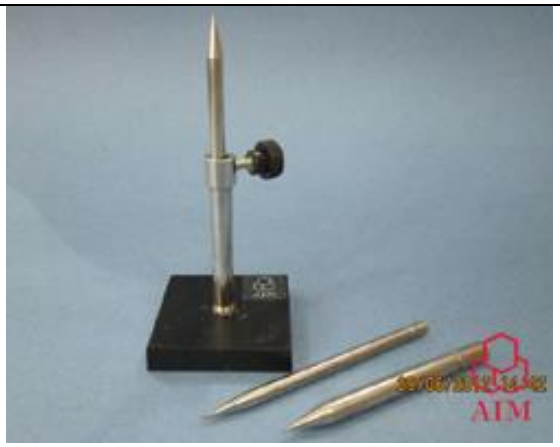
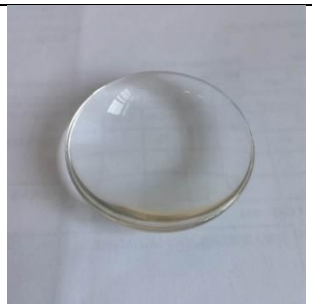
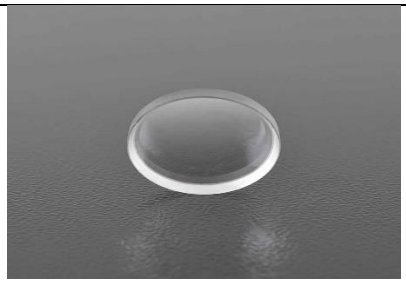
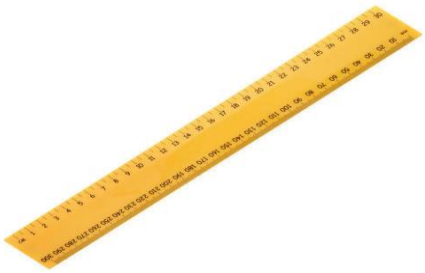
AIM

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

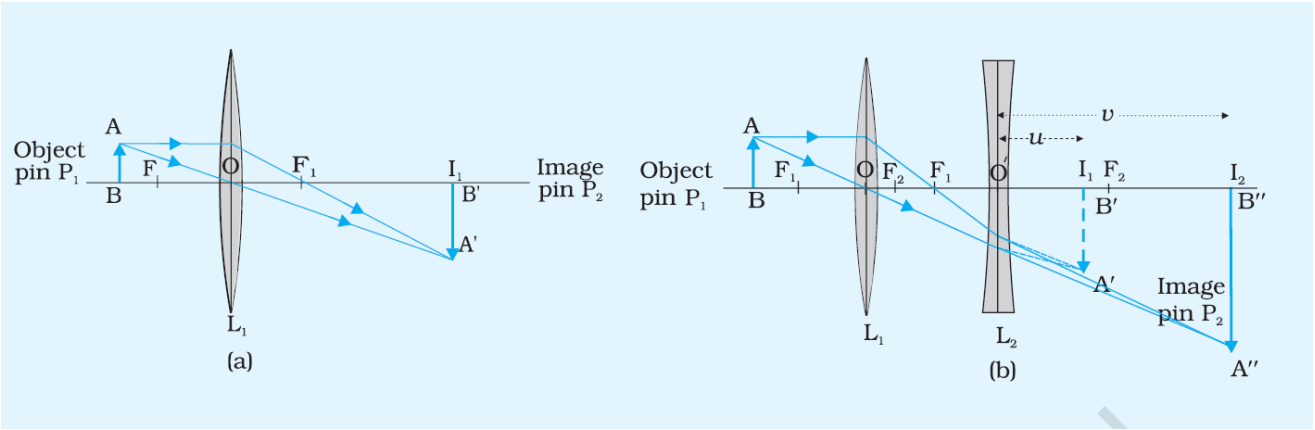
APPARATUS AND MATERIAL REQUIRED

	
An optical bench	two sharp-edged needle (pins)
	
Convex lens (≈15cm)	Four uprights (with clamps)
	
Concave lens	metre scale

- **Focal length of convex lens should be smaller than the focal length of concave lens**

PRINCIPLE

As the image formed by a concave lens is always virtual and erect, so, its focal length cannot be determined directly. However, it can be determined by introducing a convex lens in between the object and the concave lens.



