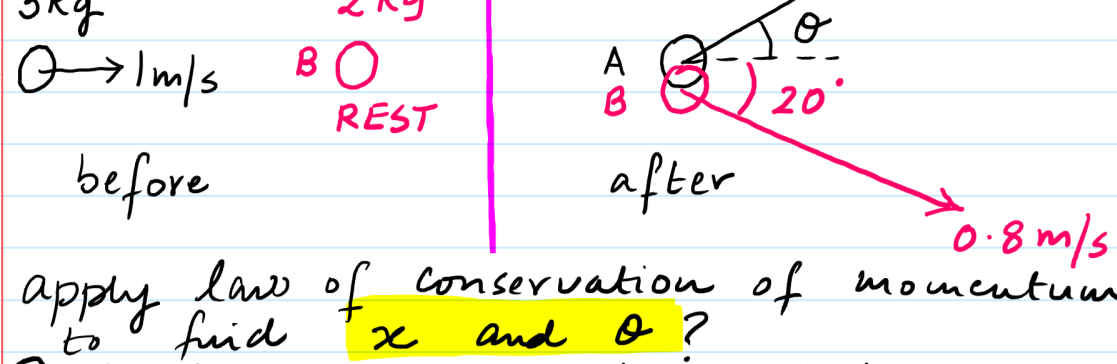


How to apply Law of Conservation of momentum in **Two dimensions** x m/s



apply law of conservation of momentum to find x and θ ?

① L.O.C.O.M in the horizontal plane
 $\rightarrow (3)(1) + (2)(0) = (3)(x \cos \theta) + (2)(0.8 \cos 20)$
 $3 = 3x \cos \theta + 1.5$
 $3x \cos \theta = 1.5$
 $x \cos \theta = 0.5 \rightarrow \text{①}$

② L.O.C.O.M in the Vertical plane
 $\uparrow 0 + 0 = (3)(x \sin \theta) + (2)(-0.8 \sin 20)$
 $3x \sin \theta = (2)(0.8 \sin 20)$
 $3x \sin \theta = 0.55$
 $x \sin \theta = 0.18 \rightarrow \text{②}$

To find θ eq ② \div eq ①

$\frac{x \sin \theta}{x \cos \theta} = \frac{0.18}{0.5}$
 $\tan \theta = \frac{0.18}{0.5} \therefore \theta = 20^\circ$

find x by substituting in eq ① or ②

$x \cos \theta = 0.5$ from ①
 $x \cos 20 = 0.5$
 $x = 0.53 \text{ m/s}$

How to apply Principle of Conservation of momentum in situations where the initial momentum of the system is zero.



Reason :- Since the initial momentum of the system is ZERO \therefore for L.O.C.O.M to be valid, the final momentum of the system must also remain ZERO.

This is only possible if the 2 bodies have equal momentum in the opposite direction so that they cancel out the effect of each other \therefore when bullet goes forward, the gun must recoil backwards with equal momentum

Cal. the Recoil velocity of the Gun?

Principle of Conservation of momentum
 $\rightarrow 0 + 0 = (0.005)(300) + (2)(-V)$
 $(2)(V) = (0.005)(300)$ method ①
 $V = 0.75 \text{ m/s}$

dy. formula :-

$\rightarrow 0 + 0 = (m)(v) + (M)(-V)$
 $(M)(V) = (m)(v)$
 $MV = mv$ method ②
 $(2)(V) = (0.005)(300)$
 $V = 0.75 \text{ m/s}$

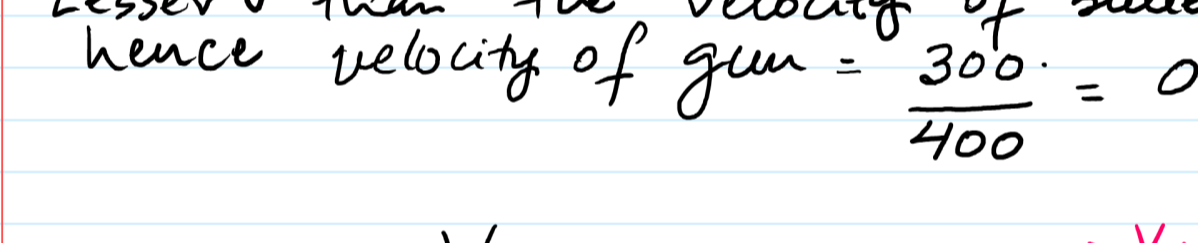
The above working can also be done using ratio method.

According to $p = mv$, m and velocity are inversely proportional to each other hence

$M = 2 \text{ kg}$ $m = 0.005 \text{ kg}$ method ③

Since mass of gun is 400 times heavier than the mass of bullet \therefore due to inverse relationship, the velocity of Gun must be "400 times" lesser than the velocity of bullet

hence velocity of gun = $\frac{300}{400} = 0.75 \text{ m/s}$



Example Show that

(i) $\frac{M}{m} = \frac{v}{V}$

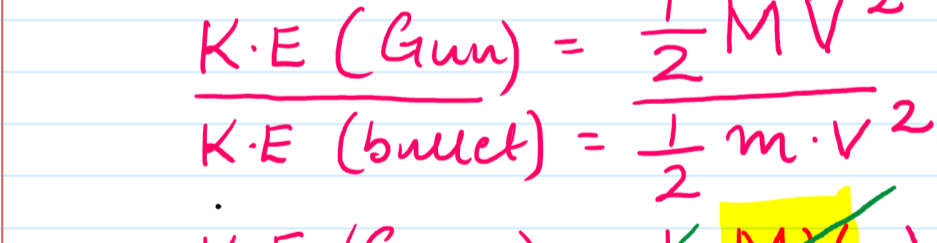
$\rightarrow 0 + 0 = (m)(v) + (M)(-V)$
 $MV = mv$
 cross multiply.
 $\frac{M}{m} = \frac{v}{V}$ shown.

