4.2 Impulse

Impulse = *Change in momentum ($\Delta\rho$)*

* As we saw last day $\Delta p = m\Delta\vec{v} = \vec{F}_{net}\Delta t$

ex. Luigi is sick of taking orders. He swings a 9.0 kg hammer at 16 m/s when Mario's moustache brings it to a stop in 0.25 s. What is the net force exerted on Mario's moustache?

$$\frac{m\Delta\vec{v}}{\Delta t} = \frac{F\Delta t}{\Delta t}$$

$$\vec{F}_{net} = \frac{(9.0\text{ kg})(0-16\text{ m/s})}{(0.25\text{ s})}$$

$$= -580\text{ N}$$

↑ backwards

ex. A soccer player kicks a 0.450 kg ball at 25.0 m/s East.

a) If the goalie stops the ball by exerting 215 N of force, how long does it take the ball to stop?

$$\frac{\vec{F}_{net}\Delta t}{\vec{F}_{net}} = \frac{m\Delta v}{\vec{F}_{net}}$$

$$\Delta t = \frac{m\Delta\vec{v}}{\vec{F}_{net}}$$

$$\Delta t = \frac{(0.450\text{ kg})(0-25\text{ m/s})}{-215\text{ N}}$$

(− opposes motion)

$$= 0.052\text{ s}$$

b) If the goalie stops a 6.5 kg bowling ball travelling at the same velocity in the same amount of time, how much force is required?

$$\frac{\vec{F}_{net}\Delta t}{\Delta t} = \frac{m\Delta\vec{v}}{\Delta t}$$

$$\vec{F}_{net} = \frac{(6.5)(0-25)}{0.0523}$$

$$= -3100\text{ N}$$

ex. Coaches for many sports such as baseball, tennis, golf will often tell their athletes to "follow through" with their swing. How does this help a weaker player hit the ball farther or harder?

$$\vec{F}_{net}\Delta t = m\Delta v$$

($\vec{F}_{net}$: const.; Δt: increase; m: const.; Δv: increase)

more time in contact with the ball (or other) means greater change in velocity.

ex. Using the principle of impulse, explain why an airbag can help people sustain less damage during a collision.

$$\vec{F}_{net}\Delta t = m\Delta\vec{v}$$

($\vec{F}_{net}$: decreases since Δt increased; Δt: more time slowing down; m: const.; $\Delta\vec{v}$: const.)

more time to slow down means less force required.

<u>Mini Lab</u>: Calculate the force required for a student to land a jump from their desk with bent knees.

m = 75 kg

Height = 0.92 m

Stopping distance = 0.40 m

$\Delta d = \frac{1}{2}(\vec{v}_2 - \vec{v}_1)\Delta t$

$\vec{v}_2^{\,2} = \vec{v}_1^{\,2} + 2\vec{a}\Delta d$

phase 1: falling

$\vec{v}_2^{\,2} = \vec{v}_1^{\,2} + 2\vec{a}\Delta d$

$= 0 + 2(9.8)(0.92)$

$v_2 = \sqrt{18.032} = 4.25\ m/s$

phase: how long to slow down?

$v_1 = 4.25\ m/s$

$v_2 = 0$

$\Delta d = 0.40\ m$

$\frac{2\Delta\vec{d}}{\Delta\vec{v}} = \Delta t$

$\Delta t = \frac{2(0.4)}{4.25} = 0.188\ s$

practice: handout

Now

$\vec{F}_{net} = \frac{m\Delta\vec{v}}{\Delta t}$

$= \frac{(75)(4.25)}{0.188} = \boxed{1693\ N}$