ACTIVITY

AIM

To obtain a lens combination with the specified focal length by using two lenses from the given set of lenses.

MATERIAL REQUIRED

A set of lenses, a lens holder with a stand, a white screen, a half-meter scale, optical bench with uprights.

THEORY

1. By a convex lens, the real image of a distant object is formed at a distance equal to the focal length of the lens.
2. If two lenses of focal lengths f_1 and f_2 are kept in contact then, the combination behaves like a single lens of focal length F. The focal length, F of combination, is given by,

$$\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2} \text{ or } F = \frac{f_1 f_2}{f_1 + f_2}$$

The power of the combination (P) of two lenses having powers P_1 and P_2 is given by,

$$\boxed{P = P_1 + P_2}$$

Since,

$$\left| P = \frac{1}{f} \right|$$

The unit of power is a diopter.

A convex or converging lens has positive power and a concave or diverging lens has negative power.

To acquire a lens combination with a focal length $f = 10$ cm from a given set of lenses, the power of the lens combination is determined as follows:

$$P = \frac{1}{10 \text{ cm}} = \frac{1}{0.1 \text{ m}} = +10\text{D}$$

If one of the lenses from the given set, L_1, has a focal length of 15 cm, its power (P_1) is calculated as:

$$P_1 = \frac{1}{15 \text{ cm}} = \frac{1}{0.15 \text{ m}} = +6.67\text{D}$$

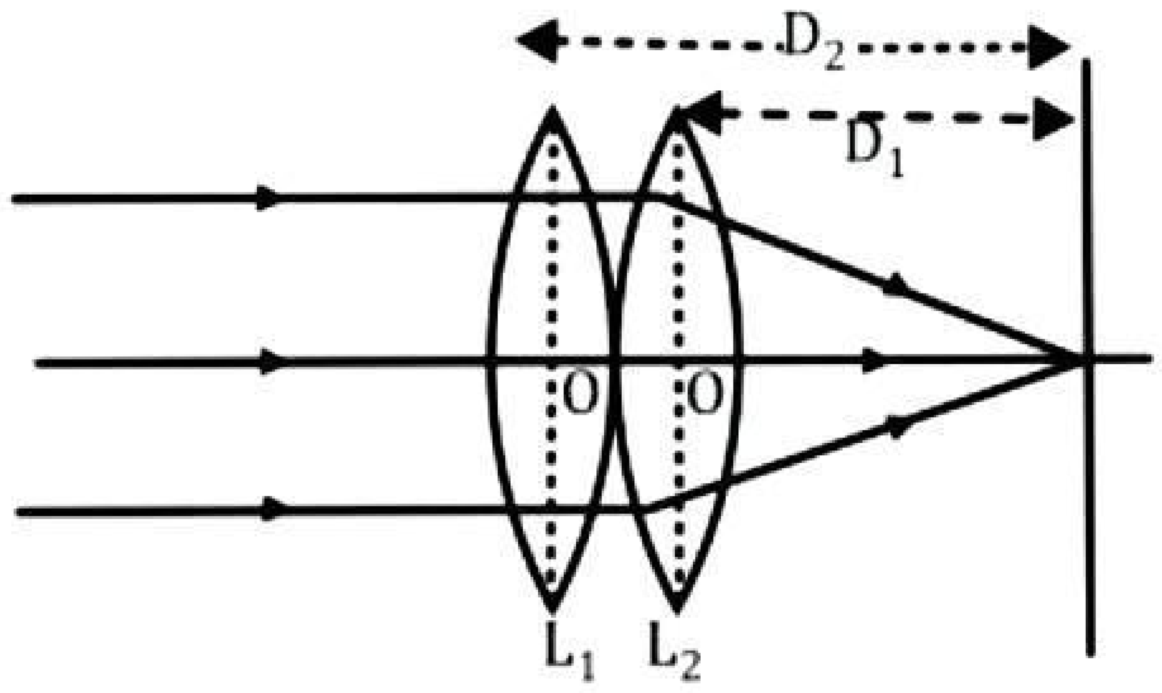
Now, the power of the second lens in the combination is determined by subtracting P_1 from P :

$$\begin{aligned} P_2 &= P - P_1 \\ &= +10\text{D} - (+6.67\text{D}) \\ &= +3.33\text{D} \end{aligned}$$

