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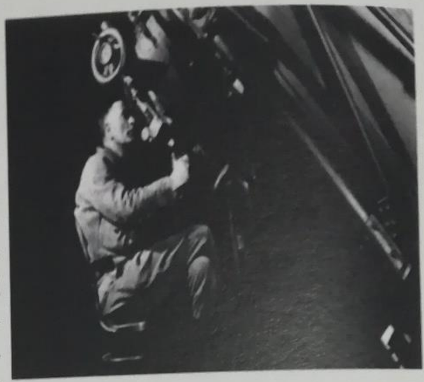
Experiment-6: Lenses



Edwin Hubble (1889-1953) American astronomer.

Hubble was born and grew up in the United States. He studied law at Oxford University and worked as a lawyer. He then studied astronomy at the University of Chicago and studied on astronomy. For the rest of his life, he worked at the Wilson Mountain Observatory. He studied on galaxy named Andromeda. At those days, most astronomers believed that the Milky Way was the whole universe. His studies showed that the Andromeda Galaxy is just another galaxy, and thus there are other galaxies outside our own. Hubble's observations was also some of the greatest proofs on the *Big Bang* theory as he have found that. Because he found that stars and planets are moving far away from the Earth basing on the observations of the spectrum of the light. Then he has concluded that all the planets were moving away from each other. This meant that the universe was expanding.

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6.1. Objectives:

Our goal in this experiment is to measure the focal lenght of the convergent lens with the help of a plane mirror using the self-parallelization method. Our other aim is to experimentally test the lens formula of the convergent lens.

6.2. Equipments:

Optical rail and lens holders, scaled holders, converging lenses with short and long focal lengths, illuminating objects (bulb & letter L), screen and a ruler.

6.3. Experiment:

Section II:

Instructions:

In this section, once more the "L-letter" illuminated by a bulb will be used as object in the experiment. Preferring to use the lens with shorter focal lengths, an image on the screen will appear and by varying the distance of the object (S) for 10 different values, the distance of the image, (S') and the image length (h') can be obtained.

Object's length h = ...

Table of data:

Measure. #	S (cm)	S' (cm)	h' (cm)	Magnification $m=S'/S$	h'/h	$1/S$ (cm^{-1})	$1/S'$ (cm^{-1})
1	20	19.4		0.97		0.050	0.052
2	21	18.6		0.89		0.048	0.054
3	22	17.8		0.81		0.045	0.056
4	23	17.2		0.75		0.043	0.058
5	24	16.6		0.69		0.042	0.060
6	25	16.1		0.64		0.04	0.062
7	26	15.7		0.60		0.038	0.064
8	27	15.4		0.57		0.037	0.065
9	28	15.1		0.54		0.036	0.066
10	29	14.8		0.51		0.034	0.068
11	30	14.4		0.48		0.033	0.069

Calculations:

$\frac{1}{S}+\frac{1}{S'}=\frac{1}{f}$ equation is known as the "focus formula". If $\frac{1}{S'}=f(\frac{1}{S})$ graph is plotted, it will be linear. As this line intersects the axes at the values of $(\frac{1}{f})$, f can be calculated by using the intersection points of the drawn graph.

Section III:

Instructions:

In this section, a telescope will be constructed by using two lenses with different focal lengths. In accordance with the telescope principles, the lens with the greater focal length should be placed to the object (Figure 6.3).

$$\boxed{\frac{1}{f}=\frac{1}{S}+\frac{1}{S'}}$$

Calculation of Section-II:

