Q.1 A boy is walking under an inclined mirror at a constant velocity V m/s along the x-axis as shown in figure. If the mirror is inclined at an angle $\theta$ with the horizontal then what is the velocity of the image?

(A) $V \sin \theta \hat{i} + V \cos \theta \hat{j}$

(B) $V \cos \theta \hat{i} + V \sin \theta \hat{j}$

(C) $V \sin 2\theta \hat{i} + V \cos 2\theta \hat{j}$

(D) $V \cos 2\theta \hat{i} + V \sin 2\theta \hat{j}$

Sol.  

Q.2 A telescope has focal length of objective and eyepiece as 200 cm and 5 cm respectively. What is the value of magnifying power ?

(A) 40  

(B) 80  

(C) 50  

(D) 0.01

Sol. [A] $\frac{f_o}{f_e} = \frac{200}{5} = 40$

Q.3 A plane mirror is Inclined at an angle $\theta = 30^\circ$ with the horizontal surface. A particle P is projected with velocity $V = 10$ m/s as shown in figure. Time when the image will come momentarily at rest w.r.t. to the particle –

(A) $\sqrt{3}$  

(B) $\sqrt{2}$  

(C) $\frac{1}{\sqrt{2}}$  

(D) $\frac{1}{\sqrt{3}}$ [D]

Q.4 The magnification produced by an astronomical telescope for normal adjustment is 10 and the length of telescope is 1.1m. The magnification when image is formed at least distance of distinct vision (D = 25 cm) is –

(A) 14  

(B) 6  

(C) 16  

(D) 18

Sol. [A] $10 = \frac{f_o}{f_e}$

$1.1 f_o = 1m = 100 cm \ & f_e = 0.1 m = 10 cm$

Now; When final image is at D

$MP = f_o \left( \frac{1}{D} + \frac{1}{f_e} \right) = 100 \left( \frac{1}{25} + \frac{1}{10} \right) = 14$

Q.5 A telescope of objective lens diameter 2m uses light of wavelength 5000 Å for viewing stars. The minimum angular separation between two stars whose image is just resolved by telescope -

(A) $4 \times 10^{-4}$ rad  

(B) $0.25 \times 10^{-6}$ rad  

(C) $0.31 \times 10^{-6}$ rad  

(D) $5 \times 10^{-3}$ rad

Sol. [C] $\Delta \theta = \frac{1.22 \lambda}{a} \therefore \Delta \theta = \frac{1.22 \times 5000 \times 10^{-10}}{2} = 3050 \times 10^{-10} = 3.05 \times 10^{-7}$ rad.

$\approx 0.31 \times 10^{-6}$ rad.

Q.6 An astronomical telescope has a converging eyepiece of focal lengths 5 cm and objective of focal lengths 80 cm. When the final image is formed at least distance of distinct vision (25 cm), the separation between the two lenses is-

(A) 75.0 cm  

(B) 80.0 cm  

(C) 82.2. cm  

(D) 85.0 cm

Sol. [C] $1 = f_o t \frac{f_t D}{f_e + D} = S_o t \frac{5 \times 25}{5 + 25}$

$= S_o t \frac{125}{30} = 84.16 = 84.2 cm$

Q.7 The magnification produced by an astronomical telescope for normal adjustment is 10 and the length of telescope is 1.1m. The magnification when image is formed at least distance of distinct vision is –

(A) 14  

(B) 6  

(C) 16  

(D) 18

Sol. [A] $10 = \frac{f_o}{f_e}$

$L = f_o + f_e = 110 cm$

$\therefore f_o = 100 cm \ & f_e = 10 cm$
Q.8 In a microscope the focal lengths of two lenses are 1.5 cm and 6.25 cm. If an object is placed at 2 cm from objective and final image is formed at 25 cm from eye – lens, the distance between two lenses is -
(A) 6 cm  
(B) 7.75 cm  
(C) 9.25 cm  
(D) 11 cm

