Topic : Geometrical optics and Wave optics

1. The focal length f is related to the radius of curvature r of the spherical convex mirror by -

A. $f=r$

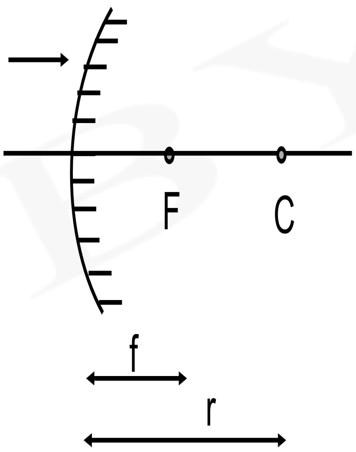
B. $f=-\frac{1}{2}r$

C. $f=+\frac{1}{2}r$

D. $f=-r$

As per sign convention, we take the focal length of a spherical convex mirror to be positive, and it is half of the radius of curvature.

$\therefore f=+\frac{1}{2}r$



2. A short straight object of height $100 \mathrm{~cm}$ lies before the central axis of a spherical mirror whose focal length has absolute value $|f|=40 \mathrm{~cm}$. The image of the object produced by the mirror is of height $25 \mathrm{~cm}$ and has the same orientation as of the object. One may conclude from the information :

A. Image is real, same side of the concave mirror.

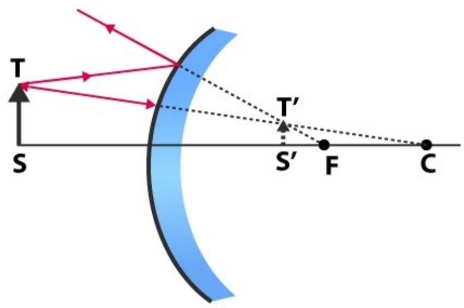
B. Image is virtual, opposite side of the convex mirror. ✔

C. Image is virtual, opposite side of the concave mirror.

D. Image is real, same side of the convex mirror.

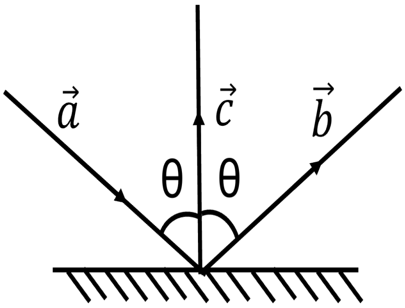
The image is upright with respect to the object, this is only possible in case of virtual image.

The height of image is less than the height of object, this is possible only in convex mirrors.



Hence, option (B) is the correct answer.

3. The incident ray, reflected ray and the outward drawn normal are denoted by the unit vectors, $\vec{a}$, $\vec{b}$ and $\vec{c}$ respectively. Then, choose the correct relation for these vectors.

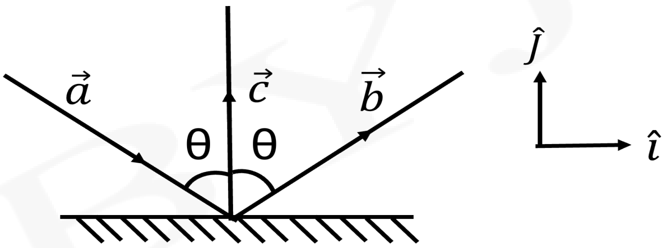


A. $\vec{b} = 2\vec{a} + \vec{c}$

B. $\vec{b} = \vec{a} - \vec{c}$

C. $\vec{b} = \vec{a} + 2\vec{c}$

D. $\vec{b} = \vec{a} - 2(\vec{a}.\vec{c})\vec{c}$



From diagram,

$$\vec{a} = \sin\theta\,\hat{i} - \cos\theta\,\hat{j}$$

$$\vec{b} = \sin\theta\,\hat{i} + \cos\theta\,\hat{j}$$

$$\vec{c} = \hat{j}$$

So,

$$\vec{a} - 2(\vec{a}.\vec{c})\vec{c}$$
$$= (\sin\theta\,\hat{i} - \cos\theta\,\hat{j}) - 2\left[(\sin\theta\,\hat{i} - \cos\theta\,\hat{j}).(\hat{j})\right]\hat{j} = \sin\theta\,\hat{i} - \cos\theta\,\hat{j} + 2\cos\theta\,\hat{j}$$
$$= \sin\theta\,\hat{i} + \cos\theta\,\hat{j} = \vec{b}$$

Hence, option (D) is correct.

4. The refractive index of a converging lens is 1.4. What will be the focal length of this lens if it is placed in a medium of same refractive index? Assume the radii of curvature of the faces of lens are R_1 and R_2 respectively.

