1. $\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{20.0\text{ cm}} + \frac{1}{5.00\text{ cm}} = 0.0500\,\frac{1}{\text{cm}} + 0.200\,\frac{1}{\text{cm}} = 0.250\,\frac{1}{\text{cm}}$

$f = \frac{1}{0.250}\text{ cm} = \underline{4.00\text{ cm}}$

or:

$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i} = \frac{d_i}{d_o \cdot d_i} + \frac{d_o}{d_i \cdot d_o} = \frac{d_i + d_o}{d_o \cdot d_i}$ $\qquad f = \frac{d_o \cdot d_i}{d_o + d_i} = \frac{20.0\text{ cm} \cdot 5.00\text{ cm}}{20.0\text{ cm} + 5.00\text{ cm}} = \underline{4.00\text{ cm}}$

f is positive, thus the lens is converging

2. $\frac{1}{d_i} = \frac{1}{f} - \frac{1}{d_o} = \frac{1}{10.0\text{ cm}} - \frac{1}{50.0\text{ cm}} = 0.100\,\frac{1}{\text{cm}} - 0.0200\,\frac{1}{\text{cm}} = 0.0800\,\frac{1}{\text{cm}}$

$d_i = \frac{1}{0.0800}\text{ cm} = \underline{12.5\text{ cm}}$

or:

$\frac{1}{d_i} = \frac{1}{f} - \frac{1}{d_o} = \frac{d_o}{d_o \cdot f} - \frac{f}{f \cdot d_o} = \frac{d_o - f}{d_o \cdot f} =$ $\qquad d_i = \frac{d_o \cdot f}{d_o - f} = \frac{50.0\text{ cm} \cdot 10.0\text{ cm}}{50.0\text{ cm} - 10.0\text{ cm}} = \underline{12.5\text{ cm}}$

d_i is positive, thus the image is real

3. $\frac{1}{d_i} = \frac{1}{f} - \frac{1}{d_o} = \frac{1}{5.00\text{ cm}} - \frac{1}{1.00\text{ cm}} = 0.200\,\frac{1}{\text{cm}} - 1.00\,\frac{1}{\text{cm}} = -0.800\,\frac{1}{\text{cm}}$

$d_i = -\frac{1}{0.800}\text{ cm} = \underline{-1.25\text{ cm}}$

or:

$\frac{1}{d_i} = \frac{1}{f} - \frac{1}{d_o} = \frac{d_o}{d_o \cdot f} - \frac{f}{f \cdot d_o} = \frac{d_o - f}{d_o \cdot f} =$ $\qquad d_i = \frac{d_o \cdot f}{d_o - f} = \frac{1.00\text{ cm} \cdot 5.00\text{ cm}}{1.00\text{ cm} - 5.00\text{ cm}} = \underline{-1.25\text{ cm}}$

d_i is negative, thus the image is virtual

4. $\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{4.50\text{ cm}} + \frac{1}{-6.50\text{ cm}} = 0.2222\,\frac{1}{\text{cm}} - 0.1538\,\frac{1}{\text{cm}} = 0.0684\,\frac{1}{\text{cm}}$

$f = \frac{1}{0.0684}\text{ cm} = \underline{14.6\text{ cm}}$

or:

$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i} = \frac{d_i}{d_o \cdot d_i} + \frac{d_o}{d_i \cdot d_o} = \frac{d_i + d_o}{d_o \cdot d_i}$ $\qquad f = \frac{d_o \cdot d_i}{d_o + d_i} = \frac{4.50\text{ cm} \cdot (-6.50\text{ cm})}{4.50\text{ cm} - 6.50\text{ cm}} = \underline{14.6\text{ cm}}$

f is positive, thus the lens is converging

d_i is negative, thus the image is virtual

5. $\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{7.50\text{ cm}} + \frac{1}{-4.50\text{ cm}} = 0.1333\,\frac{1}{\text{cm}} - 0.2222\,\frac{1}{\text{cm}} = -0.0889\,\frac{1}{\text{cm}}$

$f = \frac{1}{-0.0889}\text{ cm} = \underline{\underline{-11.3\text{ cm}}}$

or:

$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i} = \frac{d_i}{d_o \cdot d_i} + \frac{d_o}{d_i \cdot d_o} = \frac{d_i + d_o}{d_o \cdot d_i}$ $\qquad f = \frac{d_o \cdot d_i}{d_o + d_i} = \frac{7.50\text{ cm} \cdot (-4.50\text{ cm})}{7.50\text{ cm} - 4.50\text{ cm}} = \underline{\underline{-11.3\text{ cm}}}$

f is negative, thus the lens is <u>diverging</u>

d_i is negative, thus the image is <u>virtual</u>

6. a) $\frac{1}{d_i} = \frac{1}{f} - \frac{1}{d_o} = \frac{1}{12.0\text{ cm}} - \frac{1}{240\text{ cm}} = 0.083333\,\frac{1}{\text{cm}} - 0.004167\,\frac{1}{\text{cm}} = 0.079167\,\frac{1}{\text{cm}}$

$d_i = \frac{1}{0.079167}\text{ cm} = \underline{12.6\text{ cm}}$

or:

$\frac{1}{d_i} = \frac{1}{f} - \frac{1}{d_o} = \frac{d_o}{d_o \cdot f} - \frac{f}{f \cdot d_o} = \frac{d_o - f}{d_o \cdot f} =$ $\qquad d_i = \frac{d_o \cdot f}{d_o - f} = \frac{240\text{ cm} \cdot 12.0\text{ cm}}{240\text{ cm} - 12.0\text{ cm}} = \underline{\underline{12.6\text{ cm}}}$

b) $h_i = \frac{d_i \cdot h_o}{d_o} = \frac{12.6\text{ cm} \cdot 160\text{ cm}}{240\text{ cm}} = \underline{8.42\text{ cm}}$

7. a) $\frac{1}{d_i} = \frac{1}{f} - \frac{1}{d_o} = \frac{1}{5'000\text{ mm}} - \frac{1}{24.0\text{ mm}} = 0.0002000\,\frac{1}{\text{mm}} - 0.04167\,\frac{1}{\text{mm}} = 0.04187\,\frac{1}{\text{mm}}$

$d_i = \frac{1}{0.04187}\text{ mm} = \underline{23.9\text{ mm}}$

or:

$\frac{1}{d_i} = \frac{1}{f} - \frac{1}{d_o} = \frac{d_o}{d_o \cdot f} - \frac{f}{f \cdot d_o} = \frac{d_o - f}{d_o \cdot f} =$ $\qquad d_i = \frac{d_o \cdot f}{d_o - f} = \frac{5'000\text{ mm} \cdot 24.0\text{ mm}}{5'000\text{ mm} - 24.0\text{ mm}} = \underline{\underline{23.9\text{ mm}}}$

b) $h_i = \frac{d_i \cdot h_o}{d_o} = \frac{24.0\text{ mm} \cdot 1'800\text{ mm}}{5'000\text{ mm}} = \underline{8.46\text{ mm}}$