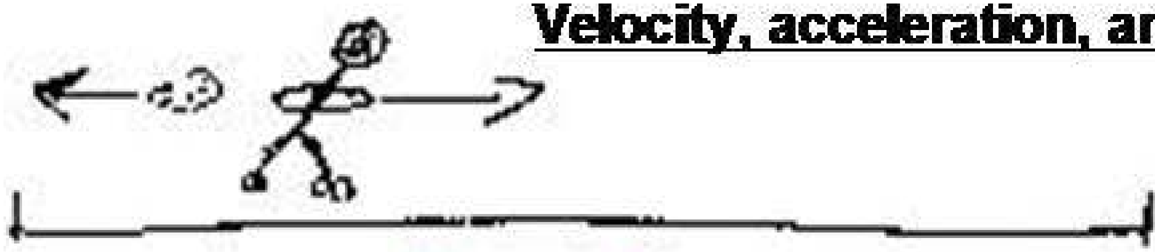
Velocity, acceleration, and force in rocket demo



$t=0$
$v_i=0$
$x=0$

$t=4s$
$x=10m$

observation

$$\bar{v}=? \qquad \bar{v}=\frac{\Delta x}{\Delta t}=\frac{10m}{4s}=2.5\frac{m}{s}$$

one way

$a=?$ (assume const a)

$$\Delta x=\frac{1}{2}at^2 \Rightarrow a=\frac{2(\Delta x)}{t^2}$$

$$a=\frac{2(10m)}{(4s)^2}=1.25\frac{m}{s^2}$$

$$v_f=? \qquad v_f=at=\left(1.25\frac{m}{s^2}\right)(4s)=5\ \frac{m}{s}$$

another way

$v_f=?$ (assume a=const) $\bar{v}=\frac{v_f+v_i}{2}$

$$2.5\ \frac{m}{s}=\frac{v_f+0}{2} \Rightarrow v_f=5\ \frac{m}{s}$$

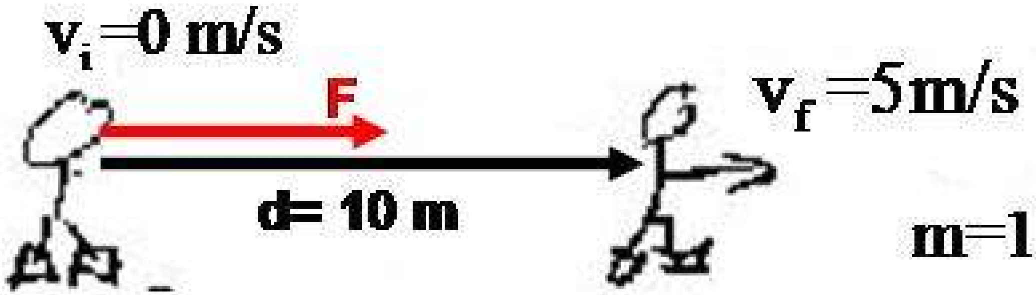
$$a=? \qquad a=\frac{v_f-v_i}{\Delta t}$$

$$a=\frac{(5-0)\frac{m}{s}}{4s}=1.25\frac{m}{s^2}$$

$F=?$ $F=ma$

$F=(113kg)(1.25m/s^2)=141$ N (about 32 lb)

Kinetic energy & Work Energy Theorem in rocket demo



m=113kg

Note Work done here is entirely due to non conservative forces (gas pressure release-like explosion).
$W_{nc}=\Delta E=\Delta K$