A. Zero

B. $\frac{R_1R_2}{R_1 - R_2}$

C. Infinite

D. 1

As per Lens maker's formula:

$$\frac{1}{f} = \left[\frac{n_2}{n_1} - 1\right]\left[\frac{1}{R_1} - \frac{1}{R_2}\right]$$

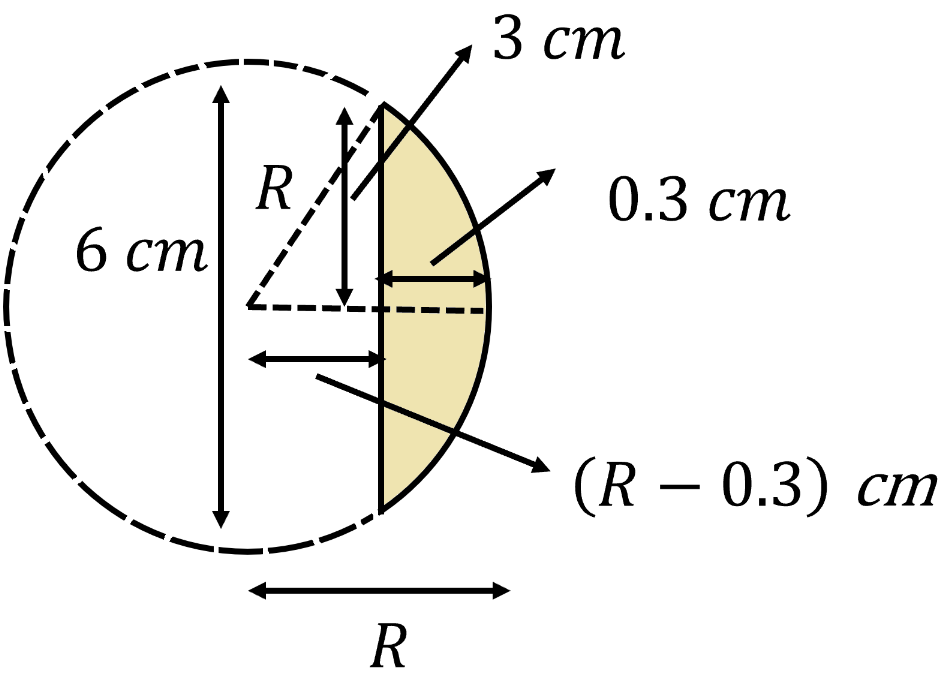
Since Refrcative indexes, n_1 and n_2 are equal.

$\frac{1}{f} = 0$

$\Rightarrow f \to \infty$

5. The thickness at the centre of a planoconvex lens is 3 mm and the diameter is 6 cm. If the speed of light in the material of the lens is $2 \times 10^8 \text{ ms}^{-1}$, the focal length of the lens kept in air is :

- **A.** 0.30 cm
- **B.** 1.5 cm
- **C.** 15 cm
- **D.** ✔ 30 cm



Applying Pythagoras theorem, we have,

$$R^2 = 3^2 + (R - 0.3)^2$$

$$\Rightarrow R^2 = 9 + R^2 + 0.09 - 2 \times 0.3R$$

$$\Rightarrow 0.6R = 9.09$$

$$\Rightarrow R = 15.15 \text{ cm}$$

Also,

$$\mu = \frac{c}{v} = \frac{3 \times 10^8}{2 \times 10^8} = 1.5$$

Now, using Lens maker formula,

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

$$\Rightarrow \frac{1}{f} = (1.5 - 1)\left(\frac{1}{15.15}\right)$$

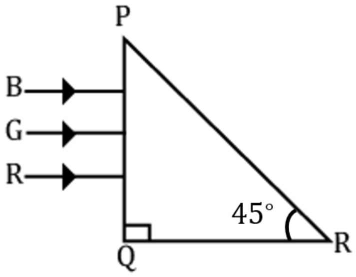
$$\Rightarrow f = 30.3 \text{ cm} \approx 30 \text{ cm}$$

6. Your friend is having eye sight problem. She is not able to see clearly a distant uniform window mesh and it appears to her as non-uniform and distorted. The doctor diagnosed the problem as:

- A. Myopia and hypermetropia
- B. Astigmatism
- C. Myopia with astigmatism
- D. Presbyopia with astigmatism

If distant objects are blurry then problem is myopia.
If objects are distorted then problem is astigmatism.
So she is having both myopia and astigmatism.

7. Three rays of light, namely red (R), green (G) and blue (B) are incident on the face PQ of a right-angled prism PQR as shown in the figure. The refractive indices of the material of the prism for red, green and blue wavelengths are $1.27, 1.42$ and 1.49 respectively. The colour of the ray(s) emerging out of the face PR will be :

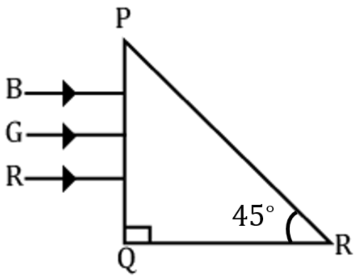


A. Blue

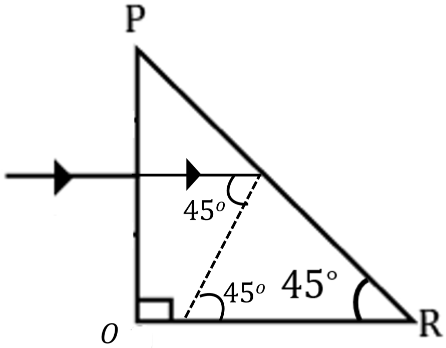
B. Green

C. Red

D. Blue and Green



Since, the rays are incident normally on the face PQ, all the rays will go undeflected towards the face PR.