Sol. [D]
For objective lens
\[
\frac{1}{1.5} = \frac{1}{v_0} - \frac{1}{2} \Rightarrow v_0 = 6\text{ cm}
\]

For eye lens:
\[
\frac{1}{-25} = \frac{1}{-u_e} + \frac{1}{6.25} \Rightarrow u_e = 5\text{ cm}
\]

\[L = v_0 + u_e = 6 + 5 = 11\text{ cm}\]

Q.9 Magnification of a compound microscope is 30. Focal length of eye - piece is 5 cm and image is formed at a distance of 25 cm from eye - piece. The magnification of objective lens is -
(A) 6  
(B) 5  
(C) 7.5  
(D) 10

Sol. [B]
MP = \(m_o \times m_e\)
\[
m_e = 1 + \frac{D}{f_e} = \frac{1 + 25}{5} = 6
\]

\[30 = m_o \times 6 \Rightarrow m_o = 5\]

Q.10 The mirror of length 2\(\ell\) makes 10 revolutions per minute about the axis crossing its mid point O and perpendicular to the plane of the figure. There is a light source in point A and an observer at point B of the circle of radius R drawn around centre O (\(\angle AOB = 90^\circ\)).

What is the proportion \(\frac{R}{\ell}\) if the observer B first sees the light source when the angle of mirror \(\psi = 15^\circ\)?

(A) \(\delta = 0^\circ\)  
(B) \(\delta = 180^\circ\)  
(C) \(\delta = 90^\circ\)  
(D) we can't find out deviation as other two angles A and B in figure is not given  

Sol.
\[ \theta_2 + \theta_3 + 135^\circ = 180^\circ \]
\[ \theta_3 = 45^\circ - \theta_2 \]
\[ \theta_1 + \theta_2 = 90^\circ \]
\[ 45^\circ - \theta_2 + \theta_4 = 90^\circ \]
\[ \theta_4 = 45^\circ + \theta_2 \]
\[ 90^\circ - \theta_4 + \theta_3 + 135^\circ = 180^\circ \]
\[ 45^\circ - \theta_2 + \theta_3 + 135^\circ = 180^\circ \]
\[ \theta_3 = \theta_2 \]
\[ \therefore \theta_6 = \theta_1 \text{(By snell law)} \]
\[ \therefore \delta = 180^\circ \]

Q.12 If an object moves towards a plane mirror with a speed \( v \) at an angle \( \theta \) to the perpendicular to the plane of the mirror, find the relative velocity between the object and the image -

\[ v_0 \]
\[ v_1 \]
\[ v \]
\[ \theta \]
\[ \theta_1 \]

(A) \( v \) 
(B) \( 2v \) 
(C) \( 2v \cos \theta \) 
(D) \( 2v \sin \theta \) 

[C]

Sol. Only normal component of plane mirror will be change, it becomes reverse so, relative velocity of image w.r.t. object 
\[ = 2 \, v \cos \theta \]

Q.13 An opaque sphere of radius \( R \) lies on a horizontal plane. On the perpendicular through the point of contact there is a point source of light at a distance \( R \) above the sphere. The area of the shadow on the plane is

\[ A_0 = \sqrt{(2R)^2 - R^2} = \sqrt{3} \, R \]

So Area
\[ = \pi \left( \sqrt{3} \, R \right)^2 = 3\pi R^2 \]

Q.14 A body of mass 100g is tied to one end of spring of constant 20 N/m. The distance between pole of mirror and mean position of the body is 20cm. The focal length of convex mirror is 10cm. One of the amplitudes of vibration of the image is -

(A) 10 cm 
(B) 50 cm 
(C) 0.67 cm 
(D) 0.33 cm 

[C]

Sol. 
\[ K = mg \]
\[ x = \frac{mg}{20K} = \frac{1}{20} = 5 \text{ cm}, \]

Apply 
\[ \frac{1}{v} + \frac{1}{u} = \frac{1}{f} \]

Q.15 A concave mirror is placed on a horizontal table with its axis directed vertically upwards. Let \( O \) be the pole of the mirror and \( C \) its centre of

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curvature. A point object is placed at C. It has a real image, also located at C. If the mirror is now filled with water, the image will be-

(A) Real and will remain at C
(B) Real and located at a point between C and \( \infty \)
(C) Virtual and located at a point between C and O
(D) Real and located at a point between C and O

Sol.[D]

From the above figure it is clear that real image (I) will be formed between C and O.

