Ray optics - 12

Shift From Glass Slab

\[ \mu = \frac{x}{x'} \]

1st surface:

\[ \frac{n_2}{n_1} = \frac{d}{d'} \]

\(d, d'\) measured from 1st

\[ \mu = \frac{x}{x'} \]

\[ x' = \mu x \text{ at } I_1 \]

2nd surface:

\[ \frac{n_2}{n_1} = \frac{d}{d'} \]

\(d, d'\) measured from 2nd

\[ \mu = \frac{t + x'}{d'} \]

\[ d' = \frac{t + x'}{\mu} = \frac{t + ux}{\mu} \]
Shift: \((x+t) = \left(\frac{t+ux}{u}\right)\)

\[= \frac{ux + ut - t - ux}{u}\]

\[= t \left(\frac{u-1}{u}\right)\]

When surrounding medium is air

if surrounding medium is different.

### Table

<table>
<thead>
<tr>
<th>Surrounding Medium</th>
<th>Shift = (t \left(1 - \frac{\text{usurrounding}}{u_{\text{slab}}}\right))</th>
</tr>
</thead>
</table>

### Conditions:
1. Rays should be paraxial
2. Medium should be same on both sides of slab
3. Shift is independent of object’s distance
4. If \(S = +ve\) \(\rightarrow\) in direction of incident Ray
   \(S = -ve\) \(\rightarrow\) in direction opp to incident Ray
(Q1)

\[ u = 1 \quad M = 1.5 \quad a \quad d = 1 \quad \text{Find shift} \]

\[ \theta \]

\[ \leq 10\text{cm} \]

\[ \leq 15\text{cm} \]

Solution:

\[ \delta = t \left(1 - \frac{u}{M} \right) = 15 \left(1 - \frac{1}{1.5} \right) = 15 \times 0.6 \]

\[ \delta = +5\text{cm} \quad \text{(the means in direction of incident ray)} \]

\[ \theta \]

\[ \leq 5\text{cm} \]

\[ \leq 10\text{cm} \]

\[ \leq 15\text{cm} \]

(02)

\[ M = 2 \quad M = 1.5 \quad M = 2 \quad \text{Find shift} \]

\[ \theta \]

\[ \leq 10\text{cm} \]

\[ \leq 5\text{cm} \]

\[ \leq 15\text{cm} \]

Solution:

\[ \delta = t \left(1 - \frac{M_{\text{surrounding}}}{M_{\text{lab}}} \right) = 15 \left(1 - \frac{2}{1.5} \right) \]

\[ \delta = 15 \times \left(-0.5 \right) = -7.5\text{cm} \quad \text{(the means shift opp to incident ray)} \]
Composite Slabs

Net shift depends only on media at both ends only

The medium in between the slabs & distances between slab doesn't matter.

\[ S = S_1 + S_2 + S_3 \]

\[ S_1 = 30 \left( 1 - \frac{1}{1.5} \right) = 30 \times 0.6666 = +10\text{cm} \]

\[ S_2 = 20 \left( 1 - \frac{1}{2} \right) = 20 \times 0.5 = +10\text{cm} \]

\[ S_3 = 15 \left( 1 - \frac{1}{1.5} \right) = 15 \times 0.6666 = +5\text{cm} \]

Net shift \[ S = S_1 + S_2 + S_3 = 25\text{cm (true)} \]
No. focal length \( f \) becomes virtual object.

\[
f = \frac{1}{u} - \frac{1}{v} = \frac{-100}{40} = \frac{-60}{60}
\]

Now using the mirror formula:

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u = \frac{-100}{60}
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v = \frac{-100}{60}
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After reflection from mirror, Rays will try to reach $I_2$ (120 cm from mirror) but will suffer refraction again from slab $S$ shift.

\[ d = t \left(1 - \frac{1}{u}\right) = 15 \left(1 - \frac{1}{15}\right) = 5 \text{ cm} \]

So final image is at 128 cm from mirror.