

Solutions

2.1 $3(4) + 1(1) = 4v$: $v = 3.25 \text{ m s}^{-1}$. KE before = $24 + 0.5 = 24.5 \text{ J}$; after = $\frac{1}{2}(4)(3.25)^2 = 21.125 \text{ J}$; lost = 3.375 J .

2.2 $6 = v_A + v_B$ and $\frac{1}{2}(6) = v_B - v_A$: $v_B = 4.5$, $v_A = 1.5 \text{ m s}^{-1}$ (A still moves forward, slower).

2.3 The loss is zero exactly when $(1 - e^2)(u_A - u_B)^2 = 0$: either $e = 1$ (perfectly elastic) or the particles were already moving together ($u_A = u_B$, no collision).

3.1 (a) Momentum: $2mu = 2mv_P + mv_Q$; restitution: $eu = v_Q - v_P$. Substituting $v_P = v_Q - eu$: $2u = 2v_Q - 2eu + v_Q = 3v_Q - 2eu$, so $v_Q = \frac{2u(1+e)}{3}$ ✓. (b) From (a), $v_P = \frac{2(1+e)u}{3} - eu = \frac{(2-e)u}{3}$. KE after = $\frac{1}{2}(2m) \left(\frac{(2-e)u}{3} \right)^2 + \frac{1}{2}m \left(\frac{2(1+e)u}{3} \right)^2 = \frac{mu^2}{9} [(2-e)^2 + 2(1+e)^2] = \frac{mu^2}{9} (6 + 3e^2) = \frac{mu^2}{3} (2 + e^2)$. Loss = $\frac{1}{2}(2m)u^2 - \frac{mu^2}{3}(2 + e^2) = mu^2 - \frac{2mu^2}{3} - \frac{e^2mu^2}{3} = \frac{1}{3}(1 - e^2)mu^2$, so $k = \frac{1}{3}$ ✓. (c) Impulse on Q = $m\Delta v$: $m \cdot \frac{2(1+e)u}{3} = \frac{8mu}{9} \Rightarrow \frac{2(1+e)}{3} = \frac{8}{9} \Rightarrow 1 + e = \frac{4}{3}$, so $e = \frac{1}{3}$.

3.2 Right positive: momentum $2(5) + 3(-1) = 7 = 2v_A + 3v_B$; restitution $e = \frac{v_B - v_A}{5 - (-1)} = \frac{v_B - v_A}{6} = \frac{1}{4}$, so $v_B = v_A + 1.5$. Then $2v_A + 3v_A + 4.5 = 7$: $v_A = 0.5$, $v_B = 2 \text{ m s}^{-1}$ (both right). KE before = $25 + 1.5 = 26.5 \text{ J}$; after = $0.25 + 6 = 6.25 \text{ J}$; lost = 20.25 J .

Local review guidance: both equations with consistent signs; both speeds fully simplified before any energy statement; loss factorised to show the $(1 - e^2)$ factor. This is authored classroom guidance.