Conservation of Momentum WS 58

1) Ball

$m_1 = 0.50\ kg$

$V_1 = 21.0\ \frac{m}{s}$

Bottle

$m_2 = 0.20\ kg$

$V_2 = 0\ \frac{m}{s}$ $\quad V_2' = 30.0\ \frac{m}{s}$

What is V_1', the velocity of the ball after the impact?

Consider this as an elastic collision, so

$$m_1 V_1 + m_2 V_2 = m_1 V_1' + m_2 V_2'$$

↑ solve for V_1'

$$V_1' = \frac{(m_1 V_1 + m_2 V_2) - m_2 V_2'}{m_1}$$

$$V_1' = \frac{\left(0.50\ kg \cdot 21.0\frac{m}{s} + 0.20\ kg \cdot 0\ \frac{m}{s}\right) - \left(0.20\ kg \cdot 30\ \frac{m}{s}\right)}{0.50\ kg}$$

$$V_1' = \frac{\left(10.5\ kg\frac{m}{s} - 6\ kg\frac{m}{s}\right)}{0.50\ kg}$$

$$V_1' = \frac{4.5\ kg\frac{m}{s}}{0.50\ kg} = \boxed{9.0\ \frac{m}{s}}$$

Conservation of Momentum WS5B

2) Ball Pin

$m_1 = 7.0\ Kg$ $m_2 = 2.0\ Kg$ $V_2' = 14.0 \frac{m}{s}$

$V_1 = 9.0 \frac{m}{s}$ $V_2 = 0 \frac{m}{s}$

What is V_1', the velocity of the ball after the impact? Consider this as an elastic collision, so

$m_1V_1 + m_2V_2 = m_1V_1' + m_2V_2'$

↑ solve for V_1'

$$V_1' = \frac{(m_1V_1 + m_2V_2) - m_2V_2'}{m_1}$$

$$V_1' = \frac{\left((7.0\,Kg \cdot 9.0 \frac{m}{s}) + (2.0\,Kg \cdot 0 \frac{m}{s})\right) - (2.0\,Kg \cdot 14.0 \frac{m}{s})}{7.0\,Kg}$$

$$V_1' = \frac{\left(63\ Kg\frac{m}{s} - 28\ Kg\frac{m}{s}\right)}{7.0\,Kg}$$

$$V_1' = \frac{35\ Kg\frac{m}{s}}{7.0\,Kg} = 5.0 \frac{m}{s}$$

Conservation of Momentum WS 5b

3) Alban Nick

$m_1 = 45.0\ Kg$ $m_2 = 90.0 Kg$ $V_2' = +1.0 \frac{m}{s}$

$V_1 = -2.0 \frac{m}{s}$ $V_2 = +7.0 \frac{m}{s}$

What is V_1', the velocity of Alban after the impact?

Consider this as an elastic collision, so

$$m_1 V_1 + m_2 V_2 = m_1 V_1' + m_2 V_2'$$

↑ solve for V_1'

$$V_1' = \frac{(m_1 V_1 + m_2 V_2) - m_2 V_2'}{m_1}$$

$$V_1' = \frac{\left(45.0 Kg \cdot -2.0 \frac{m}{s}\right) + \left(90.0 Kg \cdot 7.0 \frac{m}{s}\right) - \left(90.0 Kg \cdot 1.0 \frac{m}{s}\right)}{45.0 Kg}$$

$$V_1' = \frac{\left(-90.0 Kg\frac{m}{s} + 630 Kg\frac{m}{s}\right) - 90.0 Kg\frac{m}{s}}{45.0 Kg}$$

$$V_1' = \frac{450 Kg\frac{m}{s}}{45.0 Kg} = 10 \frac{m}{s}$$

4) Job

$m_1 = 75.0\ Kg$

$\vec{v}_1 = -3.0 \frac{m}{s}$

Megan

$m_2 = 60.0\ Kg$

$\vec{v}_2 = -5.0 \frac{m}{s}$

What is $\vec{v}_{1+2}$, the combined velocity of the two after impact?

