To Find the Focal length Of a Concave lens Using a Convex lens

Aim

To find the focal length of a concave lens using a convex lens.

Apparatus

An optical bench with four upright (two fixed uprights in middle, two outer uprights with lateral movement), a convex lens (less focal length), a concave lens (more focal length), two lens holders, two optical needles (one thin, one thick), a knitting needle and a half metre scale.

A Short Description about the Arrangement

As a concave lens always forms a virtual image, its focal length cannot be found directly as for a convex lens. For this purpose, indirect method is used, as described below.
An object needle O is placed on one side of a convex lens L_1 and its real inverted image I is located (by image needle) on the other side as shown in ray diagram.
The concave lens L_2 is placed between convex lens L_1 and image needle I. The concave lens diverges the rays and the image is now formed at I' as shown in ray diagram.
For concave lens, I is the virtual object and I' is the real image. Hence, $O_2I = u$ and $O_2I' = v$.
Focal length can be calculated, using lens formula

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

Theory

From lens formula,

we have, $$f = \frac{uv}{u - v}$$

where, f = focal length of concave lens L_2

u = distance of I from optical centre of lens L_2

v = distance of I' from optical centre of lens L_2.

(**Note.** According to sign convention, u and v have positive values (being measured in direction of incident light). Since $v > u$, $u - v$ is negative. Hence f comes negative.)

Ray diagram

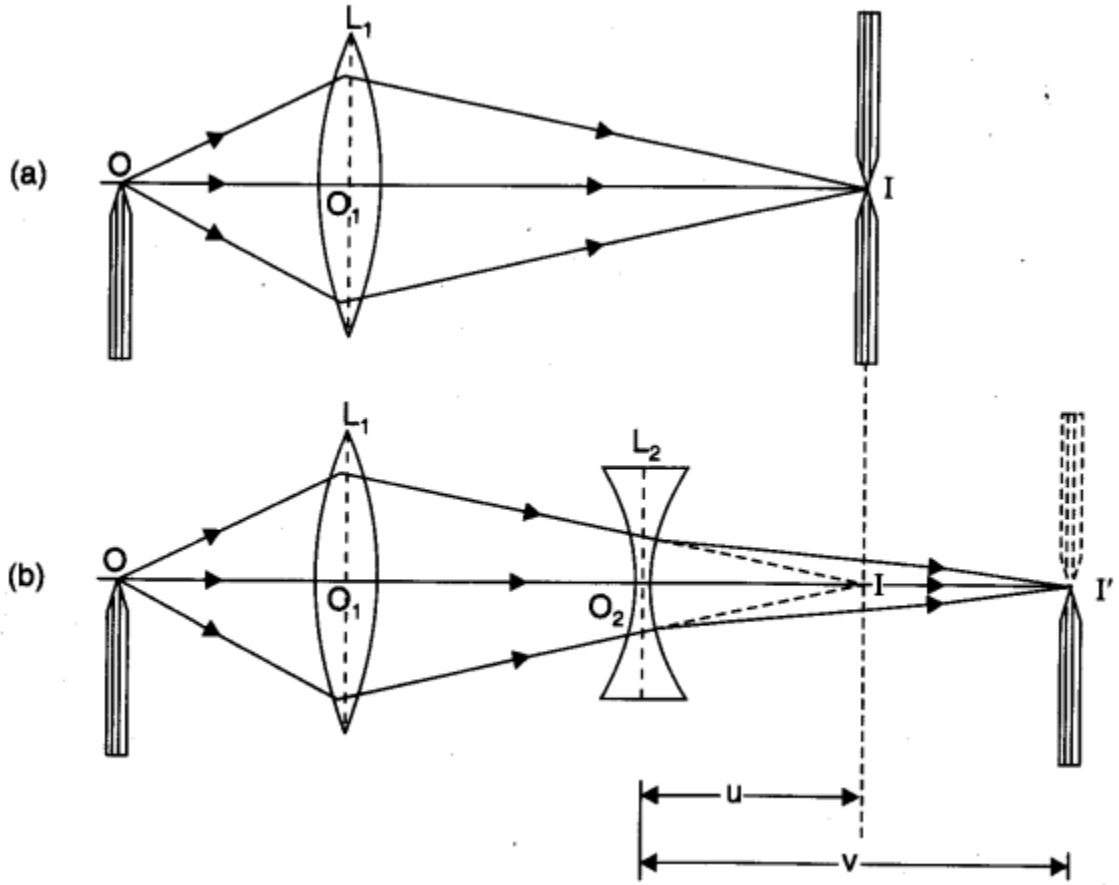

Fig. Focal length of a concave lens.

