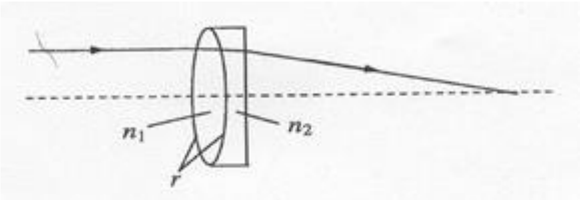
Q- An achromatic doublet consists of a biconvex positive lens of refractive index μ_1 in contact with a plano concave lens of refractive index μ_2. All curved surfaces have a radius of curvature R = 25 cm.

(a) If μ_{1red} = 1.49 what is the focal length of the biconvex lens for red light?

(b) If μ_{2red} = 1.54 what is the focal length of the plano convex lens for red light?

(c) What is the focal length of the doublet for red light?

(d) If μ_{1blue} = 1.52 what must be the value of μ_{2blue} for the combination to be achromatic?



The focal length of lens is related with the refractive index and the radius of curvature is given by Lanes maker's formula

$$\frac{1}{f} = (\mu - 1)\left(\frac{1}{r_1} - \frac{1}{r_2}\right)$$

where μ is the refractive index and r_1 and r_2 are the radii of curvature of the two surfaces of the lens.

a) Using Cartesian sign convention (direction of incident ray + ve) for the biconvex lens for red light we can write

$$\frac{1}{f_{1r}} = (\mu_{1r} - 1)\left(\frac{1}{r} - \frac{1}{-r}\right) = (1.49 - 1)\left(\frac{2}{25}\right) = \frac{0.98}{25}$$

or f_{1r} = 25/0.98 = **25.5 cm.**

b) For the Plano concave lens, we can write

$$\frac{1}{f_{2r}} = (\mu_{2r} - 1)\left(\frac{1}{-r} - \frac{1}{\infty}\right) = (1.54 - 1)\left(\frac{1}{-r}\right) = -0.54/r$$

or f_{2r} = - 25/0.54 = **- 46.3 cm.**

c) The focal length of a combination of two lens in contact is given by

$$\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2}$$, gives

or $\frac{1}{F_r} = \frac{0.98}{25} - \frac{0.54}{25} = \frac{0.44}{25}$

or

F_r = **56.8 cm.**

d) The focal length of the combination can be written directly for blue light as

$$\frac{1}{F_b} = (\mu_{1b} - 1)\left(\frac{2}{r}\right) + (\mu_{2b} - 1)\left(\frac{1}{-r}\right)$$

Or $\frac{1}{F_b} = (1.52 - 1)\left(\frac{2}{25}\right) + (\mu_{2b} - 1)\left(\frac{1}{-25}\right)$

Or $\frac{1}{F_b} = 0.52\left(\frac{2}{25}\right) + (\mu_{2b} - 1)\left(\frac{1}{-25}\right)$

but for the achromatic combination $F_r = F_b$, gives

$$\frac{1}{56.8} = 0.52\left(\frac{2}{25}\right) + (\mu_{2b} - 1)\left(\frac{1}{-25}\right)$$

or $0.0176 = 0.0416 + (\mu_{2b} - 1)\left(\frac{1}{-25}\right)$

or $(\mu_{2b} - 1) = 0.6$

or $\boldsymbol{\mu_{2b} = 1.6}$