Module 3 · Lesson

Ray Optics

PH11-10

ORIENTATION

Lesson goal: use ray diagrams and thin-lens relationships to predict image location, size, orientation, and type.

The main discipline is to make the diagram and calculation agree. A ray diagram is evidence, not decoration.

CORE CONTENT

The ray model approximates light as travelling in straight-line paths through a uniform medium. Thin-lens and mirror equations are useful when the paraxial approximation is reasonable: rays stay close to the principal axis and angles are small.

Key equations:

$$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}$$

$$m = \frac{h_i}{h_o} = -\frac{d_i}{d_o}$$

EVIDENCE	MEANING
real image	rays physically converge and image can be projected on a screen
virtual image	rays appear to diverge from a point and cannot be projected
negative magnification	inverted image in the chosen convention
$\lvert m \rvert > 1$	image is larger than object

CONCEPT CHECK

1. In a thin-lens ray diagram, a ray through the optical centre is usually drawn:

   - A. as strongly curved
   - B. approximately straight
   - C. parallel then stopped
   - D. backwards only

   Answer: B.

2. A real image can be:

   - A. projected onto a screen
   - B. seen only by extending imaginary rays
   - C. formed without any light rays
   - D. created only by a plane mirror

   Answer: A.

3. If $|m| > 1$, the image is:

   - A. smaller
   - B. the same size
   - C. magnified
   - D. always virtual

   Answer: C.

4. Short response: explain why sign convention must be stated before using the thin-lens equation.

APPLIED PRACTICE

Worked Example

An object is $0.40\ \text{m}$ from a convex lens with focal length $0.15\ \text{m}$. Find the image distance.

1. State the equation:

$$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}$$

2. Substitute:

$$\frac{1}{0.15} = \frac{1}{0.40} + \frac{1}{d_i}$$

3. Solve:

$$6.667 = 2.500 + \frac{1}{d_i}$$

$$d_i = 0.240 \text{ m}$$

Final answer: the image forms 0.240 m on the opposite side of the lens. With this convention it is a real image.

Practice Problem

An object is 0.30 m from a convex lens with focal length 0.10 m. Calculate image distance and magnification, then state whether your ray diagram should show a real or virtual image.

DEEP PRACTICE AND WRITING

Prompt: evaluate whether a thin-lens model is adequate for a classroom lens experiment. Your answer must mention the paraxial approximation and one source of image error.

Strong response pattern:

1. identify the model,
2. state the useful assumption,
3. identify a limitation,
4. judge whether the model is sufficient for the given purpose.

MAINTENANCE LOOP

Fast retrieval:

1. A real image can be projected on a _____.
2. $|m| > 1$ means the image is _____.
3. The thin-lens equation should be used only after stating the _____.

STUDENT WORKING