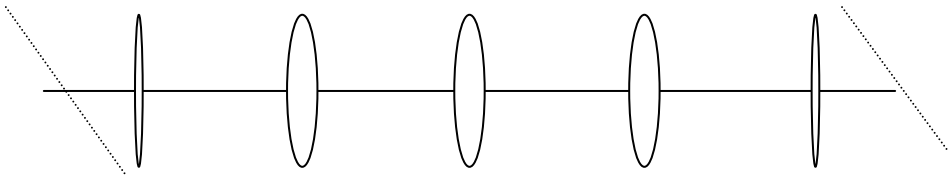
OPTICS, 114210 Homework exercises

A. Geometrical Optics

1. Ray-tracing

1.1. A periscope is constructed from five thin lenses of diameter D, having focal lengths 2F, F, F, F and 2F, situated in planes x=0, 2F, 4F, 6F and 8F respectively. (At the ends are two mirrors at 45º to the axis, but these can be ignored in this problem).
(a) Draw a ray diagram showing how a group of rays entering the first lens parallel to the axis are refracted through the system
(b) What is the angular field of view of the periscope?



1.2. A goldfish swims in spherical globe of water with refractive index 4/3 and radius R. At a certain moment, the fish is at distance R/4 from the wall of the globe. Where is the image of the goldfish, as seen from outside the globe, and by how much is it magnified? Is it inverted?

1.3. A swimming pool filled with water of refractive index 4/3 has depth 2m. How deep does it appear to be when viewed
(a) from above, (b) at an angle of 45º to the vertical?

1.4. Why do an animal's eyes shine in the light reflected from your car headlights? Why does the colour of the reflection depend on the animal (cats reflect green, we reflect red)?

1.5. A microscope is constructed from an objective lens with effective focal length 2mm, a tube lens with focal length 200mm and an eyepiece with effective focal length 10mm. The object is in the focal plane of the objective and the intermediate image is in the common focal plane of the tube lens and that of the eyepiece (approximately). Draw a paraxial ray diagram for an off-axis point on the object and determine the magnification achieved by the microscope (assume the magnified image is a virtual image in the same plane as the object).

1.6. In order to use a microscope to investigate an inaccessible specimen, one can use a relay lens between the specimen and the objective to produce a real image, and then the microscope looks at this image. Draw a ray diagram of this system, and find how the relay lens affects the field of view and the exit pupil of the microscope.

1.7. An infrared camera uses silicon (n=3.8) micro-lenses to increase its sensitivity. A small spherical silicon lens contacts each pixel individually and uses the aplanatic principle to increase the angle of acceptance. By what factor can you increase the sensitivity of the detector for a given imaging lens?