Optics Bonus Quiz

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2. a. $f = \left(\frac{1}{s} + \frac{1}{s'}\right)^{-1}$

$$s' = \left(\frac{1}{f} - \frac{1}{s}\right)^{-1}$$

$$f = -\frac{R}{2}$$

$$s' = -\left(\frac{2}{R} + \frac{1}{s}\right)^{-1}$$

$$s' = -\left(\frac{2}{(10\text{cm})} + \frac{1}{(10\text{cm})}\right)^{-1}$$

$$\boxed{s' = -3.33\text{cm}}$$

b. $M = -\frac{s'}{s}$

$$M = \frac{y'}{y}$$

$$\therefore \frac{y'}{y} = -\frac{s'}{s}$$

$$y' = -\frac{ys'}{s}$$

$$y' = -\frac{(2\text{cm})(-3.33\text{cm})}{(10\text{cm})}$$

$$\boxed{y' = 0.67\text{cm}}$$

3. a. First, we'll focus on lens number one:

$$s' = \left(\frac{1}{f} - \frac{1}{s}\right)^{-1}$$

$$s' = \left(\frac{1}{(10\text{cm})} - \frac{1}{(15\text{cm})}\right)^{-1}$$

$$s' = 30\text{cm}$$

Next, an expression for the object distance for lens two:

$$s_2 = d - s'$$

$$s_2 = (15\text{cm}) - (30\text{cm})$$

$$s_2 = -15\text{cm}$$

Next, we will focus on lens two:

$$s_2' = \left(\frac{1}{f} - \frac{1}{s_2}\right)^{-1}$$

$$s_2' = \left(\frac{1}{f} - \frac{1}{d - s'}\right)^{-1}$$

$$s_2' = \left(\frac{1}{f} - \frac{1}{d - \left(\frac{1}{f} - \frac{1}{s}\right)^{-1}}\right)^{-1}$$

$$s_2' = \left(\frac{1}{(10\text{cm})} - \frac{1}{(15\text{cm}) - \left(\frac{1}{(10\text{cm})} - \frac{1}{(15\text{cm})}\right)^{-1}}\right)^{-1}$$

$$\boxed{s_2' = 6\text{cm}}$$

b. $s_2' > 0$

$\therefore$ The image is in the positive image space of the second lens.

$\boxed{\therefore \text{ The image is real.}}$

c. $M_{net} = M_1 M_2$

$$M_{net} = \left(\frac{s'}{s}\right)\left(\frac{s_2'}{s_2}\right)$$

$$M_{net} = \left(\frac{(30\text{cm})}{(15\text{cm})}\right)\left(\frac{(6\text{cm})}{(-15\text{cm})}\right)$$

$$M_{net} = -0.8$$

$$M_{net} < 0$$

c. $\boxed{\therefore \text{ The image is inverted.}}$