~~(iv) Amplitude~~

(iv) Velocity at 2.5 sec

(v) Acceleration at $t = 5$ sec.

A

(i) $a = 12$ unit

(ii) $\omega = \frac{2\pi}{10}$

we know,

$\omega = 2\pi n$

$\Rightarrow n = \frac{\omega}{2\pi}$

$= \frac{2\pi}{10 \times 2\pi} = \frac{1}{10} = 0.1$ Hz

(iii) At $t = 1.25$ sec

$$y = 12 \sin\left(\frac{2\pi \times 1.25}{10} + \frac{\pi}{4}\right) = 12 \sin\frac{\pi}{4}$$

$= 12$ units

(iv) At $t = 2.5$ sec

$$v = \frac{dy}{dt} = a\omega\cos(\omega t + \varphi)$$

$$\frac{dy}{dt} = 12 \times \frac{2\pi}{10} \cos\left[\frac{2\pi}{10} \times 2.5 + \frac{\pi}{4}\right]$$

$$= -5.552 \text{ units.}$$

(v) At $t = 5$ sec

Acceleration $\frac{d^2y}{dt^2} = -a\omega^2 \sin(\omega t + \varphi)$

$$= -12 \times \left(\frac{2\pi}{10}\right)^2 \sin\left(\frac{2\pi}{10} \times 5 + \frac{\pi}{4}\right)$$

$$= -0.48\pi^2 \sin\left(\pi + \frac{\pi}{4}\right)$$

$$= 3.35 \text{ units.}$$

OPTICS

Questions

1. Define light
2. list five properties of light
3. what are branches of optics.
4. What is the ~~wave~~ wavelength of visible light?
5. What is a prism?
6. what is internal reflection?

Ans

(i) light: Light is a form of energy which on entering our eyes, gives us the sensation of sights & enables us to see various object.

(ii) Wave: Wave is a moving, dynamic disturbance of matter or energy in a organised & periodic way.

(iii) ~~Hy~~ Huygen's wave theory of light: Every point that a luminous disturbance meets turns into a source of the spherical wave itself. The sum of the secondary waves which are the result of the disturbances determines what form the new wave will take.

Optics

Questions

Q & Ans

① How many peaks of the interferance will be observed in the central maxima of the diffraction pattern?

Ans In the central maximum of the diffraction pattern, there will be series of bright fringes, known as interference maxima. The first maximum corresponds ~~the~~ to the central bright spot & the higher-order maxima are located at equal intervals on either side of the central maximum. The number of interferance maxima in the central maximum is in-finite. However the intensity of the higher order maxima decreases as their order increase.

② How many peaks of the interference will be observed if the slit width is doubled while keeping the distance between the slits same:

A If the slit width is doubled while keeping the distance between the interferance maxima will decrease by a factor of 2. This is because the interference pattern depends on the ratio of the slit width to the distance between the slits. Doubling the slit width decrease this ratio, resulting in a narrower spacing between the interferance maxima. The total number of interference maxima observed will remain

the same, but they will be spaced more closely together.

(3) What is interference of light? Explain the constructive interference & distructive interference.

A Interference of light is the phenomenon that occurs when two or more waves of light overlap in space, resulting in a new wave pattern. Constructive interference occurs when the crests of two waves overlap, resulting in an increase in amplitude. Distructive interference occurs when the crest of one wave overlaps with the ~~th~~ trough of another wave, resulting in a decrease in amplitude.

(4) State the condition for steady interference pattern.

A The condition for steady interference pattern are:

i) The light source must be coherent.

ii) The light sources must be monochromatic

iii) The slits must be very narrow

iv) The distance between the slits must be small compared to the distance to the screen.

(v) The screen must be placed far enough from the slits.

(5) What are the co-herent sources?

A coherent sources are sources of light that have a constant phase difference between them. They emit waves that have ~~a~~ the same frequency, amplitude & ~~poly~~ polarization & the phase difference between them is constant.

