18-1. See the sketch below. Using Eq. (18-1),

$$\frac{1}{f_1}=\frac{n_L-n'}{n\,R_2}-\frac{n_L-n}{n\,R_1}-\frac{(n_L-n)\,(n_L-n')}{n\,n_L}\frac{t}{R_1R_2}$$

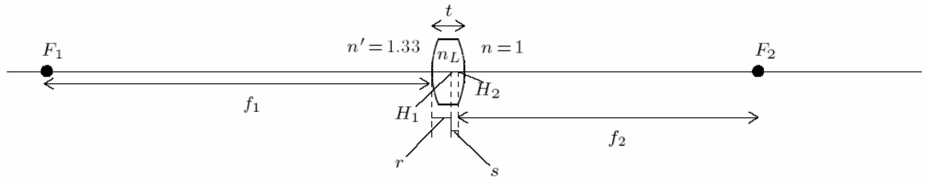
$$\frac{1}{f_1}=\frac{1.6-1}{1.33(-40\,\text{cm})}-\frac{1.6-1.33}{(1.33)\,(40\,\text{cm})}-\frac{(1.6-1.33)(1.6-1)}{1.33(1.6)}\frac{5\,\text{cm}}{(40\,\text{cm})(-40\,\text{cm})}\Rightarrow f_1=-62.05\,\text{cm}$$

$$f_2=-\frac{n'}{n}f_1=-\frac{1}{1.33}(-62.05\,\text{cm})=46.66\,\text{cm}$$

Further, using Eq. (18-3),

$$r=\frac{n_L-n'}{n_LR_2}f_1\,t=\frac{1.6-1}{1.6\,(-40\,\text{cm})}(-62.05\,\text{cm})\,(5\,\text{cm})=2.91\,\text{cm}$$

$$s=-\frac{n_L-n}{n_L\,R_1}f_2\,t=\frac{1.6-1.33}{1.6(+40\,\text{cm})}(46.66\,\text{cm})(5\,\text{cm})=-0.98\ \text{cm}$$



18-3. Using Eq. (18-1)

$$\frac{1}{f_1}=\frac{n_L-n'}{n\,R_2}-\frac{n_L-n}{n\,R_1}-\frac{(n_L-n)\,(n_L-n')}{n\,n_L}\frac{t}{R_1R_2}$$

$$\frac{1}{f_1}=\frac{1.5-1}{10\,\text{cm}}-\frac{1.5-1}{-20\,\text{cm}}-\frac{(1.5-1)^2}{1.5}\frac{5\,\text{cm}}{(10\,\text{cm})(-20\,\text{cm})}\Rightarrow f_1=12.63\,\text{cm}$$

$$f_2=-\frac{n'}{n}f_1=-1\,(12.63\text{cm})=-12.63\,\text{cm}$$

Further, using Eq. (18-3),

$$r=\frac{n_L-n'}{n_LR_2}f_1\,t=\frac{1.5-1}{1.5\,(10\,\text{cm})}(12.63\,\text{cm})\,(5\,\text{cm})=2.105\,\text{cm}$$

$$s=-\frac{n_L-n}{n_L\,R_1}f_2\,t=\frac{1.5-1}{1.5(-20\text{cm})}(-12.63\,\text{cm})(5\,\text{cm})=-1.0525\ \text{cm}$$

Then $s_0=8\,\text{cm}+r=10.105\,\text{cm}$ and,

$$-\frac{f_1}{s_o}+\frac{f_2}{s_i}=1\Rightarrow-\frac{12.63}{10.105}+\frac{(-12.63\,\text{cm})}{s_i}=1\Rightarrow s_i=-5.614\,\text{cm left of }H_2$$

That is $s_i=-5.614\,\text{cm}+s=-6.67\,\text{cm}$ left of V_2. The magnification is,

$$m=-\frac{n\ s_i}{n'\,s_o}=-\frac{(1)(-5.614)}{(1)\,(10.105)}=+0.556$$

So, $h_i=m\,h_o=0.556\times1\text{in}=0.556\,\text{in}$.

18-9. The lens matrix is,

$$\begin{bmatrix}1 & 0\\ 1/10 & 1\end{bmatrix}\begin{bmatrix}1 & 5\\ 0 & 1\end{bmatrix}\begin{bmatrix}1 & 0\\ -1/10 & 1\end{bmatrix}=\begin{bmatrix}1/2 & 5/4\\ -1/20 & 3/2\end{bmatrix}$$

