Momentum, Impulse & Collisions

Momentum · 8 questions · step-by-step answers at the end

Name: Date: Score: / 8

USEFUL EQUATIONS

P = m**V** **J** = $\mathbf{F}_{\text{avg}}\Delta t = \Delta\mathbf{P}$ $m_1v_1 + m_2v_2 = m_1v_1' + m_2v_2'$ $v' = (m_1v_1 + m_2v_2)/(m_1 + m_2)$

$v_{\text{cm}} = \Sigma m_i v_i \,/\, \Sigma m_i$

Questions

Show your working in the space under each question.

1. A 0.15 kg ball arrives at 40 m/s and leaves the bat at 50 m/s in the opposite direction. The contact lasts 1.2 ms. Find the impulse and the average force.

2. A 2.0 kg cart moving at 3.0 m/s hits a 1.0 kg cart at rest, and they stick together. Find their final speed and the kinetic energy lost.

3. A 60 kg skater at rest throws a 2.0 kg ball forward at 15 m/s. What is her recoil speed?

4. A force on a 0.15 kg ball rises linearly from 0 to 600 N and back to 0 over 0.020 s. Find the ball's speed if it started at rest.

5. A moving ball hits an identical ball at rest head-on in an elastic collision. What happens?

6. A 3 kg object at 4 m/s (east) collides elastically with a 1 kg object at rest. Find both final velocities.

7. Why don't we conserve momentum for a ball falling toward Earth alone?

8. A stationary 5 kg shell explodes into 2 kg (moving at 9 m/s east) and 3 kg pieces. Find the velocity of the 3 kg piece.

Step-by-step answers

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1. $J = m\Delta v = 0.15(50 - (-40)) = \mathbf{13.5\ N{\cdot}s}$; $F = J/\Delta t = 13.5/0.0012 \approx \mathbf{1.1 \times 10^4\ N}$.

2. 1. Momentum before: (2.0)(3.0) + (1.0)(0) = 6.0 kg·m/s.
2. After (stuck together): $(3.0)v' = 6.0 \rightarrow v' = \mathbf{2.0\ m/s}$.
3. KE before = ½(2.0)(3.0)² = 9.0 J. KE after = ½(3.0)(2.0)² = 6.0 J.
4. Lost: **3.0 J** (a third), which became heat, sound and deformation.

Answer: v′ = 2.0 m/s; 3.0 J of KE lost

3. $0 = 2.0(15) + 60v \rightarrow v = \mathbf{-0.50\ m/s}$ (backward).

4. $J = ½(600)(0.020) = 6.0$ N·s; $v = 6.0/0.15 = \mathbf{40\ m/s}$.

5. They **swap velocities**: the first stops and the second moves off at the original speed.

6. $v_1' = (3 - 1)/(4)\cdot 4 = \mathbf{2\ m/s}$; $v_2' = 2(3)/4\cdot 4 = \mathbf{6\ m/s}$, both east.

7. Gravity is an **external** force on the ball, so its momentum grows. Include Earth in the system and the total is conserved.

8. $0 = 2(9) + 3v \rightarrow v = \mathbf{-6\ m/s}$ (6 m/s west).