Homework 6 Solutions

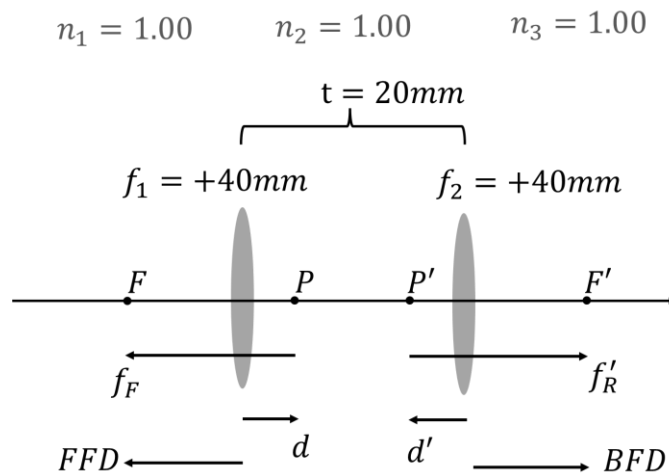## 1.   Two Positive Lens Configuration

Find the location of the planes P, P', F, F' in addition to the BFD and FFD for a two positive lens configuration. You must use Gaussian reduction.

$$f\_1=+40mm$$

$$f\_2=+40mm$$

$$t=20mm$$

Assume this configuration is in air with $n = 1.00$.

$$n_1 = 1.00 \qquad n_2 = 1.00 \qquad n_3 = 1.00$$

$$t = 20mm$$

$$f_1 = +40mm \qquad\qquad f_2 = +40mm$$

$$\varphi = \varphi_1 + \varphi_2 - \varphi_1\varphi_2\tau$$

$$\varphi = \frac{1}{+40mm} + \frac{1}{+40mm} - \frac{1}{+40mm}\cdot\frac{1}{+40mm}\cdot 20mm = 0.0375\ mm^{-1}$$
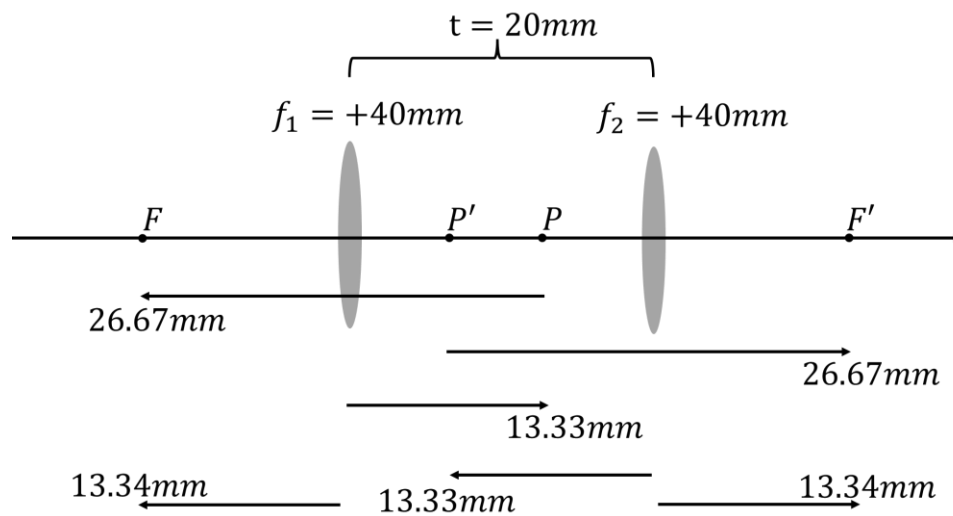
$$f_E = \frac{1}{0.0375mm^{-1}} = 26.67mm$$

$$f_F = -f_E = -26.67mm$$

$$f_R' = +f_E = 26.67mm$$

$$d = n\delta = +n\frac{\varphi_2}{\varphi}\frac{t}{n} = +\frac{\varphi_2}{\varphi}t = 13.33mm$$

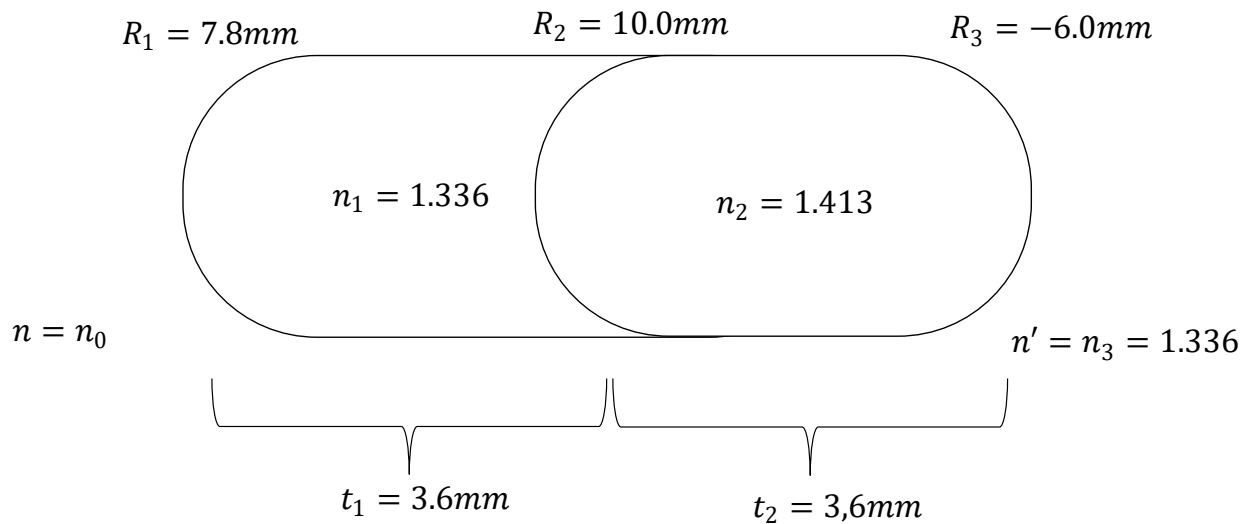$$d' = n\delta' = -n\frac{\varphi_1}{\varphi}\cdot\frac{t}{n} = -\frac{\varphi_1}{\varphi}\cdot t = -13.33mm$$

