AQA AS Newton's Laws, Momentum and Impulse worksheet

35–40 minutes independent practice + 15–20 minutes review | 38 marks

Specification points covered

• 3.4.1.5(a) Newton's first law and equilibrium. • 3.4.1.5(b) Newton's second law and F = ma for constant mass. • 3.4.1.5(c) Newton's third law and interaction pairs.	• 3.4.1.6(a–c) Momentum and rate of change of momentum. • 3.4.1.6(d–f) Impulse and force–time graphs. • 3.4.1.6(g–j) Conservation of momentum, collisions and explosions.

Orbital servicing and docking

A service craft manoeuvres, docks with a satellite and tests a deformable collision buffer.
Track the chosen system and positive direction before applying force, impulse or momentum equations.

1. Thruster forces

1. State Newton's first, second and third laws of motion using AQA-appropriate wording. [3 marks]

2. An 850 kg service craft produces a forward thrust of 1.80 kN while a control thruster produces 250 N in the opposite direction. Calculate the craft's acceleration. [2 marks]

3. Draw a free-body diagram for the craft in Question 2. Show only forces acting on the craft and label the forward direction. [2 marks]

2. The first docking

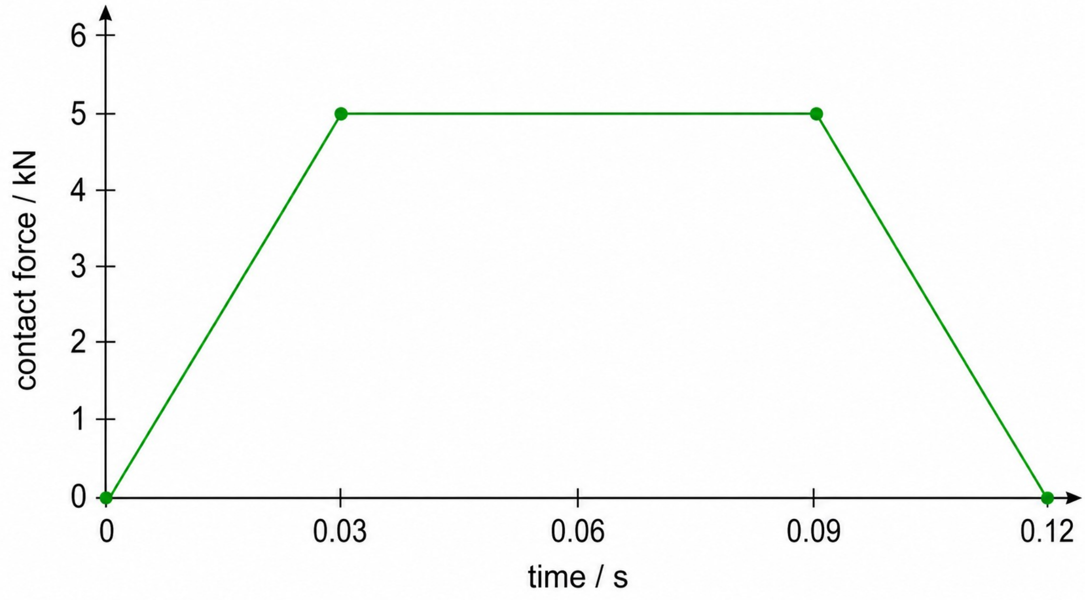
4. The main thruster pushes exhaust gas backwards. Use Newton's third law to identify the force pair and explain why the two forces do not cancel on the craft. [3 marks]

5. The 850 kg craft moves at 0.650 m s^{-1} and docks with a stationary 1200 kg satellite. They move together after impact. Calculate their common velocity. [3 marks]

6. Calculate the total kinetic energy before and after the docking in Question 5. State whether kinetic energy is conserved and classify the collision. [3 marks]

3. Reading the contact record

7. The force–time graph shows a later contact force on the craft. Calculate the impulse. The force acts opposite to the craft's motion. [3 marks]



8. The 850 kg craft initially moves at 0.650 m s^{-1}. Use the impulse from Question 7 to calculate its velocity immediately after the contact force has acted. [3 marks]

4. Controlling collision forces

9. Calculate the average contact force during the 0.120 s collision. [1 mark]

10. A redesigned docking buffer gives the same impulse over 0.240 s. Calculate the new average force and explain why the longer contact time reduces the risk of damage. [3 marks]

11. A stationary 850 kg craft ejects a 20.0 kg tool at 4.00 m s^{-1} backwards relative to the original stationary frame. Calculate the velocity of the remaining 830 kg craft. [3 marks]

12. A soft docking collar deforms during impact. Explain the trade-off between contact time, peak force, momentum change and kinetic-energy transfer. State which quantities are conserved for the complete isolated system. [3 marks]

5. Reconstructing the event

13. Write a structured reconstruction of the docking event using all three Newton laws, momentum conservation and impulse. Explain how the force–time record and velocity measurements can test whether the model is consistent, and identify why action–reaction forces must be assigned to different bodies. **[6 marks]**

Review and improve

- ☐ I use a signed direction in every momentum calculation.
- ☐ I read impulse as area under a force–time graph.
- ☐ I place a third-law pair on two different bodies.