Dr. Bob

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1. The angle of reflection for spherical mirrors is the same for all colors of light with the same incident angle.

   $\Rightarrow$ No chromatic aberration

   The angle of refraction for lenses will be different for different colors of light even if they have the same angle of incidence. This leads to chromatic aberration.

2. 

$$f = 10\,cm$$
$$n = 1.50$$
$$R_1 = \infty$$
$$R_2 = ?$$

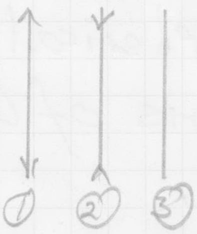
$$\frac{1}{f} = (n-1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right) \quad \left(\frac{1}{R_1} \to 0\right)$$

$$\frac{1}{f} = \frac{-(n-1)}{R_2} = \frac{1-n}{R_2}$$

$$R_2 = f(1-n) = 10\,cm(1-1.50)$$

$$\boxed{R_2 = -5.0\,cm}$$

3. $f_{tot} = 40cm$



$f_1 = 20cm$

$f_2 = -10cm$

$P = \frac{1}{f}$ $P = P_1 + P_2 + P_3$

$$\frac{1}{f_{tot}} = \frac{1}{f_1} + \frac{1}{f_2} + \frac{1}{f_3}$$

$$f_3 = \left(\frac{1}{f_{tot}} - \frac{1}{f_1} - \frac{1}{f_2}\right)^{-1}$$

$$= \left(\frac{1}{40cm} - \frac{1}{20cm} + \frac{1}{10cm}\right)^{-1}$$

$f_3 = 13\,cm$

Converging lens

4.

Planconvex $R_1 \to \infty$

So $\frac{1}{R_1} \to 0$

$$\frac{1}{f} = (n-1)\left(0 - \frac{1}{R_2}\right) = \frac{1-n}{R_2}$$

$$\frac{1}{f} = \frac{1-n}{R_2}$$

Because when $R_1 \to 0$, $\frac{1}{R_1} \to 0$.

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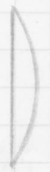
5.



$\frac{1}{R_1} = 0$ $R_2 = -25cm$

$n_b = 1.523$ blue

$n_r = 1.514$

from problem 4

$$f = \frac{R_2}{1-n}$$

a) Blue: $f_b = \frac{-25cm}{1-1.523} = 47.80cm$

Red: $f_r = \frac{-25cm}{1-1.514} = 48.64 cm$

Difference $f_r - f_b = 48.64cm - 47.80cm$

$f_r - f_b = 0.84cm$

b) This phenomenon is called chromatic aberration.

6.

$R_1 = -10cm$ $f = -35cm$

$R_2 = -22cm$

$$\frac{1}{f} = (n-1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

$$\frac{1}{f}\left(\frac{1}{R_1} - \frac{1}{R_2}\right)^{-1} = n-1$$

$n = 1.52$

$$n = \frac{1}{f}\left(\frac{1}{R_1} - \frac{1}{R_2}\right)^{-1} + 1 = \frac{1}{-35cm}\left(\frac{1}{-10cm} + \frac{1}{22cm}\right)^{-1} + 1$$

7. $R = 15\text{ cm}$

a) The optical power will be zero. The effects of the two lenses cancel each other. You can see this by looking at the shape of the two lenses together. They form a rectangular block with parallel front & back faces.

b). From problem 5 $n_1 = 1.50$

1st lens. $f_1 = \frac{R_2}{1-n_1} = \frac{-15\text{ cm}}{1-1.50}$ $R_2 = -15\text{ cm}$

$$f_1 = 30\text{ cm} = 0.30\text{ m}$$

$R_2 = 15\text{ cm}$

2nd lens $f_2 = \frac{R_2}{1-n_2} = \frac{15\text{ cm}}{1-1.52}$

English crystal = Crown glass

$n_2 = 1.52$

$$f_2 = -28.85\text{ cm} = -0.2885\text{ m}$$

$$P = \frac{1}{f_1} + \frac{1}{f_2} = \frac{1}{0.30\text{ m}} - \frac{1}{0.2885\text{ m}}$$

$$\boxed{P = -0.13\ \delta}$$

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8. $h_o = 5\,mm$ $d_o = 10\,cm = 0.10\,m$

$P = 5\,\delta$

$$f = \frac{1}{P} = \frac{1}{5\,m^{-1}} = 0.20\,m$$

a) $$d_i = \left(\frac{1}{f} - \frac{1}{d_i}\right)^{-1} = \left(\frac{1}{0.20\,m} - \frac{1}{0.10\,m}\right)^{-1}$$

$$d_i = -0.20\,m$$

b) $$M = \frac{-d_i}{d_o} = \frac{-(-0.20\,m)}{0.10\,m}$$

$$M = 2.0$$

c) Converging lens

9. $M = 0.5$ $P = -5.0\,\delta$

a) $d_i = ?$

$$f = \frac{1}{P} = \frac{-1}{5.0\,m^{-1}} = -0.20\,m$$

$$M = \frac{-d_i}{d_o} \qquad d_i = -d_o M$$

$$\frac{1}{f} = \frac{1}{d_i} + \frac{1}{d_o} = \frac{-1}{d_o M} + \frac{1}{d_o}$$

$$d_o = f\left(1 - \frac{1}{M}\right)$$

$$= (-0.20\,m)\left(1 - \frac{1}{0.5}\right)$$

$$\boxed{d_o = 0.20\,m}$$

b) $d_i = -d_o M = -(0.20m)(0.5)$

$$\boxed{d_i = -0.10m}$$

$$f = \left(\frac{1}{d_i} + \frac{1}{d_o}\right)^{-1}$$

$$= \left(\frac{-1}{0.10m} + \frac{1}{0.20m}\right)^{-1}$$

$f = -0.20m$ ✓ Same as above.

c) Diverging lens

10. 

$R_1 = 12cm$ $n = 1.50$

$R_2 = -24cm$ $\frac{1}{f} = (n-1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$

a) $f = \left[(n-1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)\right]^{-1}$

$$= \left[(1.5-1)\left(\frac{1}{12cm} + \frac{1}{24cm}\right)\right]^{-1}$$

$$\boxed{f = 16cm}$$

b) $d_i = \left(\frac{1}{f} - \frac{1}{d_o}\right)$ $d_o = 20cm$

$d_i = \left(\frac{1}{16cm} - \frac{1}{20cm}\right)$ $d_i = 80cm$

c) $M = \frac{-d_i}{d_o} = \frac{-80cm}{20cm} = -4.0$

$$\boxed{M = -4.0}$$