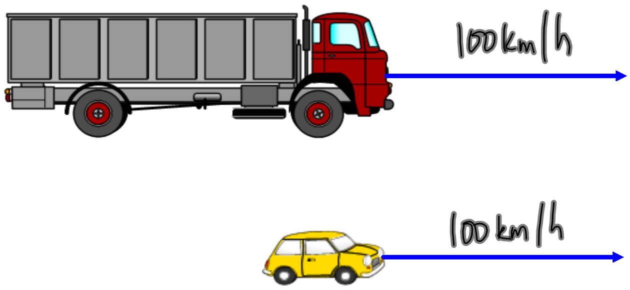
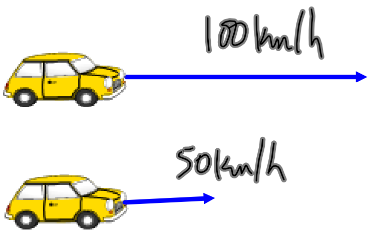
5.4 Newton's Laws & Momentum



more momentum



has more momentum

Momentum depends on both mass and velocity. It is the product of the object's mass and its velocity.

$$\vec{p} = m\vec{v}$$

where $\vec{p}$ is the momentum (kg m/s)

m is the mass (kg)

$\vec{v}$ is the velocity (m/s)

MP | 197

$m = 0.300\text{ kg}$

$\vec{v} = 5.55\text{ m/s [N]}$

$\vec{p} = ?$

$\vec{p} = m\vec{v}$

$\vec{p} = (0.300\text{ kg})(5.55\text{ m/s [N]})$

$\vec{p} \doteq 1.66\text{ kg·m/s [N]}$

Newton's Second Law: $\vec{F} = m\vec{a}$

$$\vec{F} = \frac{\Delta\vec{p}}{\Delta t}$$

$$\vec{F}\Delta t = \Delta\vec{p}$$

Impulse

Impulse is the product of the force (unbalanced) and the time interval over which it acts on an object.

$$\vec{J} = \vec{F}\Delta t$$

where $\vec{J}$ is the impulse (N·s)
$\vec{F}$ is the unbalanced force (N)
Δt is the time interval (s)

MP/199

$\vec{F} = 5.25 \times 10^3 N [W]$

$\Delta t = 5.45 \times 10^{-4} s$

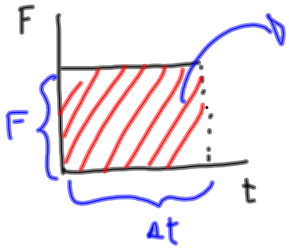
$\vec{J} = ?$

$\vec{J} = \vec{F}\Delta t$

$\vec{J} = (5.25 \times 10^3 N [W])(5.45 \times 10^{-4}$

$\vec{J} \doteq 2.86$ N·s [W]

Consider a F-t graph:

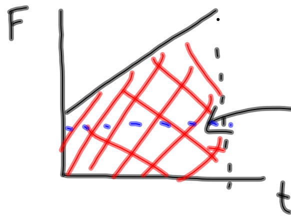


area of rectangle = l × w

area = $F\Delta t$

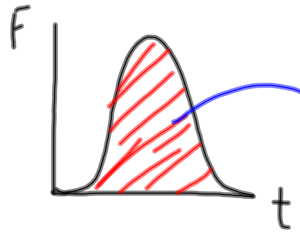
impulse!

area$_{F\text{-}t}$ = impulse



area of a trapezoid = $\frac{1}{2}(h_1+h_2$

area = □ + Δ



area
① count "squares"
② use calculus (if yo

Recall Newton's Second Law:

$$\vec{F} = m\vec{a}$$

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

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

$$\vec{F}\Delta t = m(v_2 - v_1)$$

$$\vec{F}\Delta t = mv_2 - mv_1$$

$$\vec{F}\Delta t = \vec{p}_2 - \vec{p}_1$$

Impulse = $\vec{F}\Delta t = \Delta\vec{p}$

same.

(Newton's 2nd Law was originally written as $F = \frac{\Delta p}{\Delta t}$)

So: $\vec{J} = \Delta\vec{p}$

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

Impulse Momentum Theorem.

MP|201

$m = 0.060\,kg$

$\vec{v}_1 = 48\,m/s$ [toward] (+)

$\vec{v}_2 = 35\,m/s$ [away] (−)

$\Delta t = 25\,ms$ $(25\times10^{-3}s)$

a) $\vec{J} = ?$

b) $\vec{F} = ?$

a) According to Impulse-Momentum Theorem:

$$\vec{J} = \Delta\vec{p}$$

$$\vec{J} = \vec{p}_2 - \vec{p}_1$$

$$\vec{J} = m\vec{v}_2 - m\vec{v}_1$$

$$\vec{J} = m(\vec{v}_2 - \vec{v}_1)$$

$$\vec{J} = 0.060\,kg\left(-35\tfrac{m}{s} - 48\tfrac{m}{s}\right)$$

$$\vec{J} = 0.060\,kg\left(-83\tfrac{m}{s}\right)$$

$$\vec{J} \doteq -5.0\,kg\cdot\tfrac{m}{s}$$

$N\cdot s = kg\cdot\frac{m}{s^2}\cdot s = kg\cdot\frac{m}{s}$

$\vec{J} \doteq 5.0\,kg\cdot\frac{m}{s}$ [away from the wall]

b) $\vec{J} = \vec{F}\Delta t$

$$\vec{F} = \frac{\vec{J}}{\Delta t}$$

$$\vec{F} = \frac{5.0\,kg\cdot\frac{m}{s}\text{ [away]}}{25\times10^{-3}s}$$

$$\vec{F} \doteq 2.0\times10^2\,N \text{ [away]}$$

↑ Force of the wall on the ball.

Force of the ball on the wall is $2.0\times10^2\,N$ [toward the wall]

To Do:

PP|197

PP|200

PP|203