

f/5.6 Photographic Objective

Total Field 45° ($\bar{u} = \tan 22.5$ in object space)

$$f/\# = f_e / d_{ep} = 5.6$$

$$\bar{u} = .4142$$

a) Locate entrance and exit pupils.

Trace preliminary chief ray -

arbitrary ray through center of stop.

(u at stop = .300 ← arbitrary)

Pupil Locations:

$$EP \rightarrow V_1 = -2.317$$

2.317 to the right of surface 1

$$V_8 \rightarrow XP = -1.019$$

1.019 to the left of surface 8

Preliminary ray: $u = .2380$ in object space

scale by $.4142 / .2380 = \underline{1.740}$ to get Chief Ray

Divide by n_i to get Chief Ray angles.

YNU Method

Entrance Pupil 0 1 2 3 4 5 6 7 8 9 Exit Pupil

C	.30845	-.01725	-.17094	.36219	-	-.01725	.38197	-.23607	
t	?	.599	.655	.288	.455	.200	.215	.879	?
n	1.000	1.6202	1.000	1.5785	1.000	1.000	1.5315	1.6202	1.000

ϕ	-.19130	-.01070	.09889	.20953	0.000	.00917	-.03388	-.14641	
t/n	<u>(-2.317)</u>	.3697	.655	.1825	.455	.200	.1404	.5425	<u>(-1.019)</u>

Preliminary Chief Ray

y	0	-.5515	-.4245	-.1965	-.1365	0	.0600	.1022	.2634	0
nu	.2380	.3435	.3480	.3286	.300*	.300*	.3006	.2971	.2585	
u										

Chief Ray - scale by 1.740

\bar{y}	0	-.9598	-.7388	-.3420	-.2376	0	.1044	.1779	.4584	0
\bar{nu}	.4142	.5978	.6057	.5718	.5221	.5221	.5232	.5171	.4499	
\bar{u}	.4142	.3690	.6057	.3622	.5221	.5221	.3416	.3192	.4499	

y										
nu										
u										

* arbitrary

b) Determine BFD and f_e

Trace a ray from infinity at a height = 1.

$$V_8 \rightarrow F' = 8.198$$

$$\text{BFD} = 8.198$$

$$f'_R = f_e = -1/u' \quad u' = -.0999$$

$$f'_R = f_e = 10.01$$

$$d' = s' = \text{BFD} - f'_R = -1.812$$

(in front of surface 8)

c) Determine the Lagrange invariant and the stop and pupil diameters.

$$\text{From } f/\# : \quad d_{ep} = f_e / S.6 = 1.788$$

$$\text{Entrance Pupil Radius} = .894$$

At entrance pupil:

$$\bar{u} = .4142 \quad \bar{y} = 0$$

$$y = r_{ep} = .894 \quad n = 1.00$$

$$W = n \bar{u} y = .370$$

Stop:

$$\bar{u} = .5221$$

$$n = 1.000$$

$$\rightarrow y = .709$$

$$d_{stop} = 1.417$$

Exit Pupil:

$$\bar{u} = .4499$$

$$n = 1.000$$

$$\rightarrow y = .822$$

$$d_{xp} = 1.645$$

Can also be determined from marginal ray scaled to r_{ep} .

d) Determine the cardinal points and PP'.

Trace a reverse ray from infinity.

$$F \rightarrow V_1 = 8.555$$

$$FFD = -8.555$$

$$f_F = -1/u$$

$$u = .0999$$

$$f_F = -10.01$$

$$f_e = -f_F = 10.01 \quad (\text{as before})$$

$$d = \delta = FFD - f_F = 1.455$$

(P is to the right of surface 1)

$$\text{Lens thickness} = \sum x_i = 3.291$$

$$PP' = 3.291 - \delta + \delta' = .024$$

Nodal Points et Principal Planes.

e) Draw the system to scale showing the marginal and chief rays, pupils and cardinal points.

The marginal and chief rays have already been traced.

For an object at infinity -

$$\begin{aligned} \bar{y} \text{ at } F' &= n\bar{u} \cdot BFD + \bar{y}_8 \\ &= .4499 (8.198) + .4584 \end{aligned}$$

$$\bar{y} (F') = 4.1$$

Image Height

Summary

$$f_e = f'_R = 10.01$$

$$\phi = .0999$$

$$f_F = -10.01$$

$$d = \delta = 1.455$$

$$PP' = .024$$

$$d' = \delta' = -1.812$$

$$BFD = 8.198$$

$$FFD = -8.555$$

Entrance Pupil : 2.317 to the right of ①

Exit Pupil : 1.019 to the left of ②

$$M = .370$$

$$d_{\text{stop}} = 1.417$$

$$d_{\text{ep}} = 1.788$$

$$d_{\text{xp}} = 1.645$$

