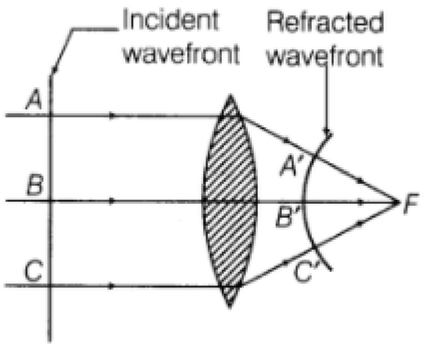
Solution

Class 12 - Physics

2020-2021 - Paper-6

Section A

1. Given: real depth = 15 cm, μ = 1.5
   Let the apparent depth be x.
   Now, μ = $\frac{15}{x}$
   Thus, x = $\frac{15}{\mu}$ = $\frac{15}{1.5}$ = 10cm
   Distance through which the pin appears to be raised is = 15 −10 = 5 cm
   And it does not depend on the location of the slab.
2. If the wavelength of light incident on a convex lens is increased, speed of **light increases** hence the power **will** reduce its focal length will also increase.
3. In young's double slit experiment, angular separation is given by,
   $\theta=\frac{\beta}{D}=\frac{\frac{D\lambda}{d}}{D}=\frac{\lambda}{d}$
   Angular separation does not depend on D i.e., the distance of separation between slits and screen. Therefore, θ remains unaffected.
   OR
   A wavefront is a surface through the points, having the same phase of disturbances. While a ray of light is a path along which light travels. It is always perpendicular to the wavefront and in outward direction from the source.
4. Given: $\theta=0^{\circ}$
   Number of images $n=\frac{360^{\circ}}{\theta}-1$
   $=\frac{360^{\circ}}{0^{\circ}}-1$ = infinite
   Hence, infinite number of images of an object held between two parallel plane mirrors.
   OR
   An inverted telescope will not work as a microscope.
   The objective and eyepiece of the microscope should have small focal lengths. But the objective of the telescope has large focal length and larger aperture than the eyepiece. Therefore, the inverted telescope would not work as a good microscope
5. 

6. For distance Z≤Z_F, ray optics is the good appropriate
   Fresnel distance $Z_F=\frac{a^2}{\lambda}=\frac{\left(3\times10^{-3}\right)^2}{5\times10^{-7}}$ = 18 m
   This example shows that even with a small aperture, diffraction spreading can be neglected for rays many metres in length. Thus, ray optics is valid in many common situations.
7. Wavelength of light in water is less than that in air. The fringe width is directly proportional to the wavelength. Therefore, the fringes will become narrower.
8. Here it is given that angle of prism, A = 5°, μ_R = 1.641 and μ_B = 1.659
   As we know that $\delta=(\mu-1)A$, therefore we have
   $\delta_B=\left(\mu_B-1\right)A$ and $\delta_R=\left(\mu_R-1\right)A$
   So, $\delta_B-\delta_R=\left(\mu_B-\mu_R\right)A$
   = (1.659 - 1.641) $\times$ 5 = 0.09°

OR

It is because of interference of light waves reflected from the upper and lover surfaces of the thin film of soap bubbles. The coloured interference fringes are produced due to the fact that constructive and destructive interference depend upon the wavelength of light used.

9. If light is monochromatic, a dark fringe will be formed at the point. However, if light is white, the fringe seen will be coloured. However, the yellow colour and its neighbouring colours shall be absent.
10. When light is emitted from a source, then the particles present around the source in all directions begins to vibrate. The locus of all such particles which are vibrating in the same phase is termed as wavefront.

11. **(b)** Both A and R are true but R is NOT the correct explanation of A

Explanation: Suppose the amplitude of waves from each slit is a. Therefore, intensity due to each slit - a^2.
When interference is destructive,
the resultant amplitude = a - a = 0
$\therefore$ Minimum intensity = 0
When interference is constructive the resultant amplitude
= a + a = 2a

Maximum intensity = $(2a)^2 = 4a^2$
= 4 times the intensity due to each slit.

12. **(d)** A is false and R is also false
Explanation: A is false and R is also false

13. **(c)** A is true but R is false
Explanation: The frequency of all three beams is independent of the source of light, therefore, it remains the same in all media.

14. **(a)** Both A and R are true and R is the correct explanation of A
Explanation: Both A and R are true and R is the correct explanation of A

Section B

15. **(d)** The fringe width will decrease
Explanation: The fringe width is given by
$\beta = \frac{D\lambda}{d}$
Therefore, when blue light (light of lesser wavelength) is used, the fringe width will decrease.

