MOMENTUM

- Momentum is the product of mass x velocity
- It is a <u>vector</u> quantity ∴ the direction of the object is critical. We used signs +ve & -ve to represent the direction of the velocities and momentums.

e.g. $6ms^{-1}$ → [8kg]

$p = mv$

$p = 8kg \times 6ms^{-1}$

$= +48\ kg\ ms^{-1}$

or

$48\ kg\,ms^{-1}$ →

or

$9ms^{-1}$ ← [12kg]

$p = mv$

$p = 12kg \times -9ms^{-1}$

$p = -108\ kg\,ms^{-1}$

or

$108\ kg\,ms^{-1}$ ←

MOMENTUM IS ALWAYS CONSERVED (FUNDAMENTAL LAW OF PHYSICS)

(unless an external force acts).

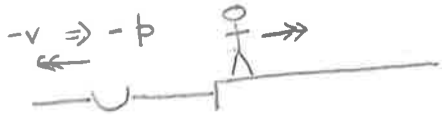
e.g. Man in boat at boat club

$V = 0 \therefore p = 0$

as man steps out of boat

$+V \Rightarrow +p$

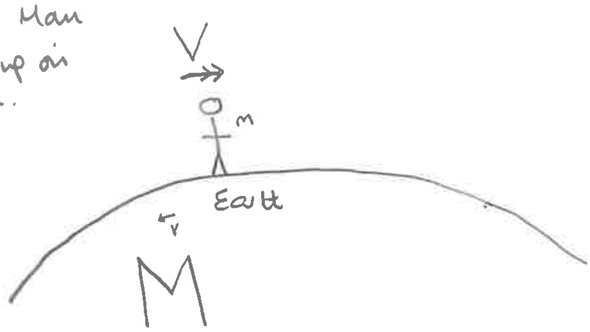
$-v \Rightarrow -p$



$-p + p = 0$

Momentum conserved as before man moved momentum was $p = 0$.

e.g. Man walking on Earth.



- When man was stationary $p = 0$
- When he starts moving:

$$M_{earth} \times \overleftarrow{v} = m_{man} \overrightarrow{V_{man}}$$

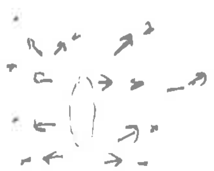
$-p = +p$ ∴ momentum conserved.

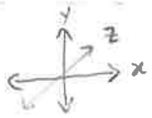
As M_{earth} is so much bigger, effect is not noticeable.

e.g. Hand grenade

Before explosion $p = 0$

<u>after</u> Fragment of metal, of mass m moving at velocity v in x, y & z planes





Sum of momentums in each plane will be zero

∴ MOMENTUM CONSERVED.

Using conservation of momentum :

- 2 object collide & stick together :

Before Collision

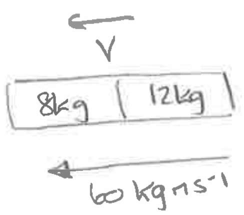
Total momentum before collision p_b = sum of momentums

$p_B = m_1 V_1 + m_2 V_2$

$p_b = (8kg \times 6ms^{-1}) + (12kg \times -9ms^{-1})$ ← vector ∴ sign is critical.

$p_b = 48 - 108 = \underline{\underline{-60\, kgms^{-1}}}$

After Collision : momentum alway conserved ∴ $p_b = p_{after}$



Solve for new velocity :

$p_{after} = p_{before} : -60 kgms^{-1}$

$-60 kgms^{-1} = (8kg + 12kg) \cdot V$

$V = \dfrac{-60 kgms^{-1}}{20 kg}$

$V = \underline{\underline{-3ms^{-1}}}$ or $3ms^{-1}$ ←

MOMENTUM & NIInd LAW

- We know Newtons 2nd Law States :

$F = ma$ we also know that $a = \dfrac{v-u}{t}$

Subst in $a = \dfrac{v-u}{t}$

$F = m\left(\dfrac{v-u}{t}\right)$

$F = \dfrac{mv - mu}{t} = \dfrac{\text{change in momentum}}{\text{time}}$

∴ The force equal to 'rate of change of momentum

The change of momentum is known as the impulse.

$\therefore$ Impulse $Ft = mv - mu$.

Units of Impulse are **Ns**

A ball of 80g is moving at $15ms^{-1}$ hits a wall at right angles and bounces off along the same line at $10ms^{-1}$.

(a) What is the magnitude of the Impulse of the wall on the ball?

(b) The ball is estimated to be in contact with the wall for $3.0 \times 10^{-2}s$. What is the average force on the ball?

(a) Impulse $= Ft = mv - mu$

$= (0.08 \times -10ms^{-1}) - (0.08 \times 15ms^{-1})$

$= -2.0\,Ns$ or $-2kgms^{-1}$

(note: we must use the -ve to indicate the direction of the velocity.

(b) Impulse $= Ft = mv - mu$.

$\therefore$ Ave Force $= \frac{mv - mu}{t}$

$= \frac{-2kgms^{-1}}{3 \times 10^{-2}s} = -66\frac{2}{3}\,N$

The average force on the ball is $-66\frac{2}{3}\,N$

As the ball changes direction, the force is in the opposite direction to the initial velocity.