Solution

CET25P9 RAY OPTICS AND OPTICAL INSTRUMENTS

Class 12 - Physics

1. **(a)** its wavelength decreases

   Explanation: The energy of the light is related to the frequency. When the light enters the medium, the apparent speed of light changes. If the frequency changed, the energy would not be conserved. The wavelength changes to balance the change in speed. When light enters from air to glass (from rarer to denser medium), its speed decreases as a consequence its wavelength also decreases.

2. **(a)** Microscope will decrease but that of telescope will increase.

   Explanation: Microscope will decrease but that of telescope will increase.

3.

   (b) 10 s

   Explanation: Exposure time, $t \propto d^2$

   $\therefore t_2 = \frac{d_2^2}{d_1^2} t_1 = \frac{120^2}{60^2} \times 2.5 = 10s$

4.

   (d) Diamond to air

   Explanation: Diamond to air

5.

   (d) $\frac{R}{2}$

   Explanation: The relationship between **the focal length f** and **radius** of **curvature r** for spherical mirror is given by R = 2f.
   Therefore, $f = \frac{R}{2}$

6.

   (b) 21 cm

   Explanation: 

   Distance between two positions of lens, L_1L_2 = 40 cm and OI = 100cm

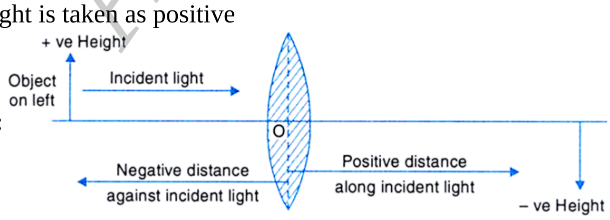
   Let distance of object from L_1 = x, therefore u = -x, hence x + 40 + x = 100 or x = 30 cm

   For L_1 we have, u = -30 cm and v = 70 cm

   Putting values in lens formula,
   $\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$
   $\frac{1}{f} = \frac{1}{70} + \frac{1}{30}$
   On solving we get, f = +21 cm

7.

   (c) incident light is taken as positive

   Explanation: 

8.

   (c) 21.28 cm

   Explanation: $\frac{1}{f} = (\frac{\mu_2}{\mu_1} - 1)(\frac{1}{R_1} - \frac{1}{R_2})$

   For violet light,
   $\frac{1}{f_v} = (1.5 - 1)(\frac{1}{R_1} - \frac{1}{R_2}) = 0.5(\frac{1}{R_1} - \frac{1}{R_2})$
   For red light,

$\frac{1}{f_r} = (1.47 - 1)(\frac{1}{R_1} - \frac{1}{R_2}) = 0.47(\frac{1}{R_1} - \frac{1}{R_2})$
Hence, $f_r = \frac{0.5}{0.47} f_v = 1.064 \times 20 = 21.28cm$

9. **(a)** Become infinite
Explanation: $\frac{1}{f} = (\frac{\mu_2}{\mu_1} - 1)(\frac{1}{R_1} - \frac{1}{R_2})$
Since, $\mu_2 = \mu_1$,
$\frac{1}{f} = 0, \ hence\ f = \infty$

10. **(a)** 32 cm
Explanation: $\frac{1}{f} = (\frac{\mu_2}{\mu_1} - 1)(\frac{1}{R_1} - \frac{1}{R_2})$
In air,
$\frac{1}{f} = (\frac{1.5}{1} - 1)(\frac{1}{R_1} - \frac{1}{R_2}) = 0.5(\frac{1}{R_1} - \frac{1}{R_2})$
In water,
$\frac{1}{f'} = (\frac{1.5}{4/3} - 1)(\frac{1}{R_1} - \frac{1}{R_2}) = \frac{1}{8}(\frac{1}{R_1} - \frac{1}{R_2})$
Hence, f' = 4f = 4×8 = 32 cm

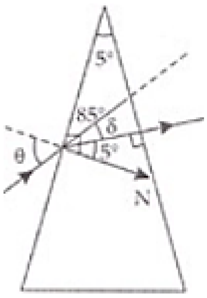
11. **(a)** 20.0
Explanation: In case of normal adjustment, final image is formed at infinity.
So magnifying power is given by , $m = \frac{f_o}{f_e} = \frac{100}{5} = 20$