Here, $i = 45^{\circ}$

For total internal reflection at face PR,
$i > i_c$

$\Rightarrow 45^{\circ} > i_c$

$\Rightarrow 45^{\circ} > \sin^{-1}\left(\frac{1}{\mu}\right)$

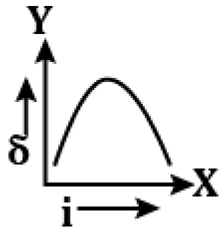
$\Rightarrow \mu > \sqrt{2}$

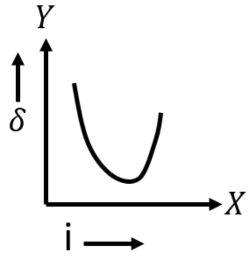
$\Rightarrow \mu > 1.414$

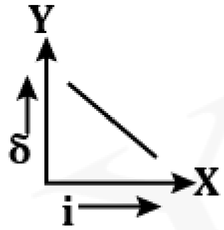
$\because \mu_G \text{ and } \mu_B$ are more than 1.414 and μ_R is less than 1.414.
So, TIR will take place for green and blue rays.

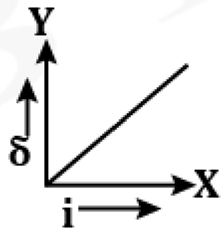
$\therefore$ Only red ray will come out of face PR.

8. The expected graphical representation of the variation of angle of deviation $'\delta'$ with angle of incidence $'i'$ in a prism is :

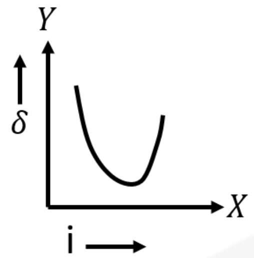
A. 

B. 

C. 

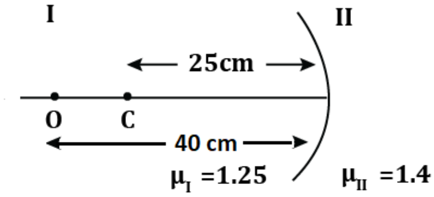
D. 

We know that the angle of deviation depends upon the angle of incidence as
$\delta = (i + e - A)$, where, i is the angle of incidence, e is the angle of emergence and A is the angle of prism.
When the angle of incidence and angle of emergence are equal, then the angle of deviation will be minimum. Thus, it can be called a minimum deviation.
The deviation produced by the prism is maximum when either the angle of incidence or angle of emergence is 90°. This is known as the grazing angle. At this condition, either incident ray or emergent ray will graze along the surface of the prism.
For any other angle of deviations except the angle of minimum deviation, the angle of incidence and angle of emergence can't be interchanged. That means it has specific values. From the relation between the angle of incidence and angle of deviation, we can say that it is not a linear relationship.
If we determine experimentally, the angles of deviation corresponding to different angles of incidence and then plot $'i'$ (on x-axis) and $'\delta'$ (on y-axis) we get a curve as shown in figure.



Hence, option (b) is correct.

9. Regions I and II are separated by a spherical surface of radius $25 \mathrm{~cm}$. An object is kept in region I at a distance of $40 \mathrm{~cm}$ from the surface. The distance of the image from the surface is :

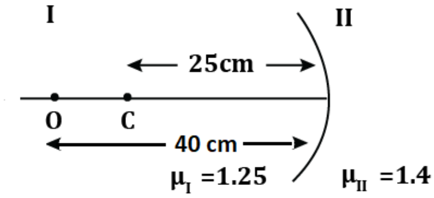


A. $55.44 \mathrm{~cm}$

B. $9.52 \mathrm{~cm}$

C. $18.23 \mathrm{~cm}$

D. $37.58 \mathrm{~cm}$



On applying the equation, for refraction due to a single spherical surface,

$$\frac{\mu_2}{v}-\frac{\mu_1}{u}=\frac{\mu_2-\mu_1}{R}$$

Here,

$$\frac{\mu_{\mathrm{II}}}{v}-\frac{\mu_{\mathrm{I}}}{u}=\frac{\mu_{\mathrm{II}}-\mu_{\mathrm{I}}}{R}$$

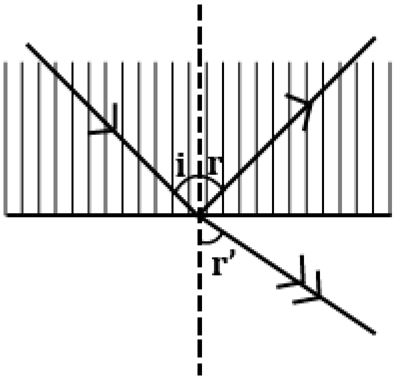
$$\Rightarrow \frac{1.4}{v}-\frac{1.25}{(-40)}=\frac{1.4-1.25}{(-25)}$$

On solving this, we get,

$v=-37.58 \mathrm{~cm}$

Hence, option (D) is the correct answer.

