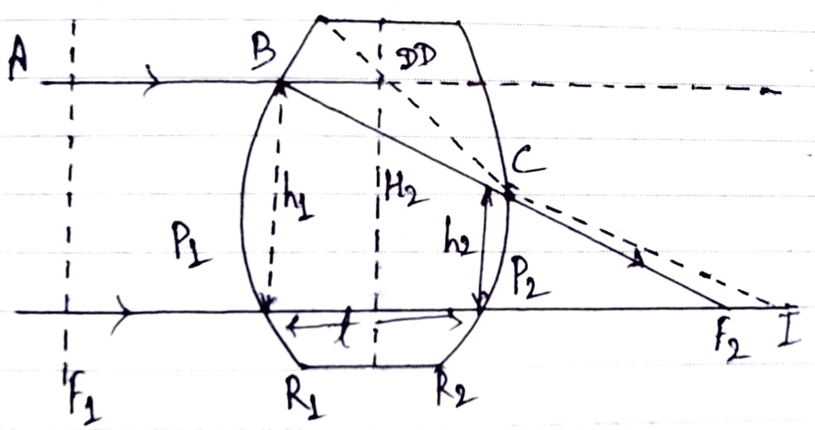
Thick lens formula :→

Let us consider a convex lens of thickness t and refracture under μ placed in air. Let R_1 and R_2 be the radii of curvature of the focus of the lens. the lens is a combination of two refrating surface with poles P_1 and P_2 as shown in fig.



Let a ray AB parallel to the principle axis be incident on the first surface at hight h_1 above the axis after refraction at the first surface it follows the path BC in the lens and meets the second surface at a height h_2 above the axis, this ray if produced forward would meet the axis at I. which serveres after refraction at the second surface, the emergent ray intersects the principle axis at F_2 which is the second focal point of the lens the incident ray AB produced forward and the emeregent ray CF_2 produced backward meet at D. the plane thought D and perpendicular to the axis is the second principle point. thus H_2F_2 is the focal length f of the lens.

Now, the formula for refraction at single surface is,

$$\frac{\mu}{v} - \frac{1}{u} = \frac{\mu - 1}{R}$$

Hence, for refraction at the first surface we have,

$u = \infty$, $V = P_1 I$ and $R = R_1$

$$\therefore \frac{\mu}{P_1 I} - \frac{1}{\infty} = \frac{\mu - 1}{R_1}$$

OR, $$\frac{1}{P_1 I} = \frac{\mu - 1}{\mu R_1} \quad \text{——— (1)}$$

For refraction at the second surface we have,

~~For~~ $u = P_2 I$, $V = P_2 F_2$ and $R = R_2$ and μ will be replaced by $1/\mu$.

$$\therefore \frac{1/\mu}{P_2 F_2} - \frac{1}{P_2 I} = \frac{1/\mu - 1}{R_2} = \frac{-\mu - 1}{\mu R_2}$$

or, $\frac{1}{\mu P_2 F_2} - \frac{1}{P_2 I} = \frac{-\mu - 1}{\mu R_2}$

$$\frac{1}{P_2 F_2} - \frac{\mu}{P_2 I} = \frac{-\mu - 1}{R_2}$$

$$\frac{1}{P_2 F_2} - \frac{\mu}{P_2 I} + \frac{1 - \mu}{R_2} \quad \text{———} \quad (ii)$$

or, from similar ΔDF_2H_2 and CF_2P_2.

And from similar ΔBIP_1 and CIP_2, we have,

$$\frac{H_2 F_2}{P_2 F_2} = \frac{h_1}{h_2} = \frac{P_1 I}{P_2 I}$$

$$\frac{1}{P_2 F_2} = \frac{1}{H_2 F_2} \cdot \frac{P_1 I}{P_2 I} = \frac{1}{f} \cdot \frac{P_1 I}{P_2 I}$$

——— (iii)

Substituting the value of $1/P_2F_2$ in equation ——(ii), we get,

$$\frac{1}{f} \cdot \frac{P_1 I}{P_2 I} = \frac{\mu}{P_2 I} + \frac{1-\mu}{R_2}$$

$$\frac{1}{f} = \frac{\mu}{P_1 I} + \frac{P_2 I}{P_1 I} \cdot \frac{1-\mu}{R_2}$$

But from the fig.

$$P_2 I = P_1 I - P_1 P_2 = P_1 I - t$$

$$\therefore \frac{1}{f} = \frac{\mu}{P_1 I} + \left(\frac{P_1 I - t}{P_1 I}\right)\left(\frac{1-\mu}{R_2}\right)$$

$$= \frac{\mu}{R_1 I} + \left(\frac{1-t}{P_1 I}\right)\left(\frac{1-\mu}{R_2}\right)$$

But from —— (1)

$$\frac{1}{P_1 I} = \frac{\mu - 1}{\mu R_1}$$

$$\therefore \frac{1}{f} = \mu\left(\frac{\mu-1}{\mu R_1}\right) + \left\{1 - t\left(\frac{\mu-1}{\mu R_1}\right)\left(\frac{1-\mu}{R_2}\right)\right\}$$

Notations

Wednesday

23

January
2013

Week 04
23rd Day

$$\frac{1}{f} = \frac{\mu - 1}{R_1} - \frac{\mu - 1}{R_2} + \frac{t(\mu - 1)^2}{\mu R_1 R_2}$$

$$\frac{1}{f} = (\mu - 1)\left\{\frac{1}{R_1} - \frac{1}{R_2} + \frac{t(\mu - 1)}{\mu R_1 \cdot R_2}\right\} \qquad \text{(IV)}$$

This is the required formula for a thick lens.

The — End