كلية العلوم

نموذج إجابة مادة ضوء

الفرقة الأولي علوم

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Part B "Optics"

Q1) Choose the correct answer: -- [10 marks]

The right answers is in red color

1. As light travel from a vacuum $(n = 1)$ to a medium such as glass $(n > 1)$, which of the following properties remains the same?
   (a) Wave length (b) Wave speed (c) Frequency

2. If the index of refraction of water is 1.33, then the critical angle for water-air boundary is:
   (a) 0.752^o (b) 48.8^o (c) zero

3. In case of convex lens when $p = q$ then image will be at distance:
   (a) f (b) 2f (c) infinity

4. A light passing through the center of curvature of a concave mirror is reflected on the mirror surface by an angle θ of magnitude:
   (a) 0^o (b) 90^o (c) $0 < \theta < 90^o$

5. The power of a convex lens ($f = 5cm$) is:
   (a) $0.2\,m^{-1}$ (b) $20\,m^{-1}$ (c) $20\ cm^{-1}$

6. Which length is used to correct the defect of long sightedness?
   (a) Convex lens (b) Cylindrical lens (c) Concave lens

7. In compound microscope, the ratio between the focal length of the eye piece and that of the objective is:
   (a) greater than one (b) equal one (c) less than one

8. A light passing through the optical center of a convex lens is ……..
   (a) reflected (b) refracted (c) no one

9. If the object is located at the center of curvature, its image is formed at the …………
   (a) center of curvature (b) focal point (c) infinity

10. If the optical path for material (n = 1.3) is 3.90 mm. Then its geometrical path is:
   (a) 2mm (b) 4mm (c) 3mm

Q2) -- [10 marks]

Derive an expression for the lenses equation.

Answer

Consider a lens having an index of refraction *n* and two spherical surfaces of radii of curvature R_1 and R_2, as in Fig. (1). An object is placed at point O at a distance p_1 in front of surface 1. For this example, p_1 has been chosen so as to produce a virtual image I_1 to the left lens. This image is then used as the object for surface 2, which results in a real image I_2.

$n_1 = 1$

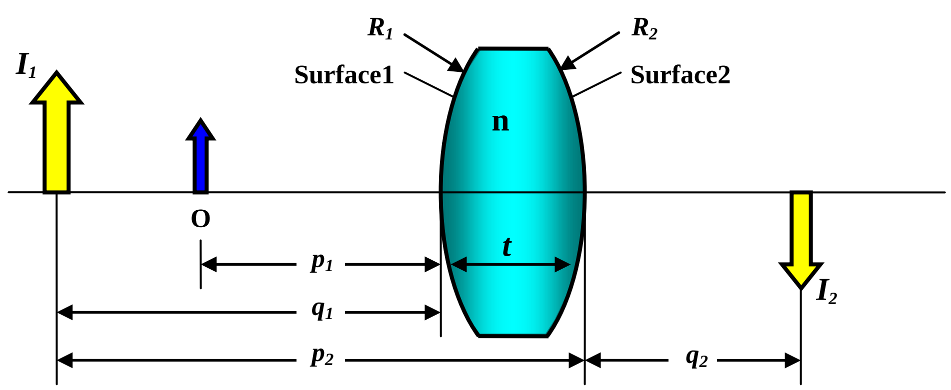


Fig. (1): To locate the image of a lens, the image at I_1 formed by the first surface is used as the object for the second surface. The final image is at I_2

Using Eq. (??) and assuming $n_1 = 1$ because the lens is surrounded by air, we find that the image formed by surface 1 satisfies the equation

$$\frac{1}{p_1} + \frac{n}{q_1} = \frac{n-1}{R_1}. \tag{1}$$

Now we apply Eq. (??) to surface 2, taking $n_1 = n$ and $n_2 = 1$. That is, light approaches surface 2 as if it had come from I_1. Taking p_2 as the object distance and q_2 as the image distance for surface 2 gives

$$\frac{1}{p_2} + \frac{n}{q_2} = \frac{1-n}{R_2} . \qquad (2)$$

But $p = -q_1 + t$, where *t* is the thickness of the lens. (Remember q_1 is a negative number and p_2 must be positive by our sign convention.) For a thin lens, we can neglect *t*. In this approximation and from Fig. (1), we see that $p_2 = -q_1$. Hence, Eq. (2) becomes

$$-\frac{n}{q_1} + \frac{1}{q_2} = \frac{1-n}{R_2} . \qquad (3)$$

Adding Eqs. (1) and (3), we find that

$$\frac{1}{p_1} + \frac{1}{q_2} = (n-1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right) . \qquad (4)$$

For the thin lens, we can omit the subscripts on p_1 and q_2 in Eq. (4) and call the object distance *p* and the image distance *q*, as in Fig. (2). Hence, we can write Eq. (4) in the form

$$\frac{1}{p} + \frac{1}{q} = (n-1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right) . \qquad (5)$$

This equation relates the image distance *q* of the image formed by a thin lens to the object distance *p* and to the thin lens properties (index of refraction and radii of curvature). It is valid only for paraxial rays and only when the lens thickness is small relative to R_1 and R_2.