16. **(a)** 549 nm
Explanation: $\mu = \frac{v_1}{v_2}$
Also, $\mu = \frac{\lambda_1}{\lambda_2}$
This gives $\frac{v_1}{v_2} = \frac{\lambda_1}{\lambda_2}$
Putting the values of $v_1 = 1.94 \times 10^8, v_2 = 3 \times 10^8 and\ \lambda_1 = 355nm$, we get
$\lambda_2 = 549nm$

17. **(c)** 2.0 $\times 10^8 \mathrm{ms}^{-1}$
Explanation:
Using, $\mu = \frac{c}{v}$
$1.5 = \frac{3\times10^{-8}}{v} \Rightarrow v = 2.0 \times 10^8 \mathrm{ms}^{-1}$

18. **(d)** 2 : 1
Explanation: $\frac{I_1}{I_2} = \frac{a^2}{b^2} = \frac{4}{1} \quad \therefore \frac{a}{b} = \frac{2}{1}$

19. **(c)** 2 cm and 12 cm
Explanation: In normal adjustment, m = f_o/f_e = 6. Therefore $f_o = 6\ f_e$

Now, $f_o + f_e = 14$

or $7f_e = 14$ or f_e = 2 cm

Hence, f_o = 12 cm

20. **(a)** Total internal reflection
Explanation: Total internal reflection principle is used in optical fibre.

21. **(d)** red

Explanation: $\because$ c $= \nu\lambda$ and ν is constant during refraction so $c \propto \lambda$. The velocity of red color is maximum in the glass as $\lambda_V < \lambda_R$

OR In air, all the colours of light travel with the same velocity with the same velocity, but in glass, velocities of different colors are different. Velocity of red color is largest and velocity of violet color is smallest. Therefore, after travelling through the glass slab, red color will emerge first.

22. **(c)** rectangular hyperbola

Explanation:

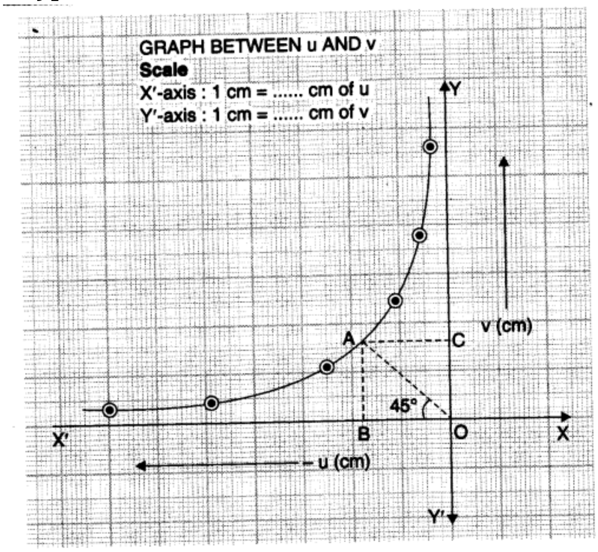


Fig. Graph between u and v. It is a rectangular hyperbola.

Section C

23. The relationship between refractive index μ, prism angle A and angle of minimum deviation δ_m is given by

$$\mu = \frac{\sin\left(\frac{A+\delta_m}{2}\right)}{\sin\left(\frac{A}{2}\right)}$$

Given, $\delta_m = A$

Substituting the value of δ_m, we have

$\therefore \mu = \frac{\sin A}{\sin(A/2)}$

On solving, we have

$$\mu = \frac{2\sin\frac{A}{2}\cos\frac{A}{2}}{\sin\frac{A}{2}} = 2\cos\frac{A}{2}$$

For the given value of refractive index, $\mu = \sqrt{3}$, we have

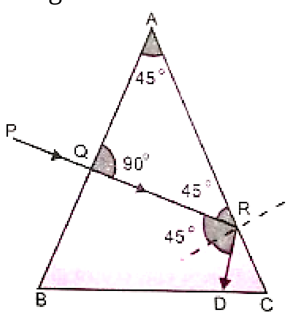
$\cos\frac{A}{2} = \frac{\sqrt{3}}{2}$ or $\frac{A}{2} = 30$

A = 60°

This is the required value of prism angle.

OR

The incident ray PQ failing normally on face AB of the prism, goes straight striking face AC at 45^0 as shown in the figure. As Critical angle = 45^0, therefore the refracted ray QR suffers total internal reflection and goes along RD.



