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Physics - Interference Tutorial Sheet.

Q1. What is interference of light?

The modification in the distribution of light energy obtained by the superposition of two waves of equal frequency and constant phase diffrence in region of superposition is called interference.

Q2. Is there any conservation of energy in the phenomenon of Interference? Explain.

There is no loss of energy due to interference. The energy is only transferred from the points of minimum displacement to maximum displacement i.e. there is only redistribution of energy. Thus, energy is conserved.

Q3. What are conditions to get good interference pattern?

~~i) Conditions for sustained interference :-~~

→ The two sources should continuously emit waves of the same wavelenght or frequency.

→ The amplitude of two waves must be equal or near to equal.

→ The distance betwee sources and screen should be reasonable as too large disteme reduces intensity and too close can cause overla[p]

→ The seperation b/w two coherent sources must be small i.e. very close to each oth[er]

→ The background must be dark.

Q4. Explain why two independent sources can never be coherent?

In actual practice, it is not possible to have two independent sources which are coherent because incase of any change in phase at the time when the waves are emitted from the sources affets two coherent sources diffrently. They will not be in same phase and ~~have~~ move with diffrent phase diff.

Q6. Name two broad methos for production of coherent sources.

Use a single source and the beam is arranged to split it into two beams seems coming from diffrent sources called virtual sources.

Method 1: Young Double Slit

Method 2: ~~Fere~~ Fresnel Biprism

Q5. What are conditions for minima and maxima in an interference pattern?

If path diffrence is an even multiple of $\lambda/2$ then waves arrive in same phase producing maximum intensity or the crest of one wave falls upon crest of other and trough of one falls upon trough then intensity maximizes.

If path diff is an odd multiple of $\lambda/2$ then waves arrive in diffrent phase producing minimum intensity ~~or~~ the crest of one waves falls on trough of other wave and vice-versa. Then the resultant will be minima.

Q7. What is Fresnel Biprism? How will you determine wavelength of light using Fresnel Biprism?

After YDSE, Fresenal brought another way to perform same experiment to study interference pattern. Biprism is a combination of two prism with their bases joined and their two faces making an angle of about 179° and other angle of 30'. Each half of prism produces virtual image of source by refraction. The Fresenal used the biprism to get two coherent source of monochromatic light from a single source calling it Fresnel Biprism.

The measurement of fringe width in a biprism enable one to determine wavelength of light if D (distance of source to centre of screen) and d (distance b/w sources) are known i.e.:-

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

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

Q8. What is ~~int~~ effect of interference pattern when monochromatic light in Fresnel Biprism is replaced by white light?

Instead of monochromatic light, when white light is used in the biprism experiment, then the central fringe will be white as all colours will meet in phase. All other fringes will be coloured. These coloured fringes will be due to fact that different colours of white sources will meet in diff. phases. These fringes will overlap each other at very small distance from C.

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Q9. Why does the centre of Newton's ring appear dark in reflected light?

We know, for bright fringe

$$d_n = \sqrt{\frac{(2n-1)\, 2R\lambda}{\mu}}$$

for dark fringe,

$$d_n = \sqrt{\frac{4Rn\lambda}{\mu}}$$

When $n = 0$,

diametre of dark ring is zero and bright ring is $\sqrt{\frac{2R\lambda}{\mu}}$

Therefore central ring is dark

∴ As while counting ordi of rings 1, 2, 3 .. etc. the Central bring is not counted.

Q10. What change would you expect in interference pattern of Newton's ring if plane mirror replace trasperent plate?

Q11. Explain the terms: fringes of equal thickness and fringes of equal inclination.

Fringes of equal inclination:- These fringes are formed when light from an extended source falls on a thin film of an optically denser medium.

Fringes of equal thickness! These periodic fringes appear in the images. The sources must be monochromatic for the fringe thickness to be constant and good intensity.

Q12. Describe Newton's rings experiment for measuring the wavelength of monochromatic light and give the necessary theory. What will happen if little water is introduced b/w the lens and the plate?

