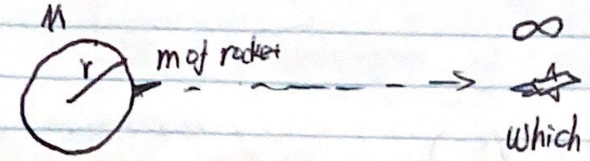


came to a stop.

which $E_k = 0$ / $E_p = 0$

$\Sigma E_i = \Sigma E_f$

$E_{pi} + E_{ki} = \cancel{E_{pf}}^{0} + \cancel{E_{kf}}^{0}$

$E_{pi} + E_{ki} = 0$

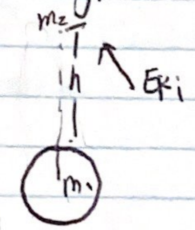
$-\frac{GM\cancel{m}}{r} + \frac{1}{2}\cancel{m}v^2 = 0$

$v = \sqrt{\frac{2GM_p}{r_p}}$

$v = \sqrt{\frac{2 \times 6.67 \times 10^{-11} \times 5.98 \times 10^{24}}{6.38 \times 10^{6}}}$

$v = 11.2\ km/s$

Determine v_f of a piece of a rocket launch straight up if comes back down from a height of 405 km. Ignore air friction.



$\Sigma E_i = \Sigma E_f$

$E_{pi} + \cancel{E_{ki}}^{0} = E_{pf} + E_{kf}$

$E_{pi} - E_{pf} = E_{kf}$

$-\frac{GM\cancel{m}}{r} - \left(-\frac{GM\cancel{m}}{r}\right) = \frac{1}{2}\cancel{m}v_f^2$

$-GM\left(\frac{1}{r_i} - \frac{1}{r_f}\right) = \frac{1}{2}v_f^2$

$\sqrt{+2GM\left(\frac{1}{r_f} - \frac{1}{r_i}\right)} = v_f$

$v_f = 2.73 \times 10^3\ m/s$

Momentum

Inertia is generally described as an object resistent to motion.

Momentum is the tendency to continue moving.

$\vec{p} = m\vec{v}$ momentum is a vector

unit: (kg·m/s)

$\Delta\vec{p} = \Delta(m\vec{v})$ $\begin{cases} \Delta p = \Delta m \cdot \vec{v} \\ \Delta p = m \cdot \Delta\vec{v} \\ \Delta p = \Delta m \Delta\vec{v} \end{cases}$

Impulse !!!

$\boxed{\vec{J} = \vec{F}\Delta t}$ or $\vec{J} = \vec{F}_{net}\,\Delta t$ (unit : Ns)

momentum.

(unit: $km/s^2 \cdot s$ = $kg\,m/s$)

[have same units]

Impulse Momentum Theorem

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

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

ex. A 5.0 kg mass is accelerated from rest to 3.5m/s in 2.5s. Find the net force acting on the force.

① $V_f = V_i + at$ $\qquad a \times m = 1.4 \times 5 = 7N$

$3.5 = 0 + a \times 2.5$

$a = 1.4 m/s^2$

② $F_{net} \cdot \Delta t = \Delta\vec{p}$

$F_{net} \cdot \Delta t = m \cdot \Delta V$

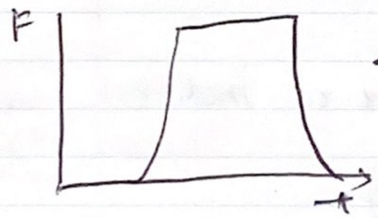
$F_{net} \cdot \Delta t = m(V_f - V_i)$

$F_{net} \cdot 2.5 = 5(3.5 - 0)$

$F_{net} = 7N$

~~ex 2. A 13kg ball is c~~

Graph F vs t



A is impulse

$\boxed{\text{Area} = \Delta\text{momentum} \,/\, \text{impulse}}$

Law of conservation of Momentum

In a closed isolated system, momentum is conserved.

