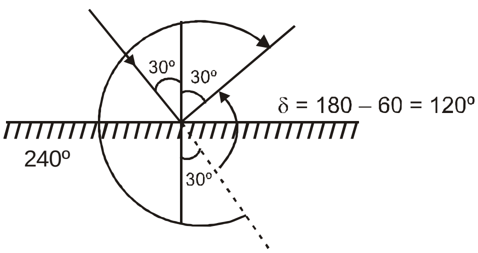
Geometrical Optics

EXERCISES

ELEMENTARY

Q.1 (2)

Q.2 (4)



$\delta = 120°$ Anticlockwise = (360° – 120°) clockwise

Q.3 (2)

Q.4 (3)

Mirror height = man height

$$= \frac{160}{2} = 80$$

Q.5 (3)

$$n = \frac{360°}{\theta} - 1 = \frac{360°}{60} - 1 = \frac{300°}{60}$$

n = 5

Q.6 (B)

Lateral inversion refers to inverted image of object when kept in front of mirror.

Image of HOX appears same as HOX.

Q.7 (3)

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

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

$$v = \frac{f}{2}$$

Q.8 (4)

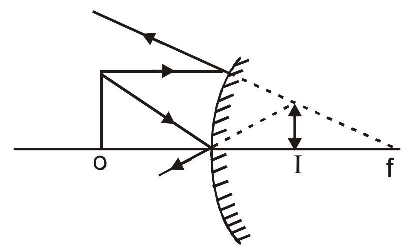
$$\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$$

$$\frac{1}{v} + \frac{1}{-40} = \frac{1}{-20}$$

v = – 40 cm

$$m = \frac{-v}{u} = -\frac{-(-40)}{40} = 1$$

Q.9 (3)



Q.10 (1)

v = 2u

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

u = – 30 cm

Q.11 (A)

By using mirror formula

u = +x; f = –f

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

$$\frac{1}{v} = \frac{1}{v} = \frac{-(x+f)}{xf} = -\text{ve (always)}$$

so if object virtual, image always real.

Q.12 (3)

$\lambda = 420$

$$\lambda_w = \frac{\lambda}{\mu} = \frac{420}{4} \times 3 = 315 \text{ nm}$$

Q.13 (4)

Velocity and wavelength change but frequency remains same.

Q.14 (1)

$$x = \frac{24}{\frac{1}{1} / \frac{4}{3}} = \frac{24}{\left(\frac{3}{4}\right)} = \frac{24 \times 4}{3} = 32 \text{ cm}$$

Q.15 (1)

$$\mu = \frac{h}{h'} \Rightarrow h' = \frac{8}{4/3} = 6\,m$$

Q.16 (4)

For TIR medium at refraction must be rarer.

Q.17 (3)

$$\frac{3}{2}\sin C = \frac{4}{3}\sin 90$$

$$\Rightarrow \quad C = \sin^{-1}\left(\frac{8}{9}\right)$$

Q.18 (3)

$$n \propto \frac{1}{v} \propto \frac{1}{\lambda}$$

Q.19 (4)

We know that $\theta_C = \sin^{-1}\frac{1}{\mu_{glass}}$

and μ_{glass} depends on wavelength of light

$$\mu_{glass} \propto \frac{1}{\lambda}$$

When λ is minimum the μ will be maximum & hence θ_C will be minimum.
λ is minimum for voilet hence θ_C is minimum for voilet light.

Q.20 (3)

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

$$\frac{\sin\left(\frac{60+30}{2}\right)}{\sin(30)} = \frac{1\times 2}{\sqrt{2}} = \sqrt{2}$$

Q.21 (1)

$\mu_{blue} > \mu_{red}$

Q.22 (2)

$$\mu \propto \frac{1}{\lambda}, \lambda_r > \lambda_\upsilon$$

Q.23 (1)

$\sqrt{2}\sin 30° = \sin e$

$e = 45°$

Deviation $= 45° - 30° = 15°$

Q.24 (2)

$$\frac{n_R - n_i}{R} = \frac{n_R}{v} - \frac{n_i}{u}$$

$$\frac{2-1}{10} = \frac{2}{v} - \frac{1}{-20} \quad \Rightarrow \quad v = 40 \text{ cm}$$

Q.25 (1)

$$\frac{1}{V} - \frac{3}{2\times 30} = \frac{1-\frac{3}{2}}{+20} \qquad \frac{1}{V} = -\frac{1}{40} + \frac{1}{20} = +\frac{1}{40}$$

V = 40 cm.

Q.26 (3)

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

$$\frac{1}{v} - \left(\frac{1}{-5}\right) = \frac{1}{10}$$

v = 10 cm
|m| = 2 (magnified)

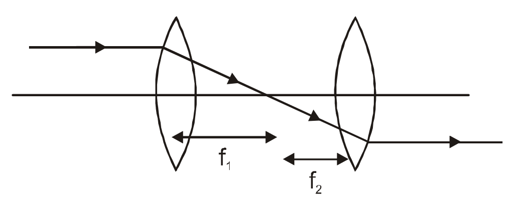
$$\frac{1}{v} - \left(\frac{1}{-5}\right) = \frac{1}{10}$$

v = 10 cm
|m| = 2 (magnified)

Q.27 (3)

Lens changes its behaviour if R.I. of surrounding becomes greater than R.I. of lens.
$\mu_{lens} < 1.33$

Q.28 (3)



Distance between lens is $= f_1 + f_2$

Q.29 (4)

Q.30 (2)

$$\frac{1}{f_{air}} = \left(\mu_{g-1}\right)\left(\frac{1}{R_1 - R_2}\right)$$

$$\frac{1}{f_{water}} = \left(\frac{\mu_g}{\mu_w} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

$$\frac{f_{water}}{f_{air}} = \frac{\left(\frac{3}{2} - 1\right)}{\left(\frac{3/2}{4/3} - 1\right)}$$

$f_{water} = 4\, f_{air}$

$P = \frac{1}{f}$ Power decrase

Q.31 (1)

$P = P_1 + P_2$

$= + 4 + (- 3)$

$= + 1$

Q.32 (3)

$P_L = P_1 + P_2$

$P_L = \frac{1}{f_L}$

Q.33 (1)

$\omega = \left(\frac{\mu_v - \mu_r}{\mu_y - 1}\right)$

Q.34 (1)

$\omega = \left(\frac{1.62 - 1.42}{1.5 - 1}\right)$

$= \frac{0.2}{0.5} = \frac{4}{10} = 0.4$

Q.35 (2)

$\omega = \frac{n_v - n_r}{\left(\frac{n_v + n_r}{2}\right) - 1} = \frac{6}{25}.$

Q.36 (3)

$\delta \propto (\mu - 1) \Rightarrow \mu_R$ is least so δ_R is least.

Q.37 (2)

Angular dispersion does not depends upon dispersive power

Q.38 (4)

$MP = \left(1 + \frac{D}{f}\right) = \left(1 + \frac{25}{5}\right) = 6$

Q.39 (2)

For normal adjustment

$m = -\frac{f_0}{f_e}$

When final image is at least distance of distinct vision from eyepiece,

$m' = -\frac{f_0}{f_e}\left(1 + \frac{f_e}{d}\right) = 10\left(1 + \frac{5}{25}\right) = 12$

Q.40 (2)

For a compound microscope $m \propto \frac{1}{f_o f_e}$

Q.41 (3)

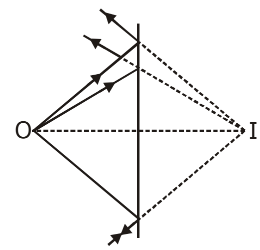
Magnifying power of a microscope $m \propto \frac{1}{f}$

Since $f_{violet} < f_{red}$; $\therefore$ $m_{violet} > m_{red}$

JEE-MAIN
OBJECTIVE QUESTIONS

Q.1 (2)

All the reflected rays meet at a point, when produced backwards.



Q.2 (1)

There is a phase change of 180º in reflection.

Q.3 (1)

By the laws of reflection angle of incidence = angle of reflection $\angle i = \angle r$

Q.4 (2)

An image is called a real image if the rays after reflection or refraction actually meet hence converging rays from real image.

When rays actually meet real image is formed

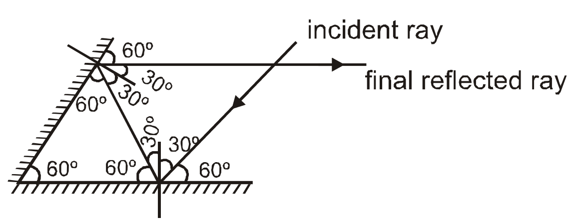
Q.5 (4)

Irrespective of the type of mirror.

Q.6 (4)

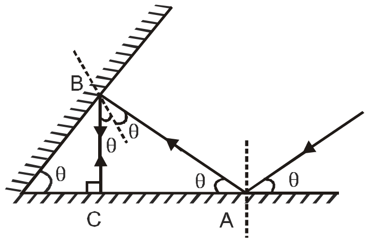
Minimum distance between object and image is zero when image concides with the object i.e., object is placed at 2F.

Q.7 (2)



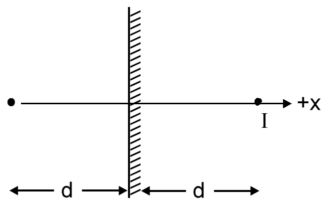
final ray is II to first mirror.

Q.8 (2)

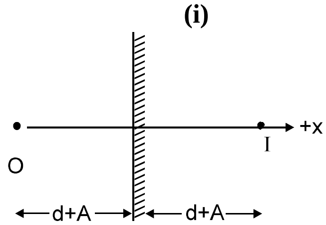


In ΔABC $90^\circ + 3\theta = 180^\circ \Rightarrow \theta = 30^\circ$

Q.9 (3)



(i)



(ii)

From figure (i) and (ii) it is clear that if the mirror moves distance 'A' then the image moves a distance '2A'.

Therefore Amplitude of SHM of image = 2A

Q.10 (3)

If time in the clock is T_1 & time in image clock is T_2 then.

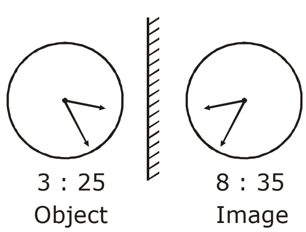
$T_1 + T_2 = 12 : 00 : 00$

$4 : 25 : 37 + T_2 = 12 : 00 : 00$

$T_2 = 07 : 34 : 37$

Q.11 (A)

A plane mirror forms inverted image of object line perpendicular to it.



Q.12 (D)

Deviation produced by plane mirror is given by

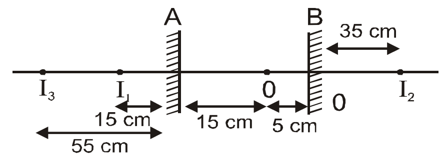
$\delta = 180 - 2i$

here $i = 90 - 60 = 30^\circ$

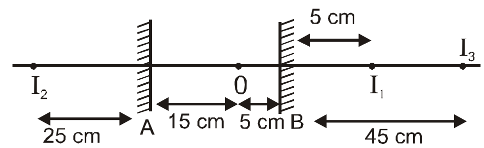
$\delta = 180 - 60 = 120^\circ$

Q.13 (3)

Taking first reflection by A.

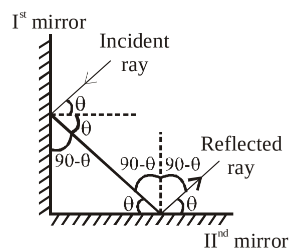


Taking first reflection by B



Q.14 (B)

From the following figure we can see that incident & reflected ray are parallel to one another.



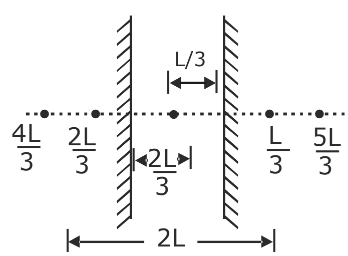
Q.15 (2)

Perpendicular distance between object & mirror is equal to perpendicular distance between image & mirror.

Initially the separation between object and image is 200 cm. After 6s the mirror has moved 30 cm towards the object. Hence object-mirror separation is 70 cm. So object image separation is 140 cm.

Q.16 (A)

By image formations



Q.17 (3)

All the images formed by two plane.

Mirror inclined to each other form images which lie on a circle.

Q.18 (C)

First reflection = 3
Second reflection = 3
Third reflection = 1
Total = 7

Q.19 (A)

By the formula for the number of image formed

$\frac{360}{\theta} - 1$ where θ is angle between the mirror.

No. of images = $\frac{360}{\theta} - 1 = 5$

Q.20 (B)

Only concave mirror forms larger image of an object.

Q.21 (4)

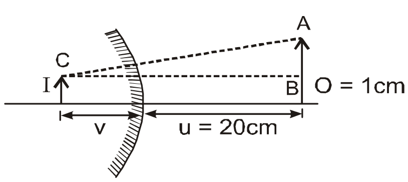
Given $\frac{-v}{u} = \pm 2 \Rightarrow v = \pm 2$

from $\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$

$\pm\frac{1}{2u} + \frac{1}{u} = \frac{1}{-f}$

after solving u = –30, –10 cm

Q.22 (A)



$\frac{1}{v} = \frac{1}{f} - \frac{1}{u} = \frac{1}{10} - \frac{1}{(-20)} = +\frac{3}{20}$; $v = +\frac{20}{3}$ cm

$I = -\frac{v}{u} \times O = -\frac{\frac{20}{3}}{(-20)} \times 1 = \frac{1}{3}$

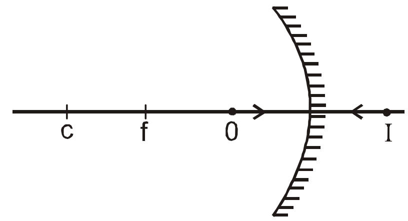
∴ The distance between tip of the object and image is = AC = $\sqrt{(BC)^2 + (AB)^2}$

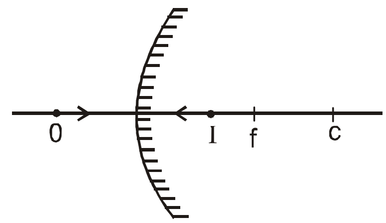
$S = \sqrt{\left(20 + \frac{20}{3}\right)^2 + \left(1 - \frac{1}{3}\right)^2} = \sqrt{\frac{6404}{9}}$ cm

Q.23 (3)

Only a portion of incident light is reflected by mirror and rest is transmitted in mid water. So intensity of reflected light is less than intensity of incident light & hence image formed is less bright.

Q.24 **(3)**





only in above two cases image moves towards mirror.

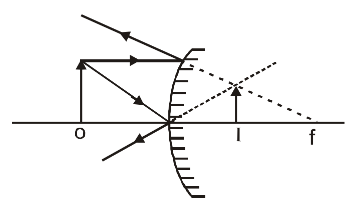
Q.25 (3)

Paraxial rays are considered because they form nearly a point image of a point source.

Q.26 (1)

It is created at focus ie + 20 cm, when object is at infinity

Q.27 (3)



Q.28 (3)

$\frac{I}{O} = -\frac{v}{u}$

If O and I are on same sides of PA . $\frac{I}{O}$ will be positive which implies v and u will be of opposite signs.

Similarly if O and I are on opp. sides, $\frac{I}{O}$ will be -ve which implies v and u will have same sign.

If O is on PA, I = $\left(-\frac{V}{u}\right)$ (O) = 0

⇒ I will also be on. P.A.

Q.29 (2)

$\frac{1}{-f} = \frac{1}{-v} + \frac{1}{-u} \quad \Rightarrow \quad \frac{1}{v} = \frac{-1}{u} + \frac{1}{f}$

Slope = – 1 intercept = $\frac{1}{f}$ (positive)

Q.30 (A)

For real inverted image formed by concave mirror.

v = – ve, u = – ve f = – ve

$\Rightarrow \frac{u}{f}$ & $\frac{v}{f}$ are positive

$\Rightarrow$ A is right answer.

2nd Method,

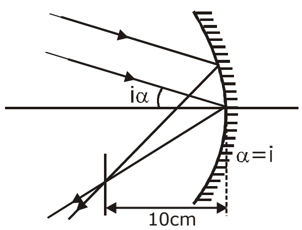
$$\frac{1}{v}+\frac{1}{u}=\frac{1}{f}$$

$$\Rightarrow \frac{1}{v/f}+\frac{1}{u/f} = 1 \Rightarrow \frac{1}{y}+\frac{1}{x} = 1$$

$\Rightarrow$ xy = x + y

$\Rightarrow$ xy – x – y + 1 = 1 $\Rightarrow$ (x – 1) (y – 1) = 1 Hence (A)

Q.31 (4)



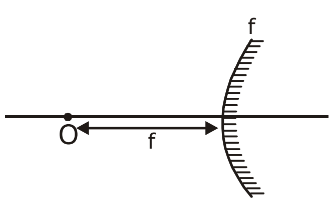
So diameter of the image = fα

$$= 10 \times \left(1 \times \frac{\pi}{180}\right) = \frac{\pi}{18}$$

Q.32 (2)

Using mirror formula

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



Here u = –f, f = +f

$$\frac{1}{v}+\frac{1}{(-f)}=\frac{1}{f}$$

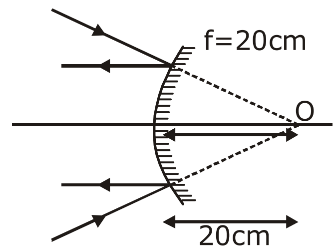
$$\Rightarrow v = \frac{f}{2}$$

Q.33 (1)

Using mirror formula

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

Here we have a virtual object so sign of u is positive.



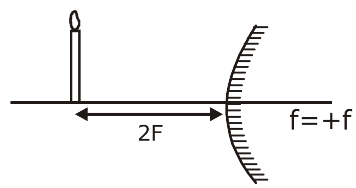
Here f = +20

u = 20

$$\frac{1}{v}+\frac{1}{20}=\frac{1}{20} \Rightarrow \frac{1}{v} = 0$$

v = ∞

Q.34 (2)



Taking u = – 2f & f = +f

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

$$\frac{1}{v}+\frac{1}{-2f}=\frac{1}{f}$$

$$\Rightarrow \frac{1}{v} = \frac{1}{f} + \frac{1}{2f} = \frac{2+1}{2f}$$

$$m = -\frac{v}{u} = \frac{-2f/3}{-2f} = \frac{1}{3}$$

Q.35 (2)

Magnification is –3 because image is real & inverted.

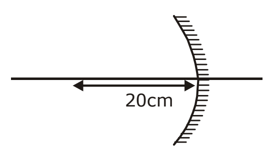
$$m = \frac{-v}{u}$$

$$-3 = \frac{-v}{u}$$

v = 3u.

given u = –20 cm

v = –60 cm



By using mirror formula

$$\frac{1}{60} - \frac{1}{20} = \frac{1}{f}$$

f = –15 cm

Q.36 (4)
Here u = –30 cm, f = –15 cm
object is at centre of curvature
⇒ image will be real and of same size.

Q.37 (2)

Using mirror formula $\frac{h_i}{h_0} = \frac{-v}{u}$

Given $\frac{h_i}{h_0} = \frac{1}{2} = -\frac{v}{u}$

hence $v = -\frac{u}{2}$

given
u = –40 ⇒ v = 20
Using mirror formula

$$-\frac{1}{40} + \frac{1}{20} = \frac{1}{f}$$

$$\frac{1}{f} = \frac{1}{40}$$

f = 40
convex mirror with focal length = 40 cm

Q.38 (2)
Given

$m = +2 = -\frac{v}{u}$

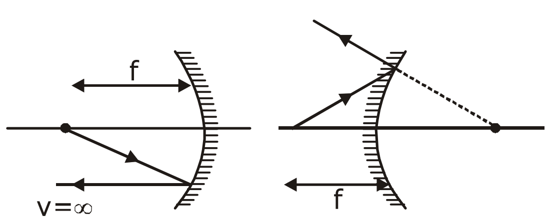
v = –2u
Using mirror formula

$$\frac{-1}{2u} + \frac{1}{u} = \frac{1}{10}$$

$\frac{1}{2u} = \frac{1}{10}$ u = 5 cm Ans.

Q.39 (1)
Incorrect statement
A concave mirror forms only virtual image for any position of real object.

Q.40 (B)



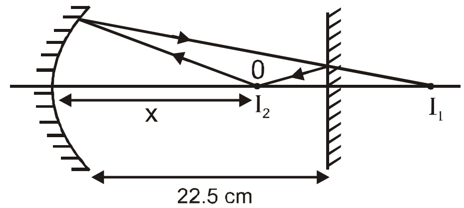
In convex mirror Image is not at infinity (∞)

Q.41 (B)
Using mirror formula
From the data given we get
v = +10, u = –50

$$\frac{1}{10} - \frac{1}{50} = \frac{1}{f} \Rightarrow f = \frac{50}{4}$$

$$R = \frac{50}{2} = 25\text{cm}$$

Q.42 (B)



I_1 is the image formed by concave mirror.
For reflection by concave mirror
u = – x, v = – (45 – x), f = – 10 cm,

$$\frac{1}{-10} = \frac{1}{-(45-x)} + \frac{1}{-x}$$

$\frac{1}{10} = \frac{x+45-x}{x(45-x)} \Rightarrow x^2 - 45x + 450 = 0 \Rightarrow x = 15$ cm, 30 cm
but x = 30 cm is not acceptable because x < 22.5 cm.

Q.43 (D)
Given

$$m = \frac{h_i}{h_0} = \frac{h}{nh} = \frac{1}{n} = -\frac{v}{u}$$

$$v = -\frac{u}{n}$$

Using mirror formula

$$-\frac{n}{u} + \frac{1}{u} = \frac{1}{f} = -\left(\frac{n-1}{u}\right) = \frac{1}{f}$$

u = –f(n – 1)
| u | = f(n – 1)

Q.44 (2)

$$\mu = \frac{\lambda_V}{\lambda_m} = \frac{6000}{4000} = 1.5$$

Q.45 (3)
i = 2r
1 sin i = n sin r
⇒ 2 sin i/2 cos i/2 = n sin i/2
⇒ cos i/2 = (n/2)
⇒ $i = 2\cos^{-1}(n/2)$

Q.46 (A)

$$\text{Displacement} = \frac{t\sin(i-r)}{\cos r}$$

and 1sin i = n × sinr
Since i and r are small angles. and i = nr
Displacement = t (i – r)

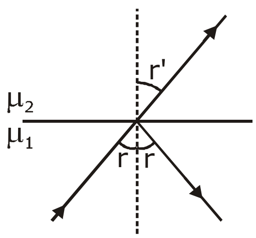
$$\therefore \text{ Displacement} = t\, i\left(1-\frac{r}{i}\right)$$

$$= t\,\theta\left(1-\frac{1}{n}\right) = \frac{t\theta\,(n-1)}{n}$$

Q.47 (1)

$r + r' = 90^o \Rightarrow r' = (90 - r)$

$\mu_1 \sin r = \mu_2 \cos r$



$$\tan r = \frac{\mu_2}{\mu_1}$$

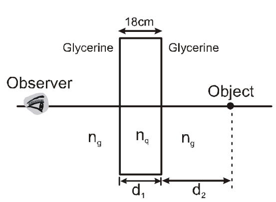
$$\text{Critical angle} = \sin^{-1}\frac{\mu_2}{\mu_1} = \sin^{-1}(\tan r)$$

Q.48 (1)

Q.49 (1)

$$n_{quartz} = 2\ ;\ n_{glycerine} = \frac{4}{3}$$

$$\Rightarrow \frac{n_{quartz}}{n_{glycerine}} = \frac{2}{4/3} = \frac{3}{2} = \mu_{rel}$$



$$\text{shift} = t\left(1-\frac{1}{\mu_{rel}}\right) = 18\left(1-\frac{1}{3/2}\right) = 6\text{ cm}$$

Q.50 (3)

From the formula

$$\frac{\text{Appartent depth}}{\text{Real depth}} = \frac{n_{air}}{n_{glass}}$$

$$\text{Apparent depth} = \text{Real depth} \times \frac{n_{air}}{n_{glass}}$$

The letter which appear least raised has maximum Apparent depth and hence it has minimum μ for glass.

$$\mu \propto \frac{1}{\lambda}$$

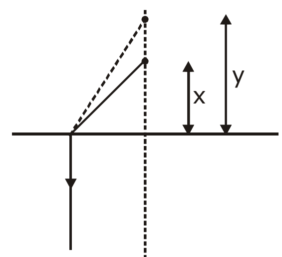
for μ to be minimum λ should be maximum which is for Red.

Q.51 (1)

$$\frac{d'}{d} = \frac{x}{18} = \mu$$

$$x = 18 \times \frac{4}{3} = 24\text{m}$$

Q.52 (1)



$$\frac{y}{x} = \frac{4}{3}$$

$$\Rightarrow \frac{dy}{dt} = \frac{4}{3}\frac{dx}{dt} = 8\text{ m/sec}$$

Q.53 (A)

Sun has elliptical shape when it ireses and sets due to the phenomenon of atmospheric refraction.

Q.54 (C)

Real depth = d = 1m
Virtual depth = d' = 0.9m

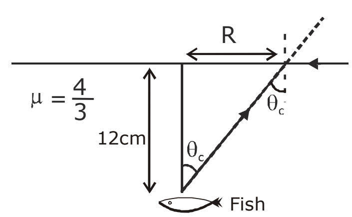
$$\frac{d'}{d} = \frac{1}{\mu}$$

$$\mu = \frac{1}{0.9} = \frac{10}{9}$$

Q.55 (1)

$$\sin\theta = \frac{1}{\mu} = \frac{C_A}{C_B} \Rightarrow C_B = \frac{V}{\sin\theta}$$

Q.56 (4)



$\tan \theta_C = \frac{R}{12}$ ...... (1)

A ray of light intering at 90º from rarer medium makes an angle of refraction equal to critical angle in the denser medium and critical angle is given by

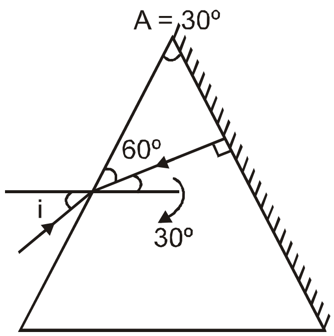
$\theta_C = \sin^{-1} \frac{3}{4}$

$\theta_C = \tan^{-1}\frac{3}{\sqrt{7}}$ ...... (2)

Equation (1) & (2)

$\frac{3}{\sqrt{7}} = \frac{R}{12} \Rightarrow R = \frac{12 \times 3}{\sqrt{7}}$

Q.57 (3)



$\frac{\sin i}{\sin 30^o} = \sqrt{2} \Rightarrow \sin i = \sqrt{2} \times \frac{1}{2} = \frac{1}{\sqrt{2}} \Rightarrow i = 45^o$.

Q.58 (3)

We know that formula for deviation

$\delta = i + e - A$ & $r_1 + r_2 = A$

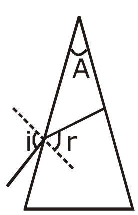
$i = i$ $r_2 = 0$ $r_1 + 0 = A$

$e = 0$ $r_1 = A$

$A = A$

$1 \sin i = \mu \sin A$

Because angles



are small $i = \mu A$

Q.59 (C)

$\delta = A\left(\frac{n_p}{n_s} - 1\right) \Rightarrow \delta \propto A$ and $\delta \propto \left(\frac{n_p}{n_s} - 1\right)$

Q.60 (B)

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

$v = -R$ for all values of μ.

Q.61 (B)

For minimum deviation $i_{min} = e$

and $r_1 = \frac{A}{2} = r_2 = r$

$\delta = i + e - A = 2(i_{min} - r) = 38^o$ ... (1)

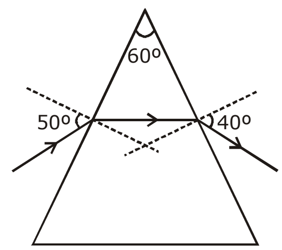
Now

$44^o = 42^o + 62 - 2r \Rightarrow r = 30^o$ ... (2)

From (1) and (2)

$i_{min} = 49^o$

Q.62 (2)

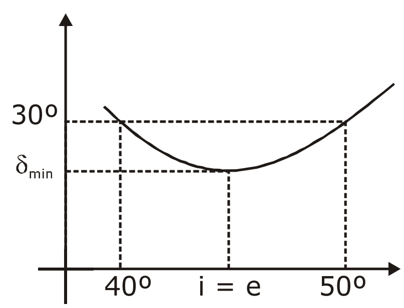


From the formula

$\delta = i + e - A$

$\delta = 50 + 40 - 60 = 30^o$

$\delta_{min} < 30^o$.



Q.63 (C)

$\delta_{min} = i + e - A$

$\delta_{min} = A$

So $2A = 2i$

$i = A$

Now for refraction on first surface.

$\sin i = \mu \sin r_1$

$\sin A = \mu \sin A/2$

[For minimum deviation $r_1 = r_2 = A/2$]

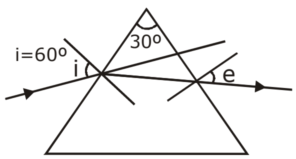
$2\cos\frac{A}{2} \sin\frac{A}{2} = \sqrt{3} \sin\frac{A}{2}$

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

$\frac{A}{2} = 30 \Rightarrow A = 60^o$

Q.64 (4)
Given angle of incidence I_1
Given angle of emergence I_2
Condition for minimum devidation
$i = e \quad \Rightarrow \therefore \; I_1 = I_2$

Q.65 (1)

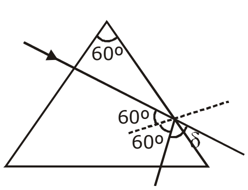


$\delta = 30° = i + e - A$
$60 + e - 30 = 30$
$e = 0$

Q.66 (1)
For minimum deviation
$r_1 = r_2 = r \Rightarrow 2r = A$
$r = \dfrac{A}{2} = 30°$
Now from Snell's law
$1 \sin i = \sqrt{2} \sin 30°$
$i = 45°$

Q.67 (C)
$\mu \sin \theta_C = 1$
$\theta_C = \sin^{-1}\left(\dfrac{1}{\mu}\right)$
$\mu = \left(\dfrac{1}{\sin \theta_C}\right)$
$\theta_C < \theta$
$\sin \theta_C < \sin \theta$
$\dfrac{1}{\mu} < \dfrac{1}{\sqrt{2}}$
$\mu > \sqrt{2}$.