10. A ray of light passes from a denser medium to a rarer medium at an angle of incidence i. The reflected and refracted rays make an angle of 90° with each other. The angle of reflection and refraction are respectively r and r'. The critical angle is given by :



A. $\sin^{-1}(\cot r)$

B. $\tan^{-1}(\sin i)$

C. $\sin^{-1}(\tan r')$

D. $\sin^{-1}(\tan r)$ ✓

According to the given problem,

$r + r' + 90^{\circ} = 180^{\circ}$ and

$r' = 90 - r = 90 - i$

Applying Snell's law with the given data,

$n_1 \sin i = n_2 \sin r' = n_2 \sin(90 - i)$

$\Rightarrow n_1 \sin i = n_2 \cos i$

$\Rightarrow \tan i = \dfrac{n_2}{n_1}$

Now, we know, the critical angle is given by,

$\sin C = \dfrac{n_2}{n_1} = \tan i$

$\Rightarrow C = \sin^{-1}(\tan i) = \sin^{-1}(\tan r) \quad [\because i = r]$

Hence, (D) is the correct answer.

11. A ray of laser of a wavelength $630\ \mathrm{nm}$ is incident at an angle of 30° at the diamond-air interface. It is going from diamond to air. The refractive index of diamond is 2.42 and that of air is 1. Choose the correct option.

- **A.** angle of refraction is 24.41°
- **B.** angle of refraction is 30°
- **C.** refraction is not possible
- **D.** angle of refraction is 53.4°

For a ray of light travelling from diamond to glass, the critical angle is given by,

$$\sin\theta_c = \frac{1}{\mu_d} = \frac{1}{2.42}$$

$$\sin\theta_c \approx 0.4 \Rightarrow \theta_c < 30^\circ\ (\because \sin 30^\circ = 0.5)$$

It is given that $i = 30^\circ$.
As $i > \theta_c$, the ray of light will undergo total internal reflection.

Hence, (C) is the correct answer.

12. A prism of refractive index μ and angle of prism A is placed in the position of minimum angle of deviation. If minimum angle of deviation is also A, then A in terms of refractive index is

A. $2\cos^{-1}\left(\frac{\mu}{2}\right)$

B. $\sin^{-1}\left(\frac{\mu}{2}\right)$

C. $\sin^{-1}\left(\sqrt{\frac{\mu-1}{2}}\right)$

D. $\cos^{-1}\left(\frac{\mu}{2}\right)$

The formula relating the refractive index μ, Angle of prism A and angle of minimum deviation δ_{min} is

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

Given that, $\delta_{min} = A$

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

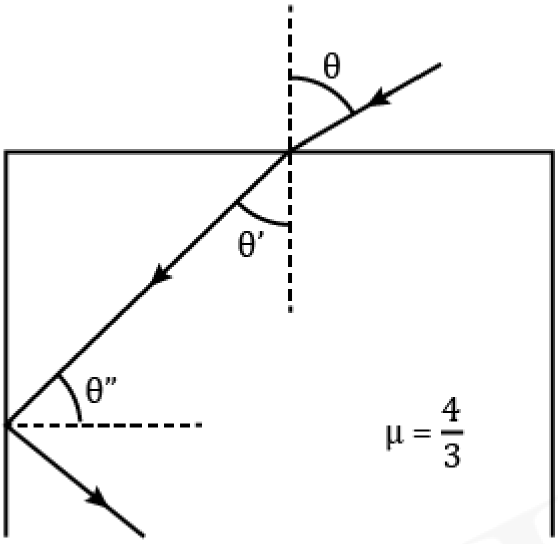
$$\Rightarrow \mu = \frac{\sin A}{\sin\frac{A}{2}} = \frac{2\sin\left(\frac{A}{2}\right)\cos\left(\frac{A}{2}\right)}{\sin\left(\frac{A}{2}\right)}$$

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

$$\Rightarrow A = 2\cos^{-1}\left(\frac{\mu}{2}\right)$$

Hence, option (A) is correct.

13. A ray of light entering from air into a denser medium of refractive index $\frac{4}{3}$, as shown in figure. The light ray suffers total internal reflection at the adjacent surface as shown. The maximum value of angle θ should be equal to

