4A

1) a) $F_G = mg$

$F_G = 3 \cdot 9.8 = \boxed{29.4\,N}$

b) $p = mv = 3 \cdot 4 = 12\ N \cdot s$

c) $\Delta p = m\Delta v = m(v_f - v_i)$

$\Delta p = 3(2 - 4)$

$\boxed{\Delta p = -6\,N \cdot s}$

d) Original $p = 12\,N \cdot s$

$12\,N \cdot s + 3\,N \cdot s = \boxed{15\,N \cdot s}$

push

2) Newton's 3rd Law

→ forces are equal

→ time of the collision is the same for both vehicles

$$\Delta p = \text{Impulse} = \underbrace{\Sigma F \cdot t}_{\text{Same for both vehicles}}$$

$\boxed{\text{Impulse is the same for both.}}$

3) a) $\boxed{\text{No}}$ $\Delta p = m \Delta V$

→ mass is the same for both cases

→ ΔV is the same for both cases as they both come to a stop

b) $\boxed{\text{Yes}}$, Method 1 will take a longer amount of time as you move your arms back.

c) $\boxed{\text{Yes}}$ $\Delta p \rightarrow$ same $t \rightarrow$ greater for Method 1

$$\underset{\text{same}}{\Delta p} = \underset{\downarrow}{\Sigma F} \cdot \underset{\uparrow}{t}$$

3) d) $\boxed{\text{Method one}}$ is the better option

$$\underset{\substack{\uparrow \\ \text{same as} \\ \text{Method 2}}}{\Delta p} = \underset{\substack{\uparrow \\ \text{smaller}}}{\Sigma F} \cdot \underset{\substack{\uparrow \\ \text{larger}}}{t}$$

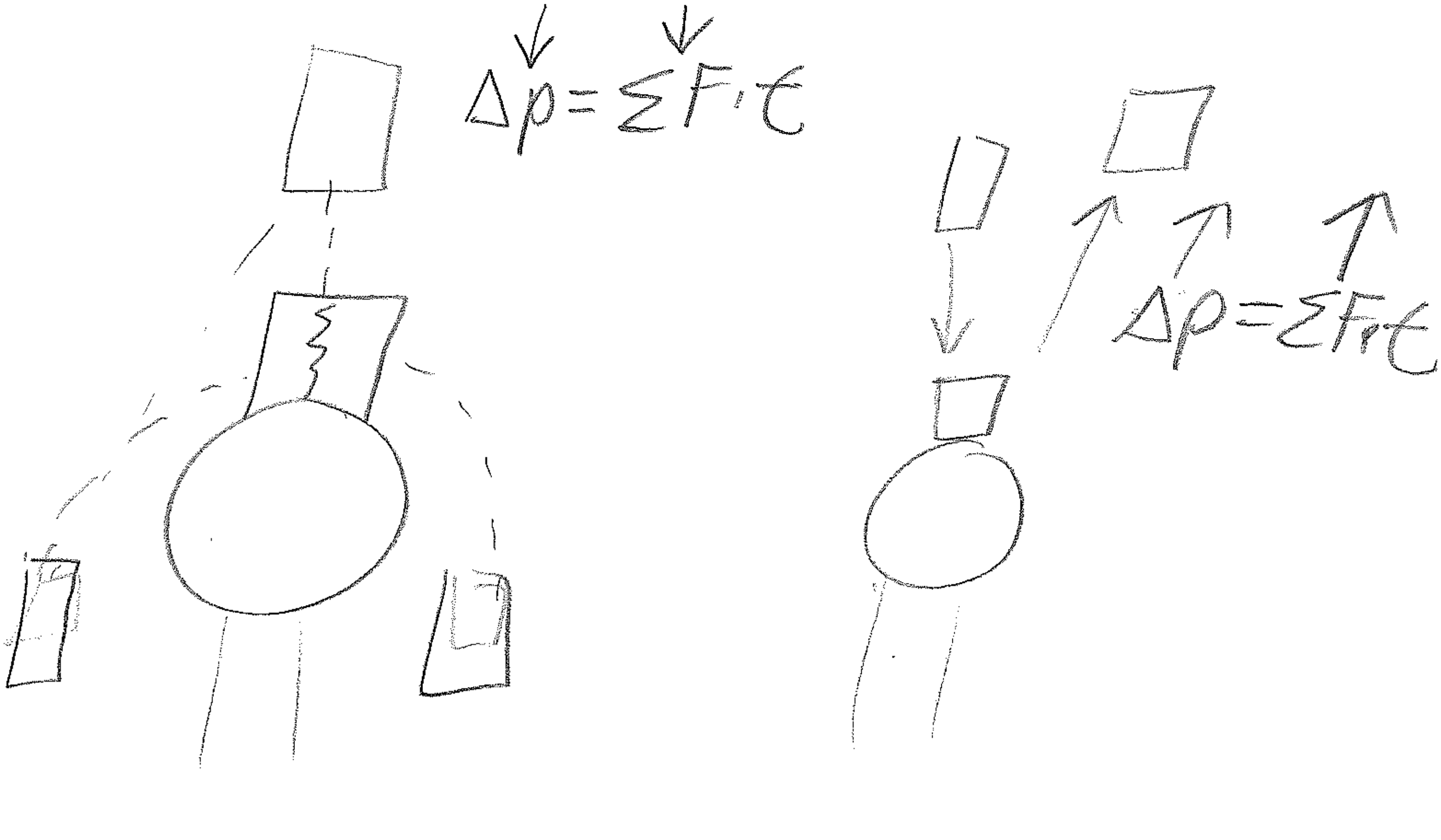
Impact force is reduced because of the increased contact time.