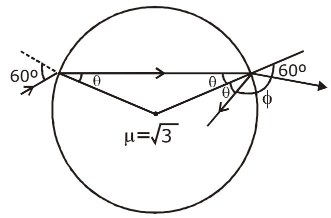
Q.68 (C)
Normal incidence
$i = 0, r_1 = 0, r_2 = A = 60°$
$\sin C = \dfrac{1}{\mu} = \dfrac{2}{3}$



C = 42

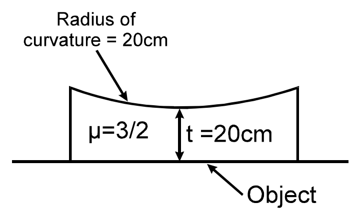
The incident angle is greater than critical angle so ray will suffer TIR.
$\delta = \pi - 2\theta$ (in case of reflection)
$\delta = 180 - 120 = 60°$

Q.69 (2)
Applying Snell's law on surface of incidence $\theta = \sin^{-1}\left(\dfrac{\sin 60}{\sqrt{3}}\right)$



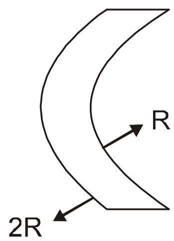
$\phi = 180 - [60 + \theta]$
$\phi = 180 - \left[60° + \sin^{-1}\left(\dfrac{\sin 60°}{\sqrt{3}}\right)\right]$
$= 180° - [60 + 30] = 90°$

Q.70 (1)



Considering refraction at the curved surface,
$u = -20$; $\mu_2 = 1$
$\mu_1 = 3/2$; $R = +20$
applying $\dfrac{\mu_2}{v} - \dfrac{\mu_1}{u} = \dfrac{\mu_2 - \mu_1}{R}$
$\Rightarrow \dfrac{1}{v} - \dfrac{3/2}{-20} = \dfrac{1 - 3/2}{20} \Rightarrow v = -10$
i.e. 10 cm below the curved surface or 10 cm above the actual position of flower.

Q.71 (1)
$\dfrac{1}{f} = (\mu - 1)\left(\dfrac{1}{R_1} - \dfrac{1}{R_2}\right)$
$\Rightarrow \dfrac{1}{-24} = (1.5 - 1)\left(\dfrac{1}{2R} - \dfrac{1}{R}\right)$
$\Rightarrow \dfrac{1}{-24} = \dfrac{1}{2}\left(-\dfrac{1}{2R}\right)$
$R = 6$ cm $\Rightarrow 2R = 12$ cm



Q.72 (1)

Given $R_A = 0.9\ R_B$

$$\frac{1}{f_A} = \frac{1}{f_B}$$

$$(1.63 - 1)\ \frac{2}{R_A} = (x_B - 1)\ \frac{2}{R_B}$$

$x_B = 1.7$

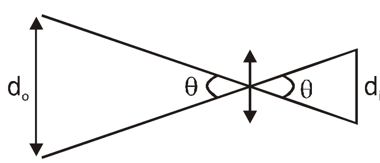
Q.73 (3)

Lens changes its behaviour if R.I. of surrounding becomes greater than R.I. of lens.

$\mu_{lens} < 1.33$

Q.74 (4)

Image of sun is formed in the focal plane. So,



Diameter of image =

$$f\theta = \frac{100 \times 0.5^o}{180^o} \times \pi \times 10 \text{ mm} = 9.$$

Q.75 (D)

For vertical erect image by diverging lens.

u, v and f are negative

$\therefore\ \frac{u}{f} = +\text{ve}$ and $\frac{v}{f} = +\text{ ve}$

$$\frac{1}{f} = \frac{1}{v} - \frac{1}{u}1 = \frac{f}{v} - \frac{f}{u}\frac{1}{y} = \frac{1}{x} + 1$$

$y = \frac{x}{x+1}$ since x & y are +ve graph lies in first quadrant.

Also, at x = 0, y = 0 and at x = ∞ ,, y = 1

Q.76 (A)

Using the given formula

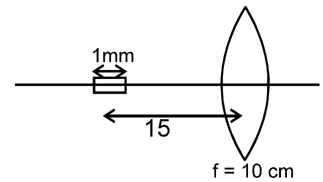
$\delta = (n - 1)A$

and $r_1 + r_2 = A$

and for δ_{min} $r_1 = r_2 = r = A/2$

Hence $\delta_{min} = r$.

Q.77 (2)



$$\frac{1}{10} = \frac{1}{v} - \frac{1}{(-15)} \quad \Rightarrow \quad v = +30 \text{ cm}$$

for small object $|dv| = \frac{v^2}{u^2}\ |du|$

$$= \left(\frac{30}{15}\right)^2 \times 1 = 4 \text{ mm}$$

Q.78 (1)

$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f} \qquad ...(1)$$

$$m = \frac{v}{u} \qquad ...(2)$$

from (1) and (2) $m = \frac{f}{f+u}$

here $m = -\frac{18}{2} = -9$ {only real images can be formed on the screen, which is inverted}

$$\therefore\ -9 = \frac{f}{f+(-10)}$$

$\therefore\ -9f + 90 = f$

$10f = 90$

$f = 9$ cm

Q.79 (4)

We know that P = IA & P × t = E

Hence $IA = \frac{E}{t}$

Initially energy/sec $= I \times \pi \left(\frac{d}{2}\right)^2 = \frac{\pi d^2 I}{4}$

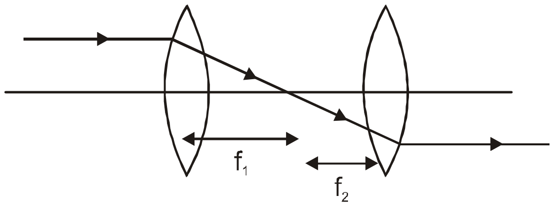
Now energy/sec $= I\left[\pi\left(\frac{d}{2}\right)^2 - \pi\left(\frac{d}{4}\right)^2\right]$

$$= I\pi d^2 \left[\frac{3}{16}\right]$$

So, Now $\frac{\text{Final Intensity}}{\text{Initial Intensity}} = \frac{I\pi d^2\ 3/16}{I\pi d^2/4} = \frac{3}{4}$

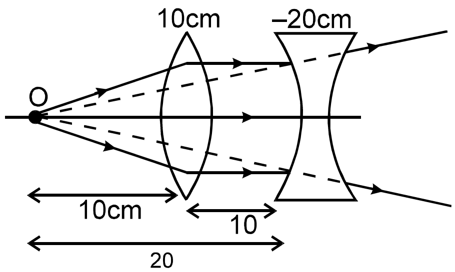
Focus will not change.

Q.80 (C)



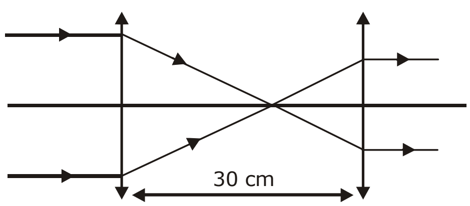
Distance between lens is $f_1 + f_2$

Q.81 (1)



Q.82 (2)

The rays coming from infinity parallel to principal axis and paraxial meet on focus after refraction and the rays originating from focus of the lens originate parallel to principal axis afer refraction.



Q.83 (4)

$f_A = f_B = f_C = f_{net} \quad \Rightarrow P_A = P_B = P_C = P_{net} \quad = P$

Q.84 (1)

Using the formula $P = \dfrac{1}{f(\text{in m})}$

$p_1 = 2D$

$f_1 = \dfrac{100}{2} = +50$ cm

$f_2 = -10$

$f_2 = -100$ cm

$$\frac{1}{f_{eq}} = \left[\frac{1}{f_1} - \frac{1}{f_2}\right]$$

$$= \left[\frac{1}{50} - \frac{1}{100}\right] = \left[\frac{2-1}{100}\right] = \frac{1}{100}$$

$f_{eq} = 100$ cm

Q.85 (1)

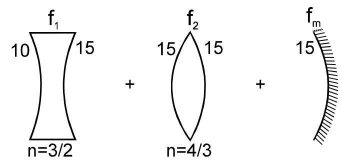
We know that on cutting the lens into two parts perpendicular to its principal axis power of the two parts will be P/2 each. Let initial power of lens be P.

Then $(P_1)_f = (P_2)_f = P/2$

$P_f = (P_1)_f = (P_2)_f = P \quad \therefore \quad P_i = P_f$

No change in power hence no change in focal length.

Q.86 (4)



$$\frac{1}{f_1} = \left(\frac{3}{2} - 1\right)\left(\frac{-1}{10} - \frac{1}{15}\right) = -\frac{1}{12} \; ; \quad \frac{1}{f_2} = \left(\frac{4}{3} - 1\right)$$

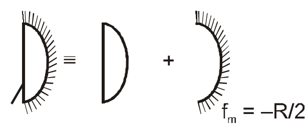
$$\left(\frac{2}{15}\right) = \left(\frac{2}{45}\right); \quad \frac{1}{f_m} = -\frac{2}{15}$$

$$\Rightarrow \quad \frac{1}{f_\ell} = \frac{1}{f_1} + \frac{1}{f_2} \quad \frac{1}{f_{eq}} = \frac{1}{f_m} - \frac{2}{f_\ell} = -\frac{1}{18}$$

$\Rightarrow f_{eq} = -18$ cm

So, the combination behaves as a concave mirror

Q.87 (2)



$$\frac{1}{-10} = \frac{2}{-R} - \frac{2}{f_\ell}$$

$$\frac{2}{R} = \frac{1}{10} - \frac{2}{56} = \frac{56-20}{560} = \frac{36}{560}$$

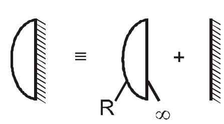
$$\frac{1}{R} = \frac{18}{560}$$

$$(\mu - 1)\frac{18}{560} = \frac{1}{56}$$

$$\mu - 1 = \frac{10}{18}$$

$$\mu = 1 + \frac{10}{18} = \frac{28}{18} = \frac{14}{9}.$$

Q.88 (A)

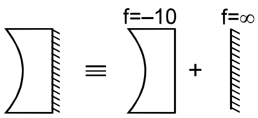


$$\frac{1}{f} = \frac{1}{\infty} - \frac{2}{f_\ell} = -\frac{2}{f_\ell} = \frac{1}{-28}$$

$$f_\ell = 56 \text{ cm} \Rightarrow (\mu - 1)\left(\frac{1}{R}\right) = \frac{1}{56} \text{ ......(i)}$$

$$\left(\frac{14}{9} - 1\right)\frac{1}{R} = \frac{1}{56} = \frac{280}{9} \text{ cm}$$

Q.89 (3)



$$\frac{1}{F} = \frac{1}{f_m} - \frac{2}{f_L} = 0 - \frac{2}{-10} \Rightarrow F = 5$$

Q.90 (4)

$$\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2} - \frac{d}{f_1 f_2} = 0$$

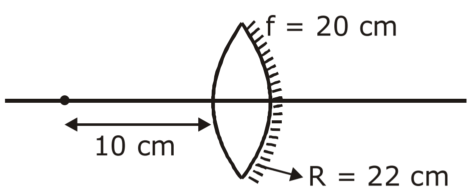
$$= \frac{1}{25} + \frac{1}{-20} - \frac{d}{-500} = 0$$

$$= \frac{20 - 25}{500} = -\frac{d}{500}$$

d = 5 cm.

Q.91 (B)

The focal length of mirror formed will be $f_m = R/2$



$f_m = -11$cm

[–ve sign as concave mirror is formed]

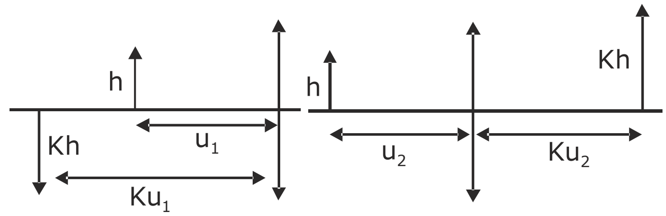
$f_\ell = 20$cm

$$\frac{1}{f_{eq}} = \frac{1}{f_m} - 2\left[\frac{1}{f_\ell}\right]$$

$$= \frac{-1}{11} - \frac{-2}{20} = \frac{-10 - 11}{110}$$

$$f_{eq} = \frac{-110}{21}$$

Q.92 (B)



For case 1

$u = -u_1 \Rightarrow v = -ku_1 \quad \Rightarrow \quad f = -f$

$$\frac{1}{ku_1} + \frac{1}{u_1} = \frac{1}{f} \quad \text{......... (1)}$$

For case 2

$u = -u_2 \Rightarrow v = ku_2 \quad \Rightarrow f = -f$

$$-\frac{1}{ku_2} + \frac{1}{u_2} = \frac{1}{f} \quad \text{......... (2)}$$

On solving (1) & (2)

$$f = \frac{1}{2}(u_1 + u_2)$$

Q.93 (C)

From the formula

$$h_0 = \sqrt{h_1 \times h_2} = \sqrt{8 \times 12.5} = 10 \text{ cm}$$

Q.94 (D)

All are true.

Q.95 (A)

Answer is A because A net angle of dispersion by each surface slope is equal to zero.

Q.96 (D)

ω is property of material.

Q.97 (D)

Dispersion will not occur for a monochromatic light.

Q.98 (2)

$$\omega = \frac{n_v - n_r}{\left(\frac{n_v + n_r}{2}\right) - 1} = \frac{6}{25}.$$

Q.99 (1)

1.6333 - 1 = 1.6161 = 0.0172

n_y-1

$$\frac{1.6333 - 1.6161}{1.6247 - 1} = 0.276$$

Q.100 (2)

Angular dispersion does not depends upon dispersive power

Q.101 (2)

Ray of Red light bends minimum because it has maximum λ & minimum μ.

Q.102 (A)

$$\frac{\omega_1}{f_1}+\frac{\omega_2}{f_2}=0$$

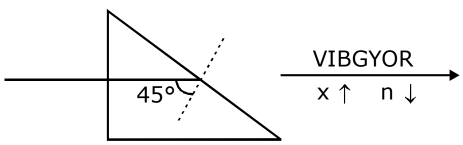
$$\frac{1}{f_1}=\frac{-\omega_2}{\omega_1}\times\frac{1}{f_2}\quad\left(\because \frac{\omega_1}{\omega_2}=\frac{2}{1}\right)$$

$$\frac{1}{f_1}=\frac{-2}{f_2}$$

$$\Rightarrow \frac{1}{f_1}+\frac{1}{f_2}=\frac{1}{10}\ \Rightarrow \frac{-2}{f_2}+\frac{1}{f_2}=\frac{1}{10}$$

$\Rightarrow f_2 = -10\text{cm}$ $\Rightarrow f_1 = 5\text{cm}$

Q.103 (A)



$\sin C = \frac{1}{\mu}$

for red $C > 45^o$

Q.104 (B)

$$\frac{1}{f_1}+\frac{1}{f_2}=+ve$$

$$\frac{\omega_1}{f_1}+\frac{\omega_2}{f_2}=0 \Rightarrow \frac{\omega_1}{f_1}=\frac{-\omega_2}{f_2}$$

$\omega_2 < \omega_1 \Rightarrow |f_2| < |f_1|$

Q.105 (2)

By constitution of simple microscope we can observe it

Q.106 (4)

$$MP=\left(1+\frac{D}{f}\right)=\left(1+\frac{25}{5}\right)=6$$

Q.107 (3)

Q.108 (3)

Q.109 (3)

In normal adjustment

$$m=-\frac{f_0}{f_e}$$

so $50=-\frac{100}{f_e} \Rightarrow f_e = -2$ cm

($\because$ eyepiece is concave lens)

and $L = f_0 + f_e = 100 - 2 = 98$ cm

Q.110 (2)

γ = magnifying power

$$\gamma = 1+\frac{D}{F}$$

$$= 1+\frac{25}{f}$$

Q.111 (4)

Q.112 (1)

$$m = 1+\frac{D}{f}$$

Q.113 (4)

Q.114 (2)

For normal adjustment

$$m=-\frac{f_0}{f_e}$$

When final image is at least distance of distinct vision from eyepiece,

$$m'=-\frac{f_0}{f_e}\left(1+\frac{f_e}{d}\right)=10\left(1+\frac{5}{25}\right)=12$$

Q.115 (2)

$$m=\frac{-f_0}{f_e}$$

$m = 10 \times 20 = 200$ cm

Q.116 (4)

$f=\frac{1}{p}=\frac{1}{2}$ metre

$f = 0.5$ m this is positive so lense is convex lense.

Q.117 (C)

By using $m_\infty = \frac{(L_\infty - f_0 - f_e).D}{f_0 f_e}$

$\Rightarrow 45 = \frac{(L_\infty - 1 - 5)\times 25}{1\times 5}$ $\Rightarrow L_\infty = 15$ cm

Q.118 (2)

For a compound microscope $m \propto \frac{1}{f_o f_e}$

Q.119 (2)

In microscope final image formed is enlarged which in turn increases the visual angle.

Q.120 (4)

Magnification of a compound microscope is given by

$$m = \frac{v_0}{u_0} \times \frac{D}{u_e} \Rightarrow |m| = m_0 \times m_e$$

Q.121 (3)

Magnifying power of a microscope $m \propto \frac{1}{f}$

Since $f_{violet} < f_{red}$; $\therefore m_{violet} > m_{red}$

Q.122 (1)

$L_\infty = v_0 + f_e \Rightarrow 14 = v_0 + 5 \Rightarrow v_0 = 9$ cm

Magnifying power of microscope for relaxed eye

$$m = \frac{v_0}{u_0} \cdot \frac{D}{f_e} \text{ or } 25 = \frac{9}{u_0} \cdot \frac{25}{5} \text{ or } u_0 = \frac{9}{5} = 1.8 \text{ cm}$$

Q.123 (2)

$$m_\infty = \frac{v_0}{u_0} \times \frac{D}{f_e}$$

From $\frac{1}{f_0} = \frac{1}{v_0} - \frac{1}{u_0}$

$$\Rightarrow \frac{1}{(+1.2)} = \frac{1}{v_0} - \frac{1}{(-1.25)} \Rightarrow v_0 = 30 \text{ cm}$$

$$\therefore |m_\infty| = \frac{30}{1.25} \times \frac{25}{3} = 200$$

$$\therefore |m_\infty| = \frac{30}{1.25} \times \frac{25}{3} = 200$$

Q.124 (1)

When the final image is at the least distance of distinct vision, then

$$m = -\frac{f_0}{f_e}\left(1 + \frac{f_e}{D}\right) = \frac{200}{5}\left(1 + \frac{5}{25}\right) = \frac{200 \times 6}{5 \times 5} = -48$$

When the final image is at infinity, then

$$m = -\frac{f_0}{f_e} = \frac{200}{5} = -40$$

Q.125 (1)

In terrestrial telescope erecting lens absorbs a part of light, so less constant image. But binocular lens gives the proper three dimensional image.

Q.126 (4)

In this case $|m| = \frac{f_0}{f_e} = 5$ ...(i)

and length of telescope $= f_0 + f_e = 36$ ...(ii)

Solving (i) and (ii), we get $f_e = 6$ cm, $f_o = 30$ cm

Q.127 (3)

$$f_o = \frac{1}{1.25} = 0.8 \text{ m and } f_e = \frac{1}{-20} = -0.05 \text{ m}$$

$\therefore |L_\infty| = |f_o| - |f_e| = 0.8 - 0.05 = 0.75$ m = 75 cm

and $|m_\infty| = \frac{f_0}{f_e} = \frac{0.8}{0.05} = 16$

Q.128 (3)

In normal adjustment

$$m = -\frac{f_0}{f_e}$$

so $50 = -\frac{100}{f_e} \Rightarrow f_e = -2$ cm

($\because$ eyepiece is concave lens)

and $L = f_0 + f_e = 100 - 2 = 98$ cm

Q.129 (4)

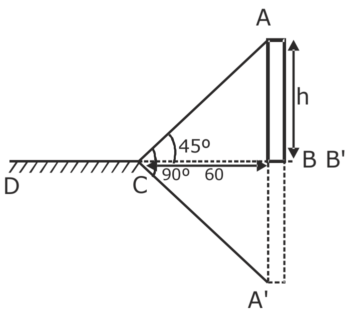
In this case $|m| = \frac{f_0}{f_e} = 5$ ...(i)

and length of telescope $= f_0 + f_e = 36$ ...(ii)

Solving (i) and (ii), we get $f_e = 6$ cm, $f_o = 30$ cm

JEE-ADVANCED
OBJECTIVE QUESTIONS

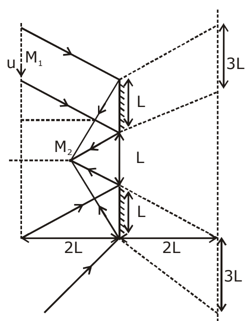
Q.1 (B)



Let A'B' be the image of tower AB. The foot of tower coincides with foot of image. Let the mirror be CD then from the given condition and from Δ CAB.

tan 45º = $\frac{h}{60}$ ⇒ h = 60m

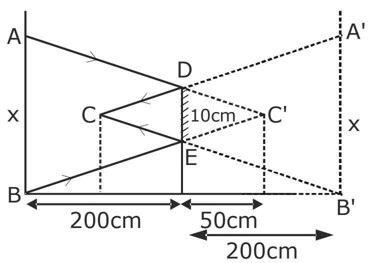
Q.2 (C)



M_1 moves on line parallel to the mirrors so to find out where M_2 will be able to see image of M_1 we have to find the total length where M_1 is visible of M_2 so rays originate from M_1 & after reflection meet at M_2. By using similar triangles. We find total visible length is equal to (3L + 3L) = 6L.

Hence time duration will be = $\frac{\text{Distance}}{\text{speed}} = \frac{6L}{u}$

Q.3 (C)

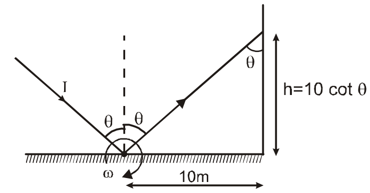


Lets assume that a width of x (cm) is visible to man then from similar triangles.

Δ DEC ~ ΔA'B'C

$\frac{250}{x} = \frac{50}{10}$ ⇒ x = 50 cm

Q.4 (B)



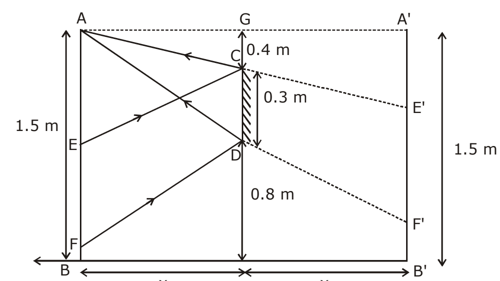
When mirror is rotated with angular speed ω, the reflected ray rotates with angular speed 2ω (= 36 rad/s)

speed of the spot = $\left|\frac{dh}{dt}\right| = \left|\frac{d}{dt}(10\cot\theta)\right|$

$= \left|-10\,\text{cosec}^2\theta\,\frac{d\theta}{dt}\right| = \left|-\frac{10}{(0.6)^2}\times 36\right|$

= 1000 m/s.

Q.5 (D)



Let AB be the object whose image formed by plane mirror CD is A'B'. The portion visible to the object can be drawn as shown in the ray diagram and EF is the length visible to him.

To calculate EF : Δ AGC ~ Δ AA'E' & Δ AGD ~ Δ AA'F'

In Δ AGC & Δ AA'E' | In Δ AGD & Δ AA'F'

$\frac{AG}{GC} = \frac{AA'}{A'E'}$ | $\frac{AG}{GD} = \frac{AA'}{A'F'}$

$\frac{x}{0.4} = \frac{2x}{A'E'}$ | $\frac{x}{0.7} = \frac{2x}{A'F'}$

A'E' = 0.8 | A'F' = 1.4

Now A'F' - A'E' = E'F' = EF

1.4 – 0.8 = 0.6 = EF

Q.6 (A)

Let AB be the street lamp of ht 3h and CD be the man of hieght h.

From Δ ABE and Δ CDE

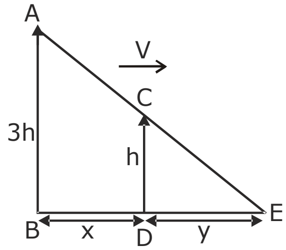
$\frac{BE}{AB} = \frac{DE}{CD}$

The rate at which shadow is increasing is $\frac{dy}{dt}$.

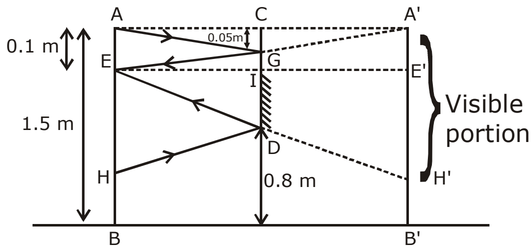
$$\frac{x+y}{3h} = \frac{y}{h}$$

$$\frac{dx}{dt} = v$$

$$\frac{dy}{dt} = \frac{v}{2}$$



Q.7 (C)



Let AB be the boy with his eye level at E and A'B' be the image then the visible portion is AH. Δ EID ~ Δ EE'H'

$$\frac{EI}{ID} = \frac{EE'}{E'H}$$

Now we know that EE' = 2 EI, ID = 0.6 m

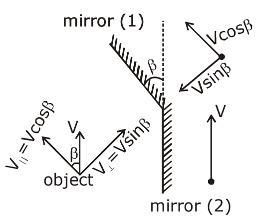
& AH = A'H' = A'E' + E'H'

E'H = 1.2 And AH=1.2 + 0.1 = 1.3 m.

Hence boy cannot see his feet.

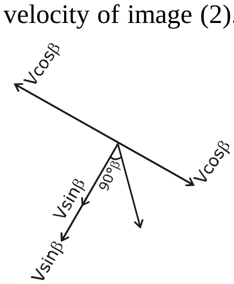
Q.8 (B)

We know that the component of velocity parallel to mirror remains same for image but for perpendicular component.



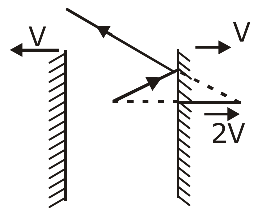
$V_I = -V_0$

Now to find relative velocity $\vec{V}_{12} = \vec{V}_1 - \vec{V}_2$ where $\vec{V}_{12}$ is relative velocity $\vec{V}_1$ is velocity of image (1) & $\vec{V}_2$ is velocity of image (2).



$\vec{V}_{12}$ = 2 sinβ on performing vector subtraction.

Q.9 (B)



We know that from formula $V_m = \frac{V_I + V_0}{2}$

where V_m = Velocity of mirror

V_m = Velocity of image

V_m = Velocity of object

We can write velocity of image for first mirror after Ist reflection

$V_I = 2\,V$

For second reflection this velocity becomes velocity of object.

$$-V = \frac{2V + V_I}{2}$$

$V_I = -4\,V$

$|V_I| = 4\,V$

Thus after n[th] reflection

$V_I = 2\,N\,V$

Q.10 (B)

Component of velocity of object ⊥ to mirror follows the condition.

$$V_{IM} = -V_{OM}\,[\text{for z component only}]$$

$$V_I - 8 = -[5-8]$$

$$V_I = 11\hat{k}$$

The remaining components remain same as that of the object so $V_I = 3\hat{i} + 4\hat{j} + 11\hat{k}$

Q.11 (C)

$$v = \frac{uf}{u-f} = \frac{(-15)\times(-10)}{-15+10} = -30 \text{ cm},$$

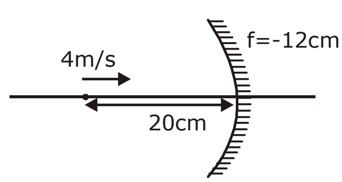
$$m = -\frac{v}{u} = -2 \quad \therefore A'B' = C'D' = 2 \times 1 = 2 \text{ mm}$$

$$\text{Now } \frac{B'C'}{BC} = \frac{A'D'}{AD} = \frac{v^2}{u^2} = 4$$

⇒ B′C′ = A′D′ = 4 mm

∴ Perimeter length = 2 + 2 + 4 + 4 = **12 mm Ans.**

Q.12 (C)



Using mirror formula

$$\because \frac{1}{v}+\frac{1}{u}=\frac{1}{f} \Rightarrow \frac{1}{v}+\frac{1}{-20}=\frac{1}{-12}$$

v = –30cm real.

$$\frac{dv}{dt}=\frac{-v^2}{u^2}v_{0m}$$

$$(V_I-0)=\frac{-v^2}{u^2}(V_0-0)$$

$$V_I=-\left(\frac{30}{20}\right)^2 u$$

V_I = –9cm/s towards right.
So away from the mirror.

Q.13 (B)

Using mirror formula

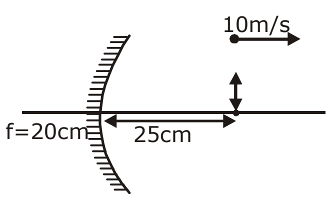
$$\frac{h_i}{h_0}=\frac{-v}{u}=\frac{-uf}{u(u-f)}$$

$$h_i=\frac{-f}{(u-f)}h_0$$

$$\frac{dh_i}{dt}=\frac{-f}{u-f}\frac{dh_0}{dt}$$

$$V_I=\frac{-20}{-15-(-20/2)}\times 2=-4\text{mm/s}$$

Q.14 (C)



u = –25cm
f = –20 cm
v = –100 cm
Using mirror formula

$$\frac{dv}{dt}=-\left(\frac{100}{25}\right)^2\times 10=-160\hat{i}$$

$$\frac{h_i}{h_0}=\frac{-v}{u}=\frac{f}{(f-u)}$$

$$\frac{dh_i}{dt}=\frac{-20\times 1}{(-20+25)^2}\times -10 = 8\ \hat{j}\ \text{m/sec.}$$

Q.15 (A)

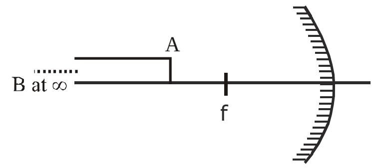


Figure shows a rod of infinite length with point A at distance u and B at infinity.
By using mirror formula we find the image of point A & B.
Point A
u = –u f =– f

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

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

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

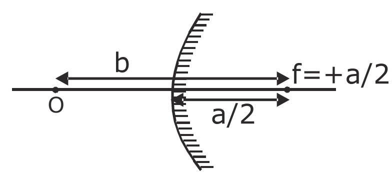
Point B
u = – ∞ f = – f

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

v = – f.

$$\text{Distance}=\frac{uf}{u-f}-f=\frac{f^2}{u-f}$$

Q.16 (C)



So $u=-\left(b-\frac{a}{2}\right)$ Using mirror formula

$$\frac{1}{v}=\frac{1}{f}-\frac{1}{u}=\frac{1}{\frac{a}{2}}\frac{1}{\left(b-\frac{a}{2}\right)}$$

by solving

$$\frac{1}{v}=\frac{4b}{a(2b-a)} \Rightarrow v=\frac{a(2b-a)}{4b}$$

so distance from focus $=\frac{a}{2}-v$

$$\Rightarrow \frac{a}{2}-a\frac{(2b-a)}{4b}=\frac{a^2}{4b}$$

Q.17 (B)
Image is large and real.
Concave mirror such that object is closer than image.
Mirror should be placed towards left of I.

