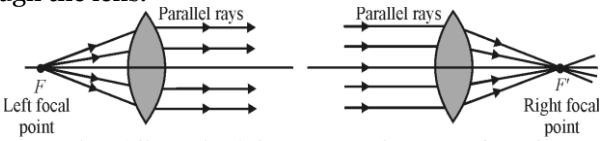
LU4: LAB 1-4A - D: Measuring the focal length of a lens

REFERENCES:

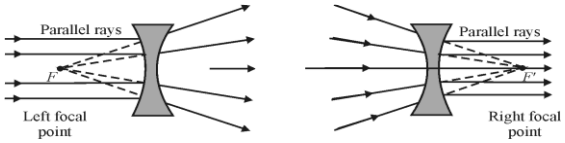
- *Fundamentals of Light & Lasers* (OPTEC), 3rd edition
- Module 4, Lab 1-4A, Part D, pages 44–47.
- http://optecvideo.opteccrm.org, Video 13: Read these instructions and watch the videos before doing the lab.
  - Course 1: Fundamentals of Light and Lasers
  - Lab Activity Video
  - Choose Video #
    - Lab 1.4A-D begins at 7:25.
    - It would be good to watch the whole video though.

THEORY:

The focal point of a positive (converging) lens is the point at which a light source would be placed to produce parallel rays after passing through the lens or, conversely, the point at which rays parallel to the axis of the lens converge after passing through the lens.



Rays parallel to the axis of a negative (diverging) lens spread apart after they pass through the lens. The focal point is the point at which a light source would be placed to produce the rays if the lens was not there (point from which the rays "appear" to come). Conversely, light rays aimed at the focal point through the lens will emerge from the lens parallel to each other.



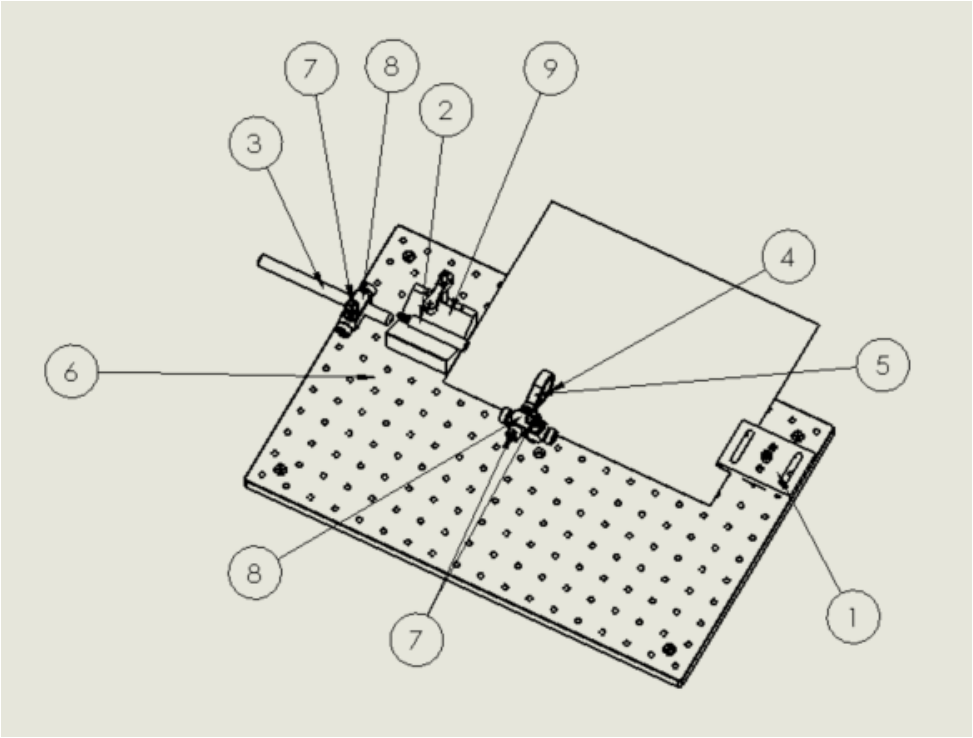
The focal length of the lens is the distance from the lens to the focal point of the lens.

OBJECTIVE:

Measure the focal length of a positive & a negative lens using parallel laser beams.
To do a comprehensive and precise Lab Write-up.
Take appropriate pictures to prove/show lab work.

EQUIPMENT:

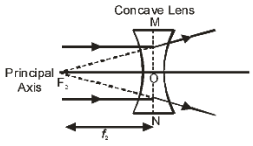
Base, Mounting (key 1)
2 - Laser Diode Power Supplies
Laser Diode Module #2 (key 2)
Laser Diode Module #1 (key 3)
Lens, Convex (key 4)
Lens, Concave (key 4)
Lens Mount, Fixed (key 5)
Optical Plate/Board (key 6)
(3) Post (key 7)
(2) Right-Angle Clamp (key 8)
V-Clamp (key 9)
Flashlight
Misc Hardware



SET-UP: Read the entire SET-UP and PROCEDURE before starting the lab.