(6)
What is the importance of Young's experiment?

A
Young's experiment is important because it provided the first experimental evidence of the wave nature of light. It demonstrated the interference of light waves & the wave particle duality of light.

(7)
Write down the conditions for bright band & dark band in terms of path difference:

A The conditions for bright & dark band in terms of path difference Δx are given by:

Bright band

The path difference between the two waves must be an integer multiple of the wavelength for constructive interference to occur & for a bright band to be observed.

$$\Delta x = m\lambda$$

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Dark band

The path difference between the two waves must be an odd multiple of half the wave-length for destructive interference to occur and for a dark band to be observed.

$$\Delta x = \left(m + \frac{1}{2}\right)\lambda$$

(8) write down the equation of resulting intensity due to interference of light waves.

A

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

(9) Q 17a How the coherent sources are obtained?

Ans

Coherent sources are sources of wave. Such as light waves that have a constant phase difference & frequency. coherent sources can obtain in several waves.

(1) Division of wave front: A single wave front can be devided into two or more parts using a beam splitter or partially reflected mirror.

(2) Reflection: Reflection of a wave from mirror can creat coherent source as the reflected wave will have the same frequency.

(3) Diffraction grating: ~~A different~~ A diffraction grating is a device that consists of a large number of equally spaced parallel slits.

(1) Laser: A laser is an artificial source of coherent light that uses stimulated emission to create a beam of light.

Q what is diffraction of light?

A Diffraction of light is the bending & ~~spreading~~ spreading out of light waves as they pass through a narrow opening or around an obstacle. When light waves encounter an object that has a size similar to or smaller than the wave length such as a narrow slit or a sharp edge, the waves spread out & interfere with each other, creating a diffraction pattern.

1)

P.T.O

(11) What are the differences in between the Fresnel & Fraunhofare types of diffraction?

A.

Fresnel	Fraunhofare
(1) If the source of light & screen is at a finite distance from the obstacle, then the diffraction called Fresnel diffraction.	(1) If the source of light & screen is at infinite distance from the obstacle then the diffraction is called Fraunhofare diffraction.
(2) The corresponding rays are not parallel	(2) The corresponding rays are parallel.
(3) The wave fronts falling on the obstacle are not plane.	(3) The wave fronts falling on the obstacle are planes.
(4) Incident wave fronts are spherical.	(4) Incident wave fronts on the diffracting obstacle are plane.
(5) No lens is required	(5) lens is required.

O.t.q

(12) What is the difference in between Interference & diffraction?

A

Interference	Diffraction.
(1) Interference pattern is result of superposition of light coming from two different wave fronts of two coherent sources.	(1) Diffraction pattern is result of superposition of light coming from different parts of the same wave front
(2) Interference fringes are of equal width.	(2) Diffraction fringes have unequal width.
(3) In interference pattern all bright bands have same intensity	(3) In diffraction pattern all bright bands are not of same intensity. Central maximum has height intensity.
(4) In Interference Pattern dark band is perfectly dark.	(4) In diffraction pattern dark band is not perfectly dark

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(11) What are conditions for the secondary minima & secondary maxima?

A

Conditions for secondary maxima & minima are:

Secondary Maxima: secondary maxima occur when the path difference between the waves from the two slits is an odd multiple of half the wavelength. mathematically, this can be expressed as

$$d \sin\theta = \left(m + \frac{1}{2}\right)\lambda$$

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Secondary minima : Secondary minima occur when the path difference between the waves from the two slits is an even multiple of half the wavelength. mathematically this can be expressed as

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

Optics

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(1) Coherent source

(a) Coherent sources are two or more sources of waves that emit waves of the same frequency & have a constant phase difference between them.

Production of coherent sources:

There are two general methods for producing co-herent sources.

i) By the division of wave front.

ii) By the division of Amplitude.

