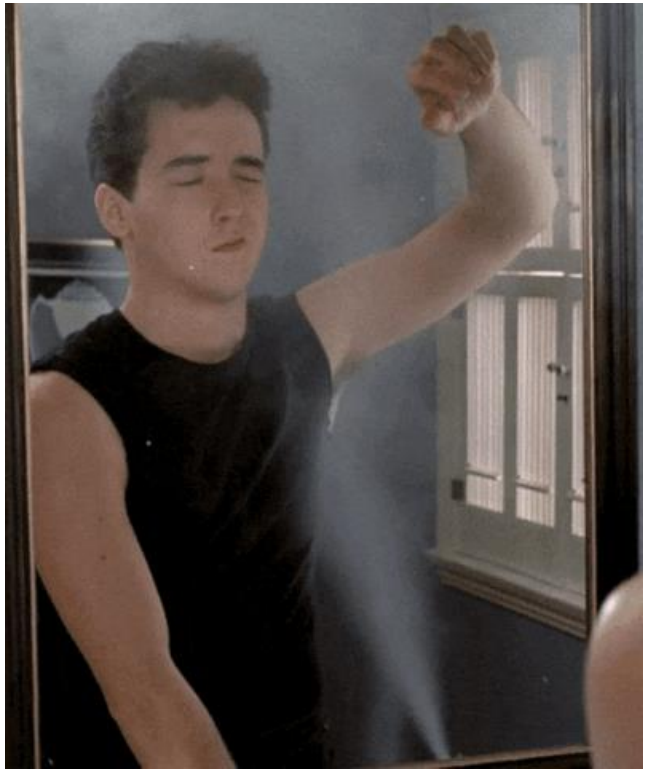


Momentum (formula)

And impulse

Newton's Third Law

- For every action there is an equal but opposite reaction!
- $F_1 = -F_2$
- We know $F = ma$ therefore
- $m_1 a_1 = -m_2 a_2$
- But $a = \frac{v-u}{t}$ so substituting
- $m_1 \frac{v_1 - u_1}{t_1} = -m_2 \frac{v_2 - u_2}{t_2}$
- Now the time of contact is the same so *t* cancels giving
- $m_1(v_1 - u_1) = -m_2 (v_2 - u_2)$

$$m_1(v_1 - u_1) = -m_2\,(v_2 - u_2)$$

- Expand the brackets
- $m_1 v_1 - m_1 u_1 = -m_2\, v_2 + m_2 u_2$

  Rearrange
- $m_1 v_1 - m_1 u_1 = m_2 u_2 - m_2\, v_2$
- Now lets look what this means and rearrange it

$$m_1 v_1 - m_1 u_1 = m_2 u_2 - m_2\ v_2$$

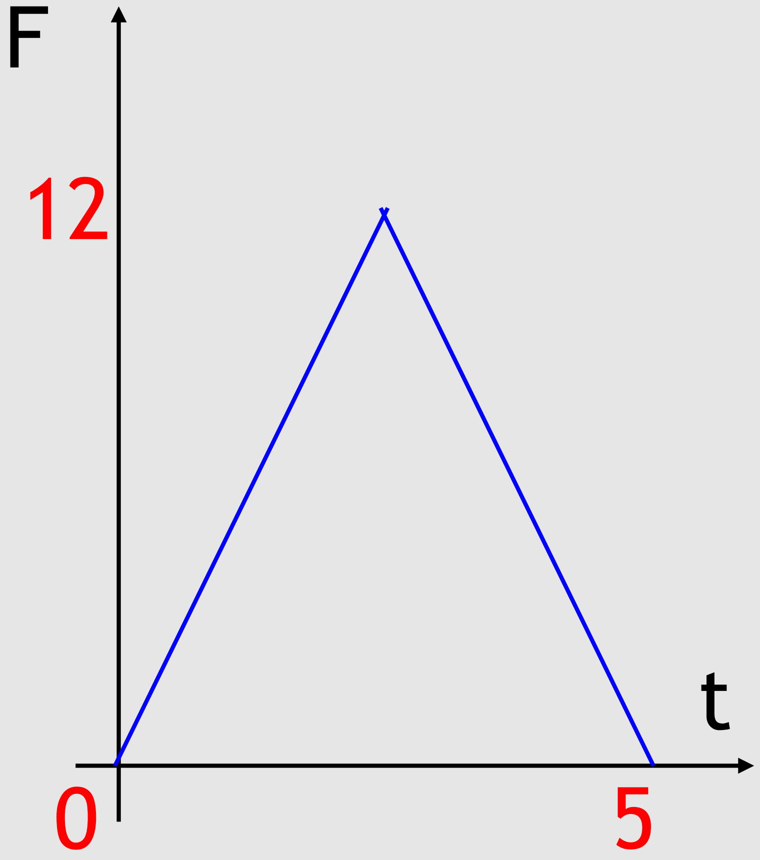
- $m_1 v_1 - m_1 u_1$ is the change in momentum of object 1
- $m_2 u_2 - m_2\ v_2$ is the change in momentum of object 2
- So this says
- **The change in momentum of object 1 is equal to the change in momentum of object 2. (notice that if object 1 gains momentum, object 2 loses momentum)**
- **Isn’t this another way of saying “In the absence of external forces momentum is conserved”**

