§5-4 Impulse & Momentum

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

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

m is the mass (kg)

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

MP/197

$m = 0.300\ kg$

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

$\vec{p} = ?$

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

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

$\vec{p} = 1.665\ kg \cdot m/s\ [N]$

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

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

where $\vec{J}$ is the impulse (N·s)

$\vec{F}$ is the force acting on the object (N)

Δt is the duration that the force acts (s)

mp 199

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

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

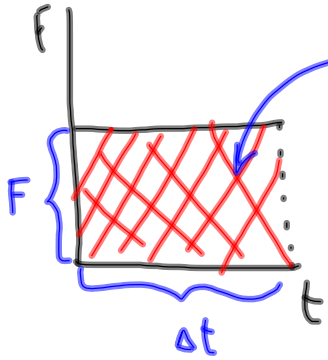
$\vec{J} = ??$

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

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

$\vec{J} = 2.86\ N \cdot s\ [W]$

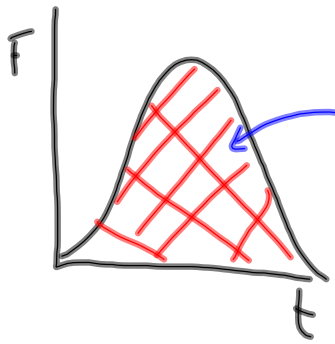
Consider a F-t graph:



area of rectangle = l x w

area = $F\Delta t$ ← Impulse.

AREA under F-T = IMPULSE



① count squares
② use calculus!
③ use Logger Pro.

Recall Newton's Second Law:

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

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

$$* \longrightarrow \vec{F}\Delta t = m\Delta \vec{V}$$

$$\vec{F}\Delta t = m(\vec{V}_2 - \vec{V}_1)$$

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

($m\vec{V}_2 = \vec{P}_2$, $m\vec{V}_1 = \vec{P}_1$)

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

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

← Impulse - Momentum Theorem

An object's change in momentum is equal to the impulse on an object.

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

↑ A more practical expression for Impulse - Momentum Theorem.

MP|201

$m = 0.060\ kg$

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

$\vec{v}_2 = 35\ m/s\ [away]$ (−)

a) $\vec{J} = ?$

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

a) Using the Impulse-Momentum Theorem, we know:

$$\vec{J} = \Delta\vec{p}$$
$$\vec{J} = \vec{p}_2 - \vec{p}_1$$
$$\vec{J} = m\vec{v}_2 - m\vec{v}_1$$
$$\vec{J} = m(\vec{v}_2 - \vec{v}_1)$$
$$J = 0.060\ kg(-35\ m/s - 48\ m/s)$$
$$J = 0.060\ kg(-83\ m/s)$$
$$J = -5.0\ kg \cdot m/s$$
$$\boxed{\vec{J} = 5.0\ kg \cdot m/s\ [away]}$$

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

$$\vec{F} = \frac{\vec{J}}{\Delta t}$$
$$\vec{F} = \frac{5.0\ kg \cdot m/s\ [away]}{25 \times 10^{-3}\ s}$$
$$\vec{F} \doteq 2.0 \times 10^{2}\ N\ [away]$$

Newton's 3rd Law

- The wall pushes the ball away (200 N)
- The ball pushes the wall toward (200 N)

To DO

① PP|197 (momentum)

② PP|200 (Impulse)

③ PP|203 (imp-mom theorem)