(b) Interference

The phenomenon of redistribution of energy due to super position of light waves from two coherent sources is called interference.

(*) Necessary condition of Interference:

(1) The sources must be monochromatic.

(2) Two coherent sources are required.

(3) There must be a phase difference or path difference between the two waves.

(4) The amplitude of the waves must be same

(5) The two waves must travel with the same velocity.

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(c) Constructive Interference:

In constructive interference the amplitude of the resultant wave is greater than that of either individual wave.

Destructive Interference:

In destructive ~~int~~ interference the amplitude of the resultant wave is less that of either individual wave.

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③ ⓐ

Formation of Newton's ring:

Newton's ring's are formed when a flat glass plate & a convex lens are placed in contact with each other, creating a small air gap between them. When light is directed onto the glass plate, some of the light is reflected off the to surface of the plate & some is transmitted through the plate & reflects off the surface of the lens.

The two reflected rays then interfere with each other, creating a pattern of bright & dark rings. These rings are formed because the thickness of the air gap between the glass plate & the lens varies at different points of the surface of the plate, which causes a difference in the path length of the two reflected rays. This path length difference leads to interference which causes the rings.

The bright rings correspond to point of constructive interference, where the path length difference is equal to an integer multiple of the wave length of the light. The dark rings correspond to point of destructive interference, where the path length difference is equal to a half integer multiple of the wave length of the light. The center of the

Pattern correspond to the point of closest contact between the glass plate & the lens where the air gap is thinnest & the length difference is zero.

Q

Why the rings are circular & the central spot is dark?

Ans

The rings in the Newton's rings pattern are circular because the thickness of the air gap between the glass plate and the convex lens changes continiously from the center to the edges of the pattern. The bright and dark fringes in the pattern are due to the interference of light waves. The central spot is dark because the air gap is at its thinnest at the center, causing the reflected rays to destructively interfere with each other.

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(9)(a)

Distinguish between Interference & diffraction

Interference	Diffraction
(1) Interference pattern is result of superposition of light coming from two different wave fronts of two coherent sources.	(1) Diffraction pattern is result of superposition of light coming from different parts of the same wave front.
(2) Interference fringes are of equal width.	(2) Diffraction fringes have unequal width.
(3) In interference pattern all bright bands have same intensity.	(3) In diffraction pattern all bright bands are of same intensity. central maximum has highest intensity.
(4) In interference pattern dark band is perfectly dark.	(4) In diffraction pattern dark band is not perfectly dark.

(5) Diffraction:

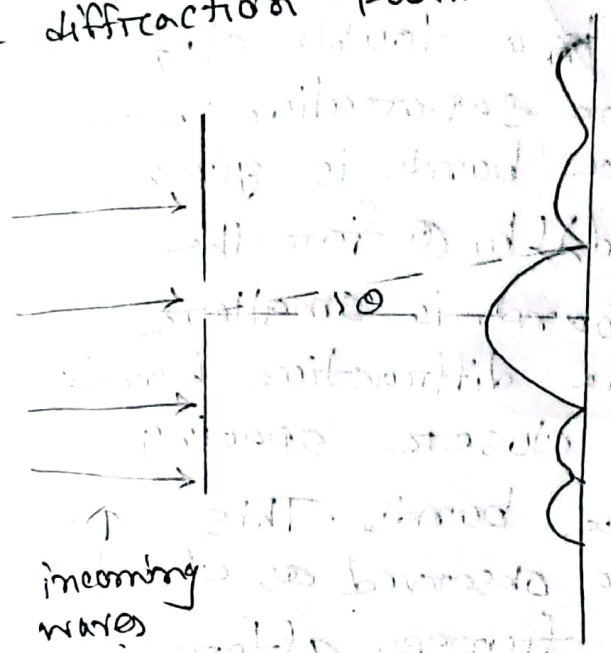
Diffraction is the bending of light which results from limiting how much of a wave front contributes to a reflected or transmitted wave.

