Name____

Physics 111 Quiz #6, November 4, 2022

Please show all work, thoughts and/or reasoning in order to receive partial credit. The quiz is worth 10 points total.

I affirm that I have carried out my academic endeavors with full academic honesty.

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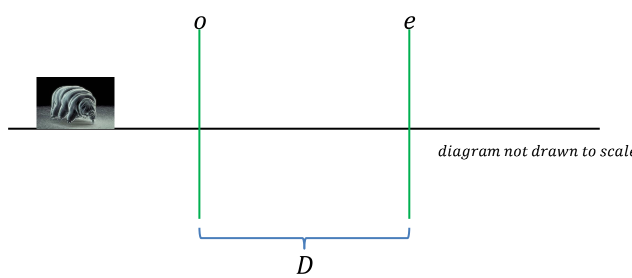
1. Tardigrades (or water bears) are a species of aquatic invertebrates that are about $1mm$ in height and length. Suppose you wanted to view some water bears in the lab and to do this you use a microscope. The microscope you use has two lenses. The first one, closest to the specimen is called the objective lens, labeled o in the figure below. The objective lens has a focal length $f_o = 6mm$. The second lens, closest to your eye and farthest from the specimen is called the eyepiece, labeled e in the figure below, has a focal length $f_e = 18mm$. The objective lens and eyepiece are separated by a distance $D = 200mm$. If the head of the water bear is $6.2mm$ to the left of the objective lens, where will the image of the water bear be with respect to the objective lens?

A water bear. Image from https://www.britannica.com/animal/tardigrade



$$\frac{1}{d_{oo}} + \frac{1}{d_{io}} = \frac{1}{f_o} \rightarrow \frac{1}{d_{io}} = \frac{1}{f_o} - \frac{1}{d_{oo}} = \frac{1}{6mm} - \frac{1}{6.2mm} = 0.00538mm^{-1} \rightarrow d_{io} = 186mm$$

The image of the water bear appears $186mm$ to the right of the objective lens. It is a real image.

2. What magnification does the objective lens produce and what is the size of the water bear's image from the objective lens?

$$M_o = \frac{d_{io}}{d_{oo}} = \frac{186mm}{6.2mm} = 30$$

$$M_o = 30 = \frac{h_{io}}{h_o} \rightarrow h_{io} = M_o h_o = 30 \times 1mm = 30mm$$

3. The image of the water bear from the objective lens becomes the object for the eyepiece. With respect to the eyepiece, what is the location of the final image of the water bear?

$$D = d_{io} + d_{oe} \rightarrow d_{oe} = D - d_{io} = 200mm - 186mm = 14mm$$

$$\frac{1}{d_{oe}} + \frac{1}{d_{ie}} = \frac{1}{f_e} \rightarrow \frac{1}{d_{ie}} = \frac{1}{f_e} - \frac{1}{d_{oe}} = \frac{1}{18mm} - \frac{1}{14mm} = -0.01598mm^{-1} \rightarrow d_{ie} = -63mm$$

The image of the water bear appears $63mm$ to the left of the eyepiece, on the same side of the lens as the object. The final image is a virtual image.

4. What is the magnification of the eyepiece and what would be the height of the water bear that you would view by looking through the eyepiece?

$$M_e = \frac{d_{ie}}{d_{oe}} = \frac{63mm}{14mm} = 4.5$$

$$M_e = 4.5 = \frac{h_{ie}}{h_{oo}} \rightarrow h_{ie} = M_e h_{oo} = 4.5 \times 30mm = 135mm$$

5. Suppose that the water bear begins to swim around in the dish at a speed of its body length per second, or $v_o = 1\frac{mm}{s}$. When you look through the eyepiece, how fast will the water bear appear to be swimming?

$$h_{ie} = M_e h_{oo} = M_e(M_o h_o) = M_e M_o h_o \rightarrow \frac{h_{ie}}{\Delta t} = M_e M_o \frac{h_o}{\Delta t} \rightarrow v_{ie} = M_e M_o v_o$$

$$v_{ie} = M_e M_o v_o = 4.5 \times 30 \times 1\frac{mm}{s} = 135\frac{mm}{s}$$