§5-4 Momentum + Newton's Laws (p195)

Momentum depends on the mass of an object and its velocity. It is the product of mass and velocity.

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

Where $\vec{p}$ is momentum $\left(kg \cdot \frac{m}{s}\right)$

m is the mass (kg)

$\vec{v}$ is velocity $\left(\frac{m}{s}\right)$

MP | 197

$m = 0.300 kg$

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

$\vec{p} = ?$

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

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

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

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

The momentum of the hockey puck is $1.66 kg \cdot \frac{m}{s}$ [N]

Impulse

Impulse depends on the force acting on an object and the duration that the force acts. It is the product of the force and the time interval.

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

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

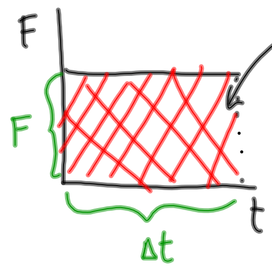
mp/199

$F = 5.25\times10^{3}\,N\,[W]$
$\Delta t = 5.45\times10^{-4}\,s$
$\vec{J} = ?$

$\vec{J} = \vec{F}\Delta t$
$\vec{J} = (5.25\times10^{3}\,N\,[W])(5.45\times10^{-4}\,s)$
$\vec{J} \doteq 2.86\,N\cdot s\,[W]$

The impulse of the golf club on the golf ball is $2.86\,N\cdot s\,[W]$

Consider a F-t graph:

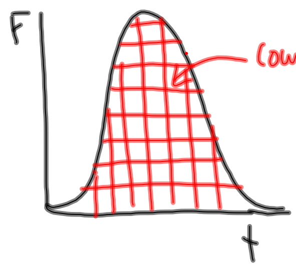


Area of a rectangle = l×w

Area = $F\Delta t$

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

So: $\vec{J}$ = area under a F-t graph



count squares
or use Calculus
or use Logger Pro / TI-85
(technology)

Recall Newton's Second Law:

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

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

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

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

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

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

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

Newton's Second Law was originally written as: $\vec{F} = \frac{\Delta\vec{p}}{\Delta t}$

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

← Impulse is equal to the object's change in momentum

IMPULSE - MOMENTUM THEOREM

alternatively:

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

MP|201

$m = 0.060\,kg$

$\vec{v}_1 = 48\frac{m}{s}$ [towards] + +48 m/s

$\vec{v}_2 = 35\frac{m}{s}$ [away] − −35 m/s

$\Delta t = 25\,ms$

a) $\vec{J} = ?$

b) $\vec{F}_{wall\ on\ ball} = ?$

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

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

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

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

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

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

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

$\vec{J} \doteq -5.0\ kg\cdot\frac{m}{s}$ or $N\cdot s$

$\frac{kg\cdot m}{s^2}\cdot s$ → $kg\cdot\frac{m}{s}$

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

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

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

$\vec{F} = \frac{5.0\,kg\cdot\frac{m}{s}\ [away]}{25 \times 10^{-3}\,s}$ (498) m

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

$\vec{F} \doteq 2.0\times10^{2}\ N$ [away] ← the force of the wall on the ball.

(wall on the ball)

Note that the force of the ball on the wall would be $2.0\times10^{2}\,N$ [toward]. (Newton's 3rd law)

TODO: PP|197 (momentum)
PP|200 (impulse)
PP|203 (imp-mom)