EXPERIMENT NO. 7
FOCAL LENGTH OF CONVEX LENS BY DISPLACEMENT METHOD

Aim: To determine focal length of a lens by displacement method.

Apparatus: A convex lens, lens stand, a screen with graph paper on it, Extended source of light (Most preferable a filament bulb, else an illuminated slit) metre scale.

Diagram:

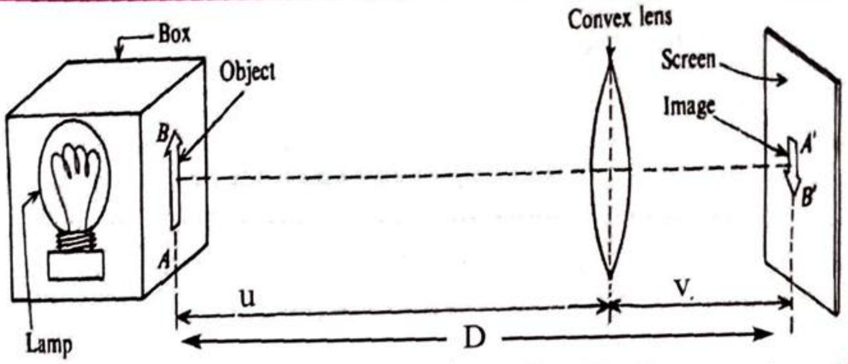

Fig. 7.1 experimental arrangement for displacement method

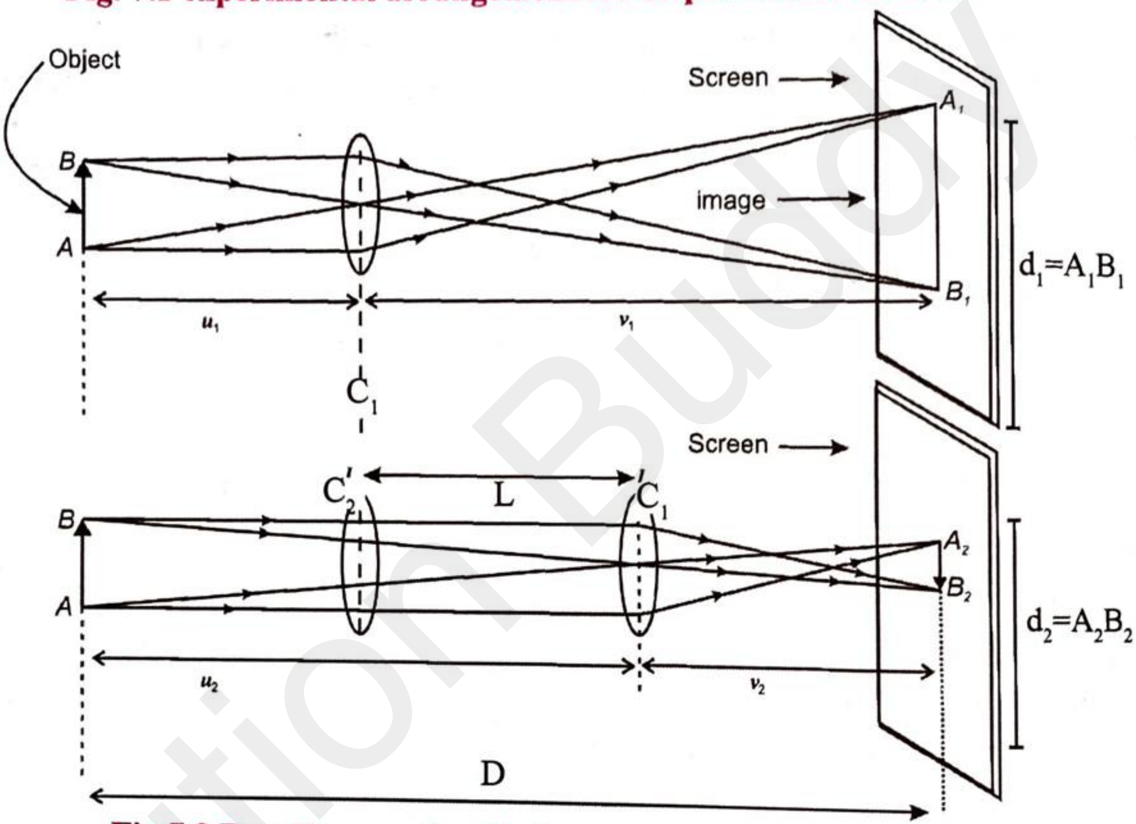

Fig.7.2 Ray diagram for displacement method

Theory:

For a convex lens, if the object is at $2f$, its real image is also at $2f$. In this case, the separation between object and the image is minimum and it is 4f. Thus, for obtaining a real image, the screen must be at a distance greater than $4f$. Let this distance be D. As shown in the figures above, there are two positions of the lens when real image is obtained at the same distance $D > 4f$ from the object. These two positions are called conjugate foci separated by a distance L. (For $D = 4f$, these two positions coincide). From the principle of reversibility of light, it can be easily understood that the distances u and v should just interchange.

