OPTI 201R Midterm 1 October 5, 2017

Answer all questions. Show your work. Partial credit will be given. Don't spend too much time on any one problem. Use separate sheets of paper and don't cram your work into the spaces below. Problems are worth 10 points each.

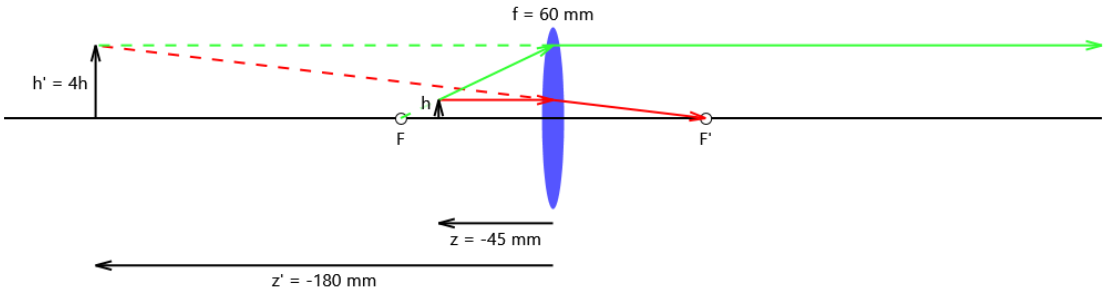
For problems 1-8, provide the requested values and draw a sketch of the system. The basic thin lens in air equations are

$$\frac{1}{z'} - \frac{1}{z} = \frac{1}{f} \quad and \quad m = \frac{z'}{z}$$

1. Given the image distance $z' = -180mm$ and a lens of focal length $f = 60mm$, what is the object distance z and the magnification m?

The object distance is given by $z = \left[\frac{1}{-180} - \frac{1}{60}\right]^{-1} = -45mm.$

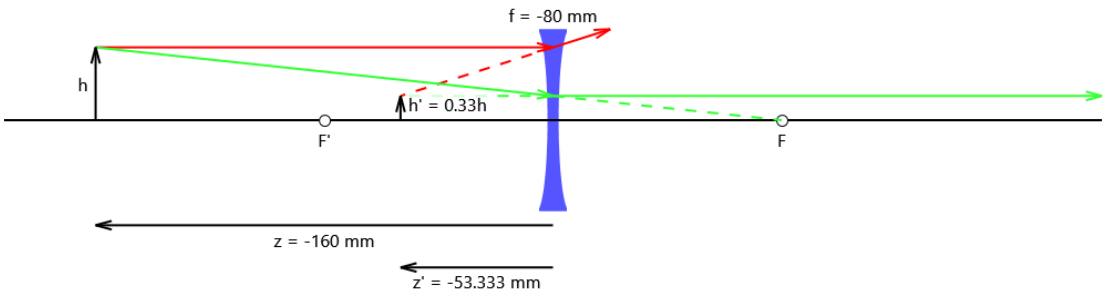
The magnification is given by $m = \frac{z'}{z} = \frac{-180}{-45} = 4.$



2. Given the object distance $z = -160mm$ and a lens of focal length $f = -80mm$, what is the image distance z' and the magnification m?

The image distance is given by $z' = \left[\frac{1}{-80} + \frac{1}{-160}\right]^{-1} = -53.333mm.$

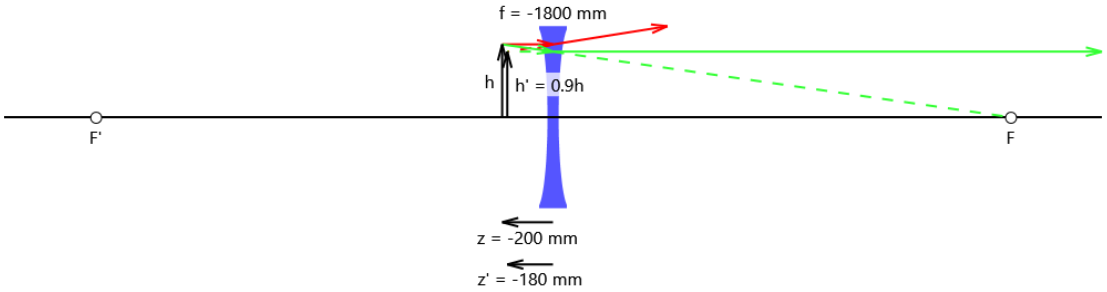
The magnification is given by $m = \frac{z'}{z} = \frac{-53.333}{-160} = 0.333.$



3. Given the object distance $z = -200mm$ and the image distance $z' = -180mm$, what is the lens focal length f and the magnification m?

The lens focal length is given by $f = \left[\frac{1}{-180} - \frac{1}{-200}\right]^{-1} = -1800mm.$

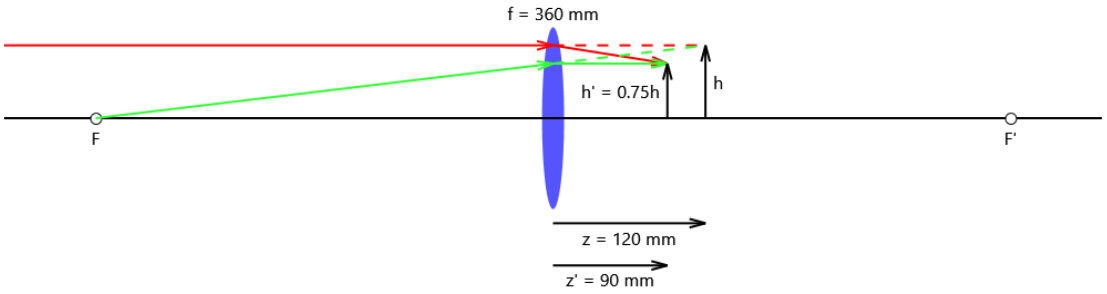
The magnification is given by $m = \frac{z'}{z} = \frac{-180}{-200} = 0.9.$



4. Given the object distance $z = 120mm$ and the magnification $m = 0.75$, what is the lens focal length f and the image distance z'?

The lens focal length is given by $f = \frac{mz}{1-m} = \frac{(0.75)(120)}{1-0.75} = 360mm.$

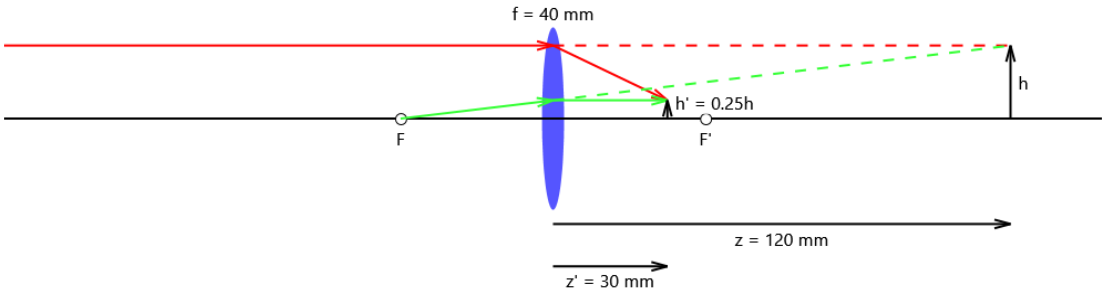
The limage distance is given by $z' = m \cdot z = (0.75)(120) = 90mm.$



5. Given a lens of focal length $f = 40mm$ and a magnification $m = 0.25$, what is the object distance z and the image distance z'?

The object distance is given by $z = f\left[\frac{1}{m} - 1\right] = 40\left[\frac{1}{0.25} - 1\right] = 120mm.$

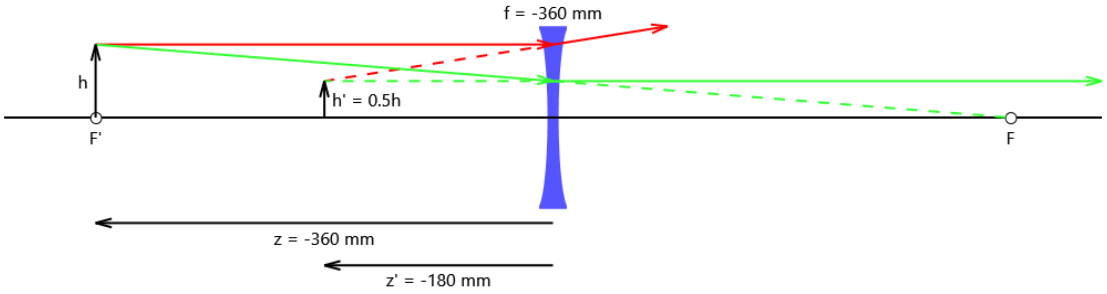
The limage distance is given by $z' = m \cdot z = (0.25)(120) = 30mm.$



6. Given an image distance $z' = -180mm$ and a magnification $m = 0.5$, what is the focal length f and the object distance z?

The lens focal length is given by $f = \frac{z\prime}{1-m} = \frac{-180}{1-0.5} = -360mm.$

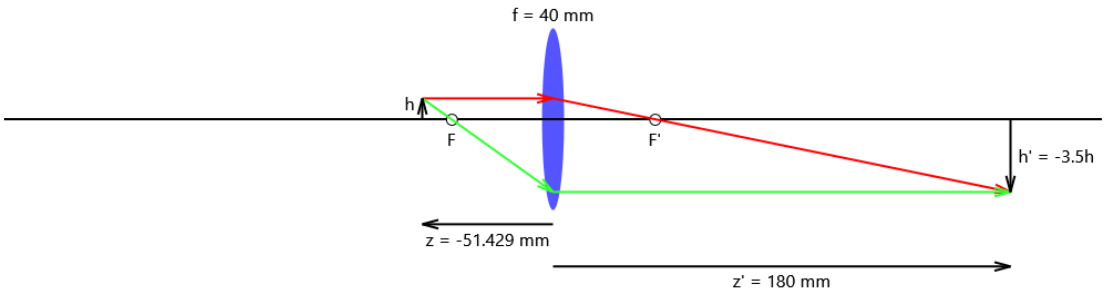
The object distance is given by $z = \frac{z\prime}{m} = \frac{-180}{0.5} = -360mm.$



7. Given the image distance $z' = 180mm$ and a lens of focal length $f = 40mm$, what is the object distance z and the magnification m?

The object distance is given by $z = \left[\frac{1}{180} - \frac{1}{40}\right]^{-1} = -51.429mm.$

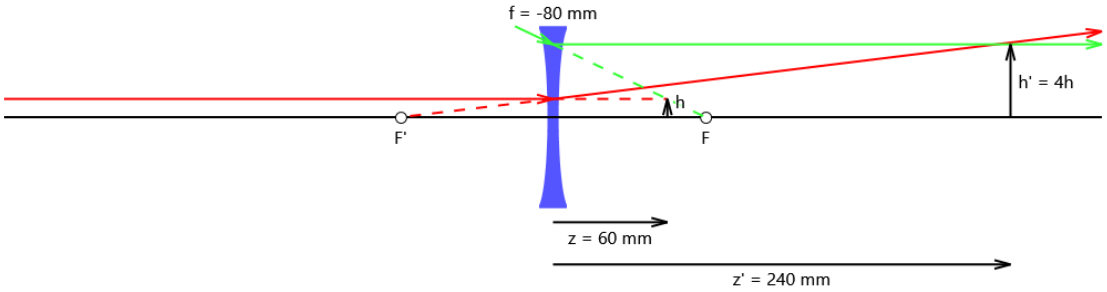
The magnification is given by $m = \frac{z\prime}{z} = \frac{180}{-51.429} = -3.5.$



8. Given the object distance $z = 60mm$ and a lens of focal length $f = -80mm$, what is the image distance z' and the magnification m?

The image distance is given by $z' = \left[\frac{1}{-80} + \frac{1}{60}\right]^{-1} = 240mm.$

The magnification is given by $m = \frac{z'}{z} = \frac{240}{60} = 4.$



9. N-LaF2 is a type of glass with refractive index of 1.744.

a) If a ray inside the glass strikes the surface of the N-LaF2 at an angle $\theta = 25°$ with respect to the surface normal, what is the angle θ' of the refracted ray outside of the glass if it is in air?
From Snell's law

$$1.744 sin 25° = sin\theta'$$

$$\theta' = 47.48°$$

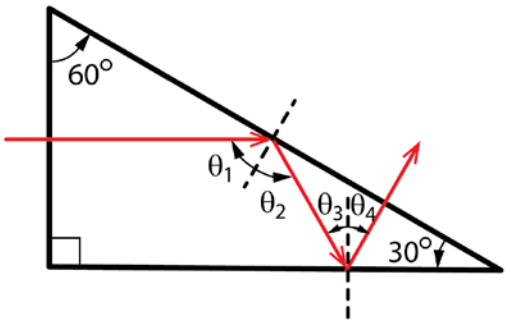
b) Is this angle θ above or below the critical angle for this material?

The critical angle for this material is given by

$$\theta_c = sin^{-1}\left(\frac{1}{1.744}\right) = 34.98°$$

so $\theta = 25° < \theta_c$.

10. The Figure below shows a 30-60-90 prism with a ray traced through it.



a) Is parity conserved for this prism?

Two (even) reflections means that the parity is conserved.

b) What are the angles $\theta_1, \theta_2, \theta_3$ and θ_4 (use the sign convention)?

From the geometry, θ_1 is clockwise and must be $\theta_1 = -60°$. From the law of reflection, $\theta_2 = 60°$. From the geometry, θ_4 is clockwise and must be $\theta_4 = -30°$. From the law of reflection, $\theta_3 = 30°$.

c) Circle the correct tunnel diagram for the 30-60-90 prism.