$$\Delta KE_{Craft} = \frac{1}{2}mv_f^{\,2} - \frac{1}{2}mv_i^{\,2}$$

$$\Delta KE_{Craft} = \{\frac{1}{2}(113)5^2 - 0\}kg\frac{m^2}{s^2} = 1412\ J$$

Work Energy Theorem $W=\Delta KE$

Work $W=F\bullet d$

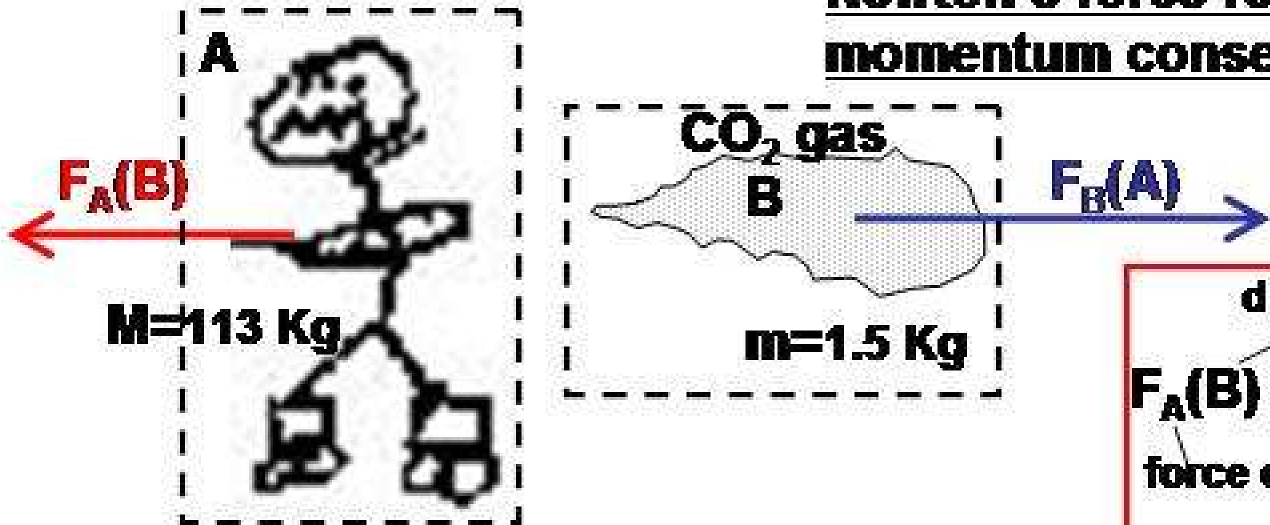
$$\therefore F\bullet d = \Delta KE = \frac{1}{2}mv_f^{\,2} - \frac{1}{2}mv_i^{\,2}$$

$$F\,(10m) = \frac{1}{2}(113)5^2 = 1412J$$

$$F = \frac{1412}{10}\frac{J}{m} = 141\frac{J}{m} = 141\ N$$

force of gas on croft

Newton's force reaction force (3rd) Law & momentum conservation in rocket demo



Newton's 3rd Law

due to B · due to A

$$F_A(B) = -F_B(A)$$

force on A · force on B

(simple but powerful !!)

Newton's 2rd Law $F = ma \quad or \quad F = \dfrac{\Delta p}{\Delta t} \quad where \quad p = mv$

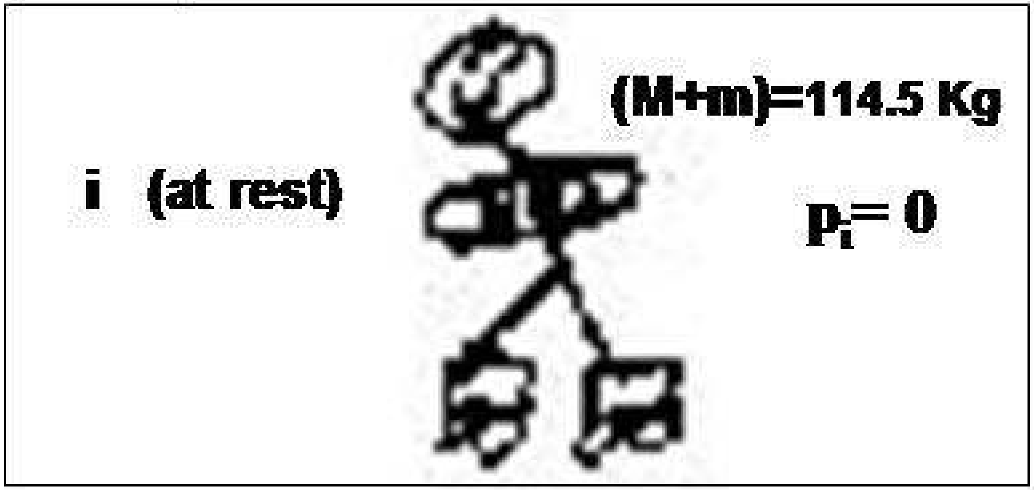
A+B system: no external forces $\Rightarrow$ momentum conservation