1. Mount a post directly on the board (no post holder) near the midpoint of a short end of the breadboard
2. Place a non-reflecting object at the end of the breadboard opposite the post to contain the laser beams.
3. Mount a laser diode module #1 in a right-angle clamp. Mount the clamp on the post in #1.
    a. You will need to "shim" the laser diode, the right-angle clamp hole-diameter is larger than the laser.
4. Mount a laser diode module #2 in the V-clamp. Mount the V-clamp on the breadboard.
5. Align the two assemblies so that the two laser beams are parallel to a row of holes and each other with less than 2.54 cm separation.
6. Turn on laser #1.
7. Use an index card to align the beam from laser #1 with the breadboard (parallel to a row of holes) and at a consistent height along the length of the board (parallel and perpendicular).
8. Turn on diode laser #2. Align it to laser #1 or vice versa.
9. Assemble the double (bi) convex lens into a lens mount.
10. Attach the lens assembly to the end of a post.
11. Use a right-angle clamp and a second post to mount the lens assembly in the path of the laser beams and about 100mm (10 cm) from laser diode #2.
12. Use the mounting plate to clamp an 8-1/2" x 11" piece of paper or thin cardboard along the path of the laser beams. Locate the paper against the V-clamp and under the lens assembly.

PROCEDURE: Read this complete procedure before following it.

1. Adjust the lens assembly so that the parallel laser beams are centered on the lens and are equal distance from the midpoint of the lens. Again, they do not need to be vertically or horizontally oriented.
    a. 
2. The two laser beams converge to the lens' focal point (F) once they transmit through it then diverge again.
    a. Use an index card to **find the point** of convergence (F) and **mark that location** on the paper.
    b. **Do this 3 - times**. **Prove** this in the Lab Write-up (drawing, picture). This is the lens' *focal point* (F).
    c. **Measure and record** the distance from the 3 - focal points to the midpoint of the lens thickness (centerline). This is the *focal length* (f).
    d. **Record the 3 - data points, Calculate the average & record** in the Lab Write-up data table.
        i. Be sure to label all data tables, pictures, etc. **in the correct manner.**
        ii. All tables are to have boarders as shown in the Lab Write-up Instructions.
3. Remove the lens from the optical plate and then repeat with the flashlight.
    a. Hold the lens near a wall, screen or the paper (observation screen) on the optical plate.
    b. Shine the beam from the flashlight through the lens. Must be steady. *Mounting it may be better.*
    c. Adjust the distance of the lens from the observation screen to best focus the beam from the flashlight (smallest bright spot at the center). There may be a "halo" around the bright spot.
        i. You may want to mount the flashlight in from of the lens and then just move a screen (index card) to find the same distance.
    d. **Measure & record** 3 - times the distance from focus spot to the lens. **Record** in data table.
    e. **Calculate the average** the 3 - data points and **record.**
    f. **Calculate & record** the percent difference in f.
4. Replace the converging lens with the negative (diverging) lens and align the lens with the laser beams as in step 1.
5. Use an index card to locate the 2 - diverging beams after they transmit through the lens.
    a. 

6. Extend the paths of the two beams (imaginary beams) backwards to a point between the lens and the lasers until they meet (if necessary, mark the location of the midpoint of the thickness of the lens and remove the lens assembly). The point at which they meet is the focal point of the lens.
7. Do this 3 – times to **Measure** "f" from "F" to the midpoint of the lens thickness.
8. **Record** the focal length as instructed for the converging lens; steps 1 – 3.
    a. NOTE: According to sign convention (see text), this distance will be negative because it is on the side of the lens from which the light is propagating; see drawing in 5a
    b. NOTE: **All drawings show laser light propagating from left to right.**
9. **Take 4 – pictures** and include in Lab Write-up:
    a. One of the 2 - laser diodes positions and set-up
    b. One of the converging lens lab
    c. One of the diverging lens lab.
    d. One of the paper with all the markings and measurements.

10. EXTRA CREDIT (</=20 points):
    a. Mount both lenses in two different assemblies with the laser beams transmitting equally through them.
    b. Concave first. Convex second. Align the 2 – F's (this is not easy).
    c. **Describe** how the two laser beams propagate after leaving the convex lens (same distance apart, parallel, converging, diverging, disappeared, brighter, dimmer) and **why**?
        i. **Include** a picture of this set-up
        ii. **Include** dimensions showing the distance between the two lenses.
        iii. **Include** measurements of distance between the 2 - laser beams over 100 cm.

ANALYSIS:

1. A method of research in which a problem is identified and observations, experiments or other relevant data are gathered, a hypothesis is formulated, and is empirically tested.
    a. Hypothesis: a supposition or proposed explanation made on the basis of limited evidence as a starting point for further investigation.
2. Identify the problem (objective) to solve or accomplish.
    a. THINK: hypothesize a possible outcome; include in objective.
3. Use the lab to complete the objective and test your hypothesis.
4. Perform the experiment(s).
    a. Gather the data.
5. Analyzed the results of the process.
    a. An examination of data and facts to uncover and understand the cause/effect relationships.
    b. Accept, reject, or modify the hypothesis.
    c. Explain your reasoning.

DISCUSSION:

- Telescopes, microscopes, cameras, and the eye all have focusing lenses.
- A focusing camera focuses by adjusting the distance from the lens to the film or digital medium.
- The eye focuses by changing the shape of the lens.