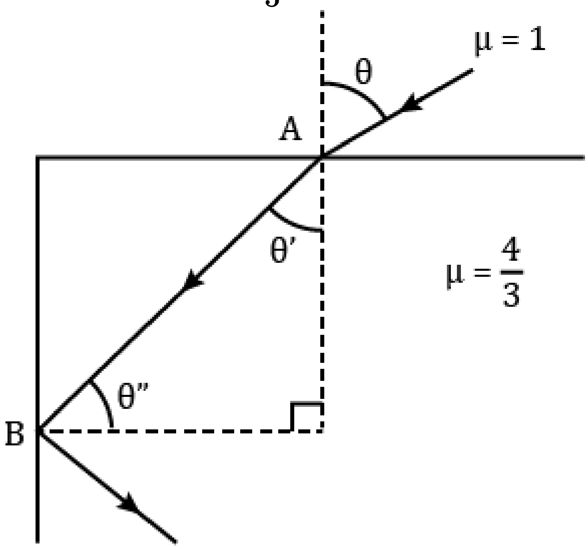


A. $\sin^{-1}\frac{\sqrt{7}}{3}$

B. $\sin^{-1}\frac{\sqrt{5}}{4}$

C. $\sin^{-1}\frac{\sqrt{7}}{4}$

D. $\sin^{-1}\frac{\sqrt{5}}{3}$



At maximum angle θ ray at point B, goes in gazing emergence,

Applying Snell's law at point B,

$$\frac{4}{3} \times \sin\theta\text{"} = 1 \times \sin 90^\circ$$

$$\theta" = \sin^{-1}\left(\frac{3}{4}\right)$$

From the figure,

$$\theta' = \left(\frac{\pi}{2} - \theta"\right)$$

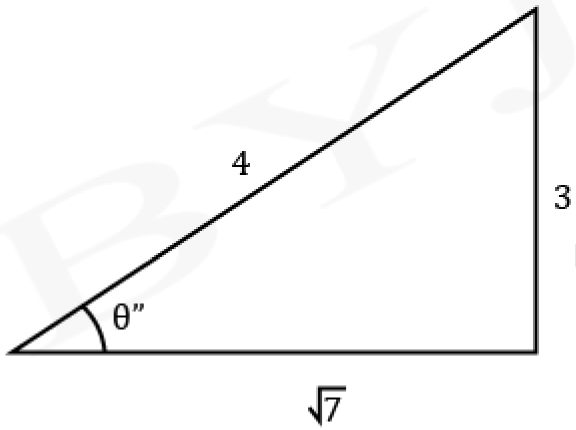
Now applying snell's law at point A,

$$1 \times \sin\theta = \frac{4}{3} \times \sin\theta'$$

$$\sin\theta = \frac{4}{3} \times \sin\theta'$$

$$\sin\theta = \frac{4}{3} \times \sin\left(\frac{\pi}{2} - \theta"\right)$$

$$\sin\theta = \frac{4}{3} \times \cos\theta''$$



From the above triangle,

$$\theta'' = \sin^{-1}\left(\frac{3}{4}\right) = \cos^{-1}\left(\frac{\sqrt{7}}{4}\right)$$

$$\Rightarrow \sin\theta = \frac{4}{3} \times \cos\left[\cos^{-1}\left(\frac{\sqrt{7}}{4}\right)\right]$$

$$\Rightarrow \sin\theta = \frac{4}{3} \times \frac{\sqrt{7}}{4}$$

$$\Rightarrow \theta = \sin^{-1}\left(\frac{\sqrt{7}}{3}\right)$$

Hence, option (A) is correct.

14. Car B overtakes another car A at a relative speed of 40 ms^{-1}. How fast will the image of car B appear to move, in the mirror of focal length 10 cm, fitted in car A, when the car B is 1.9 m away from the car A?

- **A.** 0.1 ms^{-1}
- **B.** 0.2 ms^{-1}
- **C.** 40 ms^{-1}
- **D.** 4 ms^{-1}

$V_{B,A} = 10 \text{ ms}^{-1}$
$f = 10 \text{ cm} = 0.1 \text{ m}$
$u = 1.9 \text{ m}$

As the focal length is positive, it is a concave mirror.

Now, $\frac{1}{f} = \frac{1}{v} + \frac{1}{u}$

$$\frac{1}{-0.1} = \frac{1}{v} + \frac{1}{-1.9}$$

$$\frac{1}{v} = \frac{1}{1.9} - \frac{1}{0.1} = \frac{18}{1.9}$$

$$\therefore v = -0.1055 \text{ m}$$

From the mirror equation, we can write,
$\Rightarrow f^{-1} = u^{-1} + v^{-1}$

Differentiating both sides w.r.t. time,

$$0 = (-1)u^{-2}\frac{du}{dt} + (-1)v^{-2}\frac{dv}{dt}$$

$$\Rightarrow u^{-2}\frac{du}{dt} = -v^{-2}\frac{dv}{dt}$$

$$\Rightarrow \frac{1}{u^2}\frac{du}{dt} = -\frac{1}{v^2}\frac{dv}{dt}$$

Here, $\frac{du}{dt} \to \text{speed of object w.r.t. mirror}$
$\frac{dv}{dt} \to \text{speed of image w.r.t. mirror}$

Now, $V_{B,A} = \frac{du}{dt} = 40 \text{ ms}^{-1}$
$u = -1.9 \text{ m}, \ v = -0.1055 \approx -0.1 \text{ m}$

$$\therefore \frac{1}{(-1.9)^2} \times 40 = -\frac{1}{(-0.1)^2} \times \frac{dv}{dt}$$

After calculating, we get, $\frac{dv}{dt} = -0.11 \text{ m/s}^{-1}$

Negative sign indicated that, as object is moving towards the mirror, the image is moving away from it.

Hence, (A) is the correct answer.

15. An object is placed beyond the center of curvature C of the given concave mirror. If the distance of the object is d_1 from C and the distance of the image formed is d_2 from C, the radius of curvature of this mirror is :

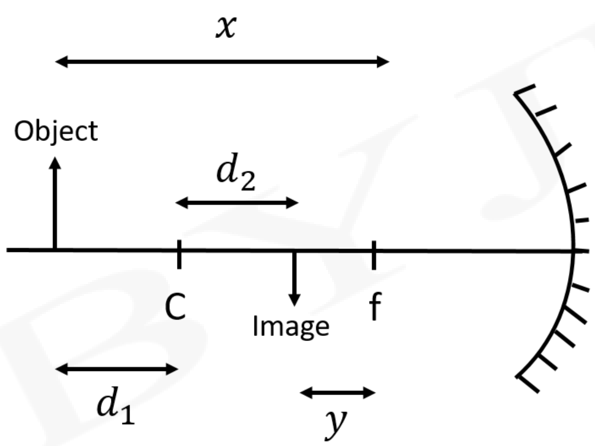
A. $\frac{d_1 d_2}{d_1 - d_2}$

B. $\frac{d_1 d_2}{d_1 + d_2}$

C. $\frac{2 d_1 d_2}{d_1 - d_2}$

D. $\frac{2 d_1 d_2}{d_1 + d_2}$

Since, the object lies beyond the center of curvature of the mirror, the image will lie between C and f.