$\Delta \vec{P}_{total} = 0$

$\Delta \vec{P}_1 + \Delta \vec{P}_2 = 0$

$\vec{P}_{1f} - \vec{P}_{1i} + \vec{P}_{2f} - \vec{P}_{1i} = 0$

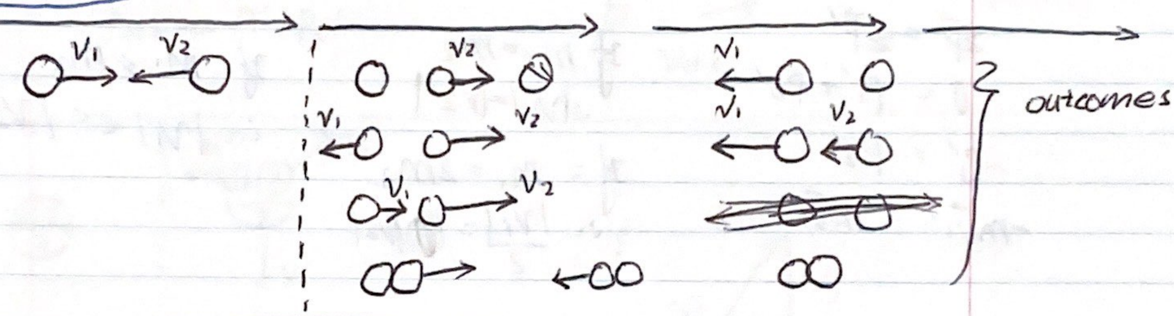
$\vec{P}_{1f} + \vec{P}_{2f} = \vec{P}_{1i} + \vec{P}_{2i}$

$\therefore \Sigma P_i = \Sigma P_f$

or $\Sigma \vec{P} = \Sigma \vec{P}'$

1-D

(event)



Elastic Collision: Kinetic energy and Momentum are both conserved. Objects bouce off one another [Not realistic. no loss of energy (ex sound and heat energy)].

Inelastic Collision: Kinetic energy lost due to sound/heat. Momentum is conserved. Objects bounce off one another [Most Cases]

Perfectly Inelastic: Kinetic energy is not conserved. Momentum is conserved. Objects stuck together.

ex. A 3.5 kg cart moves to the right with a velocity of 3.5 m/s and collides with a 4.5 kg cart moving to the left at 1.5 m/s. If the 3.5 kg cart continues to move to the right at 0.5 m/s. What is the final velocity of cart 2?

$\sum \vec{P} = \sum \vec{P}'$

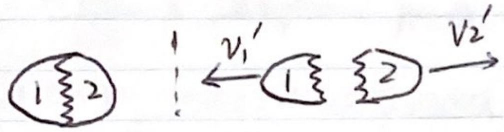
$\vec{P}_1 + \vec{P}_2 = \vec{P}_1' + \vec{P}_2$

$m_1\vec{v}_1 + m_2\vec{v}_2 = m_1\vec{v}_1' + m_2\vec{v}_2'$

$$\frac{m_1\vec{v}_1 + m_2\vec{v}_2 - m_1\vec{v}_1'}{m_2} = \vec{v}_2'$$

$$\frac{3.5\times 3.5 + 4.5\times(-1.5) - 3.5\times(0.5)}{4.5} = \vec{v}_2' \qquad \therefore \vec{v}_2 =$$

ex.



$\sum \vec{P} = \sum \vec{P}'$

$0 = P_1' + P_2'$

$-P_1' = P_2'$

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

If $m_1 = m_2$

$\therefore |v_1'| = |v_2'|$

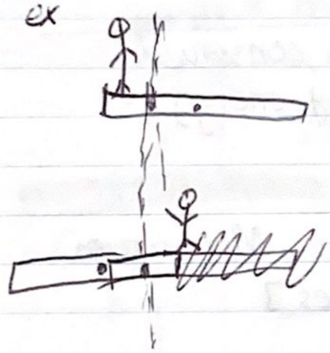
If: $m_1 = 2m_2$

$\therefore \frac{|v_1|}{2} = |v_2|$

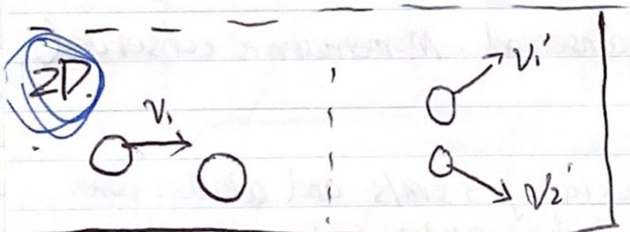
If $m_1 \geq m_2$

$\therefore |v_1'| << |v_2'|$

ex



2D.



