An object is placed 30 cm in front of lens A.

(a) Calculate the position of the final image as a distance along the optic axis from lens A. State clearly whether the final image is right or left of lens B.

(b) State whether the final image in (a) is erect or inverted and justify your choice.

(c) If the original object is 1.00 cm high, what is the size of the final image?

(d) State clearly and give your reason whether the final image is real or virtual.

**NOTE:** Signs are important in this problem and sign errors will not be treated as "trivial." In (a) and (c), no credit if a reason for your answer is not given.

\[ f_A = -30 \text{ cm}, \quad f_B = 60 \text{ cm}, \]
\[ \frac{1}{s_A} + \frac{1}{s'_A} = \frac{1}{f_A} \Rightarrow s_A = 30 \text{ cm} \]
\[ s'_A = \left( \frac{1}{f_A} - \frac{1}{s_A} \right)^{-1} = \left( -\frac{1}{30} \right)^{-1} = -180 \text{ cm} \]
\[ s_B = s'_A + 30 \text{ cm} = -150 + 30 = -120 \text{ cm} \]
\[ \frac{1}{s_B} + \frac{1}{s'_A} = \frac{1}{f_B} \Rightarrow \quad s''_B = \left( \frac{1}{s'_B} - \frac{1}{f_B} \right)^{-1} = \frac{180}{60} \text{ cm} \]

**Minus sign:** on the left of lens B

(b) \[ M = m_A \cdot m_B = \left( -\frac{s'_A}{s_B} \right) \cdot \left( -\frac{s''_B}{s'_A} \right) = \frac{1}{2} \times 4 = 2.00 \] positive sign: the image is erect

(c) \[ \frac{5}{2} \text{ points} \quad \frac{\text{image}}{\text{obj}} \Rightarrow \text{image} = m \times \text{obj} = 2 \times 1.00 \text{ cm} = 2.00 \text{ cm} \]

(d) Since the final image distance is a negative number \( (s''_B = -180 \text{ cm}) \), the final image is virtual.

\[ +5 \text{ points} \]