Answer on Question#53681 - Physics - Optics

An equiconvex lens (of refractive index $n = 1.5$) is placed in contact with plane mirror as shown in the figure. A small needle with its tip on the principal axis is moved along the axis until its inverted image is found at the position of the needle. The distance of the needle from the lens is measured to be $L = 30$ cm. Now a few drops of a liquid are put in between the lens and the plane mirror and the new position of the image is located to be at $l = 45$ cm. Calculate the refractive index n_l of the liquid.

<u>Solution:</u>

Since the position of the image coincides with the position of the object, the object distance L equals the doubled focal length of the system. Let the focal length of the lens be f then the focal length f' of the system without liquid is defined as follows

$$\frac{1}{f} + \frac{1}{f} = \frac{1}{f'}$$

Therefore

$$f' = \frac{f}{2}$$

Since $L = 2f'$, we obtain that $f = L = 30$ cm. Dropping the liquid between lens and the mirror results in adding the biconcave lens with the same curvature of the surfaces as the equiconvex lens. Therefore its focal length is defined by

$$f(n-1) = f_l(n_l - 1)$$

Therefore

$$f_l = f\frac{n-1}{n_l - 1}$$

The focal length of the new system on the one hand is given by

$$\frac{1}{f''} = \frac{1}{f'} - \frac{1}{f_l}$$

and on the other hand it's given by

$$\frac{1}{f''} = \frac{2}{l}$$

Thus

$$\frac{1}{f'} - \frac{1}{f_l} = \frac{2}{l}$$

$$\frac{2}{f} - \frac{1}{f}\frac{n_l - 1}{n - 1} = \frac{2}{l}$$

$$\frac{1}{L}\left(2-\frac{n_l-1}{n-1}\right)=\frac{2}{l}$$

$$n_l=2n-1-(n-1)\frac{2L}{l}=2\cdot 1.5-1-(1.5-1)\frac{2\cdot 30\text{cm}}{45\text{cm}}=1.33$$

<u>Answer:</u> 1.33.