e) $\Delta p = \Sigma F \cdot t$ $\qquad t \rightarrow 3t$

$\frac{\Delta p}{t} = \Sigma F$ $\qquad$ mult $= \frac{1}{3} = \frac{1}{3}$

$\frac{1}{3} \cdot \Sigma F$ $\boxed{\text{One third of the original net force}}$

4) It will hurt more if it bounces because a greater change in momentum (impulse) is required to make it stop then move in the opposite direction. This will result in a greater net force on your head.



5) a) $\Delta x = -1.5\,m$

$v_i = 0\,m/s$

$a = -9.8\,m/s^2$

$v_f = ?$

$v_f^2 = v_i^2 + 2a\Delta x$

$v_f^2 = 0^2 + 2 \cdot -9.8 \cdot -1.5$

$v_f^2 = 29.4$

$v_f = -5.42\,m/s$

$\downarrow$

$\boxed{\text{speed} = 5.42\,m/s}$

5) b) $\Delta p = m\Delta v = \Sigma F \cdot t$

$m(v_f - v_i) = \Sigma F \cdot t$

$138g \rightarrow .138kg$

$.138(-5.42 - 0) = \Sigma F \cdot .01$

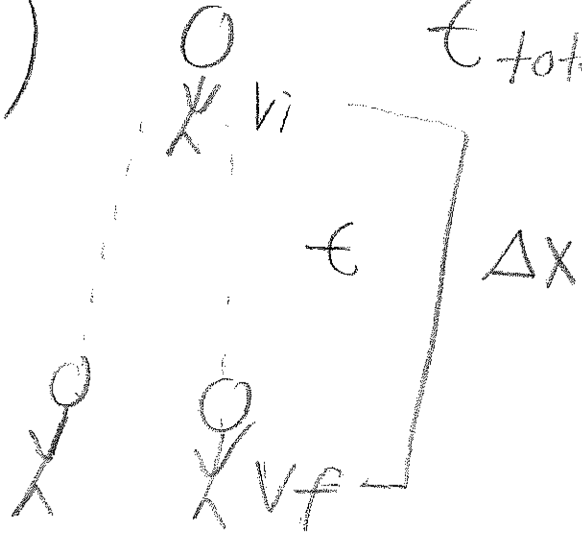
$\boxed{\Sigma F = -74.8N}$

c) $\dfrac{\Delta p}{t} = \Sigma F$ mult $= \dfrac{1}{4}$

$t \rightarrow 4t$

$\boxed{\frac{1}{4} \cdot \Sigma F}$

6) a)



$t_{total} = 10s$

$V_i = 0 m/s$

$t = 5s$

$a = -9.8 m/s^2$

$\Delta x = ?$

$\Delta x = V_i t + \frac{1}{2} a t^2$

$\Delta x = 0 \cdot 5 + \frac{1}{2} -9.8 \cdot 5^2$

$\Delta x = -122.5m$

$\boxed{\text{height} = 122.5m}$

b) $V_f = ?$ $V_f = V_i + at$

$V_f = 0 + -9.8 \cdot 5$

$V_f = -49 m/s$

$\boxed{\text{Speed} = 49 m/s}$

6) c) $\Delta p = m\Delta v = \Sigma F \cdot t$

$$\Delta p = m(v_f - v_i) = \Sigma F \cdot t$$

$$70 \cdot (-49 - 0) = \Sigma F \cdot .01$$

$$\boxed{\Sigma F = -343{,}000\,N}$$

Section 4B

7) a) $\sum p_i = \sum p_f$

$$m_1 v_{i1} + m_2 v_{i2} = (m_1 + m_2) v_f$$

$$(3)(10) + (2)(0) = (3+2) v_f$$

$$30 + 0 = 5 v_f$$

$$\boxed{v_f = 6 \text{ m/s} \quad \text{(for both)}}$$

b) $\sum p_i = \sum p_f$

$$m_1 v_{i1} + m_2 v_{i2} = m_1 v_{f1} + m_2 v_{f2}$$

$$(3)(10) + (2)(0) = (3)(4) + (2) v_{f2}$$

$$30 + 0 = 12 + 2 v_{f2}$$

$$18 = 2 v_{f2}$$

$$v_{f2} = 9 \text{ m/s}$$

$$\boxed{\begin{array}{l} \text{Blue: } v_f = 4 \text{ m/s} \\ \text{Red: } v_f = 9 \text{ m/s} \end{array}}$$

8) a) No, the Law of Conservation of Momentum says the momenta before and after an event must be equal. There's no way for the final total momentum to be zero (both at rest) if the total initial momentum is non-zero (one moving, one at rest).

b) Yes. Assuming billiard balls are about the same mass, if they were moving in opposite directions, the total momentum would be zero if their velocities are equal in magnitude. Thus, you can then end up with both at rest since that total momentum is zero as well.

