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Conservation of momentum and collisions worksheet

AQA AS 7407 and first-year A Level 7408 | OCR A AS H156 and A Level H556

35–40 minutes independent practice + 15–20 minutes review | 35 marks

Specification points covered

- AQA 7407 / 7408: 3.4.1.6 selected one-dimensional momentum conservation, elastic/inelastic collisions, separation and mean impact force; 3.4.1.8 selected kinetic-energy accounts.
- OCR A H156 / H556: 3.5.2(a)–(c), restricted here to one-dimensional interactions; 3.5.1(c)–(d) selected momentum change and impulse. No two-dimensional questions are included.

HarbourLine's parcel-carrier team tests joining, rebound and emergency separation on straight level tracks. Small carts model the full carriers. Treat each body as a particle, keep a consistent sign convention and identify the isolated horizontal system for each event. Account separately for total momentum and total kinetic energy.

1. Principles and collision types [4 marks]

Use precise wording that identifies the system and the quantity that is conserved.

(a) State the principle of conservation of momentum, including the condition required for it to apply. [2 marks]

(b) State what is meant by a perfectly elastic collision. [1 mark]

(c) State what is meant by an inelastic collision. [1 mark]

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2. A joined one-dimensional collision [4 marks]

Take motion to the right as positive. Cart A has mass 0.40 kg and velocity +3.0 m s^{-1}. It collides with stationary cart B of mass 0.60 kg. The carts stick together. External horizontal forces during contact are negligible.

(a) Calculate the velocity of the joined carts immediately after the collision. [2 marks]

(b) Calculate the kinetic energy transferred from the kinetic store during the collision. [2 marks]

3. A rebound collision [6 marks]

Take motion to the right as positive. Cart A has mass 0.20 kg and initial velocity +3.0 m s^{-1}. It collides head-on with stationary cart B of mass 0.30 kg. After the collision, A has velocity -0.60 m s^{-1}. External horizontal forces during contact are negligible.

(a) Calculate the velocity of cart B after the collision. [2 marks]

(b) Calculate the total kinetic energy before and after the collision. [2 marks]

(c) Classify the collision and justify your answer. [1 mark]

(d) State the relationship between the changes in momentum of carts A and B. [1 mark]

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4. An internal separation [4 marks]

Two carts are initially stationary and held together by a compressed spring. When released, cart A of mass 0.45 kg moves left at 2.2 m s^{-1}. Cart B has mass 0.75 kg. External horizontal forces are negligible.

(a) Calculate the velocity of cart B. [2 marks]

(b) Explain why the total kinetic energy increases while total momentum remains zero. [2 marks]

5. Rebound and contact force [5 marks]

Take motion to the right as positive. Autonomous parcel carrier A has mass 1.50 kg and moves at +2.40 m s^{-1}. It collides with stationary carrier B of mass 2.50 kg. After the collision A rebounds at -0.40 m s^{-1}. The carriers are in contact for 0.080 s. External horizontal forces are negligible during the collision.

(a) Calculate the velocity of carrier B immediately after the collision. [2 marks]

(b) Calculate the change in momentum of carrier A. [1 mark]

(c) Calculate the average force exerted on carrier A during the collision. [1 mark]

(d) State the average force exerted on carrier B, including its direction. [1 mark]

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6. A sequence of one-dimensional collisions [8 marks]

Three test carts P, Q and R move along the same straight, level track. Take motion to the right as positive. Cart P has mass 0.40 kg and initially moves at +3.0 m s^{-1}; cart Q of mass 0.80 kg is stationary. After P collides with Q, P continues to the right at +0.40 m s^{-1}. Cart Q then collides with stationary cart R of mass 0.50 kg and the two carts couple together. External horizontal forces are negligible during both collisions.

(a) Calculate the velocity of cart Q immediately after the first collision. [2 marks]

(b) Calculate the kinetic energy transferred from the kinetic store in the first collision and classify this collision. [3 marks]

(c) Calculate the velocity of the coupled Q-R carts after the second collision. [2 marks]

(d) Calculate the total kinetic energy transferred from the start of the sequence to the end of the second collision. [1 mark]

7. Collision language corrections [4 marks]

For each statement, give a precise scientific correction.

(a) "The collision lost momentum because the kinetic energy decreased." [2 marks]

(b) "An inelastic collision always makes the objects stick together." [2 marks]

Review: conserve signed total momentum for an isolated system, then compare total kinetic energy to classify the event. Inelastic objects need not remain joined.

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