Q.16 A small piece of wire bent into an L shape with upright and horizontal portions of equal lengths, is placed with the horizontal portion along the axis of the concave mirror whose radius of curvature is 10 cm. If the bend is 20 cm from the pole of the mirror, then the ratio of the lengths of the images of the upright and horizontal portions of the wire is -

(A) 1 : 2  
(B) 3 : 1  
(C) 1 : 3  
(D) 2 : 1

Sol.[B] Focal length of mirror \( f = \frac{R}{2} = \frac{10}{2} = 5 \) cm

Part PQ \( \rightarrow \) transverse magnification

length of image \( L_1 = \left( \frac{f}{f-u} \right) \times L_0 \)

\[ = \left[ \frac{-5}{-5-(-20)} \right] L_0 = -\frac{L_0}{3} \]

For part QR : - longitudinal magnification

length of image \( L_2 = \left( \frac{f}{f-u} \right)^2 L_0 = \frac{L_0}{9} \)

So \( \frac{L_1}{L_2} = \frac{3}{1} \)

Q.17 A real inverted image in a concave mirror is represented by: (u, v, f are coordinates)

\[ (A) \quad u/f, -v/f \quad (B) \quad -u/f, v/f \quad (C) \quad u/f, v/f \quad (D) \quad u/f, -v/f \]

[A]

Q.18 An object is placed in front of a convex mirror at a distance of 50 cm. A plane mirror is introduced covering the lower half of the convex mirror. If the distance between the object and plane mirror is 30 cm, it is found that there is no parallax between the images formed by two mirrors. Radius of curvature of mirror will be -

(A) 12.5 cm (B) 25 cm (C) \( \frac{50}{3} \) cm (D) 18 cm

Sol.[B] According to property of plane mirror it will form image at a distance of 30 cm behind it

\[ \frac{1}{f} = \frac{1}{v} + \frac{1}{u} \Rightarrow 1 \times f = \frac{1}{10} + \frac{1}{-50} = \frac{4}{50} \]

\[ \Rightarrow f = \frac{25}{2} \text{ cm} \Rightarrow R = 2f = 25 \text{ cm} \]
Q.19 A slab of glass, of thickness 6 cm and refractive index 1.5, is placed in front of a concave mirror, the faces of the slab being perpendicular to the principal axis of the mirror. If the radius of curvature of the mirror is 40 cm and the reflected image coincides with the object, then the distance of the object from the mirror is -
(A) 30 cm (B) 22 cm (C) 42 cm (D) 28 cm

Sol. [C]
\[ \Delta x = \left(1 - \frac{1}{\mu} \right)t = \left(1 - \frac{1}{1.5} \right) \times 6 = 2 \text{cm}, \text{ Distance of object from concave mirror} = 40 + 2 = 42 \text{ cm} \]

Q.20 A glass rod of rectangular cross-section is bent into the shape shown in Fig. (a). A parallel beam of light falls perpendicularly on the flat surface A. Determine the minimum value of the ratio R/d for which all light entering the glass through surface A will emerge from the glass through surface B. The index of refraction of the glass is 1.5.

\[ \alpha \]

Fig. (a) \[ R \]

Q.21 Two transparent slabs are of equal length. One is made of a material A of R.I. 1.5 and the other of materials B and C, the ratio of thickness being 1 : 2. The R.I. of C is 1.6. When light passes through them, the two slabs have the same number of waves. The R.I. of B is –
(A) 1.4 (B) 1.3 (C) 1.1 (D) 1.05

