5.7.1 Conservation of momentum in explosions

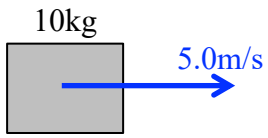
Momentum (p) is defined as the product of an objects mass (m) and velocity (v):

$$p = m \times v$$

videos

Momentum is a vector quantity (it has a direction and size).

On this course, we only deal with momentum in one dimension (forwards and backwards). We usually take momentum to the right to be positive and momentum to the left to be negative.



(1)✐ What is the momentum of the block, above? What are the units?

(2)✐ What would the momentum of the block (above) be is the arrow was pointing to the left?

Conservation of momentum

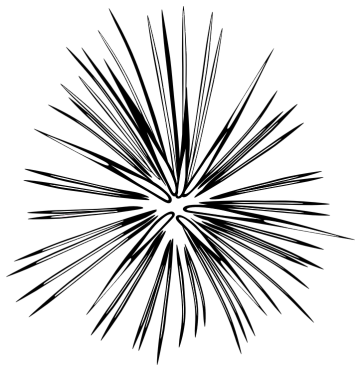
The law of conservation of momentum tells us that:

"In a system where no external forces act, momentum remains constant."

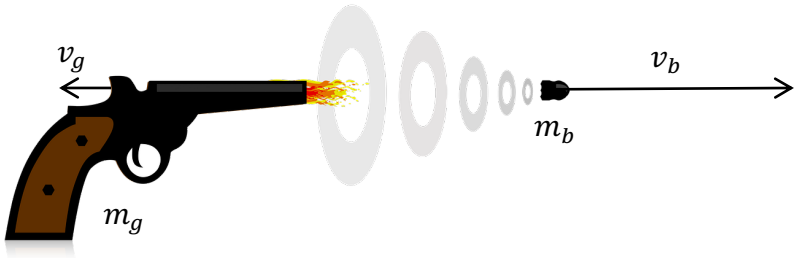
This is very useful in solving problems where objects, which are initially stationary, fly apart (explosions), and where objects collide (collisions).

Explosions

When an explosion occurs, pieces fly in all directions. It would be strange to see all the pieces heading in one direction. This is a consequence of the conservation of momentum. The stationary object before the explosion has zero momentum (momentum $p = m \times v$, and $v = 0m/s$). This must mean the total momentum after the explosion must also be zero. In 1 dimension, pieces heading to the right (which have positive momentum) must be balanced by pieces heading to the left (which have negative momentum).



Consider a gun firing a bullet:



Before the gun fires, the bullet and the gun are stationary, and so have zero total momentum. After firing the bullet goes right, and so has positive momentum ($= m_b \times v_b$). The gun recoils left and has negative momentum ($= m_g \times v_g$). The momentum of the two added together should equal zero, because momentum is conserved. We can write:

$$m_b \times v_b + m_g \times v_g = 0$$
$$\therefore m_b \times v_b = -m_g \times v_g$$

(3)✐ The mass of the gun m_g is very much larger than the mass of the bullet m_b. How will the velocities of the bullet and gun compare? Explain.

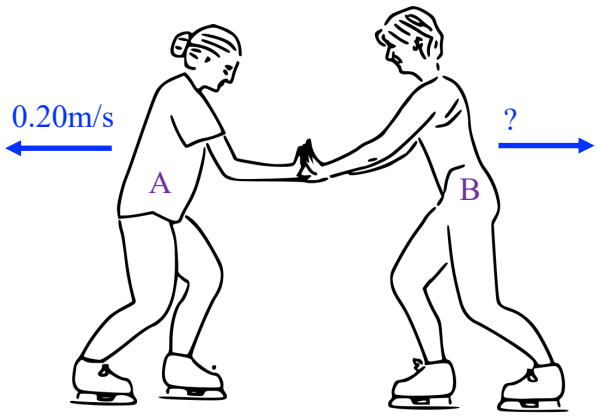
Worked example

Question:
A hand gun has a mass of 1.5kg, and a bullet has a mass of 0.016kg. If the gun recoils at -3.2m/s, what is the velocity of the bullet?

Answer:
By conservation of momentum, the momentum (of the bullet + gun) before the firing (= zero) is equal to the momentum (of the bullet + gun) after firing.

$$total\ momentum\ before = total\ momentum\ after$$
$$0 = m_b \times v_b + m_g \times v_g$$
$$0 = 0.016 \times v_b + 1.5 \times (-3.2)$$
$$\therefore v_b = \frac{1.5 \times 3.2}{0.016} = 300m/s$$

(4)✐ A hand gun has a mass of 2.3kg, and a bullet has a mass of 0.020kg. If the gun recoils at 2.5m/s, what is the velocity of the bullet?



(5)✐ Two ice skaters, who are initially stationary, push apart. Skater A has a mass of 72kg, and skater B has a mass of 64kg. Skater A moves left with a velocity of -0.20m/s. What is the velocity of skater B after pushing apart? (Ignore any friction.)