Now, refractive index, $\mu = \frac{1}{sinC}$ = $\frac{1}{\sin\ 45^o}$ $= \sqrt{2} = 1.414$

24. a. Refractive index of glass μ = 1.5 . So, Speed of light in glass is v= $\frac{c}{\mu}$ = 2 $\times 10^8$ m/s

b. The speed of light in glass is not independent of the colour of light. The refractive index of a violet component of white light is greater than the refractive index of a red component. Hence, the speed of violet light is less than the speed of red light in the glass. Hence, violet light travels slower than red light in a glass prism.

OR

By the principle of superposition, the resultant displacement at the observation point will be y = y_1 + y_2 = a [cos ωt + cos $(\omega t+\phi)$]

= 2a cos $\frac{\phi}{2}$$\cdot$ cos $\left(\omega t+\frac{\phi}{2}\right)$

Amplitude of the resultant displacement = 2a cos $\frac{\phi}{2}$

$\because$ Intensity $\propto$ (amplitude)^2

$\therefore$ Intensity, I = 4ka^2 cos $\frac{\phi}{2}$, where k = a proportionality constant.

If I_0 is the intensity of each source, then I_0 = ka^2 and I = 4I_0 cos^2 $\frac{\phi}{2}$

For constructive interference:

cos $\frac{\phi}{2}$ = $\pm$1 or $\frac{\phi}{2}$ = nπ or ϕ = 2nπ

For destructive interference :

cos $\frac{\phi}{2}$ = 0 or $\frac{\phi}{2}$ = (2n + 1) $\frac{\pi}{2}$ or ϕ = (2n + 1)π

25. Relation between diffraction from each slit to the interference Pattern in a double-slit experiment:
   a. If slit width in interference Pattern is reduced to the size of a wavelength of light used; the interference pattern thus obtained in the double slit experiment is modified by diffraction from each of two slits.
   b. The diffraction pattern is itself due to the interference of wavelength belonging to the same but different order of spectrum.
26. Angular width 2θ is given by = $\frac{2\lambda}{d}$

   Given, λ = 6000 $\overset{\circ}{A}$

   In case of new wavelength (assumed λ' here), angular width decreases by 30% = $\left(\frac{100-30}{100}\right)$ = 0.70 (2θ)

   $\frac{2\lambda'}{d}=0.70\times(\frac{2\lambda}{d})$

   $\therefore\quad\lambda'=4200\overset{\circ}{A}$
27. Here we have, λ = 6563 $\overset{\circ}{A}$ = 6563 $\times$ 10^{-10} m

   $\lambda'-\lambda$ = 15 $\overset{\circ}{A}$ = 15 $\times$ 10^{-10}

   Now according to the formula, $\lambda'-\lambda=\frac{V_s\lambda}{c}$

   $V_s=\frac{c}{\lambda}(\lambda'-\lambda)$

   $=\frac{3.0\times10^8}{6563\times10^{-10}}\times15\times10^{-10}$

   = 6.8566 $\times$ 10^5 ms^{-1}

   Therefore, the speed with which the star is receding away from the Earth is 6.87 × 10^5 m/s.
28. We know that, I = I_1 + I_2 + $2\sqrt{I_1I_2}$ cos ϕ

   Therefore, I_{max} = I_1 + I_2 + $2\sqrt{I_1I_2}$ cos 0^o

   = I + $\delta I)+2\sqrt{I(I+\delta I)}$

   As $\delta I<<I$, therefore, I_{max} = I + I + 2I = 4I

   Again from I = I_1 + I_2 + $2\sqrt{I_1I_2}$ cos ϕ

   I_{min} = I + (I + $\delta I)+2\sqrt{I(I+\delta I)}$ cos 180^o

   I_{min} = 2I + δI - 2I $\left(1+\frac{\delta I}{I}\right)^{1/2}$

   = 2I + δI - 2I $\left[1+\frac{1}{2}\frac{\delta I}{I}+\frac{\frac{1}{2}\left(\frac{1}{2}-1\right)}{2}\left(\frac{\delta I}{I}\right)^2\right]$

$= 2I + \delta I - 2I - \delta I + \frac{1}{4} I \left(\frac{\delta I}{I}\right)^2$

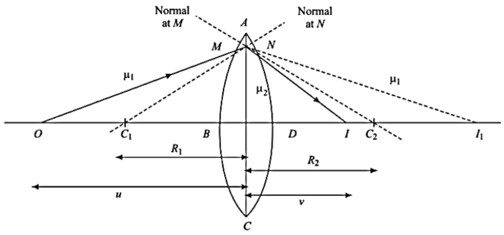
$I_{min} = \frac{(\delta I)^2}{4I}$

29. i. $m = \frac{f_0}{f_e}(1+f_e/D)$

The distance of the eyepiece is so adjusted that the objective's image lies within its focal length. The eyepiece magnifies this image so that the final image is magnified and inverted with respect to the object condition: By increasing f_0 or decreasing f_e

ii. (a) No chromatic aberration.
(b) No spherical aberration.
(c) Mechanical advantage - low weight, easier to support.
(d) Mirrors are easy to prepare.
(e) More economical.

