CBSE Test Paper-04

Class - 12 Physics (Ray Optics and Optical Instruments)

1. The diameter of a plano-convex lens is 6 cm and the thickness at the centre is 3 mm. If the speed of light in the material of the lens is $2 \times 10^8 \mathrm{ms}^{-1}$ the focal length of the lens is
   a. 15 cm
   b. 30 cm
   c. 20 cm
   d. 10 cm
2. A person can see clearly only up to a distance of 30 cm. He wants to read a book placed at a distance of 50 cm from his eyes. What is the power of the lens he requires for his spectacles?
   a. -1.67 D
   b. -1.33 D
   c. -1.0 D
   d. -2.0 D
3. A person uses spectacles of power +2D, He is suffering from
   a. Presbyopia
   b. Short sightedness or myopia
   c. Long sightedness or hypermetropia
   d. Astigmatism
4. An object and a screen are mounted on an optical bench and a converging lens is placed between them so that a sharp image is received on the screen. The linear magnification of the image is 2.5. The lens is now moved 30 cm nearer the screen and a sharp image is again formed on the screen. The focal length of the lens is
   a. 14.9 cm
   b. 14.3 cm
   c. 14.0 cm
   d. 14.6 cm
5. A point object is placed at the centre of a glass sphere of radius 6 cm and refractive index 1.5. The distance of virtual image from the surface of sphere is
   a. 2 cm

b. 4 cm
c. 6 cm
d. 12 cm

6. In a simple microscope why the focal length of the lens should be small?
7. Write the necessary conditions, for the phenomenon of total internal reflection to take place.
8. What are the laws of refection?
9. A virtual image, we always say, cannot be caught on a screen. Yet when we 'see' a virtual image, we are obviously bringing it on to the 'screen' (i.e. the retina) of our eye. Is there a contradiction?
10. A convex lens of crown glass $(\mu_g = 1.5)$ has a focal length of 15 cm. The lens is placed in
    a. water $(\mu_w = 1.33)$ and
    b. carbon bisulphide $(\mu_c = 1.65)$.

    Determine in each case, whether the lens behaves as a converging or diverging lens and determine its focal length.
11. Two thin lenses of power +4D and -2D are in contact. What is the focal length of the combination?
12. An object of size 3.0 cm is placed 14 cm in front of a concave lens of focal length 21 cm. Describe the image produced by the lens. What happens if the object is moved further away from the lens?
13. A convex lens of focal length 15 cm, and a concave mirror of radius of curvature 20 cm are placed coaxially 10 cm apart. An object is placed in front of the convex lens so that there is no parallax between the object and its image formed by the combination. Find the position of the object.
14. A vessel 20 cm deep is half filled with oil of refractive index 1.37 and the other half is filled with water of refractive index 1.33. Find the apparent depth of the vessel when viewed from above.
15. A parallel beam of light traveling in water (refractive index = $\frac{4}{3}$) is refracted by a spherical air bubble of radius 2 mm situated in water. Assuming the light rays to be paraxial,
    a. find the position of the image due to refraction at the first surface and the position of the final image and
    b. draw a ray diagram showing the positions of both the images.

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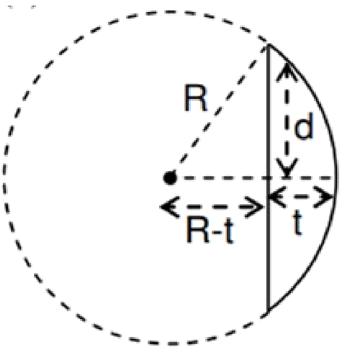
Answers

1. (b) 30 cm

   Explanation: 

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

   $R^2 = d^2 + (R - t)^2$

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

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

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

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

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

   f = 30 cm
2. (b) -1.33 D

   Explanation: u = -50 cm, v = -30 cm

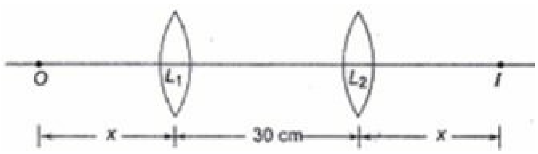
   $\frac{1}{f} = \frac{1}{v} - \frac{1}{u} = \frac{1}{-30} - \frac{1}{-50} = \frac{-1}{75}$

   Hence f = -75 cm

   and P = 100/-75 D = -1.33 D
3. (c) Long sightedness or hypermetropia

   Explanation: In hypermetropia the image of near by objects is formed behind the retina, hence a converging lens (convex lens) of suitable power is used to correct the defect. Focal length and hence the power of convex lens is positive.

   Hence lens of positive of power is used to correct hypermetropia or long sightedness.
4. (b) 14.3 cm

Explanation: 

$OL_1 = IL_2$ = 40 cm and OI = 100cm

for L_1 we have, u = -x cm and v = 30 + x cm

m = v/u = -2.5

or $\frac{30+x}{-x} = -2.5$ or x = 20 cm

Hence u = -20 cm and v = +50 cm, putting these values in lens formula and solving, we get

f = 14.3 cm.

5. (c) 6 cm

   Explanation: The rays from the point object fall normally on the surface of the sphere and hence emerge undeflected. When produced backward, they meet at O. Thus a virtual image is formed at center itself.
   Therefore, distance of virtual image from the surface of the sphere = 6cm.

6. This is because the angular magnification is inversely proportional to the focal length.

7. Necessary conditions for the total internal reflection are:

   i. Light must travel from denser medium to rarer medium.
   ii. The angle of incidence (in the denser medium) must be greater than the critical angle i_c where
   $\sin i_c = \frac{1}{\mu}$

8. Laws of reflection:

   i. The incident rays, the reflected ray and the normal lie in the same plane.
   ii. The angle of incident (i) is equal to the angle of reflection (r), i.e. $\angle i = \angle r$.