To achieve a focal length of 10 cm in the combination, the focal length (f_2) of the second lens to be selected is calculated as:

$$f_2 = \frac{1}{P_2} = \frac{1}{+3.33\text{D}} = \frac{+3.00}{10\text{ m}} = +30\text{ cm}$$

DIAGRAM



Focusing parallel beam of light on combination of two convex lenses

PROCEDURE

1. Take the optical bench and level it with the help of spirit level.
2. In one upright fix the screen which consists of white cardboard and in another upright fix a wire gauge.
3. Attach the 6 V bulb along with its stand on third upright and set one lens L_1 on fourth upright as shown in Figure.
4. Mount the uprights on the optical bench. Take care that the centre of the bulb, wire gauge, lens and the screen must be at same height.
5. Swi6tch on the bulb and take the image of brightly illuminated distant wire gauge on the screen.

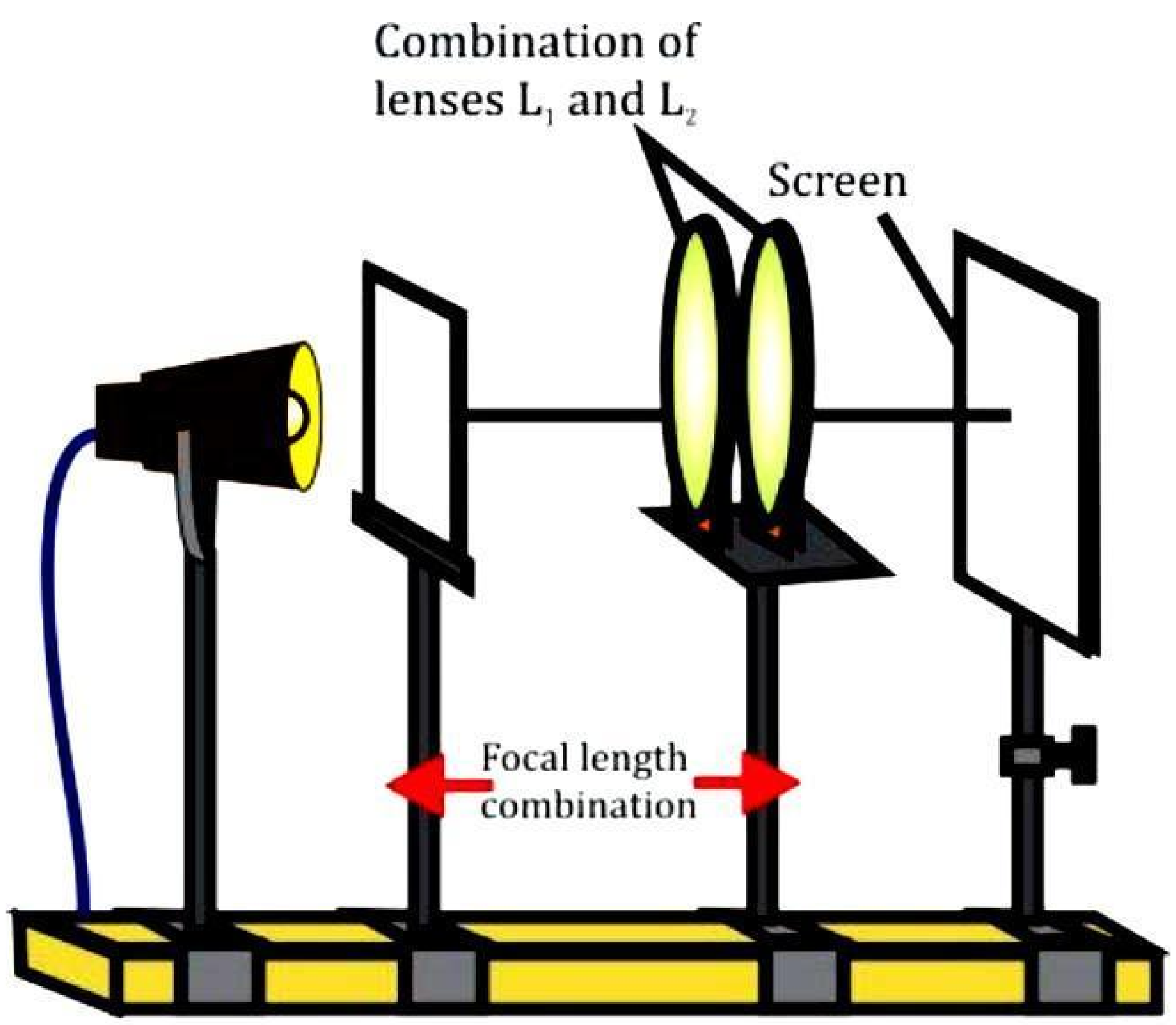


Fig. Study of focal length of combination of lenses

6. Measure the distance between the lens and screen where the sharp image is formed. Record it as focal.

7. length, f_1 = ... cm. 7. Follow the similar procedure by replacing the first lens L_1 by second converse lens La having power + 3.33.
8. Measure its focal length and record it as f_2 = ... cm.
9. Then take both the lenses L_1 and L_2 on the upright in contact with each other.
10. Obtain a sharp distinct image of the brightly illuminated distinct wire gauge on the screen and measure its focal length.
11. Record the focal length of the lens combinations as f = ... cm.
12. You will find that the focal length of combination of lenses comes out to be 10 c.

RESULT

1. The focal length of the combination of two lenses in contact is given by,

$$F = \frac{f_1 f_2}{f_1 + f_2} = \_\_\_\_\_\_ \text{ cm.}$$

2. The measured value of the focal length of the line combination = _______ cm.
3. F is verified theoretically and experimentally within the error limits.

PRECAUTIONS

1. Lenses taken for the activity should be thin.
2. The aperture of lenses should be the same.
