Mass 1 rests on a frictionless inclined plane, supported by a Hooke's law spring of constant k = 111.2 N/m. Mass 2 slides down the plane and collides with 1 and sticks to 1. If the maximum compression of the spring is 35.0 cm from its length just before impact, calculate the distance 2 moves from rest before colliding with 1.

\[ m_1 = 1.25 \text{ kg} \]
\[ m_2 = 0.75 \text{ kg} \]

(i) As \( m_2 \) slides down from the top, gravitational potential energy is transformed into kinetic energy \([\text{no friction!}]:\)

\[ m_2 g \cdot \sin 30^\circ \cdot d = \frac{m_2}{2} v^2 \]

\[ \Rightarrow v^2 / g = d \quad (1) \]

(ii) The subsequent collision with \( m_1 \) is inelastic, i.e., part of the kinetic energy \( \frac{1}{2} m_2 v^2 \) is dissipated. We assume the collision to be instantaneous and hence momentum conservation at the moment of impact applies:

\[ (m_1 + m_2) v' = m_2 v \quad (2) \]

where \( v' \) is the speed of \((m_1 + m_2)\) immediately after the collision.
(iii) The compression \((\Delta x)_1\) of the spring before the collision is given by the balance of forces:

\[ m_1 g \sin \Theta = \frac{m_1 g}{2} = k (\Delta x)_1 \]

With \( m_1 = 1.25 \text{ kg} \) and \( k = 111.2 \text{ N/m} \) we find:

\[ (\Delta x)_1 = 5.508 \text{ cm} \quad (\text{+2}) \quad (3) \]

(iv) After the collision, \((m_1+m_2)\) compresses the spring another distance \((\Delta x)_2 = 35.0 \text{ cm}\). The maximal compression relative the relaxed length of the spring is:

\[ (\Delta x)_{\text{max}} = (\Delta x)_1 + (\Delta x)_2 = 40.508 \quad (4) \]

(v) After the collision we have energy conservation:

\[ \frac{m_1+m_2}{2} (V')^2 + (m_1+m_2) \frac{g}{2} (\Delta x)_2 + \frac{k (\Delta x)^2}{2} = \frac{1}{2} (\Delta x)_{\text{max}}^2 \]

\[ \frac{1}{2} = \sin 30^\circ \]

This equation is solved numerically for \((V')^2\):

\[ (V')^2 = 5.528 \left( \frac{m}{s} \right)^2 \]

\[ \Rightarrow \quad V^2 = \frac{39.28 \left( \frac{m}{s} \right)^2}{\text{eq.}(2)} \]

We substitute this value for \(v^2\) into eq. (1):

\[ d = 4.01 \text{ m} \]