To determine the wavelength λ of light, the source S is replaced by a given source of monochromatic light. Focus the travelling microscope on the Newton's ring formed.

d_n and d_{n+m} of nth and (n+m)th dark rings and Radius of curvature R. Taking $\mu = 1$, the wavelength λ will be :-

$$\frac{d_n^2}{4R} = \frac{n\lambda}{\mu} \quad -(1)$$

for d_{n+m} the diametre of (n+m)th dark ring.

$$\frac{d_{n+m}^2}{4R} = \frac{(n+m)\lambda}{\mu} \quad -(2)$$

Sub (1) and (2),

$$\frac{d_{n+m}^2 - d_n^2}{4R} = \frac{m\lambda}{\mu}$$

$$\lambda = \frac{\mu(d_{n+m}^2 - d_n^2)}{4Rm}$$

If $\mu = 1$ then $\lambda = \frac{d_{n+m}^2 - d_n^2}{4Rm}$.

Let the refractive index of material of glass be μ_1 and glass plate is μ_2 and the refractive index of water be μ then

$$\mu_1 > \mu > \mu_2$$

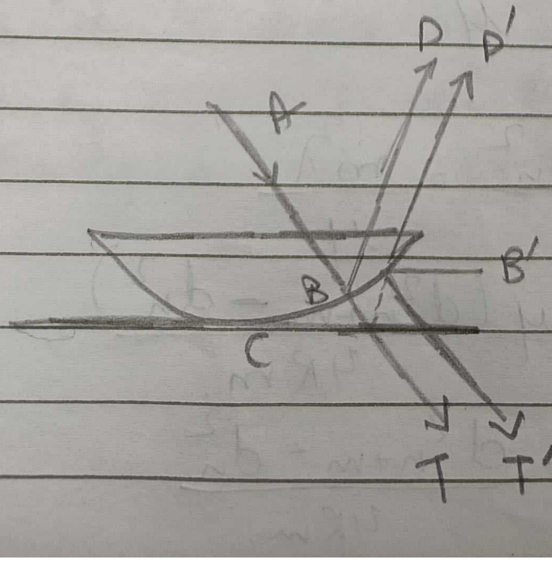
If water is placed b/w a convex lens and glass plate then reflection in both cases will be denser to rarer and the two interfering rays are reflected under same condition. So centre point will be bright as in refracted system.

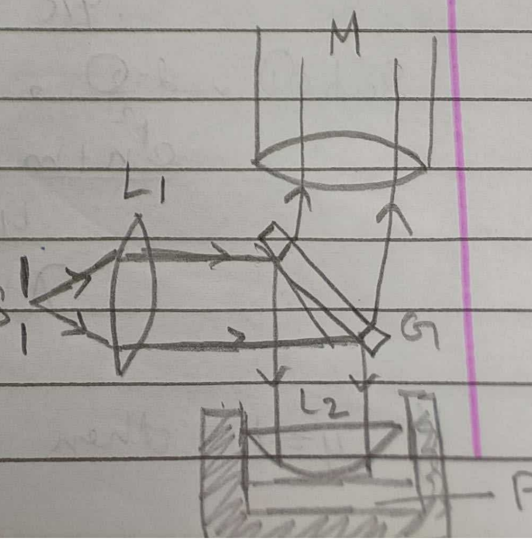
$$\lambda = \frac{\mu(d^2_{n+m} - d^2_n)}{4Rm}$$

So, if $\mu = 1.33$ [illegible]

Q13. What are Newton's rings? Describe and explain formation of Newton's rings in reflected monochromatic light.

When the air film is illuminated normally by monochromatic light circular interference fringes are observed. The fringes are concentric circles. With monochromatic light bright and dark circular fringes are produced in air film. The rings gradually become narrower as their raddii increase. The interference rings so formed were first navigated by Newton and were called Newton's rings.





The convex surface of lens makes contact with the plate at point C and encloses a thin film of air or rare transparent liquid.
The light from a monochromatic extended source is held parallel by a convex lens L, and is incident at angle of 45°. The glass plate G reflects the light vertically downwards. The reflected part suffers phase change of π because the air film is backed by glass plate. These two reflected rays interfere and give rise to interference pattern in form of circular rings.

Q14. What are applications of high reflection and anti reflection coating?

AntiReflection coating :- reduces the reflection of light from surface.

- Used on eyeglasses, photographic lenses and solar cells to reduce glare, improve asthetic, make the wearer's eyes more visible and on solar cell to reduce reflection losses to improve efficiency.

High Reflection Coating :- applied to increase reflectance of light from surface while reducing absorption and scatter.

- On medical devices like endoscopy and microscope
- improve efficiency of lasers.

Q15. What is the purpose of glass plate incline at 45° in Newton ring experiment?