Distance of the object from the focus is :
$x = f + d_1$
Distance of image from the focus is :
$y = f - d_2$
Using Newton's formula for mirror :
$xy = f^2$
$(f + d_1)(f - d_2) = f^2$
$f^2 - f d_2 + f d_1 - d_1 d_2 = f^2$

$$\Rightarrow f = \frac{d_1 d_2}{d_1 - d_2}$$

$$\Rightarrow R = \frac{2 d_1 d_2}{d_1 - d_2}$$

16. If we need a magnification of 375 from a compound microscope of tube length 150 mm and an objective of focal length 5 mm, the focal length of the eye-piece should be close to:

A. 22 mm

B. 2 mm

C. 12 mm

D. 33 mm

Magnification of compound microscope for least distance of distinct vision setting(strained eye)

$$M = \frac{L}{f_0}\left(1 + \frac{D}{f_e}\right)$$

where L is the tube length
f_0 is the focal length of objective
D is the least distance of distinct vision $= 25 \text{ cm}$

$$\text{i.e.} \qquad 375 = \frac{150}{50}\left(1 + \frac{250}{f_e}\right)$$

$$\text{i.e.} \qquad 125 = 1 + \frac{250}{f_e}$$

$$\text{i.e.} \qquad \frac{250}{f_e} = 124$$

$$\therefore \quad f_e \approx 2.016 \text{ mm} = 2 \text{ mm}$$

17. Given below are two statements : One is labelled as Assertion A and the other is labelled as reason R.

A : For a simple microscope, the angular size of the object equals the angular size of the image.

R : Magnification is achieved as the small object can be kept much closer to the eye than $25\ \mathrm{cm}$ and hence it subtends a large angle.

In the light of the above statements, choose the most appropriate answer from the options given below.

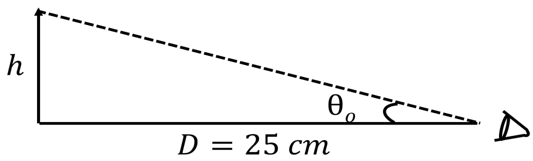
A. Both A and R are true, but R is **NOT** the correct explanation of A.

B. Both A and R are true, and R is the correct explanation of A.

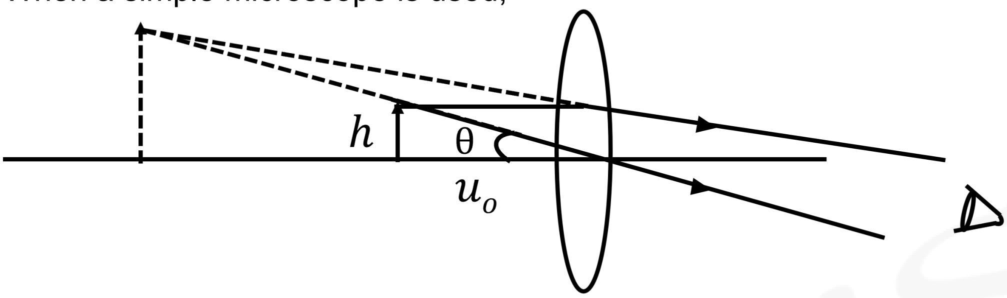
C. A is true, but R is false.

D. A is false, but R is true.

When object is placed at $D = 25\ \text{cm}$,
$\theta_o = \dfrac{h}{D}$



When a simple microscope is used,



From the ray diagram, we can see that, the angular size of the object equals the angular size of the image$(= \theta)$.

Also, $\theta = \dfrac{h}{u_o}$

This angle is greater than θ_o and $u_o < 25\ \text{cm}$.

Hence, magnification is achieved as the small object can be kept much closer to the eye than $25\ \text{cm}$ and hence it subtends a large angle.

Therefore, both A and R are true, but R is **NOT** the correct explanation of A.

18. The magnifying power of a telescope at normal adjustment with tube length 60 cm is 5. What is the focal length of its eye piece?

A. 20 cm

B. 40 cm

C. 30 cm

D. 10 cm

For telescope, at normal adjustment,

$$\text{Tube length, } L = f_o + f_e = 60 \text{ cm}$$

$$\text{magnification, } m = \frac{f_o}{f_e} = 5$$

$$\Rightarrow f_o = 5f_e$$

$$\therefore L = 5f_e + f_e = 60 \text{ cm}$$

$$\Rightarrow f_e = 10 \text{ cm}$$

$\therefore$ focal length of eye-piece, $f_e = 10 \text{ cm}$

Hence, option (D) is correct.

