Examples ch4:

EXAMPLE I: If an object is located 6.0 cm in front of a lens of focal length + 10.0 cm, where will the image be formed?

SOLUTION

The given quantities are s = + 6.0cm, and f = + 10.0cm, while the unknown quantities are s' and m.

$$\frac{1}{s} + \frac{1}{s'} = \frac{1}{f}$$

$$s' = \frac{s \times f}{s - f}$$

$$s' = \frac{(+6) \times (+10)}{(+6) - (+10)} = \frac{+60}{-4} = -15.0 \text{ cm}$$

EXAMPLE 2 An object is placed 12.0 cm in front of a diverging lens of focal length 6.0 cm. Find the image.

SOLUTION The given quantities are $s = +12.0$ cm and $f = -6.0$ cm, while the unknown quantities are s' and m. We substitute directly in Eq. (4b), to obtain

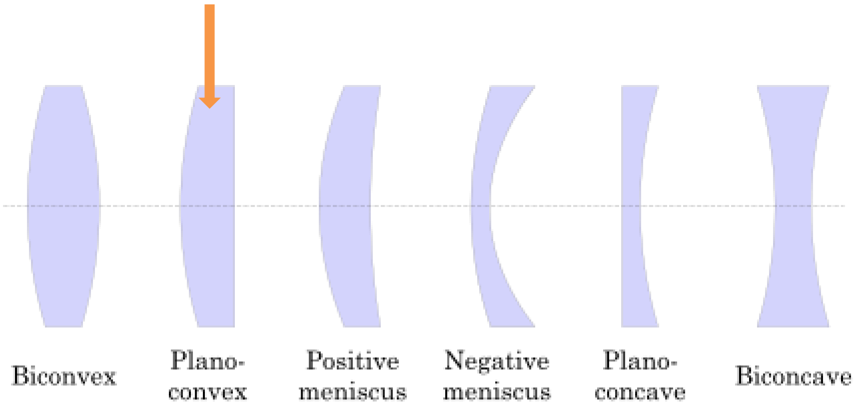
$$s' = \frac{(+12) \times (-6)}{(+12) - (-6)} = \frac{-72}{+18}$$

from which $s' = -4.0$ cm. For the image size Eq. (4c) gives

$$m = -\frac{s'}{s} = -\frac{-4}{12} = +\tfrac{1}{3}\times$$

The image is therefore to the left of the lens, virtual, erect, and one-third the size of the object.

EXAMPLE 3: A plano-convex lens having a' focal length of 25.0 cm [Fig.



is to be made of glass of refractive index n = 1.520. Calculate the radius of curvature of the grinding and polishing tools that must be used to make this lens.

SOLUTION: - Since a plano-convex lens has one flat surface, the radius for that surface is infinite, and r_1 in Eq. (4d) is replaced by 00. The radius r_2 of the second surface is the unknown. Substitution of the known quantities in Eq.

$$\frac{1}{f} = (n - 1)\left(\frac{1}{r_1} - \frac{1}{r_2}\right)$$

$$\frac{1}{s} + \frac{1}{s'} = (n - 1)\left(\frac{1}{r_1} - \frac{1}{r_2}\right)$$

$$\tfrac{1}{25} = (1.520 - 1)\left(\frac{1}{\infty} - \frac{1}{r_2}\right)$$

Transposing and solving for r_2, we have

$$\tfrac{1}{25} = 0.520\left(0 - \frac{1}{r_2}\right) = -\frac{0.520}{r_2}$$

giving $$r_2 = -(25 \times 0.520) = -13.0 \text{ cm}$$

If this lens is turned around, as in the figure, we shall have $r_1 = +13.0$ cm and $r_2 = \infty$.

EXAMPLE 4: - The radii of both surfaces of an equiconvex lens of index 1.60 are equal to 8.0 em. Find its power.

SOLUTION: n = 1.60, r_1 = 0.080 m, and r_2 = -0.080 m (see table 1 and fig1 for the shape of an equiconvex lens).

$$P = (n-1)\left(\frac{1}{r_1} - \frac{1}{r_2}\right) = (1.60-1)\left(\frac{1}{0.080} - \frac{1}{-0.080}\right) = 0.60\frac{2}{0.080} = +15.0\text{ D}$$

ملاحظة : ضروري وضع علامة + او – امام نواتج power lens , radii and object and image distance

Ch4:Problems

Q1: A positive meniscus (convex-concave) thin lens (n=1.5) whose radii of curvature are 5 cm and 10 cm is positioned in contact with a plano-concave thin lens(n= 1.6) of radius 6 cm. what is the effective focal length of the lens system? Compute its power as well.

Q2: Find the radius of curvature of the convex lens of index of refractive 1.52 when the radius of one face twice the other and the power of lens 20 D ?

Q3: An object located 16 cm in front of a thin lens has its image formed on the opposite 48 cm from the lens. Calculate the focal length and power of the lens and magnification?

Q4: An object 4 cm high is located 20 cm in front of lens whose focal length -5 cm . calculate a) the power of lens b) the image distance

c) the lateral magnification.

Q5: two lenses having focal length f_1 =+8 cm , f_2 =-12 cm are placed 6 cm apart . if an object 3 cm high is located 24 cm in front of the first lens. Find the position final image and image length.

Q6: compute the focal length of the bi- concave thin lens whose radii of curvature are (10 &20)cm . If t is made of flint glass(1.66) and immersed in water(n_m= 1.33)

Q7:bi –convex thin lens of index 1.5 is known to have a focal length of 50 cm n air . when immerse in a transparent liquid to focal length is measured to be 250 cm. determine the refractive index of the liquid medium.