$m_1 v_1 - m_1 u_1 = m_2 u_2 - m_2\, v_2$

- Δmomentum or Δp is called IMPULSE
- $F_1 = m_1 \frac{v_1 - u_1}{t} = F_2 = -m_2 \frac{v_2 - u_2}{t}$
- Impulse must also equal
- $F_1 t = m_1 (v_1 - u_1)$ so also has units Ns

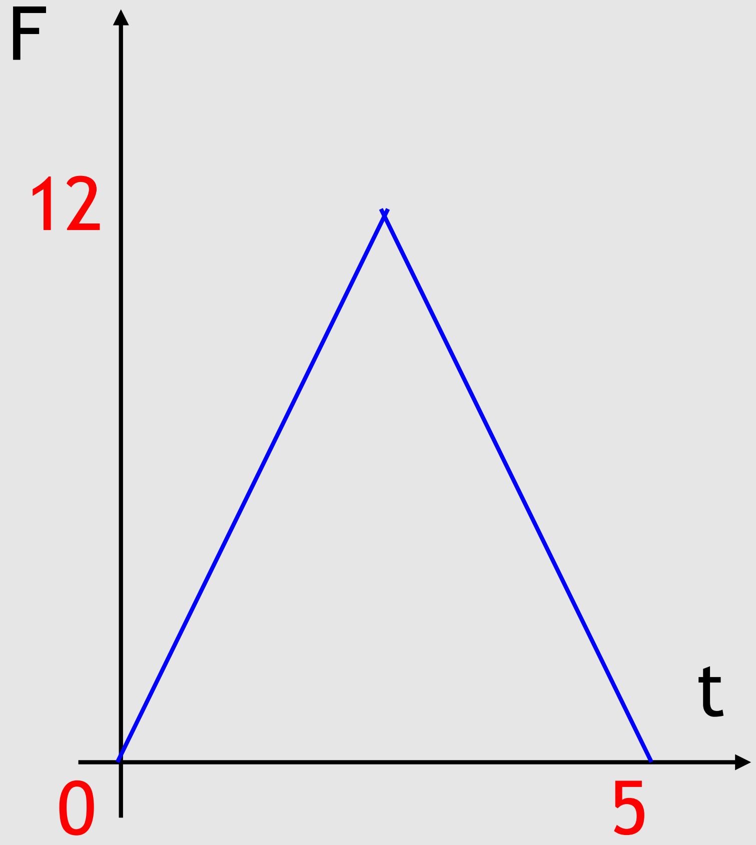
Force time graphs

- ***Impulse or change in momentum must also be equal to the AREA under an F-t graph***



Force time graphs

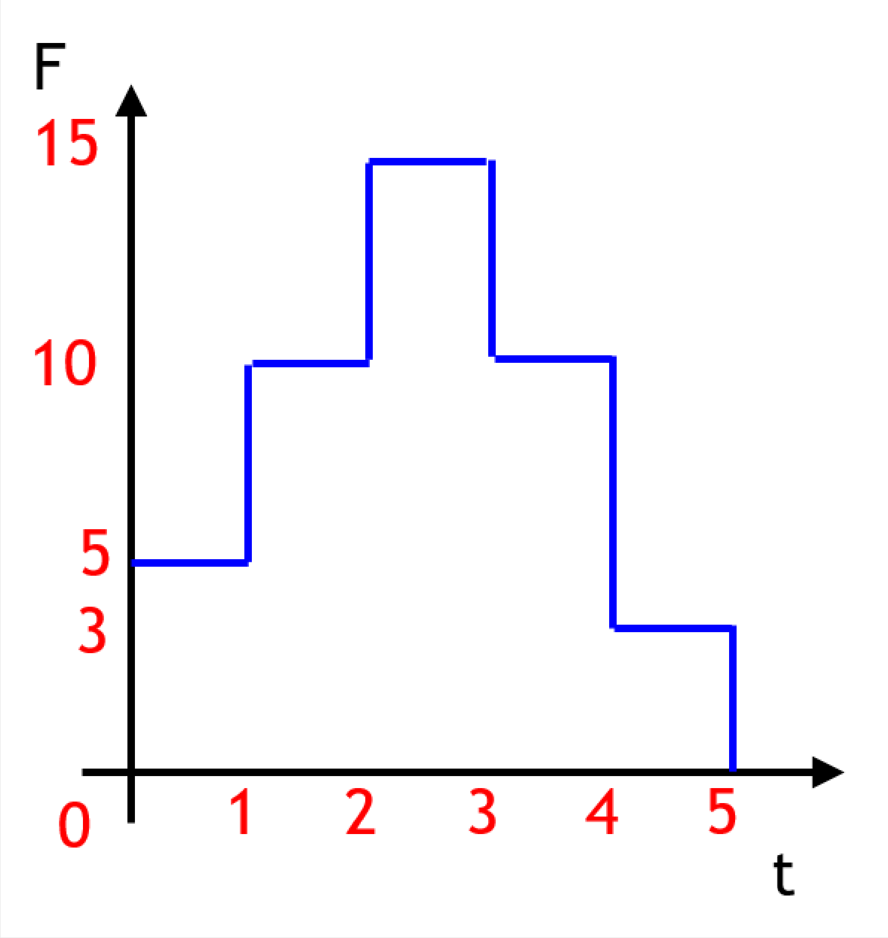
For force-time graphs:
area under graph
= Ft
= Δp (change in momentum)
= impulse
Impulse = area under the graph
= ½ x 12 x 5 = 30 N s.