(ii) Show that

$\frac{\text{K.E of gun}}{\text{K.E of bullet}} = \frac{V}{v}$

$\frac{\text{K.E (Gun)}}{\text{K.E (bullet)}} = \frac{\frac{1}{2} M V^2}{\frac{1}{2} m \cdot v^2}$
 $\frac{\text{K.E (Gun)}}{\text{K.E (bullet)}} = \frac{\frac{1}{2} \cdot \cancel{M \cdot V} \cdot V}{\frac{1}{2} \cdot \cancel{m \cdot v} \cdot v}$ since $M \cdot V = m \cdot v$ hence cancels.
 $\frac{\text{K.E (gun)}}{\text{K.E (bullet)}} = \frac{V}{v}$ shown.

Conclude \therefore The ratio of K.E of the 2 bodies actually depends on the ratio of their velocities.



Example Q Cal. ratio of $\frac{\text{K.E Gun}}{\text{K.E bullet}}$ = ??

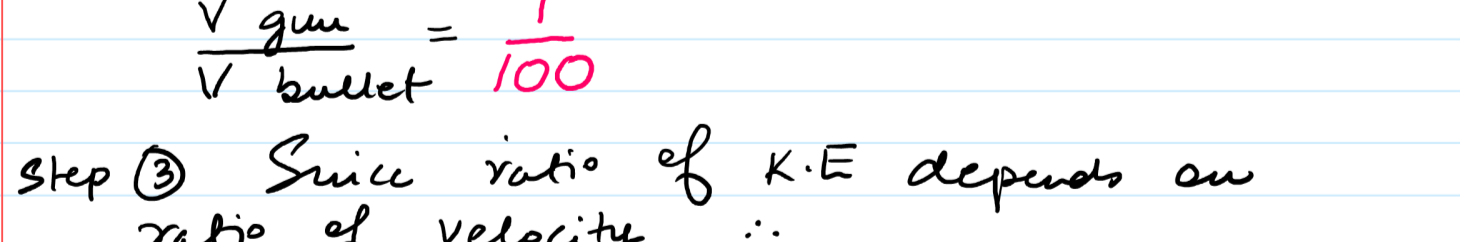
Step ① $\frac{M_{\text{gun}}}{M_{\text{bullet}}} = \frac{10}{0.1} = \frac{100}{1}$

Step ② Since $m \propto \frac{1}{v}$
 $\frac{v_{\text{gun}}}{v_{\text{bullet}}} = \frac{1}{100}$

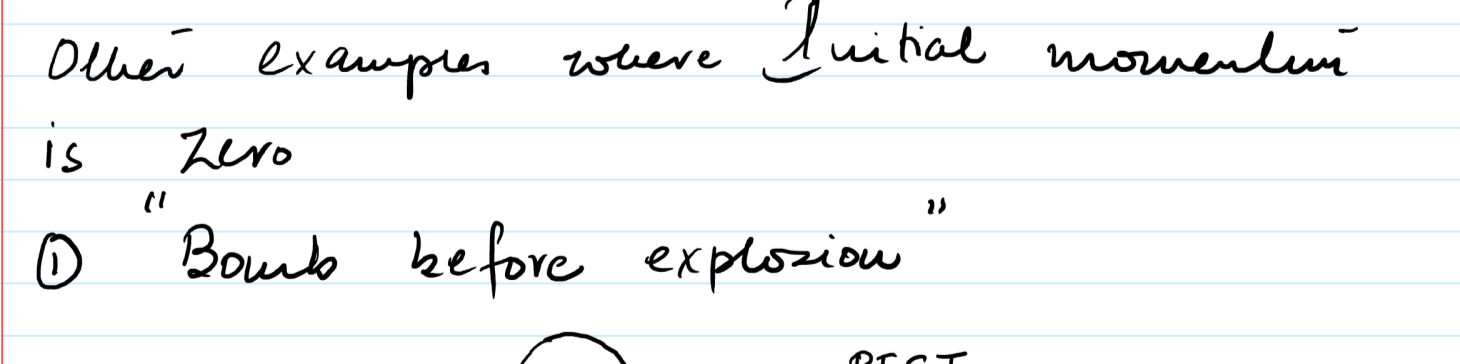
Step ③ Since ratio of K.E depends on ratio of velocity \therefore
 $\frac{\text{K.E gun}}{\text{K.E bullet}} = \frac{1}{100}$

Other examples where Initial momentum is zero

① "Bomb before explosion"



after explosion, it breaks into fragments.



Ratio of $\frac{m_A}{m_B} = \frac{12}{8}$

Ratio of $\frac{V_A}{V_B} = \frac{8}{12}$

Ratio of $\frac{\text{K.E (A)}}{\text{K.E (B)}} = \frac{8}{12}$

Total K.E is given as "E"

find fraction of K.E possessed by A $\frac{8}{8+12} E$

find fraction of K.E possessed by B $\frac{12}{8+12} E$