2014 OPTI 340. Midterm #1.

Solutions. (ver 2).

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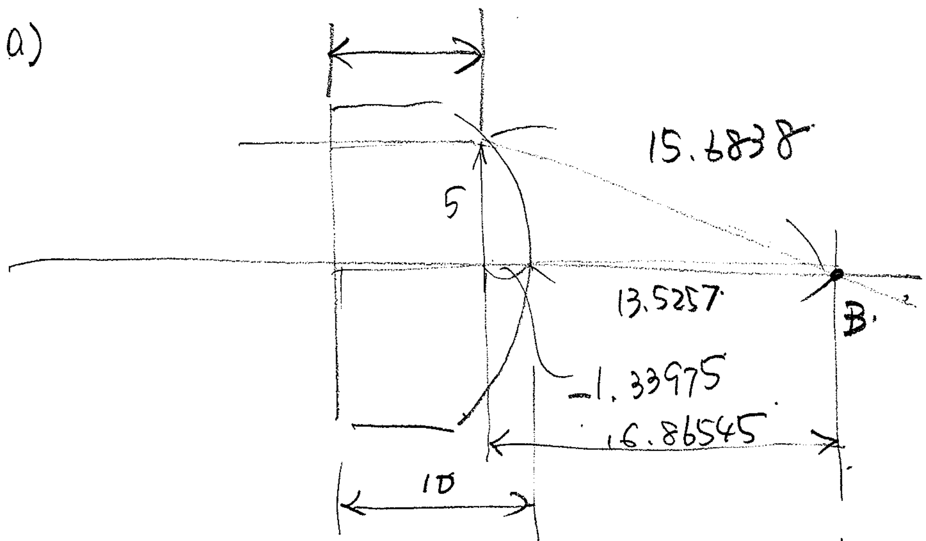
Pb 1 ①

$10 - 1.33975 = 8.66025$

a)



$1.5 \times 8.66025 + 15.6838$
$= 28.6761$
OPL along marginal ray

on-axis

$1.5 \times 10 + 13.5257$
$= 28.5257$
OPL along chief ray

b)

c) Does hold

d) Aberration exists. Therefore object at -Inf and the point B (marginal focal point) does not satisfy perfect imaging condition.

or

c) Does Not hold in the sense of stational OPL for perfect imaging system

d) Aberration exist.

I graded c) & d) based on the logic student want to show. (Y.T.)

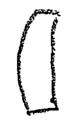
Pb 2.

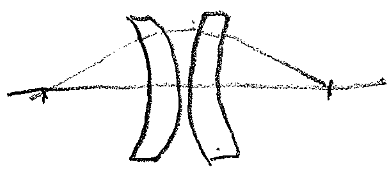
1. 10 mm. (from symmetry of the system).

2. $C1 = +1$. $C2 = -1$.

3. $$B_1 = -\frac{2\cdot(2^2-1)(+1)}{2+2} = -\frac{2\cdot 3\cdot 1}{4} = -1.5$$

$$B_2 = -\frac{2(2^2-1)(-1)}{2+2} = -\frac{2\cdot 3\cdot(-1)}{4} = +1.5$$



4. 

5. Two element design.

$$S_{I_{\text{element 1}}} = S_{I_{\text{element 2}}} = \frac{h^4\left(\frac{\phi}{2}\right)^3}{4}\left\{\frac{2^2}{(2-1)^2} - \frac{2(+1)^2}{2+2}\right\}$$

$$= \frac{h^4\left(\frac{\phi}{2}\right)^3}{4}\left\{4 - \frac{1}{2}\right\}$$

$$= \frac{h^4\phi^3}{32}\cdot\frac{7}{2} = \frac{7}{64}h^4\phi^3.$$

$$\therefore S_{total} = 2\times\frac{7}{64}h^4\phi^3 = \frac{7}{32}h^4\phi^3$$

$$S_{thick} \underset{C=0}{=} \frac{h^4\phi^3}{4}\left\{\frac{2^2}{(2-1)^2}\right\} = h^4\phi^3$$

For S_{thick} is minimized

$$\therefore \frac{S_{I\_2\,element}}{S_{I\_1\,element}} = \frac{7}{32}$$

(3)

Problem 3.

$$\varepsilon_y = -8(F/\#)\overline{W}_{040}\, y_p^3 - 12(F/\#)\overline{W}_{060}\, y_p^5$$

$$\varepsilon_y(y_p = 1) = -8(F/\#)\overline{W}_{040} - 12(F/\#)\overline{W}_{060} \underset{\uparrow}{=} 0$$