Procedure

To determine rough focal length of convex lens

1. Mount the convex lens in lens holder.
2. Go out in the open and face the lens towards distant tree or building.
3. Obtain the image of the tree or the building on a white painted wall (screen) and move the lens forward and backward to get a sharp image on the wall.
4. Measure the distance between the lens and the wall (screen). This will be equal to the rough focal length of the mirror.

   To set the convex lens
5. Follow steps 2 to 4 of Experiment 2 To set the object needle
6. Follow steps 5 to 8 of Experiment 2 To set the image needle at I
7. Follow steps 21 to 27 of Experiment 2 To set the concave lens
8. Clamp the holder with concave lens on fixed upright on the I side of the convex lens.

9. Fix this upright at some distance away from the convex lens.
10. Set the concave lens surface in same manner as convex lens surface with principal axes of the lenses coinciding.
    To set the image needle at I'
11. Repeat steps 4 and 5 of the experiment.
    To get more observations
12. Follow steps 29, 30 and 31 of Experiment 2.

Observations

Rough focal length of convex lens = ...

Actual length of the knitting needle x = ...

Observed distance between the concave lens and image

Needle when knitting needle is placed between them y = ...

Index correction for u as well as v $x - y$ = ...

Table for u, v and f

Serial No. of Obs.	*Position of*					*Observed*		*Corrected*		$f = \frac{uv}{u-v}$
	O (cm)	L_1 at O_1 (cm)	I (cm)	L_2 at O_2 (cm)	I' (cm)	$u = IO_2$ (cm)	$v = I'O_2$ (cm)	u (cm)	v (cm)	(cm)
(1)	(2a)	(2b)	(2c)	(2d)	(2e)	(3a)	(3b)	(4a)	(4b)	(5)
1.										f_1 =
2.										f_2 =
3.										f_3 =

Calculations

1. Find difference of positions of L_2 and I and write it as observed u in column 3a.
2. Find difference of positions of L_2 and I' and write it as observed v in column 36.
3. Apply index correction and write corrected values of u and v in columns 4a and 46.
4. Calculate f = uv/u-v and write in column 5.
5. Take mean of different values of as recorded in column 5.

$$\text{Mean } f = \frac{f_1 + f_2 + f_3}{3}$$

= ..... cm.

Result

The focal length of the given concave lens = -……cm

Precautions

1. Focal length of the convex lens should be less than the focal length of concave lens so that the combination is convex.
2. The lenses must be clean. .
3. Other precautions are same as given in Experiment 3.

Viva Voce

Question. 1. Define a spherical lens.
Answer. Read Art. 8.01 (a).

Question.2. Describe different types of lenses.
Answer. Read Art. 8.01 (b).

Question.3. Describe different types of convex lenses.
Answer. Read Art. 8.01 (c).

Question.4. Describe different types of concave lenses.
Answer. Read Art. 8.01 (d).

Question.5. Define different terms associated with spherical lenses.
Answer. Read Art. 8.02 (1-7).

Question.6. Mention three special rays.
Answer. Read Art. 8.03.

Question.7. Define sign convention.
Answer. Read Art. 8.04 (a).

Question.8. Give rules of sign convention.
Answer. Read Art. 8.04 (b).

Question. 9. Give facts obtained from sign convention.
Answer. Read Art. 8.04 (c).

Question.10. Define and give lens formula.
Answer. Read Art. 8.05.

Question.11. Describe various assumptions made in derivation of lens formula.
Answer. Read Art. 8.06.

Question.12. Give position, nature and size of image when object is put in different positions in front of a convex lens.
Answer. Read Art. 8.07.

Question.13. Define power of a lens. Give its unit and sign.
Answer. Read Art. 8.08.

Question.14. Define a lens combination. Give expression for. its focal length and power.
Answer. Read Art. 8.09.

Question.15. Define chromatic aberration.
Answer. Read Art. 8.10 (a).

Question.16. Describe the difference between the images formed by a convex and a concave lens. .
Answer. A concave lens always forms a virtual, erect and diminished image. Image formed by a convex lens is generally real and inverted and on bringing the object near the lens the size of image goes on increasing. However, when the object is placed in front of a convex lens between its optical centre and principal focus, the image formed is virtual, erect and magnified.

Question.17. Which convex lens has more focal length, thick or thin?
Answer. A thin convex lens has more focal length. ^ ..