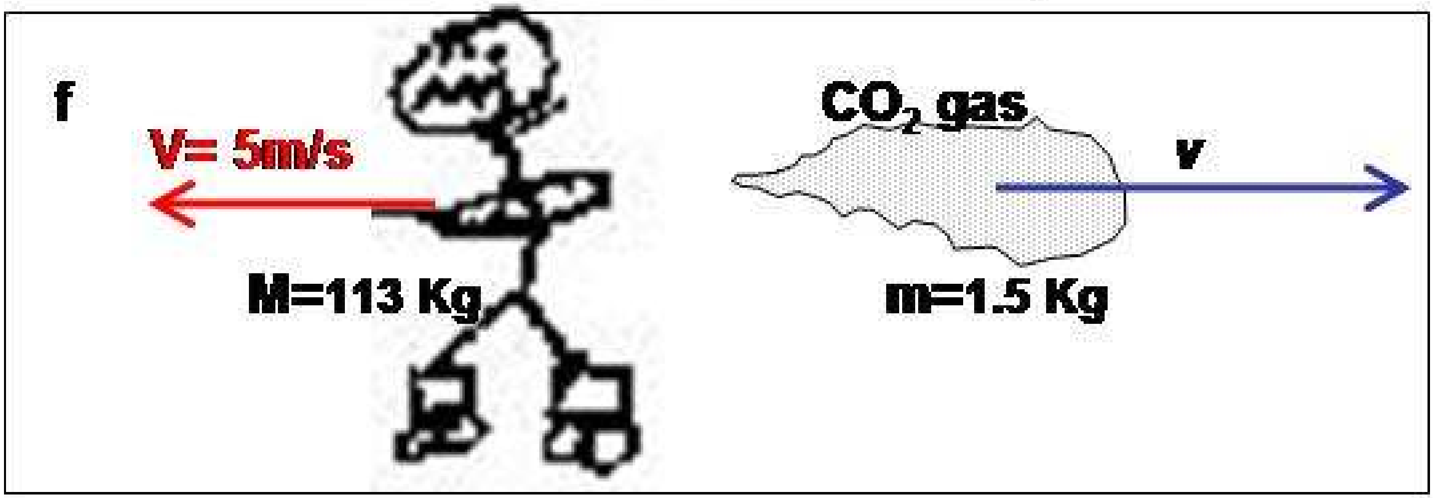
$$F_{tot} = F_A + F_B = 0 \quad \Rightarrow \quad \frac{\Delta p_{tot}}{\Delta t} = 0 \quad \Rightarrow \quad \Delta p_{tot} = \Delta p_A + \Delta p_B = 0$$

