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WORKSHEETS
ATTEMPT | CHECK | CORRECT | IMPROVE

OCR A A Level Physics | Newton's laws worksheet

35-40 minutes independent practice + 15-20 minutes review | 42 marks

Specification points covered

- 3.5.1(a) State Newton's three laws of motion.
- 3.5.1(b) Define linear momentum, $p = mv$, and understand its vector nature.
- 3.5.1(c) Relate net force to rate of change of momentum, $F = \Delta p / \Delta t$, and recognise $F = ma$ as a special case.
- 3.5.1(d) Define impulse of a force; impulse = $F\Delta t$.
- 3.5.1(e) Recognise impulse as the area under a force-time graph and estimate for non-linear graphs.

How to use this worksheet

Choose a positive direction before momentum calculations. Use the vector sum of all external forces for net force. Show numerical working in blank space and use the ruled lines for complete scientific statements.

1. Newton's laws - precise statements [4 marks]

Use wording that would be accepted in an OCR A examination answer.

(a) State Newton's first law of motion. **[1 mark]**

(b) State Newton's second law of motion. **[1 mark]**

(c) State Newton's third law of motion. **[2 marks]**

2. Momentum is a vector [5 marks]

Take motion to the right as positive throughout this question. The total mass of the loaded tug and trailer is 600 kg.

(a) Write the equation that defines linear momentum and state its SI unit. **[1 mark]**

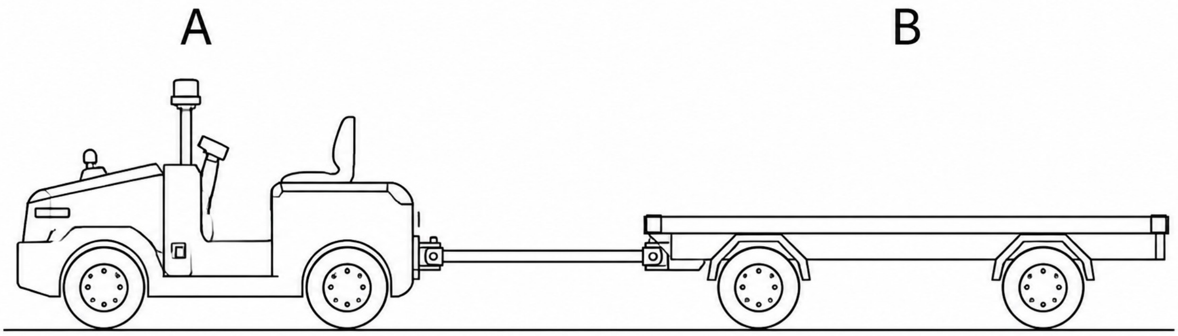
(b) Calculate the momentum when the vehicle travels at +5.0 m s^{-1}. **[1 mark]**

(c) During a reversing test, the vehicle travels at -1.20 m s^{-1}. Calculate its momentum. **[1 mark]**

(d) Calculate the change in momentum from the motion in part (b) to the motion in part (c). Include the sign. **[2 marks]**

Scenario: HarbourLine autonomous cargo tug

At an offshore-wind assembly port, an electric tug A tows a cargo trailer B along a straight, level service lane. Engineers test the system's acceleration, braking and pneumatic end-of-lane buffer.



3. Resultant force and acceleration [7 marks]

The loaded tug and trailer have total mass 600 kg. During the first test, the driving force is 1.62 kN to the right and the total resistive force is 420 N to the left.

(a) Calculate the net (resultant) force on the vehicle. **[1 mark]**

(b) Calculate the acceleration of the vehicle. **[1 mark]**

(c) Later, the vehicle moves at constant velocity while the resistive force is 900 N to the left. Determine the driving force and explain your answer using Newton's first law. **[2 marks]**

(d) The trailer is disconnected, so the moving mass becomes 390 kg. In a calibration run the same 1.20 kN net force acts. Calculate the new acceleration and explain why it is greater than in part (b). **[3 marks]**