The angle b/w the incoming ray and the glass plate is 45 degree to make turns the light rays to 90° and that's why they fall normally on the plano convex lens.

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Que 16. Find the ratio of intensity at the centre of a bright fringe in an interference pattern to intensity at one point quarter of distance b/w two fringes from centre.

Que 17.

Two waves of a single source having an amplitude A interferance.

The resulting amplitude :-

$$A_r^2 = A_1^2 + A_2^2 + 2A_1A_2 \cos\phi$$

ϕ = phase diff b/w two waves.

$I \propto A^2$ So,

$$I_r = I_1 + I_2 + 2\sqrt{I_1 I_2} \cos\phi$$

When the maxima occurs at centre,

$\phi = 0$.

$$I_r = 4I \quad \text{--- (1)}$$

Since the phase diff. b/w two successive frings is 2π, the phase diff. b/w two points seperated by a distance equal to one quater of distance b/w the two succesive fringes equal to :-

$$\phi = 2\pi\left(\frac{1}{4}\right) = \frac{\pi}{2} \text{ radian}$$

$$I_{r_2} = 4I\cos^2\left(\frac{\pi/2}{2}\right) = 2I \quad \text{--- (2)}$$

Using eq (1) and (2),

$$\frac{I_{r_1}}{I_{r_2}} = \frac{4I}{2I} = 2.$$

Que17

$I_{max} = (a_1 + a_2)^2$
$I_{min} = (a_1 - a_2)^2$

$$\frac{I_{max}}{I_{min}} = \frac{(a_1 + a_2)^2}{(a_1 - a_2)^2} \cancel{= \frac{2a_1(a_1+a_2)^2}{(a_1+a_2)(a_1-a_2)}}$$

$$\cancel{\frac{I_{max}}{I_{min}} = \frac{a_1 + a_2}{a_1 - a_2}}$$

Given, $\frac{I_1}{I_2} = \sqrt{\frac{a_1^2}{a_2^2}} = \sqrt{\frac{81}{1}}$

$$\frac{a_1}{a_2} = \frac{9}{1}$$

$$a_1 = 9a_2$$

Thus,

$$\frac{I_{max}}{I_{min}} = \frac{9a_2 + a_2}{9a_2 - a_2} = \frac{10\cancel{a_2}}{8\cancel{a_2}} = \frac{5}{4}$$

$I_{max} : I_{min} = 5:4$ Ans.

Q18 for maxima,

$$y = \frac{n \times \lambda \times D}{d}$$

when $\lambda = 600$, $n = 12$, So,

$$y = \frac{12 \times 600 \times D}{d} \quad \text{①}$$

when $\lambda = 480$, $n = ?$

$$y = \frac{480 \times n \times D}{d} \quad \text{②}$$

Equate eq ① and ②,

$$\frac{\cancel{12} \times \cancel{600} \times \cancel{D}}{\cancel{d}} = \frac{\cancel{480} \times n \times \cancel{D}}{\cancel{d}}$$

$$\boxed{15 = n} \text{ Ans.}$$

Q20. $\lambda = 6\times10^{-5}\,cm = 6\times10^{-3}\,m$

$\mu = 1.5$

$n = 5 \quad t = ?$

$(\mu-1)t = n\lambda$

$(1.5-1)t = 5\times6\times10^{-3}$

$t = \dfrac{36\times10^{-2}}{0.5}$

$t = 6\times10^{-2}\,m$ Ans.

Q22.

Q20.

$$x_0 = \frac{\beta}{\lambda}(\mu-1)t$$

$x_0 = 5\beta \quad \lambda = 6\times10^{-7}\,m \quad \mu = 1.5$

$5\cancel{\beta} = \dfrac{\cancel{\beta}}{6\times10^{-7}}(1.5-1)t$

$30\times10^{-6} = 0.5\,t$

$6\times10^{-6}\,m = t$ Ans.

Q21. $\beta = 0.431\,mm = \cancel{431\,m} \; 431\times10^{-6}\,m$

$\lambda = 5.89\times10^{-5}\,cm = 5.89\times10^{-7}\,m$

$x_0 = 1.89\times10^{-3}\,m$

$\mu = 1.59 \quad t = ?$

$$x_0 = \frac{\beta}{\lambda}(\mu-1)t$$

$$1.89\times10^{-3} = \frac{431\times10^{-6}}{5.89\times10^{-7}}(1.59-1)t$$

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$$t = \frac{5.89 \times 1.89}{431 \times 0.59} \times 10^{-6}$$

$$t = 4.38 \times 10^{-6} m.$$

Q22.