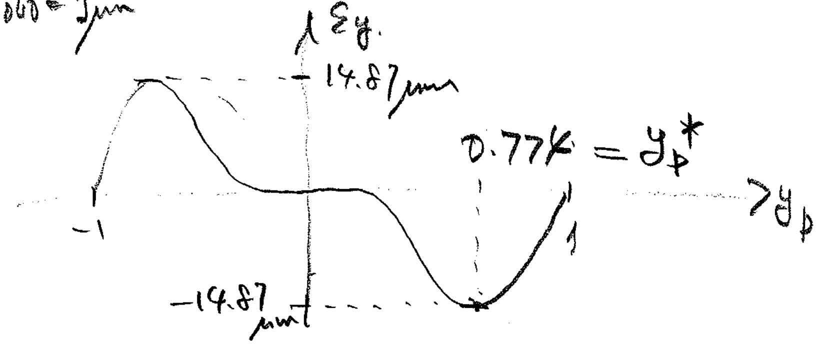
Full correction

$$\therefore \overline{W}_{060} = -\frac{2}{3}\overline{W}_{040}$$

$$\therefore \varepsilon_y = -8(F/\#)\overline{W}_{040}\, y_p^3 + 8(F/\#)\overline{W}_{040}\, y_p^5$$

$$= -80\, y_p^3 + 80\, y_p^5 \quad [\mu m]$$

$F/\# = 10$
$W_{040} = 1\mu m$



$$\frac{\partial \varepsilon_y}{\partial y_p} = 0 \rightarrow -3y_p^2 + 5y_p^4 = 0$$

$$y_p^2(-3 + 5y_p^2) = 0$$

$$y_p^2 = \frac{3}{5} \quad \therefore y_p = \sqrt{0.6} = 0.774$$

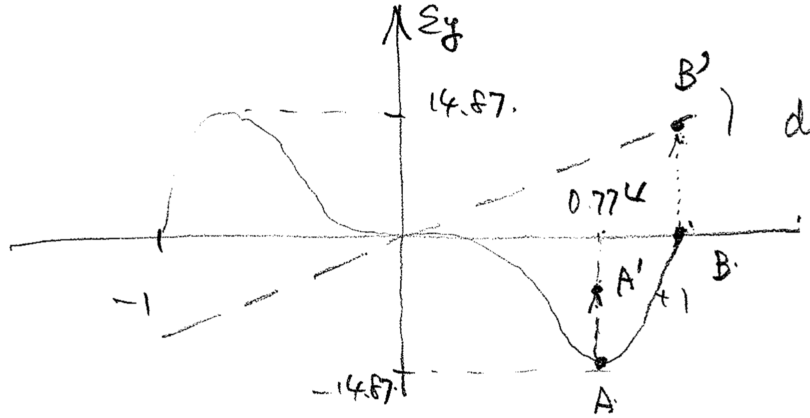
$$\varepsilon_y(y_p = y_p^* = 0.774) = -80\Big(\underbrace{\sqrt{\tfrac{3}{5}}^{\,3} - \sqrt{\tfrac{3}{5}}^{\,5}}_{0.1859}\Big)$$

$$= -14.87\ \mu m$$

Spot extent $\therefore$ 29.74 μm

④

$$\varepsilon_y = -4(F/\#)\overline{W}_{020}y_p - 8(F/\#)\overline{W}_{040}y_p^3 + 8(F/\#)\overline{W}_{060}y_p^5$$



Consider point B & B'

B' $\quad \varepsilon_y (y_p = 1) = -4(F/\#)\overline{W}_{020} = -40\overline{W}_{020}$

A' $\quad \varepsilon_y (y_p = y_p^* = 0.774) = -4 \times 10\,\overline{W}_{020}(0.774) \underbrace{-80(y_p^3 - y_p^5)\Big|_{y_p = y_p^*}}_{= -14.87}$

minimum blur condition.

$$-40\overline{W}_{020} = -(-40\overline{W}_{020} \times 0.774 - 14.87)$$

$$= 30.96\,\overline{W}_{020} + 14.87$$

$$\therefore -70.96\,\overline{W}_{020} = 14.87$$

$$\overline{W}_{020} = \underline{-0.2095} \quad [\mu m].$$

$$\delta z = 8(F/\#)^2\,\overline{W}_{020}$$

$$= 8 \times 100 \times (\underset{\mu m}{-0.2095}) = -167.64\,\mu m.$$

point B' : $-40\overline{W}_{020} = -40(-0.2095) = 8.38$

spot extent $\therefore$ $\underline{16.76\,\mu m}$