12.
(b) 5
Explanation: Two plane mirrors places asymmetrically at 70 degrees.
Number of images $\frac{360}{70}$ = 5 (highest integral value)

13.
(d) 1.5
Explanation: Refractive index = $\frac{6000}{4000}$ = $\frac{3}{2}$ = 1.5

14.
(d) 1.47
Explanation: the refractive index of liquid must be equal to refractive index of glass=1.47

15. **(a)** 7.5°
Explanation:



A = 5^o
$\mu = 1.5$
$i_2 = 0^o$
$r_2 = 0^o$
$r_1 + r_2 = A$
$r_1 = A - r_2 = 5 - 0 = 5^o$
$\mu = \frac{\sin i_1}{\sin r_1}$
$\Rightarrow \sin i_1 = \mu \sin r_1$
$sini_1 = 1.5 \times \sin 5^\circ$
$sini_1 = 1.5 \times 0.087$

$\sin i_1 = 0.1305$

thus $i_1 = 7.5^o$

16. **(a)** focal length of eyepiece and objective.
Explanation: Magnification $\frac{m \propto 1}{f_o f_e}$
So, magnifying power of a microscope depends on focal length of eyepiece and objective only.

17.
(d) both objective and eye-piece have short focal lengths
Explanation: Angular magnification or magnifying power of compound microscope is defined as ratio of angle made at eye by image formed at infinity to the angle made by object, if placed at distance of distinct vision from an unaided eye.
Magnification = $\frac{LD}{f_o f_e}$
where, L- length of the tube of microscope, D = 25 cm
Now as, $m \propto 1/f_o$
and $m \propto 1/f_e$
∴ both eye piece and objective must be of smaller focal lengths, so, that magnification is higher.

18.
(c) 1.50
Explanation: 1.50

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

20.
(c) $\frac{f}{x}$
Explanation: u = f + x
Using mirror formula,
$\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$
Or, $\frac{1}{v} - \frac{1}{(f+x)} = -\frac{1}{f}$
∴ v = $-\frac{f(f+x)}{x}$
So, the magnification = $|m| = \frac{v}{u} = \frac{f}{x}$

21.
(d) red colour.
Explanation: For a glass prism, the angle of minimum deviation will be smallest for the light of red color.
As wavelength of red color is maximum among all, hence, $\mu \propto \frac{1}{\lambda}$, hence $\mu$is smaller. As μ decreases, angle of deviation decreases.

22.
(b) $3 \cdot 00$
Explanation: Here, $\lambda = 5{,}000\ \mathring{A} = 5 \times 10^{-7}$ m and $\nu = 2 \times 10^{14}$ Hz
Therefore, speed of light in the material,
$v = \nu\lambda = 2 \times 10^{14} \times 5 \times 10^{-7} = 10^8\ ms^{-1}$
Hence, the refractive index of the material,
$\mu = \frac{c}{v} = \frac{3 \times 10^8}{10^8} = \mathbf{3}$

23.
(c) high resolving power
Explanation: Resolving power is directly proportinal to aperture.

24. **(a)** fitting eye-piece of high power
Explanation: Magnification of telescope can be increased by using eyepiece of lower focal length (f_e). Since power is inversely proportional to focal length, eyepiece of large power will increase magnification of the telescope.

25.
(c) zero

Explanation: zero

26.

(d) Both Convex mirror and Concave mirror

Explanation: Concave mirror is used as objective. A secondary convex mirror is used to reflect the light reflected by objective towards eyepiece.

27.

(d) 2 cm upward

Explanation: Shift S = t$\left(\frac{1-1}{\mu}\right)$

Substituting the given data we get,

S = 6$\left(\frac{1-1}{1.5}\right)$

or, S = 6$\left(\frac{1-2}{3}\right)$ = 2cm upward

28.

(b) complete image will be formed

Explanation: Image formed will be complete when upper half of lens is blocked. Intensity of the image will decrease as the incident rays from upper half are cut off.