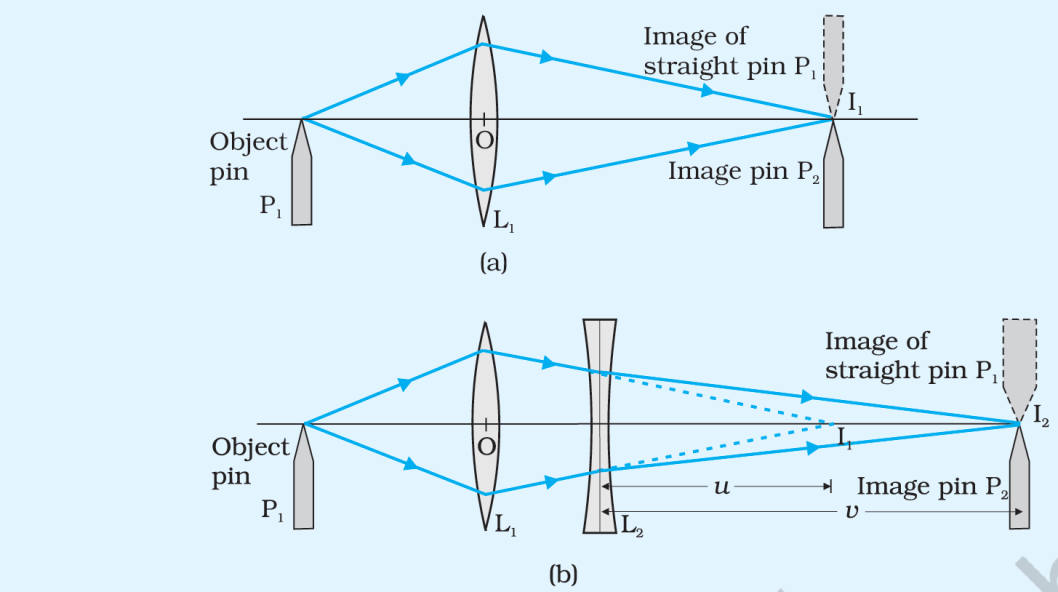
- A convex lens L_1 converges the light rays starting from the object AB to form a real and inverted image A'B' at position I_1 [Fig. (a)].
- If a concave diverging lens L_2 is inserted between the lens L_1 and point I_1 as shown in Fig. (b), for concave lens L_2 image A'B' behaves as virtual object.
- A real and inverted image A''B'' is formed at point I_2 by the diverging lens L_2. Thus, for the concave lens L_2 the distances $O'I_1$ and $O'I_2$ would be the distances *u* and *v*, respectively.
- It is important to note that the focal length of convex lens L_1 must be smaller than the focal length of the concave lens L_2.
- The second image A''B'' is formed only when the distance between lens L_2 and first image A'B' is less than the focal length of L_2.
- The focal length of the concave lens L_2 can be calculated from the relation $\frac{1}{v}-\frac{1}{u}=\frac{1}{f}$ or $f=\frac{uv}{u-v}$

  For concave lens both '*u*' and '*v*' are positive and since $u < v$, *f* will always be negative.

