EXAMPLE: Calculate the recoil velocity of an unconstrained rifle of mass 5.0 kg after it shoots a 50 g bullet at a speed of 300 m s^{-1}, with respect to the Earth

$$\vec{P}_{total(before)} = \vec{P}_{total(after)}$$

$$\vec{P}_{gun+bullet} = \vec{P}_{gun} + \vec{P}_{bullet}$$

$$m_{gb}\vec{v}_{gb} = m_g\vec{v}_g + m_b\vec{v}_b$$

$$0 = (5.0kg)\vec{v}_g + (0.050kg)(300ms^{-1})$$

$$-(5.0kg)\vec{v}_g = (0.050kg)(300ms^{-1})$$

$$\vec{v}_g = \frac{(0.050kg)(300ms^{-1})}{-5.0kg}$$

$$\vec{v}_g = -3.0ms^{-1}$$

$$\vec{v}_g = 3.0ms^{-1}$$ [opposite the motion of the bullet]

EXAMPLE: A 1.0 kg ball moving with a velocity of 2.0 m s^{-1} to the right collides straight-on with a stationary 2.0 kg ball . After the collision, the 2.0 kg ball moves off to the right with a velocity of 1.2 m s^{-1}. What is the velocity of the 1.0 kg ball after the collision?

A B (+)

+ right
- left

$m_A = 1.0 kg$
$m_B = 2.0 kg$

$$\vec{P}_{total(before)} = \vec{P}_{total(after)}$$

$$\vec{P}_{A_1} + \vec{P}_{B_1} = \vec{P}_{A_2} + P_{B2}$$

$$m_A \vec{u}_A + m_B \vec{u}_B = m_A \vec{V}_A + m_B \vec{V}_B$$

$$\frac{m_A \vec{u}_A + \cancel{m_B \vec{u}_B}^{\,0} - m_B \vec{V}_B}{m_A} = \vec{V}_A$$

$$\frac{(1.0kg)(+2.0 ms^{-1}) - (2.0kg)(+1.2 ms^{-1})}{1.0kg} = \vec{V}_A$$

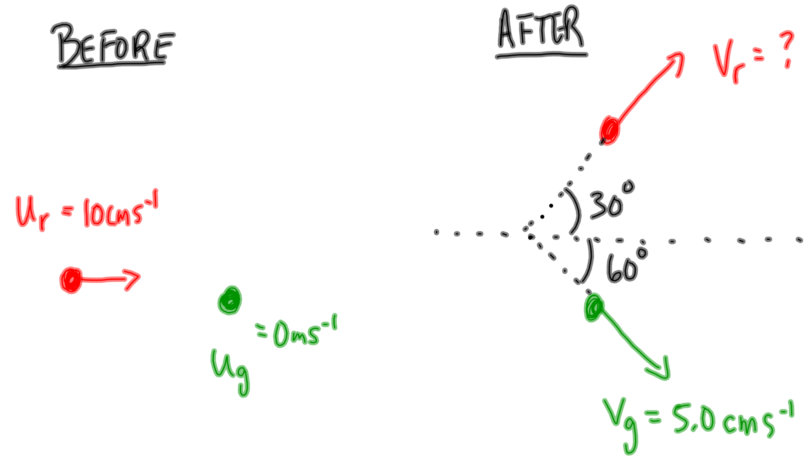
$$\frac{2.0 kg \cdot ms^{-1} - 2.4 kg \cdot ms^{-1}}{1.0kg} = \vec{V}_A$$

$$-0.40 ms^{-1} = \vec{V}_A$$

$$\vec{V}_A = 0.40 ms^{-1} \text{ [left]}$$

Example

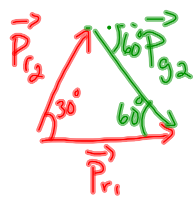
Consider the collision with two identical billiard balls given below

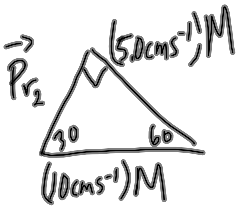


$$\vec{P}_{total(before)} = \vec{P}_{total(after)}$$

$$\vec{P}_{r_1} + \cancel{\vec{P}_{g_1}}^{\,0} = \vec{P}_{r_2} + \vec{P}_{g_2}$$

$$\vec{P}_{r_1} = \vec{P}_{r_2} + \vec{P}_{g_2}$$





let M be the mass

$$\sin\theta = \frac{opp}{hyp}$$

$$P_{r_2} = (10 cms^{-1})M \sin 60°$$

$$P_{r_2} = \left(\frac{10\sqrt{3}}{2} cms^{-1}\right)M$$

so the momentum of the red ball after the collision is $\left(\frac{10\sqrt{3}}{2} cms^{-1}\right)M$

so the velocity is $((5\sqrt{3}) cms^{-1})$

$$v = \frac{P}{m}$$