19. The eye can be regarded as a single refracting surface. The radius of curvature of this surface is equal to that of cornea $7.8 \mathrm{~mm}$. This surface separates two media of refractive indices 1 and 1.34. Calculate the distance from the refracting surface at which a parallel beam of light will come to focus.

A. $1 \mathrm{~cm}$

B. $2 \mathrm{~cm}$

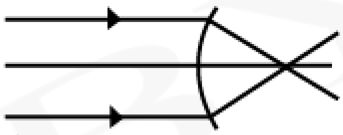
C. $4.0 \mathrm{~cm}$

D. $3.1 \mathrm{~cm}$

Using refraction at curved surfave is,

$$\frac{\mu_2}{v}-\frac{\mu_1}{u}=\frac{\mu_2-\mu_1}{R}$$

$R=7.8 \mathrm{~mm}$



Given,
$\mu_1=1$
$\mu_2=1.34$

$$\Rightarrow \frac{1.34}{v}-\frac{1}{\infty}=\frac{1.34-1}{7.8}[\because u=\infty]$$
$\therefore V=30.7 \mathrm{~mm}=3.07 \mathrm{~cm} \approx 3.1 \mathrm{~cm}.$

20. The diameter of the objective lens of a telescope is 250 cm. For light of wavelength 600 nm. Coming from a distant object, the limit of resolution of the telescope is close to-

A. $2.7 \times 10^{-7} \text{ rad}$

B. $1.5 \times 10^{-7} \text{ rad}$

C. $2.9 \times 10^{-7} \text{ rad}$

D. $4.5 \times 10^{-7} \text{ rad}$

Limit of resolution, $\theta = \dfrac{1.22\lambda}{d}$

$$\theta = \frac{1.22 \times 600 \times 10^{-9}}{250 \times 10^{-2}} \approx 3.0 \times 10^{-7} \text{ rad}$$

Hence, (C) is the correct answer.

21. Consider the diffraction pattern obtained from the sunlight incident on a pinhole of diameter $0.1\ \mu\text{m}$. If the diameter of the pinhole is slightly increased, it will affect the diffraction pattern such that:

A. its size decreases, but intensity increases

B. its size increases, but intensity decreases

C. its size increases and intensity increases

D. its size decreases and intensity decreases

For diffraction through a single slit, for first minimum.

$\sin\theta = \dfrac{1.22\lambda}{D}$

If D is increased, then $\sin\theta$ will decrease, i.e θ will decrease.
$\therefore$ size of circular fringe will decrease, but intensity increases.

22. If the source of light used in a Young's double slit experiment is changed from red to violet:

A. the fringes will become brighter.

B. consecutive fringe lines will come closer.

C. the central bright fringe will become a dark fringe.

D. the intensity of minima will increase.

We know, wavelength of red light is greater than that of the violet light $i.e.\ \lambda_v < \lambda_r$.

Also, fringe width, $\beta = \dfrac{\lambda D}{d}$

$\therefore \beta_v < \beta_r$

So, when source is changed to violet from red, consecutive fringes will come closer.

23. In a Young's double slit experiment, the width of one of the slit is three times the other slit. The amplitude of the light coming from a slit is proportional to the slit-width. Find the ratio of the maximum to the minimum intensity in the interference pattern.

- A. $4:1$ ✔
- B. $2:1$
- C. $3:1$
- D. $1:4$

Given:
Slit width, $d_2 = 3d_1$
Also, $A \propto d$

$$\therefore \frac{A_1}{A_2} = \frac{1}{3}$$

Assuming, $A_1 = x$, $A_2 = 3x$

We know that,

$$I_{\text{max}} = (A_1 + A_2)^2 = 16x^2$$

$$I_{\text{min}} = (A_1 - A_2)^2 = 4x^2$$

Now,

$$\frac{I_{\text{max}}}{I_{\text{min}}} = \frac{16x^2}{4x^2}$$

$$\Rightarrow \frac{I_{\text{max}}}{I_{\text{min}}} = \frac{4}{1} = 4:1$$

24. Two coherent light sources having intensities in the ratio $2x$ produces an interference pattern. The ratio $\dfrac{I_{\max}-I_{\min}}{I_{\max}+I_{\min}}$ will be :

A. $\dfrac{2\sqrt{2x}}{x+1}$

B. $\dfrac{\sqrt{2x}}{2x+1}$

C. $\dfrac{2\sqrt{2x}}{2x+1}$

D. $\dfrac{\sqrt{2x}}{x+1}$

Let,
$I_1 = 2x$
$I_2 = 1$

So,

$$I_{\max} = \left(\sqrt{I_1}+\sqrt{I_2}\right)^2$$

$$\Rightarrow I_{\max} = \left(\sqrt{2x}+\sqrt{1}\right)^2 = 2x+1+2\sqrt{2x}$$

$$I_{\min} = \left(\sqrt{I_1}-\sqrt{I_2}\right)^2$$

$$\Rightarrow I_{\min} = \left(\sqrt{2x}-\sqrt{1}\right)^2 = 2x+1-2\sqrt{2x}$$

Now,
$I_{\max}-I_{\min} = 4\sqrt{2x}$

$I_{\max}+I_{\min} = 4x+2$

Hence,

$$\frac{I_{\max}-I_{\min}}{I_{\max}+I_{\min}} = \frac{4\sqrt{2x}}{4x+2} = \frac{2\sqrt{2x}}{2x+1}$$

