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WORKSHEETS
ATTEMPT | CHECK | CORRECT | IMPROVE

OCR A Physics | Conservation of momentum and collisions worksheet

35-40 minutes AS core | optional second-year AL extension | 56 marks total

Specification points covered

- 3.5.2(a) State and apply the principle of conservation of momentum.
- 3.5.2(b) Describe and analyse collisions and interactions of bodies in one and two dimensions.
- 3.5.2(c) Distinguish between perfectly elastic and inelastic collisions.

Course level guide
Questions 1-7 are AS content and form a 37-mark core route. Questions 8-10 are clearly labelled AL content. Define the system, choose a positive direction and show calculations in the blank working areas.

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]**

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.

(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 [7 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}.

(a) Calculate the velocity of cart B after the collision. **[3 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]**

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 [6 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. **[3 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]**

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]**

AS review and improve

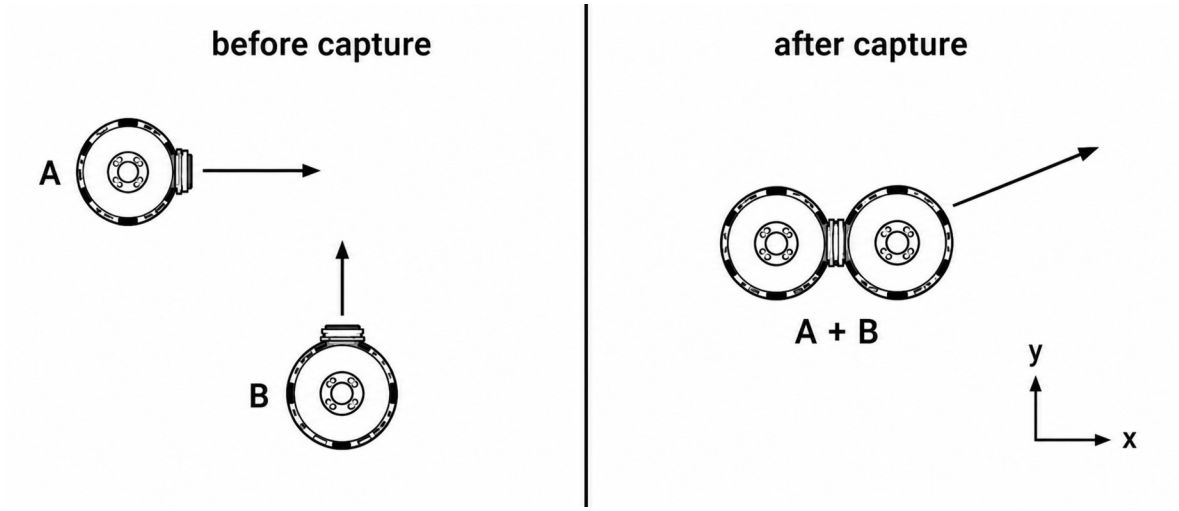
- ☐ I can identify the complete system and state when its total momentum is conserved.
- ☐ I can use signed velocities consistently in one-dimensional interactions.
- ☐ I can distinguish conservation of total momentum from conservation of kinetic energy.

AL CONTENT - SECOND-YEAR ONLY

Questions 8-10 use conservation of momentum in two dimensions. This content is assessed at A Level and is not part of the AS assessment route.

Scenario: air-bearing satellite capture simulator

Engineers test two round satellite modules on a horizontal air-bearing platform. The platform reproduces near-frictionless motion in two dimensions. Module A has mass 0.80 kg and moves east at 3.0 m s^{-1}. Module B has mass 1.20 kg and moves north at 1.0 m s^{-1}. Resultant external horizontal forces are negligible. The diagram is not to scale.



8. AL content - initial momentum of the two-module system [4 marks]

(a) Calculate the eastward x-component of the total momentum before capture. **[1 mark]**

(b) Calculate the northward y-component of the total momentum before capture. **[1 mark]**

(c) Calculate the magnitude of the total momentum before capture. **[1 mark]**

(d) Calculate the direction of the total momentum, measured north of east. **[1 mark]**

9. AL content - trial 1: modules dock and remain joined [7 marks]

The modules lock together during capture. Their combined mass is 2.00 kg.

(a) Calculate the x- and y-components of the velocity of the joined modules. **[2 marks]**

(b) Calculate the speed of the joined modules. **[1 mark]**

(c) Calculate the total kinetic energy before and after capture, and hence determine the energy transferred from the kinetic store. **[3 marks]**

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

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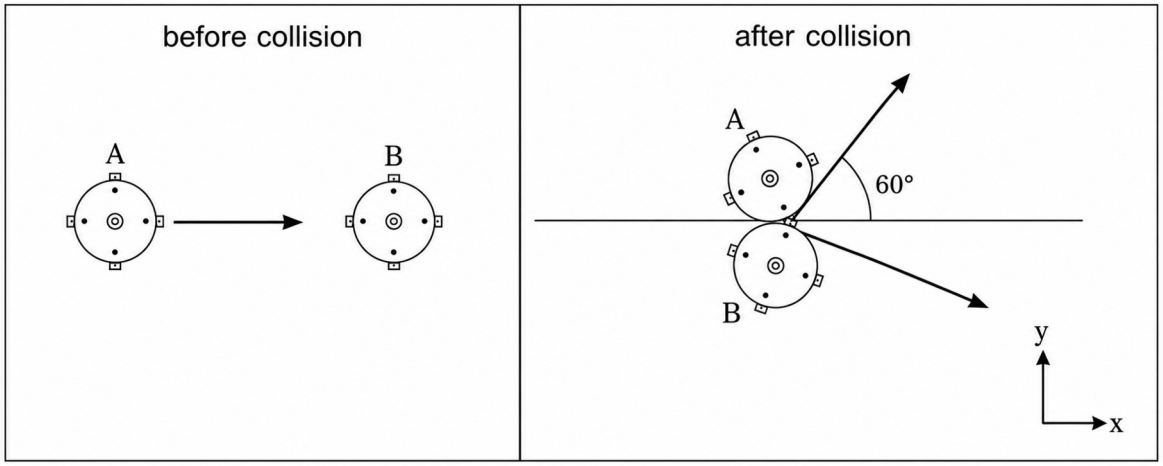
10. AL content - trial 2: the docking mechanism deflects the modules [8 marks]

In a separate trial, module B is initially stationary. Module A again moves east at 3.0 m s^{-1}. After the collision A moves at 1.20 m s^{-1}, 60° north of east. Module B moves south of east. The diagram is not to scale.



(a) Calculate the x- and y-components of the momentum of A after the collision. **[2 marks]**

(b) Use conservation of momentum to determine the x- and y-components of the momentum of B after the collision. **[2 marks]**

(c) Calculate the speed and direction of B after the collision. **[2 marks]**

(d) The initial kinetic energy is 3.60 J. Calculate the total kinetic energy after the collision and classify the collision. **[2 marks]**