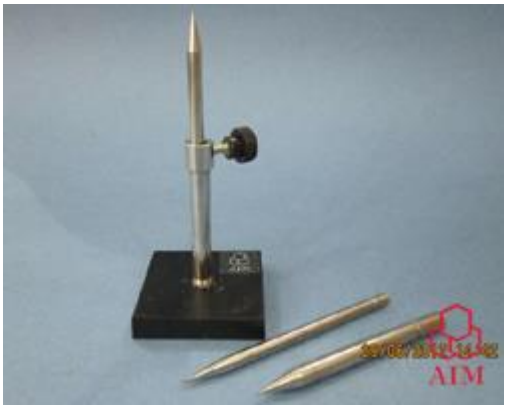
AIM

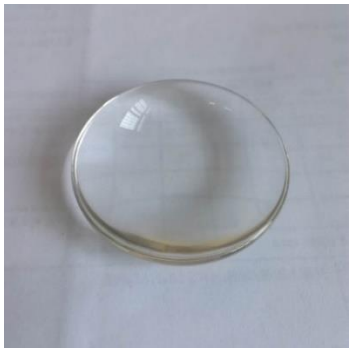
To find the focal length of a convex lens by plotting graphs between *u* and *v* or between 1/*u* and 1/*v*.

APPARATUS AND MATERIAL REQUIRED

An optical bench



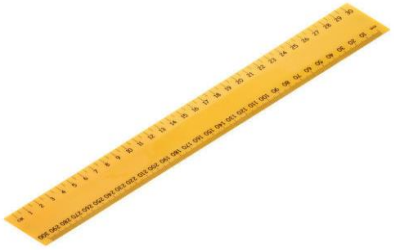
two sharp-edged needle (pins)



convex lens of less than 20 cm focal length

three uprights (with clamps)

metre scale



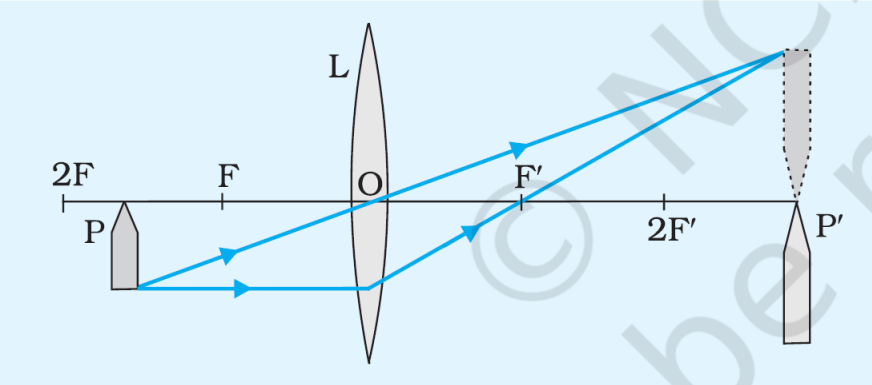
PRINCIPLE

- According to Lens formula $\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$
- Using new cartesian sign convention for real image (v = positive) and *u*= negative, $f = \frac{uv}{u+v}$.

  In this result, the positive values of *u* and *v* are substituted.
- The focal length of the lens may also be determined by plotting graphs between *u* and *v* or between 1/*u* and 1/*v*.

PROCEDURE

1) Find the rough focal length of the lens by obtaining a sharp image of any distant object on the screen (wall/ sheet of paper) and measuring the distance between the lens and the image with a scale.
2) Place the optical bench on a rigid table or on a platform and make it horizontal with the help of levelling screws provided at the base of the bench.
3) Clamp the convex lens on an upright and mount it vertically almost near to the middle of the optical bench such that its principal axis is parallel to the optical bench.
4) Place the vertically mounted sharp pins P and P' on left and right hand sides of the lens respectively. Adjust the pins P and P' so that the heights of the tips of these pins become equal to the height of the optical centre O of the lens from the base of the optical bench. Let the pin P be the object pin and the pin P' be the image pin. Put a small piece of paper on one of the pins (say on image pin P') to differentiate it from the object pin P'.



5) Displace the object pin P (on left side of the lens) to a distance slightly less than 2*f* from the optical centre O of the lens. Locate the position of the real and inverted image on the other side of the lens above the image pin P'.
6) Using the method of parallax, adjust the position of the image pin P' such that the image of the object pin P coincides with the image pin P'.
7) Note the upright position of the object pin, convex lens and image pin on the optical bench and record the readings in an observation table.
8) Move the object pin P closer to the optical centre O of the lens (say by 2 cm or 3 cm). Repeat the experiment and record at least six sets of readings for various distances of object pin between *f* and 2*f* from the lens.

Link: https://youtu.be/r5COs8RLjqc / https://youtu.be/DMGcflxwimc

OBSERVATIONS

1. Approximate focal length of the convex lens = ... cm
2. Length of the index needle as measured by the metre scale, L_0 =... cm

S.No.	Lens position a(cm)	Object needle position b(cm)	Image needle position c(cm)	Object distance u = a - b	Image distance v = a - c	$\frac{1}{u}$	$\frac{1}{v}$	$f = \frac{uv}{u+v}$	Δf
1.									
2.									
3.									
4.									
5.									
6.									

