Exercise 3: Page 64

1. $\sum p_{before} = \sum p_{after}$ $\rightarrow +$
$m_1v_{1i} + m_2v_{2i} = m_1v_{1f} + m_2v_{2f}$
$2(5) + (1)(-2) = (2+1)v_f$
$v_f = 2,7\ m\cdot s^{-1}$ to the right

2.1 Conservation of momentum

2.2 $\sum p_{before} = \sum p_{after}$ $\rightarrow +$
$m_1v_{1i} + m_2v_{2i} = m_1v_{1f} + m_2v_{2f}$
$(2)(3) + (5)(-3) = (2)(-2,5) + 5v_f$
$v_f = -0,8$
$= 0,8\ m\cdot s^{-1}$ to the left

2.3 $F_{net}\Delta t = mv_f - mv_i$ $\rightarrow +$
$= 5(-0,8) - 5(-3)$
$= 11\ N\cdot s$ to the right

2.4 $F_{net} = \frac{\Delta p}{\Delta t}$
$= \frac{-11}{0,5}$
$= -22\ N$
Force exerted on 5 kg ball = 22 N to the right.
Therefore, the force of the 5 kg ball on the 2 kg ball = 22 N left

3.1 $\sum p_{before} = \sum p_{after}$ $\rightarrow +$
$m_1v_{1i} + m_2v_{2i} = m_1v_{1f} + m_2v_{2f}$
$2(3) + 3(-2) = 2(-1,5) + 3v_f$
$v_f = 1\ m\cdot s^{-1}$ to the right

3.2 The law of conservation of momentum:
The total linear momentum of a closed system is conserved in magnitude and direction.

3.3 $F_{net}\Delta t = mv_f - mv_i$ $\rightarrow +$
$F_{net}(0,02) = 3(1) - 3(-2)$
$F_{net} = 450\ N$ to the right

3.4 450 N left

3.5 $F_{net}\Delta t$ (impulse) = Δp (change in momentum)

It follows that: $F_{net} = \frac{\Delta p}{\Delta t}$

When a vehicle has a crumple zone or airbags, the time it takes to reach a velocity of 0 $m \cdot s^{-1}$ (standstill) increases.
The change in momentum remains the same.
The force decreases.
Therefore, there are fewer and less serious injuries.

4.1
$$\sum p_{before} = \sum p_{after} \qquad \rightarrow +$$
$$m_1v_{1i} + m_2v_{2i} = m_1v_{1f} + m_2v_{2f}$$
$$(700)(0) + (5)(0) = 700(-4) + 5v_f$$
$$v_f = 560 \text{ m} \cdot \text{s}^{-1} \text{ to the right}$$

4.2 The law of conservation of momentum

5.
$$\sum p_{before} = \sum p_{after} \qquad \rightarrow +$$
$$m_1v_{1i} + m_2v_{2i} = m_1v_{1f} + m_2v_{2f}$$
$$(50 + 5)(4) + (10)(0^*) = (50 + 5 + 10)v_f \qquad (* \text{ no horizontal component})$$
$$220 + 0 = (50 + 5 + 10)v_f$$
$$v_f = 3{,}38 \text{ m} \cdot \text{s}^{-1} \text{ to the right}$$

6.1.1 Impulse (K on L) $= mv_f - mv_i \qquad \rightarrow +$
$= 1{,}5(2) - 1{,}5(-6)$
$= 12 \text{ kg} \cdot \text{m} \cdot \text{s}^{-1}$ to the right

6.1.2 Impulse (L on K) $= mv_f - mv_i \qquad \rightarrow +$
$= 2(-3) - 2(3)$
$= -12$
$= 12 \text{ kg} \cdot \text{m} \cdot \text{s}^{-1}$ to the left

6.2 Equal magnitudes, opposite directions

6.3.1 $\Sigma E_{Ki} = \frac{1}{2}m_Kv_{Ki}^2 + \frac{1}{2}m_Lv_{Li}^2$
$= \frac{1}{2}(2)(3)^2 + \frac{1}{2}(1{,}5)(6)^2$
$= 36$ J

6.3.2 $\Sigma E_{Kf} = \frac{1}{2}m_Kv_{Kf}^2 + \frac{1}{2}m_Lv_{Lf}^2$
$= \frac{1}{2}(2)(3)^2 + \frac{1}{2}(1{,}5)(2)^2$
$= 12$ J

6.4 The collision was inelastic. $\Sigma E_{K\ before} > \Sigma E_{K\ after}$; E_K is converted to sound, heat energy, etc.

7.1 The law of conservation of momentum:
The total linear momentum of a closed system is conserved.