29. **(a)** 4f

Explanation: 4f

30. **(a)** 2f

Explanation: The focal length of each part will be 2f

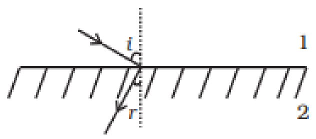
31. **(a)** total internal reflection of light in the air during a mirage

Explanation: The ionosphere is transparent optical medium and radio wave is reflected back. Reflection through the transparent surface is total internal reflection so that internal reflection of radio waves takes place.

32. **(a)** smaller

Explanation: When light travels from air to a medium of refractive index μ, its wavelength decreases by a factor μ i.e. becomes 1/μ.

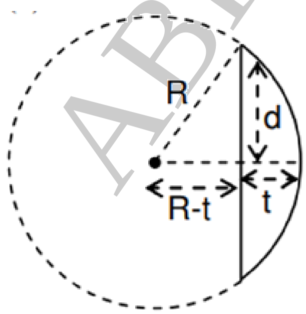
33.

(c) 

Explanation: According to Snell's law, μ= sini/sinr, The materials with negative refractive index responds to Snell's law just the opposite way. If incident ray from air (Medium 1) incident on those materials, the ray refract or bend the same side of the normal.

34.

(b) 30 cm

Explanation: 

$\mu = \frac{c}{v} = \frac{3}{2}$

From figure, $R^2 = d^2 + (R - t)^2$

$R^2 - d^2 = R^2\left\{1 - \frac{t}{R}\right\}^2$

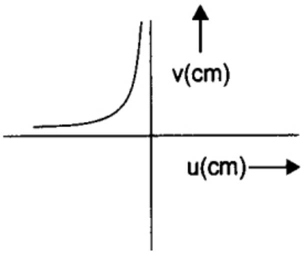
$1 - \frac{d^2}{R^2} = 1 - \frac{2t}{R}$ [neglecting higher terms]

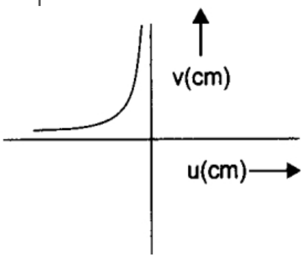
Thus, $R = \frac{d^2}{2t} = \frac{(3)^2}{2\times(0.3)} = \frac{90}{6} = 15cm$

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

$\frac{1}{f} = \left(\frac{3}{2} - 1\right)\left(\frac{1}{15}\right)$
f = 30 cm

35. **(a)** 90°
Explanation: Number of images, $n = \frac{360^o}{\theta} - 1$
$\theta = \frac{360}{(n+1)} = \frac{360}{4} = 90^\circ$

36.
(d)


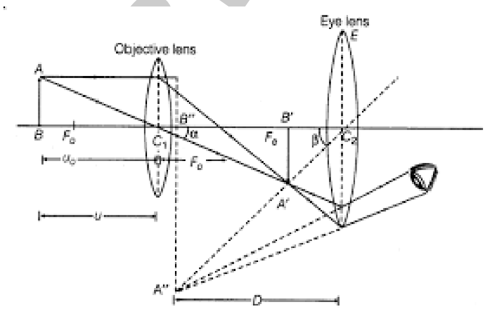
Explanation:


37.
(b) $F_1 + F_2$
Explanation: $F_1 + F_2$

38. **(a)** the objective has a long focal length and the eye-piece has a short focal length
Explanation: Magnifying power of telescope is directly proportional to $\frac{f_o}{f_e}$.
Hence, f_o should be large and f_e should be small.