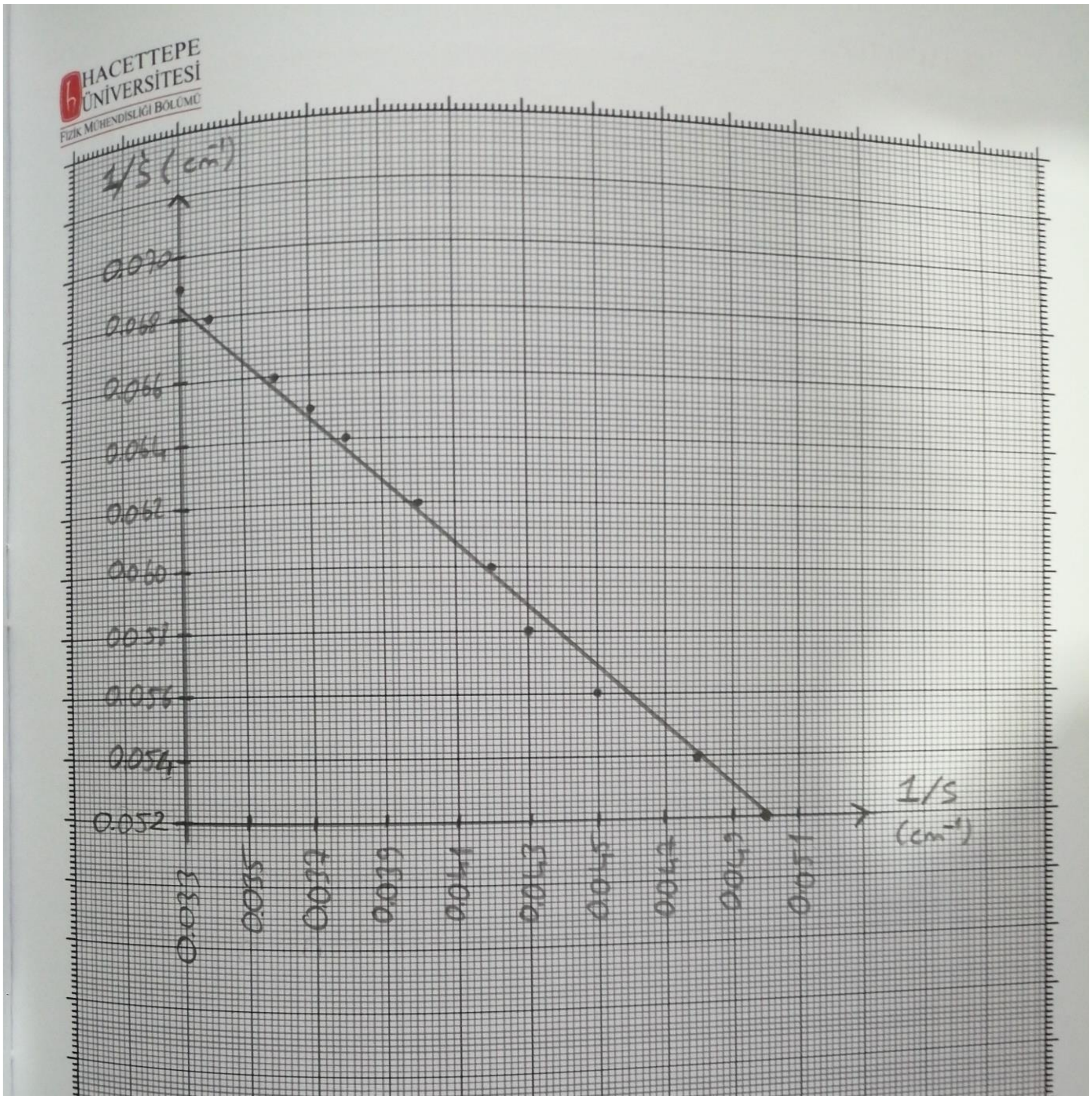
- The focus of the point that intersects the x-axis : f_1
- The focus of the point that intersects the y-axis : f_2
- Point intersecting the x-axis : (0.0502, 0.0520)
- Point intersecting the y-axis : (0.0330, 0.0684)
- $1/f_1 = 0.0502\ cm^{-1} + 0.0520\ cm^{-1} = 0.1022\ cm^{-1} \Rightarrow f_1 = 9.785\ cm$
- $1/f_2 = 0.0330\ cm^{-1} + 0.0684\ cm^{-1} = 0.1014\ cm^{-1} \Rightarrow f_2 = 9.862\ cm$
- $f_{ort} = \frac{f_1+f_2}{2} = \frac{9.785cm+9.862cm}{2} = \frac{19.647cm}{2} \Rightarrow f_{ort} = 9.824\ cm$

Relative Error :

- $f_{theorical} = 100\,mm = 10\,cm$
- $f_{experiment} = f_{ort} = 9.824\,cm$

$$\boxed{\%\ error = \frac{|f_{theorical} - f_{experiment}|}{f_{theorical}} \times 100}$$

$$\%\ error = \frac{|10cm - 9.824cm|}{10cm} \times 100 = \frac{0.176cm}{10cm} \times 100 = \%1{,}76$$



6.4. Results and Discussions:

In this experiment, our aim is to experimentally demonstrate the "Lens formula" derived for the convergent lens. For this, we measured the distance of the object to the lens 11 times. Later, we drew a graph with a method different from the x-y graph were used in normal experiment. The benefit of this method is to use the points of the x and y axes intersected by the line formed in the graph. So we found "f" using the intersection points. Using the lens formula, we found two focal lenghts with these two points and by averaging them we found the "experimental focal lenght".

When we calculated the experimental eror of the focal lenght, the value was 1.76%. This value is quite acceptable. Constantly operating light source, lens without distortion, correct lenght measurement, correct calculations and regularity of the line drawn in the graphic provide this error rate.