30. let us consider refractive index of the surrounding medium and the lens material is μ_1, μ_2



For refraction at surface ABC, we have

$\frac{\mu_2}{v_1} - \frac{\mu_1}{u} = \frac{\mu_2 - \mu_1}{R_1}$ ...(i)

For refraction at surface ADC, we have

$\frac{\mu_1}{v} - \frac{\mu_2}{v_1} = \frac{\mu_1 - \mu_2}{R_2}$ ...(ii)

Adding equation (i) and (ii), we get

$\frac{\mu_1}{v} - \frac{\mu_1}{u} = (\mu_2 - \mu_1)\left[\frac{1}{R_1} - \frac{1}{R_2}\right]$

$\frac{1}{v} - \frac{1}{u} = \left[\frac{(\mu_2 - \mu_1)}{\mu_1}\right]\left[\frac{1}{R_1} - \frac{1}{R_2}\right]$ ...(iii)

If the object is placed at infinity (u=∞), the image will be formed at the focus, i.e. v = f

Therefore

$\frac{1}{f} - \frac{1}{\infty} = (\mu_{21} - 1)\left[\frac{1}{R_1} - \frac{1}{R_2}\right]$ ...(iv)

From eq. (iii) and (iv), we have

$\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$

Thin lens formula.

31. Focal length of the convex lens, f_1 = 30 cm.

Focal length of plane concave lens of liquid be = f_2

and,

Combined focal length, F = 45.0 cm

As, $\frac{1}{f_1} + \frac{1}{f_2} = \frac{1}{F}$

$\frac{1}{f_2} = \frac{1}{F} - \frac{1}{f_1} = \frac{1}{45} - \frac{1}{30}$

$= -\frac{1}{90}$

f_2 = -90 cm

For glass lens, ket R_1 = R, R_2 = -R

Using lens maker's formula,

$\frac{1}{f_1} = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$

We have,

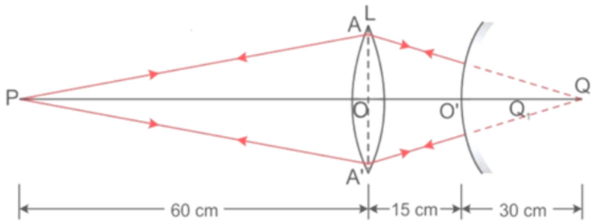
$\therefore \quad \frac{1}{30} = \left(\frac{3}{2} - 1\right)\left(\frac{1}{R} + \frac{1}{R}\right)$

$= \frac{1}{2} \times \frac{2}{R} = \frac{1}{R}$

Thus, R = 30 cm
For liquid lens,
R_1 = -R = -30.0 cm
$R_2 = \infty$
$\frac{1}{f_2} = (\mu_l - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$
$= (\mu_l - 1)\left(\frac{1}{-30} - \frac{1}{\infty}\right)$
$\Rightarrow\ \frac{1}{-90} = (\mu_l - 1) \times \frac{1}{-30}$
$\Rightarrow\ (\mu_l - 1) = \frac{30}{90} = \frac{1}{3}$
$\Rightarrow\ (\mu_l - 1) = \frac{30}{90} = \frac{1}{3}$
$\mu_l = 1 + \frac{1}{3} = \frac{4}{3}$,this is required refractive index

Section D

32. Focal length of convex lens is, f = +20 cm
Object distance from the lens, u = -60 cm
Distance between the mirror and the lens, d = 15 cm,
Focal length of the mirror, f = +10 cm
The ray diagram is shown in the figure:



Applying the lens formula,
$\frac{1}{20} = \frac{1}{v'} - \frac{1}{-60}$
After solving we get,
v' = +30 cm
This image is the object for the mirror, which is formed at 15 cm behind the mirror. So this is the case of a virtual object.
Applying the mirror formula, we get,
$\frac{1}{10} = \frac{1}{v} + \frac{1}{15}$
After solving we get,
v = +30 cm
So, the final image is formed 30 cm behind the mirror is virtual in nature.

OR

i. $\mu = \sin i_c$ or $n_{21} = \sin i_c$
where n_{21} is the refractive index of rarer medium 1 with respect to denser medium 2.
ii. As μ depends on wavelength, therefore, critical angle for the same pair of media in contact will be different for different colours.

33. i. The resultant displacement is given by
$y = y_1 + y_2$
$= a\cos\omega t + a\cos(\omega t + \phi)$
$= a\cos\omega t\,(1 + \cos\phi) - a\sin\omega t\sin\phi$
Put $R\cos\theta = a(1 + \cos\phi)$
$R\sin\theta = a\sin\phi$
$\therefore R^2 = a^2\left(1 + \cos^2\phi + 2\cos\phi\right) + a^2\sin^2\phi$
$= 2a^2(1 + \cos\phi) = 4a^2\cos^2\frac{\phi}{2}$
$I = R^2 = 4a^2 cos^2\phi/2 = 4I_0 cos^2\phi/2$
ii. Condition for constructive interference is given by:-
$\cos\frac{\phi}{2} = \pm 1$ or $\frac{\phi}{2} = n\pi$ or $\phi = 2n\pi$

condition for destructive interference, is given by:-

cos $\frac{\phi}{2}$ = 0 or $\frac{\phi}{2} = (2n+1)\frac{\pi}{2}$ or $\phi = (2n+1)\pi$

34. The fringe width in the interference pattern is inversely proportional to the separation between the coherent sources ($\beta = \frac{D\lambda}{d}$. When the distance d between the coherent source is large, the fringe width becomes very small. In such a case, the fringes may overlap and the interference pattern may not be observed.

    Fringe width in air, $\beta = \frac{D\lambda}{d}$

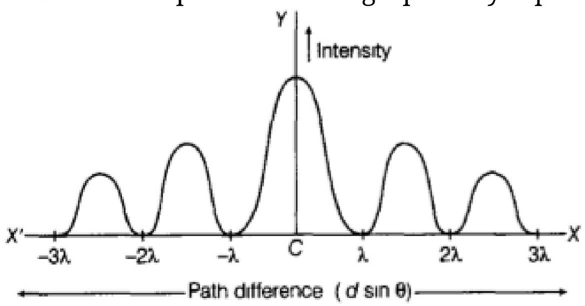
    Fringe width in liquid, $\beta' = \frac{D\lambda'}{d} = \frac{D\lambda}{d\mu}$

    $\Rightarrow \beta' = \frac{\beta}{\mu}$

    or $\beta' = \frac{2.0}{1.33} = 1.5mm$

35. In case of single slit, the diffraction pattern obtained on the screen consists of a central bright band having alternate dark and weak bright band of decreasing intensity on both sides.

    The diffraction pattern can be graphically represented as

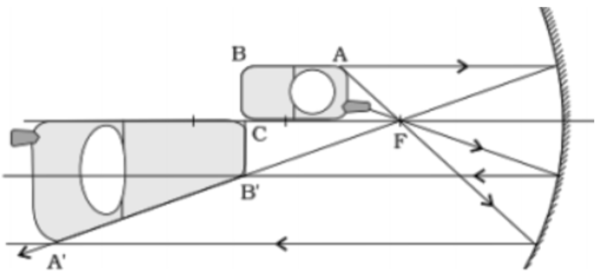


    Points to compare the intensity distribution between interference and diffraction are:

    a. In the interference,it is produced due to two different wave fronts, but in diffraction, it is produced due to different parts of same wave fronts.
    b. In the interference, fringe width is same size, but in diffraction, central fringe is twice as wide as other fringes.
    c. In the interference, all bright fringes have same intensity, but in diffraction, all the bright fringes are not of the same intensity.
    d. In interference, the widths of all the fringes are same but in diffraction, fringes are of different widths. The point C corresponds to the position of central maxima and the position$-3\lambda, 2\lambda, -\lambda, \lambda, 2\lambda, 3\lambda.....$ are secondary minima. The above conditions for diffraction maxima and minima are exactly reverse of mathematical conditions for interference maxima and minima.

36. i. The ray diagram for the formation of the image of the phone is shown as below. The image of the part which is on the plane perpendicular to principle axis will be on the same plane. It will be of the same size i.e. B'C = BC.

    The mobile phone has many rectangles that are at different positions with different distances from the mirror. As there are different object distances, so their images and magnification are different.



    ii. As the laws of reflection are to be true for all points of the remaining part of the mirror, the image will be that of the whole object. However, as the area of the reflecting surface has been reduced, the intensity of the image will be low, i.e. half.

