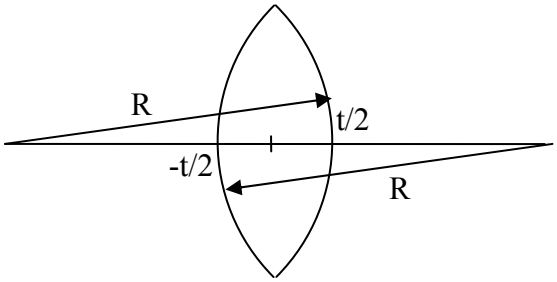
OPTICS, 114210 Homework exercises
A. Geometrical Optics

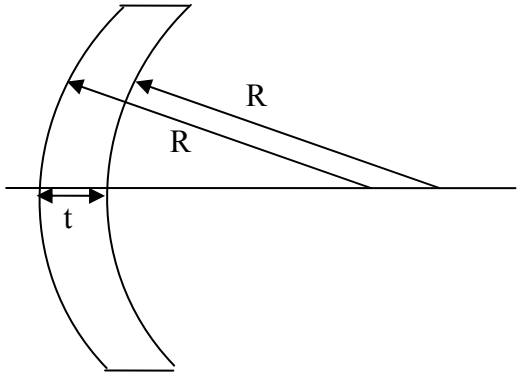
2. Cardinal points and planes

2.1 Two coaxial thin lenses with focal lengths f_1 and f_2 are separated by axial distance x. Find the effective focal length and principal planes of the combination.

2.2 A lens of thickness t is made from glass with refractive index n=1.5 and has equal and opposite radii of curvature +R and –R at its two surfaces. Define the origin of the optical axis at the centre of the lens, so that the two vertices are at ±½t.
Find the focal points F_1 and F_2 and the principal points H_1 and H_2 for the following cases**:**
(a) t=0
(b) t=2R
(c) t=6R.
(d) Draw a ray diagram showing the paths of a group of rays incident parallel to the axis for the case (c) t=6R.
(e) An object is situated around the point (-5R, 0). In the case (c) above, where is the image situated, and what is its magnification?

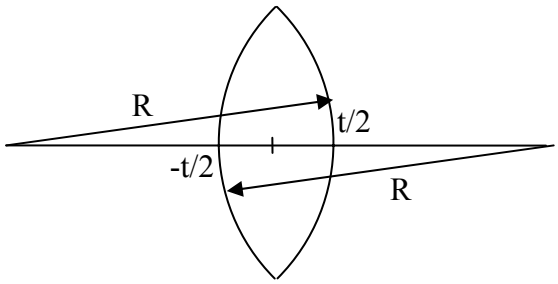


2.3 A glass shell has refractive index 1.5, thickness t and equal radii of curvature R (same sign) on both sides.
(a) Without making a calculation, decide whether it behaves as a diverging or converging lens.
(b) Find the focal length and principal planes of the shell.



2.4 A symmetrical camera lens is constructed from three coaxial thin lenses with focal lengths +20, -20 and +20 mm respectively, separated by 5mm.
(a) Find the effective focal length of the combination
(b) The lens is used to photograph an object 30m high at distance 1.0 km. What will be the height of the image on the film?
(c) Is the image upright or inverted?
(d) What is the distance between the film in (b) and the lens closest to it?

2.5 Find the thickness of a symmetrical double-convex lens ($R_1 = -R_2$) of glass with refractive index n such that its focal length is infinite.



2.6 This "non-window" problem was once set as a challenge to optical engineers in the journal "Applied Optics". You are given a window of thickness D and refractive index n, with air on both sides. Design an optical system, which can be built with additional components on either or both sides of the window, and results in any ray passing straight through as if the window did not exist (optically). You need to design a system consisting of: lens, the given window, lens.

(a) What do you require of the principal planes?
(b) What value do you require for the focal length of the system?
(c) Can you find a system with these properties?

(n.b., the optical engineers were expected to solve the non-paraxial problem, which is much more difficult!)