

Momentum

FORMULAS

momentum: $p = mv$ measured in $\text{kg}\cdot\text{m/s}$

impulse: $\Delta p = F\Delta t = m(\Delta v) = mv_f - mv_i$ measured in N·s

elastic collision (kinetic energy is conserved): $m_1v_{1i} + m_2v_{2i} = m_1v_{1f} + m_2v_{2f}$

inelastic collision (energy escapes): $m_1v_{1i} + m_2v_{2i} = (m_1 + m_2)v_f$

LAW OF CONSERVATION OF MOMENTUM

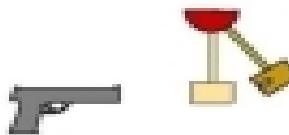
When no external force acts on a system, the total momentum of the system remains constant.

total momentum before collision = total momentum after collision

Example 1: What is the momentum of a 1500-kg car moving at 10 %?

Solution: $p = mv = (1500 \text{ kg})(10 \%) = 1.5 \times 10^4 \text{ kg}\cdot\text{m/s}$

Example 2: A 3.50-g bullet is fired into a 3.75-kg block of wood suspended from a string. The bullet is embedded in the block of wood, and they move off together with a speed of 0.885 %. What was the velocity of the bullet before the collision?



Solution: This is an example of an inelastic collision, since some energy went into deforming the block (specifically, making a hole in it).

$$\begin{aligned} m_{\text{bullet}} \cdot v_{\text{bullet}} + m_{\text{wood}} \cdot v_{\text{wood}} &= (m_{\text{bullet}} + m_{\text{wood}})v' \\ (3.50 \times 10^{-3} \text{ kg})v_{\text{bullet}} + (3.75 \text{ kg})(0) &= (3.50 \times 10^{-3} + 3.75 \text{ kg})(0.885 \%) \\ 3.7535 - 0.885 &= 949 \text{ m/s} \\ v_{\text{bullet}} &= \frac{3.50 \times 10^{-3}}{3.50 \times 10^{-3}} = 949 \text{ m/s} \end{aligned}$$

EXERCISES

A. What is the momentum of an electron with a mass of $9.11 \times 10^{-31} \text{ kg}$, moving at a velocity of $3.25 \times 10^7 \text{ m/s}$?

B. The momentum of a 2.25-kg object is $55.5 \text{ kg}\cdot\text{m/s}$. At what velocity is it moving?

C. A bullet travelling at 750 % has a momentum of $6.5 \text{ kg}\cdot\text{m/s}$. What is its mass?

D. What impulse is exerted by a hockey stick exerting a force of 110 N on a puck during the 0.05 s they are in contact?

E. What velocity will a 40-kg child sitting on a 50-kg wagon acquire, if pushed from rest by a force of 85 N for 2.0 s?