

Conservation of Momentum

Instructions: Momentum is a **vector**: it changes if the **speed** changes or if the **direction** changes. Show your working and give every answer a **unit**.

Momentum

Conservation of Momentum in a closed system *

* as long as **no external forces** act on the objects, e.g. friction

HINT

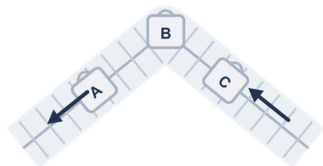
Principle of conservation of momentum: in a **closed system**, the total momentum **before** an event is equal to the total momentum **after** it.

Momentum is a **vector** — if two objects move in opposite directions, give one a **+** and the other a **-**.

Is There a Change in Momentum?

momentum is mass $\times$ velocity — and velocity is a vector

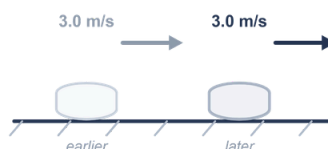
1



suitcases on a baggage belt going round a corner at a steady speed

MOMENTUM CHANGES ☐ changes ☐ stays the same
☐ speed ☐ direction ☐ neither

2



puck sliding across smooth ice at a steady 3.0 m/s in a straight line

MOMENTUM CHANGES ☐ changes ☐ stays the same
☐ speed ☐ direction ☐ neither

3



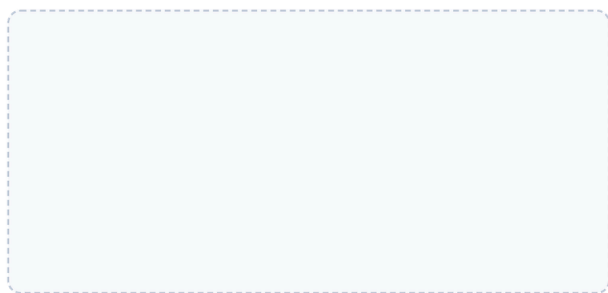
car braking from 20 m/s to 8 m/s in a straight line

MOMENTUM CHANGES ☐ changes ☐ stays the same
☐ speed ☐ direction ☐ neither

Make Up Your Own Conservation of Momentum Question

label every mass and velocity

YOUR BEFORE & AFTER DIAGRAM



YOUR QUESTION

WORKING & ANSWER

Exam-Style Question

[9 marks]

Trolley **A** has a mass of **750 g** and moves along a level bench at **42 cm/s**. It collides with trolley **B**, which has a mass of **1.8 kg** and is at rest. After the collision the two trolleys move off **joined together**, as shown in Figure 1.

BEFORE



AFTER



Figure 1 — not to scale

- (a) Convert the mass of A into kilograms and its velocity into metres per second. [2]
- (b) Calculate the momentum of trolley A before the collision. [2]
- (c) State the total momentum of the two trolleys after the collision. Explain your answer. [2]
- (d) Calculate the velocity of the trolleys after the collision. Give your answer to 2 significant figures. [3]

Rate of Change of Momentum

Instructions: A force is how quickly momentum changes. To make a collision **safer**, increase the time, **t**. Show your working and give every answer a **unit**.

Resultant Force = Rate of Change of Momentum — in Words

... in Symbols

HINT [3]

- 1 The **change in momentum** is the **same**.
- 2 The **time taken, t**, is **longer**.
- 3 So the **impact force is smaller** ($F = \Delta p \div t$).

Reducing the Impact Force — Safety Features

increase the time, t

DRAW THE COLLISION

HOW DOES THIS IMPROVE SAFETY?

CALCULATE THE IMPACT FORCE

mass = **1200 kg**
velocity: **15 m/s** → **0 m/s**
time to stop = **0.60 s**

F = _____ N

Increasing the Impact Force — Hitting a Ball

decrease the time, t

DRAW THE IMPACT

WHY IS THE FORCE SO BIG?

CALCULATE THE IMPACT FORCE

mass = **45 g**
velocity: **0** → **60 m/s**
contact time = **0.50 ms**

F = _____ N

Exam-Style Question — Crash Mats

[9 marks]

A gymnast of mass **48 kg** drops from a beam and lands feet-first at **6.0 m/s**. She lands either on the **bare floor** or on a thick **crash mat**, as shown in Figure 1.

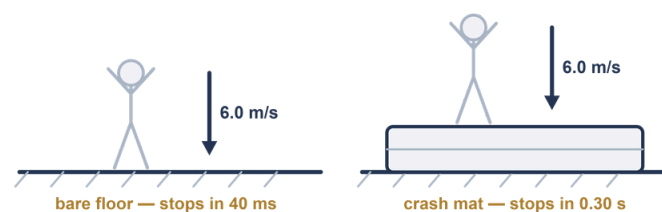


Figure 1 — not to scale

- (a) Explain how landing on the crash mat reduces the risk of injury to the gymnast. **[4]**

- (b) Calculate the change in momentum of the gymnast as she lands. **[2]**

- (c) She lands on the bare floor and stops in 40 ms. Calculate the average force on her. Give your answer in **kN**. **[3]**