Momentum

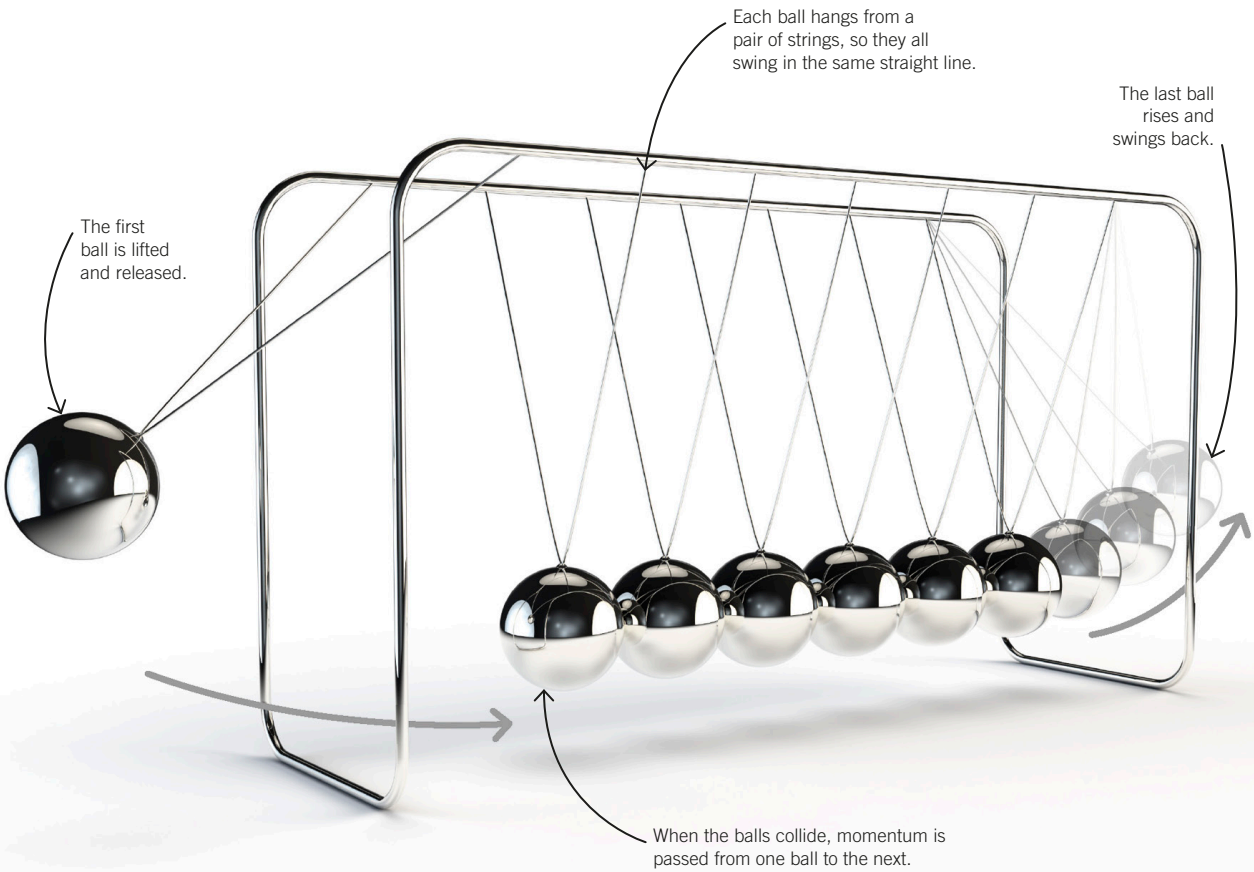
When objects collide, the effect one object has on another depends on a quantity called momentum. The greater the mass of a moving object or the faster the object is moving, the greater its momentum and the greater the effect it can have.

Key facts

- ✓ **The greater an object's mass or the faster it is moving, the more momentum it has.**
- ✓ **Momentum = mass × velocity.**
- ✓ **The law of conservation of momentum says that in a system not affected by external forces, total momentum is the same before and after a collision.**
- ✓ **Momentum is a vector, so calculations must take into account the direction the object is moving in.**

Conservation of momentum

Newton's cradle is a device that demonstrates a law known as conservation of momentum. According to this law, when a system is not affected by external forces, the total momentum in the system is the same before and after a collision. When one of the metal balls is lifted and allowed to hit the others, its momentum passes from ball to ball, making the last ball rise and repeat the cycle.



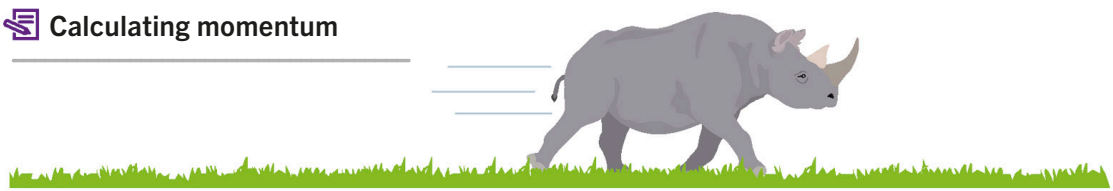
Formula for momentum

Both velocity and mass affect an object's momentum, as the equation below shows. Shooting stars are often no bigger than grains of sand, but they have great momentum because of their speed. Large vehicles such as freight trains have enormous momentum due to their great mass and can cause dangerous collisions even when moving slowly. Momentum is a vector, so calculations must take into account the direction in which the object is moving.

$$\text{momentum (kg m/s)} = \text{mass (kg)} \times \text{velocity (m/s)}$$

$$p = m \times v$$

Calculating momentum



Question 1

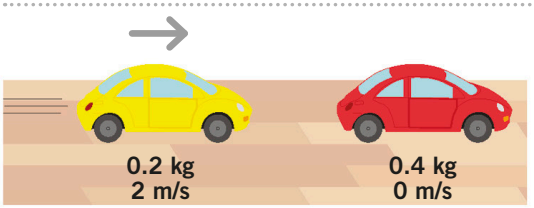
A rhinoceros has a mass of 1000 kg and is traveling at 15 m/s. How much momentum does it have?

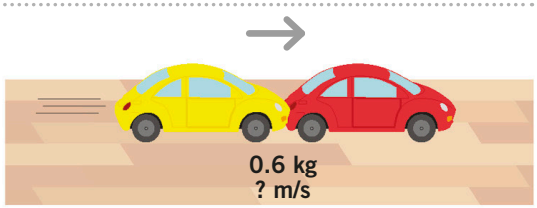
Answer 1

$p = m \times v$

$= 1000 \text{ kg} \times 15 \text{ m/s}$

$= 15\,000 \text{ kg m/s}$





Question 2

A toy car with a mass of 0.2 kg hits another toy car with a mass of 0.4 kg while traveling at 2 m/s. The two cars stick together and continue moving in the same direction. What speed are they going at?

Answer 2

The total momentum is conserved, so use the following equation to work out the answer:

momentum before collision = momentum after collision

momentum before = (0.2 kg × 2 m/s) + (0.4 kg × 0 m/s)

= 0.4 kg m/s

momentum after = 0.4 kg m/s

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

$$= \frac{0.4 \text{ kg m/s}}{0.2 \text{ kg} + 0.4 \text{ kg}}$$

$= 0.67 \text{ m/s}$