

Solutions

2.1 $p = mv = 1200 \text{ kg} \times 18 \text{ m s}^{-1} = 2.2 \times 10^4 \text{ kg m s}^{-1}$.

2.2 The system starts at rest, so $0 = m_{\text{skater}}v_{\text{skater}} + m_{\text{ball}}v_{\text{ball}}$: $v_{\text{skater}} = -\frac{3.0 \text{ kg} \times 4.0 \text{ m s}^{-1}}{60 \text{ kg}} = -0.20 \text{ m s}^{-1} = 0.20 \text{ m s}^{-1}$ backwards.

2.3 No external force acts on the system (the system is isolated).

2.4 $p_{\text{before}} = p_{\text{after}}$: $2.0 \times 1.5 + 1.0 \times 0.50 = 3.0 V$, so $V = \frac{3.5 \text{ kg m s}^{-1}}{3.0 \text{ kg}} = 1.2 \text{ m s}^{-1}$ forwards.

3.1 A. Take the truck's direction as positive: $2mv - mv = 3mV$, so $V = \frac{v}{3}$. B forgets the mass ratio; C keeps the speed unchanged; D adds the momenta wrongly.

3.2 B. Only on the frictionless track is there no external horizontal force on the pair. A, C and D each have an external force (friction, a component of weight, the falling mass's pull).

3.3 (a) P exerts a force on Q and Q exerts an equal and opposite force on P. (b) Total momentum, because no external force acts on the two gliders. (c) Right positive, P's initial direction: $0.25 \times 0.20 + 0.15 \times (-0.40) = 0.25 \times (-0.10) + 0.15 v_Q$: $0.050 - 0.060 = -0.025 + 0.15 v_Q$, so $v_Q = \frac{0.015}{0.15} = 0.10 \text{ m s}^{-1}$ to the right.

3.4 (a) It is conserved: the forces between the spheres are internal to the system, and no external horizontal force acts. (b) Momentum conservation requires the outgoing momentum to equal A's incoming momentum. Kinetic energy conservation then requires $\frac{1}{2}mv^2$ to match as well; two equal spheres at half the speed would conserve momentum but carry only half the kinetic energy, so the only solution satisfying both is one sphere leaving at (almost) the same speed.