3. Axes of lenses should be parallel to each other.

SOURCES OF ERROR

1. Lenses may not be in contact.
2. The thickness of the given lenses may cause an error.
3. Spherical aberration of the lenses may cause an error in finding the exact focal length.

VIVA- VOCE

Q 1. What is the radius of curvature of a plane surface?
Ans. The radius of curvature of a plane surface is infinity.

Q 2. Is the focal length of a thin convex lens greater than that of a thick one?
Ans. Yes, the focal length of a thin convex lens is greater than that of a thick one.

Q 3. On what factors does the focal length of a lens depend?
Ans. The focal length of a lens depends upon the following factors:
(i) radii of curvature of its surface
(ii) refractive index of the material of the lens
(iii) colour of the incident ray

Q 4. Write a relation between the focal length and the radii of curvature.
Ans. $\frac{1}{f} = (n-1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$

Where, f = focal length of the lens
n = refractive index of the material of the lens R_1 and R_2 are the radii of curvature of spherical sur faces.

Q 5. What is the relation between the power of a lens and the refractive index of the material of the lens?

Ans. Power of a lens, $P = (n-1)\left[\frac{1}{R_1} - \frac{1}{R_2}\right]$

Where, n = refractive index of the material of the lens R_1 and R_2 are the radius of curvature of its spherical surfaces.

Q 6. What is the focal length of a combination of two lenses having a focal length f_1 and f_2 ?

Ans. When two lenses of focal length f_1 and f_2 are in contact, then the combination behaves as a single lens of focal length F, which is given by:

$$\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2} \text{ or } F = \frac{f_1 f_2}{f_1 + f_2}$$

Q 7. At what distance should the eye be placed from the needle while removing the parallax?

Ans. The eye should be placed at a distance more than the least distance of a distinct vision which varies from 25 cm to 30 cm for a normal eye.