$$FFD = f_F + d = 13.34mm$$

$$BFD = f_R' + d' = 13.34mm$$

2.   Eye Model

Using Gaussian reduction, determine the Gaussian properties (position of P and P' planes from

vertices 1 and 3; F, F', N and N' planes from the P, P' planes) of an eye model. If the front of the

eye is in air ($n = 1.00$).

$R_1 = 7.8mm$ $R_2 = 10.0mm$ $R_3 = -6.0mm$

$n_1 = 1.336$ $n_2 = 1.413$

$n = n_0$ $n' = n_3 = 1.336$

$t_1 = 3.6mm$ $t_2 = 3,6mm$

$$\varphi_{\mathrm{n}} = (n_{\mathrm{n}} - n_{\mathrm{n}-1}) \cdot \frac{1}{R_{\mathrm{n}}} = \frac{(n_{\mathrm{n}} - n_{\mathrm{n}-1})}{R_n}$$

$$\tau_n = \frac{t_n}{n_n}$$

$\varphi_1 = \dfrac{(1.336 - 1.00)}{7.8mm}$	$\varphi_2 = \dfrac{(1.413 - 1.336)}{10.0mm}$	$\varphi_3 = \dfrac{(1.336 - 1.413)}{-6.0mm}$
$= 0.04308 \ mm^{-1}$	$= 0.00770 \ mm^{-1}$	$= 0.01283 \ mm^{-1}$

$\tau_1 = \dfrac{t_1}{n_1} = \dfrac{3.6mm}{1.336}$	$\tau_2 = \dfrac{t_2}{n_2} = \dfrac{3.6mm}{1.413}$
$= 2.695 \ mm$	$= 2.548 \ mm$

Combining first two surfaces

$$\varphi_{12} = \varphi_1 + \varphi_2 - \varphi_1 \cdot \varphi_2 \cdot \tau_1 = 0.04988 mm^{-1}$$

$$\delta_{12} = V_1 P_{12} = \frac{\varphi_2}{\varphi_{12}} \tau_1 = 0.4159\ mm$$

$$\delta'_{12} = V_2 P'_{12} = -\frac{\varphi_1}{\varphi_{12}} \tau_1 = -2.327\ mm$$

Reduced distance from P'_{12} to V_3

$$\tau_{12-3} = P'_{12} V_3 = \tau_2 - \delta'_{12} = 4.875\ mm$$

$\varphi_{12} = 0.04988 mm^{-1}$	$\varphi_3 = 0.01283\ mm^{-1}$
$\tau_{12-3} = P'_{12} V_3 = \tau_2 - \delta'_{12} = 4.875\ mm$	

Adding surface 3

$$\varphi = \varphi_{12} + \varphi_3 - \varphi_{12} \cdot \varphi_3 \cdot \tau_{12-3}$$

$$\varphi = 0.05960\ mm^{-1}$$

$$f_E = \frac{1}{\varphi} = 16.78\ mm$$

$$f_F = -n_0 f_E = -16.78\ mm$$

$$f'_R = n_3 f_E = 22.41\ mm$$

$$\delta_{12-3} = P_{12} P = \frac{\varphi_3}{\varphi} \cdot \tau_{12-3} = 1.050 mm$$

$$\delta'_{12-3} = V_3 P' = -\frac{\varphi_{12}}{\varphi} \cdot \tau_{12-3} = -4.080\ mm$$

$$d = n_0 \delta = V_1 P = V_1 P_{12} + P_{12} P = 0.4159 + 1.050 = 1.4657\ mm$$

$$d' = n_3 \delta' = n_3 (V_3 P') = n_3 \delta'_{12-3} = -5.451 mm$$

$$PN = f'_R + f_F = 22.41 - 16.78 = 5.64 mm$$

$P'N' = PN = 5.64mm$

$FFD = f_F + d = -16.78 + 1.47 = 15.31mm$

$BFD = f'_R + d' = 22.41 - 5.45 = 16.96mm$

$PP' = 3.6 + 3.6 - 1.47 - 5.45 = 0.28$