EXPERIMENT

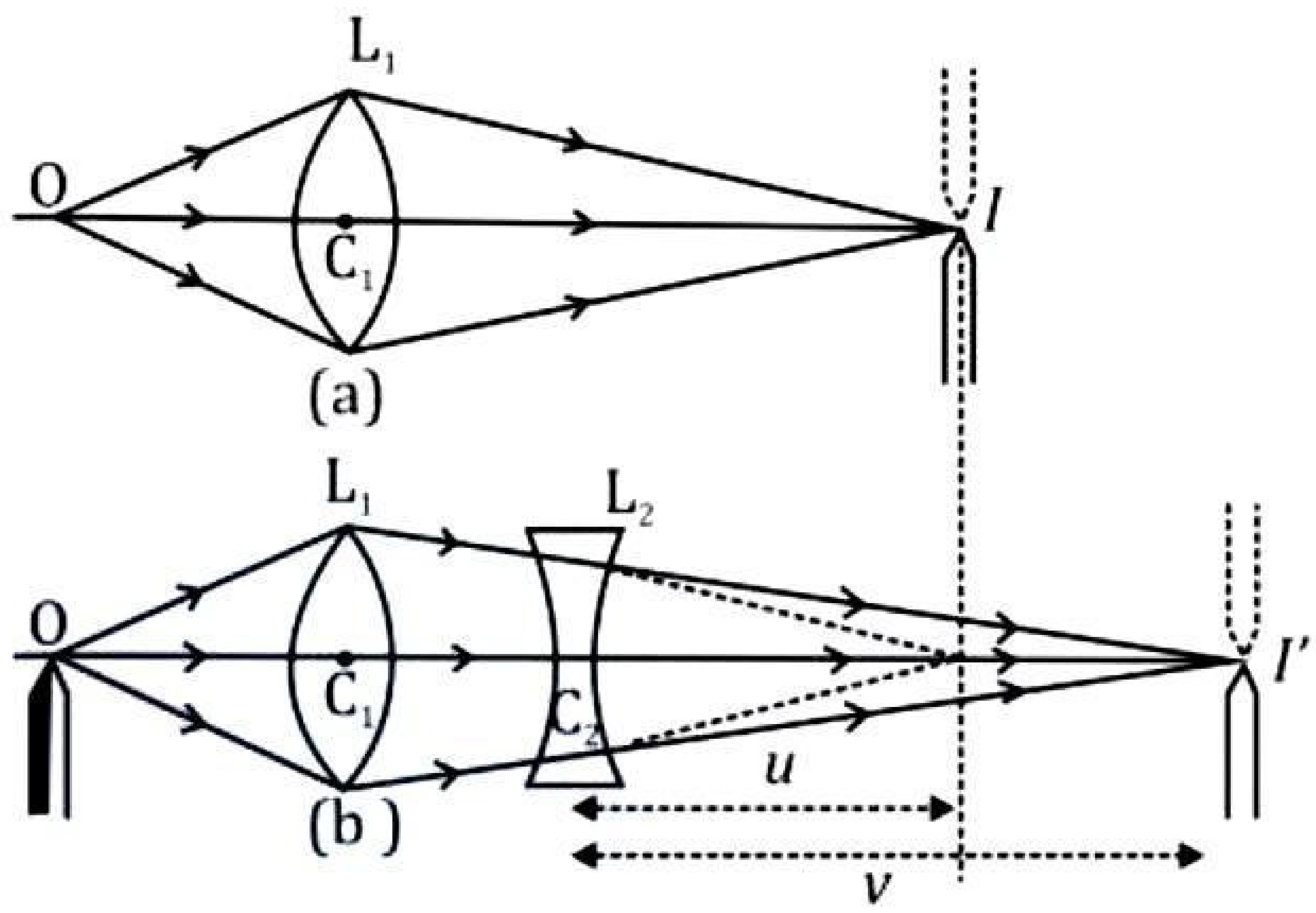
AIM

To find the focal length of a concave lens, use a convex lens.

MATERIAL REQUIRED

An optical bench with four uprights (two for optical needles and two for lenses), a concave lens with holder, a convex lens with holder, two optical needles, a knitting needle and a half-meter scale.

DIAGRAM

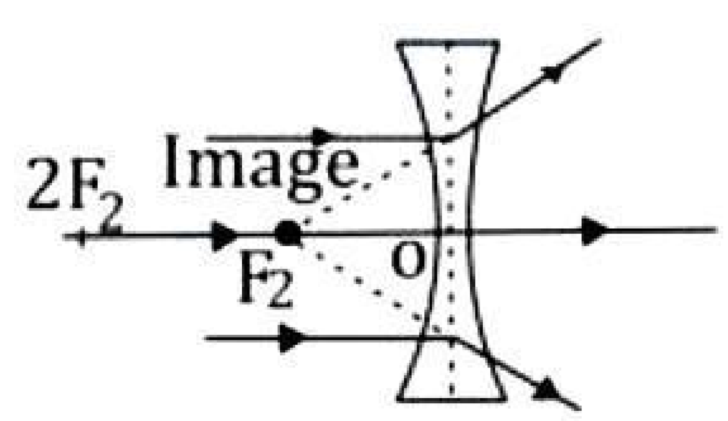
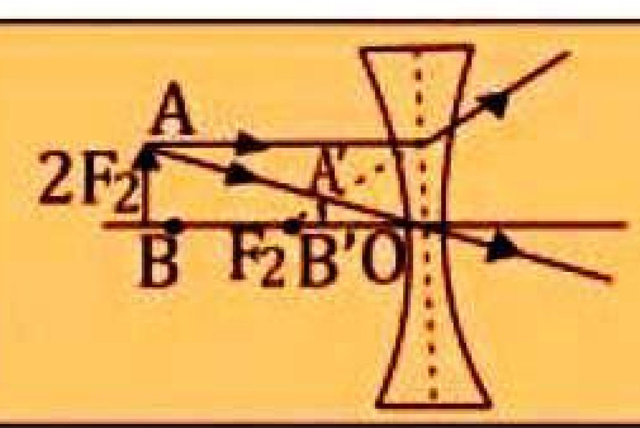


Formation of real image by convex lens, Focal length of a concave lens and convex lens.

THEORY

1. Image formation by a concave lens: In a concave lens, irrespective of the position of the object in front of the lens, the image is always formed diminished, virtual, and erect and on the same side of the lens at the focus or between the focus and optical centre.
2. Position and nature of image formed by a concave (diverging) lens for.

DIFFERENT POSITIONS OF OBJECT

S.No.	Position of the object O	Position of the image I	Nature and size of the image	Ray diagram
1.	At infinity	At focus F_2	Virtual erect and highly diminished (point sized)	
2.	Anywhere between in-finity and the optical centre	Between focus and optical centre	Virtual erect and smaller than the object	

When an object (O) is placed in front of a convex lens, its real and inverted image (I) is formed. If a concave lens (L_2) is interposed between the convex lens (L_1) and image needle (I), the refracted rays from the convex lens (L_1) diverge after passing through the concave lens (L_2) and produce the image at I' which is the image of I because I behaves as a virtual object for the concave lens.
The focal length of the concave lens, f can be determined by using the lens formula,

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

Or

$$\boxed{f = \frac{uv}{u - v}}$$

Where,
$u = L_2 I$ – the distance between the image I and the concave lens L_2
$v = L_2 I'$ – the distance between the image I' and the concave lens L_2

PROCEDURE

1. Keep an optical bench on the table and arrange the three uprights on the optical bench. In the central upright, mount the convex lens with its holder and mount the two needles on their uprights one on each side of the convex lens. Check that the tips of the needles and the centre of the lens should be at the same height.
2. Place the object needle (O) on the optical bench on the left side of the lens between f and 2f, i. e. approximately 1.5 times the rough focal length of the lens. Look from the other side of the lens. Adjust the position of the imaging needle till the parallax is removed tip to tip between the imaging needle and the image of the object needle.
3. Record the positions of the object needle (O), the imaging needle, (I) and the convex lens (L_1).
4. Keeping the positions of the object (O), the convex lens (L_1) gently mount the concave lens (L_2) on another upright between the convex lens (L_1) and the imaging needle (I) in such a way that the optical centre of the lens (L_2) be at the same height as the lens (L_1) and the axis of the lens (L_2) be also parallel to the optical bench.
5. Adjust the position of a concave lens (L_2) and the imaging needle (I), get the position of the new image (I′)and remove the parallax tip to tip between the imaging needle (I) and the new image (I′) of the object needle O, obtained by the combination of convex and concave lenses. Record the position of an image (I′).
6. Determine the index corrections as done earlier and record them.
7. Repeat the experiment at least five more times by changing the position of the object needle (O)or concave lens (L_2) concerning the convex lens (L_1) or the position of both.

OBSERVATION

1. Least count of the meter scale = ________ cm
2. The rough focal length of a given convex lens = ________ cm
3. The actual length of the knitting needle, x = ________ cm
4. Observed length of the knitting needle when it is held between the concave lens (L_2) and the imaging needle (I), y = __________ cm
5. Index correction for object distance (u) as well as the image distance (v), $I_c = (x - y)$ = __________ cm

TABLE FOR THE FOCAL LENGTH OF CONCAVE LENS

S. No.	Position of					Observed distance		Corrected distance		$f = \frac{uv}{u-v}$ (cm)
	Object needle O(cm)	Image needle I(cm)	Convex lens L_1(cm)	Concave lens L_2(cm)	Image needle I′ (cm)	$u' = O_2I$ (cm)	$v' = O_2I'$ (cm)	$u = u' + (\pm I_c)$ (cm)	$v = v' + (\pm I_c)$ (cm)	
1.										$f_1 = ...$
2.										$f_2 = ...$
3.										$f_3 = ...$
4.										$f_4 = ...$
5.										$f_5 = ...$
6.										$f_6 = ...$

CALCULATION

Mean value of the focal length of the given concave lens, $= \frac{f_1+f_2+f_3+f_4+f_5+f_6}{6} =$ __________ cm.

