Conservation of Momentum

Universal Solution Method Examples

Equations

$p = p'$ • momentum before an event = momentum after event [conservation of momentum]
$p_1 + p_2 = p_1' + p_2'$ • momentum of two objects before an event = momentum of two objects after event [conservation of momentum]
$m_1v_1 + m_2v_2 = m_1v_1' + m_2v_2'$ • conservation of momentum applied to two bodies in one dimension.

Universal Solution Method Examples

1. William Tell fires a 0.1 kg arrow at a 1.2 kg block of wood on his son's head. If the arrow hits the block at 50 m/s and sticks into it and the son's head is frictionless, how fast will the arrow/block combination travel directly thereafter?

LIST: $m_1 = 0.1\ kg \quad m_2 = 1.2\ kg \quad v_1 = 50\ m/s \quad v_2 = 0$

DON'T THINK:
$p = p'$
$p_1 + p_2 = p_1' + p_2'$
$m_1v_1 + m_2v_2 = m_1v_1' + m_2v_2'$

THINK: $v_2 = 0$, Inelastic collision: final speeds are the same: $v_1' = v_2' = v'$

APPLY:
$m_1v_1 + 0 = m_1v' + m_2v'$
$m_1v_1 = (m_1 + m_2)v'$

SOLVE v':
$v' = m_1v_1 / (m_1 + m_2)$
$v' = (0.1\ kg \cdot 50\ m/s) / (0.1kg + 1.2kg)$
$\underline{v' = 3.8\ m/s}$

2. A 2 kg pumpkin is bowled at 6 m/s across a frozen pond ($\mu = 0$). Shortly after its release, an explosion within causes the pumpkin to separate into a 1.5 kg piece and a 0.5 kg piece. If the 1.5 kg piece continues forward at 3 m/s, what is the final speed of the 0.5 kg piece?

LIST: $m_1 = 1.5\ kg \quad m_2 = 0.5\ kg \quad v_1 = v_2 = 6\ m/s \quad v_1' = 3\ m/s \quad v_2' = ?$

DON'T THINK:
$p = p'$
$p_1 + p_2 = p_1' + p_2'$
$m_1v_1 + m_2v_2 = m_1v_1' + m_2v_2'$

THINK: Explosion—initial speeds are equal: $v_1 = v_2 = v$

APPLY:
$m_1v + m_2v = m_1v_1' + m_2v_2'$
$(m_1 + m_2)v = m_1v_1' + m_2v_2'$

SOLVE v_2':
$m_2v_2' = (m_1 + m_2)v - m_1v_1'$
$v_2' = ((m_1 + m_2)v - m_1v_1') / m_2$
$v_2' = ((1.5\ kg + 0.5\ kg)\ 6\ m/s - 1.5\ kg \cdot 3\ m/s)/(0.5\ kg)$
$\underline{v_2' = 15\ m/s}$

3. A dynamics cart collides and sticks to a cart initially at rest. The moving cart had a mass of 1.25 kg and stationary cart had a mass of 0.75 kg. After the collision, the two carts move at 0.58 m/s. What was the initial speed of the moving cart?

LIST: $m_1 = 1.25\ kg \quad m_2 = 0.75\ kg \quad v_1 = ? \quad v_2 = 0 \quad v' = 0.58\ m/s$

DON'T THINK:
$p = p'$
$p_1 + p_2 = p_1' + p_2'$
$m_1v_1 + m_2v_2 = m_1v_1' + m_2v_2'$

THINK: $v_2 = 0$, Inelastic Collision—final speeds are equal: $v_1' = v_2' = v'$

APPLY:
$m_1v_1 + 0 = m_1v' + m_2v'$
$m_1v_1 = v'(m_1 + m_2)$

SOLVE v_1:
$v_1 = v'(m_1 + m_2) / m_1$
$v_1 = 0.58\ m/s\ (1.25\ kg + 0.75\ kg) / 1.25\ kg$
$v_1 = 0.93\ m/s$

4. Snoopy rides a wagon at 4.3 m/s along a level sidewalk and then jumps forward off the wagon. Snoopy's mass is 2.4 kg and the wagon comes to a complete stop when Snoopy jumps forward. If Snoopy flies through the air at 6.7 m/s, what was the mass of the wagon?

LIST: $m_1 = 2.4\ kg \quad m_2 = ? \quad v = 4.3\ m/s \quad v_1' = 6.7\ m/s \quad v_2' = 0$

DON'T THINK:
$p = p'$
$p_1 + p_2 = p_1' + p_2'$
$m_1v_1 + m_2v_2 = m_1v_1' + m_2v_2'$

THINK: $v_2' = 0$, Explosion—initial speeds are the same: $v_1 = v_2 = v$

APPLY:
$m_1v + m_2v = m_1v_1' + 0$

SOLVE m_2:
$m_2v = m_1v_1' - m_1v$
$m_2v = m_1 (v_1' - v)$
$m_2 = m_1 (v_1' - v) / v$
$m_2 = 2.4\ kg\ (6.7\ m/s - 4.3\ m/s) / 4.3\ m/s$
$\underline{m_2 = 1.4\ kg}$