9) The elastic collision would be dangerous since, when objects bounce off each other, it results in greater force than objects deforming or sticking together, which is more dangerous.

10) a) The 140 kg player (more mass = more inertia)

b) The 70 kg & 140 kg players ($70 \times -8 = -560$ N·s, $140 \times -4 = -560$ N·s, which are greater in magnitude than the other: $80 \cdot 2 = 160$ N·s)

c) $\Sigma p_i = \Sigma p_f$

$$m_1 v_{i1} + m_2 v_{i2} = (m_1 + m_2) v_f$$

$$(80)(2) + (70)(-8) = (80+70) v_f$$

$$160 - 560 = 150 v_f$$

$$-400 = 150 v_f$$

$$\boxed{v_f = -2.67 \text{ m/s}}$$

d) $\Sigma p_i = \Sigma p_f$

$$m_1 v_{i1} + m_2 v_{i2} = (m_1 + m_2) v_f$$

$$(80)(2) + (140)(-4) = (80+140) v_f$$

$$160 - 560 = 220 v_f$$

$$-400 = 220 v_f$$

$$\boxed{v_f = -1.82 \text{ m/s}}$$

e) Into smaller: $\Delta p = m\Delta v = 80(-2.67-2)$

$$= 80(-4.67)$$

$$\boxed{= -373.6 \text{ N·s}}$$

Into bigger: $\Delta p = m\Delta v = 80(-1.82-2)$

$$= 80(-3.82)$$

$$\boxed{= -305.6 \text{ N·s}}$$

Into bigger would hurt less
(less impulse = less force if t is equal)

11) a) The Black Magic
Less mass = less inertia which means it would be easier to get moving from rest

b) Elastic (bouncing off)

c) $\sum p_i = \sum p_f$

$m_1 v_{i1} + m_2 v_{i2} = m_1 v_{f1} + m_2 v_{f2}$

$(0.567)(17.89) + (0.145)(-33.53) = (0.567)(-3) + (0.145) v_{f2}$

$10.14 - 4.86 = -1.70 + 0.145 v_{f2}$

$5.28 = -1.70 + 0.145 v_{f2}$

$6.98 = 0.145 v_{f2}$

$\boxed{v_{f2} = 48.1 \text{ m/s}}$

d) $\sum p_i = \sum p_f$

$m_1 v_{i1} + m_2 v_{i2} = m_1 v_{f1} + m_2 v_{f2}$

$(0.737)(13.41) + (0.145)(-33.53) = (0.737)(-2) + (0.145) v_{f2}$

$9.88 - 4.86 = -1.47 + 0.145 v_{f2}$

$5.02 = -1.47 + 0.145 v_{f2}$

$6.49 = 0.145 v_{f2}$

$\boxed{v_{f2} = 44.8 \text{ m/s}}$

e) $\frac{48.1\text{ m}}{1\text{ s}} \times \frac{1\text{ mi}}{1600\text{ m}} \times \frac{60\text{ s}}{1\text{ min}} \times \frac{60\text{ min}}{1\text{ hr}} = \boxed{108\text{ mph}}$

$\frac{44.8\text{ m}}{1\text{ s}} \times \frac{1\text{ mi}}{1600\text{ m}} \times \frac{60\text{ s}}{1\text{ min}} \times \frac{60\text{ min}}{1\text{ hr}} = \boxed{101\text{ mph}}$

f) Lighter bats since its smaller mass means its easier to swing, which means it can be swung faster. Overall, this leads to a greater momentum and a greater velocity of the baseball after it's hit.

12) a) $a = -9.8\text{ m/s}^2$ $\quad v_i = 0\text{ m/s}$

$\Delta x = -0.36\text{ m}$ $\quad v_f = ?$

$v_f^2 = v_i^2 + 2a\Delta x$

$v_f^2 = 0 + 2(-9.8)(-0.36)$

$v_f^2 = 7.056$

$\boxed{v_f = -2.66\text{ m/s}}$

b) $p = mv = (80)(-2.66)$

$\boxed{p = -212.8\text{ N}\cdot\text{s}}$

Mass of Whole Population:

$80 \times (7.5 \times 10^9) = 6 \times 10^{11}\text{ kg}$

c) $\sum p_i = \sum p_f$

$$m_1 v_{i1} + m_2 v_{i2} = (m_1 + m_2) v_f$$

$$(6\times10^{11})(-2.66) + (5.972\times10^{24})(0) = (6\times10^{11} + 5.972\times10^{24}) v_f$$

$$-1.596\times10^{12} + 0 = (5.972\times10^{24}) v_f$$

$$v_f = -2.67\times10^{-13} \text{ m/s}$$

No, this is a very very small velocity, so it would not be noticed at all