OR

d = 0.15mm $= 15 \times 10^{-4}$m

$\lambda = 450\text{nm} = 4.5 \times 10^{-7}$m

D = 1m

i. a. The distance of nth order bright fringe from central fringe is given by

$y_n = \frac{Dn\lambda}{d}$

For second bright fringe,

$y_2 = \frac{2D\lambda}{d} = \frac{2\times1\times4.5\times10^{-7}}{1.5\times10^{-4}}$

$y_2 = 6\times10^{-3}\mathrm{m}$

The distance of the second bright fringe,

y_2 = 6mm

b. The distance of nth order dark fringe from central fringe is given by

$y_n' = (2n-1)\frac{D\lambda}{2d}$

For second dark fringe, n = 2

$y_n' = (2\times2-1)\frac{D\lambda}{2d} = \frac{3D\lambda}{2d}$

$y_n' = \frac{3}{2}\times\frac{1\times45\times10^{-7}}{1.5\times10^{-4}}$

The distance of the second dark fringe,

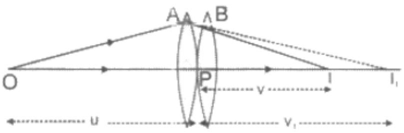
$y_n' = 45\mathrm{mm}$

ii. With increase of D, fringe width increases as

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

Section E

37. i.



Two thin lenses, of focal length f_1 and f_2 are kept in contact. Let O be the position of the object and let u be the object distance. The distance of the image (which is at I_1), for the first lens is v_1

This image serves as object for the second lens. Let the final image be at I. We then have

$\frac{1}{f_1} = \frac{1}{v_1} - \frac{1}{u}$

$\frac{1}{f_2} = \frac{1}{v} - \frac{1}{v_1}$

Adding, we get

$\frac{1}{f_1} + \frac{1}{f_2} = \frac{1}{v} - \frac{1}{u} = \frac{1}{f}$

$\therefore \frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2}$

$\therefore$ P = $P_1 + P_2$

ii. A ray of light passing from the air through an equilateral glass prism undergoes minimum deviation.

Thus, At a minimum deviation

$r = \frac{A}{2} = 30^\circ$

We are given that, $i = \frac{3}{4}A = 45^\circ$

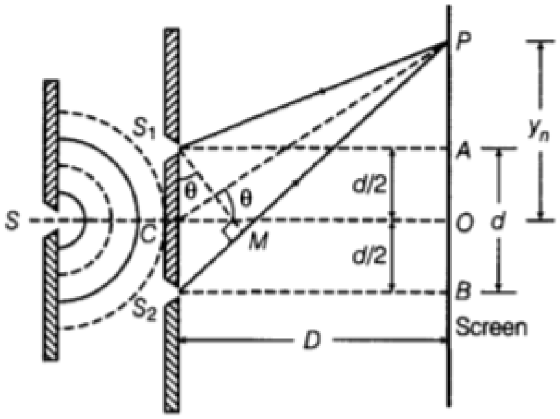
$\therefore \mu = \frac{\sin 45^\circ}{\sin 30^\circ} = \sqrt{2}$

$\therefore$ Speed of light in the prism v = $\frac{c}{\mu} = \frac{c}{\sqrt{2}}$

= $(2.1\times10^8\ \mathrm{ms^{-1}})$

OR

Let two coherent sources of light, S_1 and S_2 are derived from a source S. Now, suppose S_1 and S_2 are separated by distance d. The slits and screen are distance D apart.



Considering any arbitrary point P on the screen at a distance Y_n from the centre O. The path difference between interfering waves is given by S_2P - S_1P

i.e. Path difference= S_2P - S_1P = S_2M

S_2P - $S_1P = \mathrm{d}\sin\theta$

where, $s_1M \perp s_2P$

$[\because \angle S_2S_1M = \angle OCP$ (by geometry)

$\Rightarrow \quad S_1P = PM \Rightarrow S_2P = S_2M]$

If θ is small, then $\sin\theta \approx \theta \approx \tan\theta$

$\therefore$ Path difference,

$S_2P - S_1P = S_2M = d\sin\theta \approx d\tan\theta$

Path difference $= d\left(\frac{y_n}{D}\right)$ ...... (i)

$[\because$ In $\Delta PCO, \tan\theta = \frac{OP}{CO} = \frac{y_n}{D}]$

For constructive interference

Path difference $= n\lambda$ where, n = 0, 1, 2, [from Eq. (i)]

$\Rightarrow \quad y_n = \frac{Dn\lambda}{d}$

$\Rightarrow \quad y_{n+1} = \frac{D(n+1)\lambda}{d}$

$\because$ Fringe width of dark fringe = $y_{n+1} - y_n$

$B = \frac{D\lambda}{d}(n+1) - \frac{Dn\lambda}{d}$

$= \frac{D\lambda}{d}(n+1-n) = \frac{D\lambda}{d}$

Fringe width of dark fringe, $\beta = \frac{D\lambda}{d}$

For destructive interference

Path difference $= (2n-1)\frac{\lambda}{2}$, where n = 1, 2, 3,....