Distinguish between Fresnel & Fraunhofer diffraction.

Fresnel	Fraunhofer
(1) If the source of light & screen is at a finite distance from the obstacle, then the diffraction called Fresnel diffraction.	(1) If the source of light & screen is at infinite distance from the obstacle then the diffraction is called Fraunhofer diffraction.
(2) The corresponding rays are not ~~equal~~. parallel.	(2) The corresponding rays are parallel.
(3) The wave fronts falling on the obstacle are not plane.	(3) The wave fronts falling on the obstacle are planes.
(4) Incident wave fronts are spherical.	(4) Incident wave fronts are plane.
(5) No lens required	(5) lens required.

(c) Single slit diffraction

Diffraction is the bending & spreading of waves when they encounter an obstacle or aperature. When light passes through a single slit, it diffracts & creates a diffraction pattern on screen. The pattern consists of a bright central maximum & alternative dark & bright fringes on either side of the maximum. This is known as a single slit diffraction pattern.



(A) Determination the band width of the central maximum

→ If the screen is far away from the aperture

$$\tan\theta \approx \sin\theta \approx \frac{y}{D}$$

$$\Rightarrow \sin\theta = \frac{\lambda}{d} = \frac{y}{D}$$

$$\Rightarrow y = \frac{\lambda D}{d}$$, central maxima band width ; $\Delta y = \frac{2\lambda D}{d}$

(5) (a)

In a double slit diffraction pattern, interference bands & diffraction bands are observed. The distance between the interference band is smaller than the diff distance between the diffraction band. This is because the distance between the slit (d) is much larger than the width of each slits (b) in a double slit setup. The angular separation between the interference bands is given by $\theta = \frac{\lambda}{b}$ As $d > b$, θ for the interference bands is smaller than θ for the diffraction bands leading to the closer spacing of the interference bands. This pattern can be observed as closely spaced bright fringes alternative with dark fringes in the double-slit diffraction pattern.

(6)

To calculate the missing orderer of an interference band due to double slits diffraction, we use the formula $m\lambda = d\sin\theta$, where m = orderer of the interference band; λ = wavelength of light, d = distence between the slits, θ is angle diffraction.

If one of the interference band is missing we can find the value of m fore that missing band by first determining the value of θ fore the missing band using the formula $\sin\theta = \frac{m\lambda}{d}$. Then we can solve fore m using the formula

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

(6)

(a)

Polarized light: Polarized light waves are light waves in which the vibrations occur in single plane.

Producing of polarized light:

Polarized by

→ Transmission
→ reflection
→ scattering
→ Refraction.

(b)

Plane of vibration: A plane including the direction of light propagation & direction of electric field.

Plane of polarization: A plane perpendicular plane of vibration

~~Potte~~

Potential application of polarized ~~wave~~ light or polarization:

Polarization use in sunglass to reduce the glare.

Polaroid filters are used in plastic industries to performing stress analysis test.

~~Infered~~

Infrared spectroscopy uses polarization.

It is used in seismology

With the help of polarization 3D movies are produced & shown.