Sol. [B]

Q.22 A ray of light travels from a medium of refractive index \( \mu \) to air. Its angle of incidence in the medium is \( i \), measured from the normal to the boundary, and its angle of deviation is \( \delta \). \( \delta \) is plotted against \( i \) which of the following best represents the resulting curve -

(A) \[ \delta \]

(B) \[ \delta \]

Sol. Consider the representative rays shown in Fig. (b). A ray entering the glass through surface A and passing along the inner side of the rod will be reflected by the outer side with the smallest angle \( \alpha \), at which the reflected ray is tangent to the inner side. We have to consider the conditions under which the ray will undergo total internal reflection before reaching B.
Q.23 Critical angle for light going from medium (i) to (ii) is θ. The speed of light in medium (i) is v, then speed in medium (ii) is -
(A) v (1 – cos θ)   (B) v / sin θ
(C) v / cos θ   (D) v (1 – sin θ)  [B]
Sol. \[ \mu_1 = \frac{1}{\sin \theta} = \frac{\mu_1}{\mu_2} = \frac{v_2}{v_1} \Rightarrow v_2 = \frac{v_1}{\sin \theta} \]
\[ \therefore v_2 = \frac{v}{\sin \theta} \]

Q.24 A prism of refractive index \( \mu \) and angle A is placed in the minimum deviation position. If the angle of minimum deviation is \( \Delta \), then the value of A in terms of \( \mu \) is -
(A) \( \sin^{-1} \left( \frac{\mu}{2} \right) \)   (B) \( \sin^{-1} \left( \sqrt{\frac{\mu - 1}{2}} \right) \)
(C) \( 2\cos^{-1} \left( \frac{\mu}{2} \right) \)   (D) \( \cos^{-1} \left( \frac{\mu}{2} \right) \)
Sol. \[ \mu = \sin \frac{\left( \Delta + \delta_m \right)}{2} \] \[ \therefore \mu = \frac{\sin A}{\sin A/2} = 2\cos A/2 \] \[ \therefore A = 2\cos^{-1}(\mu/2) \]

Q.25 Light is incident normally on face AB of a prism as shown in figure. A liquid of refractive index \( \mu \) is placed on face AC of the prism. The prism is made of glass of refractive index 3/2. The limits of \( \mu \) for which total internal reflection takes place on face AC is:
(A) \( \mu > \sqrt{\frac{3}{2}} \)   (B) \( \mu < \frac{3\sqrt{3}}{4} \)
(C) \( \mu > \sqrt{3} \)   (D) \( \mu < \frac{\sqrt{3}}{2} \)
Sol. [B]
Q.26 A prism having an apex angle 4° and refractive index 1.5 is located in front of a vertical plane mirror as shown in figure. Through what total angle is the ray deviated after reflection from mirror –
(A) 176°   (B) 4°   (C) 178°   (D) 2°
Sol.[C]
\[ \delta_{	ext{prism}} = (\mu - 1)A = (1.5 - 1)4 = 2 \]
\[ \delta_{	ext{total}} = \delta_{	ext{prism}} + \delta_{	ext{mirror}} = 2° + (180° - 2) = 178° \]
Q.27 A given ray of light suffers minimum deviation in an equilateral prism P. Additional prisms Q and R of identical shape and material are now added to P, as shown in the figure. The ray will suffer -
(1) greater deviation   (2) same deviation
(3) no deviation   (4) total internal reflection
Sol. [2]
Q.28 A spherical surface of radius R separates two medium of refractive indices \( \mu_1 \) and \( \mu_2 \), as shown in Fig. Where an object should be placed in the medium 1 so that a real image is formed in medium 2 at the same distance?
Q.29
A convex lens of focal length 20 cm is cut into two equal parts so as to obtain two plano-convex lenses as shown in fig. (B). The two parts are then put in contact as shown in fig. (C). What is the focal length of combination (A) zero (B) 5 cm (C) 10 cm (D) 20 cm

