

# OPT 300

## Computational Laboratory #1: Geometric Optics and Ray Tracing

Assigned 2007/2/21

Due 2007/3/6

Dr. Anders M. Jorgensen

In this lab you will acquire the basic skills for designing optical systems. You will investigate the basics of geometric optics, manual ray tracing, and possibly computer based ray tracing. A formal typed report is required. Show all your work, including derivations, sketches, calculations, and plots. Include an introduction, a conclusion, and a list of references. Some of the questions will require you to make reasonable assumptions to arrive at a result. These questions can have several different correct answers depending on the assumptions that you make. Be sure to state these assumptions and why they are reasonable. Collaboration and discussion of the lab with your classmates is encouraged, but each person must write a distinct report (i.e. no identical reports please). Be sure to reference your sources of information.

### Geometric optics

Consider an equiconvex thin lens with the following properties

- Laser wavelength 656 nm
- Diameter ( $D$ ) = 100 mm
- F-ratio = 10
- Material: BK7

This lens is installed in an optical system and illuminated by a well-collimated laser (656 nm) beam 100 mm in diameter. The optical system places an aperture stop in front of the lens, centered on the optical axis with an opening of  $0.75D$ .

1. What color is the light produced from this laser?
2. What is the index of refraction of the lens at this wavelength?
3. Determine the effective focal length ( $f$ ) of the lens.
4. How much light is removed from the original beam by the aperture stop?
5. What is the focal ratio (F-ratio) of the optical system?
6. Determine the shape of the lens surfaces and state the appropriate details.
7. Calculate the effective focal length if the laser wavelength is 486 nm.  
focused spot?
8. Where is the image of an object located  $3F/2$  from the lens?
9. What is the system magnification for the object in the previous question?
10. Specify a lens that would have the same focal point for 486 and 656 nm light.

## Practical lens

Consider a bi-convex lens whose radii of curvature differ by 20%:

- Aperture radius: 15 mm
- Material: BK7
- Effective focal length: 300 mm
- *Edge* thickness of lens: 10 mm
- Analysis wavelength: 656 nm.

Where appropriate, manually trace rays through the optical system. Determine the following:

1. Plot the index of refraction of the lens from 400 nm to 700 nm.
2. What are the positions of the first and second focal points?
3. What are the positions of the first and second principal points?
4. What is the back focal length of the lens?
5. Plot the shape of the principal surfaces over the aperture radius (you will not be able to use the paraxial approximation for this).
6. How far from the front surface of the lens is the second principal point?