$$f_1=1/C=-20\,\text{cm},\ f_2=-1/C=20\,\text{cm}$$

$$q=-A/C=10\,\text{cm},\ p=D/C=-30\,\text{cm}$$

$$r=(D-1)/C=-10\,\text{cm},\ s=(1-A)/C=-10\,\text{cm}$$

18-12. (a) The lens matrix is,

$$\begin{bmatrix} 1 & 15 \\ 0.5/(-4) & 3/2 \end{bmatrix}\begin{bmatrix} 1 & 8 \\ 0 & 1 \end{bmatrix}\begin{bmatrix} 1 & 30 \\ (-0.5)/(4\times 1.5) & 2/3 \end{bmatrix}=\begin{bmatrix} 1/3 & 16/3 \\ -1/6 & 1/3 \end{bmatrix}$$

$$f_1=1/C=-6\,\text{in},\ f_2=-1/C=6\,\text{in}$$
$$q=-A/C=2\,\text{in},\ p=D/C=-2\,\text{in}$$
$$r=(D-1)/C=4\,\text{in},\ s=(1-A)/C=-4\,\text{in}$$

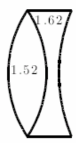
(b) Parallel light focuses at F_2, measured from the output plane (or right surface) by $q=2\,\text{in}$.

18-14. (a), (b) The lens matrix is

$$\begin{bmatrix} 1 & 0 \\ \frac{0.62}{20} & 1.62 \end{bmatrix}\begin{bmatrix} 1 & 1/2 \\ 0 & 1 \end{bmatrix}\begin{bmatrix} 1 & 0 \\ \frac{-0.1}{-20\,(1.62)} & \frac{1.52}{1.62} \end{bmatrix}\begin{bmatrix} 1 & 1 \\ 0 & 1 \end{bmatrix}\begin{bmatrix} 1 & 0 \\ \frac{-0.52}{(20)(1.52)} & \frac{1}{1.52} \end{bmatrix}=\begin{bmatrix} 0.9764 & 0.96755 \\ 0.009182 & 1.0333 \end{bmatrix}$$

$$f_1=1/C=-150\,\text{cm},\ f_2=-1/C=150\,\text{cm}$$
$$q=-A/C=160\,\text{cm},\ p=D/C=-140\,\text{cm}$$
$$r=(D-1)/C=10\,\text{cm},\ s=(1-A)/C=10\,\text{cm}$$

(c) Consider each lens separately in air:



$$\frac{1}{f}=\frac{n_2-n_1}{n_1}\left(\frac{1}{R_1}-\frac{1}{R_2}\right)\Rightarrow\frac{1}{f_1}=\frac{1.52-1}{1}\left(\frac{1}{20\,\text{cm}}-\frac{1}{-20\,\text{cm}}\right)=0.052\,\text{cm}^{-1}$$

$$\frac{1}{f_2}=\frac{1.62-1}{1}\left(\frac{1}{-20\,\text{cm}}-\frac{1}{20\,\text{cm}}\right)=-0.062\,\text{cm}^{-1}$$

Equivalent focal length: $\frac{1}{f_{\text{eq}}}=\frac{1}{f_1}+\frac{1}{f_2}=0.052\,\text{cm}^{-1}-0.062\,\text{cm}^{-1}\Rightarrow f_{\text{eq}}=-100\,\text{cm}$

4-11. Generally, $\boldsymbol{k}\cdot\boldsymbol{r}=k_x\,x+k_y\,y+k_z\,z$.

(a) For propagation along the z-axis, $k_x=k_y=0$, So $\boldsymbol{k}\cdot\boldsymbol{r}=k_z\,z$, with $k_z=2\,\pi/\lambda$. The waveform can then be written as,

$$\psi=A\sin(\boldsymbol{k}\cdot\boldsymbol{r}-\omega\,t)=A\sin(k_z\,z-\omega\,t)=A\sin\left[\frac{2\,\pi}{\lambda}(z-v\,t)\right]=A\sin 2\,\pi(z/\lambda-v\,t)$$

(b) In this case, $k_z=0$ and $k_x=k_y=|k|/\sqrt{2}=\frac{1}{\sqrt{2}}\frac{2\,\pi}{\lambda}$. The general form of the wave is then,

$$\psi=A\sin(\boldsymbol{k}\cdot\boldsymbol{r}\pm\omega\,t)=A\sin(k_x\,x+k_y\,y\pm\omega\,t)=A\sin\left[\frac{2\,\pi}{\sqrt{2}\lambda}(x+y\pm v\,t)\right]=A\sin 2\,\pi\left(\frac{x}{\sqrt{2}\lambda}+\frac{y}{\sqrt{2}\,\lambda}\pm v\,t\right).$$

If one is interested in the wave displacement only on the line $x=y$,

$$\psi=A\sin 2\,\pi\left(\frac{2x}{\sqrt{2}\lambda}\pm v\,t\right).$$

(c) In this case $\boldsymbol{k}=\frac{k}{\sqrt{3}}(\hat{\boldsymbol{x}}+\hat{\boldsymbol{y}}+\hat{\boldsymbol{z}})$ and $\boldsymbol{k}\cdot\boldsymbol{r}=\frac{k}{\sqrt{3}}(x+y+z)$, with $k=2\,\pi/\lambda$. The waveform is then,

$$\psi=A\sin(\boldsymbol{k}\cdot\boldsymbol{r}\pm\omega\,t)=A\sin\left[\frac{k}{\sqrt{3}}(x+y+z)\pm\omega\,t\right]=A\sin\left[\frac{2\,\pi}{\sqrt{3}\lambda}(x+y+z\pm v\,t)\right]$$

4-12. Let $\tilde{z} = a + i\,b$ where a and b are real.

