For refraction at the first surface with
\( r = \infty \), \( s^{(1)} = 35 \text{ cm} \), \( n_1 = n_{air} = 1 \), \( n_2 = n_g = 2 \),
we have

\[
\frac{\frac{1}{n_1}}{s^{(1)}} + \frac{\frac{1}{n_2}}{s^{(1)}} = \frac{n_2 - n_1}{r} = 0
\]

Thus

\[
s^{(')}(1) = -\left(\frac{n_2}{n_1}\right)s^{(1)} = -2 \times 35 \text{ cm} = -70 \text{ cm}
\]

It is a virtual image at 70 cm to the left of the first surface. As a result, with respect to the second refraction surface, it is a real object with \( s^{(2)} = s^{(')}(1) + d = 80 \text{ cm} \). With \( r = 40 \text{ cm} \), \( n_1 = 2 \), \( n_2 = 1 \)

\[
\frac{\frac{1}{n_1}}{s^{(2)}} + \frac{\frac{1}{n_2}}{s^{(')}(2)} = \frac{n_2 - n_1}{r}
\]

\[
\Rightarrow \frac{2}{80} + \frac{1}{s^{(')}(2)} = \frac{(-1)}{40}
\]

\[
\therefore s^{(')}(2) = -20 \text{ cm}
\]

It is a virtual image at 20 cm to the left of the second refracting surface.
1-(2) \[ \begin{pmatrix} A & B \\ C & D \end{pmatrix} = R_{21} T_{1} R_{10} \]

\[ \begin{pmatrix} 1 & 0 \\ \frac{n_1 - u_2}{n_2 R_2} & \frac{n_1}{n_2} \end{pmatrix} \begin{pmatrix} 1 & d \\ 0 & 1 \end{pmatrix} \begin{pmatrix} 1 & 0 \\ \frac{n_0 - u_1}{n_1 R_1} & \frac{n_0}{u_1} \end{pmatrix} \]

\[ = \begin{pmatrix} 1 & 0 \\ \frac{2-1}{40} & 2 \end{pmatrix} \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix} \begin{pmatrix} 1 & 0 \\ 0 & \frac{1}{2} \end{pmatrix} \]

\[ = \begin{pmatrix} 1 & 0 \\ \frac{1}{40} & 2 \end{pmatrix} \begin{pmatrix} 1 & 5 \\ 0 & \frac{1}{2} \end{pmatrix} \]

\[ = \begin{pmatrix} 1 & 5 \\ \frac{1}{40} & \frac{9}{8} \end{pmatrix} \]

1-(3) \[ S_i = -\frac{A s_0 + B}{C s_0 + D} = -\frac{35 + 5}{\frac{35}{40} + \frac{9}{8}} = -20 \text{ cm}^2 \]
2-(1) With \( s_o = +10 \text{m}, \ R = +20 \text{m}, \)

\[
\frac{1}{s_o} + \frac{1}{s'} = -\frac{2}{R}
\]

\[
\Rightarrow \quad \frac{1}{10} + \frac{1}{s'} = -\frac{2}{20}
\]

\[
\therefore \ \ s' = -5 \text{m}
\]

It is a virtual image at 5 m to the right of the reflecting surface.

From \( m = \frac{y_i}{y_o} = \frac{5}{s} = -\frac{5}{10} = -\frac{1}{2} \)

\[
y_i = m y_o = \left(\frac{1}{2}\right) y_o = +0.25 \text{m}
\]

It has the same orientation as the object.

2-(2) At a distance of 2 m away, the observer now is at 2 m + 5 m = 7 m from the image.

The linear size of \( y_i = 0.25 \text{m}. \) Thus the angular size of \( y_i \) to the observer is

\[
\alpha = \frac{y_i}{7} = \frac{0.25 \text{m}}{7 \text{m}} = \frac{1}{28} \text{ radian}
\]
3 - (1) From Snell's law,
\[ \frac{N_a \sin \theta}{N_g \sin \theta} = \frac{N_a \sin \theta'}{N_g \sin \theta'} \]
and
\[ \frac{N_g \sin \theta''}{N_a \sin \theta''} = \frac{N_g \sin \theta'''}{N_a \sin \theta'''} \]
\[ N_a \sin \theta = 1.5 \]
\[ N_g = 1 \]
For a glass plate with the two side surfaces parallel to each other, we have \( \theta' = \theta'' \).
As a result,
\[ \frac{N_a \sin \theta}{N_g \sin \theta} = \frac{N_g \sin \theta'}{N_a \sin \theta'} = \frac{N_a \sin \theta''}{N_g \sin \theta''} \]
\[ \therefore \theta'' = \theta = 60^\circ \]

3 - (2) The reflected light intensity as a function of wavelength \( \lambda \) is given by
\[ I_{\text{refl}}(\lambda, d) = I_{\text{inc}}(\lambda) \left( 1 - \cos \left( \frac{2\pi \left( \frac{N_a \sin \theta}{N_g \sin \theta'} \right)}{\lambda} \right) \right)^2 \]
The dark lines are those wavelengths \( \lambda \) with
\[ \frac{2\pi \frac{N_a \sin \theta}{N_g \sin \theta'}}{\lambda} = 2\pi m \]
\[ \therefore \lambda = \frac{2d}{m} \sin \theta'' \] \( N_a = \frac{d}{m} \)
In the visible range from 400 nm to 700 nm, we have the dark lines \((T(\lambda, d) = 0)\) at

\[
\lambda = 625.00 \text{ nm} \quad (m = 8)
\]
\[
= 556.56 \text{ nm} \quad (m = 9)
\]
\[
= 500.00 \text{ nm} \quad (m = 10)
\]
\[
= 454.55 \text{ nm} \quad (m = 11)
\]
\[
= 416.67 \text{ nm} \quad (m = 12)
\]

3-(3) When the gap is increased to \(d' = 5005 \text{ nm}\), the dark lines appear at

\[
\lambda' = \frac{d'}{m}
\]

and in the visible range,

\[
\lambda' = 625.62 \text{ nm} \quad (m = 8)
\]
\[
= 556.11 \text{ nm} \quad (m = 9)
\]
\[
= 500.50 \text{ nm} \quad (m = 10)
\]
\[
= 455.00 \text{ nm} \quad (m = 11)
\]
\[
= 417.08 \text{ nm} \quad (m = 12)
\]

The shift in the dark lines is on average

\[
\Delta \lambda = \lambda' - \lambda = \frac{d'}{10} = 0.5 \text{ nm}
\]