Consider this as an inelastic collision, so $m_1\vec{v}_1 + m_2\vec{v}_2 = (m_1 + m_2)\vec{v}_{1+2}$

solve for $\vec{v}_{1+2}$

$$\vec{v}_{1+2} = \frac{m_1\vec{v}_1 + m_2\vec{v}_2}{(m_1 + m_2)} = \frac{\left(\left(75.0\ Kg \cdot -3.0 \frac{m}{s}\right) + \left(60.0\ Kg \cdot -5.0 \frac{m}{s}\right)\right)}{(75.0\ Kg + 60.0\ Kg)}$$

$$\frac{\left(-225\ Kg\frac{m}{s} - 300\ Kg\frac{m}{s}\right)}{135\ Kg} =$$

$$\frac{-525\ Kg\frac{m}{s}}{135\ Kg} = \boxed{-3.9 \frac{m}{s}}$$

5)

A) Bullet: $m_1 = 0.020\ kg$, $V_1 = 200\ \frac{m}{s}$ — Wood: $m_2 = 0.30\ kg$, $V_2 = 0\ \frac{m}{s}$

What is $\vec{V}_{1+2}$, the combined velocity of the bullet and wood after impact? Consider this as an inelastic collision, so $m_1 V_1 + m_2 V_2 = (m_1 + m_2)\vec{V}_{1+2}$ ↑ solve for $\vec{V}_{1+2}$

$$\vec{V}_{1+2} = \frac{m_1 \vec{V}_1 + m_2 \vec{V}_2}{(m_1 + m_2)} = \frac{\left((0.020\ kg \cdot 200\ \frac{m}{s}) + (0.30\ kg \cdot 0\ \frac{m}{s})\right)}{(0.020\ kg + 0.30\ kg)}$$

$$\vec{V}_{1+2} \quad \frac{4\ kg\ \frac{m}{s}}{0.32\ kg} = 12.5\ \frac{m}{s}$$

B) Recoil?

Bullet: $m_1 = 0.020\ kg$, $V_1 = 200\ \frac{m}{s}$, $V_1' = 0\ \frac{m}{s}$ — Gun: $m_2 = 6.0\ kg$, $V_2 = 0\ \frac{m}{s}$, $V_2' = ?$

Elastic, so $m_1 V_1 + m_2 V_2 = m_1 V_1' + m_2 V_2'$

$$V_2' = \frac{(m_1 V_1 + m_2 V_2) - m_1 V_1'}{m_2} = \frac{(0.020\ kg \cdot 0\ \frac{m}{s} + 6.0\ kg \cdot 0\ \frac{m}{s}) - (0.020\ kg \cdot 200\ \frac{m}{s})}{6.0\ kg}$$

$$= -0.67\ \frac{m}{s}$$

Conservation of Momentum WS-58

6)

Isko	Camera	
$m_1 = 68\,kg$	$m_2 = 2.0\,kg$	$V_{1+2} = 0\,\frac{m}{s}$
$V_1 = ?$	$V_2 = 12\,\frac{m}{s}$	

A) $m_1V_1 + m_2V_2 = (m_1 + m_2)\cdot V_{1+2}$ $\quad V_{1+2} = 0$, so

$m_1V_1 + m_2V_2 = 0$

$V_1 = \frac{-m_2V_2}{m_1} = \frac{(-2.0\,kg \cdot 12\,\frac{m}{s})}{68\,kg} = -0.35\,\frac{m}{s}$

B) $r \cdot t = d$, so $t = \frac{d}{r} = \frac{15.0\,m}{0.35\,\frac{m}{s}} = 43\,s$

Conservation of Momentum WS-5B

7) Moose

$m_1 = 620\ kg$

$v_1 = 0\ \frac{m}{s}$

Locomotive

$m_2 = 10{,}000\ kg$

$v_2 = 10.0\ \frac{m}{s}$

This is an inelastic collision, so

$$m_1 v_1 + m_2 v_2 = (m_1 + m_2) \cdot v_{1+2}$$

↑ solve

$$v_{1+2} = \frac{(m_1 v_1 + m_2 v_2)}{(m_1 + m_2)} = \frac{(620\ kg \cdot 0\ \frac{m}{s} + 10000\ kg \cdot 10.0\ \frac{m}{s})}{(620\ kg + 10000\ kg)}$$