(a) $(\tilde{z} + \tilde{z}\,^*)/2 = (a + i\,b + a - i\,b)/2 = a = \mathrm{Re}(\tilde{z})$

(b) $(\tilde{z} - \tilde{z}\,^*)/2i = (a + i\,b - a + i\,b)/2i = b = \mathrm{Im}(\tilde{z})$

(c) Let $\tilde{z} = e^{i\theta} = \cos\theta + i\sin\theta$ and apply the result from (a): $\cos\theta = \left(e^{i\theta} + e^{-i\theta}\right)/2$

(d) Let $\tilde{z} = e^{i\theta} = \cos\theta + i\sin\theta$ and apply the result from (b): $\sin\theta = \left(e^{i\theta} - e^{-i\theta}\right)/2i$

4-13. (a) Note that $e^{i\pi/2} = \cos(\pi/2) + i\sin(\pi/2) = i$ so that

$$i\,A\,e^{i(\boldsymbol{k}\cdot\boldsymbol{r} - \omega t + \varphi_0)} = e^{i\pi/2}\,A\,e^{i(\boldsymbol{k}\cdot\boldsymbol{r} - \omega t + \varphi_0)} = A\,e^{i(\boldsymbol{k}\cdot\boldsymbol{r} - \omega t + \varphi_0 + \pi/2)}$$

(b) Similarly, $e^{i\pi} = \cos(\pi) + i\sin(\pi) = -1$ so that

$$-A\,e^{i(\boldsymbol{k}\cdot\boldsymbol{r} - \omega t + \varphi_0)} = e^{i\pi}\,A\,e^{i(\boldsymbol{k}\cdot\boldsymbol{r} - \omega t + \varphi_0)} = A\,e^{i(\boldsymbol{k}\cdot\boldsymbol{r} - \omega t + \varphi_0 + \pi)}$$

5-4. One could proceed directly by mimicking the development for the cosine waves leading to Eqs. (5-9) and (5-10). I choose to first convert the given fields to the cosine form and then using those equations. That is,

$$y_1 = 5\sin(\omega t + \pi/2) = 5\cos(\omega t) = 5\cos(0 - \omega t)$$
$$y_2 = 7\sin(\omega t + \pi/3) = 7\cos(\omega t + \pi/3 - \pi/2) = 7\cos(\omega t - \pi/6) = 7\cos(\pi/6 - \omega t)$$

Them using Eqs. (5-9) and (5-10):

$$y_0 = \sqrt{5^2 + 7^2 + 2\cdot 5\cdot 7\cos(\pi/6)} = 11.6$$
$$\tan\alpha = \frac{0 + 7\sin(\pi/6)}{5 + 7\cos(\pi/6)} = \alpha = 0.098\,\pi$$
$$y = 11.6\cos(0.098\,\pi - \omega t) = 11.6\cos(\omega t - 0.098\,\pi) = 11.6\sin(\omega t - 0.098\,\pi + \pi/2)$$
$$y = 11.6\sin(\omega t + 0.402\,\pi)$$

5-7. At the indicated position,

$$\psi_1 = A_1\cos(8\,\pi/3 - \omega t),\quad A_1 = 4\,\mathrm{cm}, \omega = 20/\mathrm{s}$$
$$\psi_2 = A_2\cos(3\,\pi/2 - \omega t),\quad A_2 = 2\,\mathrm{cm}, \omega = 20/\mathrm{s}$$

Using Eqs (5-9) and (5-10),

$$A = \sqrt{A_1^2 + A_2^2 + 2\,A_1\,A_2\cos(\alpha_2 - \alpha_1)} = \sqrt{20 + 16\cos(3\,\pi/2 - 8\,\pi/3)}\ \mathrm{cm} = 2.48\,\mathrm{cm}$$
$$\tan\alpha = \frac{4\sin(8\,\pi/3) + 2\sin(3\,\pi/2)}{4\cos(8\,\pi/3) + 2\sin(3\,\pi/2)} \Rightarrow \alpha = 2.51$$
$$\psi_R = (2.48\,\mathrm{cm})\cos(2.51 - (20/\mathrm{s})\,t)$$