2B. Two particles, one having twice the mass of the other, are held together with a compressed spring between them. The energy stored in the spring is 60 J.

15 marks

(a) How much kinetic energy does each particle have after they are released? Assume that all the stored energy is transferred to the particles and that neither particle is attached to the spring after they are released.

Let the two masses be \( m_1 \) and \( m_2 \), with \( v_1 \) and \( v_2 \) their respective velocities after they are released. Let \( m_1 = m \) and \( m_2 = 2m_1 = 2m \).

Before

\[
\begin{array}{c}
m_1 \quad m_2 \\
\hline
m_1 & m_2
\end{array}
\]

After

\[
\begin{array}{c}
v_1 & v_2 \\
\hline
v_1 & v_2
\end{array}
\]

Conservation of momentum:

\[
P_i = P_f = 0 \Rightarrow m_1 v_1 + m_2 v_2 = 0 \quad (1)
\]

or

\[
3m v_1 + 2m v_2 = 0 \Rightarrow v_1 = -\frac{2}{3} v_2 \quad (2)
\]

Conservation of energy:

\[
\frac{1}{2} m_1 v_1^2 + \frac{1}{2} m_2 v_2^2 = 60 \quad (3)
\]

or

\[
\frac{1}{2} m v_1^2 + \frac{1}{2} (2m) v_2^2 = 60 \quad (4)
\]

or

\[
\frac{1}{2} m (2v_2)^2 + \frac{1}{2} (2m) v_2^2 = 60 \quad (5)
\]

\[
\frac{1}{2} m (4v_2^2) + 3mv_2^2 = 60 \Rightarrow 3mv_2^2 = 60 \quad (6)
\]

\[
\therefore K_2 = \frac{1}{2} m_2 v_2^2 = \frac{1}{2} (2m) v_2^2 = m v_2^2 = \frac{60}{3} = 20 \ J
\]

\[
K_1 = \frac{1}{2} m_1 v_1^2 = \frac{1}{2} m v_1^2 = \frac{1}{2} m 4v_2^2 = 2mv_2^2 = 40 \ J
\]

(a) \( K \) of large mass = 20 J

(b) \( \frac{v \text{ of small mass}}{v \text{ of large mass}} = -2 : 1 \) (from eq. (2))