$\therefore\ u + v = D$ and $v - u = L$ $\quad \therefore\ 2u = D+L$ and $2v = D - L$

$\therefore$ Using u negative, $\dfrac{1}{f} = \dfrac{1}{u} - \dfrac{1}{(-u)}$

$$\therefore\ f = \frac{uv}{(u+v)} = \frac{D^2 - L^2}{4D}$$

Let d be the size of the object. Sizes of magnified and diminished images are d_1 and d_2 respectively.

$$\therefore\ \frac{v}{u} = \frac{d_1}{d} \quad \text{and} \quad \frac{v}{u} = \frac{d_2}{d}$$

By multiplying these equations and solving,

we get $d = \sqrt{d_1 d_2}$

as the size of the object (filament). In standard XII, you will be using this method and this formula for obtaining the distance between two coherent sources in the topic of interference of light.

Procedure:

1. Illuminate the source/filament bulb and keep it more than a metre away from the screen.
2. Adjust the height of the lens stand so that centre of the lens and filament are at the same height.
3. Adjust the position of the lens (closer to the object) to obtain a clear magnified image on the screen (Fig 1). Record size of the image on the screen as d_1, and distance between object and the screen as D. Mark the position of the lens as C_1.
4. Without disturbing positions of the object and the screen, shift the lens towards the screen to obtain a clear and diminished image on the screen (Fig 2). Record the image size as d_2 and mark position of the lens as C_2. Record the distance between C_1 and C_2 as L.
5. Repeat steps (3) and (4) for six more values of D.

Obs. No.	Distance between source and screen D … cm	Distance between positions of lens L … cm	Size of magnified image d_1 … cm	Size of diminished image d_2 … cm
1	50	20	5	1.
2	55	26	6	0.9
3	60	33	7.5	0.8
4	65	40	8	0.5
5	70	45	9.5	0.5

Observation table:

Obs. No.	D^2	L^2	$D^2 - L^2$	$4D$	$f = \frac{D^2 - L^2}{4D}$	$d_1 d_2$	$d = \sqrt{d_1 d_2}$
1	2500	400	2100	206	10.5	5	2.23
2	3025	675	2349	220	10.6	5.4	2.32
3	3600	1089	2511	246	10.4	6	2.44
4	4225	1600	2625	260	10.09	4.8	2.19
5	4900	2025	2875	280	10.2	4.75	2.16

Calculations :

Mean = $\frac{10.5 + 10.6 + 10.4 + 10.09 + 10.2}{5}$

$= \frac{51.79}{5}$

$= 10.356$

$d \sqrt{d \cdot d_2}$

$= \frac{2.23 + 2.32 + 2.44 + 2.19 + 2.16}{5}$

$= \frac{11.34}{5}$

$= 2.268$

Results:

Mean f = 10.356 cm   Mean d = 2.268 cm.

Precautions:

1. Keep the distance between object and the screen constant
2. The distance L should be greater than 4f

Additional Experiment you can do :

1. Try to determine size of the flame of a candle.
2. Measure u, determine $v = D - u$. Calculate focal length for one or two readings and verify if it matches with that calculated by using D

Multiple-choice Questions

1. In above experiment if u=30cm and v= 65 cm then linear magnification m = ...

a) 2.17   b) 21.7   c) 35cm   d) 0.35m

Questions

1. Can the above method be used for determining focal length of a) concave lens b) plano concave lens?

Yes, convex lens is called concaving lens, convex lens is called diverging lens as Negative lens

plan concave lenes are positive focal length elements that have one spherical surface to one rough surface These lense are designed the infinite conjugates (parallel light) use of simple imaginary amount - optical application.

2. What is conjugate foci?

conjugate foci => The pair of two sucj points on the principle axis of a lens, that for the object placed at one point, the image is formed at other point, are called 'conjugated foci'.

Remark and sign of teacher: