Physics 102 Homework #6

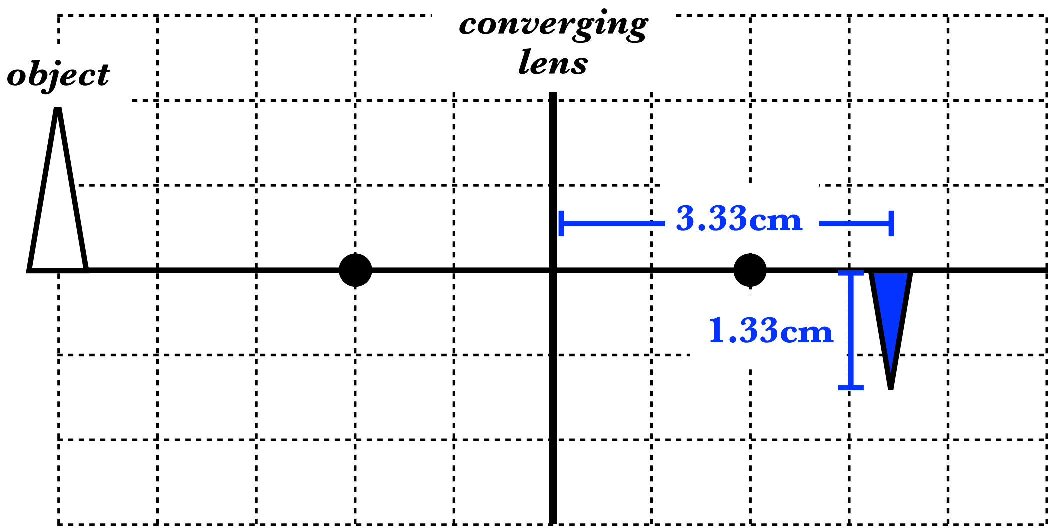
first draft due Wednesday, March 8th
final draft due Sunday, March 12th

1. The figure shows a converging lens with a focal length of 2cm. An object is 5cm to the left of the lens and is 2cm tall.

$d_o =$ **5cm**

$f =$ **2cm**

$h_o =$ **2cm**



a. Fill in the blanks above, and use the lens equation to find d_i, the image-to-lens distance.

We have $d_i = \dfrac{d_o f}{d_o - f} = \dfrac{5(2)}{5-2} =$ **3.33cm.**

b. Find the magnification of the image.

Since we know d_o and d_i, we have $M = -\dfrac{d_i}{d_o} = -\dfrac{3.33}{5} =$ **−0.667.**

c. Find the height h_i of the image.

Now that we know M, we can find

$$M = \frac{h_i}{h_o} \implies h_i = h_o M = (2\text{cm})(-0.667) = \mathbf{-1.33cm.}$$

d. Is this a real or a virtual image?

The image is inverted, so it is a **real** image.

e. Draw the image above at the correct location and with the correct size & orientation.

This is a lens, so real images appear on the opposite side from the object.

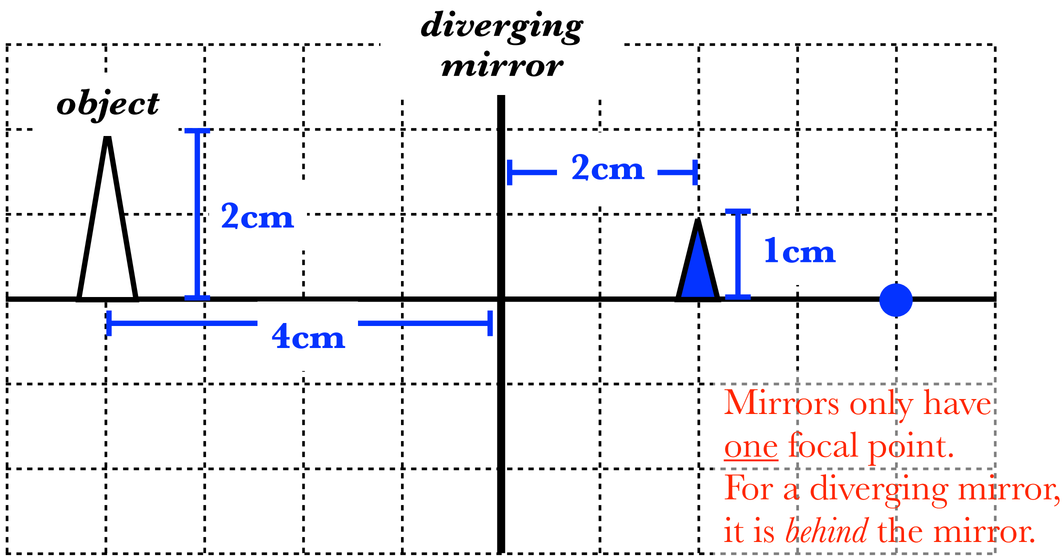
I took a point off if you drew the rays but you didn't *draw the image.*

2. The figure shows a diverging mirror with a focal length of −4cm. An object is 4cm to the left of the mirror and is 2cm tall.

d_o = **+4cm**

f = **−4cm**

h_o = **+2cm**



a. Fill in the blanks above, and find d_i, the image-to-lens distance.

We have $d_i = \dfrac{d_o f}{d_o - f} = \dfrac{4(-4)}{4-(-4)} = \dfrac{-16}{8} = $ **−2cm.**

b. Find the magnification of the image.

Since we know d_o and d_i, we have $M = -\dfrac{d_i}{d_o} = -\dfrac{-2}{4} =$ **0.5.**

c. Find the height h_i of the image.

Now that we know M, we can find $h_i = h_o M = (2\text{cm})(0.5) =$ **1cm.**

d. Draw the focal point(s) of this mirror on the picture above.

e. Draw the image above at the correct location and with the correct size & orientation.

This is a mirror, and $d_i < 0$ so the image is virtual, and virtual images appear on the opposite side from the object.

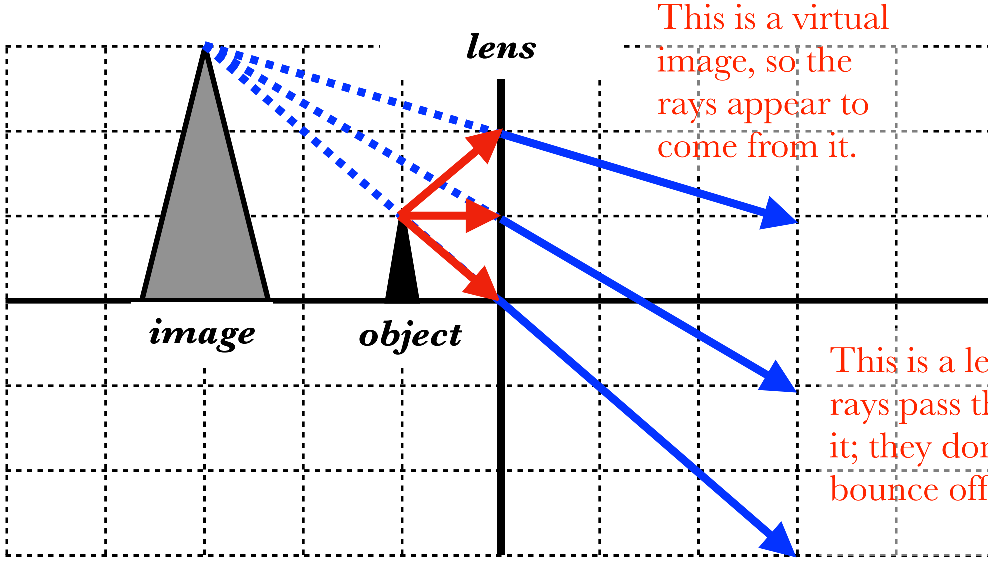
3. The figure shows an object and the image created by a lens. The grid lines are 1cm apart.

d_o is *always* positive.

d_o = **+1cm**

d_i = **−3cm**

Virtual images have negative d_i. Also, for lenses, positive d_i is on th opposite side.



a. Fill in the blanks above, and find the focal length f of the lens.

We have $\frac{1}{f} = \frac{1}{d_i} + \frac{1}{d_o} = \frac{1}{1\text{cm}} - \frac{1}{3\text{cm}} = \frac{2}{3\text{cm}}$.

This is $1/f$, so the focal length is the reciprocal of this: $f = \frac{3}{2} =$ **+1.5cm**.

b. Is the image real or virtual?

The image is upright, so it is a **virtual** image.

c. Is this a converging or diverging lens?

The focal length is positive, so the lens is **converging**.
Yes, converging lenses can create virtual images: think magnifying glasses.
They create virtual images *bigger* than the object.

d. I've drawn three rays that are emitted from the top of the object and hit the lens. Please draw what the rays do after they pass through the lens, and please use a straightedge.

4. A projector has a 0.010m tall LCD display, which is projected onto a screen by its lens. The display is 0.005 m behind the lens, and the image on the screen is 4 meters tall.

a. What is the magnification of the image? *(Be careful of units.)*

$$M = \frac{h_i}{h_o} = \frac{-4000\text{mm}}{10\text{mm}} = -400$$

Magnification has no units!

This is a real image, so the image is *inverted*: magnification is negative.

Sanity check: the image on the screen is much larger than the object inside the projector!

b. Use the magnification to find the distance from the screen to the lens

$$M = -\frac{d_i}{d_o} \implies d_i = -Md_o$$

$$\implies d_i = 400(5\text{mm}) = +2000\text{m} = +2\text{m}$$

Real images have $d_i > 0$.