Exercise 4.3 Conservation of momentum

This section will help you perfect your problem-solving using the principle of conservation of momentum.

1 **a** State the principle of conservation of linear momentum.

b Is the principle of conservation of momentum a universal law? Explain your answer.

2 A bullet of mass 25 g travelling at 120 ms^{-1} penetrates an initially stationary 1.5 kg block of wood and passes through, emerging with a speed of 85 ms^{-1}. If the block of wood is on a frictionless surface, use the principle of conservation of momentum to calculate the speed of the block of wood immediately after the bullet emerges.

3 A 4.5 kg block sliding along a horizontal frictionless surface at a speed of 4.0 ms^{-1} strikes and sticks to a stationary block of mass 1.5 kg. Use the principle of conservation of momentum to calculate the speed at which the two stuck-together blocks move.

4 A truck of mass 3.2×10^3 kg, including its load, is travelling along a road at a constant speed of 15.0 ms^{-1} when its load, of mass 800 kg, falls vertically from the back of the truck hitting the ground and stopping immediately. Calculate the speed at which the truck then travels.

5 A mass, X, of 450 g moving at a speed of 3.0 ms^{-1} collides head-on with a stationary mass, Y. Mass X stops and mass Y moves onwards at a speed of 5.0 ms^{-1}. Calculate the mass of Y.

6 A hummingbird of mass 5.0 g hovers by forcing air, of density 1.3 kgm^{-3}, downwards at a speed, v, below its wings of area 1.6×10^{-3} m^2. Calculate the value of v.

7 A mass, A, of 3.0 kg moving at 5.0 ms^{-1} collides head-on with a mass, B, of 2.5 kg moving towards it at a speed of 4.0 ms^{-1}. If the two masses stick together after the impact, calculate the speed at which they move after the collision.

8 Some chat on social media has suggested that if the total population of China were to jump to the ground from a height of 1.0 m at the same time, the motion of the Earth would change. Examine this claim using your knowledge of the conservation of momentum. (You may take the population of China to be 1.4×10^9, the mass of the Earth to be 6.0×10^{24} kg and make any other sensible assumptions necessary.)

TIP

Question 9 is a more challenging question that requires the application of conservation of momentum and conservation of kinetic energy as well as some careful mathematical manipulation.

9 To sustain nuclear fission in a nuclear power station ‘fast’ neutrons can be slowed down by their head-on bombardment elastically with stationary carbon nuclei. If the relative masses of neutrons and carbon nuclei are 1 and 12, respectively, determine the percentage by which a neutron slows down due to a collision with a carbon nucleus.