Assignment 4
Due October 4, 2011

Text readings

Thick Lenses [section 6.1]
GRIN Systems [section 6.4]
Fiberoptics [section 5.6]
Be careful about our different sign convention.

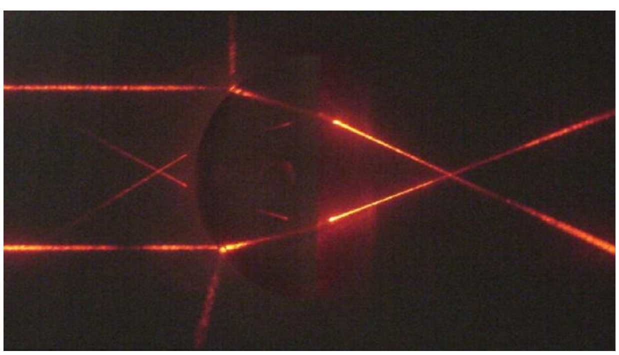
Problems

The equipment will be available in Room 1212B. Please work on these problems right away, so we can discuss your conceptual understanding, any needed theory and work out any problems.

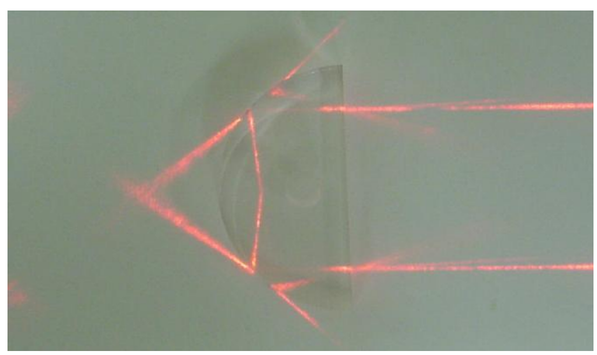
Problem 1

Plastic Semi-Disk Thick Lens: you will be given a plastic semi-disk that you used before. Measure directly the thickness and the radii of curvature of the surfaces. You already know the index of refraction for this semi-disk from your first homework.

1- Trace the lens shape on a clean paper in order to draw the principal planes, foci, etc., on it.
2- Calculate the effective focal length (F)of the thick lens.
3- Calculate the location of the primary and secondary principal planes for this plastic lens with respect to the object space and image space vertices, respectively.
4- Calculate the front and back focal lengths.
5- Experimentally, use a laser beam tracing find the location of the principal planes, the front and back focal lengths.
6- Compare you finding in part 5 to the calculated values.
7- What type of aberration do you expect for this cylindrical lens?
8- Where do you expect an object placed 15cm from the object space vertex to be imaged with respect to the image space vertex?



Laser incident from the left on the curved surface



Laser incident from the right on the plane surface

Problem 2

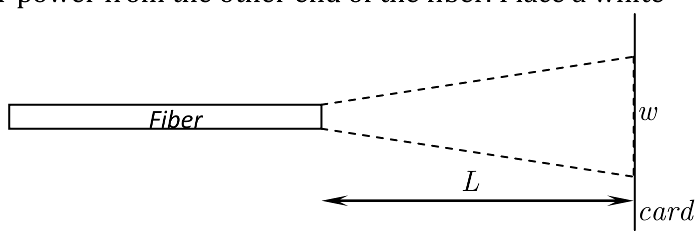
Combination of Two lenses: You will use two of the positive lenses that you know their focal lengths form previous work in order to study the effective lens produced by the two-lens combination.

1. Set the separation between the lenses to be 10cm.
2. Calculate the effective focal length ***F*** then calculate the location of the P and P' principal planes. Calculate the front and the back focal lengths.
3. Now experimentally find the back/front focal lengths.
4. Use the ***F*** and the results from part 3 to find the location of the P and P' principal plane.
5. Now experimentally find the image distance from the second lens if the object is 10 cm in front of the first lens.
6. Use the thin lens formula and the results of part 2 or 3 to verify that the measurements of part 5 are correct.

Problem 3

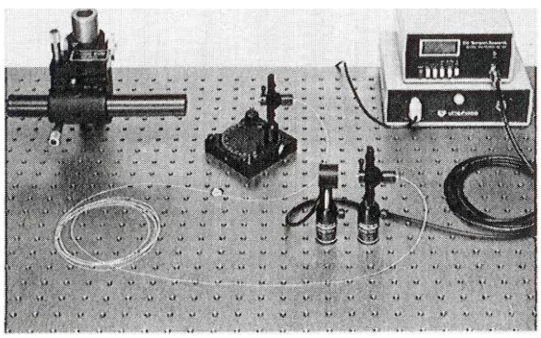
Numerical aperture of an optical fiber: You will measure the numerical aperture of a multimode fiber using a He-Ne laser, a rotating stage, power meter, and fiber positioner, see the figure below. We will go over the procedure of stripping and cleaving the fiber. I will guide you into the procedure of aligning the fiber with the laser.

a) Approximate way to measure of the fiber's numerical aperture. Align the laser and the fiber in order to get the maxim possible laser power from the other end of the fiber. Place a white card at a distance, L, away from the fiber in a darkened room. Measure the width, *w*, of the spot out of the fiber on the card. The θ_a of the fiber is approximately sin-1(w/2L). Find the numerical aperture.



b) Make sure that the laser beam passes over the center of the rotating stage and hits the center of the post on the post-holder. Otherwise you will never be able to align the system. Be sure to keep the tip of the fiber at the center of the laser beam as the stage is rotated.

   1. Measure the power accepted by the fiber as a function of the incident angle. Record you data in table.
   2. Plot the power as a function of the sine of the acceptance angle on a semi-log scale. Measure the full width of the curve at the points where the received power is at 5% of the maximum power. The half-width at this power is the experimentally determined numerical aperture of the fiber.



Problem 4
Book Problem: 6.7

Problem 5
Book Problem: 6.9

Problem 6
Book Problem: 6.13

Bonus Problems

Problems 6.5 and 6.14