* Energy: $KE = \frac{1}{2} m v^2$, $PE_g = mgh$, $PE_k = \frac{1}{2} k x^2$

OE = other energy , $W_{nc} = F d \cos\theta$

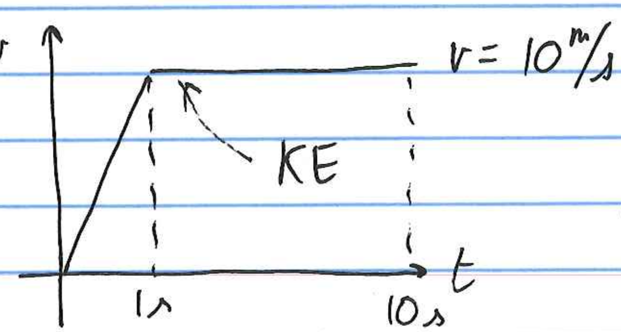
Conservation of energy:

$OE + KE + PE$ constant , W_{nc}

$$\underbrace{OE_f}_{\text{chemical ...}} + \underbrace{KE_f + PE_f}_{\text{mechanical energy}} = OE_i + \underbrace{KE_i + PE_i + W_{nc}}$$

* Power: $P = \frac{W}{\Delta t}$, $1\,\text{Watt} = 1\,W = 1\,\frac{J}{s}$

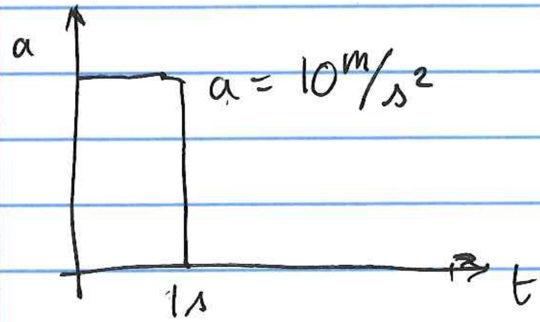
↳ rate at which work is done, at which energy is used



$m = 60\,kg$

$KE = \frac{1}{2} m v^2 = \frac{1}{2}(60\,kg)(10\,m/s)^2$

$= 3000\,J$



$P = \frac{3000\,J}{1\,s} = \underline{3000\,W}$

200W (gym)

* Momentum : $\vec{p} = m\vec{v}$ (kinematics, nothing to do with causes of motion)

units : $kg\,\frac{m}{s} = N\cdot s$

$N = kg\,\frac{m}{s^2}$

why? useful in describing collisions

* Connection with force

$$\vec{F} = m\vec{a} = m\frac{\Delta\vec{v}}{\Delta t} = m\frac{\vec{v}_f - \vec{v}_i}{\Delta t} = \frac{m\vec{v}_f - m\vec{v}_i}{\Delta t}$$

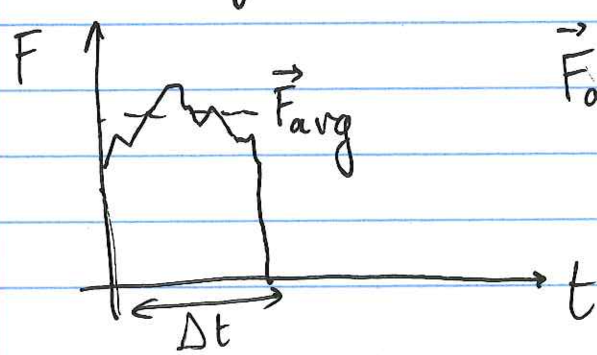
$$= \frac{\vec{p}_f - \vec{p}_i}{\Delta t} = \frac{\Delta\vec{p}}{\Delta t}$$

Newton's 2nd law : $\vec{F} = \frac{\Delta\vec{p}}{\Delta t}$

dynamics (causes) kinematic (effects)

* ~~[illegible]~~ Details of F are unknown

$$\vec{F}_{avg}\cdot\Delta t = \Delta\vec{p} = \vec{I} = \text{impulse}, \text{ units } N\cdot s$$



$$\vec{F}_{avg}\cdot\Delta t = \Delta\vec{p} = \vec{v}_f - \vec{v}_i$$

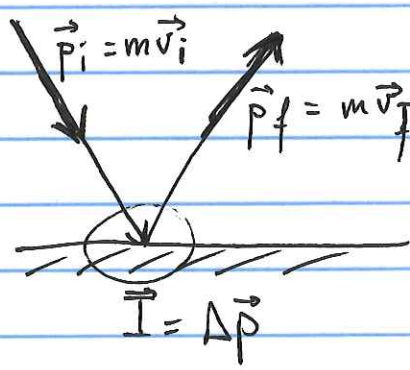
* Example: height of 1200 feet → 400m
mass of porta-potty → 200 lbs, 100 kg
(empty)

$$h = \frac{v^2 \sin^2\theta}{2g} = \frac{v^2}{2g}$$

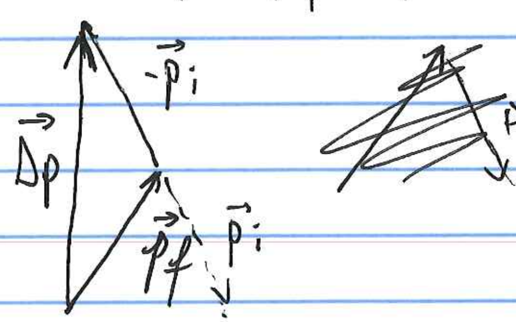
$$v^2 = 2gh \rightarrow v = \sqrt{2gh} = \sqrt{2(10)(400)}$$
$$= 90\ m/s$$