PROCEDURE

1. In case, if the focal length of the given thin convex lens is not known then rough value of its focal length (f_L) should be estimated first to ensure that its focal length is less than that of the concave lens.
2. Place the optical bench on a rigid platform and make it horizontal with the help of levelling screws provided at the base of the bench.
3. Place the uprights mounted with pin P_1 (object pin), convex lens L_1, and another pin P_2 (image pin) on the optical bench. You may put a small piece of paper on image pin P_2 to differentiate it from the image of object pin P_1 [Fig. (a)]
4. Check the collinearity of the tip of pin P_1, optical centre O of convex lens L_1, and the tip of image pin P_2 along a horizontal straight line, which is parallel to the length of the optical bench.
5. Separate object pin P_1 from the convex lens by a distance slightly greater than the focal length f_L of the lens.

6. Locate its real and inverted image at point I_1 on the other side of the lens by removing the parallax between the image pin P_2 and image of the object pin P_1 [Fig. (a)].



7. Read the positions of the uprights holding the object pin P_1, convex lens L_1, and image pin P_2 (i.e. point I_1). Record these observations in observation table.
8. From now on, do not change the position of the convex lens L_1 and the position of the object pin P_1. Insert the concave lens L_2 in between the convex lens L_1 and image pin P_2. Now the image of object pin will shift further from the convex lens L_1 to a point I_2 (say). Adjust the position of the concave lens so that the point I_2 is sufficiently away from the point I_1.
9. In case the image formed by the combination of convex and concave lenses is not distinctly visible, try to see it on moving the concave lens nearer to the point I_1 and to locate the image by using a pencil held in hand, and keeping the image pin P_2 at point I_1 as a guide to decide which way to shift the concave lens L_2. After having seen the clear image at point I_2 and ensured that it lies within the range of the optical bench, move image pin P_2 to locate the image (or point I_2) more accurately using the method of parallax [Fig. (b)]. Since the image forming at I_2 is quite enlarged, it can be blurred.
10. Note the position of uprights holding the concave lens and image pin P_2, *i.e.*, point I_2. Note the readings in the Observation Table.
11. Change the position of upright holding the object pin P_1 and repeat the steps 6 to 11. Take five sets of observations.

Link: https://youtu.be/Ye4K_FpQ5rM (best) / https://youtu.be/mnMuCkFiMkg / https://youtu.be/V8nS4lzZkU8

OBSERVATIONS

1. Focal length of the convex lens, f_L (estimated/ given) = ... cm
2. Length of the index needle , s = ... cm

Determination of u, v and f of concave lens

S.No.	Upright position of					Observed u = c –d (cm)	Observed v = g - d (cm)	Focal length *f* (cm)	Δf
	Object pin a(cm)	Convex lens L_1 b(cm)	Image formed by L_1 c(cm)	Concave lens L_2 d(cm)	Image formed by combination g (cm)				
1									
2									
3									
4									
								Mean	

CALCULATIONS

- Calculate the focal length of the concave lens using the following relation, $f = \frac{uv}{u-v}$
- Error: $\Delta f = f^2\left[\frac{\Delta v}{v^2} + \frac{\Delta u}{u^2}\right]$ where Δu and Δv are the least counts of the measuring scale.

RESULT

The focal length of the given concave mirror is $f \pm \Delta f$ = ...cm (here *f* is mean value of the focal length)

PRECAUTIONS (ANY TWO)

1. The concave lens must be placed near the convex lens (In fact, the second image I_2 is formed only when the distance between concave lens L_2 and first image I_1 is less than the focal length of the concave lens).
2. Since the image formed at I_2 is quite enlarged, it can be blurred. Therefore, it would be preferable to use a thin and sharp object pin and shine it with light using a lighted electric bulb.
3. The convex lens and the pin P_1 must not be disturbed during the second part of the experiment.
4. A diminished, real and inverted image of the image pin P_2 might also be formed by the light rays reflecting from the concave surface of the lens L_2. It should not be confused with the bold and bright image formed by the combination of convex and concave lenses.

SOURCES OF ERROR

1. If tip of object pin and optical centre of the lens are not aligned properly (if not brought at the same horizontal level), image tip and image of object pin tip will not touch each other.
2. For greater accuracy, we should use sharply pointed object pin.