Double refraction

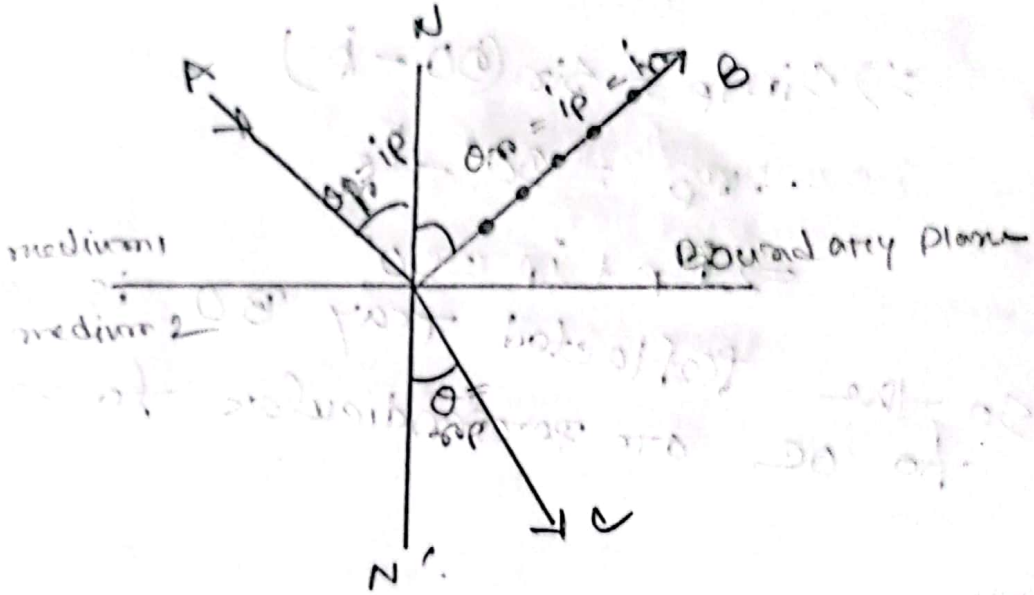
Double refraction also called birefringence an optical property in which a single ray of unpolarized light entering an anisotropic medium is split into two rays, each travelling in a different direction.

- Ray: The refracted rays which obey Snell's law is called o-ray or ordinary ray.
- Ray: The refracted rays which ~~obey~~ doesn't obey snell's law is called e-ray, or extraordinary ray.

(6) State that Brewster law & show that the reflected & refracted rays are at right angles to each other.

Ans.

Brewster law is a simple relationship between the angles of polarization and the refractive index of the medium. It states that the tangent of the polarized angles of incidence of a transparent medium is equal to its refractive index, $\mu = \tan i_p$



Hence,

Angles of incidence or polarization $\theta_i = i_p$

Angles of reflection $\theta_r = i_p$

Angles of refraction $\theta = r_p$

We have,

Snell's law, $\mu = \frac{\sin i_p}{\sin r_p}$

Brewster law, $\mu = \tan i_p$

$\therefore \frac{\sin i_p}{\sin r_p} = \tan i_p$

$\Rightarrow \frac{\sin i_p}{\sin r_p} = \frac{\sin i_p}{\cos i_p}$

$\Rightarrow \sin r_p = \cos i_p$

$\Rightarrow \sin i_p = \sin(90 - i_p)$

$\therefore r_p = 90^\circ - i_p$

$\Rightarrow r_p + i_p = 90^\circ$

So the reflacted ray BO is perpendicular to OC, OR perpendicular to each other

(c)

Optic axis : An optic axis of a crystal is a direction in which a ray of transmitted light ~~surface~~ suffers no birefringence.

Uniaxial crystal. The crystals which have only a single optic axis are called Uniaxial crystal.

Biaxial crystal - The crystals which have two different optic axes are called Bi-axial crystal.

Positive crystal : A uniaxial crystal in which the ordinary wave travels faster than the extraordinary wave except along optic axis is called positive crystal

Negative crystal : A uniaxial crystal in which the extraordinary wave travels faster than the ordinary wave except along optic axis is called Negative crystal.

8

(a)

Wave plate or retarded plate :

An optical device that can alter the polarization state of a light wave that is travelling through it.

(b) Difference between Half wave plate & Quarter wave plate.

A

Half wave plate tends to shift the polarization direction of linearly polarized light, whereas quarter wave plate tends to convert linearly polarized lift into circularly polarized light.

In addition, in half wave plate, the difference between two emerging plane polarized waves is the value of pi, whereas in quarter wave plates, it is half of the pi value.

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Wave

(3) (a)

Wave motion propagation of disturbances that is deviations from a state of rest or equilibrium from place to place in a regular & organized way.