39. **(a)** A + δ_m = 2i
Explanation: For refraction through prism,
$i_1 + i_2 = \delta + A$ and $r_1 + r_2 = A$
For minimum deviation,
$i_1 = i_2 = i$ and $r_1 = r_2 = r$
So, i = $\frac{(A+\delta_m)}{2}$
$\therefore$ A + δ_m = 2i

40.
(c) 6 mm

Explanation:


Since tower n is situated very far (2000 m), so its image is at the focal plane of objective lens.
So angle subtended by tower is equal to angle subtended by the image, $\beta = \alpha$
or $tan\beta = tan\alpha$
or $\frac{10}{2000} = \frac{A'B'}{1.2}$
$\therefore\ A'B' = 6 \times 10^{-3} m = 6mm$

41.
(d) act as a convex lens irrespective of the side on which the object lies

Explanation:

The relation between focal length f, the refractive index of the given material μ, R_1 and R_2 is known as lens maker's formula and it is $\frac{1}{f} = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$

$R_1 = \infty, R_2 = -R$

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

Here, R = 20 cm, μ = 1.5. On substituting the values, we get

$f = \frac{R}{\mu-1} = \frac{20}{1.5-1} = 40\text{cm}$

As f > 0 means converging nature. Therefore, the lens act as a convex lens irrespective of the side on which the object lies.

42. **(a)** $\frac{1}{4}$

Explanation: For prism in air angle of deviation is given as

$\delta_a = (\mu - 1)A$

$\delta_a = (\frac{3}{2} - 1)A$

= $\frac{A}{2}$

For prism in water the relative refractive index is given as

${}_w\mu_g = \frac{{}_a\mu_g}{{}_a\mu_w} = \frac{\frac{3}{2}}{\frac{4}{3}} = \frac{9}{8}$

$\delta_{water} = (\mu - 1)A$

= $(\frac{9}{8} - 1)A$

= $\frac{1}{8}A$

$\frac{\delta_w}{\delta_a} = \frac{\frac{A}{8}}{\frac{A}{2}} = \frac{1}{4}$

43.

(b) 3,640 $\overset{\circ}{A}$

Explanation: Now, $\lambda' = \frac{\lambda}{\mu} = \frac{5460}{1\cdot5}$ = 3640 $\overset{\circ}{A}$

44. **(a)** Difference between apparent and real depth of a pond

Explanation: Difference between apparent and real depth of a pond

45.

(c) 10 times nearer

Explanation: A telescope will and can not change the size of an object big or small. What it do is to magnify them if viewed from far. It is like zooming a photo. So to an observer the tree would appear 10 times closer. In fact the image in the eye is 10 times taller through the telescope than through the naked eye. That makes it seem 10 times closer.

46.

(c) 1.35

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

Putting v = 3 cm

$\mu_1 = 1$

$u = \infty$

R = 0.78 cm

$\frac{\mu_2}{3} - \frac{1}{\infty} = \frac{\mu_2-1}{0.78}$

$\therefore \mu_2 = 1.35$

47.

(d) 40 cm

Explanation: $L=f_o+f_e=44$ and $|m|=\dfrac{f_o}{f_e}=10$

This gives $f_o=40\text{cm}$

48. **(a)** π

Explanation: When a wave is reflected into rarer medium from the surface of a denser medium, it undergoes a phase change of π radian.

49.

(c) Real, magnified

Explanation: When an object is placed between f and 2f of a concave mirror, the image is formed beyond 2f. The image is real and magnified.

50. **(a)** a

Explanation: a

51.

(d) only one image

Explanation: It is like a combination of two Plano – convex lenses. Therefore only one image is formed.

52. **(a)** 3 m

Explanation: i = θ_c

In ΔSAB

$\frac{R}{h}$ = tan θ_c

$\therefore$ R = h tan θ_c

or R = $\frac{h}{\sqrt{\mu^2-1}}$ = $\frac{4}{\sqrt{\left(\frac{5}{3}\right)^2-1}}$

= $\frac{4\times3}{\sqrt{25-9}}$ = $\frac{4\times3}{4}$ = 3m

53. **(a)** move faster than its actual speed

Explanation: Let h be the actual height and h' be the apparent height of bird at any instant.

Then, $\frac{h}{h'}=\mu_{aw}$ (refractive index of air with respect to water)

= $\frac{3}{4}$ (since refractive index of water with respect to air is $\frac{4}{3}$)

If v is the actual speed and v' be the apparent speed of bird, then

v = $\frac{dh}{dt}$ and v' = $\frac{dh'}{dt}$

Thus, $\frac{v}{v'}$ = $\frac{3}{4}$

or v' = $\frac{4v}{3}$

54.