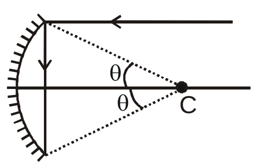
Q.18 (C)
Given
$u = -15\text{cm} \Rightarrow f = -10\text{cm} \Rightarrow v = +30$ cm
(Using mirror formula)

Now $\dfrac{dv}{du} = -\dfrac{v^2}{u^2}$

$dv = -\left(\dfrac{30}{15}\right)^2 .du$

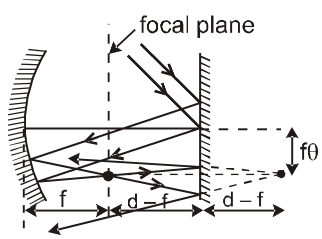
$dv = -4 \times 2$
$dv = -8$mm.

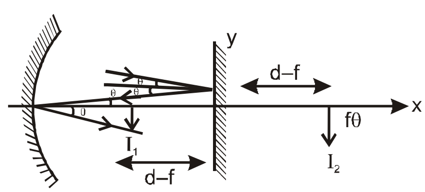
Q.19 (B)



For II[nd] reflection
Minimum value of $\theta = 45^o$

Q.20 (D)
Can be understood by the following ray diagrams :





Since, rays are almost perpendicular to P-axis
Image will form at focus of size = fθ .

Q.21 (A)
For m = 2

$m = -\dfrac{v}{u} = 2$

$V = -2u$ ....(i)

$\dfrac{1}{f} = \dfrac{1}{v} + \dfrac{1}{u} \Rightarrow \dfrac{1}{f} = \dfrac{1}{-2u} + \dfrac{1}{u}$

$\Rightarrow \dfrac{1}{f} = \dfrac{1}{2u} \Rightarrow u = \dfrac{f}{2}$

& $v = -f$
Distance between object & image = f + f/2 = 3f/2
For $m = -2$

$m = -\dfrac{v}{u} = -2$

$v = 2u$

$\Rightarrow \dfrac{1}{f} = \dfrac{1}{2u} + \dfrac{1}{u} \Rightarrow u = \dfrac{3f}{2}$ & $v = 3f$

Distance between object & image $= 3f - \dfrac{3f}{2}$.

Q.22 (C)
For M_1 $u_1 = -30$cm, $f_1 = 20$cm

$\dfrac{1}{v_1} + \dfrac{1}{u_1} = \dfrac{1}{f_1} \Rightarrow \dfrac{1}{v_1} + \dfrac{1}{-30} = \dfrac{1}{-20}$

$\Rightarrow \dfrac{1}{v_1} = \dfrac{1}{30} - \dfrac{1}{20} = \dfrac{2-3}{60} = \dfrac{-1}{60}$

$v_1 = -60$ cm
For M_2
$u_2 = +(60 - (10 + 30)) = +20$ cm
$f_2 = +10$cm

$\dfrac{1}{v_2} + \dfrac{1}{20} = \dfrac{1}{10} \Rightarrow v_2 = +20$ cm

Now for M_1

$m_1 = -\dfrac{v_1}{u_1}$

For M_2

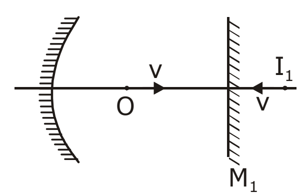
$m_2 = -\dfrac{v_2}{u_2}$

Total $M_T = m_1 \times m_2 = \dfrac{v_1}{u_1} \times \dfrac{v_2}{u_2}$

$= \dfrac{(-60)(+20)}{(-30)(+20)}$

$M_T = +2$

Q.23 (A)



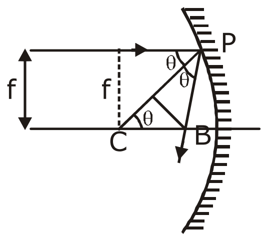
I_1 will behave as an object for M_2. Hence

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

Image will go towards right.

Q.24 (A)

The ray in this case is not paraxial so ray after reflections does not pass from focus but from point $\frac{R}{2}$ secθ from C.



$\sin\theta = \frac{f}{CP} = \frac{1}{2}$

$\Rightarrow$ θ = 30º [∵ CP = 2f]

BC = f secθ

$\frac{BC}{f} = \frac{2}{\sqrt{3}}$

Q.25 (B)

For M_1

$v = \frac{uf}{u-f} = \frac{-15\times(-10)}{-15-(-10)}$ = – 30 cm

For M_2 u = 10 cm

∴ $v = \frac{10\times(-10)}{10-(-10)}$ = – 5 cm

magnification $m = \frac{-v}{u} = -\left(\frac{-5}{10}\right) = \frac{1}{2}$

so, distance of image from CD = $\frac{1}{2} \times 3 = \frac{3}{2}$ cm

∴ distance of image from AB = $3 - \frac{3}{2} = \frac{3}{2}$ cm

Q.26 (D)

As n varies 'y', parallel slabs can be taken, and we know in parallel slabs

$n_r \sin i_r$ = constant. as $n_1 \sin i_1 = 1 \times \sin 90° = 1$

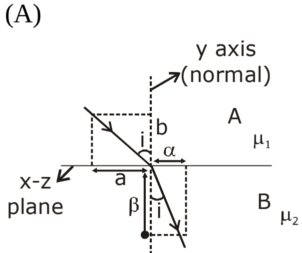
= constant

$n_{final} = n_{air} = 1$

$\Rightarrow$ $1 = 1 \times \sin r_{final} \Rightarrow r_{final} = 90°$

∴ Deviation is zero.

Q.27 (A)



From Snell's Law

$\mu_1 \sin i = \mu_2 \sin r$

$\mu_1 \frac{a}{\sqrt{a^2+b^2}} = \frac{\mu_2\,\alpha}{\sqrt{\alpha^2+\beta^2}}$

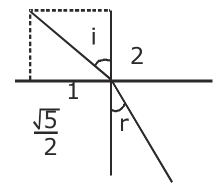
Because $\vec{r}_a$ & $\vec{r}_b$ are unit vector hence

$\sqrt{a^2+b^2} = 1$ & $\sqrt{\alpha^2+\beta^2} = 1$

so $\mu_1 a = \mu_2 \alpha$

Q.28 (C)

$2 \sin i = \frac{\sqrt{5}}{2} \sin r$



$\frac{2\times 1}{\sqrt{5}} = \frac{\sqrt{5}}{2} \sin r$

$\sin r = \frac{4}{5}$ = 53º

Now check options.

Q.29 (C)

i = 60º

Displacement = t sec r sin (i – r) = $5\sqrt{2}$

$= 15 \sec r \left[\frac{\sqrt{3}}{2}\cos r - \frac{\sin r}{2}\right] = 5\sqrt{3}$

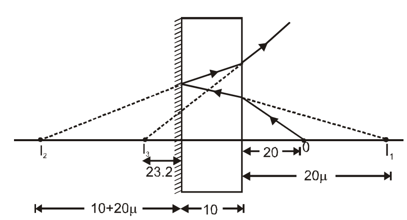
$\Rightarrow \frac{\sqrt{3}}{2} - \frac{\tan r}{2} = \frac{1}{\sqrt{3}}$

$\Rightarrow$ r = 30º

Now μ sin r = sin i

$\mu = \frac{\sqrt{3}}{2} \times \frac{1}{2} = \sqrt{3}$

Q.30 (C)



Distance of I_1 from refracting surface = 20 μ

Distance of I_2 from reflecting surface

Distance of I_1 from reflecting surface = 10 + 20 μ

Distance of I_2 from refracting surface = 20 + 20 μ

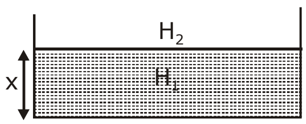
Distance of I_3 from refracting surface

$= \frac{20+20\mu}{\mu}$ = 10 + 23.2

$= \frac{20}{\mu} + 20 = 13.2$

$\mu = \frac{20}{13.2} = \frac{200}{132}$ cm.

Q.31 (C)



$\frac{\text{Apparent Depth}}{\text{Real Depth}} = \frac{\mu_2}{\mu_1}$

$\frac{(21/2)}{x} = \frac{1}{4/3}$

x = 14 cm

Q.32 (B)

$d_1 = \frac{3h}{4}$

Apparent depth of B

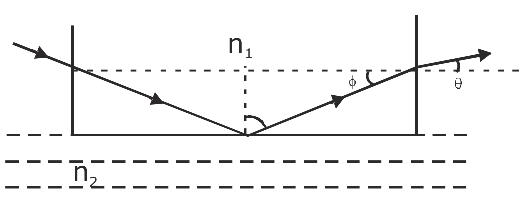
$d_2 = n_3\left(\frac{t_1}{n_1} + \frac{t_2}{n_2} + \frac{t_3}{n_3}\right)$

$d_2 = \frac{h-36}{4/3} + \frac{36}{1.5}$

$d_2 - d_1 = \frac{36}{1.5} - \frac{36}{4/3}$

= 3 mm

Q.33 (A)



$n_1 \sin\phi = 1 \times \sin\theta$

$\Rightarrow \sin\phi = \frac{\sin\theta}{n_1} \Rightarrow \cos\phi = \frac{\sqrt{n_1^2 - \sin^2\theta}}{n_1}$

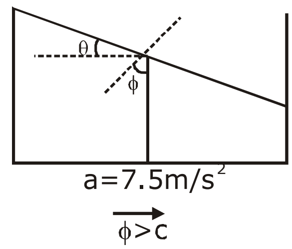
For T.I.R. $90 - \phi > C \Rightarrow \cos\phi > \sin C$

$\therefore \frac{\sqrt{n_1^2 - \sin^2\theta}}{n_1} > \sin C$

$\left\{\sin C = \frac{n_2}{n_1}\right\} \Rightarrow \frac{n_1^2 - \sin^2\theta}{n_1^2} > \frac{n_2^2}{n_1^2}$

Q.34 (B)

For TIR to take place θ > C.

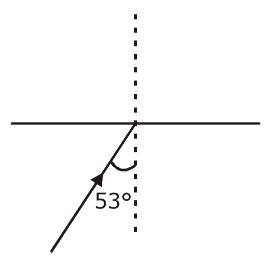


$\tan\theta = \frac{a}{g} = \frac{7.5}{10} = \frac{3}{4}$

sin θ > sin C

$\frac{3}{5} > \mu \Rightarrow \phi > C$

Q.35 (C)



$\sin C = \frac{1}{1.4}$

C = 45.58

For TIR to take place θ > C.

Q.36 (C)

For transmission

$r_2 \le \sin^{-1}(1/\mu)$ & $r_1 \le \sin^{-1}(1/\mu)$

$r_1 + r_2 \le 2\sin^{-1}(1/\mu)$ $\qquad A \le 2\sin^{-1}(1/\mu)$

$\sin^{-1}(1/\mu) \ge 45^\circ \Rightarrow \frac{1}{\mu} \ge \frac{1}{\sqrt{2}} \Rightarrow \mu \le \sqrt{2}$.

Q.37 (B)

Deviation by prism.

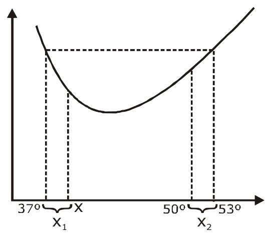
$\delta_1 = A(\mu - 1) = 4^\circ(1.5 - 1) \Rightarrow \delta_1 = 2^\circ$

for plane mirror

$i = 2^\circ$

$\delta_2 = 180^\circ - 2i = 176^\circ$ $\qquad \Rightarrow \delta = \delta_1 + \delta_2 = 178^\circ$

Q.38 (D)



In the graph for angle of deiration v/s angle of incidence the shift in angle of incidence on right side is more than that of left side $x_2 > x_1$. Hence only one angle is sutable e = 38º.

Q.39 (C)

Using formula for relation between δ_{min} & A.

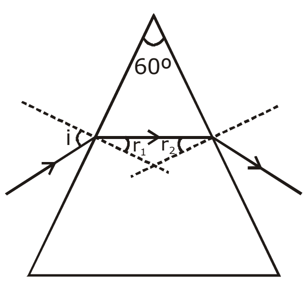
$$\mu = \frac{\sin\left(\frac{A+\delta_{min}}{2}\right)}{\sin\frac{A}{2}}$$

$$\sqrt{\frac{3}{2}} = \frac{\sin\left(\frac{90+\delta_{min}}{2}\right)}{\sin 45^o}$$

$$\sin\left(\frac{90+\delta_{min}}{2}\right) = \frac{\sqrt{3}}{2}$$

$$\frac{90+\delta_{min}}{2} = 60^o \Rightarrow \delta_{min} = 30^o$$

Q.40 (A)



For light be transmitted the ray should not suffer TIR at second refraction. Hence $r_2 < \theta_C$.

If maximum value of r_2 is less than C then the ray will be always transmitted

$r_1 + r_2 = A$

$(r_2)_{max} = 60^o - (r_1)_{min}$

For r_1 to be minimum i should be minimum

$$\sin(i_{min}) = \sqrt{\frac{7}{3}}\ \sin(r_1)_{min}$$

In limiting case $(r_2)_{max} = \theta_C$

$$\theta_C = 60 - \sin^{-1}\left(\frac{\sin i_{min}}{\mu}\right)$$

$$\left(\sin^{-1}\left(\frac{1}{\mu}\right)\right) = \left[60 - \sin^{-1}\left(\frac{\sin i_{min}}{\mu}\right)\right]$$

$$\sin^{-1}\left(\frac{\sin i}{\mu}\right) = 60 - \sin^{-1}\sqrt{\frac{3}{7}}$$

$$\frac{\sin i}{\mu} = \frac{\sqrt{3}}{2}\cos\left(\sin^{-1}\sqrt{\frac{3}{7}}\right) - \frac{1}{2}\sqrt{\frac{3}{7}}$$

$$\sin i = \sqrt{\frac{7}{3}}\left[\frac{\sqrt{3}}{2}\times\frac{2}{\sqrt{7}} - \frac{\sqrt{3}}{2\sqrt{7}}\right]$$

$$\sin i = \left[1 - \frac{1}{2}\right] \Rightarrow i = 30^o$$

Q.41 (B)

Deviation by prism = A(μ – 1) = 4º (1.5 – 1) 2º

For 90º total deviation, deviation by mirror

= 90º – 2º = 88º

180º – 2i = 88º

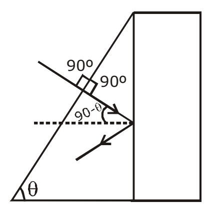
2i = 92º

i = 46º

Mirror should be rotated 1º anticlockwise.

Q.42 (A)

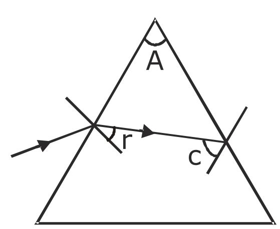
$90 - \theta \geq c$



$\cos\theta \geq \sin c$

$$\cos\theta \geq \frac{6}{5}\times\frac{2}{3} \Rightarrow \theta \leq 37^o.$$

Q.43 (B)



From properties of prism

r + C = A

$$r = A - C = 75 - \sin^{-1}\left(\frac{1}{\sqrt{2}}\right) = 30^o$$

$1.\sin i = \sqrt{2}\ \sin r$

$i = \sin^{-1}\left(\sqrt{2} \times \frac{1}{2}\right)$

$i = 45^o$

Q.44 (D)

$i = \frac{\pi}{2}$, $e = \frac{\pi}{4}$, $A = \frac{\pi}{4}$

$\frac{\sin i}{\sin r_1} = \frac{\sin e}{\sin r_2} = \mu$

$\Rightarrow \sin r_1 = \frac{1}{\mu}$ and $\sin r_2 = \frac{1}{\sqrt{2}\ \mu}$

Since $r_1 + r_2 = A = \frac{\pi}{4} \Rightarrow r_1 = \frac{\pi}{4} - r_2$

$\Rightarrow \sin r_1 = \frac{1}{\sqrt{2}} \cos r_2 - \frac{1}{\sqrt{2}} \sin r_2$

$= \sqrt{2}\sin r_1 + \sin r_2 = \cos r_2$

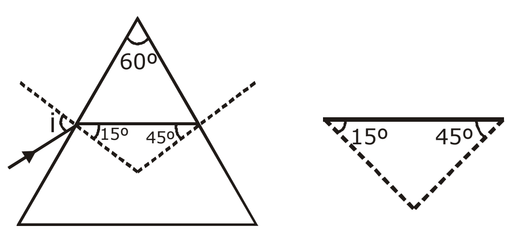
$= \frac{\sqrt{2}}{\mu} + \frac{1}{\sqrt{2}\mu} = \sqrt{1 - \frac{1}{2\mu^2}}$

$= \frac{1}{\mu^2}\left(2 + \frac{1}{2} + 2\right) = 1 - \frac{1}{2\mu^2}$

$= \frac{1}{\mu^2}\left(\frac{9}{2} + \frac{1}{2}\right) = 1$

$\mu^2 = 5 \Rightarrow \mu = \sqrt{5}$.

Q.45 (A)



On second surface for grazing emergence

$\sqrt{2}\ \sin r_2 = 1 \sin 90^o$

$r_2 = 45^o$

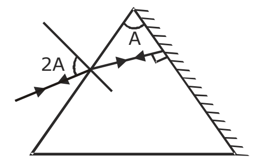
$A = r_1 + r_2 \Rightarrow r_1 = 15^o$

Now for Ist surface

$1 \sin i = \sqrt{2} \sin 15^o$

$i = \sin^{-1}\left(\frac{\sqrt{3} - 1}{2}\right)$

Q.46 (B)



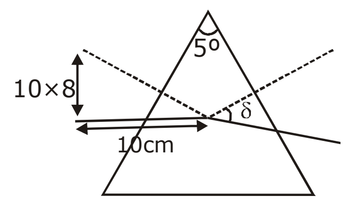
$r_2 = 0,\ r_1 = A$

$\sin 2A = \mu \sin A$

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

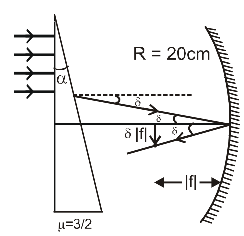
Q.47 (C)

$\delta = (1.5 - 1) \times 5^o = 2.5 \times \frac{\pi}{180}$



Q.48 (B)

Deviation by prism = $1.8^o\left(\frac{3}{2} - 1\right) = 0.9^o$



R = 20 cm |f| = 10 cm

Image will form on focal plane

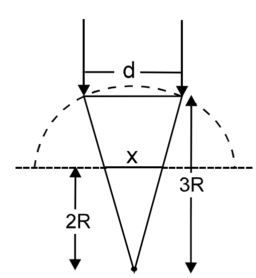
Distance of image from P–axis = |f| δ

$= 100 \times \frac{0.9\pi}{180}$ mm = 1.57 mm

Q.49 (D)

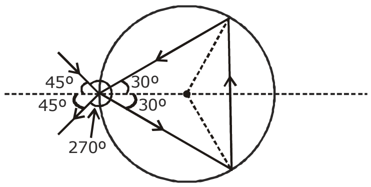
Using refraction formula at curved surface,

$\frac{3}{2v} - \frac{1}{\infty} = \frac{\frac{3}{2} - 1}{R}$; $\frac{3}{2V} = \frac{1}{2R}$; V = 3R ;



From figure $\frac{x}{2R} = \frac{d}{3R}$; $x = \frac{2}{3}$ d.

Q.50 (A)



Deviation = 90° clockwise or 270° anticlockwise.

Q.51 (C)

For first refraction

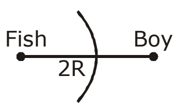
$$\frac{\mu_2}{v} - \frac{\mu_1}{u} = \frac{\mu_2 - \mu_1}{R}$$

$$\frac{3}{2\times\infty} - \frac{1}{(-x)} = \frac{3/2-1}{+10}$$

$$\frac{1}{x} = \frac{1}{20} \Rightarrow x = 20 \text{ cm.}$$

Q.52 (C)

Here $n_2 = \frac{4}{3}$



$n_1 = 1$
$u = -R$
$R = +R$

from $\frac{n_2}{v} - \frac{n_1}{u} = \frac{n_2 - n_1}{R}$

$$\Rightarrow \frac{4}{3v} + \frac{1}{R} = \frac{(4/3-1)}{R} \Rightarrow \frac{4}{3v} = \frac{1}{3R} - \frac{1}{R}$$

$\Rightarrow v = -2R$

Then the distance from the centre
= R + 2R = 3R

Q.53 (C)

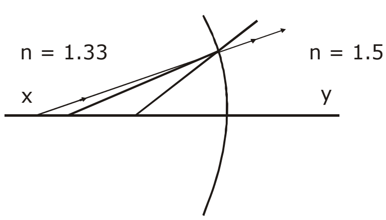
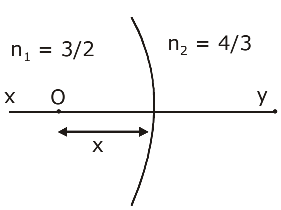


Image is always virtual because rays goes from rarer to denser medium.

Q.54 (A)



$n_2 = \frac{4}{3}$, $n_1 = \frac{3}{2}$

R = –10 cm, u = –x

$$\Rightarrow \frac{4}{3v} + \frac{3}{2x} = \frac{4/3-3/2}{-10}$$

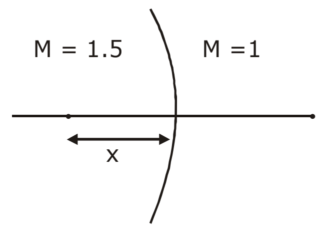
$$\Rightarrow \frac{1}{v} = \frac{3}{4} \times \left(\frac{1}{60} - \frac{3}{2x}\right)$$

for real image v > 0

$$\Rightarrow \frac{3}{4}\left(\frac{1}{60} - \frac{3}{2x}\right) > 0 \quad \Rightarrow x > 90 \text{ cm}$$

Q.55 (A)

$u = -x$
$n_2 = 1$
$n_1 = 1.5$



$$\Rightarrow \frac{1}{v} + \frac{3}{2x} = \frac{1-1.5}{-R}$$

for real image $\frac{1}{v} > 0$

$$\Rightarrow \frac{1}{2R} - \frac{3}{2x} > 0 \Rightarrow x > 3R$$

Q.56 (A)

For refraction by upper surface

$$\frac{1.6}{v_1} - \frac{1}{-2} = \frac{1.6-1}{1}$$

$$\Rightarrow \frac{1.6}{v_1} = 0.6 - 0.5 = 0.1$$

$\Rightarrow v_1 = 16$ m

For refraction by lower surface

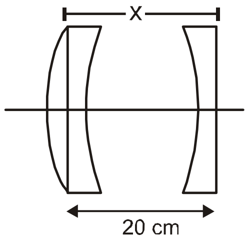
$$\frac{2}{v_2} - \frac{1}{-2} = \frac{2-1}{1}$$

$$\Rightarrow \frac{2}{v_2} = 1 - 0.5 = 0.5$$

$$\Rightarrow v_2 = \frac{2}{0.5} = 4\text{m}$$

Distance between images = (16 – 4) = 12m.

Q.57 (D)



$f_1 = \frac{(+20)(-40)}{(20-40)}$ $f_2 = -40$

$= 40$

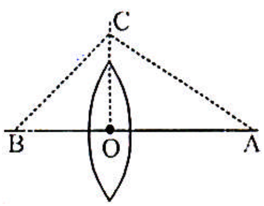
$\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2} - \frac{x}{f_1 f_2}$

$= \frac{1}{40} + \frac{1}{-40} - \frac{20}{40 \times (-40)}$

$\frac{1}{f} = \frac{1}{80}$

f = 80 cm.

Q.58 (D)



OB=y and OA=x

$y^2 + OC^2 = BC^2$ ... (1)

$x^2 + OC^2 = CA^2$ ... (2)

$BC^2 + CA^2 = (x + y)^2$ ... (3)

(3)-[(1) + (2)]

$\Rightarrow xy = OC^2$

$\frac{1}{v} - \frac{1}{u} = \frac{1}{f} \Rightarrow \frac{1}{y} + \frac{1}{x} = \frac{1}{f}$

$f = \frac{xy}{x+y} \Rightarrow f = \frac{OC^2}{AB}$

Q.59 (C)

I^{st} lens ⇒ diverging lens (concave)

⇒ focus = –5cm

2^{nd} lens ⇒ converging lens (convex)

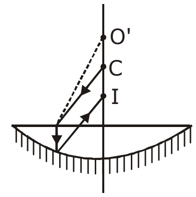
⇒ focus = +5cm

Q.60 (C)

C → A converging lens may be used and the object be placed at a distance less than f from the lens.

Q.61 (D)

The object will now appear to be placed at O' which is a point between C & ∞ for mirror. So image is formed between C & O.



Q.62 (C)

$\frac{1}{f_\ell} = p = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$

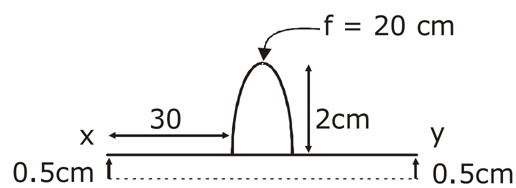
... (1)

Now $p' = \left(\frac{\mu}{\mu_0} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$

... (2)

$\frac{p'}{p} = \frac{\mu - \mu_0}{\mu_0(\mu - 1)}$

Q.63 (D)



u = –30

f = 20cm

h_0 = 0.5cm

⇒ v = +60 cm

h_i = –1cm

Q.64 (D)

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

$\Rightarrow V_{I\ell} = \frac{v^2}{u^2} . v_{0\ell} \Rightarrow (V_I - V_\ell) = \frac{v^2}{u^2}(v_0 - v_\ell)$

$\Rightarrow V_I = \frac{-v^2}{u^2} . v_\ell + v_\ell$

$\Rightarrow V_I = V_\ell \left[\frac{u^2 - v^2}{u^2}\right] = v \times \left[\frac{u^2 - v^2}{u^2}\right]$

upto 2f u < v Hence v_I = –ve

after 2f u > v Hence v_I = +ve

Q.65 (A)

There are 3 lenses touching each other and $f_1 = f_3 = 10$ cm. Let radius = R then $\frac{1}{f_1} = \left(\frac{3}{2}-1\right)\left(\frac{1}{R}+0\right) = \frac{1}{10}$

R = 5 cm

So, $\frac{1}{f_2} = \left(\frac{4}{3}-1\right)\left(\frac{-1}{R}-\frac{1}{R}\right) = \frac{-1}{3}\times\frac{2}{R}$

$\frac{1}{f_2} = \frac{-2}{15}$

$P_{eq} = P_1 + P_2 + P_3$

So $P_{eq} = \left(\frac{1}{f_1}+\frac{1}{f_3}+\frac{1}{f_2}\right) \times 100$ (diaptor)

$= \left(\frac{2}{10}-\frac{2}{15}\right) \times 100 = \frac{1000}{150}$

Power = 6.67 diaptor

Q.66 (C)

$m = 3 = \frac{v}{u} \Rightarrow v = 3u$

u = –10cm ⇒ v = +30 cm

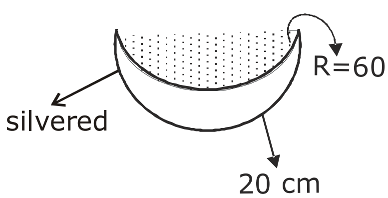
$\frac{1}{30} + \frac{1}{10} = \frac{1}{f_{eq}}$

$f_{eq} = \frac{30}{4}$ cm $f_2 = -30$

$\frac{1}{f_{eq}} = \frac{1}{f_1} + \frac{1}{f_2} = \frac{1}{f_1} - \frac{1}{30} = \frac{4}{30}$

$f_1 = 6$ cm

Q.67 (A)



convex lens horizontal

$\frac{1}{f_{eq}} = \frac{1}{f_m} - 2\left[\frac{1}{f_1}+\frac{1}{f_2}\right]$

$f_m = -10$cm

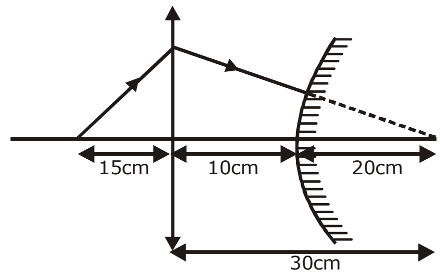
$\frac{1}{f_1} = \left(\frac{4}{3}-1\right)\left[\frac{1}{\infty}-\left(\frac{-1}{60}\right)\right] = \frac{1}{180}$

$\frac{1}{f_2} = \left(\frac{3}{2}-1\right)\left[\frac{-1}{60}-\left(\frac{1}{-20}\right)\right] = \frac{1}{60}$

$\frac{1}{f_{eq}} = \frac{-1}{10} - 2\left[\frac{3}{180}+\frac{1}{180}\right] = \frac{-26}{180} = \frac{1}{f_m}$

$\Rightarrow f_{eq} = \frac{90}{13}$ cm.

Q.68 (B)



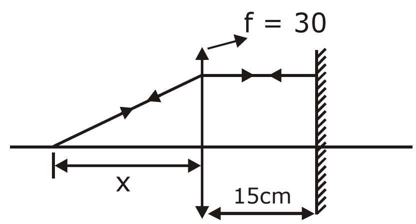
Ray retraces its path when it appears to come towards centre of curvature

R = 20

F = 10 cm

For ray to retrace its path it must fall normally on mirror.

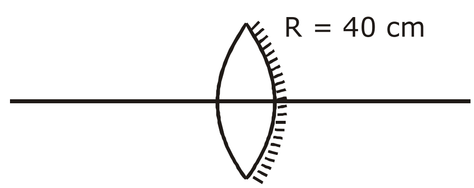
Q.69 (B)



u = –x, f = 30cm, v = +∞

$\frac{1}{\infty} + \frac{1}{x} = \frac{1}{30} \Rightarrow x = 30$

Q.70 (A)



For auto collimation the image should be formed on object so the object should be placed at centre of curvature of the equivent mirror.