4. Why F = ma is a special case [3 marks]

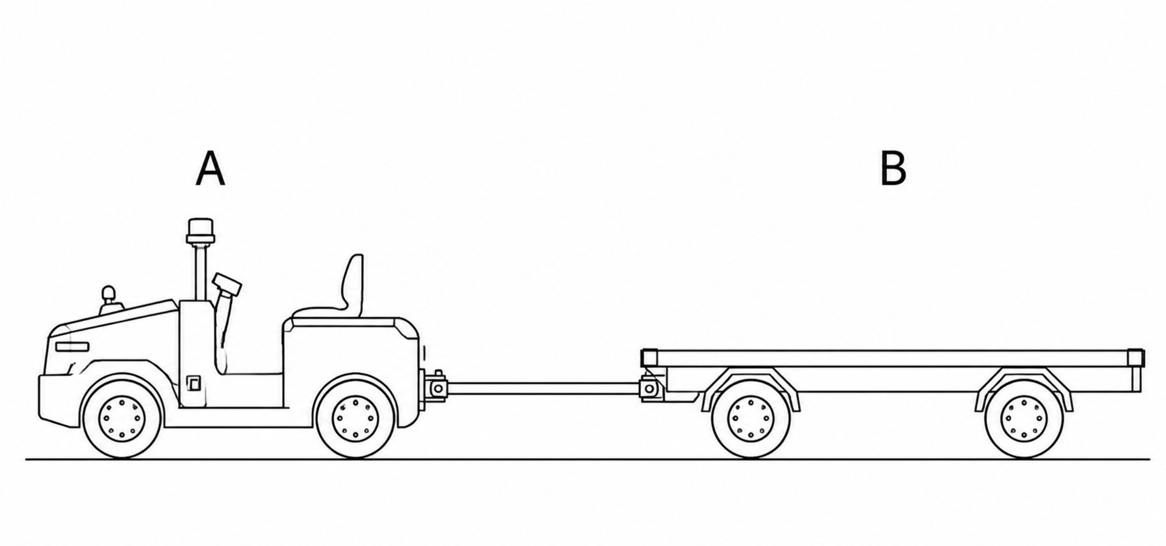
Use the general momentum form of Newton's second law.

(a) Starting with $p = mv$ and $F = \Delta p / \Delta t$, show that $F = ma$ for an object of constant mass. [2 marks]

(b) A technician substitutes the 1.62 kN driving force into $F = ma$ for Question 3(b). Explain why this is wrong. [1 mark]

5. Newton's third law at the towbar [5 marks]

Tug A pulls trailer B. The towbar exerts a horizontal force of 820 N on B to the right.



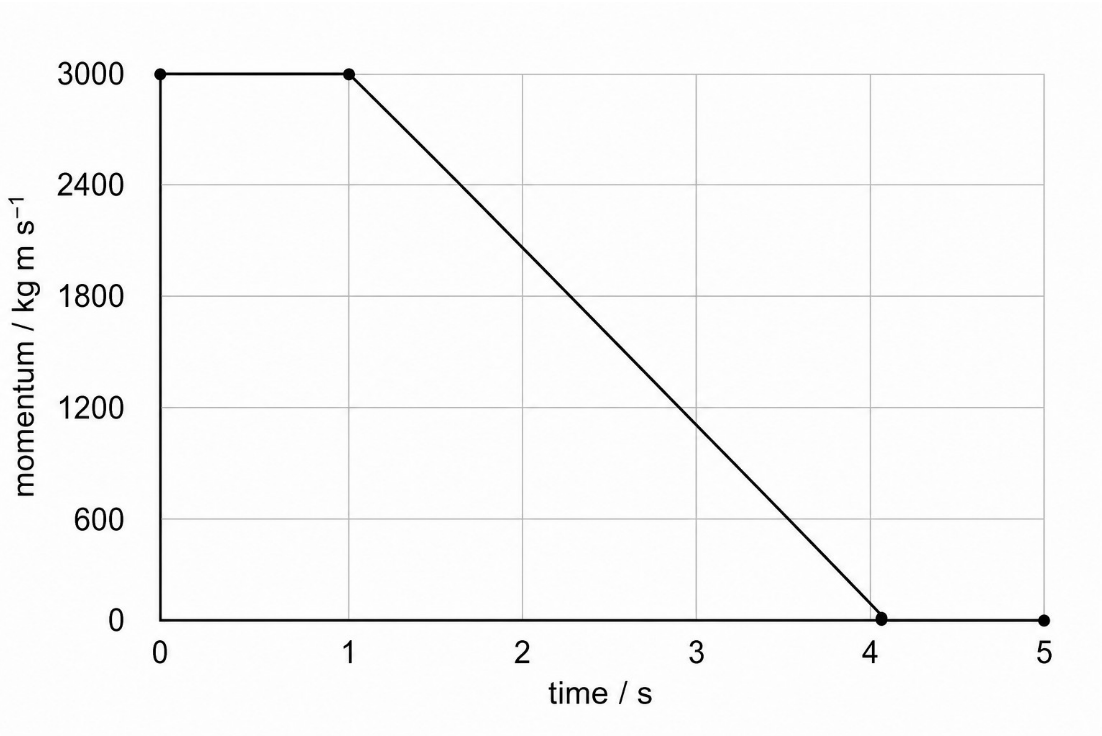
(a) State the magnitude, direction and type of the force that B exerts on A. [2 marks]

(b) Explain why the two towbar forces do not cancel when calculating the acceleration of trailer B alone. [1 mark]

(c) At constant velocity, the driving force and total resistance on the complete vehicle are equal and opposite. Give two reasons why these forces are not a Newton's third-law pair. [2 marks]

6. Reading a momentum-time graph [8 marks]

The 600 kg loaded vehicle moves to the right. The graph shows its momentum during a controlled braking test.



