Telecentric Petzval Lens

A Petzval objective is comprised of two thin lenses separated by 75 mm. The two thin lenses have the same focal length, and the effective focal length of the system is 100 mm. The system is telecentric in image space, and the object is located 250 mm to the left of the first lens. The stop diameter is 20 mm, and the object height is 20 mm. Determine the focal lengths of the thin lenses, the stop position, and the required diameters of the two lenses for the system to be unvignetted.

Solution:

\[ f_1 = f_2 \quad f = 100\text{mm} \quad t = 75\text{mm} \]

Object: 250mm to the left of L1, \( h = 20\text{mm} \)

First, design the Petzval Lens (\( P' \) between the elements):

\[ \phi = \frac{1}{f} = 0.01/\text{mm} = \phi_1 + \phi_2 - \phi_1\phi_2t \]

\[ \phi_1 = \phi_2 \quad t = 75 \]

\[ 0.01/\text{mm} = 2\phi_1 - 75\phi_1^2 \]

\[ \phi_1 = 0.02/\text{mm} \quad \text{or} \quad \phi_1 = 0.00667/\text{mm} \]

\[ f_1 = 50\text{mm} \quad \text{or} \quad f_1 = 150\text{mm} \]

But \( f_1 \) must be greater than \( t \) for a Petzval

\[ f_1 = f_2 = 150\text{mm} \]

Locate \( P' \):

\[ d = \frac{\phi_1}{\phi}t = 50\text{mm} \quad (\text{to the right of Lens 1}) \]
Locate F:

\[ FFD = f_F + d = -f + d \]

\[ FFD = -50\text{mm} \] (to the left of Lens 1)

To be telecentric in image space the stop is located at F. The stop must be located 50 mm to the left of the first element.

For aperture sizes, trace marginal and chief rays. The stop diameter is 20 mm.

Note: \( \bar{u} \) in image space is zero \( \rightarrow \) telecentric

The image size and location are not required

No vignetting: \( a_i \geq |y_i| + |\bar{y}_i| \)

L1: \( a_1 \geq |12.5| + |-5.0| = 17.5\text{mm} \)

\[ D_1 = 35\text{mm} \]

L2: \( a_2 \geq |10.0| + |-10.0| = 20.0\text{mm} \)

\[ D_2 = 40\text{mm} \]
Ray bundles for the unvignetted system: