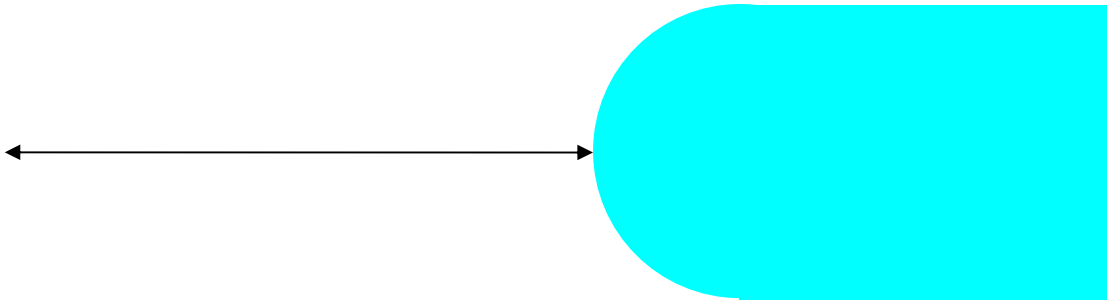
INF-GEO4310 2010
Exercises, Geometrical Optics, Part 2

1 Image formation by refraction

A cylindrical glass rod of diameter 4.00 cm has an index of refraction of 1.50. One end of the rod is shaped like a hemisphere having a radius of 2.00 cm. A small object is placed on the axis of the rod, 8.00 cm left of the vertex (see figure below). We are going to find the position of the image of the object, as well as the magnification.

a. *Which expressions from which section of the distributed text are relevant?*
b. *Find the image distance of the object from the vertex if the surrounding medium is air (refractive index n =1.00).*
c. *Find the lateral magnification.*
d. *What is the image distance if the surrounding medium is salt water having a salinity of 14.05 ? (The index of refraction of salt water is n = 1.3326 + 0.00195 s, where s is the salinity).*
e. *What is the lateral magnification now?*
f. *What are the main differences between the two situations (air/water)?*



2 Santa's image problem

Your exam will take place some time before Christmas, and the following problem may therefore be relevant:
Santa checks himself for soot from the chimney, using his reflection in a shiny spherical Christmas tree ornament having a diameter of 7.2 cm, at a distance of 75 cm.

a. *Where is the image, and is it real or virtual?*
b. *If Santa is "a jolly old elf" 1.6 m high, how tall is the image, and is it erect or inverted?*

3 Determining the focal length of a lens

Assume that the absolute values of the radii of curvature of the two surfaces of a thin lens in air are 10.0 cm and 5.0 cm and that the index of refraction is 1.5. (Hint: 2.1.7 Sign rules, page 2-6.)

a. *What is the focal length of the lens if both surfaces are convex ?*
b. *What is the focal length if one surface is convex and the other concave?*
c. *What is the focal length if the lens is double-concave?*
d. *Does it matter if we interchange the left and right surface?*

4 Image of an image

An object 8.0 cm high is placed 12.0 cm to the left of a converging thin lens having a focal length of 8.0 cm. A second converging lens having a focal length of 6.0 cm is placed 36.0 cm to the right of the first lens, on the same optical axis.

a. *Find the position, size and orientation of the image produced by the combination of the two lenses.*

5 Single-slit diffraction

You pass 633 nm laser light through a narrow slit and observe the diffraction pattern on a screen 6.0 m away. You find that the distance between the centers of the first minima is 32 mm.

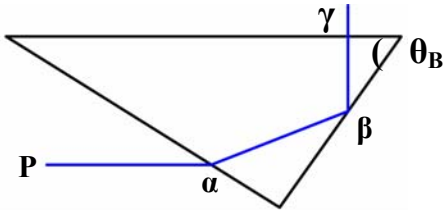
a. *How wide is the slit?*
b. *What is the distance between the second minima?*

6 Width of a grating spectrum

The wavelengths of the visible spectrum are approximately 400 to 700 nm. Assume that you are using a plane grating with 600 slits per mm and that white light falls perpendicular on the grating.

a. *Find the angular width of the first order visible spectrum.*
b. *Do the first and second order spectra overlap?*
c. *What about the second and third order spectra?*

7 The Brewster prism from the previous exercise (from the written exam 2009)



d) We put a thin plano-convex lens as a *collimator* between P and the prism.
If the radius of curvature of the spherical lens surface is R_3 and the refractive index of the lens material is $n_3 = 1.5$, at what distance from P should we place the lens?

Does it make any difference whether the planar or curved surface faces P?

Good luck!