Ministry of Higher Education & Scientific Research
University of Technology
Laser & Optoelectronic Eng. Department
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Final Examination
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Attempt Five questions

Q1- For convex-plano thin lens if you have λ=0.6 µm, n= 1.45 , the lens thickness (t)= 1.38 cm and the paraxial ray tracing results are, shown in table,1 while for principle ray the results is shown in table 2, where C_1=0.0445 cm^{-1} , C_2=0.0

	Table-1			Table-2		
Surface	y	u	u'	y	u	u'
1	0	00.087489	0.06006	4	0	-0.05592
2	0.0828	0.060006	0.0874	3.922774	-0.05592	-0.081531

Calculate astigmatisim coefficient for thin lens?

where; shape factor X=0, Magnification factor Y=1, c=4.3186, d=8.6141, EFL=400.66 mm.

(10 degree)

Q2/ Find aprocedure which can be used to minimize the structural aberration coefficient for coma σ_{II}?

(10 degree)

Q3/ Write the constraint equations for apochromatic lens? Calculate the thin lens powers for a 400-mm EFL apochromatic using the glasses (with the properties) listed in table (3) and ΔPij listed in table 4, then determine the curvatures of these lenses (assume the negative lens between the positive lenses)?

Table .3					
	Vender	Glass	vd	Pdc	Nd
1	SCHOTT	SSKN5	50.88	0.30294	1.658477
2	OHERA	FPL53	94.97	0.308158	1.438763
3	SCHOTT	BAK1	57.55	0.304724	1.572529

Table 4	
ΔP32	-0.003434
ΔP13	-0.002630
ΔP21	+0.006064

(10 degree)

Q4/ For thin lens if you have λ=0.6 µm, n= 1.4 , the lens thickness (t)= 1.3 cm and the paraxial ray tracing results are, $Ø_1$=.020308 cm^{-1} , $Ø_2$=0.0

surface	y	u	u'
1	0	0.087	0.06
2	0.08	0.06	-0.087

Calculate coma W_{131} via Seidel aberration for thin lens?

(10 degree)

Q5/ Define the following;

Stop, Entrance pupi diameter, Conic , Shap factor, Abbe number, Dispersion, merit function, Back focal length, Petzval radius, Airy disc? **(10 degree)**

Q6/ Write the equation represent the wave aberrations in polar and Cartesian corodinates?

(10 degree)

good luck

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Q1/

For thin lens formula for astigmatism is given by:

$$W_{222} = \frac{1}{2}S_{III} = \frac{1}{2}[L^2\phi\,\sigma_{III}]$$

The Lagrange invariant (Section 5.6) is given by:

$$L = n[\bar{u}y - u\bar{y}] = \bar{u}y = 0.349955$$

And since σiii=1 for astigmatisim

$$S_{III} = (0.349955)^2(0.020383)\cdot 1$$

$$S_{III} = 0.002496 \text{ cm}$$

The wavefront aberration coefficient is given by:

$$W_{222} = 0.001248 \text{ cm}$$

$$W_{222} = 20.76\,\lambda$$

Q2/

erration. A similar procedure can be used with the structural aberration coefficient for coma, σ_{II}. Figure 13.7 shows a generic plot for σ_{II}. It is a linear function described by:

$$\sigma_{II} = eX - fY \tag{13.11}$$

At the point where this plot crosses the abscissa, $\sigma_{II} = 0$. Therefore:

$$X = \left(\frac{f}{e}\right)Y \tag{13.12}$$

For an object at infinity, $X = (f/e)$. For an object at unit magnification, $X = 0$.

Consider a BK7 singlet with an object at infinity. Operating in d light, $n = 1.5168$. Consequently, $e = 3.2107$ and $f = 2.6593$. Inserting these values into Equation 13.12:

$$X = 0.8283$$

Recall from Section 11.3 that the shape factor for minimum spherical was $X = 0.7397$, which is not far from that for coma.

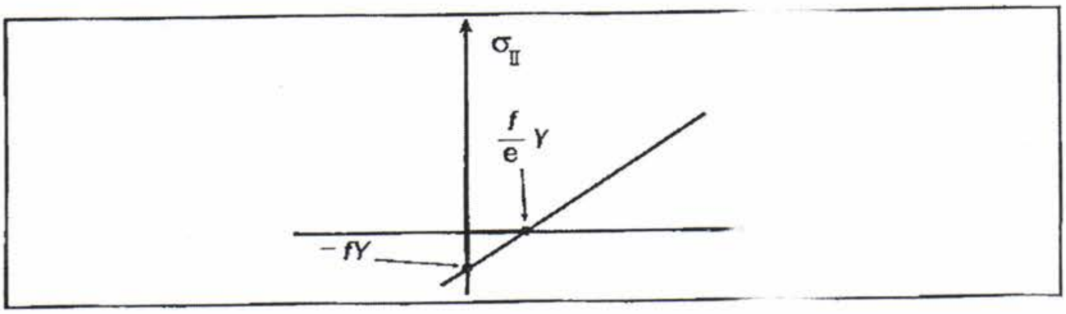

Fig. 13.7 *Generic plot of* σ_{II}.

