

Explosions and crash-landings

AS Level

9702 AS Ch.6

Chapter 6: Momentum

Lesson 6.4

Sections 6.4

Goal: Use zero total momentum to find recoil velocities, and explain where momentum goes in a crash-landing.

 velocity

01 The big picture

An object at rest has zero momentum. When it explodes or pushes apart, the pieces still have zero total momentum: they fly apart with equal and opposite momenta. Kinetic energy is created from chemical or elastic potential energy, so it is not conserved.

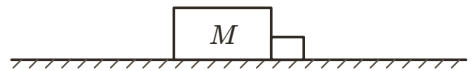
When a falling object lands and stops, its momentum is not lost: it is passed to the Earth. The Earth's mass is so large that its change in velocity is far too small to notice.

Recoil [paraphrase]

The backward motion of one part when another is pushed or fired forwards.

Fig. 1 · Pushing apart from rest

before: at rest, $p = 0$



after



Equal and opposite momenta: the small mass moves fast, the large mass slowly.

02 Key equations

From rest

$$0 = m_1 v_1 + m_2 v_2$$

Recoil velocity

$$v_2 = -\frac{m_1 v_1}{m_2}$$

Symbols and units

m mass of each part kg v velocity of each part after m s^{-1}

03 Sample problems with solutions

Sample 1 · Rifle recoil

A 4.0 kg rifle fires a 0.010 kg bullet at 400 m s^{-1} . Calculate the recoil velocity of the rifle and the total kinetic energy released.

Step 1. Total momentum stays zero:

$$v_2 = -\frac{0.010 \times 400}{4.0} = -1.0 \text{ m s}^{-1}$$

Step 2. Kinetic energy of both parts:

$$E_k = \frac{1}{2}(0.010)(400)^2 + \frac{1}{2}(4.0)(1.0)^2 = 800 + 2.0 = 802 \text{ J}$$

Answer: 1.0 m s^{-1} backwards; 802 J ($8.0 \times 10^2 \text{ J}$)

Unit check: $\frac{\text{kg m s}^{-1}}{\text{kg}} = \text{m s}^{-1} \checkmark$

04 Practice problems

P1 An object at rest explodes into pieces. What is their total momentum?

Answer: Zero

P2 Skaters of 60 kg and 40 kg push apart from rest. The 40 kg skater moves at 3.0 m s^{-1} . Find the other's velocity.

Answer: 2.0 m s^{-1} the opposite way

P3 A 2.0 kg object at rest splits into 0.50 kg at 12 m s^{-1} and the rest. Find the speed of the rest.

Answer: 4.0 m s^{-1} the opposite way

P4 A 0.50 kg ball hits the ground at 6.0 m s^{-1} and stops. What happens to its 3.0 kg m s^{-1} of momentum?

Answer: It goes to the Earth

05 Other useful information

Common mistakes

- ✗ **Wrong:** Kinetic energy is conserved in an explosion.
- ✓ **Right:** It increases; it comes from stored energy.

Exam tips

- The heavier part always moves off more slowly: equal momenta, unequal masses.

What the syllabus asks

- 9702 topic 3: apply conservation of momentum, including changes in kinetic energy. Coursebook 6.4.

Explore: [Practice questions for this lesson](#)