Pb #1.

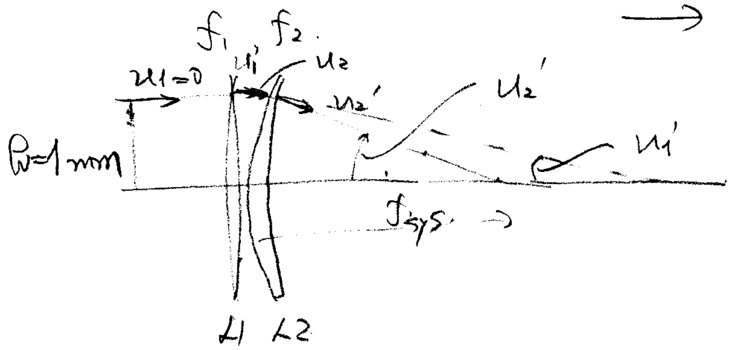
$P_1 = \frac{1}{100} \rightarrow f_1 = 100$ mm

$f_2 = 100$ mm

Thin lens in air

No spacing between L1 & L2.

$\longrightarrow$ Ray height = 1 for the two lenses.



Total power.

$$u_1' = u_1 - h\phi_1 = 0 - 1 \cdot \frac{1}{100} = -0.01$$

$$u_2' = u_2 - h\phi_2 = -0.01 - 1 \cdot \frac{1}{100} = -0.02$$

$$f_{sys} = \frac{h}{|u_2'|} = \frac{1}{0.02} = 50 \text{ mm}. \quad \text{O.K.}$$

Conjugate Factor for L1. $C = -1$.

$$B = -\frac{2(n^2-1)C}{n+2} \underset{\substack{n=1.59 \\ C=-1}}{=} 1.006 \simeq \boxed{1.}$$

Conjugate Factor for L2.

$$C = \frac{-0.01 + (-0.02)}{-0.01 - (-0.02)} = \frac{-0.03}{0.01} = -3.$$

$$B = -\frac{2(n^2-1)(-3)}{n+2} \doteqdot \boxed{1} \times 3 = 3.$$

R_1 & R_2 for Lens #2

$$\frac{R_1}{R_2} = \frac{B-1}{B+1} = \frac{3-1}{4} = \frac{2}{4} = \frac{1}{2}$$

$B = 3$ $\qquad \therefore R_2 = 2R_1$

$$\phi_{Lens\,2} = (n-1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right) = (n-1)\left(\frac{1}{R_1} - \frac{1}{2R_1}\right)$$

$$= (n-1)\left(\frac{1}{2R_1}\right) = 0.01$$

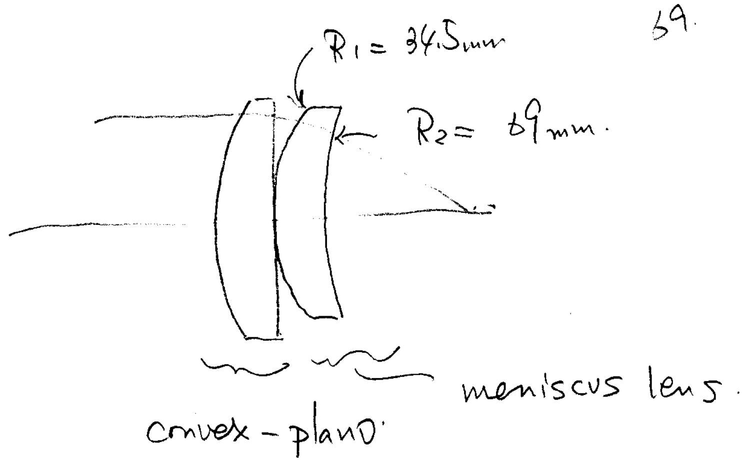
$$\therefore R_1 = \frac{n-1}{2\times 0.01} = \frac{1.69-1}{0.02} = \frac{0.69}{0.02}$$

$$\doteq 34.5\,\text{mm}$$

$$R_2 = 2R_1 = 69\,\text{mm}$$

check $\quad \phi_{Lens\,2} = (1.69-1)\left(\frac{1}{34.5} - \frac{1}{69}\right)$

$$= \frac{0.69\times 1}{69} = 0.01 \quad \text{o.k.}$$



1) Spherical Aberration and defocus.

2) $\varepsilon_y(y_p = 1) = 0 \rightarrow$ Marginal Focus.