(b) Distinguish between transverse & longitudial wave motion.

Longitudinal	Transverse
(i) The medium moves in the same direction of the wave	(i) The medium is moving perpendicular to the direction of wave.
(ii) It acts in one ~~direction~~ dimension	(ii) It acts in two dimension
(iii) The wave can't be polarized	(iii) The wave can be produced in solid & liquids surface
(iv) It is made of rarefaction	(iv) It is made of crests.
(v) The earthquake (P) wave is an example	(v) ~~the~~ Earthquake S wave is an example.

Lissajous Figure

3(a) When a particle is influenced simultaneously
5(a) by two simple harmonic motion at right
8-1 angles to each other, the resultant motion of the particle traces a curve. These curves are called Lissajous figure.

The definition of a Lissajous figure can be defined as one of ~~the~~ an infinite number of curves formed by combining two simple oscillations that are perpendicular to each other.

(b) * Composition of two simple harmonic vibrations in a straight line.

- Let the two simple harmonic vibration be represented by equations.

$$y_1 = a_1 \sin(\omega t + \alpha_1) \quad \text{—— (I)}$$

$$y_2 = a_2 \sin \sin(\omega t + \alpha_2) \quad \text{—— (II)}$$

y_1, y_2 = displacements of the particle due ~~to~~ the two vibration

a_1, a_2 = Amplitude of two vibration

α_1, α_2 = epoch angle

The resultant displacement of the particle is given by

$$Y = y_1 + y_2$$

$$= a_1 \sin(\omega t + \alpha_1) + a_2 \sin(\omega t + \alpha_2)$$

$$= a_1 (\sin\omega t \cdot \cos\alpha_1 + \cos\omega t \cdot \sin\alpha_1) + a_2 (\sin\omega t \cos\alpha_2 + \cos\omega t \sin\alpha_2)$$

$$= (a_1 \cos\alpha_1 + a_2 \cos\alpha_2) \sin\omega t + (a_1 \sin\alpha_1 + a_2 \sin\alpha_2) \cos\omega t \quad \text{——— (III)}$$

Since the amplitude a_1 & a_2 & the angles α_1 & α_2 are constant the coefficient of $\sin\omega t$ in equation (3) can be substituted by $A\cos\phi$ & $A\sin\phi$

$$A\cos\phi = a_1 \cos\alpha_1 + a_2 \cos\alpha_2 \quad \text{——— (4)}$$

$$A\sin\phi = a_1 \sin\alpha_1 + a_2 \sin\alpha_2 \quad \text{——— (5)}$$

squaring & adding eq (4) & 5

$$A^2 (\sin^2\phi + \cos^2\phi) = a_1^2 (\sin^2\alpha_1 + \cos^2\alpha_1) + a_2^2 (\sin^2\alpha_2 + \cos^2\alpha_2) + 2 a_1 a_2 (\cos\alpha_1 \cos\alpha_2 + \sin\alpha_1 \sin\alpha_2)$$

$$\Rightarrow A^2 = a_1^2 + a_2^2 + 2 a_1 a_2 \cos(\alpha_1 - \alpha_2) \quad \text{——— (6)}$$

Exam 4 Part 1, 2, 3, 4, 5, 6 Finished
[illegible]

5(a) P-2

Lissajous figure is important in acoustical measurement because

Lissjous figure have important applications in acoustical measurement such as in the measurement of the phase difference between two sound waves. In acoustic, the phase difference between two sound waves can be used to determine the direction of arrival of the sound waves to measure the distance to a sound source.

5(c)

(1) when the phase difference is zero (i.e.) the two motions are in phase & rein each other. The shape of the Lissajous figure is a straight line inclined at angle to the x-axis.

(ii) When the amplitudes of the two motions are the same, the shape of the Lissajous figure is a straight line perpendicular to the x-axis.

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