(a) Determine the net force from t = 0 to t = 1.0 s. **[1 mark]**

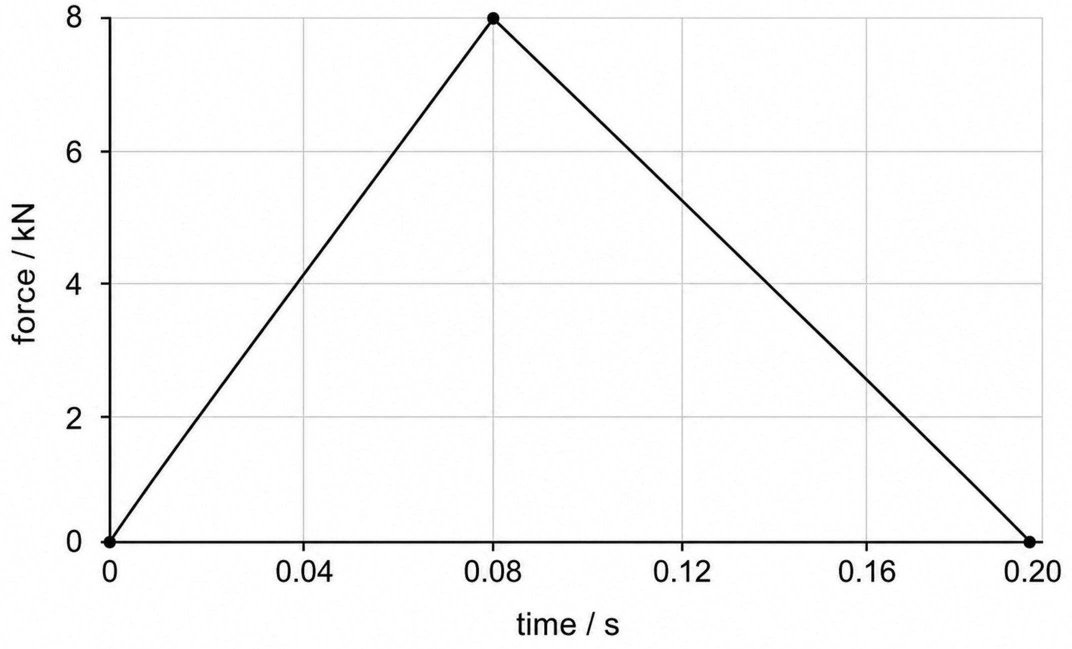
(b) Determine the magnitude and direction of the net force from t = 1.0 s to t = 4.0 s. **[2 marks]**

(c) Calculate the speed at t = 1.0 s and at t = 4.0 s. **[2 marks]**

(d) Calculate the distance travelled between t = 1.0 s and t = 4.0 s. **[3 marks]**

7. Impulse from the pneumatic buffer [6 marks]

The 600 kg vehicle reaches the end-of-lane buffer with momentum +600 kg m s^{-1}. The graph shows the magnitude of the buffer force on the vehicle. This force acts to the left throughout the contact.



(a) Use the graph to determine the magnitude of the impulse exerted by the buffer. [2 marks]

(b) Calculate the final momentum of the vehicle, including its sign. [2 marks]

(c) Calculate the velocity after contact and state its direction. [2 marks]

8. Correct the physics language [4 marks]

For each pupil statement, write one precise correction.

(a) "The momentum is accelerating while the brakes act." **[1 mark]**

(b) "At constant velocity, no forces act on the vehicle." **[1 mark]**

(c) "The 1.62 kN driving force in Question 3 is the force used in F = ma." **[1 mark]**

(d) "A Newton's third-law pair cancels because its forces are equal and opposite." **[1 mark]**

Review and improve

☐ I can state all three laws using resultant-force and interaction language.
☐ I can use signed momentum and calculate net force from its rate of change.
☐ I can identify third-law pairs and distinguish them from balanced forces.