§5-4 Momentum & Newton's Laws

Momentum - the product of an 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

$m = 0.300\,kg$

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

$\vec{p} = ?$

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

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

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

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

Impulse - the product of the force acting acting on an object and its duration.

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

Where: $\vec{J}$ is the impulse (N·s)

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

Δt is the duration that the force acts on an object (s)

mp|199

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

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

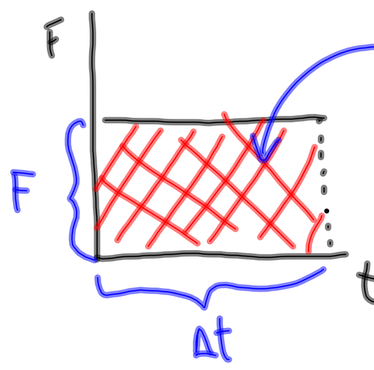
$\vec{J} = ?$

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

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

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

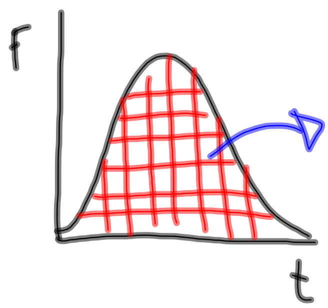
Consider a F-t graph:



area of a rectangle = $l \times W$

area = $F\Delta t$

∴ area under F-t graph = IMPULSE



① count squares
② Calculus!
③ Technology - LoggerPro

Recall Newton's Second Law:

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

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

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

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

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

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

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

Impulse-Momentum Theorem

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

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

more useable expression

MP|201

$m = 0.060\,kg$

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

$\vec{v}_2 = 35\,m/s$ [away] (−)

a) $\vec{J} = ?$

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

a) Using the impulse-momentum theorem:

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

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

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

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

$$J = 0.060\,kg(-35\,m/s - 48\,m/s)$$

$$J = 0.060\,kg(-83\,m/s)$$

$$J \doteq -5.0\,kg\cdot m/s$$

$$\vec{J} \doteq 5.0\,kg\cdot m/s\ [away]$$

$$1\,N\cdot s = kg\cdot\frac{m}{s^2}\cdot s = kg\cdot\frac{m}{s}$$

b)

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

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

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

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

← the force of the wall on the ball.

* The force of the ball on the wall is 200 N [toward] (Newton's 3rd Law)

To Do

1. PP|197 (mom)
2. PP|200 (imp)
3. PP|203 (imp-mom)