Q3/

The thin lens *apochromat*, on the other hand, has three constraining [illegible] ns:

$$\left.\begin{aligned} \phi_1 + \phi_2 + \phi_3 &= \phi \\ \left(\frac{1}{V_1}\right)\phi_1 + \left(\frac{1}{V_2}\right)\phi_2 + \left(\frac{1}{V_3}\right)\phi_3 &= 0 \\ \left(\frac{P_1}{V_1}\right)\phi_1 + \left(\frac{P_2}{V_2}\right)\phi_2 + \left(\frac{P_3}{V_3}\right)\phi_3 &= 0 \end{aligned}\right\} \tag{21.2}$$

The first constraint is on power. The second constraint is on pr[illegible]y color,

$$D = \begin{vmatrix} 1 & 1 & 1 \\ \frac{1}{V_1} & \frac{1}{V_2} & \frac{1}{V_3} \\ \frac{P_1}{V_1} & \frac{P_2}{V_2} & \frac{P_3}{V_3} \end{vmatrix}$$

which reduces to:

$$D_1 = \left[\frac{\Delta P_{32}}{v_2 v_3}\right]\phi$$

The second determinant is:

$$D_2 = \begin{vmatrix} 1 & \phi & 1 \\ \frac{1}{v_1} & 0 & \frac{1}{v_3} \\ \frac{P_1}{v_1} & 0 & \frac{P_3}{v_3} \end{vmatrix}$$

which becomes:

$$D_2 = \left[\frac{\Delta P_{13}}{v_1 v_3}\right]\phi$$

The last determinant is given by:

$$D_3 = \begin{vmatrix} 1 & 1 & \phi \\ \frac{1}{v_1} & \frac{1}{v_2} & 0 \\ \frac{P_1}{v_1} & \frac{P_2}{v_2} & 0 \end{vmatrix}$$

and this becomes:

$$D_3 = \left[\frac{\Delta P_{21}}{v_2 v_1}\right]\phi$$

The power of the first element, ϕ_1 is given by:

$$\phi_1 = \frac{D_1}{D} = \frac{\left[\frac{\Delta P_{32}}{v_2 v_3}\right]\phi}{\frac{\Delta P_{32}}{v_2 v_3} + \frac{\Delta P_{13}}{v_1 v_3} + \frac{\Delta P_{21}}{v_1 v_2}}$$

$$\phi_1 = \frac{\Delta P_{32}\ \phi}{\Delta P_{32} + \frac{\Delta P_{13}\ v_2}{v_1} + \frac{\Delta P_{21}\ v_3}{v_1}}$$

Multiply the denominator by v_1 / v_1. ϕ_1 which then becomes:

$$D = \left(\frac{P_3}{v_2 v_3} - \frac{P_2}{v_3 v_2}\right) - \left(\frac{P_3}{v_1 v_3} - \frac{P_1}{v_3 v_1}\right) + \left(\frac{P_2}{v_1 v_2} - \frac{P_1}{v_2 v_1}\right)$$

$$D = \frac{\Delta P_{32}}{v_2 v_3} + \frac{\Delta P_{13}}{v_1 v_3} + \frac{\Delta P_{21}}{v_1 v_2} \qquad (21.$$

There are three more determinants that need to be generated. The first is:

$$D_1 = \begin{vmatrix} \phi & 1 & 1 \\ 0 & \frac{1}{v_2} & \frac{1}{v_3} \\ 0 & \frac{P_2}{v_2} & \frac{P_3}{v_3} \end{vmatrix} \qquad (21.$$

$$\phi_1 = \frac{v_1 \Delta P_{32} \phi}{v_1 \Delta P_{32} + v_2 \Delta P_{13} + v_3 \Delta P_{21}} \qquad .13)$$

$$\phi_2 = \frac{\nu_2 \Delta P_{13} \phi}{\nu_1 \Delta P_{32} + \nu_2 \Delta P_{13} + \nu_3 \Delta P_{21}}$$

$$\phi_3 = \frac{\nu_3 \Delta P_{21} \phi}{\nu_1 \Delta P_{32} + \nu_2 \Delta P_{13} + \nu_3 \Delta P_{21}}$$

Substituting in the Table values, the denominator in Eq[illegible]21.13 is fou[illegible] to be:

$$\nu_1 \Delta P_{32} + \nu_2 \Delta P_{13} + \nu_3 \Delta P_{21} = -0.174722 - 0.249771 + 0.34[illegible]3 = -0.075[illegible]$$

Inserting into Equation 21.13:

$$\phi_1 = \frac{\nu_1 \Delta P_{32} \phi}{-0.07551} = \frac{-0.0004368}{-0.07551}$$

Therefore:

$$\phi_1 = 0.005785 \text{ or } f_1 = 172.869 \text{ mm}$$

Following the same procedure for Equations 21.14 and 21.1[illegible]

$$\phi_2 = 0.008269 \text{ or } f_2 = 120.927 \text{ mm}$$

$$\phi_3 = -0.011554 \text{ or } f_3 = -86.548 \text{ mm}$$