§5-4 Momentum + Newton's Laws (p195)

momentum depends on the mass of the object (direct prop.)
momentum depends on the velocity of the object (direct prop.)

* momentum is the product of mass and 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]
$\vec{p} = ?$

$\vec{p} = m\vec{v}$
$\vec{p} = (0.300\,kg)(5.55\,m/s$ [N]$)$
$\vec{p} = 1.665\,kg \cdot m/s$ [N]
$\vec{p} \doteq 1.66\,kg \cdot m/s$ [N]

Impulse

Impulse is directly related to the force acting on an object

Impulse is directly related to the duration of the interaction.

* Impulse is the product of the force and the duration.

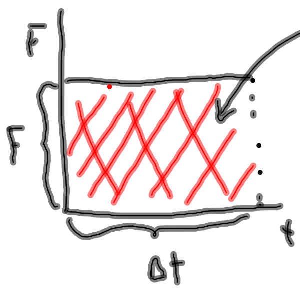
$$\vec{J} = \vec{F}\Delta t$$

where $\vec{J}$ is the impulse (N·s)

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

Δt is the duration of the interaction (s)

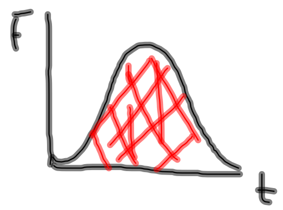
Consider a F-t graph:



area of rectangle $= l \times w$

area $= F\Delta t$

area under a F-t graph = impulse



MP|199

$\vec{F} = 5.25\times10^{3}\,N\,[W]$

$\Delta t = 5.45\times10^{-4}\,s$

$\vec{J} = ??$

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

$\vec{J} = (5.25\times10^{+3}\,N\,[W])(5.45\times10^{-4}\,s)$

$\vec{J} = 2.86125\,N\cdot s\,[W]$

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

Impulse + Momentum

Impulse ⇒ Force ⇒ acc ⇒ change in velocity ⇒ change in momentum

?? How are they related?

RECALL Newton's Second Law:

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

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

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

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

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

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

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

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

impulse = change in momentum

IMPULSE - MOMENTUM THEOREM

$$\vec{F}\Delta t = m\Delta\vec{v}$$ (alternative 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)

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

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

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

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

$$J = 0.060\text{kg}(-35\text{m/s} - 48\text{ m/s})$$

$$J = 0.060\text{kg}(-83\text{m/s})$$

$$J = -4.98 \text{ kg}\cdot\text{m/s}$$

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

b)

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

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

$$\vec{F} = \frac{4.98 \text{ kg}\cdot\text{m/s [away]}}{0.025\text{s}}$$

$$\vec{F} = 199.2 \text{ N [away]}$$

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

The force of the wall on the ball.

TO DO

PP|197, 200, 203

The force of the ball on the wall is 2.0×10^2 N [toward] (Newton's Third Law)