Assignment 1-Geometric Ray Optics
Due 25/9/09 at 4PM. Please hand to the 4th Floor Office or to me on Thursday's lecture on the day before.

1.) Imagine a thin lens positioned some distance from a highly reflective mirror. The mirror has been placed perpendicular to the optical axis such that it would reflect an optical ray travelling down the optical axis in exactly the opposite direction. Write a matrix that represents the path through the lens to the mirror and then back through the lens. You may need to develop a new ray matrix to describe the operation of the mirror.

2.) Derive an ABCD matrix that describes a thick lens. Assume that the lens is much thicker than the change in thickness due to the curvature of the two surfaces of the lens.

(a) You design a lens to correct someone's sight using a 1 cm thick convex-concave plastic lens with a refractive index of 1.25 and radii of curvature of 3 metres and 1 metre on the back and front faces respectively. If this lens is sitting in air-

(i) Derive where a ray entering the lens at (1,0) crosses the optic axis

(ii) Thin lenses have the twin properties that: 1) all rays passing through the optical axis of the lens remain undeviated irrespective of their slope, and, 2) that all rays parallel to the optical axis are focused at the focal point of the lens. Show whether a general thick lens also exhibits these properties. What is the focal length of this lens?

(b) What is the focal length of the lens if it were to be immersed in water (assume $n_{water} \sim 1.33$)

3.) Looking at figure 3.4 from the lecture notes, show that the path length difference between adjacent reflected rays corresponds to the value given in equation 3.12.

4.) See figure 3.6 in the notes

Lasers do not necessarily give a monochromatic output but can give out a large number of signals with different frequencies (which is called multi-mode operation). We wish to design an optical spectrum analyzer (OSA) to examine the output of a laser pointer based on a diode laser. Typically modes will appear across the entire gain width of the active medium, and in this case we find the gain peak to be around 1nm wide, centred on 675 nm (vacuum wavelength). The laser gain media is contained in a Fabry-Perot resonator and laser modes can only exist at frequencies for which the laser cavity is in resonance (an axial mode). The laser cavity in this case is 1 mm long and the refractive index of the diode material is 2.

An important design parameter for an OSA is that the free spectral range is greater than the largest frequency separation between signals entering the OSA. We also need to design the OSA so that its resolution is significantly higher than the smallest details we wish to see in the incoming signal (say 10 times higher).

(a) What is the spacing between adjacent axial modes of the laser? How many modes fall in the gain curve?

(b) What limits can be placed on the size of the optical spectrum analyzer so that an unambiguous output is obtained?

(c) What cavity Finesse is required for the interferometer, and hence, what reflectivity mirrors are required?