$$= \frac{100{,}000\ kg\ \frac{m}{s}}{10620\ kg}$$

$$\vec{v}_{1+2} = 9.42\ \frac{m}{s}$$

Conservation of Momentum WS-5B

8) Genevieve
$m_1 = ?$
$v_1 = 2.0 \frac{m}{s}$

Skateboard
$m_2 = 4.0\ kg$
$v_2 = 15.5 \frac{m}{s}$

$\vec{v}_{1+2} = 3.0 \frac{m}{s}$

Inelastic, so

$$m_1 v_1 + m_2 v_2 = (m_1 + m_2) \cdot \vec{v}_{1+2}$$

↑ solve

$$m_1 = \frac{\left((m_1 + m_2) \cdot \vec{v}_{1+2}\right) - m_2 v_2}{v_1}$$

$m_1 = ($

Physics 1P — Traeger

Momentum Problem Set 32-34, 42-49, 69-71

32) $m_1 = 35\,Kg$ $m_2 = 57\,Kg$ + = East

$v_1 = +3.7\,\frac{m}{s}$ $v_2 = -4.3\,\frac{m}{s}$ − = west

Total Momentum $= m_1 v_1 + m_2 v_2$

$(35\,Kg \cdot 3.7\,\frac{m}{s}) + (57\,Kg \cdot -4.3\,\frac{m}{s}) = 129.5\,Kg\frac{m}{s} + (-245.1\,Kg\frac{m}{s})$

$p_{total} = -115.6\,Kg\frac{m}{s}$

33) $m_1 = 35\,Kg$ $m_2 = 57\,Kg$ + = North

$v_1 = 3.7\,\frac{m}{s}$ $v_2 = -4.3\,\frac{m}{s}$ − = South

$(35\,Kg \cdot 3.7\,\frac{m}{s}) + (57\,Kg \cdot -4.3\,\frac{m}{s}) = -115.6\,Kg\frac{m}{s}$

34) $m_1 = 12\,Kg$ $m_2 = 25\,Kg$ $m_3 = 1\,Kg$ + = East

$v_1 = 120\,\frac{m}{s}$ $v_2 = -18\,\frac{m}{s}$ $v_3 = 350\,\frac{m}{s}$ − = west

$(12\,Kg \cdot 120\,\frac{m}{s}) + (25\,Kg \cdot -18\,\frac{m}{s}) + (1\,Kg \cdot 350\,\frac{m}{s}) = 1340\,Kg\frac{m}{s}$

42) $m_1 = 85\,Kg$ $m_2 = 110\,Kg$

$v_1 = 4\,\frac{m}{s}$ $v_2 = -7\,\frac{m}{s}$

$m_1 v_1 + m_2 v_2 = (m_1 + m_2) v_{1+2} \therefore v_{1+2} = \frac{(m_1 v_1 + m_2 v_2)}{(m_1 + m_2)}$

$v_{1+2} = \frac{((85\,Kg \cdot 4\,\frac{m}{s}) + (110\,Kg \cdot -7\,\frac{m}{s}))}{(85\,Kg + 110\,Kg)} = \frac{-430\,Kg\frac{m}{s}}{195\,Kg} =$

$= -2.2\,\frac{m}{s}$

43) $m_1 = 0.55\,Kg$ $m_2 = 0.45\,Kg$ $V_{1+2} = ?$

$V_1 = 5.8\,\frac{m}{s}$ $V_2 = -3.9\,\frac{m}{s}$

$m_1 V_1 + m_2 V_2 = (m_1 + m_2) V_{1+2}$

$V_{1+2} = \frac{(m_1 V_1 + m_2 V_2)}{(m_1 + m_2)} = \frac{((0.55\,Kg \cdot 5.8\frac{m}{s}) + (0.45\,Kg \cdot -3.9\frac{m}{s}))}{(0.55\,Kg + 0.45\,Kg)}$

$V_{1+2} = 1.44\,\frac{m}{s}$

44) $m_1 = 0.25\,Kg$ $m_2 = 0.45\,Kg$

$V_1 = 3.4\,\frac{m}{s}$ $V_2 = -3.9\,\frac{m}{s}$ $V_{1+2} = ?$

$m_1 V_1 + m_2 V_2 = (m_1 + m_2) V_{1+2}$

$V_{1+2} = \frac{(m_1 V_1 + m_2 V_2)}{(m_1 + m_2)} = \frac{((0.25\,Kg \cdot 3.4\frac{m}{s}) + (0.45\,Kg \cdot -3.9\frac{m}{s}))}{(0.25\,Kg + 0.45\,Kg)}$