RESULT

The focal length of the given concave lens, = __________cm.

PRECAUTIONS

1. All the uprights must be vertical.
2. The index correction should be applied with the proper sign.
3. The parallax should be removed carefully from tip to tip.
4. The heights of the object needle and image needle must be the same as that of the centre of the convex lens and concave lens.
5. The convex lens should preferably be of a small focal length so that the combination will behave like a converging lens.
6. While finding the second position of the imaging needle (I′), the position of the object needle and the convex lens should be kept unchanged.
7. To locate the position of the image, the eye must be placed at a distance of about 30 cm behind the object needle.

SOURCES OF ERROR

1. The uprights may not be vertical.
2. The parallax may not be removed perfectly.
3. Human error.

VIVA- VOCE

Q 1. Which types of lenses are used in microscopes and telescopes?

Ans. Convex lens

Q 2. Is a ray of light passing through a lens reflected or refracted?

Ans. It is refracted on passing through a lens.

Q 3. Does the focal length of a lens depend upon u and v?

Ans. No sir, the focal length of a lens does not depend upon u and v. When u is changed, v changes, but f remains constant.

Q 4. What is the lens maker's formula?

Ans. $\frac{1}{f} = \left(\frac{n_2 - n_1}{n_1}\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$

where n is the refractive index of the material of the lens, R_1 and R_2 are radii of curvature of the surface of the lens.

Q 5. Can you name the factors on which the focal length of a lens depends?

Ans. The focal length of a lens depends upon (i) the radii of curvature of the surfaces of the lens and (ii) the nature of the material of the lens.

Q 6. What is the relation between the power of a lens and focal length?

Ans. Power (P) $= \frac{1}{\text{focal length (f)}}$

Q 7. The power of a lens is −2D. What is its focal length? Is it a converging or a diverging lens?

Ans. $P = \frac{1}{f(\text{ meter })}$ or $f = \frac{1}{-2} = -0.5$ m. It is a diverging lens.

Q 8. What is the power of a lens whose focal length is 50 cm ?

Ans. $P = \frac{100}{f(m)} = \frac{100}{50} = 2D.$

Q 9. What is the radius of curvature of a plane surface?

Ans. The radius of curvature of a plane surface is infinite i.e., $R = \infty$.

Q 10. Which of the convex lenses (thick or thin) has a larger focal length?

Ans. A thin convex lens has a larger focal length.

Q 11. What will be the effect on the focal length of a lens when immersed in water?

Ans. The focal length of a lens increases on immersing in water.

Q 12. We cannot find a rough focal length of a concave lens. Why?

Ans. We cannot find the rough focal length of a concave lens as it forms a virtual image.

Q 13. What is the nature of the image formed by a concave lens?

Ans. The image formed by a concave lens is always virtual, erect, and smaller in size than the object.

Q 14. State the practical uses of lenses.

Ans. Lenses are used in optical instruments like microscopes, telescopes, photographic cameras, and spectacles for correcting defects of vision.

Q 15. A real object is placed in front of a concave lens of focal length f at a distance f from the lens. Where is the image formed?

Ans. A virtual image is formed at a distance $\frac{f}{2}$ from the lens. It follows from the lens formula.

Q 16. An equal convex lens of focal length f is cut into two equal parts by a plane perpendicular to the principal axis of the lens. What is the focal length of each part?

Ans. $\frac{1}{f} = (n-1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right) = \frac{2(n-1)}{R_1}$

(where $R_2 = R_1$)

when the lens is cut one of the surfaces becomes a plane, for which $R_2 = \infty$.

$$\frac{1}{f'} = (n-1)\left(\frac{1}{R_1} - \frac{1}{\infty}\right) = \frac{(n-1)}{R_1} = \frac{1}{2f}$$

$$\therefore f' = 2f.$$

Q 17. Two lenses of focal length f_1 and f_2 are held coaxially d distance apart. What is the equivalent focal length?

Ans. The focal length f of such a combination of lenses is given by

$$\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2} - \frac{d}{f_2 f_2}$$

Q 18. The focal length of a lens is −30 cm. What is the nature of the lens?

Ans. Concave or diverging lens.

Q 19. What assumptions have been made in the derivation of the lens formula?

Ans. The following assumptions are made:

(i) The lens is thin.

(ii) The lens has a small aperture.

(iii) The object lies close to the principal axis,

(iv) The incident ray makes small angles with the principal axis.

Q 20. What do you mean by the refraction of light?

Ans. Refraction of light is the phenomenon of change in the path of light going from one medium to another.