Impulse of a force $\vec{I}$

The impulse $\vec{I}$ of a force $\vec{F}$ is defined as the product of the force acting and the time Δt for which it acts

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

- vector quantity
- N s

$kg \cdot m s^{-2} \cdot s = kg \cdot m s^{-1}$
(momentum)

Relationship between Impulse + Change in momentum.

Recall:

$$\vec{F}_{net} = \frac{\Delta \vec{p}}{\Delta t}$$

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

$$\vec{I}_{net} = \Delta \vec{p}$$

OR

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

← Another form of Newton's Second Law

(Impulse - Momentum Theorem)

The impulse of the net force is equal to the change in momentum that it causes

Impulse and change of momentum

$$\vec{I}_{net} = \Delta\vec{p}$$

$\vec{J}$

This is really just another form of Newton's Second Law.

Newton's Second Law: [The impulse of a net force acting on a body is equal to the change in momentum of the body that it produces]

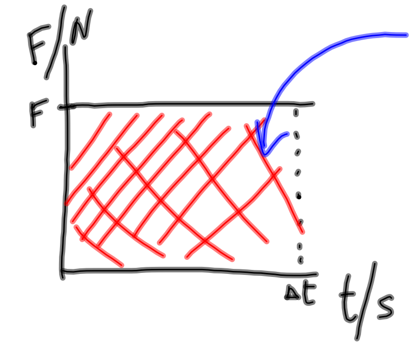
Impulse: units are N s → $kg\,m\,s^{-2}\,s$ → $kg\,m\,s^{-1}$

momentum: units are $kg\,m\,s^{-1}$

Same unit!

Momentum can be expressed as $kg\,m\,s^{-1}$ or N s

Force - time graph



area of a rectangle $= l \times w$

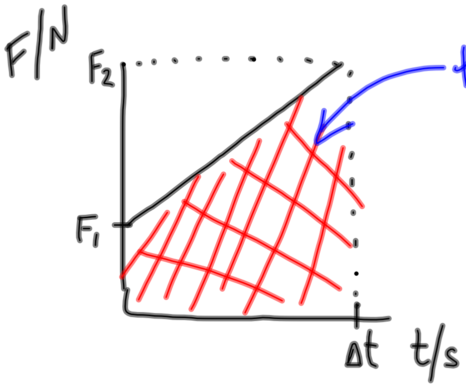
area $= F\Delta t$

$\therefore$ area = Impulse!

(or change in momentum)

The area under a Force - time graph gives the impulse of F_{net} during time Δt.

What happens when the force is not constant?

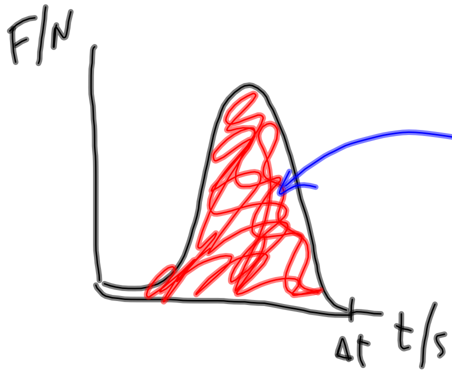


the area still represents the impulse,

but

$$\text{area} = \frac{1}{2}(h_1 + h_2)b$$

$$\text{area} = \frac{1}{2}(F_1 + F_2)\Delta t$$

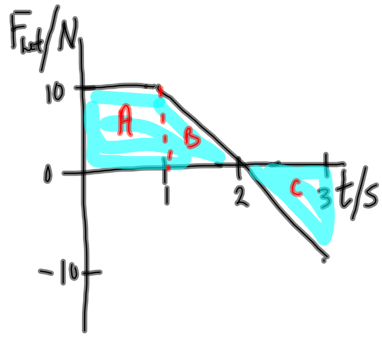


area = ??

1. count squares on the grid on the graph
2. use Calculus (if you know the equation for the curve)
3. use technology (i.e. Logger Pro)

Example

The graph shows the way in which a net force acting on a body of mass 3.0 kg varies with the time for which it acts.



Determine:

a) the total impulse of the force

b) the change in momentum of the body as a result of the force

c) the final velocity of the body if its initial velocity was $-5.0\,ms^{-1}$

a) The area is simply the Area of A (B and C cancel out)

$\vec{I}_{net}$ = area of A

$\vec{I}_{net} = (10N)(1s)$

$\vec{I}_{net} = 10\,Ns$

b) $\Delta\vec{p} = \vec{I}_{net}$

$\therefore \Delta\vec{p} = 10\,N{\cdot}s$ or $10\,kg\,ms^{-1}$

c) $v = ?$

$u = -5.0\,ms^{-1}$

$m = 3.0\,kg$

$\Delta p = 10\,N{\cdot}s$

$\Delta\vec{p} = m\Delta\vec{v}$ or $\Delta\vec{p} = \vec{p}_2 - \vec{p}_1$

$\Delta\vec{p} = mv - mu$

$\Delta\vec{p} = m(v-u)$

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

$\Delta\vec{p} = m(v-u)$

$v - u = \frac{\Delta\vec{p}}{m}$

$v = \frac{\Delta\vec{p}}{m} + u$

$v = \frac{10\,Ns}{3.0\,kg} + (-5.0\,ms^{-1})$

$v = 3.3\,ms^{-1} - 5.0\,ms^{-1}$

$v \doteq -1.7\,ms^{-1}$

What happens when two bodies collide?