Show your work on numerical problems to receive full credit.

1. (10 points) A diverging lens with a focal length of 10.0 cm is placed 15.0 cm to the right of a converging lens with a focal length of 15.0 cm. If a 20.0 cm tall object is placed 45.0 cm to the left of the converging lens, state the location of the final image, height of the final image, orientation (inverted or upright) of the final image, and whether the image is real or virtual.

\[ \frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f} \]

\[ \frac{1}{45.0 \text{cm}} + \frac{1}{d_i} = \frac{1}{15.0 \text{cm}} \]

\[ d_i = \frac{1}{\frac{1}{45.0 \text{cm}} - \frac{1}{15.0 \text{cm}}} = 22.5 \text{cm} \]

\[ M = -\frac{d_i}{d_o} = -\frac{22.5 \text{cm}}{45.0 \text{cm}} = -0.5 \]

\[ d_f = 30.0 \text{cm} \]

\[ M = -\frac{20.0 \text{cm}}{7.5 \text{cm}} = 4 \]

a. A 632.8 nm He-Ne laser is directed through a double slit and measurements are made on the resulting interference pattern. The third order maximum is a distance of 18.3 cm from the central maximum when the viewing screen is a distance of 750 mm from the slits. What is the separation of the slits?

\[ d \sin \theta = m \lambda \]

\[ d = \frac{m \lambda}{\sin \theta} = \frac{3(632.8 \times 10^{-9} \text{m})}{0.237} \approx 0.8 \times 10^{-6} \text{ m} \]

b. The viewing screen is now moved to a distance of 1000 mm. What is the new distance on the screen between the third order maximum and the central maximum?

\[ \tan \theta = 0.244 \]

\[ 0.244 = \tan \theta \]

\[ \theta = 6.24 \text{ radian} \]

\[ \sin \theta = 0.237 \]
3. (5 points) An object is placed 90.0 cm from a glass lens (n=1.52) with one concave surface of radius 22.0 cm and one convex surface of radius of 18.5 cm.

a. What is the focal length of this lens?

\[ R_1 = 22.0 \text{ cm} \]
\[ R_2 = -18.5 \text{ cm} \]
\[ \frac{1}{f} = (1.52 - 1) \left( \frac{1}{22.0 \text{ cm}} - \frac{1}{18.5 \text{ cm}} \right) \]
\[ f = 22.4 \text{ cm} \]

b. For the final image, give its location, orientation (upright or inverted), magnification, and state whether it is real or virtual.

\[ \frac{1}{d_0} + \frac{1}{d_i} = \frac{1}{f} \]
\[ \frac{1}{90.0 \text{ cm}} + \frac{1}{d_i} = \frac{1}{22.4 \text{ cm}} \]
\[ d_i = -64.2 \text{ cm} \]

**Virtual**

**M** = \[ \frac{-64.2 \text{ cm}}{90 \text{ cm}} \] = \[ 0.71 \text{ UPRI} \text{ CNT.} \]

Equations:

\[ d \sin \theta = m \lambda \quad m = 0, 1, 2, 3, \ldots \]

\[ d \sin \theta = (m + \frac{1}{2}) \lambda \quad m = 0, 1, 2, 3, \ldots \]

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