(A) \( \left( \frac{\mu_2 - \mu_1}{\mu_2 + \mu_1} \right) R \) (B) \( \left( \frac{\mu_2 + \mu_1}{\mu_2 - \mu_1} \right) R \) (C) \( \left( \frac{\mu_2 + \mu_1}{\mu_2} \right) R \) (D) \( \left( \frac{\mu_2}{\mu_2 + \mu_1} \right) R \) [A]

Q.29
A convex lens of focal length 20 cm is cut into two equal parts so as to obtain two plano-convex lenses as shown in fig. (B). The two parts are then put in contact as shown in fig. (C). What is the focal length of combination

(A) zero (B) 5 cm (C) 10 cm (D) 20 cm

Q.30
Focal length of the shown plano-convex lens is 15 cm. Plane surface of the lens is silvered. An object is kept on the principal axis of the lens at a distance 20 cm. Image of the object will form at.

(A) 60 cm, left (B) 60 cm, right (C) 12 cm, left (D) 30 cm, right [C]

Q.31
The relation between \( n_1 \) and \( n_2 \) if the behaviour of light ray is as shown in the fig. is -

(A) \( n_2 > n_1 \) (B) \( n_1 >> n_2 \) (C) \( n_1 > n_2 \) (D) \( n_1 = n_2 \) [A]

Q.32
A diverging lens, focal length \( f_1 = 20 \) cm is separated by 5 cm from a converging mirror, focal length \( f_2 = 10 \) cm. Where should an object be placed from the lens so that a real image is formed at the object itself?

(A) 30 cm (B) 60 cm (C) 10 cm (D) 40 cm [B]

Sol.
For lens \( f = -20 \), \( u = ?, v = -(20 - 5) = -15 \)

\[
\frac{1}{-20} = \frac{1}{-15} - \frac{1}{u}
\]

\[
\frac{1}{u} = \frac{1}{20} - \frac{1}{15}
\]

\( u = -60 \)

Q.33
The diagram shows a concavo-convex lens. What is the condition on the refractive indices so that the lens is diverging.

(A) \( 2\mu_3 \leq \mu_1 + \mu_2 \) (B) \( 2\mu_3 > \mu_1 + \mu_2 \) (C) \( \mu_3 > 2(\mu_1 - \mu_2) \) (D) None of these [B]

Q.34
A convex lens is made up of three different materials as shown in the figure. For a point object placed on its axis, the number of images formed are -

(A) \( n_2 > n_1 \) (B) \( n_1 >> n_2 \) (C) \( n_1 > n_2 \) (D) \( n_1 = n_2 \) [A]
Q.35 Interference fringes were produced in Young’s double slit experiment using light of wavelength 5000 Å. When film of thickness $2.5 \times 10^{-3}$ cm was placed over one slit, the fringe pattern shifts by a distance equal to 20 fringe width. The refractive index of film material is -

(A) 1.25  (B) 1.33  (C) 1.4  (D) 1.5

Sol. [C] \[\frac{D}{d} \left( \mu - 1 \right) t = \frac{20D\lambda}{d} \]

\[\Rightarrow \mu - 1 = \frac{20\lambda}{t} = \frac{20 \times 5000 \times 10^{-10}}{2.5 \times 10^{-5}} \]

\[\therefore \mu - 1 = 0.4 \]

\[\therefore \mu = 1.4 \]

Q.36 In YDSE if a slab whose refractive index can be varied is placed in front of one of the slits. Then the variation of resultant intensity at mid point of screen with $\mu$ will be best represented by ($\mu$ is greater than or equal to 1)

(A) $I_0$  (B) $\frac{I_0}{2}$  (C) $\frac{I_0}{4}$  (D) $\frac{I_0}{8}$

Sol. [C] In an interference experiment, third bright fringe is obtained on the screen with a light of 700 nm. What should be the wavelength of light source in order to obtain 5th bright fringe at the same point