(d) (i) Between F and C, (ii) Between P and F

Explanation: When the object is placed between C and F in front of a concave mirror, the imager is formed beyond C. Image is magnified, real and inverted.

When the object is placed between P and F in front of a concave mirror, the image is formed behind the mirror. Image is magnified, virtual and erect.

55.

(b) He has to direct the beam at an angle to the vertical which is slightly less than the critical angle of incidence for total internal reflection

Explanation: He has to direct the beam at an angle to the vertical which is slightly less than the critical angle of incidence for total internal reflection.

56.

(d) convergent lens of focal length 3.5 R

Explanation: $\frac{1}{f}=(\frac{\mu_2}{\mu_1}-1)(\frac{1}{R_1}-\frac{1}{R_2})$

R_1 = -R and R_2 = R, hence,

$\frac{1}{f}=\left(\frac{1.5}{1.75}-1\right)\left(\frac{1}{-R}-\frac{1}{R}\right)=\left(\frac{1.5-1.75}{1.75}\right)\left(\frac{-2}{R}\right)=\frac{0.5}{1.75R}=\frac{1}{3.5R}$

or f = 3.5 R

Since focal length is positive, the lens acts as a converging lens.

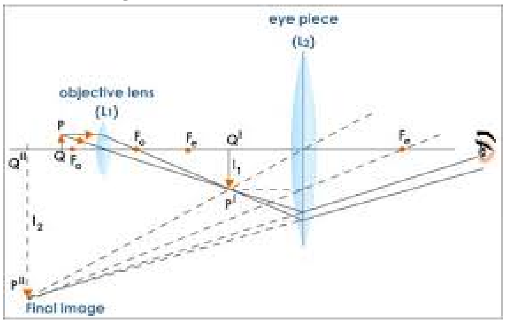
57.

(d) moves away from the lens with a non-uniform acceleration

Explanation: When an object approaches a lens with uniform speed, its image moves away from the lens to infinity with non-uniform acceleration.

58.

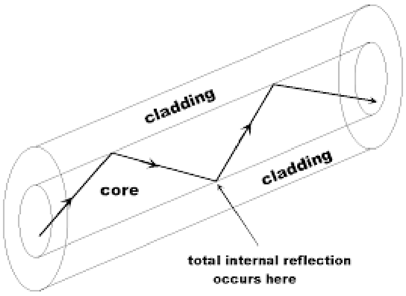
(d) Real, inverted and magnified

Explanation: 

Intermediate image (P'Q') is formed by objective which is a convex lens and the object (PQ) is placed at a distance slightly greater than the focal length. Hence, producing a real, inverted and magnified image.

59. **(a)** Total internal reflection

Explanation: Optical fibres are fabricated with high-quality composite glass/quartz fibres. Each fibre consists of a core and cladding. The refractive index of the material of the core is higher than that of the cladding. When a signal in the form of light is directed at one end of the fibre at a suitable angle, it undergoes repeated total internal reflections along the length of the fibre and finally comes out at the other end as shown in figure.



60.

(b) spherical aberration

Explanation: spherical aberration

61.

(c) f = 2R

Explanation: $\frac{1}{f}=(\frac{\mu_2}{\mu_1}-1)(\frac{1}{R_1}-\frac{1}{R_2})$

For plano convex lens, R_1 = infinite and R_2 = -R

Hence, $\frac{1}{f}=(1.5-1)(\frac{1}{\infty}-\frac{1}{-R})$

or f = 2R

62.

(c) 2 cm and 12 cm

Explanation: In normal adjustment, m = f_o/f_e = 6. Therefore $f_o = 6 f_e$

Now, $f_o + f_e = 14$

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

Hence, f_o = 12 cm

63.

(d) lesser than the focal length of eyepiece

Explanation: lesser than the focal length of eyepiece

64.

(b) Full image will be formed but will be less bright

Explanation: Image will be formed at the same position and same height but intensity of image formed will be less hence its brightness will be less as less number of light rays will form the image. Light rays from the covered portion will not contribute to image formation.

65.

(d) 60°

Explanation: 60°

66.

