GEOMETRIC OPTICS DAY 9: LENS EQUATION AND TWO-ELEMENT SYSTEMS

CED 13.4 · Skill 2.B · FRQ: MR

PREDICT AT 2F

An object is placed at $2f$ of a converging lens. Predict the image position and size: **at f / at 2f / at infinity** and **reduced / same size / enlarged**.

ONE-LENS EQUATIONS

$$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i} \qquad m = -\frac{d_i}{d_o} = \frac{h_i}{h_o}$$

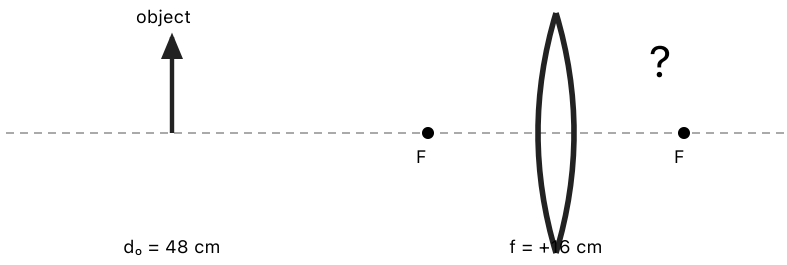
Sign	Meaning
$f > 0$	converging lens
$f < 0$	diverging lens
$d_i > 0$	real image on far side
$d_i < 0$	virtual image on object side

NOTES / REASONING

SINGLE-LENS EXAMPLE

WE DO A converging lens has $f = +16\,\text{cm}$. An $8.0\,\text{cm}$ object is $48\,\text{cm}$ away. Find d_i, m, h_i, and the image description.

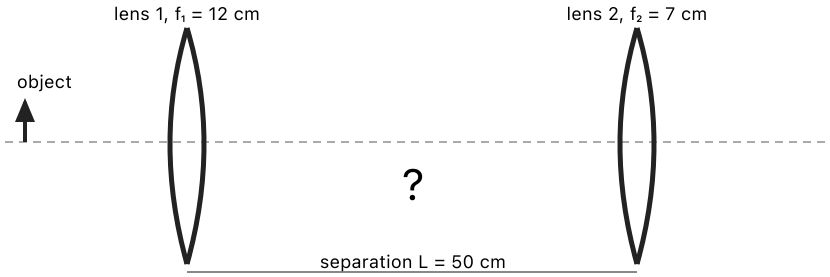
COMPLETE THE CONSTRUCTION AFTER CALCULATING



Add the principal rays and image only after committing to the signs. The equation and diagram must agree on image side, orientation, and relative size.

TWO-LENS METHOD

PLACE EACH CALCULATED IMAGE ON THE COMMON AXIS



1. Solve lens 1 for d_{i1} and m_1.
2. Place image 1 on the common axis.
3. For lenses separated by L, calculate $d_{o2} = L - d_{i1}$.
4. Solve lens 2; then $m_{\text{total}} = m_1 m_2$.

Use the diagram values: $f_1 = 12\,\text{cm}$, $d_{o1} = 18\,\text{cm}$, $L = 50\,\text{cm}$, and $f_2 = 7.0\,\text{cm}$. Find both image distances and m_{total}, then draw both images on the axis.

PRACTICE

1. A diverging lens has $f = -16\,\text{cm}$ and $d_o = 32\,\text{cm}$. Find d_i and m.

2. In the worked two-lens system, state the orientation and size factor of the final image relative to the original object.

3. Explain what a negative d_{o2} would mean in a two-lens calculation.

4. State one check that could reveal an incorrect intermediate-image sign before the final answer is submitted.