Home Assignment 01-19 [Sully Roy]

(1) The image of a needle placed at 45 cm from a lens is formed on screen placed 90 cm on the other side of the lens. Find the displacement of the image, if the object is moved 5 cm away from the lens. Also find the power of the lens.

Ans Given,

object distance, $u = -45$ cm

image distance, $v = 90$ cm

Now, from lens's formula

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

$$\Rightarrow \frac{1}{90} - \frac{1}{-45} = \frac{1}{f}$$

$f = 30$ cm

Now, when needle is moved 5 cm away from the lens,

new object distance $= -(45+5)$

$= -50$ cm

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

$$\Rightarrow \frac{1}{30} + \frac{1}{-50} = \frac{1}{v'}$$

new image distance, $v' = 75$ cm

Displacement $= v - v'$

$= 90 - 75$

$= 15$ towards the lens

(2) A lens of power +3 D and another of power −1.5 D are placed in contact, will the combination be convergent or divergent? Also, find the focal length and power of the combination.

Ans. Given, $P_1 = +3$ D

$P_2 = -1.5$ D

∴ Power of combination

$P = P_1 + P_2$

$P = 3 + (-1.5)$

$P = 3 - 1.5$

$P = 1.5$

As P is positive so, the combination is convergent.

$\therefore f = \frac{1}{P}$

$f = \frac{1}{1.5}$ m

$= 0.67$ m or 67 cm

(3) Find the nature and focal length of a lens which must

be placed in contact with a concave lens of focal length 0.25 m in order that the lens combination may produce a real image 5 times the size of the object on the same side of the combination.

Ans: for convex lens
focal length, $f = 10$ cm
power of lens, $P = 10$ D
for concave lens
focal length, $f = -25$ cm
power of lens, $P = -4$ D
In combination
object distance, $u = -20$ cm
image distance, $v = ?$
magnification $= \frac{-v}{u}$

$$\Rightarrow \frac{-5}{1} = \frac{-v}{-20}$$

$$\Rightarrow v = 100 \text{ cm}$$

By lens formula

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

$$\Rightarrow \frac{1}{f} + \left(-\frac{1}{25}\right) = \frac{1}{100} - \left(-\frac{1}{20}\right)$$

$$\Rightarrow \frac{1}{f} - \frac{1}{25} = \frac{1}{100} + \frac{1}{20}$$

$$\Rightarrow \frac{1}{f} - \frac{1}{25} = \frac{20 + 100}{100 \times 20}$$

$$\Rightarrow \frac{25 - f}{25f} = \frac{120}{2000}$$

$$\Rightarrow \frac{25f}{25 - f} = \frac{2000}{12}$$

$$\Rightarrow 25 \times 12 f = 20(25 - f)$$

$$\Rightarrow 300f = 5000 - 20f$$

$$\Rightarrow 500f = 5000$$

$$\Rightarrow f = 10$$

$$\text{Power} = \frac{1}{f} = \phi = \frac{100}{f}$$

Power of Convex lens $= \frac{100}{10} = 10$ d

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(4) You are provided with lenses of powers +10 D, +5 D, −5 D, −20 D and −10 D. Taking a pair of lenses at a time, which two lenses will you select to have (i) total focal length (ii) both the lenses are kept in contact in each case.

(i) 20 cm (ii) −10 cm

(iii) −20 cm (iv) 20/3 cm

Ans Total power, $P = P_1 + P_2$

Total focal length, $\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2}$

(i) When lenses of 10 D and −5 D are taken, total power

$P = P_1 + P_2$

$= (10\ D + (-5\ D))$

$= 10\ D - 5\ D$

$= 5\ D$

Hence, focal length $= 100/P = 20$ cm

(ii) When lenses of 10 D and −20 are taken, total power

$P = P_1 + P_2$

$P = 10\,D - 20\,D$

$P = -10\,D$

focal length $= \frac{100}{-10} = -10$ cm

(iii) when lenses of $+5\,D$ and $-10\,D$

$P = -5\,D$

$f = \frac{100}{-5} = -20$ cm

(iv) when lenses of $10\,D$ and $5\,D$ are taken

$P = 15\,D$

$f = \frac{100}{15} = \frac{20}{3}$ cm