Using a combination of lenses to determine the focal length of a single concave lens

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As is well known, a concave lens does not generate a real image and, hence, the measurement of its focal length has to be indirectly carried out. However, when used in combination with another convex lens, the image formed can be real and, therefore, the focal length measurement can be made directly. This is the principle used when a human wears concave lens spectacles but gets a real image formed on her/his retina. The measurement can be made more simplistic if the incoming beam is parallel. Parallel beam can be obtained from a distant object but it may not be possible to get distant objects at all instances. Hence this experiment also provides a simple means of generating a parallel beam.

If the light source is placed at the focal point, a convex lens will give parallel beam as output. This parallel beam can be further used to carry out the combination-of-lens method.

Apparatus: A LED light as a point source, two convex lenses of known focal length and a concave lens of unknown focal length, graph paper and lens holders.

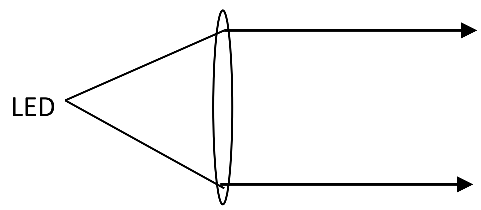
Procedure:

1) Place a convex lens of known focal length in front of a point source of Light Emitting Diode (LED). Place the lens at approximately the distance equal to the focal length f_1 so that the light emergent from the lens is parallel.

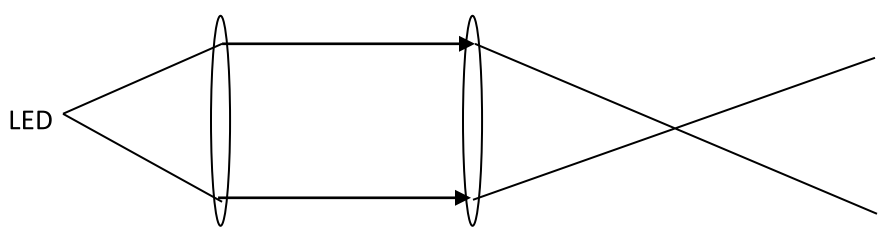
2) Place a graph paper at different locations between the LED and the lens and also at locations beyond the lens to determine the size of the image. If the lens is placed at appropriate location, then the emergent beam will have the same size of image irrespective of location of the graph paper. If the size of the image changes with distance (from the convex lens) then the beam is either divergent or convergent and the light source is not at the focal point. Move the lens to a slightly different location and try again by measuring the size of the image.

[This is the point where the skill of students is to be tested. When a student keeps the light source at the focal point (also on the optical axis), the emergent beam is, indeed, parallel.]

3) Note the distance from the LED and the size of the image, in **table 1**



4) Place another convex lens of unknown focal length f_2, at some distance from first lens. If the lenses and the source of light are along one straight line, then the image of lens 2 will be a very sharp point, of as small dimension as possible.



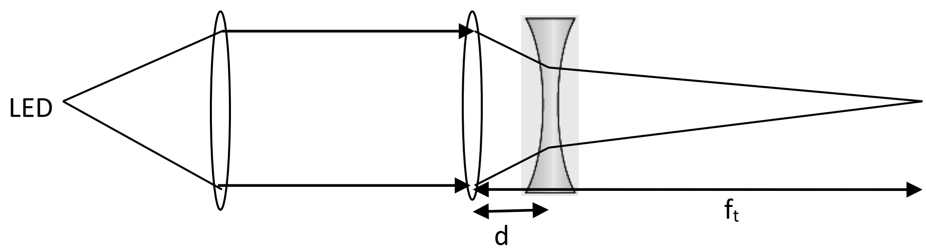
5) Place the graph paper at a point close to the second lens and measure the size of the image. Measure the distance between the graph paper and the second lens, and note down the size of the image.

6) Increase the distance between the graph paper and the second lens. The image will become smaller upto a point and then start increasing again. Note the distance (d) and the size of image (s) at increasing distances. Make 9 to 11 measurements in such a way that initially the size of the image is becoming smaller and then the size is increasing with distance.

[Note. If the source is really a point source of light (and not an *extended* source of light), the image formed will also be a point image. However, since the source of light inevitably has finite size, and if the optical alignment is not precise, the size of the image may be larger than the size of the source. Hence, the alignment skill of student is very important part of this experiment]

7) Note the readings in **table 2**. Plot a graph of d against s. You can draw two separate straight lines in the graph. The value of d for the point where the two lines meet is equal to the focal length of the lens 2 (f_2)

8) Introduce the concave lens of focal length f_3 (to be determined) between the lens 2 and image point. The image point will be shifted to a further distance of f_t. Place the concave lens as close to lens 2 as possible.



9) Repeat steps 5, 6 and 7 above and note the readings in **table 3** to find the effective focal length f_t. 'f_t' is practically measured from the screen up to midpoint of the convex lens closest to the concave lens.

$1/f_t = 1/f_2 + 1/f_3 - d/f_2f_3$

Where d is the distance between lens 2 and 3.

Table 1.

Reading No.	Distance from point source (cm)	Size of image. (cm)
1		
2		
3		
4		
5		
6		
7		

(X marks)

Table 2

Reading No.	Distance from point source (cm)	Size of image. (cm)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		

(X marks)

Draw a graph of d vs s (X marks)

Table 3

Reading No.	Distance from point source (cm)	Size of image. (cm)
1		
2		
3		
4		
5		

6		
7		
8		
9		
10		
11		

(X marks)

Draw a graph of d vs s. (X marks)

F_1 = ______________________________ (x marks)

F_2 = ______________________________ (x marks)

F_t = ______________________________ (x marks)

$1/f_t = 1/f_2 + 1/f_3 - d/f_2f_3$

F_3 = ______________________________ (x marks)