$\Rightarrow \quad \frac{y_n' d}{D} = (2n-1)\frac{\lambda}{2}$ [from Eq. (1)]

$\Rightarrow \quad y_n' = \frac{(2n-1)D\lambda}{2d}$

where, y_n' is the separation of nth order dark fringe from central fringe.

$\therefore \quad y_{n+1}' = (2n+1)\frac{D\lambda}{2d}$

$\therefore$ Fringe width of bright fringe = Separation between (n+ 1)th and nth order dark fringe from central fringe,

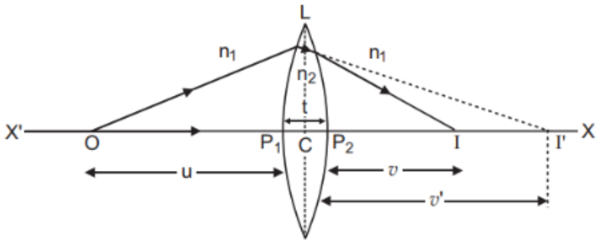
$\Rightarrow \quad \beta = y_{n+1}' - y_n'$

or $\beta = \frac{(2n+1)D\lambda}{2d} - \frac{(2n-1)D\lambda}{2d}$

$= \frac{D\lambda}{2d}[2n+1-2n+1] = \frac{D\lambda}{d}$

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

38. i. Consider the figure. Suppose L is a thin lens. The thickness of lens is t, which is very small. O is a point object on the principal axis of the lens. The distance of O from pole P_1 is u. The first refracting surface forms the image of O at I' at a distance v' from P_1.



From the refraction formula at spherical surface:

$\frac{n_2}{v'}$ - $\frac{n_1}{u}$ = $\frac{n_2-n_1}{R_1}$ ....(i)

The image I' acts as a virtual object for second surface and after refraction at second surface, the final image is formed at I. The distance of I from pole P_2 of second surface is v. The distance of virtual object (I') from pole P_2 is (v' - t).

For refraction at second surface, the ray is going from second medium (refractive index n_2) to first medium (refractive index n_1), therefore from refraction formula at spherical surface

$\frac{n_1}{v}$ - $\frac{n_2}{(v'-t)}$ = $\frac{n_1-n_2}{R_2}$ .....(ii)

For a thin lens, t is negligible as compared to v', therefore from (ii),

$\frac{n_1}{v} - \frac{n_2}{(v')}$ = $-\frac{n_2-n_1}{R_2}$ .....(iii)

Adding equations (i) and (iii), we get

$\frac{n_1}{v} - \frac{n_1}{u}$ = $(n_2 - n_1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$

or $\frac{1}{v} - \frac{1}{u}$ = $\left(\frac{n_2}{n_1} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$ .....(iv)

If the object O is at infinity, the image will be formed at second focus i.e. if u = ∞, v = f_2 = f

Therefore from equation (iv)

$\frac{1}{f} - \frac{1}{\infty}$ = $(\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$

i.e. $\frac{1}{f}$ = $(\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$ ....(v)

This is the formula of refraction for a thin lens. This formula is called Lens-Maker's Formula.

ii. **Power of a Lens:** The power of a lens is its ability to deviate the rays towards its principal axis. It is defined as the reciprocal of focal length in metres.

Power of a lens, P = $\frac{1}{f(\text{ in metres })}$ diopters $= \frac{100}{f(\text{ in cm})}$ diopters

The SI unit for power of a lens is dioptre (D).

Power of convex lens, P_1 = $\frac{1}{F_1}D = \frac{1}{0{\cdot}50} = 2$ D

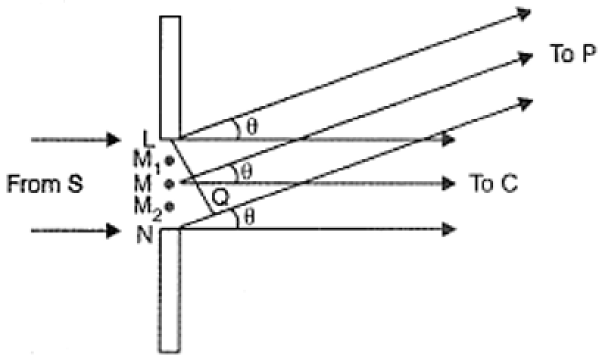
Power of concave lens, P_2 = $\frac{1}{F_2}\text{D} = \frac{1}{-0{\cdot}20} = -5$ D

$\therefore$ Power of combination of lenses in contact

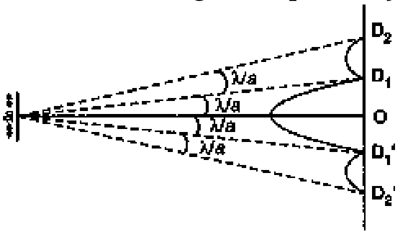
P = P_1 + P_2 = 2 - 5 = -3 D

OR

i. We can regard the total contributions of the wavefront LN at some point P on the screen, as the resultant effect of the superposition of its wavelets like LM, MM_2, M_2N. These have to be superposed taking into account their proper phase differences.