$d_{n+1} = 7 \times 10^{-3} m$

$d_n = 4.2 \times 10^{-3} m$

$R = 1m$

$$\lambda = \frac{d_{n+1}^2 - d_n^2}{4 \times R \times 1}$$

$$\lambda = \frac{49 \times 10^{-6} - 17.64 \times 10^{-6}}{4}$$

$$\lambda = \frac{31.36 \times 10^{-6}}{4}$$

$$\lambda = 7.84 \times 10^{-6} m$$ Ans.

Q23. Let diametre of 5th dark ring be, d.

$$\mu = \left(\frac{d_{air}}{d_{liq}}\right)^2$$

$$\mu = \frac{d^2}{\left(\frac{d}{2}\right)^2}$$

$$\mu = \frac{\cancel{d^2} \times 4}{\cancel{d^2}}$$

$$\boxed{\mu = 4} \text{ Ans.}$$

4.2
4.2
8 4
16 8
17.64

49
17.
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Q28.

$$2d = n\lambda$$

$$\cancel{2} \times 0.0589 \times 10^{-3} = \cancel{200}\,100 \times \lambda$$

$$589 \times 10^{-9}\ m = \lambda$$

$$589\ nm = \lambda \quad \text{Ans.}$$

Q29.

~~$\mu = 1.49$~~ ~~$\lambda = 5890 \times 10^{-10}$~~

$\mu = 1.50$

$\lambda = 4800 \times 10^{-10}\ m$

$m = 500$

$$2(\mu - 1)t = m\lambda$$

$$2(1.50 - 1)t = 500 \times 48 \times 10^{-8}$$

$$t = 240 \times 10^{-6}$$

$$t = 2.4 \times 10^{-4}\ m \quad \text{Ans.}$$

Q30. (a) when 180° out of phase.

Q31. (b) Comparable to one wavelength of light.

Q32. (a) division of amplitude.

If planoconvex lens is replaced with greater radius of curvature R then,
for both dark and bright ring,

$$d_n \propto \sqrt{R}$$

If radius of curvature increases the diameter of rings will also increase.

Q23. We know, diameter of nth ring

$$D_n = \sqrt{(n+1)\lambda R}$$

$$D_{n+1} = \sqrt{(n+2)\lambda R}$$

$$\frac{D_n}{D_{n+1}} = \sqrt{\frac{(n+1)}{(n+2)}} = \frac{10}{7}$$

Sq. both sides,

$$\frac{n+1}{n+2} = \frac{100}{49}$$

$$49n + 49 = 100n + 200$$

$$51n = 51$$

$$n = 1$$

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

$$r_n = \sqrt{\frac{n\lambda R}{\mu}}$$

$$r_{n_1} = \sqrt{\frac{n\lambda R}{\mu_1}} \qquad r_{n_2} = \sqrt{\frac{n\lambda R}{\mu_2}}$$

$$\frac{r_{n_1}}{r_{n_2}} = \sqrt{\frac{\mu_2}{\mu_1}} = \frac{10}{7}$$

$$\frac{\mu_2}{\mu_1} = \frac{100}{49}$$

$$\mu_1 : \mu_2 = 49 : 100 \text{ Ans.}$$

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Q.28. Principle of Anti reflecting coatings:-

Anti reflecting coating are thin films that reduce the amount of light that reflects off a surface and they work by causing destructive interference b/w reflected light waves.

D/B anti reflecting and high reflecting coating:-

	Anti reflecting	High reflecting
1	Reduce reflections and glare and improve clarity of images.	Increase surface reflectance and reflect almost all light of a certain λ.
2.	These are often made of silicon dioxid, titanium oxide or tantalum pentaoxide.	These are made from metal or dielectric materials with metal nanoparticles like silver.
2	AR ~~coat~~ coatings are used in high end cameras, microscope.	These are mainly used to make mirrors of lens.

Applications:-

- Corrective lense: ARCs can improve asthetics and ~~rigus~~ reduce glare.
- Solar cells: Antireflecting coating can be applied to camera lenses.
- Photolithography: Antireflective coatings are used in microelectronic photolithography to help reduce image distortions associated with reflections of substrate.