

## OBJECTIVE

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

## APPARATUS

An optical bench with four upright (two fixed upright in middle, two outer uprights with lateral movement), convex lens (20 cm focal length), convex mirror, a lens holder, a mirror holder, two optical needles, (one thin, one thick) a knitting needle, and a half meter scale.

## RAY DIAGRAM

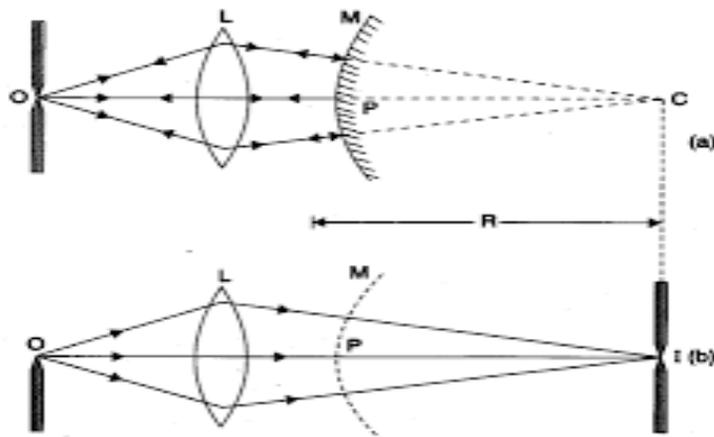


Fig. Focal length of convex mirror.

## A Short Description about the Arrangement

As a convex mirror always forms a virtual image, its focal length can not be found directly as for a concave mirror. For this purpose, indirect method is used, as describe below.

An auxiliary convex lens L is introduced between the convex mirror M and object needle O as shown in Fig. 1(a). Keeping the object needle at distance about 1.5 times rough focal length of convex lens, the position of convex mirror behind convex lens is so adjusted that a real and inverted image of object needle O, is formed at O itself. Under such condition, the light rays are incident normally over the convex mirror to retrace their path. In the absence of convex mirror, these rays would have met at centre of curvature C of the convex mirror. The distance PC gives the radius of curvature R of the mirror.

To locate the position of C, convex mirror is removed (without disturbing the object needle O and convex lens L). An image needle I is put behind the convex lens and moved to a position at which there is no parallax between tip of inverted image of O needle and tip of I needle. Position of image needle I gives Position of centre of curvature C of the mirror M [fig 1(b)].

Then,  $PC=PI=R$  and  $f = \frac{R}{2} = \frac{PI}{2}$

## THEORY (Formula used)

Focal length of a convex mirror  $f = \frac{R}{2}$

where R = radius of curvature of the mirror.

## **PROCEDURE (Stepwise)**

### **To determine rough focal length of convex lens**

1. You can estimate the rough focal length of convex lens by exposing it to sunlight and obtain a sharp point on paper. Distance between lens and paper gives rough focal length.

### **To set the lens**

2. Clamp the holder with lens in a fixed upright and keep the upright at 50 cm mark.
3. Adjust the lens such that its surface is vertical and perpendicular to the length of the optical bench.
4. Keep the upright fixed in this position throughout.

### **To set the object needle.**

5. Take the thin optical needle as object needle (O). Mount it in outer laterally move able upright near zero end.
6. Move the object needle upright and clamp it at a distance (in full cms) nearly 1.5 times the obtained rough focal length of the lens.
7. Adjust height of the object needle to make its tip lie on horizontal line through the optical centre of the lens.
8. Note the position of the index mark on the base of the object needle upright.

### **To set the convex mirror**

9. Clamp the holder with convex mirror in second fixed upright near the lens upright, keeping reflecting surface of the mirror towards lens.
10. Adjust the height of the mirror to make its pole lie on horizontal line through the optical center of the lens.
11. Make the mirror surface vertical and perpendicular to the length of the optical bench (the principle axes of mirror and lens must coincide.)
12. Move towards zero end of the optical bench (where object needle is mounted).
13. Closing left eye, keep open right eye about 30 cm away from the tip of the object needle.
14. See the inverted image of the object needle (forwarded by reflection from the convex mirror).
15. Keep the eye in a position at which the tips of the inverted image and the object needle are seen simultaneously.
16. Adjust the height of the needle so that the tips are seen in one line with right open eye.
17. Move the eye towards right. The tips will get separated. The tips have parallax.
18. Move the convex mirror back and forth till tip to tip parallax is removed.
19. Note the position of the index mark on the base of the convex mirror upright.

### **To set the image needle**

20. Remove the convex mirror, keeping upright in its position.
21. With left eye closed, see with the right open eye from the other end of the optical bench. An inverted and enlarged image of the object needle will be seen. Tip of the image must lie in the middle of the lens.
22. Mount the thick optical needle (image needle) in the fourth upright near the other end of the optical bench.
23. Adjust the height of the image needle so that its tip is seen in line with tip of the image when seen with right open eye.

24. Move the eye towards right. The tips will get separated. The image tip and the image needle tip have parallax.
25. Remove the parallax tip to tip.
26. Note the position of the index mark on base of the image needle upright.
27. Record the position of the index marks in the table against observation 2.

**To get more observations**

28. Move object needle upright towards lens by 2 cm to get observation 1. Repeat the experiment.
29. Move object needle away from lens (from position of observation 2) by 2 cm to get observation 3. Repeat the experiment.
30. Record all the observations as given ahead.

**OBSERVATIONS**

Rough focal length of the convex lens = ..... cm

**Table for focal length of convex mirror**

Serial No. of Obs.	Position of		Radius of Curvature (R)		Focal length $f = \frac{R}{2}$ (cm)
	Convex mirror P (cm)	Image Needle I (cm)	Observation PI (cm)	Corrected PI (cm)	
(1)	(2a)	(2b)	(3a)	(3b)	(4)
1.					
2.					
3.					

**CALCULATIONS**

1. Write observed PI in column 3a and corrected PI in column 3b.
2. Divide corrected PI by 2 and write in column 4.
3. Find mean of values of  $f$  recorded in column 4.

**RESULT**

The focal length of the given convex mirror = ..... cm.

**PRECAUTIONS (to be taken)**

1. Principal axis of the lens should be **horizontal** and **parallel** to the central line of the optical bench.
2. All the upright should be **vertical**.
3. The tip of the needle, centre of the mirror and centre of the lens should be at the **same height**.
4. While removing the parallax, the eye should be kept at a **minimum distance** of 30 cm from the needle.
5. **Tip to Tip parallax** should be removed.
6. **Index correction** should be applied between the image needle I and back surface of the convex mirror.

7. The convex mirror should be placed **close** to the convex lens.
8. For one set of observation, when the parallax has been removed for convex lens alone, the positions of the lens and needle O uprights should **not be changed**.

#### **SOURCES OF ERROR**

1. Focal length of lens may not be small.