23

Mirrors and Lenses

Clicker Questions

Question P1.03

Description: Reasoning with geometric optics and ray-tracing.

Question

An object is located on the optical axis and a distance of 8 cm from a thin converging lens having focal length 10 cm. the image of the object is

1. real, upright, and smaller than the object.
2. real, inverted, and smaller than the object.
3. real, inverted, and larger than the object.
4. virtual, upright, and smaller than the object.
5. virtual, inverted, and larger than the object.
6. virtual, upright, and larger than the object.
7. None of the above.

Commentary

Purpose: To develop your ability to reason qualitatively with geometric optics.

Discussion: You can plug the given values into the thin lens formulae for image position and magnification, and if you use them correctly and know how to interpret the numbers you get, you can answer this question. However, the question does not ask you to solve for the image location or magnification; it merely asks for a qualitative answer. For this, a simple ray tracing diagram will suffice, and is less prone to error.

Drawing the three principal rays from the source object through the lens, you will see that they do not converge on the opposite side of the lens, but spread apart as if they had originated at a point behind the source (farther from the lens), on the same side of the optical axis as the source point, and farther from the lens axis than the source point. So, the image is virtual, upright, and larger than the source: answer (6).

Key Points:

- Refrain from quantitative calculation when qualitative reasoning will suffice.
- Graphical representations can be powerful tools for analyzing a situation and answering questions.
- Know how to use the three "principal rays" to draw ray-tracing diagrams.

For Instructors Only

To help students appreciate the value of graphical representations for thinking and problem-solving, we must show them questions for which these tools are clearly superior to formula-driven approaches.

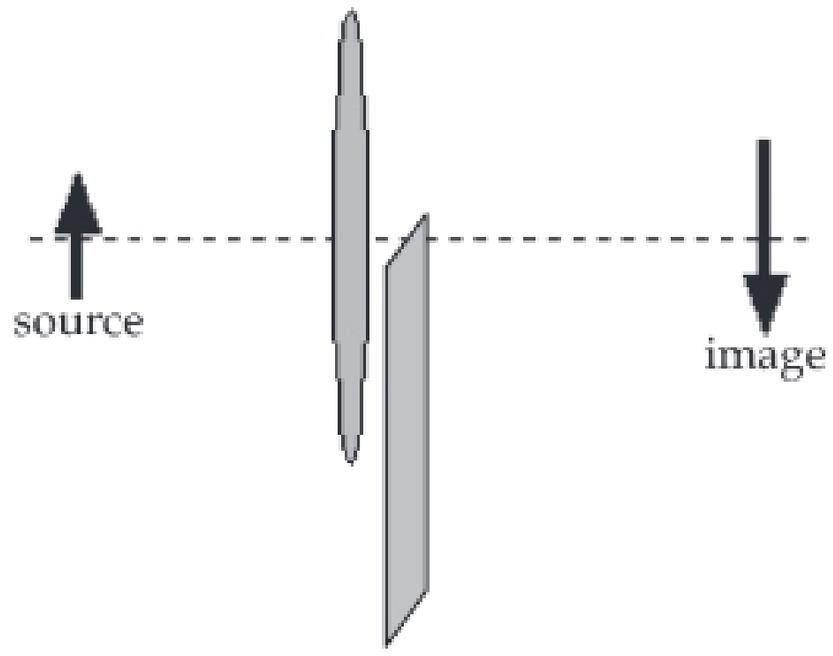
Students should be encouraged to solve this problem both ways; that will help them interpret each better.

Question P1.04

Description: Understanding ray optics and detecting a common misconception.

Question

An image is formed by a converging lens. Suppose the bottom half of the lens in covered, as shown.



What happens to the image?

1. The image disappears.
2. The image fades.
3. The image rotates.
4. The image moves relative to the lens.
5. The top half of the image disappears.
6. The bottom half of the image disappears.
7. Nothing.
8. None of the above.

Commentary

Purpose: To develop your understanding of ray optics, and confront a common misconception.

Discussion: Pick any point on the source object. Light emanates from that point in all directions. In some directions, it strikes the lens and is refracted as it passes through the front and rear surfaces. All the light from this one point that passes through the lens converges again and passes through one point on the other side of the lens, before continuing on in different directions and spreading out again. This point of convergence is the *real image* of that point on the source object, and if you put a projection screen there, you will see an image of the point. The images of adjacent points on the source object occur adjacent to each other in the image plane, creating an image of the entire source object.

Not all the light from the source point reaches that image point; only light that passes through the lens does. If the lens is made larger, more light is refracted to the image point, and the image appears brighter. If the lens is made smaller, less light is refracted, and the image appears dimmer.

If half the lens is covered, only half as much light from any source point reaches its image point, so the image fades (becomes less bright). But some light from every source point still gets to its corresponding image point, bent through the unobscured half of the lens, so the entire image is still visible. Thus, answer (2) is best.

Key Points:

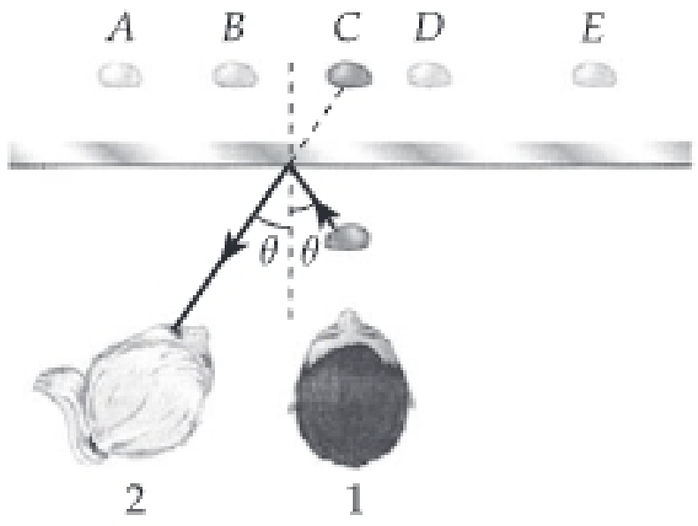
- Light from each point on a source object passes through every part of a lens on its way to the image point.
- The diameter of a lens affects the brightness of the image it creates: the larger the lens, the more light it can capture and bend, and the brighter the image.

For Instructors Only

Students very often think that half the image disappears. Others, accustomed to drawing the three "principal rays" to locate images, think that if one or more of the principal rays are disrupted, the image will disappear.

QUICK QUIZZES

1. At C.



2. (c). Since $n_{water} > n_{air}$, the virtual image of the fish formed by refraction at the flat water surface is closer to the surface than is the fish. See Equation (23.9).

3. **(a)** False. A concave mirror forms an inverted image when the object distance is greater than the focal length.

(b) False. The magnitude of the magnification produced by a concave mirror is greater than 1 if the object distance is less than the radius of curvature.

(c) True.

4. (b). In this case, the index of refraction of the lens material is less than that of the surrounding medium. Under these conditions, a biconvex lens will be divergent.

5. Although a ray diagram only uses 2 or 3 rays (those whose direction is easily determined using only a straight edge), an infinite number of rays leaving the object will always pass through the lens.

6. **(a)** False. A virtual image is formed on the left side of the lens if $p < f$.