3)

$$W = W_{020}\rho^2 + W_{040}\rho^4$$
$$= W_{020}(x_p^2 + y_p^2) + W_{040}(x_p^2 + y_p^2)^2$$

$$\varepsilon_y = -2(F/\#)\frac{\partial W}{\partial y_p} = -2(F/\#)(2W_{020}y_p + 4W_{040}y_p^3)$$

evaluate slope

$$\left.\frac{\partial \varepsilon_y}{\partial y_p}\right|_{y_p=0} = -4\underbrace{(F/\#)}_{=5}W_{020} = 80\mu m$$

$$W_{020} = -4\mu m$$

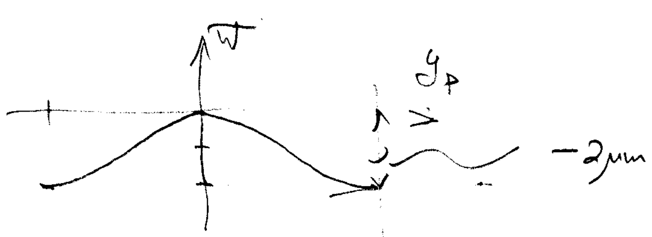
$$\varepsilon_y(y_p=1) = -2(F/\#)(2W_{020} + 4W_{040}) = 0$$

$$W_{040} = -\frac{1}{2}W_{020} = -\frac{1}{2}(-4\mu m)$$
$$= 2\mu m$$

$$W_{020} = -4\ [\mu m]$$
$$W_{040} = +2\ [\mu m]$$

$$W = -4y_p^2 + 2y_p^4 \underset{y_p^2 \overset{def}{=} Y}{=} -4Y + 2Y^2$$

$$\frac{\partial W}{\partial Y} = -4 + 4Y = 0 \Rightarrow \therefore Y = 1. \Rightarrow y_p = 1$$



Paraxial Focus, $\overline{W}_{020} = 0$

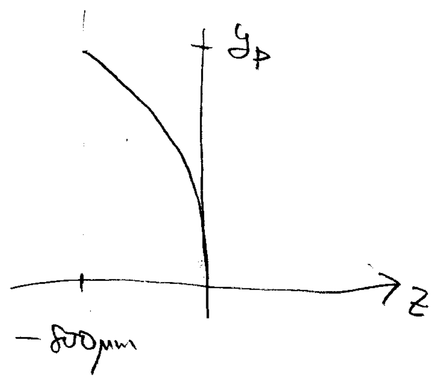
$$LA = + \frac{2(F/\#)}{y_p} TA$$

$$= \frac{2(F/\#)}{y_p} \left\{ -2(F/\#) \left(\qquad 4\overline{W}_{040}\, y_p^3 \right) \right\}$$

$$= -4(F/\#)^2 \left(\qquad + 4\overline{W}_{040}\, y_p^2 \right)$$

$$= -4\underbrace{(F/\#)^2}_{5^2=25} \left(\qquad + 8\, y_p^2 \right)$$

$$= -32(F/\#)^2 (y_p^2) \qquad -800\,(y_p^2)$$



at paraxial focus, $\quad \varepsilon_y = -2(F/\#)\ 8\overline{W}_{040}\, y_p^3$

$$= -2 \times 5 \times 4 \times 2\ y_p^3$$

$$= -80\, y_p^3$$

$\therefore \varnothing\ 160\mu m$

Extra

$$\varepsilon_y = -2(F/\#)\left(2W_{020}\,y_p + 4W_{040}\,y_p^3\right).$$

$$\frac{\partial \varepsilon_y}{\partial y_p} = -2(F/\#)\left(2W_{020} + 12W_{040}\,y_p^2\right) = 0$$

$$\therefore \quad y_p^2 = -\frac{2W_{020}}{12W_{040}} = +\frac{\cancel{2}(+4)}{12\cdot\cancel{2}} = \frac{1}{3}.$$

$$y_p = \frac{1}{\sqrt{3}} = \frac{\sqrt{3}}{3}\left(= \frac{1.73}{3} \simeq 0.57\right)$$

$$\varepsilon_y\Big|_{y_p=\frac{\sqrt{3}}{3}} = -2\underbrace{(F/\#)}_{=5}\left(2(-4)\cdot\underbrace{\frac{\sqrt{3}}{3}}_{0.577} + 4\cdot(2)\left(\frac{\sqrt{3}}{3}\right)^3\right)$$

$$\simeq 30.$$

$\therefore \quad \phi\ 60\mu m$

// from the diagram. $\phi \simeq 60\mu m$. //