

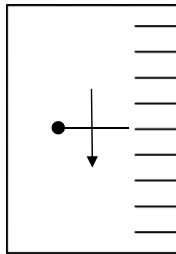
2017 SCORING GUIDELINES

Question 3

Distribution
of points

12 points total

(a) 2 points



For the arrow drawn upside down relative to the object
 For bar/circle drawn left-to-right reversed relative to the object or consistent with an (incorrect) upright arrow

1 point
 1 point

(b) i. 1 point

For correctly showing a calculation of the focal length and a correct answer with units

$$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{20 \text{ cm}} + \frac{1}{30 \text{ cm}}$$

$$f = 12 \text{ cm}$$

1 point

ii. 1 point

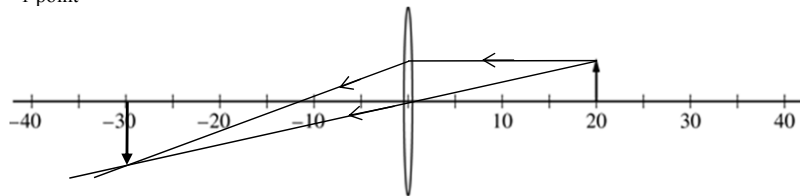
For correctly showing a calculation of the magnitude of the magnification (with or without sign) and a correct answer

$$M = d_i/d_o = 30 \text{ cm}/20 \text{ cm}$$

$$M = 1.5$$

1 point

(c) i. 1 point



For two reasonably correctly drawn rays consistent with the calculated focal length, and inclusion of an inverted image

1 point

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Question 3 (continued)

Distribution
of points(c) (continued)
ii. 2 points

For a correct explanation of how the rays drawn relate to the focal length

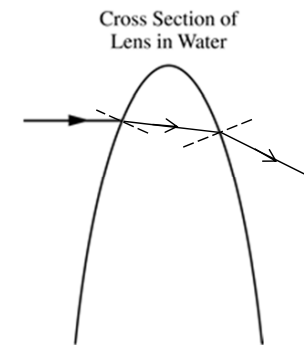
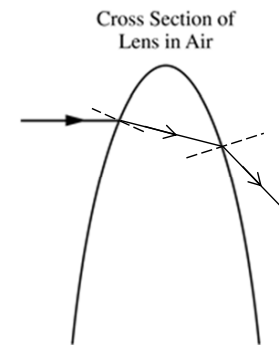
1 point

For a correct explanation of how the image relates to the magnification

1 point

Example: The horizontal ray from the object bends to cross the axis at 12 cm from the middle of the lens, which is the focal length. The image arrow is about 1.5 times the height of the object, which is the magnification.

(d) i. 2 points



For showing the downward refraction of the rays at each surface of the lens in air (i.e., toward the normal entering the lens and away from the normal leaving the lens)

1 point

For the rays refracted by the lens in water at greater angles to the normal than the corresponding angles for the lens in air — i.e., less bending (can be earned even if first point was not, scoring is relative to whatever is drawn for the lens in air)

1 point

ii. 3 points

For describing a greater focal length when the lens is in water or a comparison consistent with part (d)(i)

1 point

For describing a larger image distance and image size or a comparison consistent with part (d)(i)

1 point

For describing how the rays drawn in (d)(i) support the descriptions

1 point

Example: The rays do not bend as much as they pass from water to glass as when they pass from air to glass (and vice versa). This means parallel rays coming into the lens will converge at a farther distance, so the focal length is longer. Rays from an object also will converge farther from the lens, so the new image is farther and larger.