$V_{1+2} = -1.29\,\frac{m}{s}$

45) $m_1 = 15000\,Kg$ $m_2 = 21000\,Kg$

$V_1 = 12\,\frac{m}{s}$

$V_f = \frac{(m_1 V_1)}{(m_1 + m_2)} = \frac{(15000\,Kg \cdot 12\frac{m}{s})}{(15000\,Kg + \cancel{21000}\ 6000\,Kg)} = 8.57\,\frac{m}{s}$

46) $m_1 = 55\,Kg$ $m_2 = 3\,Kg$ $V_{1+2} = ?$

$V_1 = 0\ \frac{m}{s}$ $V_2 = 8\ \frac{m}{s}$

$m_1 V_1 + m_2 V_2 = (m_1 + m_2) \cdot V_{1+2}$

$$V_{1+2} = \frac{(m_1 V_1 + m_2 V_2)}{(m_1 + m_2)} = \frac{((55\,Kg \cdot 0\ \frac{m}{s}) + (3\,Kg \cdot 8\ \frac{m}{s}))}{(55\,Kg + 3\,Kg)} =$$

$$V_{1+2} = -0.414\ \frac{m}{s}$$

47) $m_1 = 0.015\,Kg$ $m_2 = 1.5\,Kg$

$V_1 = 500\ \frac{m}{s} - 400\ \frac{m}{s} = 100\ \frac{m}{s}$ $V_2 = 0\ \frac{m}{s}$

$$V_{1+2} = \frac{(m_1 V_1 + m_2 V_2)}{(m_1 + m_2)} = \frac{(0.015\,Kg \cdot 100\ \frac{m}{s}) + (1.5\,Kg \cdot 0\ \frac{m}{s}))}{(0.015\,Kg + 1.5\,Kg)}$$

~~$V_{1+2} = 4.95\ \frac{m}{s}$~~

$V_1 + V_2 = V_f$ ~~$\therefore V_2 = V_f - V_1 = 4.95\ \frac{m}{s} - 400\ \frac{m}{s}$~~

~~$V_2 = 395$~~

$$V_{1+2} = 1\ \frac{m}{s}$$

48) $m_1 = 40\,Kg$ $m_2 = 20\,Kg$ $V_{1+2} = 8\ \frac{m}{s}$

$V_1 = 3\ \frac{m}{s}$ $V_2 = ?$

$m_1 V_1 + m_2 V_2 = (m_1 + m_2) \cdot V_{1+2}$

solve for V_2 ↑

$$V_2 = \frac{(m_1 + m_2) \cdot V_{1+2} - m_1 V_1}{m_2}$$

$$V_2 = \frac{((40\,Kg + 20\,Kg) \cdot 8\ \frac{m}{s}) - (40\,Kg \cdot 3\ \frac{m}{s})}{20\,Kg} =$$

$$V_2 = 18\ \frac{m}{s}$$

49) $m_1 = 40\,Kg$ $m_2 = 20\,Kg$ $V_{1+2} = 8\,\frac{m}{s}$

$V_1 = -3\,\frac{m}{s}$ $V_2 = ?$

$m_1 V_1 + m_2 V_2 = (m_1 + m_2) \cdot V_{1+2}$

$$V_2 = \frac{(m_1 + m_2) \cdot V_{1+2} - m_1 V_1}{m_2}$$

$$V_2 = \frac{(40\,Kg + 20\,Kg) \cdot 8\,\frac{m}{s} - (40\,Kg \cdot -3\,\frac{m}{s})}{20\,Kg}$$

$$V_2 = 30\,\frac{m}{s}$$

69) $m_1 = 0.45\,Kg$ $m_2 = 0.95\,Kg$

$V_1 = 3.4\,\frac{m}{s}$ $V_2 = -4.9\,\frac{m}{s}$

$m_1 V_1 + m_2 V_2 = m_1 V_1' + m_2 V_2'$

$$V_1 = \frac{(m_1 V_1 + m_2 V_2) - m_2 V_2'}{m_1}$$

$\frac{1}{2} m_1 V_{1_0}^2 + \frac{1}{2} m_2 V_{2_0}^2 = \frac{1}{2} m_1 V_{1f}^2 + \frac{1}{2} m_2 V_{2f}^2$

Should have assigned 58-64.