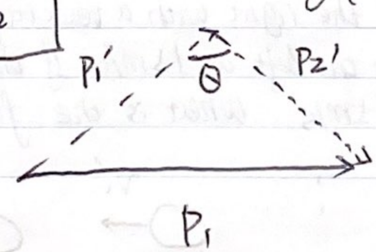
$\theta = 90°$ for elastic collision only

$\theta \neq 90$ in inelastic collision.

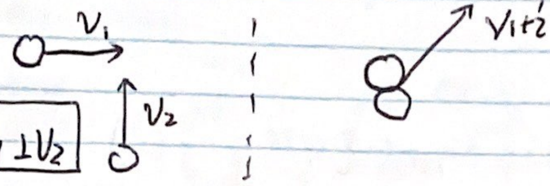
$\sum \vec{P} = \sum \vec{P}'$

$P_1 = P_1' + P_2'$

2D vector sum



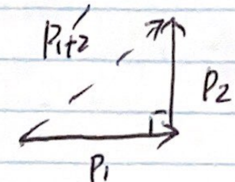
ex2.



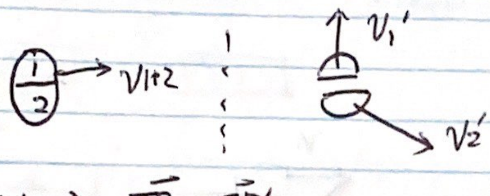
① $\boxed{V_1 \perp V_2}$

$\Sigma \vec{P} = \Sigma \vec{P}'$

$\vec{P_1} + \vec{P_2} = P_{1+2}'$

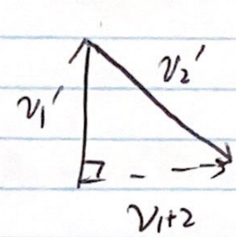


ex3.

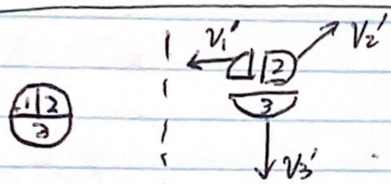


$(V_1 \perp V_{1+2})$ $\Sigma \vec{P} = \Sigma \vec{P}'$

$P_{1+2} = P_1' + P_2'$

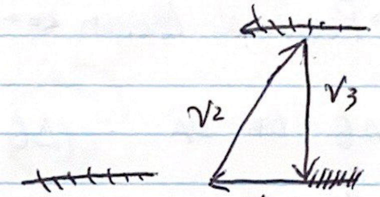


ex4.

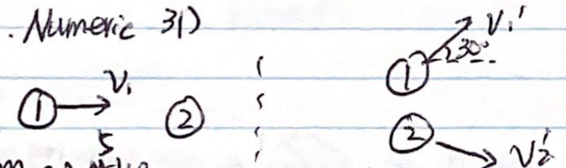


$\Sigma P = \Sigma P'$

$\vec{P}_{1+2+3} = \vec{P_1}' + \vec{P_2}' + \vec{P_3}'$



ex. Numeric 31)