9. When the reflected or refracted rays are divergent, the image is virtual. The divergent rays can be converged on to a screen with the help of a suitable converging lens. The convex lens of the eye performs this function precisely. In this case, the virtual image serves as the virtual object for the lens to produce a real image. It may be noted here that the screen is not located at the position of the virtual image. There is no contradiction.

10. For lens in glass

$\frac{1}{15}=(\mu-1)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$

$=(1.5-1)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$

$=0.5\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$ ....(i)

For lens in water

$$\frac{1}{\mathrm{f}_w}=\left(\frac{\mu_g-\mu_w}{\mu_w}\right)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$$

$=\left(\frac{1.5-1.33}{1.33}\right)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$

$=\frac{0.17}{1.33}\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$ ...(ii)

For lens in carbon bisulphide

$\frac{1}{\mathrm{f}_c}=\left(\frac{\mu_g-\mu_c}{\mu_c}\right)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$

$=\left(\frac{1.5-1.65}{1.65}\right)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$

$=-\frac{0.15}{1.65}\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$ ....(iii)

Dividing (i) by (ii) we get

f_W = -58.7 cm

The positive sign indicates that the lens in converging.

Dividing (i) by (iii), we get

f_e = -82.5 cm

The negative sign indicates that the lens behaves as a diverging lens when it is immersed in carbon bisulphide.

11. $P = P_1 + P_2 = 4 - 2 = +2D$

Since focal length $f=\frac{1}{P}$

$\therefore f=\frac{1}{2}=0.5m$ = 50 cm

12. O = 3.0 cm, u = -14cm, f = -21cm

Since $\frac{1}{v}=\frac{1}{\mathrm{f}}+\frac{1}{u}=-\frac{1}{21}-\frac{1}{14}=-\frac{35}{14\times 21}$ or v = -8.4 cm

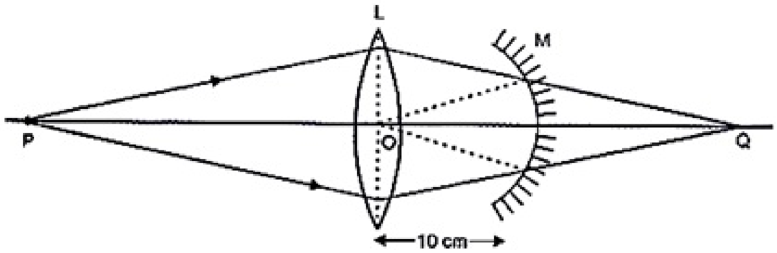
The image is located 8.4 cm, from the lens on the same side as the object.

As $m=\frac{I}{O}=\frac{v}{u}$

$I=\frac{v}{u}\times O=\frac{-8.4}{-14}\times 3$ = 1.8 cm

As size of image is +ve. So, image is erect and virtual of smaller size.

As the object is moved away from the lens, the virtual image moves towards the focus of the lens but never beyond. The image progressively diminishes in size.

13. 

Here u = ?

As there is no parallax between the object and the image.

∴ v = u

From convex lens formula, we get

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

$\frac{1}{+15} = \frac{1}{30} - \frac{1}{u}$

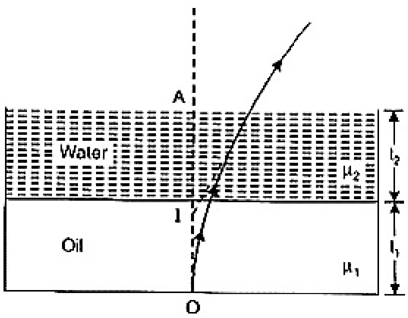
$\frac{1}{u} = \frac{1}{30} - \frac{1}{15}$

$\frac{1}{u} = -\frac{1}{30}$

∴ u = -30 cm

Now the image will form at Q which is the virtual object for concave mirror. The final image will form at the optical centre. Hence the distance of the object is 30 cm from the mirror.

14. Referring to figure given below, the apparent depth of the vessel is



$AI = \frac{t_1}{\mu_1} + \frac{t_2}{\mu_2} = \frac{t}{2}\left(\frac{1}{\mu_1} + \frac{1}{\mu_2}\right) = \frac{t(\mu_1+\mu_2)}{2\mu_2\mu_1}$

where t = 20 cm, $\mu_1 = 1.37$ and $\mu_2 = 1.33$

Substituting for t, μ_1 and μ_2 we get

AI = 15.37 cm

15. a. For refraction at the first surface, we use

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

where $\mu_1 = \frac{4}{3}, \mu_2 = 1$ and $u = \infty$ and R = 2 mm. Thus

$\frac{1}{v_1} = \frac{\frac{4}{3}}{\infty} = \frac{1 - \frac{4}{3}}{2}$

which gives v_1 = -6 mm, the negative sign indicates that the image I_1 is virtual and is on the same side as the object at a distance of 6 mm from the first surface.

For refraction at the second surface, the image I_1 serves as the virtual object which is at a distance of 6 mm + 4 mm = 10 mm from the second surface. For this refraction, we use

$\frac{\mu_1}{v_2} - \frac{\mu_2}{u} = \frac{\mu_1 - \mu_2}{R}$

where u = -10mm and R = -2mm.Thus

$\frac{\frac{4}{3}}{v_2} - \frac{1}{-10} = \frac{\frac{4}{3} - 1}{(-2)}$

Which given v_2 = -5 mm.

The final image I_2 is virtual and is formed at a distance of 5 mm from the second surface to the left of the second surface, i.e., the final image is formed at a distance of 1 mm from the first surface.

b.