Momentum & Impulse

Impulse

Bouncing Ball

§5-4 Momentum + Newton's Laws

Momentum is the product of the mass and velocity of an object.

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

Where $\vec{p}$ is momentum (kg·m/s)
m is the mass (kg)
$\vec{v}$ is velocity (m/s)

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$m = 0.300\,kg$
$\vec{v} = 5.55\,m/s\,[N]$
$\vec{p} = ??$

$\vec{p} = m\vec{v}$
$\vec{p} = (0.300\,kg)(5.55\,m/s\,[N])$
$\vec{p} \doteq 1.66\ kg \cdot m/s\,[N]$

Impulse

Impulse is the product of the force acting on an object and the duration (time interval over which the force acts)

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

where $\vec{J}$ is the impulse (N·s)

$\vec{F}$ is the unbalanced force (N)

Δt is the time interval (s)

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

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

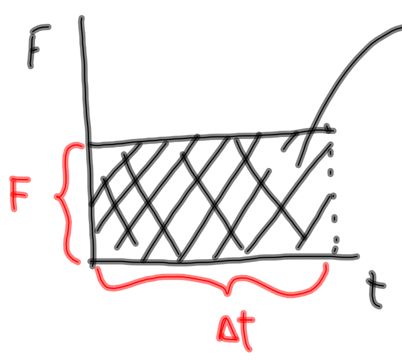
$\vec{J} = ?$

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

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

$\vec{J} \doteq 2.86\,\text{N·s [W]}$

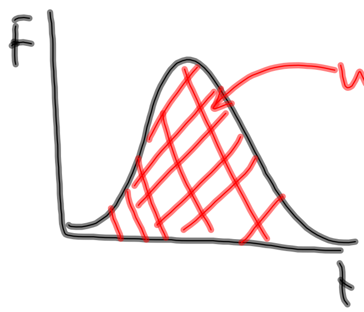
Consider F-t graph



area of rectangle = l x w

area = $F\Delta t$

area (F-t graph) = impulse



use Logger Pro to find this area.

Impulse-Momentum Theorem

Recall Newton's Second Law:

$$\vec{F}_{net} = m\vec{a}$$
$$\vec{F}_{net} = m\frac{\Delta\vec{v}}{\Delta t}$$
$$\vec{F}_{net}\Delta t = m\Delta\vec{v}$$
$$\vec{F}_{net}\Delta t = m(\vec{v}_2 - \vec{v}_1)$$
$$\vec{F}_{net}\Delta t = m\vec{v}_2 - m\vec{v}_1$$
$$\vec{F}_{net}\Delta t = \vec{p}_2 - \vec{p}_1$$
$$\vec{F}_{net}\Delta t = \Delta\vec{p}$$

impulse = change in momentum

Impulse-Momentum Theorem → $\vec{J} = \vec{F}\Delta t = \Delta\vec{p} = m\Delta\vec{v}$

MP|201

$m = 0.060\text{ kg}$ +
$\vec{v}_1 = 48\text{ m/s}$ [toward wall]
$\vec{v}_2 = 35\text{ m/s}$ [away from wall]

a) $\vec{J} = ?$
b) $\vec{F} = ?$ if $\Delta t = 25\text{ ms}$

a)
$$\vec{J} = m\Delta\vec{v}$$
$$\vec{J} = m(\vec{v}_2 - \vec{v}_1)$$
$$J = 0.060\text{ kg}(-35\text{ m/s} - 48\text{ m/s})$$
$$J = 0.060\text{ kg}(-83\text{ m/s})$$
$$J = -4.98\text{ kg·m/s}$$
$$\vec{J} \doteq 5.0\text{ kg·m/s [away]}$$

b)
$$\vec{J} = \vec{F}\Delta t$$
$$\vec{F} = \frac{\vec{J}}{\Delta t}$$
$$\vec{F} = \frac{4.98\text{ kg·m/s [away]}}{25\times10^{-3}\text{ s}}$$
$$\vec{F} \doteq 2.0\times10^{2}\text{ N [away]}$$

← force of the wall on the ball

Newton's Third Law. The force of the ball on the wall would be 2.0×10^{2} N [toward]

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