(A) 420 nm  (B) 500 nm  (C) 750 nm  (D) 630 nm

Sol. [A] \[\frac{3\lambda \mu}{d} = \frac{5\lambda \mu}{d} \]

\[\therefore \lambda' = \frac{3\lambda}{5} = \frac{3 \times 700}{5} \text{ nm} = 420 \text{ nm} \]

Q.39 In young’s double slit experiment, a coherent parallel stream of electrons, accelerated by a potential difference $V = 45.5$ volt is used to obtain interference pattern. If slits are separated by a distance $d = 66.3$ μm and distance of screen is $D = 109.2$ cm from plane of slits, calculate distance between two consecutive maxima on the screen:

[mass of electron = $9.1 \times 10^{-31}$ kg
Plank constant $h = 6.63 \times 10^{-34}$ J-s]

(A) 6 μm  (B) 2 μm  (C) 9 μm  (D) 3 μm

Sol. $\frac{1}{2} mv^2 = eV$

\[v = \sqrt{\frac{2eV}{m}} \]

\[\lambda = \frac{h}{mv} = \frac{h}{\sqrt{meV}} \]

\[\beta = \frac{\lambda D}{d} = \frac{hD}{d\sqrt{2meV}} = 3 \times 10^{-6} \text{ m} = 3 \text{ μm} \]
Q.41 Fringe width observed in the Young's double slit experiment is $\beta$. If the frequency of the source is doubled, the fringe width will –

(A) remain $\beta$  
(B) become $\beta/2$  
(C) become $2\beta$  
(D) remain $3\beta/2$  

Sol. Width of fringe = $\beta$

if frequency is doubled then, wavelength becomes halved, because velocity of light in air remain same

$\beta \propto \lambda \implies \frac{\lambda'}{\lambda} = \frac{\lambda/2}{\lambda} = \frac{1}{2} \implies \frac{\beta'}{\beta} = \frac{1}{2}$

Q.42 In Young's experiment, the ratio of maximum and minimum intensities in the fringe system is 9 : 1. The ratio of amplitudes of coherent sources is –

(A) 9 : 1  
(B) 3 : 1  
(C) 2 : 1  
(D) 1 : 1  

Sol. $\frac{I_{\text{max}}}{I_{\text{min}}} = \frac{9}{1} = \frac{(a_1 + a_2)^2}{(a - a_2)^2} \implies \frac{a_1 + a_2}{a - a_2} = \frac{3}{1}$

$\implies \frac{2a_1}{2a_2} = \frac{3+1}{3-1} = \frac{2}{1}$

Q.43 When unpolarised light beam is incident from air onto glass at polarising angle -

(A) Reflected light is polarised 100 percent  
(B) Reflected & refracted beams are partially polarized  
(C) Reflected & refracted beams are completely polarised  
(D) Refracted light is polarised 100 percent  

Sol. [A]

Q.44 If the intensities of the two interfering beams in Young’s double slit experiment be $I_1$ and $I_2$, then the contrast between the maximum and minimum intensity is good when –

(A) $I_1$ is much greater than $I_2$  
(B) $I_1$ is much smaller than $I_2$  
(C) Either $I_1$ or $I_2$ is zero  
(D) $I_1 = I_2$  

Sol. For good visibility condition is

$\text{I}_{\text{min}} = 0 \implies I_1 = I_2$

Q.45 The maximum number of possible interference maxima for slit-separation equal to twice the wavelength in Young’s double-slit experiment is –

(A) three  
(B) five  
(C) infinite  
(D) zero  

Sol. $d = 2\lambda$

Path difference $\Delta = d \sin\theta = 2\lambda \sin\theta$

Maximum path difference $\Delta_{\text{max}} = 2\lambda$

So path difference for maxima $2\lambda, \lambda, 0, \lambda, 2\lambda$