

Reflection, refraction and images from mirrors and lenses

AP Physics 2 (algebra-based) · Lab

Name: _____ Date: _____ Class: _____

How can you measure the focal length of a lens without any knowledge of its curvature? By recording where a sharp image forms for several object distances, you can test the thin lens equation and find f from the straight-line graph or from the mean of the data.

Level: AP Physics 2 (algebra-based) · **Curriculum:** AP P2 Unit 13

Aim

Find the focal length of a converging lens by measuring pairs of object and image distances, and test the thin lens equation.

Equipment

- converging lens (focal length about 15 cm) in a holder
- bright lamp or phone torch with an arrow-shaped cut-out as the object
- white card as a screen
- metre rule or optical bench

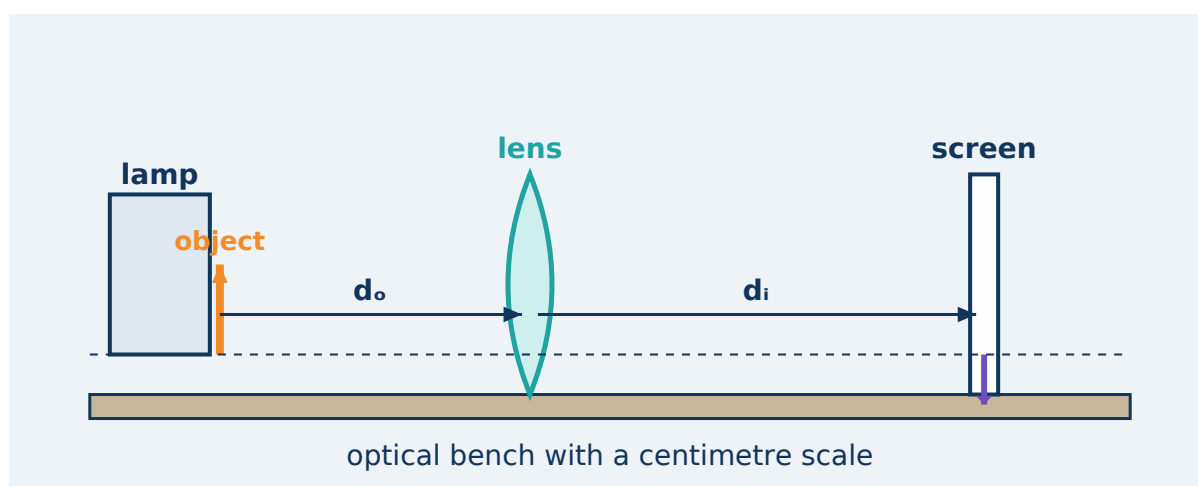
Safety

Safety

Never look at the sun or a bright lamp through the lens. Do not leave a lens in sunlight near paper or cloth, because it can start a fire.

Method

1. Fix the lamp and the arrow object at one end of the bench. Place the lens 25.0 cm from the object.
2. Move the screen until the image of the arrow is as sharp as possible. Read the lens-screen distance d_i .
3. Repeat for $d_o = 30.0, 35.0, 40.0$ and 50.0 cm.
4. For each row calculate $1/d_o$ and $1/d_i$ in m^{-1} , and their sum.



The sharp image is found by sliding the screen along the bench.

Results

Sample data for a lens whose focal length is to be found:

d_o (cm)	d_i (cm)	$1/d_o$ (m^{-1})	$1/d_i$ (m^{-1})	$1/d_o + 1/d_i$ (m^{-1})
25.0	37.4	4.00	2.67	6.67
30.0	30.2	3.33	3.31	6.64
35.0	26.0	2.86	3.85	6.70
40.0	24.1	2.50	4.15	6.65
50.0	21.5	2.00	4.65	6.65

Analysis questions

Question 1 One value of f

Use the row $d_o = 25.0$ cm to calculate the focal length, then give the mean sum $1/d_o + 1/d_i$.

Question 2 Mean focal length

The column $1/d_o + 1/d_i$ should be constant. Calculate its mean and use it to find f in centimetres.

Question 3 Graph

Plot $1/d_i$ (y-axis) against $1/d_o$ (x-axis). State the gradient expected and the meaning of the y-intercept.

Question 4 Magnification

Calculate the magnification for $d_o = 25.0$ cm and describe the image.

Question 5 Uncertainty

The position of the sharpest image is uncertain by about ± 1.0 cm. Calculate the percentage uncertainty in d_i for $d_o = 25.0$ cm. Explain why this uncertainty exists.

Question 6 Minimum object distance

Explain why no image can be projected when d_o is less than f .

Question 7 Improvements

Suggest two improvements to reduce the uncertainty in f .