

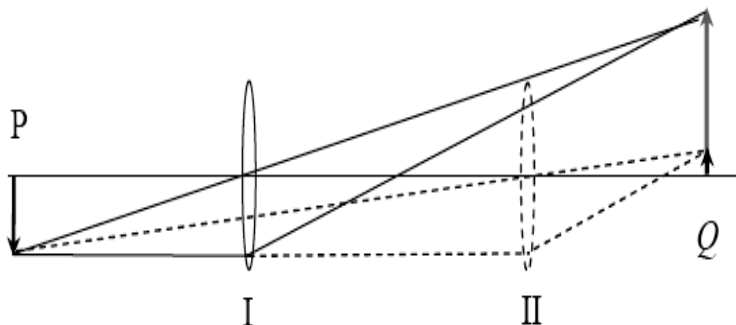
(eo211) 6. Convex Lens Focal Length Measurement: Conjugate Imaging

Translation by J D White,

1. Purpose

To measure the focal length of a concave lens using different methods: Conjugate Imaging

2. Basic Theory



Key equations:

1. P: distance from object to lens
2. Q: distance from lens to image
3. Total distance of object to screen: $D = P + Q$
4. d : difference between q for two (big and small) images, i.e. $d = \Delta q = q_{\text{big}} - q_{\text{small}}$
5. Gaussian Lens formula: $1/f = 1/P + 1/Q$ for a single lens.
6. Conjugated image equation: $f = (D^2 - d^2)/4D$ see

<http://graphics.stanford.edu/courses/cs178/applets/gaussian.html>

The key equation here is the Gaussian Lens formula. For $D > 4f$ there are two real and positive solutions to the equation:

$$\frac{1}{f} = \frac{1}{P} + \frac{1}{Q} = \frac{1}{D-Q} + \frac{1}{Q} = \frac{D-2Q}{Q(D-Q)} \rightarrow Q(D-Q) = fD - 2Qf \rightarrow Q^2 - (D+2f)Q - fD = 0$$

Note that while the discriminant is always greater than zero, i.e.,

$$((d+2f)^2 + 4fd) > 0$$

for the solution to be useful it needs to be a positive value of Q and a value of Q that is less than D .

3. Summary of Experiment

1. Distance $D > 4f$ is required to be fixed for a set of measurements. Then varying the locations of lens to find where images are made. Then calculate focal length. Note:

4. Equipment

1. Optical Rail and Laser with 45 degree mirror,
2. Two (2) apertures (with supporting hardware),
3. Spatial filter assembly (pin hole, microscope objective lens)
4. Frosted glass
5. Letter "F"
6. Mirror
7. Lens to Test

5. Procedure

- a. Align laser beam horizontal to table along the rail using 2 fixed apertures (See previous Experiments)
- b. Adjust Spatial Filter and ensure the light is collimated and continuing down the rails
- c. Lens Focal Length Measurement (Conjugate Imaging)

6. Results

Change D	$D = P+Q$	Bigger or Smaller Image	P	Q	Gauss's Lens Formula (f)	$d=\Delta Q = Q_{big}-Q_{small}$	Conjugated Imaging (f)
第一組		B					
		S					
第二組		B					
		S					
第三組		B					
		S					
第四組		B					
		S					
第五組		B					
		S					
第六組		B					
		S					
第七組		B					
		S					
第八組		B					
		S					
第九組		B					
		S					
第十組		B					
		S					
Average	Gauss's Law		cm	Conjugated		cm	

7. Questions

7.1 Lesson Topic:

a.

7.2 After-school topics:

a.