(c) a vernier scale provided on the microscope

Explanation: a vernier scale provided on the microscope

67. **(a)** a converging lens of focal length 100 cm

Explanation: behave as converging lens as ,

Combined power, P = $P_1 + P_2$ = +2 D + (-1 D) = +1 D

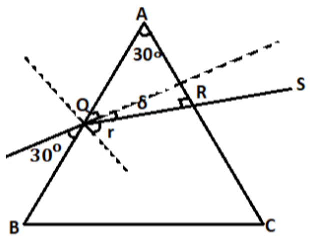
Focal length of combination, f = 1/P = 1/1 = 1 m = 100 cm

Since focal length is positive, it will behave as converging lens.

68.

(c) 30^o

Explanation:



In △AQR

∠A + ∠Q + ∠R = 180^o

30° + 90 - r + 90 = 180^o

r = 30^o

$\delta = 90^o - 30^o - r$

$\delta = 90^o - 30^o - 30^o$

$\delta = 30^o$

so angle of deviation is 30 degree.

69.

(b) $\delta_1 < \delta_2$

Explanation: Now, $\delta_1 = A(\mu_r - 1)$ = A(1 · 520 - 1) = $0 \cdot 520A$

and $\delta_2 = A(\mu_b - 1)$ = A(1 · 525 - 1) = $0 \cdot 525A$

$\therefore \delta_1 < \delta_2$

70. **(a)** $36/\sqrt{7}$

Explanation: solution

From the figure it is clear that:

$\tan C = \frac{r}{h}$

Therefore, the radius of the circle is given by

r = h tan C,

where C is critical angle at the water-air interface and h, the depth of the fish below the water surface.

Now, sin C = $\frac{1}{\mu} = \frac{1}{4/3} = 0 \cdot 75$

or C = $48 \cdot 6^\circ$

Thus, r = 12 tan 48.6^o = $13 \cdot 6 = 36/\sqrt{7}$ cm

71.

(b) two images form, one at O' and the other at O''

Explanation: two images form, one at O' and the other at O''

72.

(c) rectangular hyperbola

Explanation:

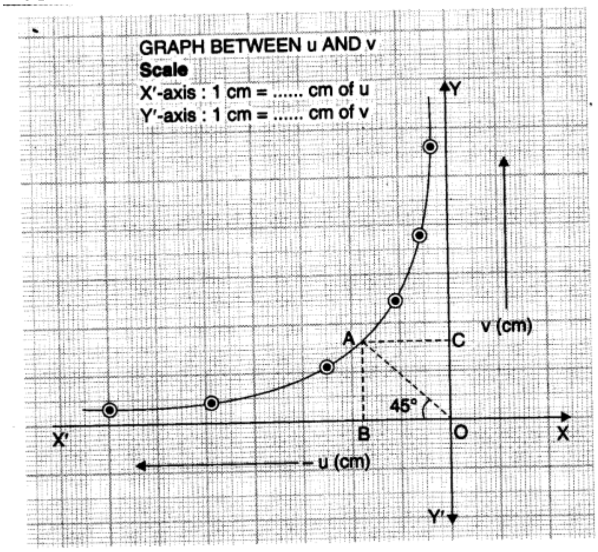


Fig. Graph between u and v. It is a rectangular hyperbola.

73. **(a)** myopia

Explanation: myopia

74.

(b) binoculars gives three dimensional view

Explanation: As both eyes are used for viewing, binoculars project a 3D image and provide a better in depth perception and a broader field of vision i.e., binocular lens gives the proper three dimensional image.

75.

(b) $\frac{5}{3}$

Explanation: f = $\frac{1}{P} = \frac{1}{5}$ m = 20 cm

Now, $\frac{1}{f} = \left(\frac{\mu_2}{\mu_1} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$

In air, $\frac{1}{20} = \left(\frac{1.5}{1} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right) = 0.5\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$ ....(i)

In liquid, $\frac{1}{-100} = \left(\frac{1.5}{\mu_1} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$ ....(ii)

Dividing (i) by (ii), we get

$-5 = \frac{0.5}{\left(\frac{1.5}{\mu_1} - 1\right)}$

On solving we get, $\mu_1 = \frac{5}{3} = 1.67$