Question.18. Can you find rough focal length of a concave lens?
Answer. No, because it does not form a real image to be obtained on a screen.

Question.19. What is the type of the eye lens?
Answer. The eye lens is convex.

Question.20. What are the practical uses of lenses?
Answer. Lenses are used in spectacles, microscopes, telescopes and other optical instruments.

Question.21. How can a convex lens be used as a magnifier?
Answer. For this purpose the lens is put very close to the eye in between the eye and the object to be magnified.

Question. 22. How will you distinguish between a glass slab, a convex lens and a concave lens without touching it?
Answer. The glass piece is put over a printed page and the virtual image of the printed matter is seen. The magnification of the image is judged.
If the image has same size as the object, the glass piece is a glass slab.
If the image is magnified, the glass piece is a convex lens.
If the image is diminished, the glass piece is a concave lens.

Question. 23. Define optical centre of a len.
Answer. It is a fixed point inside the lens on its principal axis, through which fight rays passing undedicated.

Question.24. What is the principal axis of a lens?
Answer. The straight fine passing through the centres of curvature of the curved surfaces of the lens is called the principal axis of the lens.

Question.25. What is the principal focus of a lens?
Answer. It is fixed point on the principal axis of a lens where a beam of fight incident parallel to its principal axis converges or appears to diverge after passing through the convex lens or concave lens.

Question. 26. What is the focal length of a lens?
Answer. It is the distance between optical centre and principal focus of a lens. Its S.I. unit is metre.

Question.27. Define S.I unit of power.
Answer. The Diopter is the S.I. unit of power. One diopter is the power of lens whose focal length is one metre.

Question. 28. What are the sign for the power of a convex lens and concave lens?
Answer. The power of a convex lens is positive since its focal length is positive while the power of a concave lens is negative since its focal lens is negative.

Question. 29. What is a lens maker formula?
Answer. It is relation between focal length, radii of curvature, refractive index of material of lens and refractive index of surroundings.

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

Question.30. What are the factors affecting the power of lens?

Answer.

1. Refractive index of lens material
2. Refractive index of surroundings i.e., change of medium
3. Radii of curvature
4. Wavelength of light
5. Thickness of lens.

Question.31. How the power of lens charge w.r.t. the two surrounding medium?
Answer. The power of a lens is maximum for vacuum or air and it decreases with increase in two refractive index of medium.

Question.32. How the power of lens charge w.r.t. to wavelength of light?
Answer. The power of a lens is different for different colour of light. The power of a lens is maximum of violet and minimum for red colour light.

Question. 33. Does power depend upon aperture of a lens?
Answer. No.

Question.34. Under what condition, the nature of lens change?
Answer. The refractive index of surrounding medium is greater them that of material of lens. The convex lens act as concave lens and vice-versa.

Question. 35. Under what condition, a lens does not show the refraction.
Answer. When refractive index of surrounding medium is equal to refractive index of material of lens.

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

Since, $n_2=n_1 \quad \Rightarrow \quad P=0.$

Question.36. Why goggles (Sun glasses) have zero power?
Answer. The surfaces are curved in same direction and of same radius

$$P = \left(\frac{n_2}{n_1} - 1\right)\left(\frac{1}{R} - \frac{1}{R}\right) = 0.$$

Question. 37. What type of lens is an air bubble inside water?

Answer. Concave lens.

Question.38.Define refractive index.
Answer. It is the property of a transparent medium which resist the propagation of light in that medium. It is measured in term of speed of light in a medium w.r.t. speed of light in vacuum.

Question.39.What is relative refractive index?
Answer. Relative refractive index of medium 2 w.r.t. medium 1 is the ratio of the speed of light in medium 1 to the speed of light in medium 2

$$_1n_2 = \frac{n_2}{n_1} = \frac{v_1}{v_2}$$

It does not have emit and dimensions.

Question.40.What is absolute refractive index?
Answer. Absolute refractive index of a medium is the ratio of the speed of light in vacuum to the speed of light in that medium.

$$n = \frac{\text{R.I. of the medium}}{\text{R.I. of the vacuum}} = \frac{c}{v}$$

Question.41.Is the absolute refractive can be less than unit?
Answer. No.

Question.42.What is the power of combination of a convex and concave lens of the same focal length?
Answer. Zero.

Question.43.Why is the rough focal length of concave lens not determine?
Answer. It makes virtual image for all positions of objects.

Question.44. How chromatic aberration can be minimized?
Answer. It can be minimized by taking thin and small aperture lens.