$$\Downarrow$$

$$\boxed{\Delta p_A = -\Delta p_B}$$

Conservation of momentum in rocket demo





initial momentum → $p_i = p_f$ ← final momentum

$$0 = +MV - m\,v$$

$$m\,v = MV$$

$$v = \frac{113\ \text{Kg}}{1.5\ \text{Kg}}\, 5\,\frac{\text{m}}{\text{s}}$$

$$v = 75\,\frac{\text{m}}{\text{s}}$$

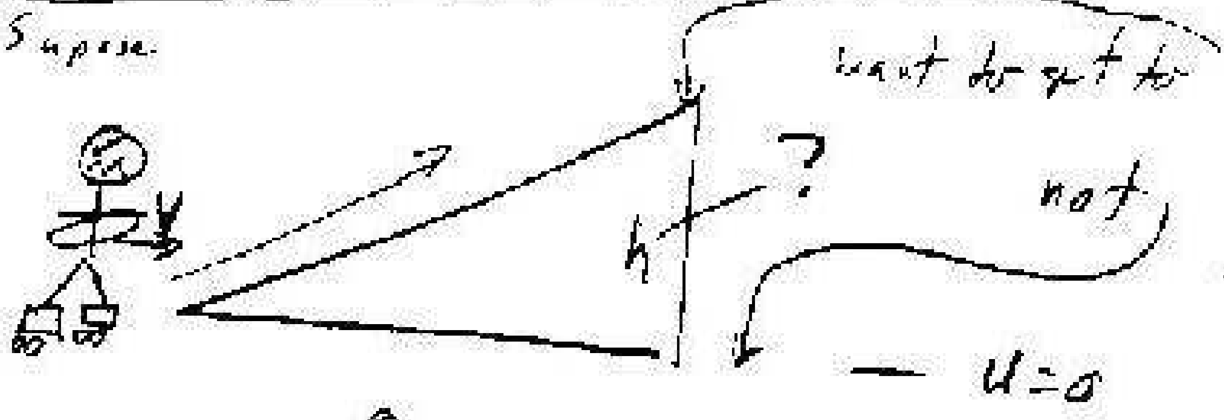
for CO_2 gas

m=1.5 Kg= mass tank after-before=(16.5-15) Kg

kinetic to potential energy conversion: design of stop-ramp for rocket demo

Build inclined plane to stop craft

Suppose



Q how high could h be

$E_i = \frac{1}{2} m v^2 + 0$

$E_f = 0 + mgh$ ($v_f = 0$, rest)

$E_i = E_f$

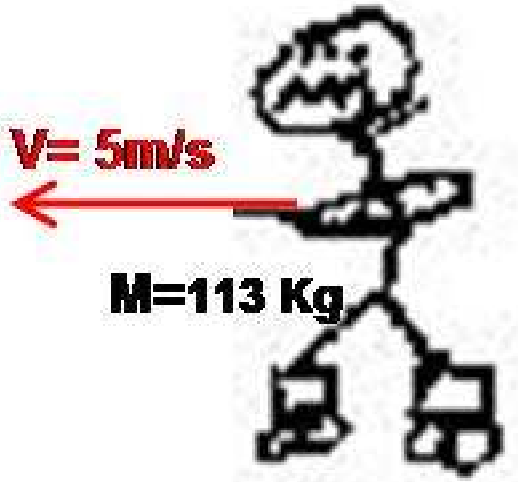
$\frac{1}{2} m v_i^2 = mgh$

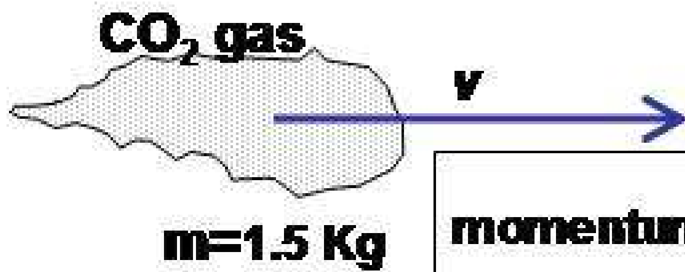
$$h = \frac{1}{2} \frac{v_i^2}{g} = \frac{1}{2} \frac{5^2}{9.8 \to 10} = 1.25\,m$$

ramp 1.25 m high should stop craft

P.S. physics works but not a very good idea

Division of energy & momentum in rocket demo





momentum conservation

$$MV = m\,v \Rightarrow \frac{v}{V} = \frac{M}{m}$$

$$\frac{KE_{gas}}{KE_{puf}} = \frac{\frac{1}{2}mv^2}{\frac{1}{2}MV^2} = \frac{m}{M}\left(\frac{v}{V}\right)^2 = \frac{m}{M}\left(\frac{M}{m}\right)^2 = \frac{M}{m}$$

$$\frac{KE_{gas}}{KE_{puf}} = \frac{M}{m} = \frac{113}{1.5} = 75!!$$

Energy to gas!!

in general

$$\frac{p_m}{p_M} = \frac{mv}{MV} = 1$$

momentum equally to both !!

$$\frac{KE_m}{KE_M} = \frac{M}{m}$$

Energy goes to the little guy!!

In radioactive decay most energy goes to smaller particle