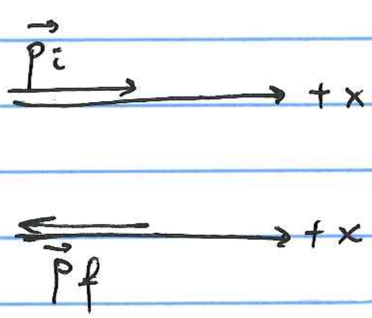
$$p = mv = (100\,kg)(90\ m/s) = \underline{9000\ N\cdot s}$$

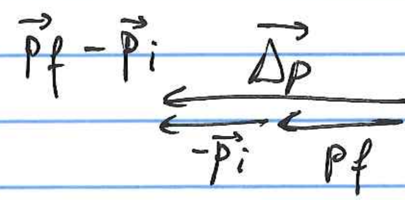
$$I_{rocket} = \underline{9000\ N\cdot s} = \Delta p = p_f - \underset{0,\,v=0}{\underset{\parallel}{p_i}}$$

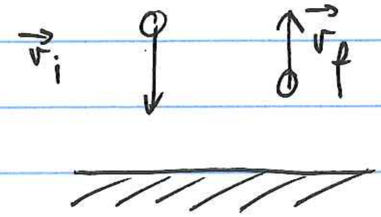


$$\Delta\vec{p} = \vec{p}_f - \vec{p}_i$$









$m = 0.1\,kg$, $|\vec{v}_i| = |\vec{v}_f| = 5.5\,m/s$

1) What is the impulse?

2) What is the force from the ground on the ball if impact lasts for 0.02 s?

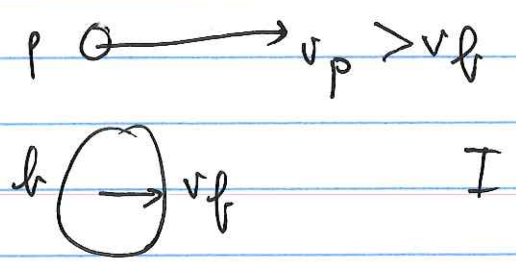
1) $\vec{I} = \Delta\vec{p} = \cancel{m}\ \vec{p}_f - \vec{p}_i = m\vec{v}_f - m\vec{v}_i$

$\vec{v}_i = -5.5\,m/s$ (down)

$\vec{v}_f = +5.5\,m/s$ (up)

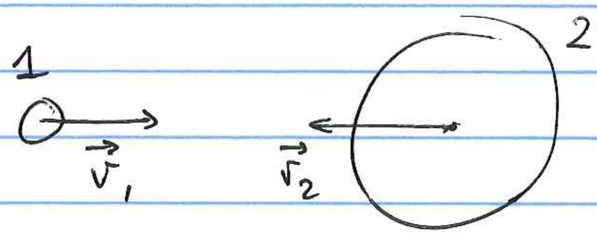
$\vec{I} = (0.1\,kg)(+5.5\,m/s) - (0.1\,kg)(-5.5\,m/s) = 1.1\,N\cdot s$

2) $\vec{F} = \dfrac{\Delta\vec{p}}{\Delta t} = \dfrac{\vec{I}}{\Delta t} = \dfrac{1.1\,N\cdot s}{0.02\,s} = 55.0\,N$

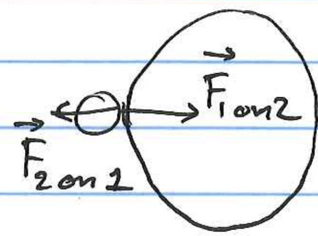


$m_p v_p = m_b v_b = p_i$

$I = \Delta p = -p_i = F\underline{\Delta t}$



2 colliding masses



$\vec{F}_{1 on 2} = -\vec{F}_{2 on 1}$ (Newton's 3rd law)

impact lasts for Δt

$$\Delta p_1 = I_1 = F_{2 on 1} \Delta t \qquad I_2 = F_{1 on 2} \Delta t = \Delta p_2$$

$$\Delta p_1 = \underline{p_{1,f} - p_{1,i}} = F_{2 on 1} \Delta t = -F_{1 on 2} \Delta t = -\Delta p_2$$

$$= -(p_{2,f} - p_{2,i}) = \underline{p_{2,i} - p_{2,f}}$$

$$\boxed{\underline{p_{1,f} + p_{2,f} = p_{1,i} + p_{2,i}}}$$

in any collision: TOTAL momentum before and after the collision is the same