Thick Lens – Varying Index

A thick lens in air has the following specifications:

\[ R_1 = 127 \, \text{mm} \]
\[ R_2 = -77 \, \text{mm} \]
\[ TH = 17 \, \text{mm} \]
\[ n = 1.472 \]

a) What is the focal length and power of this lens? Where is the image of an object at infinity located with respect to the rear vertex of the lens (the back focal distance)?

b) What are the focal length, power and back focal distance if the index of the lens is changed to 1.853?

c) What are the rear focal length, focal length, power and back focal distance if the original lens (\( n = 1.472 \)) is immersed in water (\( n = 1.333 \))?

Use Gaussian reduction for this problem.

Solution

\[ R_1 = 127 \, \text{mm} \]
\[ R_2 = -77 \, \text{mm} \]
\[ TH = 17 \, \text{mm} \]

\[ \frac{n_2 - n_1}{R_1} \quad \frac{n_3 - n_2}{R_2} \]

\[ \phi_1 = \frac{n_2 - n_1}{R_1} \quad \phi_2 = \frac{n_3 - n_2}{R_2} \]
(a) \hspace{2cm} (b) \hspace{2cm} (c)

\begin{align*}
n_1 &= 1.0 & n_1 &= 1.0 & n_1 &= 1.333 \\
n_2 &= 1.472 & n_2 &= 1.853 & n_2 &= 1.472 \\
n_3 &= 1.0 & n_3 &= 1.0 & n_3 &= 1.333 \\
\phi_1 &= 0.00372/mm & \phi_1 &= 0.00672/mm & \phi_1 &= 0.00109/mm \\
\phi_2 &= 0.00613/mm & \phi_2 &= 0.01108/mm & \phi_2 &= 0.00181/mm \\
\phi &= \phi_1 + \phi_2 - \phi_1\phi_2 & \tau &= \frac{TH}{n_2} \\
\phi &= 0.00958/mm & \phi &= 0.01711/mm & \phi &= 0.00288/mm \\
f &= 104mm & f &= 58.4mm & f &= 348mm \\
\delta' &= -\frac{\phi}{\phi}\tau & d' &= n_3\delta' \\
\delta' &= -4.48mm & \delta' &= -3.60mm & \delta' &= -4.37mm \\
d' &= -4.48mm & d' &= -3.60mm & d' &= -5.83mm \\
BFD &= f_R' + d' & f_R' &= n_3f \\
f_R' &= 104mm & f_R' &= 58.4mm & f_R' &= 463mm \\
BFD &= 99.5mm & BFD &= 54.8mm & BFD &= 457mm
\end{align*}