We, therefore, get maxima and minima, i.e., a diffraction pattern, on the screen. **Maxima and minima** are produced when the path difference between waves is a whole number of wavelengths or an odd number of half wavelengths respectively.

ii. 

Conditions for first minima on the screen

asin θ = λ

$\Rightarrow \quad \theta = \frac{\lambda}{a}$

$\therefore$ Angular width of the central fringe on the screen (from the figure)

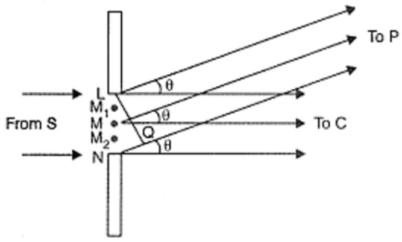
$= 2\theta = \frac{2\lambda}{a}$

Angular width of first diffraction fringe (From fig)

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

For the first diffraction, the angular width of the fringe is half that of the central fringe.

iii. Maxima becomes weaker and weaker with increasing n. This is because the effective part of the wavefront, contributing to the maxima becomes smaller and smaller, with increasing n.

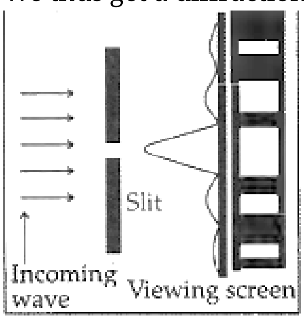
39. i. 

The diffraction pattern formed can be understood by adding the contributions from the different wavelets of the incident wavefront, with their proper phase differences. For the central point, we imagine the slit to be divided into two equal halves. The contribution of corresponding wavelets, in the two halves, are in phase with each other. Hence we get a maxima at the central point. The entire incident wavefront contributes to this maxima. **Maxima and minima** are produced when the path difference between waves is a whole number of wavelengths or an odd number of half wavelengths respectively.

All other points, for which $\theta = \left(n + \frac{1}{2}\right)\frac{\lambda}{a}$, get a net non zero contribution from all the wavelets. Hence all such points are at the points of maxima.

Points for which $\theta = \frac{n\lambda}{a}$, the net contribution, from all the wavelets, is zero. Hence these points are point of minima.

We thus get a diffraction pattern on the screen, made up of points of maxima and minima.



Secondary maxima keep on getting weaker in intensity, with increasing n. This is because, at the

ii. First secondary maxima, the net contribution is only from (effectively) $\frac{1}{3}^{\text{rd}}$ of the incident wavefront on the slit.

iii. Second secondary maxima, the net contribution is only from (effectively) $\frac{1}{5}^{\text{th}}$ of the incident wavefront on the slit and so on.

OR

Angular width is given by
$\theta = \frac{\lambda}{d}$ or $d = \frac{\lambda}{\theta}$

i. According to the question, $\lambda = 600nm = 6 \times 10^{-7}m$
   $\theta = \frac{0.1\pi}{180}\text{rad} = \frac{\pi}{1800}\text{rad}$
   $d = \frac{\lambda}{\theta}$
   $\therefore d = \frac{6\times10^{-7}\times1800}{\pi} = 3.44 \times 10^{-4}\text{m}$
ii. The frequency of a light depends on its source only.
   So, the frequencies of reflected and refracted light will be same as that of incident light.
   Reflected light is in the same medium (air).
   So its wavelength remains same as $500\overset{o}{A}$.
   We know that $\nu = \frac{c}{\lambda}$
   $= \frac{3\times10^{8}}{5000\times10^{-10}}$
   $= 6 \times 10^{18} Hz$
   This is the required frequency of both refracted and reflected light.
   We know that,
   $\mu = \frac{speed\ of\ light\ in\ air}{speed\ of\ light\ in\ water}$
   $\frac{4}{3} = \frac{3\times10^{8}}{v}$
   $v = 2.25 \times 10^{8} m/s$
   speed of light in water = $2.25 \times 10^{8} m/s$
   Wavelength of refracted light is given by $\lambda' = \frac{v}{\nu} = 0.375 \times 10^{-6} m$
   So, wavelength of refracted wave will be decreased.