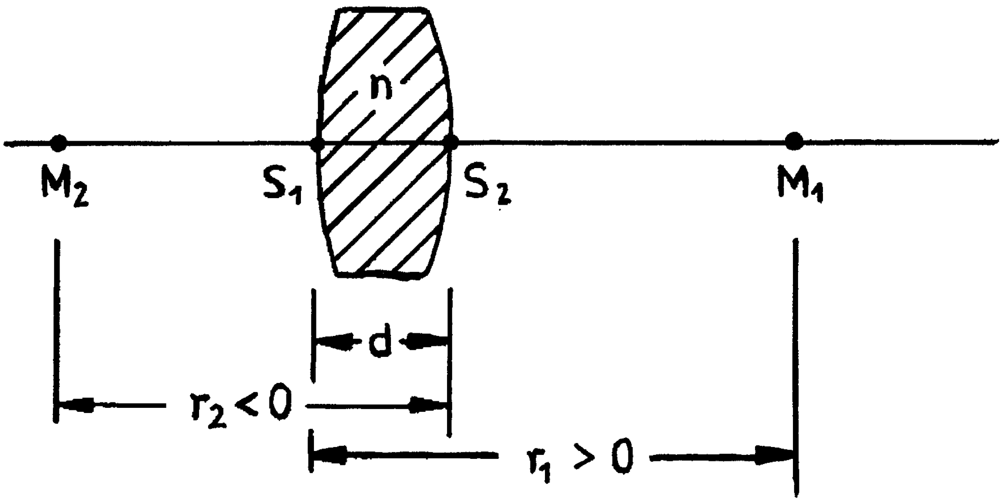
Theoretical problem 2: "Thick lens"

The focal length f of a thick glass lens in air with refractive index n, radius curvatures r_1, r_2 and vertex distance d (see figure) is given by: $f = \frac{n r_1 r_2}{(n-1)\left[n(r_2 - r_1) + d(n-1)\right]}$



Remark: $r_i > 0$ means that the central curvature point M_i is on the right side of the aerial vertex S_i, $r_i < 0$ means that the central curvature point M_i is on the left side of the aerial vertex S_i ($i = 1,2$).

For some special applications it is required, that the focal length is independent from the wavelength.

a) For how many different wavelengths can the same focal length be achieved?

b) Describe a relation between r_i ($i = 1,2$), d and the refractive index n for which the required wavelength independence can be fulfilled and discuss this relation.

   Sketch possible shapes of lenses and mark the central curvature points M_1 and M_2.

c) Prove that for a given planconvex lens a specific focal length can be achieved by only one wavelength.

d) State possible parameters of the thick lens for two further cases in which a certain focal length can be realized for one wavelength only. Take into account the physical and the geometrical circumstances.