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25. In a Young's double slit experiment two slits are separated by $2 \mathrm{~mm}$ and the screen is placed one meter away. When a light of wavelength $500 \mathrm{~nm}$ is used, the fringe separation will be:

A. $0.75 \mathrm{~mm}$

B. $0.50 \mathrm{~mm}$

C. $1 \mathrm{~mm}$

D. $0.25 \mathrm{~mm}$ ✓

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

$d=2 \times 10^{-3} \mathrm{~m}$

$\lambda=500 \times 10^{-9} \mathrm{~m}$

$D=1 \mathrm{~m}$

Now,

$$\beta=\frac{500 \times 10^{-9} \times 1}{2 \times 10^{-3}}$$

$$\beta=\frac{5}{2} \times 10^{-4}$$

$$\beta=2.5 \times 10^{-4}$$

$\beta = 0.25 \mathrm{~mm}$

26. Red light differs from blue light as they have:

A. Same frequencies and same wavelengths

B. Different frequencies and different wavelengths ✓

C. Different frequencies and same wavelengths

D. Same frequencies and different wavelengths

Red light and blue light have different frequency and different wavelength.
Red light has maximum wavelength among visible light.

27. In Young's double slit arrangement, slits are separated by a gap of $0.5 \mathrm{~mm}$, and the screen is placed at a distance of $0.5 \mathrm{~m}$ from them. The distance between the first and the third bright fringe formed when the slits are illuminated by a monochromatic light of 5890 Å is:

A. $1178 \times 10^{-6} \mathrm{~m}$

B. $1178 \times 10^{-9} \mathrm{~m}$

C. $5890 \times 10^{-7} \mathrm{~m}$

D. $1178 \times 10^{-12} \mathrm{~m}$

Given, $D=0.5 \mathrm{~m}$, $d=0.5 \mathrm{~mm}$
$\lambda=5890$ Å

Distance between first and third bright fringe $=2 \beta=\dfrac{2 \lambda D}{d}$

$$=2 \times \frac{5890 \times 10^{-10} \times 0.5}{0.5 \times 10^{-3}}$$
$$=1178 \times 10^{-6} \mathrm{~m}$$

28. With what speed should a galaxy move outward with respect to earth so that the sodium$-$D line at wavelength 5890 Å is observed at 5896 Å ?

A. 306 km/sec

B. 322 km/sec

C. 296 km/sec

D. 336 km/sec

Given:

$\lambda_{app} = 5890$ Å; $\lambda_0 = 5896$ Å

Let v be the velocity of the galaxy and c be the velocity of light in vacuum.

For $v << c$, we know that

When galaxy moving away from the earth

$$\frac{\lambda_{app}}{\lambda_0} = 1 - \frac{v}{c} \quad (\text{when}, v << c)$$

$$\Rightarrow \frac{5890}{5896} = 1 - \frac{v}{3 \times 10^8}$$

$$\Rightarrow v = 3.0529 \times 10^5 \text{ m/s} \approx 306 \text{ km/s}$$

Hence, option (A) is correct.

29. In the Young's double slit experiment, the distance between the slits varies in time as $d(t) = d_0 + a_0 \sin \omega t$; where d_0, ω and a_0 are constants. The difference between the largest fringe width and the smallest fringe width, obtained over time, is given as :

A. $\dfrac{2\lambda D(d_0)}{(d_0^2 - a_0^2)}$

B. $\dfrac{2\lambda D a_0}{(d_0^2 - a_0^2)}$

C. $\dfrac{\lambda D}{d_0^2} a_0$

D. $\dfrac{\lambda D}{d_0 + a_0}$

Fring width, $\beta = \dfrac{\lambda D}{d}$

For $\beta = \beta_{max}, \quad d = d_{min}$

And for $\beta = \beta_{min}, \quad d = d_{max}$

Now, $d = d_0 + a_0 \sin \omega t$

$\Rightarrow d_{max} = d_0 + a_0$ and $d_{min} = d_0 - a_0$

$\therefore \beta_{min} = \dfrac{\lambda D}{d_0 + a_0}$ and

$\therefore \beta_{max} = \dfrac{\lambda D}{d_0 - a_0}$

$$\beta_{max} - \beta_{min} = \frac{\lambda D}{d_0 - a_0} - \frac{\lambda D}{d_0 + a_0}$$

$$= \frac{2\lambda D a_0}{d_0^2 - a_0^2}$$

Hence, (B) is the correct answer.

30. In Young's double slit experiment, if the source of light changes from orange to blue then :

A. the central bright fringe will become a dark fringe.

B. the distance between consecutive fringes will decrease.

C. the distance between consecutive fringes will increase.

D. the intensity of the minima will increase.

We know that,

Fringe width, $\beta = \lambda D/d$

$\therefore \beta \propto \lambda$

Since, wavelength of blue colour is smaller as compared to orange colour. So, as λ decreases, fringe width also decreases.

$\therefore$ The distance between consecutive fringes will decrease.

Hence, option (B) is correct.