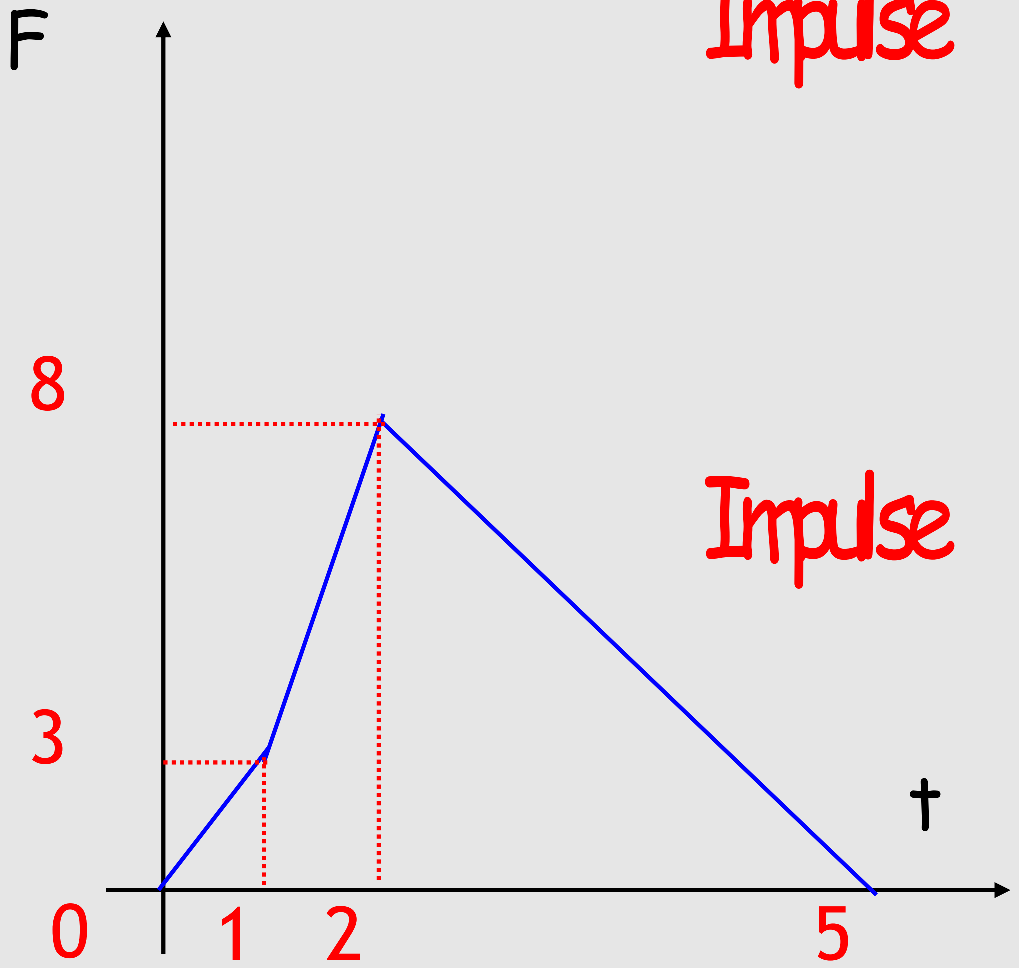


Impulse = area under the graph

$$= (1\times5)+(1\times10)+(1\times15)+(1\times10)+(1\times3)$$

$$= 43\,Ns$$





$$\text{Impulse} = \text{area under the graph}$$
$$= \tfrac{1}{2}bh + bh + \tfrac{1}{2}bh + \tfrac{1}{2}bh$$
$$= (\tfrac{1}{2}\times 1\times 3) + (1\times 3) + (\tfrac{1}{2}\times 1\times 5) + (\tfrac{1}{2}\times 3\times 8)$$
$$= 19\,\text{Ns}$$

$$\text{Impulse} = \text{area under the graph}$$
$$= Ft + Ft + Ft$$
$$= (1\tfrac{1}{2}\times 1) + (5\tfrac{1}{2}\times 1) + (4\times 3)$$
$$= 19\,\text{Ns}$$