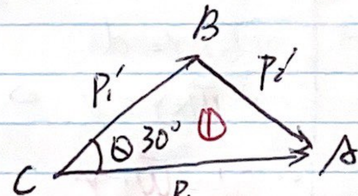


$m_1 = 0.5\,kg$ $\quad v_1 = 2.4\,m/s$

$m_2 = 0.3\,kg$ $\quad v_1' = 1.8\,m/s$

① $\Sigma \vec{P} = \Sigma \vec{P}'$

① $\vec{P_1} = \vec{P_1}' + \vec{P_2}'$



① $|P_1| = m|v_1|$

$= 0.5 \times 2.4$

$= 1.2\,kg\,m/s$

$|P_2'| = c = \sqrt{a^2+b^2-2ab\cos\angle C}$

① $= \sqrt{1.2^2 + 0.9^2 - 2 \times 1.2 \times 0.9 \cos 30°}$

$= 0.616\,kg\,m/s$

$|P_1'| = m|V_1'|$

$= 0.5 \times 1.8$

$= 0.9\,kg\,m/s$

① $P_2' = mV_2'$

$V_2' = \frac{P_2'}{m} = \frac{0.616}{0.3} = 2.05\,m/s$

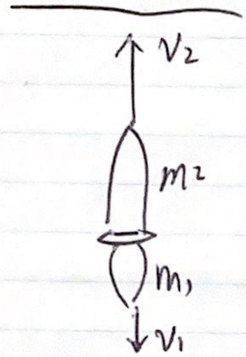
$\angle A$: $\frac{\sin A}{a} = \frac{\sin C}{c}$ ①

$A = \sin^{-1}\left(\frac{a \sin\angle C}{c}\right)$

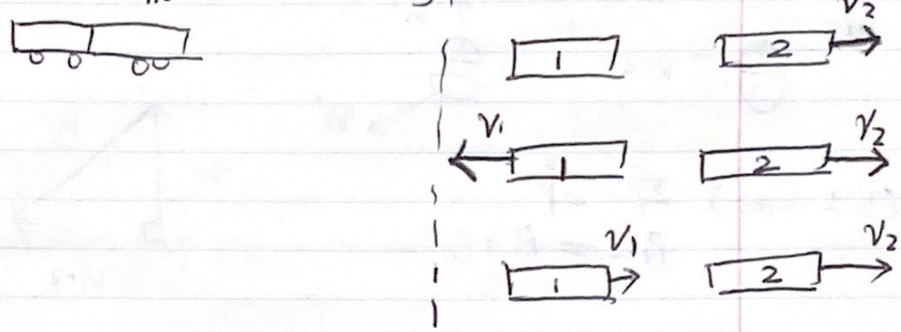
$= \sin^{-1}\left(\frac{0.9 \sin 30^\circ}{0.616}\right)$

$= 46.9^\circ$

$v_2' = 2.1 \text{ m/s } [47^\circ \text{ S of E}]$ ① ①

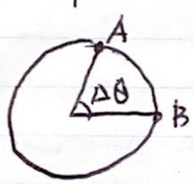


ex, ⟶ has an intial velociey |



==⇒ Rotational Motion ⇐==

- Angular position:



$\Delta\theta = \theta_B - \theta_A$ ($\Delta\theta$ unit: rad)

↑↑ angular position

- Angular velocity: Recall $\vec{v} = \frac{\vec{d}}{t}$

$\therefore \vec{\omega} = \frac{\Delta\vec{\theta}}{\Delta t}$ (unit rads/s)

↑ angular velocity

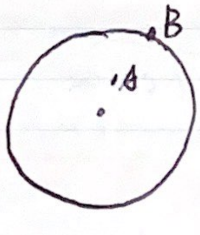
tangential velocity ⇒ ← the velocity on circumference/ road distance

$\because \theta \times r = d$

$\therefore \vec{\omega} \times r = \vec{v} \Rightarrow \left(\frac{\Delta\vec{\theta} \times r}{\Delta t} = \frac{\Delta d}{\Delta t} = \vec{v}\right)$

$\therefore \vec{v} = \vec{\omega} \cdot r$

~ problem:



$\vec{\omega}_A = \vec{\omega}_B$

$\because \theta$ is the same

$\vec{v}_A < \vec{v}_B$

$\because r_A < r_B$

$\therefore \vec{\omega}_A \cdot r_A < \vec{\omega}_B \times r_B$ ①