Q8: Compute of the object and image distance for a thin bi- convex lens .if the image is to be projected life –sized directly onto a screen . the lens has equal radii of 60 cm and n_m =1.5?

Q9: A 3 cm high object is sitting 75 cm from a thin positive lens of 25 cm focal length . Describe the resulting image completely .use both Gaussian and Newtonian formula to solve problem.

Q10: It is required that a real image twice the size of the object be formed by a thin plano-convex lens. If the lens has a radius of curvature of 50 cm and refractive index 1.5 , determine the locations of the object and image with respect to the lens a) by use of the Newtonian expression

b) by use of the Gaussian expression.

Q11: suppose that an object positioned 10 cm to the left of the positive lens is imaged 30 cm to the right of the lens where will the image appear if the object is now moved so that t is 2.5 cm from the lens? Completely describe the image in both intstances.

Q12: A compound lens consists of two thin-bi-convex lenses L_1 and L_2 of focal lengths 10 cm and 20 cm , separated by a distance of 80 cm. describe the mage corresponding to a 5 cm tall object 15 cm from the first lens.

Solution:

$$\frac{1}{s_{i1}}=\frac{1}{f_1}-\frac{1}{s_{o1}}, \quad s_{i1}=\frac{s_{o1}f_1}{s_{o1}-f_1}$$

$$s_{o2}=d-s_{i1} \qquad \begin{matrix} s_{o2}<0 \ (virtual) \\ s_{o2}>0 \ (real) \end{matrix}$$

For the compound lens system, s_{o1} is the object distance and s_{i2} is the image distance.

$$\frac{1}{s_{i2}}=\frac{1}{f_2}-\frac{1}{s_{o2}}, \quad s_{i2}=\frac{s_{o2}f_2}{s_{o2}-f_2}=\frac{(d-s_{i1})f_2}{(d-s_{i1}-f_2)}=\frac{f_2 d-\dfrac{f_2 s_{o1} f_1}{s_{o1}-f_1}}{d-f_2-\dfrac{s_{o1}f_1}{s_{o1}-f_1}}$$

بعد الصورة يعطى من العلاقة

The total transverse magnification (M_T) is given by

$$M_T=M_{T1}M_{T2}=\left(-\frac{s_{i1}}{s_{o1}}\right)\left(-\frac{s_{i2}}{s_{o2}}\right)=\frac{f_1 s_{i2}}{d(s_{o1}-f_1)-s_{o1}f_1}$$

$$s_{i2} = \frac{f_2\, d \ - \ [\frac{f_1 f_2 \ \ s_o}{(s_o \ -f_1)}]}{d-f_2 \ -[f_1 s_o \ /(s_o- \ f_1)]}$$ وحيث ان :

s02= 15 cm, d=80 cm, f=20 cm , f1= 10 cm: حيث ان

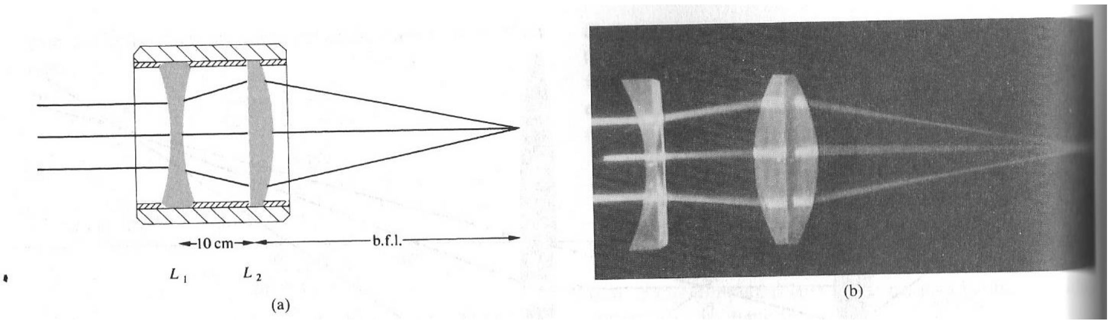
$$s_{i2} = \frac{20x80 \ - \ [\frac{10x20x15}{(10x15)}]}{80-20-[\frac{(10x15)}{15-10}]}$$

$$=\frac{100}{3} = 33.3\ cm$$

الصورة حقيقية وتقع على بعد 33.3 cm خلف العدسة الاخيرة وتكبيرها الجانبي يعطى بالعلاقة:

$$M_T=M_{T1}M_{T2}=\left(-\frac{s_{i1}}{s_{o1}}\right)\left(-\frac{s_{i2}}{s_{o2}}\right)=\frac{f_1 s_{i2}}{d(s_{o1}-f_1)-s_{o1}f_1}$$

Q13:Imagin a compound lens consisting of thin positive lens followed at an interval of 20 cm by a thin negative lens. If these have focal length of 40 cm and -40 cm respectively ,determine the front focal length and the back focal length?



Solution:

$$\left[\frac{1}{S_{o1}}\right]_{s_{i2}\to\infty} = \frac{1}{f_1} - \frac{1}{s_{i1}} = \frac{1}{f_1} - \frac{1}{d - f_2} \quad \Rightarrow \quad ffl = \left[s_{o1}\right]_{s_{i2}\to\infty} = \frac{f_1(d - f_2)}{d - (f_1 + f_2)}$$

$$= f.f.l = \frac{40[20-(-40))]}{20-[40+(-40)]} = 120\ cm$$

From the previous slide, we calculated s_{i2}. Therefore, if $s_{o1} \to \infty$ we get,

$$b.f.l = \frac{f_2\,(d-f_1)}{d-(f_1+f_{2)}} = \frac{-40(20-40)}{20-[40+(-40)]} = 40\ \text{cm}$$