InkPhysics

QUESTION WORKBOOK

# Momentum and impulse

Mechanics · Year 12

AQA 3.4.1.6 · CIE 3.1.3, 3.1.4, 3.3.1, 3.3.2, 3.3.3, 3.3.4
OCR A 3.5.1(b), 3.5.1(c), 3.5.1(d), 3.5.1(e), 3.5.2(a), 3.5.2(b), 3.5.2(c)

19 questions · 58 marks

PRINT EDITION


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## SECTION A · Warm-up

**A1** Calculate the momentum of a 2.0 kg trolley moving at 8.0 m $s^{-1}$, and state its unit. [2]

**A2** State the principle of conservation of linear momentum, including the condition under which it applies. [2]

**A3** Define the impulse of a force and state how it is related to momentum. [2]

**A4** A car travels round a bend at constant speed. Explain why its momentum changes. [2]

**A5** State the quantity represented by the area under a force–time graph. [1]

**A6** State the difference between an elastic collision and an inelastic collision, and name the quantity that is conserved in both. [2]

## SECTION B · Standard

**B1** A constant force of 20 N acts for 3.0 s on a 4.0 kg object initially at rest. Calculate (a) the impulse delivered and (b) the final velocity of the object. [4]

**B2** A 2.0 kg trolley moving at 3.0 m $s^{-1}$ collides with a stationary 1.0 kg trolley and they move off together. Calculate their common velocity. [3]

**B3** For the collision in the previous question, show that kinetic energy is not conserved by calculating the kinetic energy before and after, and state the type of collision. [4]

**B4** A 4.0 kg gun fires a 0.040 kg bullet at 200 m $s^{-1}$. Assuming the gun is free to move, calculate its recoil velocity. [3]

**B5** A squash ball of mass 60 g hits a wall at 15 m $s^{-1}$, at right angles to it, and rebounds along the same line at 9.0 m $s^{-1}$. The contact time is 7.5 ms. Calculate (a) the change in momentum of the ball and (b) the average force the wall exerts on it. [4]

**B6** During a collision, the force on a trolley rises linearly from zero to a peak of 3.0 kN in 20 ms and then falls linearly back to zero in a further 20 ms. Determine the impulse given to the trolley. [3]

**B7** A fire hose directs a horizontal jet of water at a vertical wall. Water of total mass 4.2 kg strikes the wall each second, travelling at 15 m $s^{-1}$, and does not rebound. Calculate the force the water exerts on the wall. [3]

## SECTION C · Stretch

**C1** A 3.0 kg trolley moving right at 4.0 m $s^{-1}$ collides head-on with a 1.0 kg trolley moving left at 2.0 m $s^{-1}$, and they stick together. Calculate the velocity of the combined trolleys, stating its direction. [4]

**C2** A 1000 kg car travelling at 20 m $s^{-1}$ is brought to rest in a collision. Calculate the average force on the car if it stops in (a) 0.10 s and (b) 0.50 s, and comment on the role of a crumple zone. [4]

**C3** Explain, in terms of impulse and momentum, how a seatbelt and an airbag reduce the risk of injury in a crash. [3]

**C4** A 1400 kg car ran into the back of a 2100 kg van. The two vehicles locked together, and skid marks show that they moved off at 8.0 m $s^{-1}$ immediately after the impact. The van driver states that the van was stationary when it was hit. The speed limit on the road is 13.5 m $s^{-1}$. Assuming the van driver's statement is correct, deduce whether the car was exceeding the speed limit. [4]

**C5** Two trolleys, of mass 1.2 kg and 0.80 kg, are held at rest on a smooth track with a compressed spring between them. When the spring is released, the 0.80 kg trolley moves off at 0.90 m $s^{-1}$. Calculate (a) the velocity of the 1.2 kg trolley and (b) the total kinetic energy after the release, and state where this energy came from. [4]

**C6** A rocket in deep space, far from any planet, fires its engine and accelerates. A student claims this is impossible because there is no air for the exhaust gases to push against. Explain, in terms of momentum, why the rocket does accelerate.

[4]