Lecture Supplement 13

Another Example (Single Refracting Surfaces)

Find and describe the final image produced by the 50 cm long glass rod having index \( n = 1.5 \). Let and has \( |R| = 5 \) cm.

What will you do??

SOLN.

START AT SOURCE! Light rays first go through surface (1) and then through surface (2) and then into the eye. Use the mnemonic of single surface eq'n as discussed.

For surface (1)  

\[
\frac{n}{s} + \frac{n'}{s'} = \frac{n'-n}{R} \\
\]

DROP UNITS TEMPORARILY

\[
\frac{1}{20cm} + \frac{1.5}{s'} = \frac{1.5-1}{+5cm} \\
\Rightarrow \frac{1.5}{s'} = -0.05 + 1 = 0.95 \\
\Rightarrow s' = \frac{1.5}{0.05} = 30 \text{ cm} \\
\text{image is on same side as refracted rays (and is real)} \\
\]

\[m_1 = -\frac{n's'}{n's} = -1(30cm) = -1 \leftrightarrow - \text{- sign means image is inverted}
\]

For surface (2) Image of 1st surface acts as object for 2nd surface. Correct object dist = 50 cm - 30 cm = 20 cm.

For surface (2)  

\[
\frac{n}{s} + \frac{n'}{s'} = \frac{n'-n}{R} \\
\]

FOR PLANE SURFACE, \( R \rightarrow \infty \) and \( \frac{n'-n}{R} \rightarrow 0 \)

\[
\Rightarrow \frac{n}{s} + \frac{n'}{s'} = 0 \\
\]

Now plug in:  

\[
\frac{1.5}{20cm} + \frac{1}{s'} = 0 \Rightarrow \frac{1}{s'} = -\frac{1.5}{20cm} \Rightarrow s' = -\frac{20}{1.5} \Rightarrow s' = -13.3 \text{ cm}
\]

\[m_2 = -\frac{n's'}{n's} = -1(13.3cm) = -1 \]

Note final magnification \( m_{\text{final}} = m_1m_2 \)

\[\text{[since } m_1 = \frac{y'}{y} \text{ AND } m_2 = \frac{y_2'}{y_2} \text{ AND } m_{\text{final}} = \frac{y_2'}{y_2} \]

\[m_{\text{final}} = m_1m_2 = -1(1) = -1 \]

Hence, the eye will see the final image 13.3 cm to the left of surface (2). It is inverted, virtual, \& the same size as the original object.