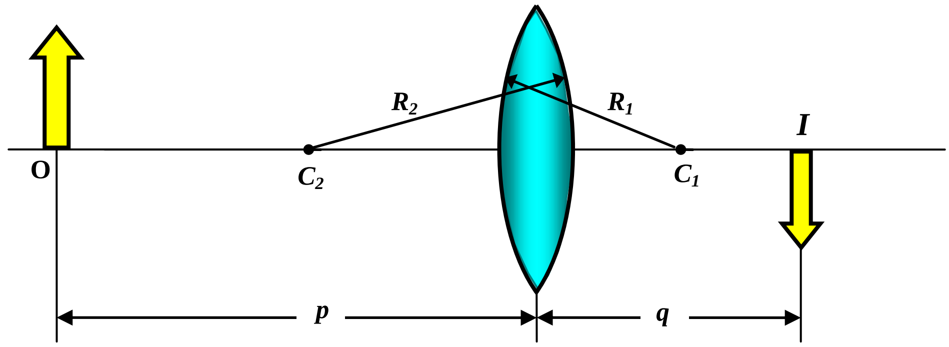


Fig. (2): The biconvex lens.

We now define the focal length f of a thin lens as the image distance that corresponds to an infinite object distance, as we did with mirrors. According to this definition and from Eq. (5), we see that as $p \to \infty,\ q \to f$; therefore, the inverse of the focal length for a thin lens is

$$\frac{1}{f} = (n-1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right). \tag{6}$$

This equation is called the ***lens makers' equation*** because it enables f to be calculated from the known properties of the lens. It can be used to determine the values of R_1 and R_2 needed for a given index of refraction and desired focal length. Using Eq. (6), we can write Eq. (5) in an alternate form identical to Eq. (??) for mirrors:

$$\boxed{\frac{1}{p} + \frac{1}{q} = \frac{1}{f}.} \tag{7}$$

A thin lens has two focal points, corresponding to incident parallel light rays traveling from the left or right. This is illustrated in Fig. (3) for biconvex lens (converging, positive f) and a biconcave lens (diverging, negative f).

Q3) -- [10 marks]

A ray of light is incident on the surface of a block of clear ice $n = 1.333$ at an angle of 40.0° with the normal. Part of the light is reflected and part is refracted. Find the angle between the reflected and refracted light.

solution

Apply Snell's law

$$n_1 \sin\theta_1 = n_2 \sin\theta_2$$

$$\theta_2 = \sin^{-1}\left(\frac{n_1 \sin\theta_1}{n_2}\right)$$

$$= \sin^{-1}\left(\frac{1\times\sin 40}{1.333}\right)$$

$$= \sin^{-1}(0.4822)$$

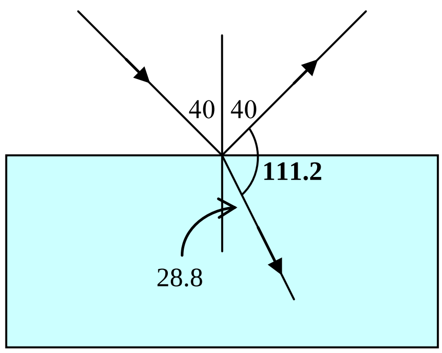
$$= 28.83$$

From the figure, the angle between the reflected and refracted light

$$= (90-40)+(90-28.8)$$

$$= 50+61.2$$

$$= 111.2^{o}$$



Q4) -- [10 marks]

An object 3.00 cm high is placed 20.0 cm from a convex mirror with a focal length of 8.00 cm. Find (a) the position of the image and (b) the magnification of the mirror.

Solution

This problem requires only substitution into the mirror and magnification equations.

(a) Find the position of the image.

Because the mirror is convex, its focal length is negative. Substitute into the mirror equation:

$$\frac{1}{p}+\frac{1}{q}=\frac{1}{f} \qquad \frac{1}{20}+\frac{1}{q}=\frac{1}{-8} \qquad \text{Solve for } q: \qquad q=-5.71\text{cm}$$

(b) Find the magnification of the mirror.

$$M=\frac{q}{p}=-\left(\frac{-5.71}{20}\right)=0.286$$