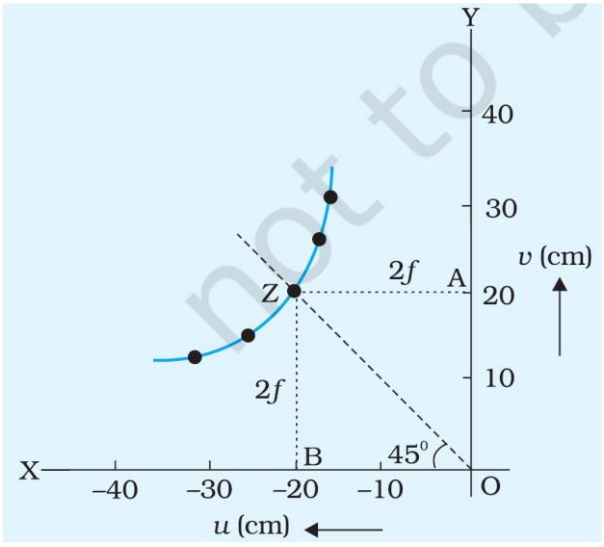
CALCULATIONS [SHOW THIS ON THE BLANK PAGE]

A. Calculate the corrected values of *u* and *v*. Compute the value of *f and error in f*. find the mean value of the focal length of the given convex lens.

$$\Delta f = f^2\left[\frac{\Delta u}{u^2} + \frac{\Delta v}{v^2}\right]$$

B. *u – v Graph:*

- Take *u* along X-axis and *v* along Y-axis.
- Scales of x- and y-axis should be same.
- Plot curve for various values of *u & v*.
- Point Z on the graph represents *u* = 2*f*; *v* = 2*f*.
- The point Z is the point of intersection of a line OZ bisecting the angle XOY with hyperbola. Draw two lines AZ and BZ perpendicular to Y- and X-axis, respectively.
- Lengths AZ and BZ are both equal to distance 2*f*.



Distance OA (= 2*f*) on Y-axis = ... cm

Distance OB (= 2*f*) on X-axis = ... cm

Mean focal length of the convex lens, *f* = *cm*

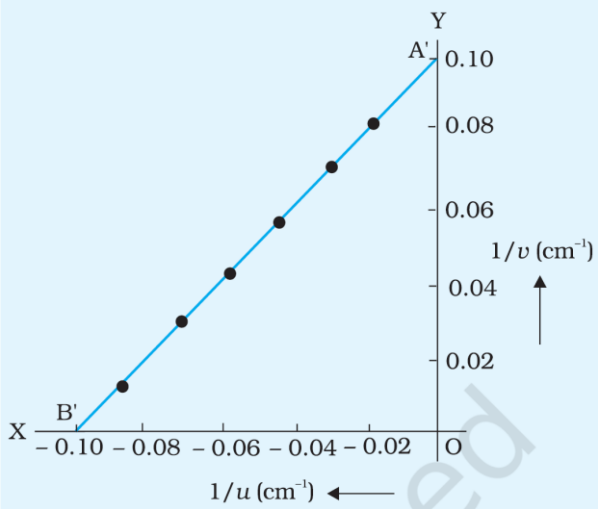
C. $1/u - 1/v$ graph:

- Draw a straight-line graph by plotting $1/u$ along the X-axis and $1/v$ along the Y-axis.
- Both the intercepts OA' (on Y-axis) and OB' (on X-axis) will be equal to distance $1/f$.

  Intercept OA' (= $1/f$) on Y-axis =...cm^{-1}

  Intercept OB' (= $1/f$) on X-axis =...cm^{-1}

  Mean focal length (f) of the convex lens = ...cm.



RESULT

The focal length of the given converging thin convex lens:

(i) from calculations $f \pm \Delta f$ = ...cm (here f is mean value of the focal length)

(ii) from $u - v$ graph =...cm, and

(iii) from $\frac{1}{u} - \frac{1}{v}$ graph =...cm.

PRECAUTIONS [WRITE TWO]

1. The uprights supporting the optical elements should be rigid and mounted vertically.
2. The aperture of the lens should be small otherwise the image formed will not be distinct.
3. Eye should be placed at a distance more than 25 cm from the image needle.
4. Tips of pins and optical centre of the lens should be at the same horizontal level.
5. The image and object needles should not be interchanged during the performance of the experiment, as this may cause change in index corrections for object distance and image distance.
6. The tip of the inverted image of the object needle must touch the tip of the image needle and must not overlap. This should be ensured while removing the parallax.
7. The corrected values of the distances u and v must be put in the formula for calculating f and then a mean of f should be taken. Calculations for f must not be made using the mean values of u and v.

SOURCES OF ERROR

1. The uprights may not be vertical.
2. Parallax removal may not be perfect.