Teacher packs in Experimental Science

PHY Pack 5

Finding the focal length of a lens using the ray box

Pack contents:

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Curriculum areas covered:

Light Energy

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Title: Finding the focal length of a lens using the ray box

Target group: Diploma in Basic Education

Also suitable for: B.Ed. Basic Education

Duration of Activity: 50 minutes plus discussion time

Learning outcomes:

At the end of the lesson the student should be able to

1. Knowledge and Understanding (KN)	KN1	Identify the different types of lenses.
	KN2	Explain the properties of the various lenses.
	KN3	Apply the lens equations, in conjunction with ray diagrams and other methods, to solve related problems dealing with lenses.
2. Cognitive Skills (CS)	CS1	Explain how the focal length of various lenses can be determined.
	CS2	Explain with diagrams the various properties of the types of lenses.
3. Key Skills (KS)	KS1	Determine the object and image distance.
	KS2	State the lens equation and determine the focal length of lenses using the lens equation.
4. Practical Skills (PS)	PS1	Set up the practical experiment.
	PS2	measure and record results accurately.
	PS2	Make and record observations, measurements and report results.

A. Teacher's Guide

Overview

Students are asked to find the object distance and image distance of the illuminated ray box. The students are then asked to determine the focal length of the lens, using the lens equation $\frac{1}{f}=\frac{1}{u}+\frac{1}{v}$ and as well plot an appropriate graph as an alternative way to determine the focal length of the lens.

Aim

The experiment is to enable students to physically observe the image produced by the lens. This is to give the student a fair idea as to how the lens equation with the measured quantities can be manipulated to obtain the focal length of the lens and also use the graphical method to determine the focal length of a lens.

Practical Skills Developed

1. Application of scientific methods including observing, measuring, collecting, recording and tabulating data.
2. Use of significant figures
3. Change of subject of an equation
4. Preparing and presenting data in graphical forms.
5. Team work and oral communication

Equipment/ Materials/ Apparatus.

Ray box with illuminated object, white screen, Lens holders, metre rule, a lens, a plain sheet of paper, a graph sheet and a pencil.

Advice to Tutors

1. Measured quantities should be repeated and averaged.
2. Encourage students to use different object distance. They should also record their readings systematically i.e. increasing or decreasing order.
3. The reading of distances from the metre rule should be done on the mark, looking vertically, with the metre rule horizontally placed.
4. Create time to discuss the physics of what is going on and to introduce the concept of focal length. The tutor should discuss the different types of lenses and their properties.

Sample Assessment Questions with answers

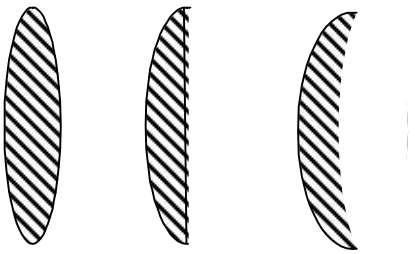
1. What is meant by the 'focal length' of a lens and what is its significance? (CS1)
   Answer: Focal length of a lens is the distance between optical centre and the principal focus.
   It determines the power of the lens.

2. State the lens equation. (KS2)

   Answer: $\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$, where f = focal length, u = object distance and v = image distance.

3. Sketch the different types of converging lenses. (KN1)

   Answer:



   a) Bi-convex **(b)** convex (converging) meniscus
   (c) Plano-convex

4. How would you improve the precision of your measurements? (PS3)

   Answer: The image formed on the screen must be sharp. The eye direction should be vertical to the figure to be read.

B. **Student Guide**

Purpose: To determine the focal length of a lens using the ray box.

Equipment/ Materials

Ray box with illuminated object, white screen, lens holder, metre rule and lens

Background

The purpose of the experiment is to study image formation by a thin lens. In particular we will find the focal length of a lens (converging) using the lens equation. In this experiment, we will be dealing only with thin lenses. A thin lens is a lens whose thickness is negligible when compared with the distance from the lens to the principal foci or any objects or images concerned.

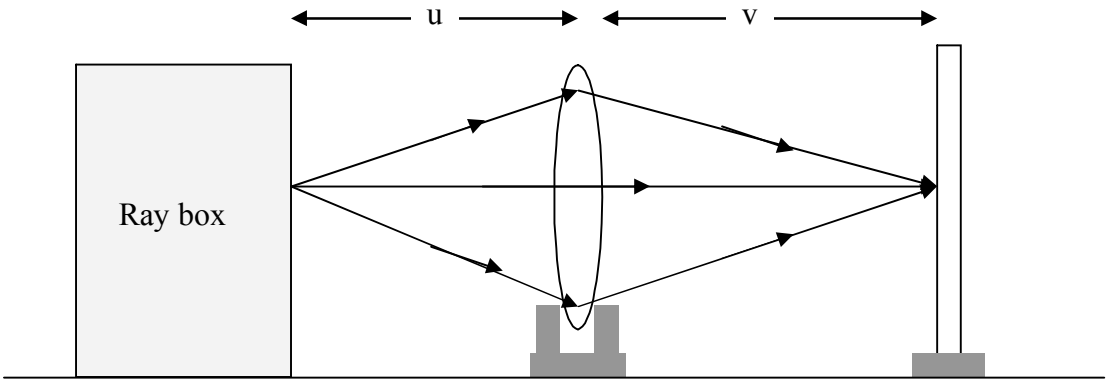


Figure 5.1: Experimental Setup for finding the refractive index of a glass block.

You are provided with a ray box, lens holder, metre rule, white screen and a lens whose focal length you are to determine. You are to set up the experiment as shown in the diagram. You need to prepare a table in which your readings can be recorded. To reduce experimental errors, repeat the experiment and find the average value of the focal length.

Procedure

1. Place the lens in its holder at a fixed distance (u) from the illuminated object.
2. Move the screen towards or away from the lens until a sharp clear image is seen on it.
3. Measure the image distance (v), between the lens and the screen.
4. Substitute the values of u and v in the formula: $\frac{1}{f}=\frac{1}{u}+\frac{1}{v}$ and hence determine the focal length (f) of the lens

5. Repeat the experiment four times by changing the object distances.
6. Find the average value of the focal length (f).
7. Construct an appropriate table for u, v, uv and $u + v$.
8. Plot a graph of uv as the ordinate against $u + v$ as the abscissa and find the slope of the graph.
9. What does the slope represent?
10. Compare the average value in Step 6 with the slope calculated in step 8.

Results and Calculations

Tabulate your results as shown below in Table 5.1

Table 5.1 Table of Results

Experiment	u/cm	v/cm	f/cm	uv/cm^2	$(u + v)$/cm
1					
2					
3					
4					
5					

Theory

Using the lens equation, $\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$, determine f for each of the records and find the average f.

Conclusion

The focal length of the lens = …….m

C. Assessment – Student's sheet

On completion of the experiment, you should answer the following questions:

1. What is meant by the 'focal length' of a lens and what is its significance? (CS1)

2. State the lens equation. (KS2)

3. Sketch the different types of converging lenses. (KN1)

4. How would you improve the precision of your measurements? (PS3)

D. Extensions to experiment

A laser source can be used as the source of light instead of the ray box.
The same procedure can be used in determining the focal length of a concave lens.

E. References and Other Useful Links

1. Abbot A. F. (1980), Ordinary Level Physics, 3rd Edition, Heinemann Books International, London.

2. Nelkon M. and Parker P., (1987), Advanced Level Physics, Heinemann Educational Publishers, London.