$\frac{1}{f_{eq}} = \frac{1}{f_m} - \frac{2}{f_\ell}$

$P_m = -\frac{1}{f_m} = \frac{-1}{20} - 2(\mu-1)\left(\frac{2}{R}\right) \Rightarrow \frac{1}{f_{eq}} = \frac{-1}{10}$

(Equivalent system is concave mirror with focal length 10 cm R = 20 cm and hence u = 20 cm)

u = 20 cm

Q.71 (B)

$$f = \frac{D^2 - d^2}{4D}$$

$$\Rightarrow f = \frac{90^2 - 20^2}{4 \times 40}$$

$\Rightarrow$ f = 21.4 cm

Q.72 (A)

$$h_0 = \sqrt{I_1 I_2}$$

$$h_0 = \sqrt{6 \times 3} = 4.2\text{cm}$$

Q.73 (A)

$\delta = \delta_1 - \delta_2 = 0$

$(\mu_1 - 1)A_1 - (\mu_2 - 1)A_2 = 0$

$(1.54 - 1)\mu - (1.72 - 1)A_2 = 0$

$\Rightarrow A_2 = 3^o$

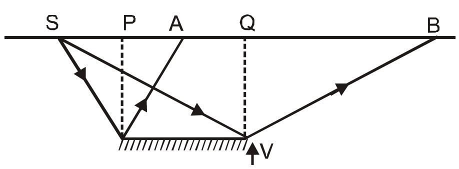
JEE-ADVANCED

MCQ/COMPREHENSION/COLUMN MATCHING

Q.1 (A, C, D)

(A) No, when object is between infinite and focus ,image is real.
(C) when object is between pole and focus, image is magnified.
(D) when object is between pole and focus image formed by convex mirror is real.

Q.2 (B, D)



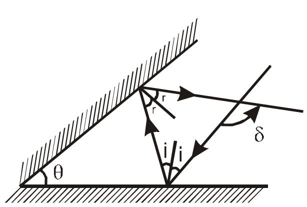
Here, sp = PA and SQ = QB
so, position of A and B doesn't depend on separation of mirror from the wall so, the patch AB will not move on the wall.

$\therefore$ SA and SB are constant
So, AB = constant.

Q.3 (A, D)

The image will look like white donkey because a small part of lines can form complete image. The image will be less intense because some light will stopped by streakes.

Q.4 (A, D)



$$\frac{\pi}{2} - i + \frac{\pi}{2} - r + \theta = \pi$$

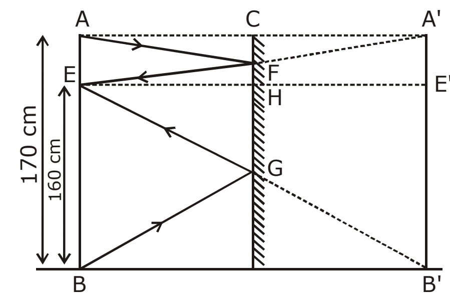
$i + r = \theta$ ....(i)

$\delta = 2i + 2r$

$\delta = 2\theta$ (Anticlockwise)

Q.5 (B, C)

Let AB be the man with his eye level at E and A'B' be the image



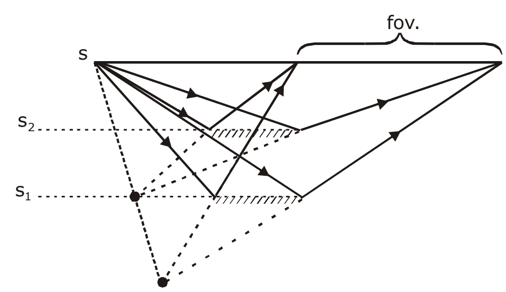
Using similar $\Delta EHG \,\&\, \Delta EE'B'$

$$\frac{EE'}{E'B'} = \frac{EH}{HG}$$

EE' = 2EH & E'B' = 160 cm
HG = 80 cm
FH = 5 cm
Hence length of mirror required is FG = 85 cm and bottom of mirror should be 80 cm or less above the ground or else feet will not be visible.

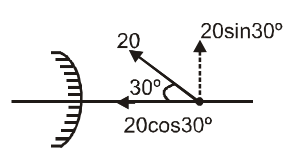
Q.6 (B, D)

Field of view is same for all positions of the mirror and hence spot on wall remains unaffected



Q.7 (B, C)

We have $v = \frac{uf}{u - f} = \frac{(-10)(10)}{-10 - 10} = +5$



$$\therefore \quad v_{ix} = -\frac{v^2}{u^2} v_{ox}$$

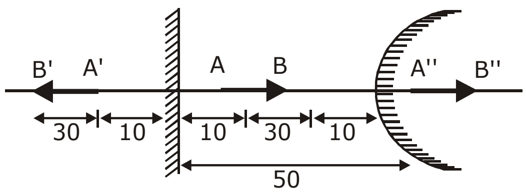
$= -\left(\frac{5}{-10}\right)^2 \times 20.\frac{\sqrt{3}}{2} = -\frac{5\sqrt{3}}{2}$ mm/sec

and $v_{iy} = -\left(\frac{v}{u}\right) v_{oy} = -\left(\frac{5}{-10}\right) \times 20 \times \frac{1}{2} = 5$ mm/s.

Hence $\tan\theta = \left|\frac{v_{iy}}{u_{ix}}\right| = \frac{5}{5\sqrt{3}/2} = \frac{2}{\sqrt{3}}$

and $v_i = \sqrt{\left(\frac{5\sqrt{3}}{2}\right)^2 + (5)^2} = \frac{5\sqrt{7}}{2}$ mm/s

Q.8 (B, C)



for A' u = –60 f = 60 v = +30

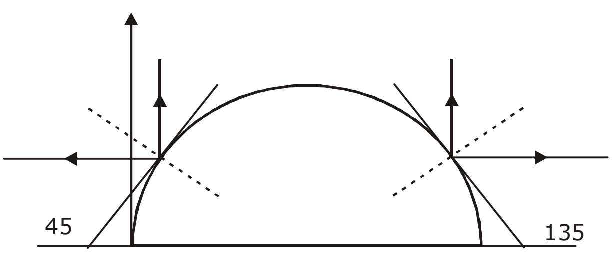
for B' u = –90 f = 60 v = +36 cm

Image length = 6cm

$\therefore$ Magnification = $\frac{1}{5}$

Q.9 (B, D)

Ray becomes vertical means angle of incidence = 45º. $\therefore$ θ with x-axis = 45º Slope = ± 1



$\frac{dy}{dx} = 2\cos\frac{\pi x}{L} = \pm 1$

$\Rightarrow 2\cos\frac{\pi x}{L} = \pm 1 \Rightarrow \cos\frac{\pi x}{L} = \frac{1}{2}$

$\Rightarrow x = \frac{L}{3} \therefore y = \frac{\sqrt{3}L}{\pi}$

$\cos\frac{\pi x}{L} = -1 \qquad \Rightarrow x = \frac{2L}{3} \therefore y = \frac{\sqrt{3}L}{\pi}$

Q.10 (A, B, D)

Refer to Q.no. F-4. Ex.1, Part–I

$f = \frac{n_1 R}{2n_2 - n_1 - n_3}$ or $\frac{n_3 R}{2n_2 - n_1 - n_3}$

If $n_2 < \frac{n_1 + n_3}{2} \Rightarrow$ f is –ve $\Rightarrow$ lens is diverging

If $n_2 > \frac{n_1 + n_3}{2} \Rightarrow$ f is +ve $\Rightarrow$ lens is converging.

If $n_2 = n_1 + n_2 \Rightarrow f = \infty$ neither converging nor diverging.

Q.11 (B,C,D)

$\mu_1 = \sin r = \mu_2 \sin i$

$r = \sin^{-1}\left(\frac{\mu_2}{\mu_1}\sin i\right)$

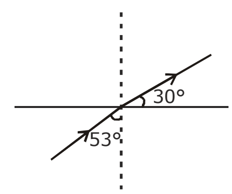
for zero deviation $\mu_2 = \mu_1$

i.e., $k_2 = 1$

If $\mu_2 > \mu_1$ condition for C.

$\mu_2.\sin\frac{\pi}{3} = \mu_1 \sin 90º$

$\Rightarrow \frac{\mu_2}{\mu_1} = \frac{\sqrt{3}}{2} = k_1$



If $k \to \infty$ $r \to 0$

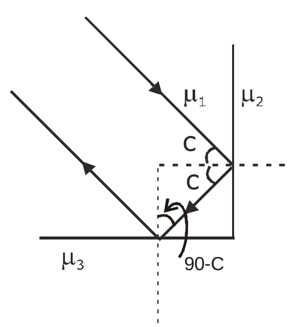
$\therefore |r - i| \to \frac{\pi}{3}$

Q.12 (B,C,D)

For critical angle

$\sin C = \frac{\mu_2}{\mu_1}$

$90º - C > \sin^{-1}\frac{\mu_3}{\mu_1}$



$\cos C > \frac{\mu_3}{\mu_1}$

$\sqrt{\mu_1^2 - \mu_1^2} > \mu_3$

$\mu_1^2 - \mu_1^2 > \mu_3^2$ ... (B)

$\mu_1^2 - \mu_3^2 > \mu_2^2$ ... (C)

$\Rightarrow \mu_1^2 + \mu_2^2 > \mu_3^2$ ... (D)

Q.13 (B, D)

$$\frac{C_y}{C_x} = \frac{\sin r}{\sin i} = \tan 30^\circ = \frac{1}{\sqrt{3}}$$

$$C_y = \frac{1}{\sqrt{3}} C_x.$$

since y is denser, total internal reflection can take place when ray is incident from y.

Q.14 (A,D)

$\delta = i + e - A$

We know that if i and e are interchanged deviation remains same.

$\delta = i + (i + 20) - 60 \Rightarrow 40 = 2i - 40$

$i = 40^\circ$ ($e = 60^\circ$)

or similarly $i = 60$ ($e = 40$)

Q.15 (B, C, D)

A $\rightarrow$ for min deviation there are two angles of incidence

B $\rightarrow$ $i = e$ so $r_1 = r_2$

C $\rightarrow$ $i = 90^\circ$ or $e = 90^\circ$ for δ_{max}

D $\rightarrow$ $\delta_{min} = (\mu - 1)A$

Q.16 (A, B)

For $d_1 = 120$ m $\frac{3/2}{v} - \frac{1}{(-120)} = \frac{3/2 - 1}{60}$

$\Rightarrow v = \infty$

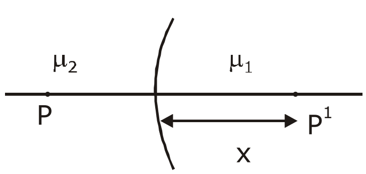
so, the ray is incident normally on the mirror. so for any value of d_2, ray retraces its path. so I_f is at O. for d_1

I_f, O $d_1 = 240$ cm $\frac{3/2}{v} - \frac{1}{(-240)} = \frac{3/2 - 1}{60}$

$\Rightarrow v = 360$ cm.

If first image is formed at mirror ray retraced its path to form image at O.

Q.17 (A, C)



$u = -x$, $n_2 = \mu_2$, $n_1 = \mu_1$, $R = -R$

$$\Rightarrow \frac{\mu_2}{v} + \frac{\mu_1}{x} = \frac{\mu_2 - \mu_1}{-R}$$

$$\Rightarrow \frac{\mu_2}{v} = \frac{-\mu_1}{x} - \frac{\mu_2 - \mu_1}{R}$$

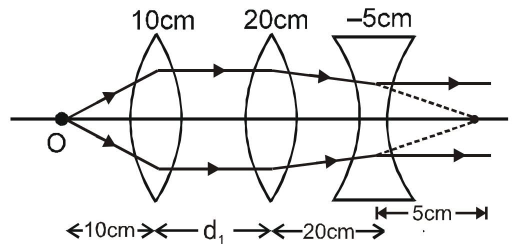
If $\mu_2 > \mu_1 \Rightarrow v = -ve$

If x is –ve and $\mu_1 > \mu_2 \Rightarrow v = +ve$

Q.18 (A, B, C)

Power, focal length and chromatic aberration of a lens depend on refractive index of the material of lens which, in turn, depends on wavelength of the incident light.

Q.19 (A, B, C)

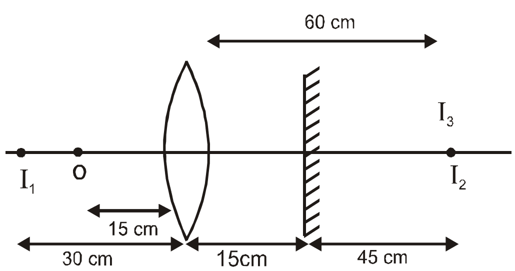


Clearly, final rays are parallel to principal axis for any value of d_1 and $d_2 = (20 - 5) = 15$ cm.

Q.20 (B, C)

$$\frac{1}{f} = \frac{1}{v} - \frac{1}{4} \qquad \frac{1}{+30} = \frac{1}{v} - \frac{1}{-15}$$

$$\frac{1}{v} = \frac{1}{30} - \frac{1}{15} = -\frac{1}{30} \qquad v = -30$$



For plane mirror $u = -30 - 15 = -45$ cm

$\Rightarrow v = +45$ cm

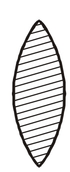
For second refraction

$u = -60$, $f = 30$ cm

$$\frac{1}{30} = \frac{1}{v} - \frac{1}{-60} \quad \frac{1}{v} = \frac{1}{30} - \frac{1}{60} = -\frac{1}{60} \quad v = -60 \text{ cm}$$

final image is real and 60 cm left from lens.

Q.21 (A, D)

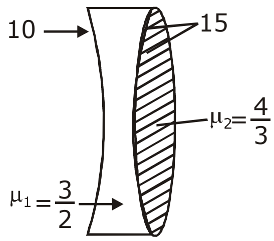


A → The image will look like a white donkey on the photograph

D → The image will be less intense compared to the case in which no

such glass is used.

Q.22 (A, C)



$$\frac{1}{f_1} = \left(\frac{3}{2} - 1\right)\left(-\frac{1}{10} - \frac{1}{15}\right) \Rightarrow \frac{1}{f_1} = -\frac{1}{12}$$

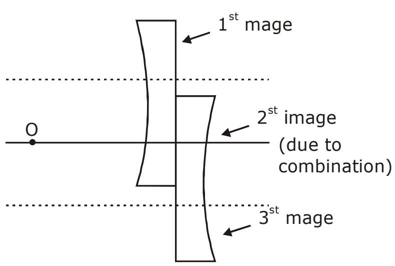
$$\frac{1}{f_2} = \left(\frac{4}{3} - 1\right)\left(\frac{1}{15} + \frac{1}{15}\right) = \frac{2}{45}$$

$$\frac{1}{f_m} = -\frac{1}{15/2} = \frac{-2}{15}$$

$$\frac{1}{f_{eq}} = -\frac{2}{15} - 2\left[-\frac{1}{12} + \frac{2}{4.5}\right] = \frac{-5}{90}$$

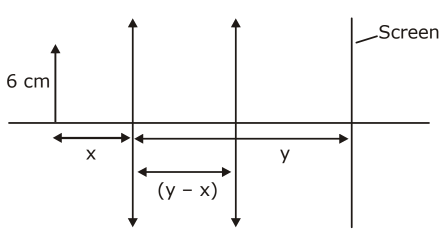
$f_{eq} = -18$ cm

Q.23 (A, C)



On cutting lens into two halves power of each section becomes P/2 on combining them again net power of system becomes P so focal length of two system (ii) and (iii) is same.

Q.24 (B, C, D)



D = 90 cm

$h_0 = h_0 = \sqrt{h_1 \, h_2} = 6\text{cm}$

$$\frac{h_1}{h_0} = \frac{v}{u} = \frac{9}{6} = \frac{3}{2}$$

v : u = 3 : 2

uv + u = 90

⇒ v = 54, u = 36 ⇒ d = 18

$$f = \frac{D^2 - d^2}{4D}$$

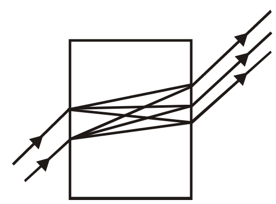
$$f = \frac{90^2 - 18^2}{4 \times 90} \Rightarrow f = 21.6 \text{ cm}$$

Q.25 (B, C)

The light splits in different colours inside the slab due to dispersion.

But the emergent rays will be parallel and will overlap with others hence giving white emergent beam.

Inside the slab rays of different colours are not parallel and they intersect each other.



Q.26 (A, B, C)

Obvious from theory

Q.27 (D)

From passage, (D) is correct.

Q.28 (C)

From passage, (C) is correct.

Q.29 (D)

From points (2) and (3) of passage :

f and f' must be of opposite sign.

Also $\omega_C < \omega_D$ and $f_C < f_D$

which is satisfied only by (D).

Q.30 (B)

$$\frac{\omega_1}{f_1} + \frac{\omega_2}{f_2} = 0$$

$$\Rightarrow \quad \frac{\omega_1}{\omega_2} = -\frac{f_1}{f_2} = \frac{1}{2} \quad \text{.................(1)}$$

$$\Rightarrow \quad \frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2} = \frac{1}{40} \quad \text{.................(2)}$$

After solving (1) & (2)

$f_1 = 20$ cm

$f_2 = -40$ cm.

Q.31 (D)
Chromatic aberration doesn't occur in case of spherical mirrors.

Q.32 (D)

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

Here v = 2.5 (Distance of Retina as position of image is fixed)

u = – x

$$\frac{1}{f}=\frac{1}{2.5}+\frac{1}{x}$$ For f_{min} :

x is minimum $\frac{1}{f_{min}}=\frac{1}{2.5}+\frac{1}{25}$

Q.33 (B)

For f_{max} : x is maximum $\frac{1}{f_{max}}=\frac{1}{2.5}+\frac{1}{\infty}$

Q.34 (B)
For near sighted man lens should make the image of the object with in 100 cm range
For lens u = – ∞ v = – 100

$$\frac{1}{f_{lens}}=\frac{1}{-100}-\frac{1}{-\infty}$$

Q.35 (C)
For far sighted man lens should make image of the nearby object at distance beyond 100 cm
For grown up person least distance is 25 cm for lens u = – 25, v = – 100

$$\frac{1}{f}=\frac{1}{-100}-\frac{1}{(-25)} \Rightarrow \frac{1}{f}=\frac{3}{100}$$

P = + 3
so no. of spectacle is = +3.

Q.36 (C)

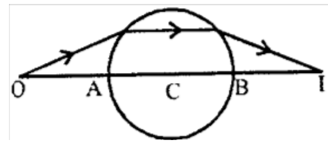
$$\frac{\mu_2}{v}-\frac{\mu_2}{u}=\frac{\mu_2-\mu_1}{R} \Rightarrow \frac{\mu}{2R}-\frac{1}{-2R}=\frac{\mu-1}{2R}$$

Q.37 (B)

$$\frac{\mu_2}{v}-\frac{\mu_2}{u}=\frac{\mu_2-\mu_1}{R} \Rightarrow \frac{\mu}{2R}-\frac{1}{\infty}=\frac{\mu-1}{R}$$

$$\Rightarrow \frac{\mu}{2}=\mu-1$$

Q.38 (B)
From the symmetry of the figure ray inside the sphere is parallel to principal axis.



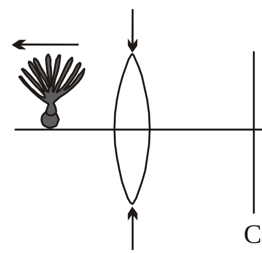
Taking refraction at A.

$$\frac{\mu}{\infty}-\frac{1}{-R}=\frac{\mu-1}{R}$$

Q.39 (A)
When we squeeze the lens f will decrease so turnip will move toward 2f(R) from f so image will move towards lens (from ∞ → 2f)

Q.40 (B)
Since image of object is moving towards R so lateral magnitude will decrease therefore lateral height will decrease.

Q.41 (A)



As turnips moves aways image will also move towards lens. So to form image on card again focal lenght of lens to be decrease. Therefore squeeze of lens to be decrease.

Q.42 (A)

Q.43 (C)

Q.44 (C)
(42) and **(44)**

$$\mu=\frac{\sin\left(\frac{A+\delta_m}{2}\right)}{\sin\frac{A}{2}} \Rightarrow \sqrt{2}=\frac{\sin\left(\frac{60^o+\delta_m}{2}\right)}{\sin 30^o}$$

$$\Rightarrow \frac{60^o+\delta_m}{2}=45^o$$

∴ δ_{min} = 30º Also i + e = A + δ .
for $\delta=\delta_{min}$ 2i = 60º + 30º ⇒ i = 45º

(c) for $\delta=\delta_{max}$

$$e=90^o \Rightarrow r_2=\sin^{-1}\left(\frac{1}{\mu}\right)$$

$\Rightarrow \quad r_2 = \sin^{-1}\left(\frac{1}{\sqrt{2}}\right) = 45^o \Rightarrow r_1 = A - r_2 = 15^o$

$\frac{\sin i}{\sin 15^o} = \mu = \sqrt{2}$

$\sin i = \sqrt{2} \ \sin 15^o$

$i = \sin^{-1}(\sqrt{2} \ \sin 15^o)$

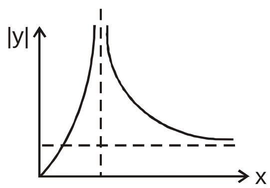
$\delta_{max} = i + e - A = 30^o + \sin^{-1}(\sqrt{2} \ \sin 15^o)$

Q.45 (A) p (B) p (C) q (D) q

(A) For converging lens (convex lens)

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

$u = -x$, $v = y$, $f = d$ (+ ve constant)



$\frac{1}{v} + \frac{1}{x} = \frac{1}{d}$

$\frac{1}{y} = \frac{1}{d} - \frac{1}{x}$

at x = 0
y = 0
For x = 0 to x = d, y = – ve
so, if x ↑ y ↓ and |y| ↑
At x = d, y = ∞
when x > d , y + ve, and
at x = ∞ , y = d
taking magnitude of y, distance graph is shown.

(B) For converging mirror (concave mirror)

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

$u = -x$, $f = -\frac{R}{2}$, $v = y$

$\frac{1}{y} - \frac{1}{x} = -\frac{2}{R}$

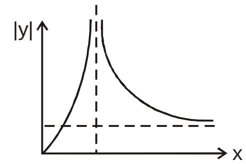
$\frac{1}{y} = \frac{1}{x} - \frac{2}{R}$

At x = 0, y = 0

for $0 < x < \frac{R}{2}$, y = +ve

and as x increases $\frac{1}{y}$ decrease so y ↑ upto $x = \frac{R}{2}$

At $x = \frac{R}{2}$, $y = \infty$



$x = \frac{R}{2} \quad y = \infty$

So, graph is (1)

when $x > \frac{R}{2}$ y (–ve)

and as x ↑, 1/y ↓ , y ↑ so, |y| ↓

At $x = \infty$, $y = -\frac{R}{2}$

graph breaks so graph is (1)

(C) For diverging Lens (concave lens)

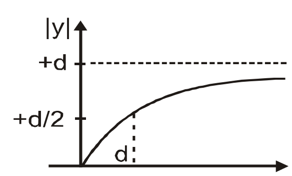
$\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$

$u = -x$, $f = -d$ $v = y$

$\frac{1}{y} + \frac{1}{x} = -\frac{1}{d}$

$\frac{1}{y} = -\frac{1}{x} - \frac{1}{d}$

⇒ y is always –ve
At x = 0, y = 0



As x ↑, y ↓ so, |y| ↑

At x = d, $y = \frac{-d}{2}$

or x = ∞, y = – d
graph is (2)

(D) For diverging Mirror (convex mirror)

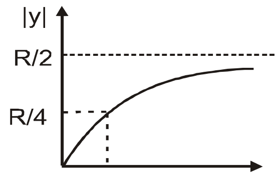
$\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$

$u = -x$, $f = +\frac{R}{2}$, $v = y$

$\frac{1}{y} - \frac{1}{x} = \frac{2}{R} \Rightarrow \frac{1}{y} = \frac{1}{x} + \frac{2}{R} \Rightarrow y =$ +ve

At x = 0 , y = 0

$\frac{dy}{dx} = \frac{y^2}{x^2}$



$x\uparrow$, $y\uparrow$

At $x = \frac{R}{2}$, $y = \frac{R}{4}$,

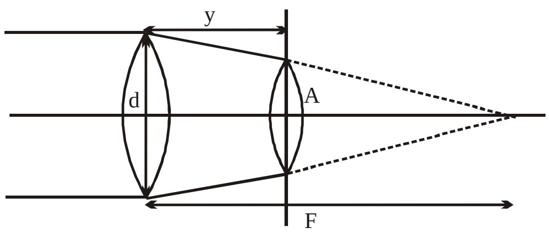
At $x = \infty$, $y = \frac{R}{2}$

taking magnitude of y distance graph is graph is (2)

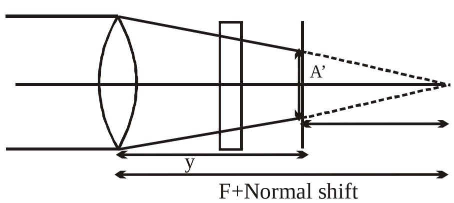
Q.46 (i) B,D;(ii)A,B,C,D;(iii) A,B,D; (iv) D
Convex mirror always forms virtual image of real object.

NUMERICAL VALUE BASED

Q.1 [12 mm]

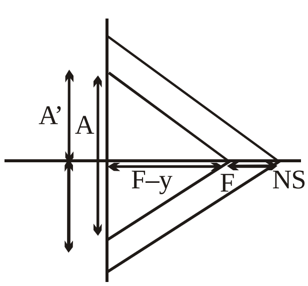


$$\frac{F-y}{F} = \frac{A}{d}$$



Normal shift = $h\left(1-\frac{1}{n}\right)$

$$\frac{A}{F-y} = \frac{A'}{F-y+h\left(1-\frac{1}{n}\right)}$$



$$A' = A\left[1+\frac{h}{F-y}\left(1-\frac{1}{n}\right)\right]$$

$$F-y = \frac{AF}{d}$$

$$A' = A\left[1+\frac{dh}{AF}\left(1-\frac{1}{n}\right)\right]$$

$$=1\left[1+\frac{2\times 3}{1\times 10}\left(1-\frac{1}{1.5}\right)\right] = 1.2 \text{ cm} = 12 \text{ mm.}$$

Q.2 [60]
Beam is parallel to base $\Rightarrow$ mm deviation

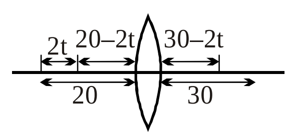
$$\mu = \frac{\sin\left(\frac{\delta+\gamma}{2}\right)}{\sin\left(\frac{\delta}{2}\right)} \Rightarrow \sqrt{3} = \frac{\sin\left(\frac{60+\gamma}{2}\right)}{\sin\left(\frac{60}{2}\right)}$$

$$\sin\left(\frac{60+\gamma}{2}\right) = \frac{\sqrt{3}}{2}$$

$$\Rightarrow \frac{60+\gamma}{2} = 60$$

$\gamma = 60°$

Q.3 [6]
$u = -(30 - 2t)$



$v = 20 - 2t$

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

$$\frac{1}{20-2t} + \frac{1}{30-2t} = \frac{1}{5}$$

$$\frac{50-4t}{600+4t^2-100t} = \frac{1}{5}$$

$250 - 20 = 600 + 4t^2 - 100t$
$4t^2 - 80\,t + 350 = 0$

$$t = \frac{40 \pm \sqrt{1600-1400}}{4} = \frac{40-14}{4} = 6.465 \text{ sec.}$$

Q.4 [10]

Refraction plane surface

$$h' = h\frac{\mu_r}{\mu_i} = \frac{20\times 3/2}{1} = 30 \text{ cm}$$

Mirror

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

$$\frac{1}{v}+\frac{1}{-45}=\frac{1}{-10}$$

$$v = -\frac{90}{7} \text{ from pole of mirror.}$$

distance of object from plane surface

$$l = 15 - \frac{90}{7} = \frac{105-90}{7} = \frac{15}{7}$$

Refraction at plane surface

$$x = 10\ l' = l\frac{\mu_r}{\mu_i}$$

$$x = l' = \frac{15}{7}\times\frac{1}{3/2} = \frac{10}{7} \Rightarrow 7x = 10$$

(location of final image from plane surface)

Q.5 [24 cm]

(I) Image by partial reflection = 12 cm below water surface

(II) For mirror object appears at

$$\frac{u}{4/3} = \frac{24}{4/3} + \frac{12}{1}$$

$$u = 24 + 12 \times \frac{4}{3} \Rightarrow \quad u = 40 \text{ cm}$$

Reflection

$$\frac{1}{v} + \frac{1}{-40} = \frac{1}{+60} \quad \Rightarrow \quad \frac{1}{v} = \frac{1}{60} + \frac{1}{40}$$

$\Rightarrow$ v = +24 cm

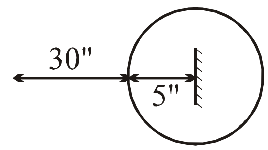
Refraction

$$\frac{AI}{1} = \frac{48}{4/3} = 36 \text{ cm}$$

Thus, distance between two images = 36 – 12 = 24 cm

Q.6 [21]

$$\frac{4}{3v} - \frac{1}{-30} = \frac{\frac{4}{3}-1}{5}$$



$$\frac{4}{3v} = \frac{1}{15} - \frac{1}{30} = \frac{1}{30}$$

v = 40" $\Rightarrow$ u = 35"

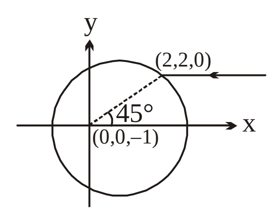
$$\frac{1}{v} - \frac{4/3}{+30} = \frac{1-4/3}{-5}$$

$$\frac{1}{v} - \frac{6}{90} + \frac{4}{90}$$

v = 9"

distance from observer = 21"

Q.7 [32]



$$\hat{n} = \frac{2\hat{i}+2\hat{j}+\hat{k}}{3}$$

$$\hat{e} = -\hat{i}$$

Using, $\hat{r} = \hat{e} - 2(\hat{e}\cdot\hat{n})\hat{n}$

$$\hat{r} = -\hat{i} - \frac{2(-2)}{3}\frac{(2\hat{i}+2\hat{j}+\hat{k})}{3}$$

$$= -\hat{i} + \frac{4}{9}(2\hat{i}+2\hat{j}+\hat{k}) = \frac{-\hat{i}+8\hat{j}+4\hat{k}}{9}$$

Q.8 [10]

$$\frac{2mg}{k} = 5\times 10^{-2}$$

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

$$\frac{1}{v} = \frac{1}{-10} - \frac{1}{-20} = \frac{-2+1}{20}$$

v = – 20 cm

d_1 = 20 cm (initial distance of image from mirror)

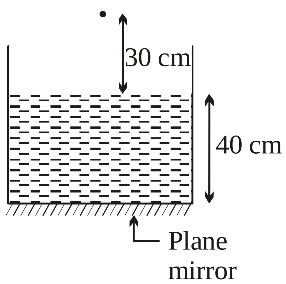
$$\frac{1}{v} = \frac{1}{-10} - \frac{1}{-15} = \frac{-3+2}{30}$$

v = – 30 cm

d_2 = 30 cm (final distance of image from mirror)

$d_2 - d_1$ = 10 cm (distance in which the image oscillates)

Q.9 [8.00]



$v_0 = -4$ m/s ↓ -ve

$v_{i/m} = -\mu v_0$

$v_{i/m} = +4/3 \times 4$

$v_{i/m} = +16/3$

$$v_{i/G} = \frac{v_{i/m}}{\mu}$$

$$v_{i/G} = \frac{+16/3}{4/3} = 4$$

$v_{i/0} = 4 - (-4) = 8$ m/s

Q.10 [5 mm]

u = – 24

$$v = \frac{uf}{u+f}$$

$$v = \frac{-24 \times 15}{-24+15} = \frac{124 \times 15}{8} = 40$$

⇒ D = 200 – 24 – 40 = 136 cm

$$\frac{R_I}{-0.03} = \frac{v}{u} = \frac{40}{-24}$$

$$R_I = \frac{40}{24} \times 0.03 = 0.05 \text{ mm}$$

⇒ d = 0.05 × 2 + 0.06 = 0.16 × 10^{-3} m

$$\beta = \frac{\lambda D}{d} = \frac{6000 \times 10^{-10} \times 136 \times 10^{-2}}{0.16 \times 10^{-3}}$$

β = 51 × 10^{-4}m = 5.1 mm

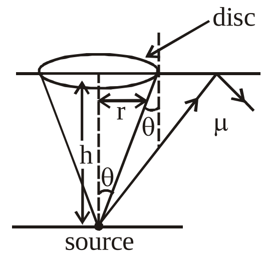
KVPY PREVIOUS YEAR'S

Q.1 (a) Object is at 2*f*, so the image is formed at the same distance from the lens (20 cm) to the right.

(b) Since light has to retrace its path, the mirror should be placed so that the previous image is at its centre of curvature. Thus the mirror must be placed 30 cm to the right of the lens.

(c) For the plane mirror, reflection forms an image 40 cm to the right of the lens. Using the lens formula, we see that the final image is formed at a distance of 40/3 cm to the left of the lens.

Q.2 (B)



r should be such that rays beyond it got totally internally reflected

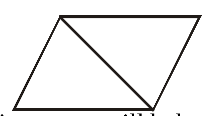
For this θ > C or sin θ > sin C

also $\mu = \frac{1}{\sin C}$ $\therefore \frac{r}{\sqrt{h^2+r^2}} > \frac{1}{\mu}$

In limiting case $\frac{r}{\sqrt{h^2+r^2}} = \frac{1}{\mu}$

solving we get $\boxed{r = \frac{h}{\sqrt{\mu^2-1}}}$

Q.3 (3)

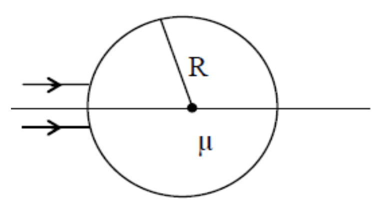


This system will behave as slab.

∴ No dispersion

No deviation

Q.4 (A)



now $\frac{\mu}{V_1} - \frac{1}{\infty} = \frac{\mu-1}{R} \Rightarrow V_1 = \frac{\mu R}{\mu-1}$

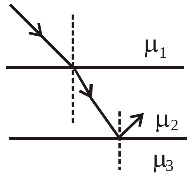
now $\frac{1}{V_f} - \frac{\mu}{-(2R - V_1)} = \frac{1-\mu}{-R}$

replace V_1 by $\frac{\mu R}{\mu - 1}$ and solving for V_f

we get $V_f = \frac{R(\mu-2)}{2(\mu-1)}$

First image is real and second is virtual.

Q.5 (D)
At first incidence light is deviated towards the normal therefore $\mu_2 > \mu_1$. Also at second incidence TIR takes place therefore $\mu_2 > \mu_3$, also $\mu_1 > \mu_3$ because for the same angle in medium μ_2, angle in μ_1 medium is less.



$\therefore \quad \mu_3 < \mu_1 < \mu_2$

Q.6 (B)
$1.5 \times \sin i = 1.2 \sin r$

$\text{Sinr} = \frac{1.5}{1.2}\sin i$

TIR should not take place

$\therefore \sin r < 1$

$\frac{1.5}{1.2}\sin i < 1$

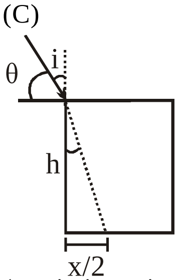
$\text{Sini} < \frac{12}{15}$

$\sin i < 0.8$

$\sin 45 = \frac{1}{\sqrt{2}} = 0.707$

$i_{max} > 45$

Q.7 (C)



$1 \times \sin i = \mu \sin r$

$\sin(90 - \theta) = \frac{4}{3}\sin r$

$\tan r = \frac{x}{2h} = \frac{4}{7 \times 2} = \frac{2}{7}$

$\sin r = \frac{2}{\sqrt{53}}$

$\cos\theta = \frac{4}{3} \times \frac{2}{\sqrt{53}} = \frac{8}{3\sqrt{53}}$

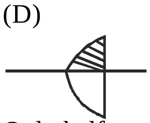
Q.8 (C)
$i = 45^\circ \geq C$

For minimum refractive index C = 45º

$\mu \sin 45^\circ = 1$

$\mu = \sqrt{2} = 1.42$

Q.9 (D)



Only half part of the lens will be used so its intensity will be decreased

Q.10 (A)

$R = \frac{h'}{\sqrt{\mu^2 - 1}}$

Q.11 (D)
$\mu_1 < \mu_3 < \mu_2$

Q.12 (A)
Perpendicular incidence so no deviation.

Q.13 (D)
$\angle i = 2\angle r$

$\frac{\sin i}{\sin r} = \sqrt{3}$

$2\cos r = \sqrt{3}$

r = 30° & i = 60°

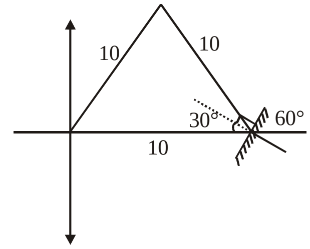
Note : But for r = 30° TIR cannot take place at B.

Q.14 (B)

$\mu(\lambda) = B + \frac{C}{\lambda^2} + \ldots$

$\mu_2 > \mu_1 > \mu_3$

Q.15 (D)



60°

Q.16 (B)
u = –10 m
R = 1.5 m

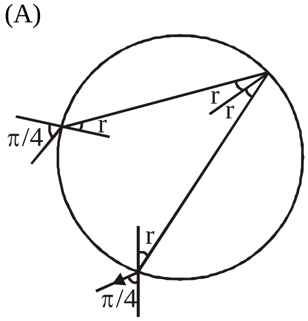
$\frac{1}{v} + \frac{1}{u} = \frac{2}{R}$

$\frac{1}{v} - \frac{1}{10} = \frac{2}{1.5}$

$v = \frac{30}{43}$

$m = -\frac{v}{u} = \frac{30}{43 \times 10} \sim 0.07$

Q.17 (A)



$S_1 = \frac{\pi}{4} - r$

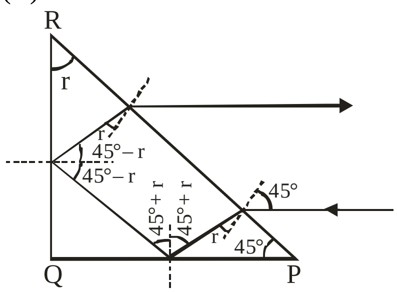
$S_2 = \pi - 2r$

$S_3 = \frac{\pi}{4} - r$

$S = S_1 + S_2 + S_3 = \frac{3\pi}{2} - 4r$

Q.18 (A)
On refraction of light, frequency remain unchanged. However speed and wavelength get change.

Q.19 (A)



$45 + r > \theta_c$ .....(1)
$45 - r > \theta_c$ .....(2)
$90° > 2\theta_c$

$45° > \theta_c$ .....(3)
$\sin 45° > \sin \theta_c$

$\frac{1}{\sqrt{2}} > \frac{1}{\mu}$

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

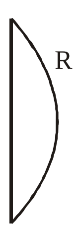
taking equation 2 only
$45 - \theta_c > r$, $\sin(45° - \theta_c) > \sin r$

$\frac{1}{\sqrt{2}}\cos\theta_c - \frac{1}{\sqrt{2}}\sin\theta_c > \frac{\sin 45}{\mu}$

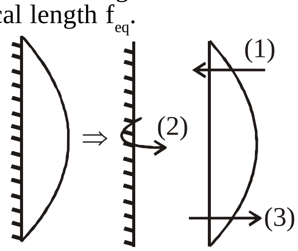
$\frac{\sqrt{u^2}-1}{\mu} - \frac{1}{\mu} > \frac{1}{\mu}$, $\sqrt{\mu^2} - 1 > 2$, $\boxed{\mu > \sqrt{5}}$

$\therefore$ Ans is $\mu > \sqrt{5}$ as this is common solution.

Q. 20 (B)



f = 10 cm
After silvering of flat face lens behave as mirror of focal length f_{eq}.



$\frac{1}{f_{eq}} = \frac{1}{f_1} + \frac{1}{f_2} + \frac{1}{f_3}$

$\frac{1}{f_{eq}} = \frac{2}{f_1} + \frac{1}{f_2}$

$\frac{1}{f_{eq}} = \frac{2}{10} + \frac{1}{\infty}$

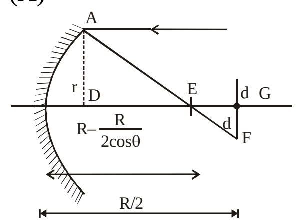
$f_{eq} = 5$

mirror formula $\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$

$\frac{1}{-5} = \frac{1}{-30} + \frac{1}{v}$

v = –6 cm
Image is real and 6 cm away from silvered lens.

Q.21 (A)



d = radius of disc
$A = \pi d^2$
From similar triangle

$$\frac{AD}{FG} = \frac{DE}{GE}$$

$$\frac{r}{d} = \frac{R - \frac{R}{2\cos\theta}}{\frac{R}{2} - \left(R - \frac{R}{2\cos\theta}\right)}$$

$$\frac{r}{d} = \frac{2\cos\theta - 1}{-\cos\theta + 1}$$

$$d = \left(\frac{-\cos\theta + 1}{2\cos\theta - 1}\right).r$$

$$\because \sin\theta = \frac{r}{R}$$

$$\therefore \cos\theta = \frac{\sqrt{R^2 - r^2}}{R}$$

$$\cos\theta = \left(1 - \frac{r^2}{R^2}\right)^{1/2}$$

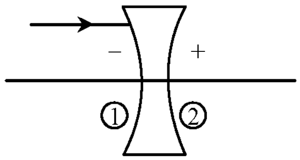
$$\cos\theta = 1 - \frac{1}{2}\frac{r^2}{R^2}$$

$$1 - \cos\theta = \frac{r^2}{2R^2}$$

$$d = \frac{r^2 \times r}{2R^2\left[2\left(1 - \frac{r^2}{2R^2}\right) - 1\right]}$$

$$d = \frac{r^3}{2R^2\left[1 - \frac{r^2}{2R^2}\right]} = \frac{r^3}{2R^2} \Rightarrow A = \pi d^2 = \frac{\pi r^6}{4R^4}$$

Q.22 (D)



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

$R_1=-0.2$; $R_2=0.2$

$n_2=1.6$; $n_1=2.0$

$$\frac{1}{f}=\left[\frac{1.6-2}{2}\right]\left[\frac{1}{-0.2}-\frac{1}{0.2}\right]$$

$$\Rightarrow \frac{(-0.4)}{2}\times\frac{2}{(-0.2)}$$

$$\frac{1}{f}=\frac{2}{1}$$

f = 0.5 metre

Converging lens as f is positive.

Q.23 (B)

Q.24 (C)

Snell law

sin i = μ sin r

$$\sin i=\left(a+\frac{b}{\lambda^2}\right)\sin r$$

Differentiating with respect to λ

$$0=\cos r\ dr\left(a+\frac{b}{\lambda^2}\right)+\sin r\left(\frac{b}{\lambda^3}(-2)\right)d\lambda$$

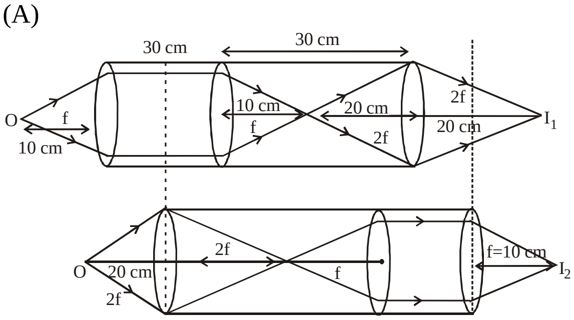
$$0=\cos r\ dr\left(\frac{a\lambda^2+b}{\lambda^2}\right)+\sin r\left(\frac{-2b}{\lambda^3}\right)d\lambda$$

$$\frac{d\lambda\ 2b\sin r}{\lambda}=\cos r\ dr\left(a\lambda^2+b\right)$$

$$dr=\frac{2bd\lambda}{\lambda}=\frac{\tan r}{\left(a\lambda^2+b\right)}$$

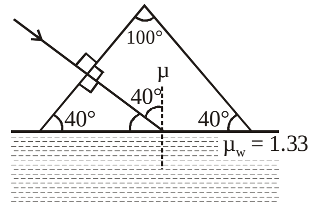
$$\delta r=\frac{\left(2b\tan r\right)\delta\lambda}{\left(a\lambda^3+b\lambda\right)}$$

Q.25 (A)



Distance between object to image in both case is 90 cm. Because object is at same position so image also be at same position in both cases.

Q.26 (B)



For TIR

$40° > \theta_c$

$\sin 40° > \sin\theta_c$

$$\sin 40° > \frac{\mu_r}{\mu_D}$$

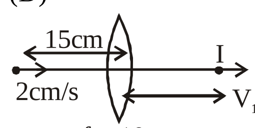
$$\sin 40° > \frac{\mu_w}{\mu_g}$$

$$\mu_g > \frac{\mu_w}{\sin 40°}$$

$$\mu > \frac{1.33}{0.64}$$

μ > 2.07

Q.27 (D)



f = 10cm

f = 10 cm

u = –15cm, f = +10 cm

$$\frac{1}{v}-\frac{1}{u}=\frac{1}{f}\Rightarrow\frac{fu}{u+f}$$

$$v=\frac{(+10)(-15)}{-15+10}$$

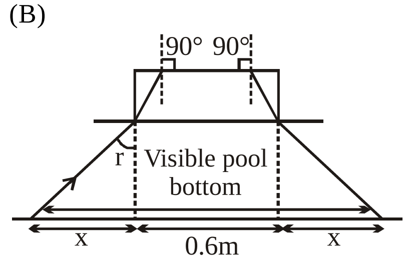
v = +30 cm

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

$$\frac{dv}{dt}=\left(\frac{+30}{-15}\right)^2 (+2\text{ cm/s})$$

$$\frac{dv}{dt}=+8\text{ cm/s (away from lens)}$$

Q.28 (B)



Snell law $1\times\sin 90° = \frac{4}{3}\sin r$

$$\sin r=\frac{3}{4}$$

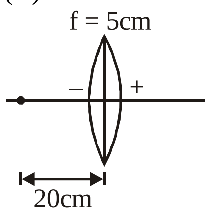
$$\tan r=\frac{3}{\sqrt{7}}$$

$x = 6 \tan r = \frac{6\times 3}{\sqrt{7}} = \frac{18}{\sqrt{7}} = 6.8$

(D) diameter = 2x + 0.6 $\Rightarrow$ 14.2

$\text{Area} = \frac{\pi D^2}{4} = \frac{3.14\times(14.2)^2}{4}\ m^2 \approx 160\ m^2$

Q.29 (A)



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

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

$v = \frac{fu}{f+u}$

$m = \frac{v}{u} = \frac{f}{f+u}$

As lens is oscillating with small amplitude A.

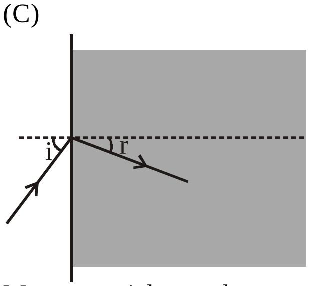
$\therefore$ Image will oscillate with m^2A

When lens move left then O will come near to lens thus I will go away. Thus image is oscillating out of phase with respect to lens.

$m = \frac{5}{5-20} \Rightarrow \frac{5}{-15} = -\frac{1}{3}$

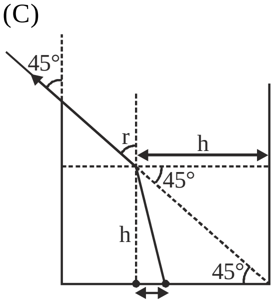
Amplitude of image $= \left(\frac{1}{3}\right)^2 A = \frac{A}{9}$

Q.30 (C)



Meta materials are the material for which refractive index is negative for them. Refraction diagram is shown, here. In question same type of diagram is given.

Q.31 (C)

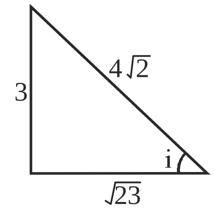


From diagram r = 45°

using snell law

$\frac{4}{3}\sin i = \sin r$

$\sin i = \frac{3}{\sqrt{2}\times 4}$



$\tan i = \frac{3}{\sqrt{23}}$

$\tan i = \frac{h-10}{h}$

h tan i = h – 10

10 = h [1 – tan i]

$h = \frac{10}{1-\tan i}$

$\Rightarrow$ 27 approx.

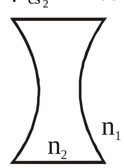
= 27 cm

Q.32 (D)

$\mu_{air} = 1$

$\mu_{water} = 1.33$

$\mu_{cs_2} = 1.6$



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

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

for diverging lens f must be – ve.

$\therefore$ for this $\frac{n_2}{n_1} > 1$

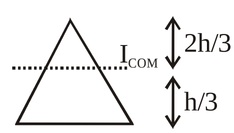
$n_2 > n_1$

$\therefore$ Lens should be filled with liquid which has more refractive index in comparison to liquid in which lens is immersed.

$\therefore$ Ans (D) is the correct option as

$\mu_{cs_2} > \mu_{water}$

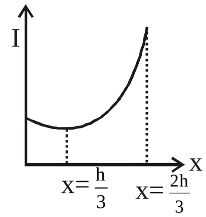
Q.33 (A)



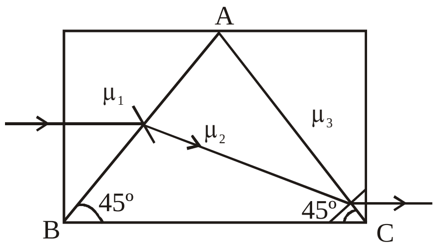
$I = I_{COM} + Mx^2$

First it will decrease because x is increasing and axis is coming closer to COM axis. After Passing COM axis, M&I will again increase.

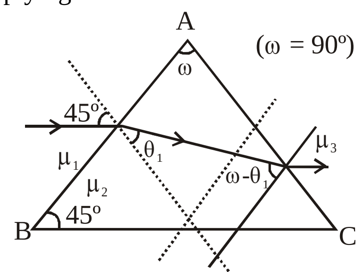
$\Rightarrow$ I is minimum about the axis passing through COM if we compare I about parallel axis



Q.34 (C)



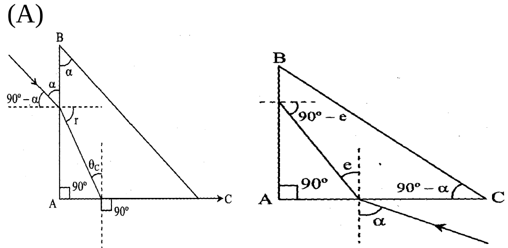
Applying snell's law



for surface AB:
$\mu_1 \sin 45^\circ = \mu_2 \sin\theta_1$ ....(1)
for surface AC :
$\mu_2 \sin(\omega - \theta_1) = \mu_3 \sin 45$
$\mu_2 \sin 45^\circ = \mu_2 \cos\theta_1$ .....(2) $\omega = 90^\circ$
Squaring and adding equation (1) & (2)

$$\frac{\mu_1^2}{2} + \frac{\mu_3^2}{2} = \mu_2^2 \Rightarrow \mu_1^2 + \mu_3^2 = 2\mu_2^2$$

Q.35 (A)



$r + \theta_c = 90^\circ$ ....(1)
$1 \times \sin(90^\circ - \alpha) = \mu \sin r$

$\cos\alpha = \mu \sin r$ ....(2)
$90^\circ - e > \theta_c$ ....(3)
$\mu \sin e = 1 \times \sin\alpha$ .....(4)
(3) & (4)
$90^\circ - \theta c > e$
$\cos\theta c > \sin e$

$$\cos\theta c > \frac{\sin\alpha}{\mu}$$

$$1 - \sin^2\theta c > \frac{1}{\mu^2}[1 - \mu^2 \sin^2 r]$$

$$1 - \frac{1}{\mu^2} > \frac{1}{\mu^2}[1 - \mu^2 \sin^2(90^\circ - \theta c)]$$

$$1 - \frac{1}{\mu^2} > \frac{1}{\mu^2} - \cos^2\theta c$$

$$1 - \frac{2}{\mu^2} > -\left[1 - \frac{1}{\mu^2}\right]$$

$$2 > \frac{3}{\mu^2}$$

(1) & (2)
$\cos\alpha = \mu \sin(90^\circ - \theta c)$
$\cos\alpha = \mu \cos\theta c$
$\cos\alpha < 1$
$\mu \cos\theta c < 1$

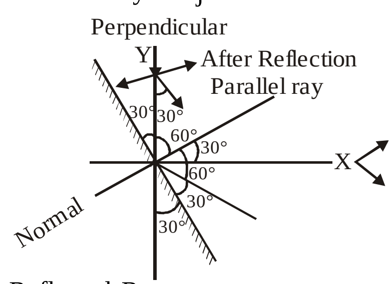
$$\sqrt{1 - \frac{1}{\mu^2}} < \frac{1}{\mu}$$

$$1 - \frac{1}{\mu^2} < \frac{1}{\mu^2}$$

$$\mu < \sqrt{2}$$

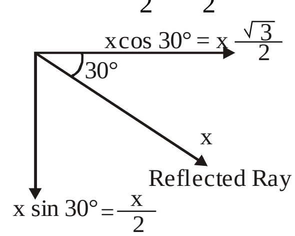
$$\therefore \sqrt{\frac{3}{2}} < \mu < \sqrt{2}$$

Q.36 **(C)**
Incident Ray = $-\hat{j}$



Reflected Ray

Vector $\Rightarrow \frac{\sqrt{3}}{2}\hat{i} - \frac{1}{2}\hat{j}$



Q.37 (B)
Theoretical

Q.38 (D)
(i) For plano-concave lens or concave lens if object is placed beyond focus image is erect.
(ii) For convex lens If object is placed beyond focus image is inverted.

Q.39 **(C)**

$$n = \frac{\sin i}{\sin r} = \frac{\sin\left(\frac{\delta_m + A}{2}\right)}{\sin\left(\frac{A}{2}\right)}$$

$$1.5 + \frac{0.004}{\lambda^2} = \frac{\sin\left(\frac{\delta_m + A}{2}\right)}{\sin\left(\frac{A}{2}\right)}$$

$$\lambda_m \propto \frac{1}{\lambda}$$

$$\therefore \delta_m(\lambda_1) > \delta_m(\lambda_2) \text{ if } \lambda_1 < \lambda_2$$

Q.40 (D)

$9\theta - \theta_1 + 90 - \theta_2 + \theta = 180$

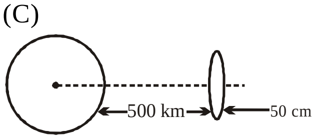
$2\theta_1 + 2\theta_2 = 180$ $\quad\quad$ $\theta = \theta_1 + \theta_2$

$\theta_1 + \theta_2 = 90$ $\quad\quad$ $\theta = 90^o$

Q.41 (B)

The double rainbow has red on the inside and violet on the outside.

Q.42 (C)



$$\frac{A_0}{A} = \left[\frac{u}{v}\right]^2 \Rightarrow A_0 = 10^{12} A$$

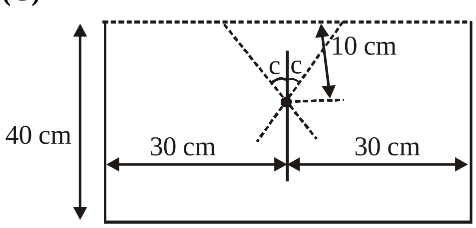
Q.43 (B)

$$d = \frac{5}{4/3} + \frac{2}{3/2} = \frac{15}{4} + \frac{4}{3} = 5.08 \text{ cm}$$

Q.44 (B)

Q.45 (C)

Q.46 **(C)**



Light will come out when the angle is less than critical angle 'C'

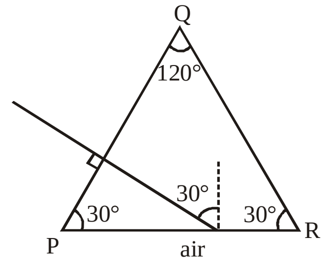
$$\sin c = \frac{1}{1.33} = \frac{3}{4}$$

$\Rightarrow$ c = 50° (approx)

$\omega t = 2c$

$$t = t = \frac{2 \times \frac{50}{180} \times 60}{2\pi} = 16.27 \text{ sec}$$

Q.47 **(C)**



Given that : $\mu_1 < \mu_2 < \mu_3 < \mu_4$

sin c < sin 30° (for emerging)

$$\frac{1}{\mu} < \frac{1}{2}$$

$\mu > 2$

So, rays 3 and 4 will emerge out

Q.48 **(D)**

R.I. of Prism B should be less than R.I. of prism A

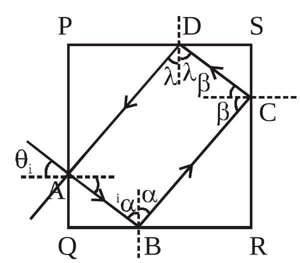
Q.49 **(C)**

From theory

Q.50 **(A)**

From theory

Q.51 **(C)**



From geometry, $\alpha + \theta_i = \frac{\pi}{2} \Rightarrow \alpha = \frac{\pi}{2} - \theta_i$

$\beta + \alpha = \frac{\pi}{2} \Rightarrow \beta = \theta_i$

$\beta + \gamma = \frac{\pi}{2} \Rightarrow \gamma = \frac{\pi}{2} - \theta_i$

Also AD||BC & AB||CD

$\therefore$ ABCD is a parallelogram & AB = CD

Also, $\Delta ABQ \cong DCDS$

$\therefore$ From trignometry

$$\frac{AQ}{QB} = \frac{CR}{BR}$$

Let length of each side of square by l, AQ = x, & QB = y

$\therefore \quad \frac{x}{y} = \frac{\ell - x}{\ell - y} \Rightarrow x = y$

$\therefore \quad \theta_i = \frac{\pi}{4}$

Q.52 (B)

Magnification (m) = $+\frac{v}{u}$

From lens formula,

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

$\therefore$ graph between $\left(\frac{u}{v}\right)$ [inverse of magnification] and u

will be straigh line with slope $\frac{1}{f}$

From graph, slope = 250

$\therefore f = \frac{1}{250} m = 0.004\, m$

Q.53 (C)

(A) Rainbow occurs because of refraction, reflection & dispersion of light.

(B) Dispersion

(C) Due to presence of concentric grooves in compact disc, light gets diffracted & produced colorful pattern.

(D) Due to scattering of blue color.

Q.54 (B)

Theoretical → B

Q.55 (A)

Since the images are being made on screen, hence real.

$\therefore$ Image will be inverted

Also since blue and white are nearer to lens, hence their real image will be far from lens as compared to red & green

Hence Ans. (A)

Q.56 (A)

$n_P \sin\theta_C = n_L \sin 90°$

$\theta_C = \sin^{-1}\left(\frac{n_L}{n_P}\right)$

$\theta_C = \sin^{-1}\left(\frac{C_A n_A + (1 - C_A) n_B}{1.5}\right)$

→ Graph between θ_C and C_A will be curve of $\sin^{-1}$, Check for C_A = 0.5, to find most appropriate graph

$\theta_C = \sin^{-1}\left(\frac{0.5(1.5) + 0.5(1.3)}{1.5}\right)$

$\theta_C = \sin^{-1}\left(\frac{14}{15}\right) \simeq 69°$

$\therefore$ Correct option is (A)

Q.57 (B,C,D)

$n_1 > n_2$

this means light is going from rarer to denser medium.

So θ_2 will always be less than θ_1

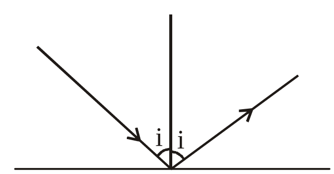
$n_2 \sin\theta_1 = n_1 \sin\theta_2$

So $\cos(\theta_2)$ will never be imaginary and also q_2 can't be 90°.

In question incorrect options are asked.

$\therefore$ (B,C,D)

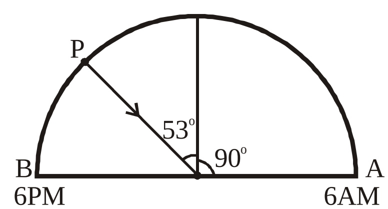
Q.58 (B)



Camera will receive minimum intensity when. Light will incident at Brewsters.s angle.

$\therefore \tan i = \mu = 4/3$

$\Rightarrow i = 53°$



time taken by sun to go from A to P

will be $\frac{12\,hr}{180^o} \times 143^o$ = 9.53 hr = 9 hr 32 min.

$\therefore$ time = 6 AM + 9 hr 32 min ⇒ 3:32 PM

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Q.1 [15cm]

$m = \frac{f}{f + u} \Rightarrow m_1 = -m_2$

$\therefore \quad \frac{f}{f + (-10)} = \frac{-f}{f + (-20)}$

So $\frac{1}{f-10} = -\frac{1}{f-20}$

$f - 10 = -f + 20$

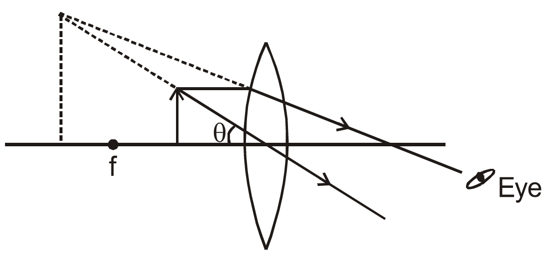
$\therefore\ 2f = +30$

$\therefore\ f = +15$ cm

Q.2 (4)

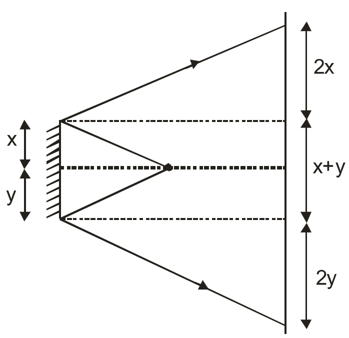
Same orientation so image is virtual. It is combination or real object and virtual image using height it is possible only from convex mirror.

Q.3 (3)



Both obtain same angle, since image can be at a distance greater than 25 cm, object can be moved closer to eye Eye

Q.4 [150]



= 3(x + y)

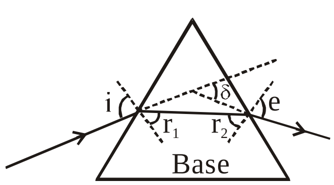
= 3(50)

= 150 cm

Q.5 **(1)**

Deviation is minimum in a prism when :

$i = e$, $r_1 = r_2$ and ray (2) is parallel to base of rism.



Q.6 **(2)**

$$\frac{1}{F} = \left[\frac{\mu_L}{\mu_S} - 1\right]\left[\frac{1}{R_1} - \frac{1}{R_2}\right]$$

If $\mu_L = \mu_S \Rightarrow \frac{1}{F} = 0 \Rightarrow F = \infty$

Q.7 **(1)**

Red light and blue light have different wavelength and different frequency.

Q.8 **[12]**

$\omega_1 = 0.02$; $\mu_1 = 1.5$; $\omega_2 = 0.03$;

$\mu_2 = 1.6$

Achromatic combination

$\therefore\ \theta_{net} = 0$

$\theta_1 - \theta_2 = 0$

$\theta_1 = \theta_2$

$\omega_1\ \delta_2 = \omega_2\ \delta_2$

& $\delta_{net} = \delta_1 - \delta_2 = 2°$

$$\delta_1 - \frac{\omega_1\delta_1}{\omega_2} = 2°$$

$$\delta_1\left(1 - \frac{\omega_1}{\omega_2}\right) = 2°$$

$$\delta_1\left(1 - \frac{2}{3}\right) = 2°$$

$\delta_1 = 6°$

$\delta_1 = (\mu_1 - 1)\ A_1$

$6° = (1.5 - 1)\ A_1$

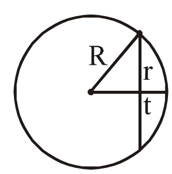
$A_1 = 12°$

Q.9 **(4)**

$R^2 = r^2 + (R - t)^2$

$R^2 = r^2 + R^2 + t^2 - 2Rt$

Neglecting t^2, we get



$$R = \frac{r^2}{2t}$$

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

$$f = \frac{R}{\mu - 1} = \frac{r^2}{2t(\mu - 1)} = \frac{(3\times10^{-2})^2}{2\times3\times10^{-3}\times\left(\frac{3}{2} - 1\right)}$$

$= \frac{9\times10^{-4}}{6\times10^{-3}\times1} \times 2$

f = 0.3 m = 30 cm

Q.10 [30]

$\lambda m = \frac{\lambda_a}{\mu} \Rightarrow \mu = \frac{3}{2}$

$\frac{\mu}{v} - \frac{1}{u} = \frac{\mu-1}{R}$

$\frac{3}{2\times10} + \frac{1}{15} = \frac{\frac{3}{2}-1}{R}$

$R = \frac{30}{13}$

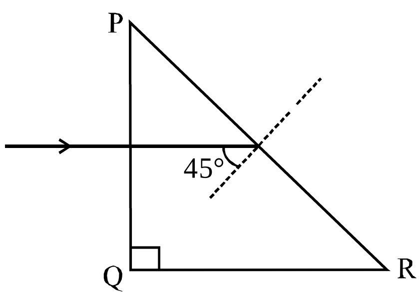
= 30

Q.11 **(2)**

If distant objects are blurry then problem is Myopia.

If objects are distorted then problem is Astigmatism

Q.12 **(2)**



Assuming that the right angled prism is an isoceles prism, so the other angles will be 45° each.

$\Rightarrow$ Each incident ray will make an angle of 45° with the normal at face PR.

$\Rightarrow$ The wavelength corresponding to which the incidence angle is less than the critical angle, will pass through PR.

$\Rightarrow$ θC = critical angle

$\Rightarrow \theta C = \sin^{-1}\left(\frac{1}{\mu}\right)$

$\Rightarrow$ If $\theta C \geq 45°$

the light ray will pass

$\Rightarrow (\theta C)\text{Red} = \sin^{-1}\left(\frac{1}{1.27}\right) = 51.94°$

Red will pass.

$\Rightarrow (\theta C)\text{Green} = \sin^{-1}\left(\frac{1}{1.42}\right) = 44.76°$

Green will not pass

$\Rightarrow (\theta C)\text{Blue} = \sin^{-1}\left(\frac{1}{1.49}\right) = 42.15°$

Blue will not pass

$\Rightarrow$ So only red will pass through PR.

Q.13 [**25**]

Q.14 (4)

Q.15 **[60]**

Q.16 **(4)**

Q.17 (2)

Q.18 (3)

Q.19 (1)

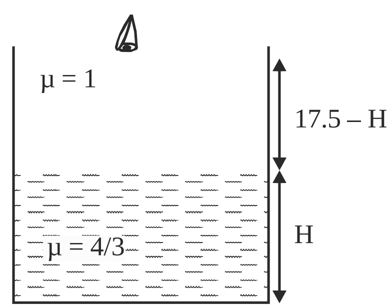
Q.20 (1)

Q.21 [600]

Q.22 (2)

Q.23 [2]

Q.24 (2)



Height of water observed by oberver

$= \frac{H}{\mu_w} = \frac{H}{(4/3)} = \frac{3H}{4}$

Height of air observed by observer = 17.5 – H

According to question, both height observed by observer is same.

$\frac{3H}{4} = 17.5 - H$

$\Rightarrow$ H = 10 cm

Option (2)

Q.25 (2)

Q.26 (3)

Q.27 [50]

Q.28 [5]

$i = A = 60^o$

$\delta_{min} = 2i - A$

$= 2 \times 60^o - 60^o = 60^o$

$$\mu = \frac{\sin^{-1}\left(\frac{\delta_{min} + A}{2}\right)}{\sin^{-1}\left(\frac{A}{2}\right)} = \sqrt{3}$$

$$V_{prism} = \frac{3\times10^8}{\sqrt{2}}$$

$$AP = 10\times 10^{-2} \times \frac{\sqrt{3}}{2}$$

$$\text{time} = \frac{5\times10^{-2}}{3\times10^8}\times\sqrt{3}\times\sqrt{3}$$

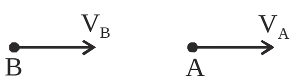
$= 5 \times 10^{-10}$ sec

Ans. 5

Q.29 (1)

Q.30 (1)

Q.31 (4)



Mirror used is convex mirror (rear-view mirror)

$\therefore V_{I/m} = -m^2 V_{O/m}$

Given,

$V_{O/m} = 40$ m/s

$$m = \frac{f}{f-u} = \frac{10}{10+190} = \frac{10}{200}$$

$$\therefore V_{I/m} = -\frac{1}{400}\times 40 = -0.1 m/s$$

$\therefore$ Car will appear to move with speed 0.1 m/s.

Hence option (4)

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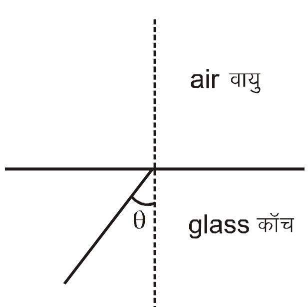
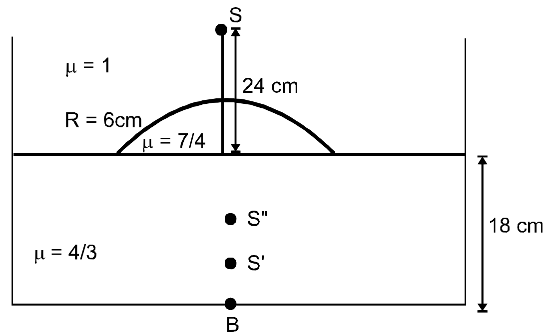
Q.1 (C)



Initially most of part will be transmitted. When $\theta > i_C$, all the light rays will be total internal reflected. So transmitted intensity = 0

So correct answer is (C)

Q.2 **[2]**



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

$$\frac{7}{4v} - \frac{1}{-24} = \frac{\frac{7}{4}-1}{6}$$

$$\frac{7}{4v} = \frac{3}{24} - \frac{1}{24} = \frac{2}{24} = \frac{1}{12}$$

$$\frac{7\times12}{4} = V = 21 \text{ cm}$$

$$\frac{21}{OS"} = \frac{7/4}{4/3}$$

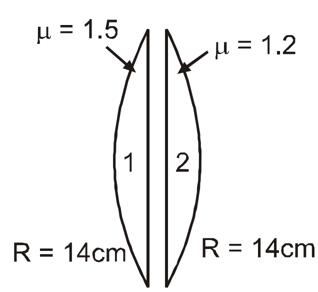
$$\frac{21}{OS"} = \frac{7}{4}\times\frac{3}{4}$$

OS" = 16

$\therefore$ BS" = 2cm

Q.3 (B)

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



$$\frac{1}{f_1} = (1.5-1)\left[\frac{1}{14} - \frac{1}{\infty}\right]$$

$$\frac{1}{f_1} = \frac{0.5}{14}$$

$$\frac{1}{f_2} = (1.2-1)\left[\frac{1}{\infty} - \frac{1}{-14}\right]$$

$$\frac{1}{f_2} = \frac{0.2}{14}$$

$$\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2} \quad = \frac{0.5}{14} + \frac{0.2}{14}$$

$$\frac{1}{f} = \frac{0.7}{14}$$

$$\frac{1}{v} = \frac{7}{140} - \frac{1}{40} \quad = \frac{1}{20} - \frac{1}{40}$$

$$\frac{1}{v} = \frac{2-1}{40}$$

v = 40 cm

Q.4 (B)

$n = \frac{c}{v}$

for metamaterials

$v = \frac{c}{|n|}$

Q.5 (C)

Meta material has a negative refractive index

$\therefore \ \sin\theta_2 = \frac{n_1}{n_2}\sin\theta_1 \Rightarrow \ n_2$ is negative

$\therefore \ \theta_2$ negative

Q.6 (C)

v = 8 m (magnification = $-\frac{1}{3} = \frac{v}{u}$)

u = –24m

$$\frac{1}{f} = \left(\frac{3}{2}-1\right)\left(\frac{1}{\infty} + \frac{1}{R}\right)$$

R = 3m

Hindi : v = 8 m (= $-\frac{1}{3} = \frac{v}{u}$)

u = –24m

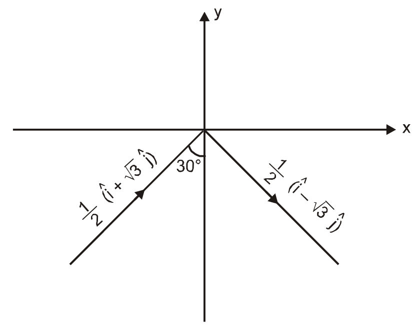
$$\frac{1}{f} = \left(\frac{3}{2}-1\right)\left(\frac{1}{\infty} + \frac{1}{R}\right)$$

R = 3m

Q.7 (A)

Angle between given rays is 120°

so angle of incidence is 30°



Q.8 (A), (C)

$$\frac{1}{f_{film}} = (n_1-1)\left(\frac{1}{R} - \frac{1}{R}\right) \Rightarrow \quad f_{film} = \infty \text{ (infinite)}$$

$\therefore$ No effect of presence of film.

<u>From Air to Glass</u>

Using single spherical Refraction :-

$$\frac{n_2}{v} - \frac{1}{u} = \frac{n_2-1}{R}$$

$$\frac{1.5}{v} - \frac{1}{\infty} = \frac{1.5-1}{R} \Rightarrow \quad v = 3R$$

$\therefore \ f_1 = 3R$

<u>From Glass to Air</u> <u>:-</u>

$$\frac{1}{v} - \frac{n_2}{u} = \frac{1-n_2}{-R}$$

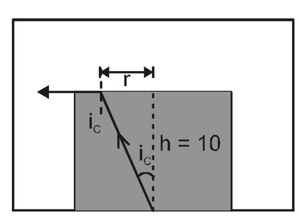
$$\Rightarrow \ \frac{1}{v} - \frac{1.5}{\infty} = \frac{1-1.5}{-R}$$

$\Rightarrow$ v = 2R

$\therefore \ f_2 = 2R$

Q.9 (C)

$$\text{Sin } i_C = \frac{r}{\sqrt{r^2+h^2}}$$



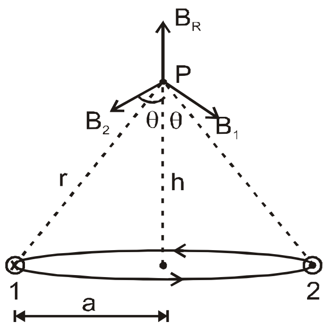
$$\Rightarrow \frac{n_\ell}{n_B} = \frac{r}{\sqrt{r^2+h^2}}$$

$$\Rightarrow n_\ell = \frac{r}{\sqrt{r^2+h^2}} \times 2.72$$

$$= \quad \frac{5.77}{11.54} \times 2.72 = 1.36$$

Q.10 (C)

$\vec{B}_R = \vec{B}$ due to ring



$\vec{B}_1 = \vec{B}$ due to wire - 1

$\vec{B}_2 = \vec{B}$ due to wire -2

In magnitudes $B_1 = B_2 = \frac{\mu_0 I}{2\pi r}$

Resultant of B_1 and $B_2 = 2B_1 \cos\theta = \frac{\mu_0 I a}{\pi r^2}$

$B_R = \frac{2\mu_0 I \pi a^2}{4\pi r^3}$

For zero magnetic field at P

$$\frac{\mu_0 I a}{\pi r^2} = \frac{2\mu o I \pi a^2}{4\pi r^3}$$

$\Rightarrow h \approx 1.2a$

Q.11 (B)

Magnetic field at mid point of two wires = $\frac{\mu_0 I}{\pi d} \otimes$

Magnetic moment of loop = $I\pi a^2$

Torque on loop = M B sin 150° = $\frac{\mu_0 I^2 a^2}{2d}$

Q.12 (B)

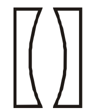
(P)  $\frac{1}{f} = \left(\frac{3}{2}-1\right)\left(\frac{1}{r}+\frac{1}{r}\right) = \frac{1}{r} \Rightarrow$ f = rs

 $\Rightarrow \frac{1}{f_{eq}} = \frac{1}{f} + \frac{1}{f} = \frac{2}{r} \Rightarrow f_{eq} = \frac{r}{2}$

(Q)  $\frac{1}{f} = \left(\frac{3}{2}-1\right)\left(\frac{1}{r}\right) \Rightarrow$ f = 2r

 $\Rightarrow \frac{1}{f} + \frac{1}{f} = \frac{2}{f} = \frac{1}{r} \Rightarrow f_{eq} = r$

(R)  $\frac{1}{f} = \left(\frac{3}{2}-1\right)\left(-\frac{1}{r}\right) = -\frac{1}{2r}$ f = –2r

 $\Rightarrow \frac{1}{f_{eq}} = \frac{1}{f} + \frac{1}{f} = -\frac{2}{2r} \Rightarrow f_{eq} = -r$

(S)  $\Rightarrow \frac{1}{f_{eq}} = \frac{1}{r} + \frac{1}{-2r} = \frac{1}{2r} \Rightarrow f_{eq} = 2r$

(B) P–2 Q –4 R–3 S – 1

Q.13 (A)

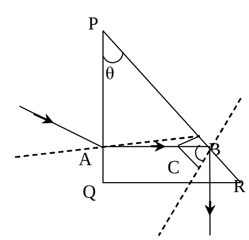
Applying snell's law at *PQ*

$1 \times \sin 45^0 = \sqrt{2} \times \sin r$

$\Rightarrow r = 30^0$

At surface *PR*

$\sin c = \frac{1}{\mu} = \frac{1}{\sqrt{2}}$



$\Rightarrow c = 45^0$

$c + \theta' = 90^0$

$\Rightarrow \theta' = 45^0$

In "PAB,

$\theta + 120^0 + 45^0 = 180^0$

$\Rightarrow \theta = 15^0$

Hence, (A)

Q.14 **(B,C,D)**

For parallel interfaces between media, snell's law can be applied for two different points.

Hence, (b, c, d)

Q.15 **(A,D)**

convex mirror forms virtual image for real object

$$\therefore \frac{1}{+10}+\frac{1}{-30}=\frac{2}{R}$$

R = 30 cm

For image formed by lens,

$$\pm 2=\frac{f}{f-30}$$

$$\Rightarrow f=20 \ Or \ 60$$

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

$$\mu=\frac{f}{R}+1$$

= 2.5 Or 1.5

Hence, (a, d)

Q.16 (A)

For lens,

$$\frac{1}{v}-\frac{1}{50}=\frac{1}{30} \qquad \Rightarrow v=75cm$$

For mirror,

$$\frac{1}{v}+\frac{1}{(75-50)}=\frac{1}{50} \qquad \Rightarrow v=-50 \text{ (At origin)}$$

As mirror is rotated by 30^0, reflected rays will rotate by 60^0.

Hence, (A)

Q.17 (A, C, D)

$\delta_m = (2i) - A$

$\Rightarrow$ 2A = 2i

$\Rightarrow$ i = A and r = A/2 (look solution at right side)

$$\mu=\frac{\sin\left[\frac{A+A}{2}\right]}{\sin\left[\frac{A}{2}\right]}=\frac{2\sin\frac{A}{2}\cos\frac{A}{2}}{\sin\frac{A}{2}}$$

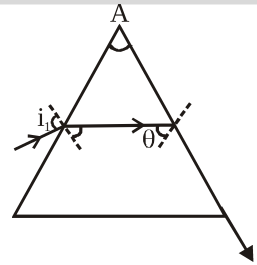
$$\mu=2\cos\frac{A}{2}$$

$1 \sin i_1 = \mu \times \sin(A-\theta_C)$

$$=2\cos\frac{A}{2}[\sin A\cos\theta_C-\cos A\sin\theta_C]$$

$$=2\cos\frac{A}{2}\left[\sin A\sqrt{1-\sin^2\theta_C}-\cos A\frac{1}{\mu}\right]$$

$$=2\cos\frac{A}{2}\left[\sin A\sqrt{1-\frac{1}{\mu^2}}-\frac{\cos A}{\left(2\cos\frac{A}{2}\right)}\right]$$



$$=2\cos\frac{A}{2}\left[\sin A\sqrt{1-\frac{1}{4\cos^2\frac{A}{2}}}-\frac{\cos A}{2\cos\frac{A}{2}}\right]$$

$$i_1=\sin^{-1}\left[\sin A\sqrt{4\cos^2\frac{A}{2}-1}-\cos A\right]$$

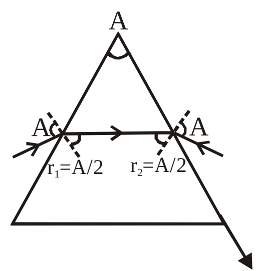
$r_1=\frac{A}{2}$ for minimum deviation.

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

Calculation of r for i = A

1 sin A = μ sin r

$$\sin A = 2\cos\frac{A}{2}.\sin r$$



$$\sin r=\frac{2\sin\frac{A}{2}\cos\frac{A}{2}}{2\cos\frac{A}{2}}=\sin\frac{A}{2} \Rightarrow \quad r=\frac{A}{2}$$

Q.18 **[8]**

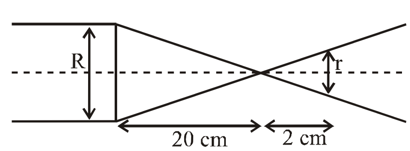
Considering Snell's law between first layer and m[th] layer.

n sin θ = (n – mΔn) sin 90º

$$1.6 \times \frac{1}{2} = (1.6 - n(0.1))1$$

$$m=\frac{0.8}{0.1}=8$$

Q.19 [130]



$$\frac{r}{R}=\frac{2}{20}=\frac{1}{10}$$

$\therefore$ Ratio of area = $\frac{1}{100}$

Let energy incident on lens be E.

$\therefore$ Given $\frac{E}{A}$ = 1.3

So final, $\frac{E}{a}$ = ??

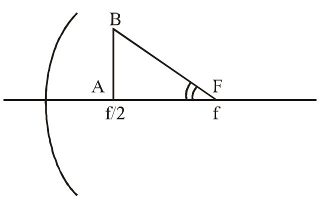
E = A × 1.30

Also $\frac{a}{A}=\frac{1}{100}$

$\therefore$ Average intensity of light at 22 cm = $\frac{E}{a}$ = $\frac{A\times 1.3}{a}$

= 100 × 1.3 = 130 kW/m^2

Q.20 (D)



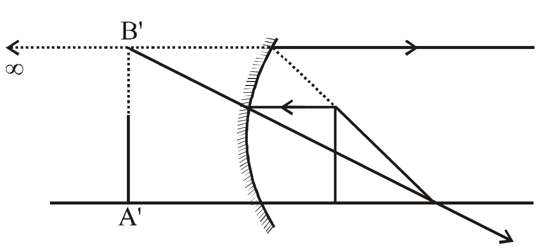
Distance of point A is f/2

Let A' is the image of A from mirror, for this image

$$\frac{1}{v}+\frac{1}{-f/2}=\frac{1}{-f}$$

$$\frac{1}{v}=\frac{2}{f}-\frac{1}{f}=\frac{1}{f}$$

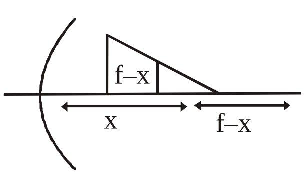
image of line AB should be perpendicular to the principle axis and image of F will form at infinity, therefore correct image diagram is



$$\frac{f}{f-u}=\frac{h_2}{h_1}$$

$$h_2=\frac{-f\left(f-x\right)}{-f+x}$$

$$h_2=f$$



$$\frac{f}{f-u}=\frac{h_2}{h_1}$$

$$h_2=\frac{-f\left(f-x\right)}{-f+x}$$

$$h_2=f$$

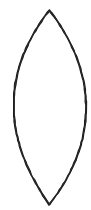
Q.21 (A,C,D)

When $n_1 = n_2 = n$

$$\frac{1}{f}=(n-1)\times\frac{2}{R}$$

So f = $\frac{R}{2(n-1)}$ .....(1)

2nd case :

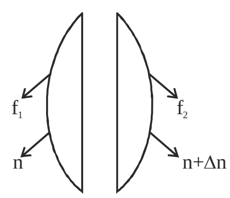


$$\frac{1}{f_1}=\frac{n-1}{R}$$

$$\frac{1}{f_2}=\frac{(n+\Delta n)-1}{R}$$

$$\frac{1}{f_{eq}}=\frac{1}{f+\Delta f}=\left(\frac{n-1}{R}\right)+\frac{(n+\Delta n)-1}{R}=\frac{2(n-1)+\Delta n}{R}$$

$$\Delta f=\left(\frac{R}{2(n-1)+\Delta n}\right)-\left(\frac{R}{2(n-1)}\right)$$



$$=\frac{R}{2}\left[\frac{(n-1)-(n-1+\Delta n)}{(n-1+\Delta n)(n-1)}\right]=\frac{-\Delta n}{(n-1)}\times\frac{R}{2}$$

$$\frac{\Delta f}{f}=-\frac{\Delta n}{2(n-1)}\ .....(2)$$

(1) Relation beteeen $\frac{\Delta f}{f}$ and $\frac{\Delta n}{n}$ is independent of R so (1) is correct.

(2) 2n – 2 < n because n < 2

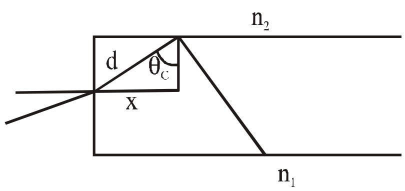
$\Rightarrow \frac{\Delta f}{f}=\frac{1}{2}\left|\frac{\Delta n}{n-1}\right|>\frac{\Delta n}{n}$ So $\frac{\Delta f}{f}>\left|\frac{\Delta n}{n}\right|$ So (2) wrong

(3) $|\Delta f|=\frac{f\Delta n}{(n-1)}=\frac{(20\times 10^{-2})}{1.5-1}$ = 40 × 10^{-3} = 0.04 So (3) is wrong

(4) If $\frac{\Delta n}{n}$ < 0 then $\frac{\Delta f}{f}$ > 0 from equation (2)

Q.22 [50.00]

For maximum time the ray of light must undergo TIR at all surfaces at minimum angle i.e. θ_C



For TIR $n_1 \sin \theta_C = n_2$

$\sin \theta_C = \dfrac{1.44}{1.5}$

In above Δ $\sin\theta_C = \dfrac{x}{d}$

$d = \dfrac{x}{\sin\theta_C}$

Similarly $D = \dfrac{L}{\sin\theta_C}$

where L = length of tube, D = length of path of light

Time taken by light

$t = \dfrac{D}{C} = \dfrac{L/\sin\theta_C}{2\times10^8}$

$t = 50 \times 10^{-9}$ s

Q.23 (C,D)

$H_1 = \dfrac{2H}{3} = \dfrac{2}{3}\times\dfrac{3}{10} = \dfrac{1}{5}$ m

for 2[nd]

$\dfrac{1}{v} + \dfrac{3}{2H} = \dfrac{-1}{2(-3)}$

$\dfrac{1}{v} = \dfrac{1}{6} - \dfrac{10}{2} = \dfrac{1}{6} - \dfrac{30}{6} = \dfrac{-29}{6}$

$H_2 = \dfrac{6}{29} > H1$

For 3[rd]

$\dfrac{1}{v} + \dfrac{3}{2H} = \dfrac{-1}{2(3)}$

$\dfrac{1}{v} = \dfrac{-1}{6} - 5 = \dfrac{-31}{6}$

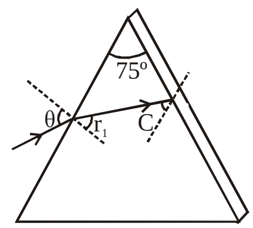
$H_3 = \dfrac{6}{31}$

so $\boxed{H_3 < H_1 < H_2}$ & $(H_2 - H_1)$

$= \dfrac{6}{29} - \dfrac{6}{31} = 0.68\text{cm}$

Q.24 [1.50]

At $\theta = 60^o$ ray incidents at critical angle at second surface So, $\sin\theta = \sqrt{3}\ \sin r_1$



$\dfrac{\sqrt{3}}{2} = \sqrt{3}\ \sin r_1$

$r_1 = 30^o$

$r_2 = 45^o = C$

$\sqrt{3}\ \sin 45^o = n \sin 90^o$

$n = \dfrac{\sqrt{3}}{2} \Rightarrow n^2 = \dfrac{3}{2}$

Q.25 [0.69]

For the given lens

u = –30 cm

v = 60 cm

& $\dfrac{1}{f} = \dfrac{1}{v} - \dfrac{1}{u}$ on solving : f = 20 cm

also $\dfrac{1}{f} = \dfrac{1}{v} - \dfrac{1}{u}$

on differentiation

$\dfrac{df}{f^2} = \dfrac{dv}{v^2} + \dfrac{du}{u^2}$

$\dfrac{df}{f^2} = f\left[\dfrac{dv}{v^2} + \dfrac{du}{u^2}\right]$

& $\dfrac{df}{f}\times100 = f\left[\dfrac{dv}{v^2} + \dfrac{du}{u^2}\right]\times100\%$

f = 20 cm, du = dv = $\dfrac{1}{4}$ cm

Since there are 4 divisions in 1 cm on scale

$\therefore \dfrac{df}{f} \times 100 = 20\left[\dfrac{1/4}{(60)^2} + \dfrac{1/4}{(30)^2}\right]\times100\%$

$= 5\left[\dfrac{1}{3600} + \dfrac{1}{900}\right]\times100\%$

$= 5\left[\dfrac{5}{36}\right]\% = \dfrac{25}{36}\% \approx 0.69\%$

Q.26 (B)

Q.27 (BCD)

Q.28 (BC)

EXERCISES

ELEMENTRY

Q.1 (2)

Q.2 (3)

Huygen's wave theory fails to explain the particle nature of light (*i.e.* photoelectric effect)

Q.3 (3)

$$I_{max} = \left(\sqrt{I_1} + \sqrt{I_2}\right)^2 = \left(\sqrt{I} + \sqrt{4I}\right)^2 = 9I$$

$$I_{min} = \left(\sqrt{I_1} + \sqrt{I_2}\right)^2 = \left(\sqrt{I} + \sqrt{4I}\right)^2 = I$$

Q.4 (4)

$$\frac{I_1}{I_2} = \frac{1}{25}, \therefore \frac{a_1^2}{a_2^2} = \frac{1}{25} \Rightarrow \frac{a_1}{a_2} = \frac{1}{5}$$

Q.5 (3)

$$\frac{a_1}{a_2} = \frac{3}{5}.$$

$$\therefore \frac{I_{max}}{I_{min}} = \frac{(a_1+a_2)^2}{(a_1-a_2)^2} = \frac{(3+5)^2}{(3-5)^2} = \frac{16}{1}$$

Q.6 (3)

For constructive interference path difference is even multiple of $\frac{\lambda}{2}$..

Q.7 (1)

$I \propto a^2$

$$I \Rightarrow \frac{a_1}{a_2} = \left(\frac{4}{1}\right)^{1/2} = \frac{2}{1}$$

Q.8 (3)

$I \propto a^2$

$$1 \Rightarrow \frac{I_1}{I_2} = \left(\frac{a_1}{a_2}\right)^2 = \left(\frac{3}{4}\right)^2 = \frac{9}{16}$$

Q.9 (2)

$\phi = \pi/3$, $a_1 = 4$, $a_2 = 31$

So, $A = \sqrt{a_1^2 + a_2^2 + 2a_1.a_2 \cos\phi} \Rightarrow A \approx 6$

Q.10 (4)

Diffraction shows the wave nature of light and photoelectric effect shows particle nature of light.

Q.11 (3)

For brightness, path difference

So second is bright.

Q.12 (3)

$$\beta = \frac{\lambda D}{d} = \frac{5000 \times 10^{-10} \times 1}{0.1 \times 10^{-3}} \text{ m} = 5 \times 10^{-3} \text{ m} = 0.5 \text{ cm}$$

Q.13 (2)

If intensity of each wave is *I*, then initially at central position $I_0 = 4I$. when one of the slit is covered then intensity at central position will be *I* only *i.e.*, $\frac{I_0}{4}$.

Q.14 (2)

Q.15 (1)

When white light is used, central fringe will be white with red edges, and on either side of it, we shall get few coloured bands and then uniform illumination.

Q.16 (2)

Q.17 (4)

In the presence of thin glass plate, the fringe pattern shifts, but no change in fringe width.

Q.18 (2)

Q.19 (1)

According to given condition

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

So, $(\mu - 1)\, t_{min} = \lambda$

$$t_{min} = \frac{\lambda}{\mu - 1} = \frac{\lambda}{1.5 - 1} = 2\lambda$$

Q.20 (2)

Diffraction is obtained when the slit width is of the order of wavelength of EM waves (or light). Here wavelength of X-rays (1-100 Å) is very-very lesser than slit width (0.6 mm). Therefore no diffraction pattern will be observed.

Q.21 (2)

Polariser produced prolarised light.

Q.22 (3)

If an unpolarised light is converted into plane polarised light by passing through a polaroid, it's intensity becomes half.

JEE-MAIN
OBJECTIVE QUESTIONS

Q.1 (1)

we know $I \propto A^2$.

$\Rightarrow \frac{I_1}{I_2} = \frac{A_1^2}{A_2^2} \quad \Rightarrow \sqrt{\frac{4}{1}} = \frac{A_1}{A_2} \Rightarrow A_1 : A_2 = 2 : 1$

Q.2 (3)

$I_{max} = \left(\sqrt{I_1} + \sqrt{I_2}\right)^2 = \left(\sqrt{4I} + \sqrt{I}\right)^2 = 9I.$

$I_{min} = \left(\sqrt{I_1} - \sqrt{I_2}\right)^2 = \left(\sqrt{4I} - \sqrt{I}\right)^2 = I.$

Q.3 (3)

Contrast indicates the ratio of maximum possible intensity on screen to the minimum possible intensity.

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

so it only depends on the source intensity.

Q.4 (2)

Given $y_1 = A_1 \sin wt$, $f_1 = 0$

$y_2 = A_2 \cos(wt + f) = A_2 \sin\left(\frac{\pi}{2} + \omega t + \phi\right)$

$f_2 = \frac{\pi}{2} + f$

$\Delta f = f_2 - f_1$

$\Delta\phi = \frac{\pi}{2} + \phi \Rightarrow \Delta\phi = \Delta\phi\left(\frac{\lambda}{2\pi}\right)$

$\Delta x = \frac{\lambda}{2\pi} \times \Delta f$

$\Delta x = \frac{\lambda}{2\pi}\left(\frac{\pi}{2} + \phi\right)$

Q.5 (3)

Amplitude depends upon intensity and phase difference.

Q.6 (4)

In interferene there should be two coherent sources and propagation of waves should be simultaneously and in same direction.

Q.7 (3)

In transverse and longitudinal waves.

Q.8 (2)

Wave nature

Q.9 (2)

Principle of Superposition.

Q.10 (2)

$y_1 = A_1 \sin 3\omega t$, $f_1 = 0$

$y_2 = A_2 \cos\left(3\omega t + \frac{\pi}{6}\right)$

$y_2 = A_2 \sin\left(\frac{\pi}{2} + 3\omega t + \frac{\pi}{6}\right)$, $f_2 = \frac{\pi}{2} + \frac{\pi}{6}$

$D f = f_2 - f_1$

$\Delta\phi = \frac{\pi}{2} + \frac{\pi}{6} = \frac{3\pi + \pi}{6} = \frac{4\pi}{6} = \frac{2\pi}{3}$

Q.11 (2)

Given $I_1 : I_2 = 100 : 1$

$\frac{\sqrt{I_1}}{\sqrt{I_2}} = 10 : 1$

$I_{max} = \left(\sqrt{I_1} + \sqrt{I_2}\right)^2 = (10 + 1)^2 = 121$

$I_{min} = \left(\sqrt{I_1} - \sqrt{I_2}\right)^2 = (10 - 1)^2 = 81$

$\frac{I_{max}}{I_{min}} = 121 : 81$

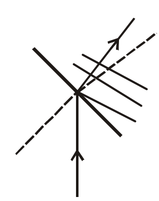
Q.12 (4)

In coherent sources initial phase remains constant.

Q.13 (2)

Phase difference changes with time.

Q.14 (1)



Wave front.

Q.15 (3)

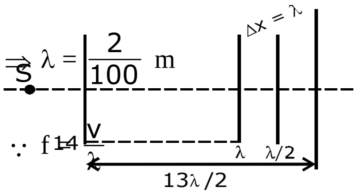
Frequency remains constant wave length decreases.

Q.16 (2)

$\Delta x = n\lambda$ (maxima)

Q.17 (1)

$\frac{13\lambda}{2} = 0.13$



$\Rightarrow \lambda = \frac{2}{100}$ m

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

$\Rightarrow f = \frac{3 \times 10^8 \times 100}{2} = 1.5 \times 10^{10}$ Hz

Q.18 (1)

we know that $\beta = \frac{\lambda D}{d}$ & $\lambda_{yellow} > \lambda_{blue}$.

$\Rightarrow$ as λ decreases, so β also decreases.

Q.19 (2)

As λ << d; we can we $\beta = \frac{\lambda D}{d}$

we get $\beta = \frac{500 \times 10^{-9} \times 1}{10^{-3}} = 0.5$ mm.

As β is not very small; hence it might so happen that till 1000th maxima, we no longer can apply

y' = 1000 × β.

Lets see if we can apply:

At 1000th maxima. Path difference is 1000 λ.

$\Rightarrow 1000\,\lambda = d \sin\theta = \frac{d \times y}{\sqrt{D^2 + y^2}}$

$\Rightarrow (5 \times 10^{-4})^2 = \frac{(10^{-3}\,m)^2 \times y^2}{D^2 + y^2}$

$\Rightarrow 0.25\, D^2 = y^2 (1 - 0.25) \Rightarrow y = \left(\frac{0.25}{0.75}\right)^{\frac{1}{2}} \times D$

$y = \frac{D}{\sqrt{3}} = 0.577$ m.

As 0.577 m. and 0.5 m. are quite distant, so we could not use y' = 1000 β for such a high maxima.

Q.20 (2)

$\Delta\phi = \frac{2\pi}{\lambda}\Delta x$

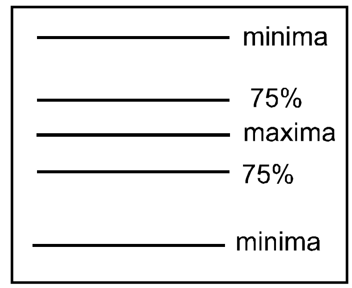
$\Delta\phi = \frac{2\pi}{5460 \times 10^{-10}} \cdot \frac{1 \times 10^{-6}}{10} = 7.692\,\pi$

Q.21 (1)

In monochromatic light, only one wave length is present.

Q.22 (4)

Lets look at the screen.



as we know that 75% intensity will correspond to a point where intensity is $3I_0$.

$\{\because I_{max} = 4I_0\}$

$I = I_0 + I_0 + 2\sqrt{I_0}\sqrt{I_0}\cos(\Delta\phi)$

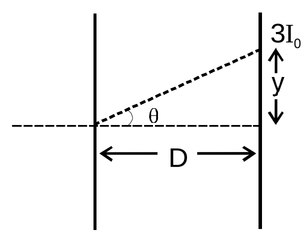
$3I_0 = 2I_0(1 + \cos\Delta\phi)$

$\cos(\Delta\phi) = \frac{1}{2}$

$\Delta\phi = \frac{\pi}{3}, 2\pi - \frac{\pi}{3}, 2\pi + \frac{\pi}{3}, \ldots\ldots\ldots$

$\Delta p = \frac{\lambda}{6}, \lambda - \frac{\lambda}{6}, \lambda + \frac{\lambda}{6}, \ldots\ldots\ldots$

$\Delta p = \frac{yd}{D}$



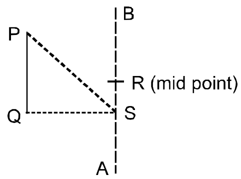
$\frac{yd}{D} = \frac{\lambda}{6} \Rightarrow y = \frac{D}{d} \times \frac{\lambda}{6}, \ldots\ldots$

$y = \frac{\beta}{6}, \beta - \frac{\beta}{6}, \beta + \frac{\beta}{6}$

$y = \frac{\lambda}{6} \times \frac{D}{d} = \frac{6000 \times 10^{-10} \times 1}{3 \times 10^{-3}} = 0.2$ mm

Q.23 (3)

Lets take any general point S on the line AB.



Clearly: for any position of S on line AB; we have for Δ PQS:

PQ + QS > PS {in any triangle sum of 2 sides is more then the third side}

$\Rightarrow$ PS – QS < 3λ.

As PS – QS represents the path difference at any point on AB $\Rightarrow$ it can never be more than 3λ. Now minimas occur at.

$\frac{\lambda}{2}, \frac{3\lambda}{2}, \frac{5\lambda}{2}$ only.

so 3 minimas below R (mid point of AB) and 3 also above R.

Q.24 (2)

$$62 = \frac{y}{\frac{\lambda_1 D}{d}} \qquad \Rightarrow y = \frac{62\lambda_1 D}{d}$$

$$\frac{x\lambda_2 D}{d} = \frac{62\lambda_1 D}{d} \Rightarrow 4 = \frac{62 \times 5893}{5461} = 67$$

Q.25 (3)

$$\Delta x = (24-1)\frac{\lambda}{2} = \frac{dy}{D}$$

$$y = (2x-1)\frac{D\lambda}{2d}$$

Q.26 (3)

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

$\lambda \downarrow \beta \downarrow$

Q.27 (2)

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

Q.28 (1)

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

$$\lambda = \frac{xd}{L}$$

Q.29 (2)

$$2\left[\frac{d}{\lambda}\right] + 1 = 7$$

Q.30 (3)

$4I_0 = I$

$I_0 = I/4$

Q.31 (3)

$$I' = 4I\cos^2\frac{\Delta\phi}{2}$$

$$\Rightarrow \cos^2\frac{\Delta\phi}{2} = \frac{1}{4} \Rightarrow \cos\frac{\Delta\phi}{2} = \pm\frac{1}{2}$$

$$\Rightarrow \Delta\phi = \frac{2x}{\lambda}\frac{dy}{D} \Rightarrow \cos\frac{\pi.dy}{\lambda D} = +\frac{1}{2}$$

$$\Rightarrow \frac{\pi.dy}{\lambda D} = \frac{\pi}{3} \Rightarrow y = \frac{\lambda D}{3d}$$

Q.32 (1)

$$\Delta\phi = \frac{d.y}{D} \times \frac{2\pi}{\lambda}$$

$$\because \; y = \frac{\lambda D}{d} \times \frac{1}{4}$$

$$\therefore \; \Delta\phi = \frac{\pi}{2} \qquad \Rightarrow I' = 4I\cos^2\frac{\Delta\phi}{2} = 2I$$

Q.33 (3)

As the D$\uparrow$ position of first maxima

i.e., y$\uparrow$ $\left(\frac{\lambda D}{d}\right)$

$\Rightarrow$ First decrease then increase.

Q.34 (3)

$I_0 = 4I$

Intensity due to one

$$\Delta\phi = \frac{d.y}{D} \times \frac{2\pi}{\lambda}$$

$$= \frac{0.25 \times 10^{-2} \times 4 \times 10^{-5}}{100 \times 10^{-2}} \times \frac{2\pi}{6000 \times 10^{-10}}$$

$\Delta\phi = \pi/3$

$$I' = I_0\cos^2\frac{\frac{\pi}{3}}{2} = \frac{3I_0}{4}$$

Q.35 (3)

$$\frac{dy}{D} \times \frac{2\pi}{\lambda} = \Delta\phi$$

$$\Rightarrow 2I = 4I\cos^2\frac{\Delta\phi}{2} \Rightarrow \cos\frac{\Delta\phi}{2} = \frac{1}{\sqrt{2}}$$

$$\Rightarrow \frac{\Delta\phi}{2} = \frac{\pi}{4} \Rightarrow \frac{d.y}{D}.\frac{2\pi}{\lambda} = \frac{\pi}{2}$$

$$\Rightarrow \frac{1\times10^{-3}\times y}{1\times500\times10^{-1}} = \frac{1}{4} \quad \Rightarrow y = 1.25\times10^{-4}\text{ m}$$

Q.36 (3)

$0.3\times10^{-3}\times\sin30^\circ = n\times500\times10^{-9} \Rightarrow n = 300$

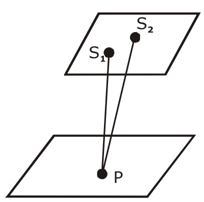
$\therefore$ 299 + 299 + 1 = 599

Q.37 (1)

$$\frac{d.d}{6D} = n\lambda$$

$$\Rightarrow \lambda = \frac{d^2}{6nD}\ [n = 1, 2, 3.....]$$

Q.38 (2)



$S_2P - S_1P = n\lambda$ = const.

$\Rightarrow$ equation of hyperbola

Q.39 (2)

For strong reflection.

$$2\mu t = \frac{\lambda}{2}, \frac{3\lambda}{2}, \frac{5\lambda}{2}\ ......$$

$$\Rightarrow \lambda = 4\mu t, \frac{4\mu t}{3}, \frac{4\mu t}{5}, \frac{4\mu t}{7}\ ......$$

$\Rightarrow$ 3000 nm. 1000 nm, 600 nm, 430 nm,333 nm.

$\Rightarrow$ only option is 600 nm.

Q.40 (2)

$$\frac{n\lambda_R D}{d} = (n+1)\frac{\lambda_B D}{d}$$

$\Rightarrow$ n. 7800 = (n + 1) 5200

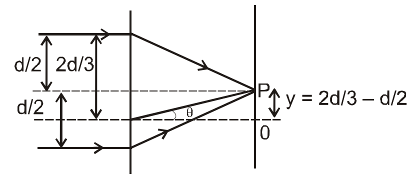
$\Rightarrow$ n = 2.

Q.41 (4)

4 × 6300 = (4.5) λ

$$\lambda = \frac{4\times6300}{9}\times2 = 5600\ \text{Å}$$

Q.42 (4)



we know that P will be the central maxima (at which path difference is zero)

Now $OP = \frac{d}{2} - \frac{d}{3} = \frac{d}{6}$

Q.43 (3)

Fourth maxima will be at y = 4β.

$$\Rightarrow y = \frac{4\lambda D}{d}$$

as $\lambda_{Green} > \lambda_{blue}$.

$\Rightarrow \beta_{Green} > \beta_{blue}$

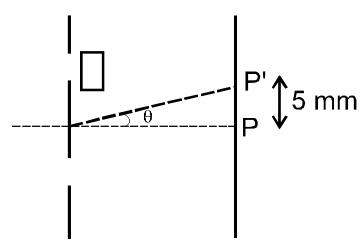
$\Rightarrow X_{Green} > X_{blue}$

Also get $\frac{X(blue)}{X(green)} = \frac{4360}{5460}$

Q.44 (4)

D = By using white light instead of single wavelength light.

Q.45 (1)



Clearly the central maxima at P(initially) shifts to P' where PP' = 5 mm.

So now, path difference at P' must be zero.

$\Rightarrow$ d sinθ = (μ – 1)t

$\Rightarrow$ d tanθ = (μ – 1)t

$$\mu = 1 + \frac{d.(PP')}{Dt}\text{; get } \mu = 1.2$$

Q.46 (4)

As we know, at the point of 75% intensity

$$\cos\phi = \frac{1}{2}$$

$$\Rightarrow \frac{2\pi}{\lambda} \times \Delta P = \frac{\pi}{3}, \frac{5\pi}{3}, \frac{7\pi}{3}, \frac{11\pi}{3}, \frac{13\pi}{3}$$

$$\Rightarrow (\mu - 1)\, t = \frac{\lambda}{6}, \frac{5\lambda}{6}, \frac{7\lambda}{6}, \frac{11\lambda}{6}, \frac{13\lambda}{6}$$

$$\Rightarrow t = \frac{\lambda}{6(\mu-1)}, \frac{5\lambda}{6(\mu-1)}, \frac{7\lambda}{6(\mu-1)}, \frac{11\lambda}{6(\mu-1)}, \frac{13\lambda}{6(\mu-1)}$$

= 0.2 μm; 1 μm, 1.4 μm, 2.6 μm.......

Hence only 1.6 μm is not possible.

Q.47 (4)

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

In water $\lambda\downarrow$ so $\beta\downarrow$

Q.48 (1)

$$\Delta\phi = \frac{2\pi}{\lambda/\mu}.x = \frac{2\pi\mu x}{\lambda}$$

Q.49 (3)

$$2I = 4I\cos^2\frac{\Delta\phi}{2} \Rightarrow \cos\frac{\Delta\phi}{2} = \frac{1}{\sqrt{2}} \Rightarrow \frac{\Delta\phi}{2} = \frac{\pi}{4}$$

$$\Rightarrow \frac{2\pi}{\lambda} \times \frac{\left(\frac{3}{2}-1\right)t}{2} = \frac{\pi}{4} \Rightarrow t = \lambda/2$$

Q.50 (2)

$$\left|(2\mu - 1)\,t - (\mu - 1).2t\right| = \frac{d.y}{D}$$

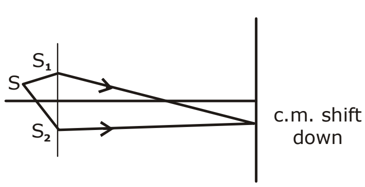
$$t = \frac{d.y}{D} \Rightarrow y = \frac{tD}{d}$$

Q.51 (4)

$$\Delta x = (2n+1)\,\frac{\lambda}{2}$$

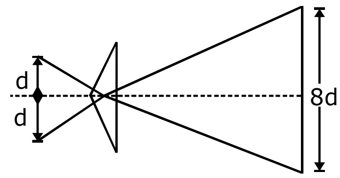
$$\Delta x = (\ell_1 + \ell_3) - (\ell_2 + \ell_4) = (2n+1)\,\frac{\lambda}{2}$$

Q.52 (4)



$$\beta = \frac{\lambda D}{d} = \text{remain same.}$$

Q.53 (2)



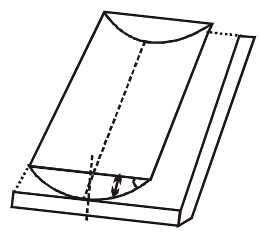
d = (μ – 1) A × 1

$$\text{no. of fringes} = \frac{8d^2.2}{\lambda D}$$

$$= \frac{16d^2}{\lambda D} = \frac{16[(\mu-1)A.1]^2}{6000 \times 10^{-10} \times 5}\ s$$

= 5.33

Q.54 (3)



t changes more rapidly when we go outwards.

⇒ path diff. changes more rapidly

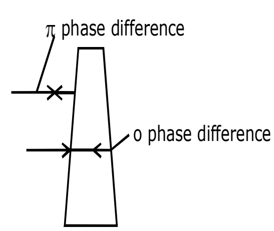
⇒ fringe width ↓

Q.55 (3)

$$\Delta\phi = \pi + (2\mu t).\frac{2\pi}{\lambda}$$

at top

$t \to 0$



Δϕ = π

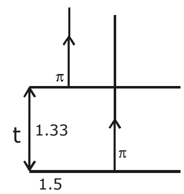
Minima for all the wave length.

Top position will appear dark.

⇒ As we move down violet Maxima will appear first.

first colour will be violet.

Q.56 (1)



$2 \times \frac{4}{3} t = 600$

t = 225 nm.

JEE-ADVANCED
OBJECTIVE QUESTIONS

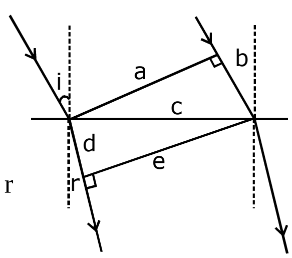
Q.1 (B)

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

$$= \frac{I_1}{I_1} \times \frac{\left(1 + \sqrt{\frac{I_2}{I_1}}\right)^2 - \left(1 - \sqrt{\frac{I_2}{I_1}}\right)^2}{\left(1 + \sqrt{\frac{I_2}{I_1}}\right)^2 + \left(1 - \sqrt{\frac{I_2}{I_1}}\right)^2}$$

$$= \frac{(1+2)^2 - (1-2)^2}{(1+2)^2 + (1-2)^2} = \frac{8}{10} = \frac{4}{5}$$

Q.2 (C)



$\sin r = \frac{d}{c}$

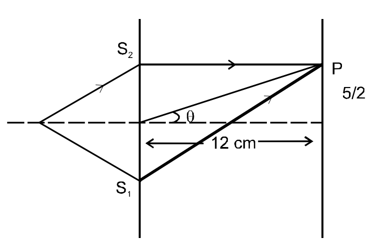
$\sin i = \frac{b}{c}$

$\Rightarrow$ isin i = u sin r

$\Rightarrow \mu = \frac{b}{d}$

Q.3 (A)

Notice that d is not very small than D; so we can not use $\Delta p = d \sin\theta$.



$S_1P - S_2P = \Delta P = \frac{\lambda}{2}$ {∵ first minima}

$\Rightarrow \sqrt{5^2 + 12^2} - (12) \quad = \frac{\lambda}{2}$ get $\lambda = 2$ cm

Q.4 (B)

As width ↑ ⇒ I ↑

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

$\Rightarrow I_1 \neq I_2$

$I_{min} \neq 0$

Q.5 (B)

Intensity in first case = $4I_0$

In second case = $4I_0 \cos^2 \frac{\Delta\phi}{2}$

$\therefore$ Average = $2I_0 \Rightarrow \frac{I_1}{I_2} = \frac{4I_0}{2I_0} = 2 : 1$

Q.6 (D)

Let us say, n[th] minima of 400 nm coincides with m[th] minima of 600 nm.

$\Rightarrow \left(n + \frac{1}{2}\right) 400 \times \frac{D}{d} = \left(m + \frac{1}{2}\right) . 600 \times \frac{D}{d}$

$\Rightarrow$ 400 n = 600m + 100.

$\Rightarrow n = \frac{6m+1}{4}$ = (some integer or non-integer) + 0.25

Hence n can never be an integer. So no minima of 600 nm coincides with any minima of 400 nm.

Q.7 (A)

$\frac{n_1.\lambda D}{d} = \frac{n_2\lambda_2.D}{d}$

$\Rightarrow n_1 \times 6500 = n_2 \times 5200$

$\Rightarrow n_1 = 4$

$n_2 = 5$

$\therefore y = \frac{4 \times 6500 \times 10^{-10} \times 120 \times 10^{-2}}{2 \times 10^{-3}}$

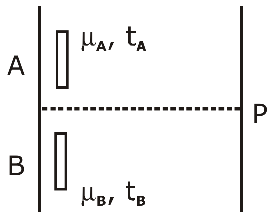
y = 0.156 cm

Q.8 (C)

Obviously; for μ = 1, O will be a maxima. As μ increases, the intensity will decrease and hence option (C).

Q.9 (D)

At point P we assume t_A provide greater path difff.



$\Rightarrow (\mu_A - 1)\, t_A - (\mu_B - 1)\, t_B$

$\Rightarrow t_B - t_A = \Delta x$

if $t_B > t_A$ Δx = +ve (shift towards A)

if $t_B < t_A$ Δx = –ve (shift towards B)

Q.10 (B)

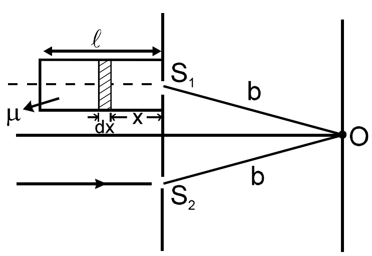
When light passes through a medium of refractive index μ, the optical path it travels is (μt).

Therefore, before reaching O light through S_1 travels $(\mu l + b)$ distance while that through S_2 travels a distance $(l + b)$

i.e. : path difference $= (\mu l + b) - (l + b) = (\mu - 1) l$.

For a small element 'dx' path difference $\Delta x = [(1 + ax) - 1]\, dx = ax\, dx$

For the whole length ;



$$\Delta x = \int_0^{\ell} ax\, dx = \frac{a\ell^2}{2}$$

For a minima to be at 'O'.

$$\Delta x = (2n + 1)\frac{\lambda}{2}$$

i.e. : $\frac{a\ell^2}{2} = (2n + 1)\frac{\lambda}{2}$.

For minimum 'a'; n = 0

$\Rightarrow \frac{a\ell^2}{2} = \frac{\lambda}{2} \Rightarrow a = \frac{\lambda}{\ell^2}$ **Ans.**

Q.11 (A)

$$\left(\frac{n_3}{n_2} - 1\right) t \times \frac{2\pi}{\lambda_2}$$

$$\therefore \frac{\lambda_1}{\lambda_2} = \frac{n_2}{n_1}$$

$$\Rightarrow \left(\frac{n_3}{n_2} - 1\right) t \times \frac{2\pi n_2}{\lambda_1 n_1}$$

$$= \frac{2\pi}{\lambda_1 n_1}(n_3 - n_2)\, t$$

Q.12 (A)

$$0.75 \times 4I = 4I \cos^2\left(\frac{\Delta\phi}{2}\right)$$

$$\cos\frac{\Delta\phi}{2} = \pm\frac{\sqrt{3}}{2}$$

$$\frac{\Delta\phi}{2} = \frac{\pi}{6}, \frac{5\pi}{6}, \frac{7\pi}{6}, \frac{11\pi}{6}, \frac{13\pi}{6}, \frac{17\pi}{6} \ldots\ldots$$

$$\Delta\phi = \frac{\pi}{3}, \frac{5\pi}{3}, \frac{7\pi}{3}, \frac{11\pi}{3}, \frac{13\pi}{3}, \frac{17\pi}{3} \ldots\ldots$$

for third Maxima $\Rightarrow \Delta\phi = 6\pi$

for second Minima $\Rightarrow \Delta\phi = 3\pi$

$\Delta\phi$ must lie between 3π and 6π

$$\Rightarrow \Delta\phi = \frac{11\pi}{3}, \frac{13\pi}{3}, \frac{17\pi}{3}$$

$\frac{\pi}{3}$ is not lying in the Range.

Q.13 (A)

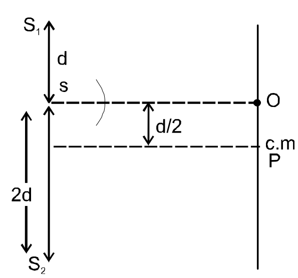
At B; $\Delta P = 4\lambda$ (maxima)

At $x = \infty$; $\Delta P = 0$ (maxima)

Hence in between; the point at which path difference is either λ, or 2λ or 3λ $\rightarrow$ they will be maximas. Hence 3 maximas.

Q.14 (B)

The 2 sources are.



As O is a maxima, Hence OP = β.

$$\Rightarrow \frac{d}{2} = \frac{\lambda.D}{(3d)}; \text{ get } \lambda = \frac{3d^2}{2D}$$

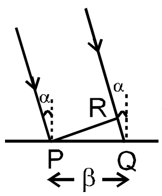
Q.15 (B)

Point O is a minima Hence the first maxima will be at

$y = \frac{\beta}{2}$ from O.

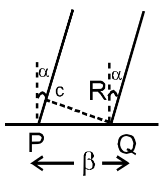
$\Rightarrow y = \frac{\lambda D}{2(2d)} = \frac{600 \times 10^{-9} \times 1}{4 \times 1 \times 10^{-3}} = 0.15$ mm.

Q.16 (C)



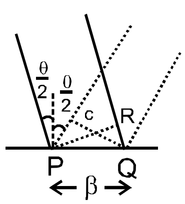
$R = \beta \sin\alpha$

QR is the difference between the light reaching at Q and P respectively



$PQ = \beta \sin\alpha$

for given case $\alpha = \frac{\theta}{2}$



For PQ to be one fringe. the path difference between the interfering light beams will change by 'λ' while moving from P to Q

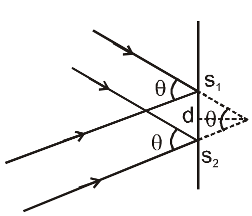
| path difference at P — path difference at Q | = λ

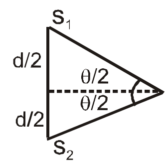
$\left|\left(\beta \sin\frac{\theta}{2} - \left(-\beta \sin\frac{\theta}{2}\right)\right)\right| = \lambda$

$\Rightarrow 2\beta \sin\frac{\theta}{2} = \lambda \quad \beta = \frac{\lambda}{2\sin(\theta/2)}$

for near normal incidence $\sin\theta \sim \theta \quad \beta = \frac{\lambda}{\theta}$

Aliter :





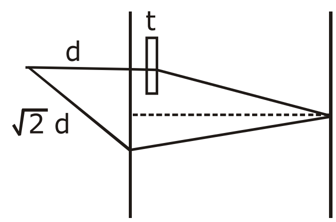
$\tan\theta/2 = \frac{d/2}{D}$ ($\because \tan\theta/2 \simeq \theta/2$)

$\therefore \theta = \frac{d}{D}$

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

$\beta = \frac{\lambda}{\theta}$

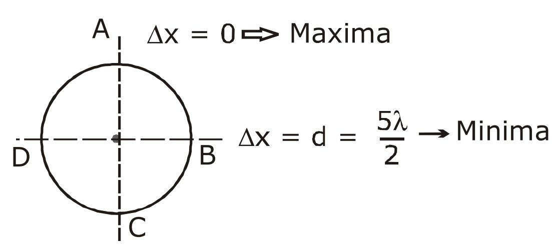
Q.17 (A)



$(\sqrt{2} - 1)\, d = (1.5 - 1)\, t$

$t = 2(\sqrt{2} - 1)\, d$

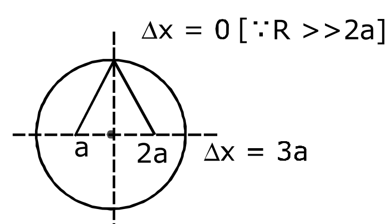
Q.18 (D)



$\Rightarrow$ A, C Bright

$\Rightarrow$ B, D Dark

Q.19 (A)

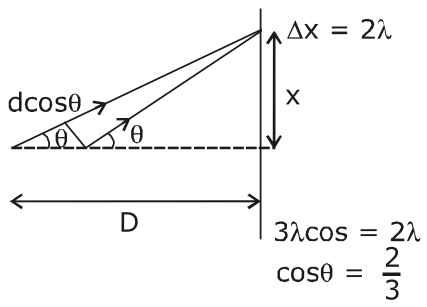


$\Rightarrow 3a = n\lambda \;\Rightarrow\; n = 15$

$\Delta x = 15\lambda \;\rightarrow$ Maxima

$\Rightarrow 14 + 14 + 14 + 14 + 4 = 60$

Q.20 (D)



$\tan\theta = \frac{x}{D} = \frac{\sqrt{5}}{2}$

Q.21 (A)

$S_1P - S_2P = \lambda/6$

$\therefore\; SS_1P - SS_2P = \lambda/3$

.....(1)

$SS_1P - SS_3P = 4\lambda/3$

.....(2)

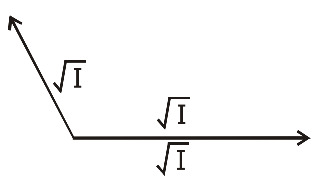
$\Rightarrow \Delta\phi = \frac{2\pi}{\lambda} \times \frac{4\lambda}{3}$

(2) – (1)

$SS_2P - SS_3P = \lambda$

$\Rightarrow \Delta\phi = \frac{2\pi}{\lambda} \times \lambda \;= 2\pi$

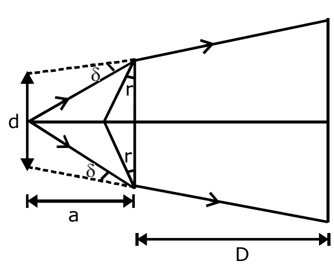
Take base SS_3P



$I_{net} = \left(2\sqrt{I}\right)^2 + \left(\sqrt{I}\right) + 2.2\sqrt{I}\sqrt{I}\cos 120^o$

$I_{net} = 3I$

Q.22 (A)



$d = 2a\delta$

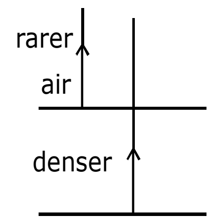
$\quad = 2a\,(\mu - 1)d$

$\beta = \frac{\lambda(a + D)}{2a(\mu - 1)\,\alpha}\left(1 + \frac{D}{a}\right)$

$a \rightarrow \infty$

$\Rightarrow \beta = \frac{\lambda}{2\alpha(\mu - 1)}$

Q.23 (A)



$2ut = \frac{\lambda}{2} \;\Rightarrow\; t = \frac{\lambda}{4}$

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MCQ/COMPREHENSION/COLUMN MATCHING

Q.1 (B,D)

$= \frac{\left(\sqrt{I_1} + \sqrt{I_2}\right)^2}{\left(\sqrt{I_1} - \sqrt{I_2}\right)^2} = \frac{9}{1}$

by checking the options : I_1 = 4 unit.I_2 = 1 unit.

and $\frac{A_1}{A_2} = \sqrt{\frac{I_1}{I_2}}$ = 2.

Q.2 (B,C)

Red ⟶ Blue

$\lambda \downarrow$

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

Q.3 (A,C)

$I(\theta) = I_0 \cos^2 \frac{\phi}{2} \left\{\Delta\phi = d\sin\theta \frac{2\pi}{\lambda}\right.$

$I(\theta) = I_0 \cos^2 \left[\frac{150 \times 10^6}{3 \times 10^8} \times \pi \times \sin\theta\right]$

$I(\theta) = I_0 \cos^2 (\sin\theta \,.\, \pi/2)$

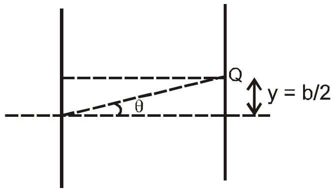
at $\theta = 30^o \;\Rightarrow\; I(\theta) = I_0 \cos^2\left(\frac{\pi}{4}\right) = \frac{I_0}{2}$

at $\theta = 90^o \;\Rightarrow\; I_0 \cos^2 \pi/2 = 0$

at $\theta = 0$

$I(\theta) = I_0 \cos^2 0 = I_0$.

Q.4 (A,C)



Clearly at Q, path difference = d sinθ

$\Rightarrow$ b sinθ $\approx$ btanθ $\approx \frac{b.y}{d} = \frac{b^2}{2d}$

Now whenever $\frac{b^2}{2d}$ will be odd multiple of $\frac{\lambda}{2}$, those λ's will be having minima at point Q.

$\Rightarrow \frac{b^2}{2d} = \frac{\lambda}{2}, \frac{3\lambda}{2}, \frac{5\lambda}{2}$ ....

$\Rightarrow \lambda = \frac{b^2}{d}, \frac{b^2}{3d}, \frac{b^2}{5d}$ .....

Q.5 (B,C,D)

The fringes next to central will be violet and there will not be a complete dark fringe.

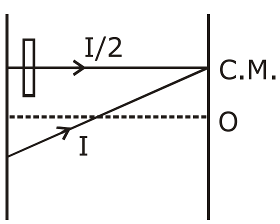
Q.6 (A,C)

Shift $\frac{d.y}{D} = (\mu - 1)t$

for C.M.

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

Q.7 (A,C,D)



A $\rightarrow$ The fringe pattern will get shifted towards covered slit.

$$\left.\begin{array}{l} I_{max.} = \left(\sqrt{I_1} + \sqrt{I_2}\right)^2 \\ I_{min.} = \left(\sqrt{I_1} - \sqrt{I_2}\right)^2 \end{array}\right\} \begin{array}{l} I_1 \neq I_2 \text{ then} \\ I_{min.} \uparrow I_{max.} \downarrow \end{array}$$

$\beta = \frac{\lambda D}{d}$ (doesn't change)

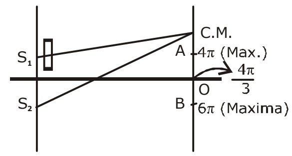
Q.8 (C,D)

Path difference at 0

$= (\mu - 1)\ t$

$= \frac{7\lambda}{3}$

$\Delta\phi = \frac{2\pi}{\lambda} \times \frac{7\pi}{3}$



$= \frac{14\pi}{3}$

At A . $\Delta x = (\mu - 1)\ t - \frac{dy_1}{D} = 2\lambda$

1.05 μm = 9000 Å + $y_1 \times 10^{-3}$

$\boxed{y_1 = .15mm}$

At B.

$\Delta x = (\mu - 1)t + \frac{dy_2}{D} = 3\lambda$

10500 Å + $\frac{1 \times 10^{-3} \times y_2}{1}$ = 3 × 4500 Å

$\boxed{y_2 = 0.3mm}$

Q.9 (A,C)

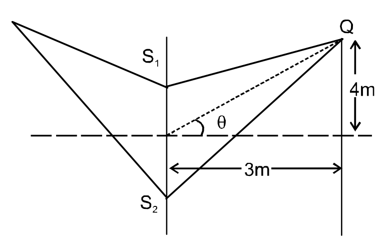
As d << D, $\Rightarrow$ path difference = d sinθ (at 0) = 1mm × sin 30º = 0.5 mm

if it is a maxima $\Rightarrow 10^{-3} \times 0.5 = (5000 \times 10^{-10})$m × (n)

n must be integer. get n = 1000.

Hence O is a maxima of intensity $4I_0$

Now

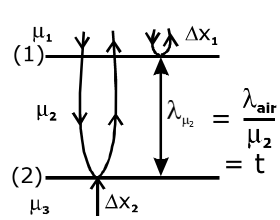


Now path difference at Q = d sinθ only $QS_1 \approx QS_2$.

d sin θ = 1 × 1/2 = 0.5 mm = integer multiple of λ .

Hence maxima.

Q.10 (A,D)



$$\Delta x = \mu_2 \frac{2\lambda_{air}}{\mu_2} + \Delta x_1 - \Delta x_2$$

$$\Delta x = 2\lambda_{air} + \Delta x_1 - \Delta x_2$$

$$\mu_3 > \mu_2 > \mu_1$$

$$\Rightarrow \Delta x_1 = \Delta x_2 = \frac{\lambda_{air}}{2}$$

$$\Delta x = 2\lambda_{air} = n\lambda_{air}$$

Maxima at Interface (1)

$$\Rightarrow \mu_1 < \mu_2 > \mu_3$$

$$\Delta x_1 = \frac{\lambda}{2},\ \Delta x_2 = 0$$

$$\Delta x = 2\lambda_{air} + \frac{\lambda_{air}}{2} = (2n+1)\frac{\lambda}{2}$$

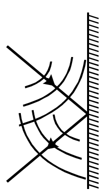
Minima at (1) interface

Q.11 (D)

Wave fronts are spherical in shape of radius ct.

Hence (D).

Q.12 (C)



The wave fronts are always perpendicular to the light rays.

Hence, (C).

Q.13 (B)

Using snell's law ;

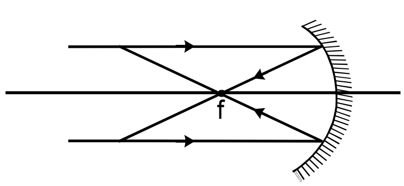
$$\frac{\sin(45^0)}{\sin r} = \frac{\sqrt{2}}{1} \Rightarrow \sin r = \frac{1}{2} \Rightarrow r = 30^0$$

Hence, (B) is correct.

Note : The shown lines are wavefronts and not rays.

Q.14 (A)

After reflection by mirror the parallel rays concentrate at the focus.

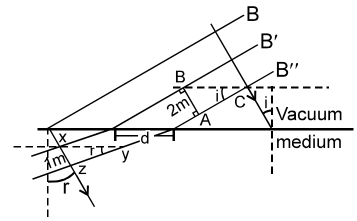


Hence the plane wave front becomes spherical concentrated at the focus.

Hence, (A).

Q.15 (A)

In Δ ABC ; $\sin(i) = \frac{2}{d}$ In Δ xyz ; $\sin(r) = \frac{1}{d}$



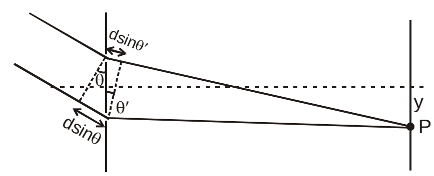
$$\Rightarrow \frac{\sin i}{\sin r} = 2 = \mu .$$

Q.16 (C)

If phase difference at point P is zero then

$$n_1 d \sin\theta = n_2 d \sin\theta'$$

$$\Rightarrow \theta' = 37°$$



and as $\tan\theta' = \frac{y}{D}$ $\Rightarrow y = -\frac{3}{4}$ m

It is negative because upper path in medium n_2 is longer than lower path in the same medium.

Q.17 (D)

Path lengths in medium 2 are equal for point O. Therefore

path difference = d sinθ

$$\lambda_{n_1} = 0.3\text{mm},\ \lambda_{n_2} = \frac{(0.3)\left(\frac{4}{3}\right)}{\frac{10}{9}} = 0.36\text{mm}$$

$$\Delta p = \frac{d\sin\theta\ \frac{4}{3}}{\frac{10}{9}},$$

$$\therefore \Delta\phi = \frac{2\pi}{\lambda}\Delta p$$

$$\Delta\phi = \frac{2\pi}{0.3\left(\frac{4/3}{10/9}\right)} \times \left(1\times\frac{1}{2}\right)\left(\frac{4/3}{10/9}\right) = \frac{10\pi}{3}$$

$$I = I_0 + I_0 + 2I_0 \cos\left(2\pi + \frac{4\pi}{3}\right) = I_0$$

Q.18 (A)

As we go up from point O, path difference will increase. At O, phase difference is $3\pi + \frac{\pi}{3}$ and when it becomes 4π, there will be maximum. Extra path difference created in medium 2 must lead to $\frac{2\pi}{3}$ phase difference.

$$\frac{2\pi}{\lambda_a} . d \sin\theta_1 . n_2 = \frac{2\pi}{3}$$

Using values $\sin\theta_1 = \frac{3}{25} \Rightarrow \tan\theta_1 = \frac{3}{\sqrt{616}} = \frac{y}{D}$

$$y = \frac{300}{2\sqrt{154}} \text{ cm} = \frac{150}{\sqrt{154}} \text{ cm}$$

Comprehension - 3 (Q.19 to Q.21)

Q.19 (ACD)

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

$\xrightarrow{\text{VIBGYOR}}$
$\lambda \uparrow$

Q.20 (A,B,D)

Angular fringe width $= \frac{\beta}{D} = \frac{\lambda}{d}$

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

Q.21 (B,D)
C is not correct
C.M.; does not change.

Q.22 **(A) q,r,s (B) p,q,r,s (C) q,r,s (D) p,q,r,s**

Initially at a distance x from central maxima on screen is

$$I = I_0 + 4I_0 + 2\sqrt{I_0}\sqrt{4I_0}\cos\frac{2\pi x}{\beta}, \text{ where } \beta = \frac{D\lambda}{d}$$

$I_{max} = 9I_0$ and $I_{min} = I_0$

(A) At points where intensity is $\frac{1}{9}$th of maximum intensity, minima is formed

$\therefore$ Distance between such points is $\beta, 2\beta, 3\beta, 4\beta, ...$

(B) At points where intensity is $\frac{3}{9}$th of maximum intensity, $\cos\frac{2\pi x}{\beta} = -\frac{1}{2}$ or $x = \frac{\beta}{3}$.

$\therefore$ Distance between such points is

$\frac{\beta}{3}, \frac{2\beta}{3}, \beta, \beta + \frac{\beta}{3}, \beta + \frac{2\beta}{3}, 2\beta, ...$

(C) $\cos\frac{2\pi x}{\beta} = 0$ or $x = \frac{\beta}{4}$.

$\therefore$ Distance between such points is

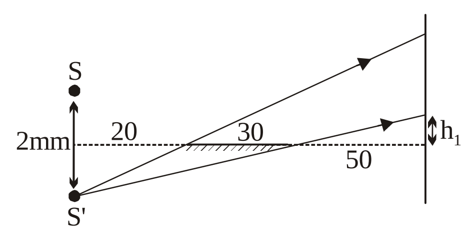
$\frac{\beta}{2}, \beta, \beta + \frac{\beta}{2}, 2\beta, ...$

(D) $\cos\frac{2\pi x}{\beta} = \frac{1}{2}$ or $x = \frac{\beta}{6}$.

$\therefore$ Distance between such points is $\frac{\beta}{3}, \frac{2\beta}{3}, \beta, \beta + \frac{\beta}{3}, \beta + \frac{2\beta}{3}, 2\beta, ...$

NUMERICAL VALUE BASED

Q.1 [0012]



$\frac{0.1}{h_1} = \frac{50}{50} \Rightarrow h_1 = 1\text{mm}$

$\frac{L + h_1}{0.1} = \frac{80}{20} \Rightarrow L + h_1 = 4 \text{ mm}$

$\Rightarrow$ L = 3 mm

$B = \frac{\lambda D}{d} = \frac{5\times10^{-7}\times1}{2\times10^{-3}} = 2.5 \times 10^{-4}$ m

$N = \frac{L}{B} = \frac{3\times10^{-3}}{2.5\times10^{-4}} = \frac{300}{25} = 12$

Q.2 [0001]

The path difference at point P,

$$\Delta x = (SS_2 - SS_1) + (S_2P - S_1P)$$

$$= \frac{dy}{D_1} + \frac{d(d/2)}{D_2}$$

For constructive interference,

$$\Delta x = \frac{dy}{D_1} + \frac{d^2}{2D_2} = n\lambda$$

$$\frac{(10^{-3})(0.5\sin\pi\ t)\times 10^{-3}}{1} + \frac{(10^{-3})^2}{2\times 2} = n\lambda$$

$$(0.5\ \sin\left(\frac{\pi}{6}\right) t) \times 10^{-6} + 0.25 \times 10^{-6}$$

$$= (5000 \times 10^{-10})n = 0.5 \times 10^{-6} n$$

$$\sin\left(\frac{\pi}{6}\right) t = \frac{0.5n - 0.25}{0.5}$$

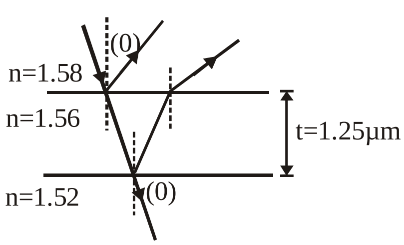
For the minimum value of t, $n = 1$.

$$\sin\left(\frac{\pi}{6}\right) t = \frac{1}{2}$$

$$\Rightarrow \quad \left(\frac{\pi}{6}\right) t = \frac{\pi}{6} \quad \text{or} \quad t = 1 \text{ sec.}$$

Q.3 **[520 nm]**

$$\therefore\ 2t\mu = \left(n + \frac{1}{2}\right)\lambda$$



(for destructive interference)

$$\Rightarrow 2t\mu = \left(n + \frac{1}{2}\right)\lambda$$

$$\Rightarrow 2t(1.56) = \left(n + \frac{1}{2}\right)\lambda$$

$$\Rightarrow 2 \times 0.25 \times 10^{-6} \times 1.56 = \left(n + \frac{1}{2}\right)\lambda$$

$$\therefore \left(n + \frac{1}{2}\right)\lambda = 7.8 \times 10^{-7} = 780 \text{ nm}$$

$$\lambda = \frac{780}{n + \frac{1}{2}}$$

$n = 0$, $\lambda = 1560$ nm

$n = 1$, $\lambda = \frac{1560}{3} = 520$ nm

$n = 2$, $\lambda = 780 \times \frac{2}{5} = 312$ nm (not possible)

Q.4 [0001]

Reflected ray from upper surface would shift by $\lambda/2$ only while reflected from lower surface would not have any shift.

$$2\mu t = n_1\lambda_1 = n_2\lambda_2$$

$\Rightarrow$ $(n_1 = n_2 + 1)$

as there is no minima in between these two wave-lengths

$$(n + 1)(512) = (n)(640)$$

$$n_2(640 - 512) = 512$$

$$n_2 = 4$$

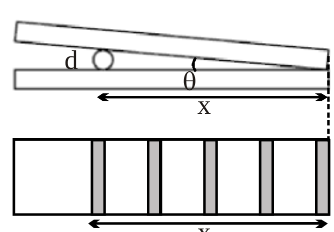
So $2 \times 1.28\ t = (4)(640)$

$$t = \frac{4\times 640}{2\times 1.28} = 1000 \text{ nm} = 1\mu\text{m}$$

Q.5 [1100]

$d = x\theta$

$x = \frac{n\lambda}{2\theta}$ = condition of dark fringe



$n = 0$, first dark fringe at join of plates

$n = 4$, fifth dark fringe at fiber

$d = x\theta = \frac{4\lambda}{2} = 2\lambda$

$d = 2 \times 550$ nm $\Rightarrow$ 1100 nm

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Q.1 (C)

$I = I_0 (\cos^2\phi)^4$

$= I_0 \times \left(\frac{3}{4}\right)^4 = 30\%$ of I_0

Q.2 (B)

Separation

Bright fringe = $\frac{\lambda D}{d}$

$f\lambda = c$

If f is doubled

λ become halved

$\therefore$ β become half

$\beta = \frac{1}{2} = 0.5$mm

Q.3 (A)

$I_{min} = 0$

$I_{max} = 4I_0$

$I_{av} = 2I_0$

Q.4 (C)

$I_0 \xrightarrow[\text{Polarizer}]{\text{First}} I_0/2 \xrightarrow[\text{IIpolarizer}]{\text{Malus law}} \left(\frac{I_0}{2}\right)\cos^2 30^o$

Q.5 (B)

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

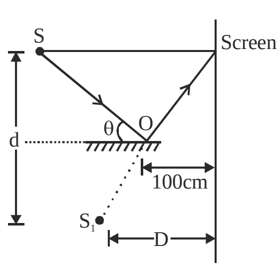
$\lambda = \frac{h}{mV} = \frac{h}{\sqrt{2mq\Delta V}}$

$\beta \propto \lambda \quad \therefore \beta \propto \frac{1}{\sqrt{\Delta V}}$ as Δ V is double

$\therefore \beta$ is $\frac{1}{\sqrt{2}}$ times of β_{old}

$\therefore \beta_{new} = 0.7\beta = 0.7$ w

Q.6 (B)



S and S_1 are source of YDSE

$\theta = 0.5 \times 10^{-3}$ radian (very small)

$D = SO\cos\theta + 100$

$= 20 \times 1 + 100$

$= 120$ cm

$d = 2 \times SO \sin\theta$

$\Rightarrow 2 \times 20 \times \theta$

$\Rightarrow 40 \times 0.5 \times 10^{-3}$ cm

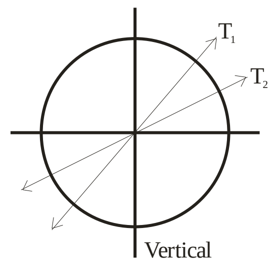
2×10^{-2} cm

$\beta = \frac{\lambda D}{d} = \frac{440 \times 10^{-6} \times 120 \times 10^2}{2 \times 10^{-2} \times 10^2}$

264×10^{-2}

$\Rightarrow$ 2.64 mm

Q.7 (A)



$I_0 = 20$ W/m^2

$I_1 = \frac{I_0}{2} = \frac{20}{2} = 10$W/m^2

$I_2 = I_1 \cos^2 30°$

$= 10\left(\frac{\sqrt{3}}{2}\right)^2 = 10 \times \frac{3}{4}$

$= 7.5$ W/m^2

Q.8 (C)

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

$I = A^2 + 4A^2 + 4A^2\cos\phi = A2(5 + 4\cos\phi)$

$I_0 = 9A^2 \Rightarrow A^2 \frac{I_0}{9}$

$I = \frac{I_0}{9}(5 + 4\cos\phi)$

Q.9 (C)

As $\mu = \mu_0 + \frac{A}{\lambda^2}$

$\mu_{red} < \mu_{blue}$

As reflected light is polarized incidence angle should be equal to Brewster angle

$i_a = \tan^{-1}(\mu)$

so $\theta_B > \theta_R$

Q.10 (D)
At central maxima
Due to 400 nm = $4I_0$
Due to 800 nm = $4T_0$
Total Intensity = $8\ I_0$

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Q.1 (1)

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

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

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

$$\frac{\left(\sqrt{2x}+1\right)^2}{\left(\sqrt{2x}-1\right)^2} - 1$$

$$\frac{\dfrac{\left(\sqrt{2x}+1\right)^2}{\left(\sqrt{2x}-1\right)^2} - 1}{\dfrac{\left(\sqrt{2x}+1\right)^2}{\left(\sqrt{2x}-1\right)^2} + 1}$$

$$\Rightarrow \frac{2x + 1\ 2\sqrt{2} - 2x - 1 + 2\sqrt{2x}}{2x + 1 + 2\sqrt{2} + 2x + 1 - 2\sqrt{2x}}$$

$$\Rightarrow \frac{4\sqrt{2x}}{4x + 2} = \left(\frac{2\sqrt{2x}}{2x+1}\right)$$

Q.2 (2)

$\sin\theta = \dfrac{1.22\lambda}{D} \Rightarrow$ If D is increased $\Rightarrow \sin\theta$ decreased

$\therefore$ size of circular fringe will decrease
Intensity will increase.

Q.3 (1)

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

$= 2.5 \times 10^{-4} = 0.25$ mm

Q.4 [3]

$$I = \frac{1}{2}(\varepsilon_0 C)\,E_0^2 = \frac{\text{Power}}{4\pi(2)^2}$$

$$\therefore \quad \frac{1}{2} \times (4\pi\varepsilon_0(c)\,E_0^2 = \frac{1000 \times 1.2}{4} \times \frac{1}{100}$$

$$\therefore \quad \frac{1}{2} \times \frac{3 \times 10^8}{9 \times 10^9} \times E_0^2 = 3$$

$\therefore \quad E_0^2 = 180$

$\therefore \quad E_0 = 13.41$ V/m

≈ 13 V/m

Q.5 **(1)**

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

$\because \lambda_V < \lambda_R$

$\therefore \beta_V < \beta_R$

And there is no change in intensity of bright and dark fringes.

Q.6 (3)

$\dfrac{A_1}{A_2} = \dfrac{1}{3}$ $\qquad A_1 = x, A_2 = 3x$

$$\frac{I_{max}}{I_{min}} = \left(\frac{(A_1 + A_2)^2}{(A_1 - A_2)^2}\right) = \frac{(4x)^2}{(2x)^2} = \frac{16}{4} = 4:1$$

Q.7 **[75]**

$I = I_0 \cos^2(\theta)$

$I = 100 \times \cos^2(30^o)$

$$I = 100 \times \left(\frac{\sqrt{3}}{2}\right)^2$$

$$I = 100 \times \frac{3}{4}$$

I = 75 Lumens.

Q.8 **[600]**

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

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

$$\lambda = \frac{6\times10^{-3}\times10^{-3}}{10}$$
$\lambda = 6 \times 10^{7}$ m = 600×10^{-9} m
$\lambda = 600$ nm

Q.9 [3]

$$c\in_0 E^2 = \frac{100}{4\pi\times3^2}$$
$$c\in_0\left(\sqrt{\frac{x}{5}}E\right)^2 = \frac{60}{4\pi\times3^2}$$
$$\Rightarrow \frac{x}{5} = \frac{3}{5}$$
$\Rightarrow x = 3$

Q.10 (2)

$$\beta = \frac{\lambda D}{d} = \frac{5890\times10^{-10}\times0.5}{0.5\times10^{-3}}$$
= 589 × 10–6 m
Distance between first and third bright fringe is 2β
= $2\times589 \times 10^{-6}$ m
= 1178×10^{-6} m **Ans. (2)**

Q.11 (1)

Resolving power (RP) $\propto \frac{1}{\lambda}$
$$\lambda = \frac{h}{P} = \frac{h}{mv}$$
So (RP) $\propto \frac{mv}{h}$
RP $\propto$ P
RP $\propto$ mv
RP $\propto$ m

Q.12 [6]

$$\frac{\Delta\lambda}{\lambda}c = v$$
$$\Delta\lambda = \frac{v}{c}\times\lambda = \frac{286}{3\times10^5}\times 630\times10^{-9} = 6\times10^{-10}\text{m}$$

Q.13 **(1)**

Q.14 (2)

Q.15 (2)

Q.16 (4)

Q.17 [30]

Q.18 [300]

Q.19 [1]
Given amplitude $\propto$ slit width
Also intensity $\propto$ (Amplitude)^2 $\propto$ (Slit width)^2
$$\frac{I_1}{I_2} = \left(\frac{3}{1}\right)^2 = 9 \Rightarrow I_1 = 9I_2$$
$$\frac{I_{min}}{I_{max}} = \left(\frac{\sqrt{I_1}-\sqrt{I_2}}{\sqrt{I_1}+\sqrt{I_2}}\right)^2 = \left(\frac{3-1}{3+1}\right)^2 = \frac{1}{4} = \frac{x}{4}$$
$\Rightarrow$ x = 1.00

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Q.1 (D)
$$\beta = \frac{\lambda D}{d}$$
$\overrightarrow{\text{VIBGYOR}}$ λ increase
$\lambda_R > \lambda_G > \lambda_B$
So $\beta_R > \beta_G > \beta_B$

Q.2 (B)
For half of maximum intensity
$2I_0 = I_0 + I_0 + 2I_0\cos\theta$
θ (Phase difference) $= \frac{\pi}{2}, \frac{3\pi}{2}, \frac{5\pi}{2}$.........
Path difference is $\frac{\lambda}{4}, \frac{3\lambda}{4}, \frac{5\lambda}{4}$.........$\left(\frac{2n+1}{4}\lambda\right)$

Q.3 (A, B, C)
$$\beta = \frac{\lambda D}{d}$$
$\beta \propto \lambda$
$\because \lambda_2 > \lambda_1 \quad \therefore \beta_2 > \beta_1$
No of fringes in a given width (m) = $\frac{y}{\beta} \Rightarrow$
$m \propto \frac{1}{\beta} \Rightarrow m_2 < m_1$
3rd maximum of $\lambda_2 = \frac{3\lambda_2 D}{d} = \frac{1800D}{d}$
5th minimum of $\lambda_1 = \frac{9\lambda_1 D}{2d} = \frac{1800D}{d}$
So, 3rd maxima of λ_2 will meet with 5th minimum of λ_1
Angular sepration = $\frac{\lambda}{d} \Rightarrow$ Angular seperation for λ_1 will be lesser

Q.4 (C,D)

Since S_1S_2 line is perpendicular to screen shape of pattern is concentric semicircle

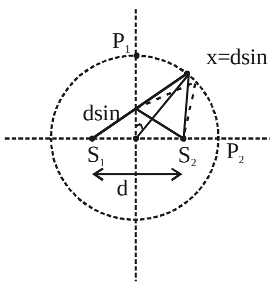
At O,

$$\frac{2\pi}{\lambda}(S_1O - S_2O) = \frac{2\pi \times 0.6003 \times 10^{-3}}{600 \times 10^{-9}} = 2001\pi$$

$\therefore$ The region very close to the point O will be dark

$\therefore$ (c, d)

Q.5 (AC)



$\lambda = 600$ nm

at P_1 $\Delta x = 0$

at P_2 $\Delta x = 1.8$ mm $= n\lambda$

No. maximum will be

$$= n = \frac{\Delta x}{\lambda} = \frac{1.8\text{mm}}{600\text{nm}} = 3000$$

at P_2 $\Delta x = 3000\lambda$

hence bright fringe will be formed.

at P_2 3000th maxima is formed.

for 'D' option $\Delta x = d\sin\theta$

$d\Delta x = d\cos\theta.d\theta$ $R\lambda = d\cos\theta.R\theta$

$$Rd\theta = \frac{R\lambda}{d\cos\theta}$$ as we move from P_1 to P_2

$\theta \uparrow \cos\theta \downarrow Rd\theta$

Q.6 (C)

(1) $\Delta x = d\sin\alpha = d\alpha$ (as α is very small)

$\alpha = \frac{.36}{180} = 2(2\times10^{-3})$rad

$$\frac{\Delta x}{\lambda} = \frac{(3\times10^{-4})(2\times10^{-3})}{6\times10^{-7}} = 1$$

so constructive interference

(2) $\beta = \frac{D\lambda}{d}$

(3) $\Delta x_p = d\alpha + \frac{dy}{D}$

$= 3 \times 10^{-4} (2 \times 10^{-3} + 11 \times 10^{-3}) = 39 \times 10^{-7}$

$$\frac{\Delta x_p}{\lambda} = \frac{39\times10^{-7}}{6\times10^{-7}} = 6.5$$ so destructive

(4) $\Delta x_p = \frac{dy}{D} = (3 \times 10^{-4}) \times 11 \times 10^{-3} = 33 \times 10^{-7}$

$$\frac{\Delta x_p}{\lambda} = \frac{33\times10^{-7}}{6\times10^{-7}} = 5.5 \Rightarrow \text{destructive}$$

Q.7 (A)