Dynamics and the loaded lift solutions

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

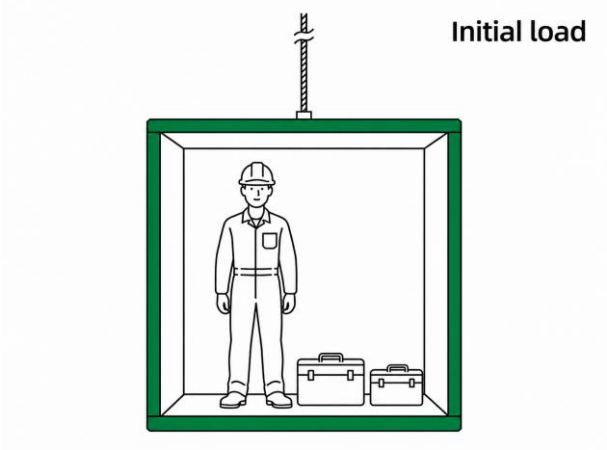
Matching solutions and teaching prompts for the class review

Specification points covered

AQA 7407 / 7408: 3.4.1.1 selected force balance and equilibrium; 3.4.1.5 selected Newton's second law and constant-mass resultant-force calculations.
OCR A H156 / H556: 3.2.1(a), (b), (c), (d) tension only, (e), (f) one-dimensional constant-force motion only. Upthrust, friction and two-dimensional motion are not assessed here.

Main scenario
At a coastal monitoring centre, a 680 kg lift car carries a 75.0 kg technician and 45.0 kg of instrument cases to a rooftop laboratory. One vertical cable supports the car and its contents.
Model the car and contents as one system. Upwards is positive; g = 9.81 m s^{-2}. Neglect air resistance, guide friction and cable mass. Each given tension is constant during its stated interval.

1. Initial journey: lift car and cable



1. Define one newton. [1 mark]

Answer / mark points: One newton is the resultant force producing an acceleration of 1 m s^{-2} in a 1 kg mass. [1]

Teacher prompt / common error: Include both 1 kg and 1 m s^{-2} in the complete definition.

2. Calculate the total mass of the lift car, technician and instrument cases. [1 mark]

Answer / mark points: Total mass = 680 + 75.0 + 45.0 = 800 kg. [1]

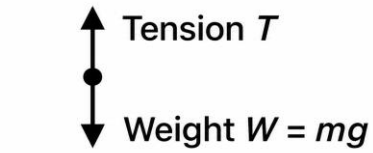
Teacher prompt / common error: The system includes the car and everything it carries. Do not add a mass to a force.

Continue your physics journey
Videos, practice and support for your next step
www.physicsuk.co.uk

3. In the blank space below, draw a free-body diagram for the combined system of the lift car and all its contents. Ignore air resistance and guide friction. Label all external forces on this system. [2 marks]

Answer / mark points: Draw tension T vertically upwards on the combined system. [1] Draw its total weight W = mg vertically downwards. [1] No other external vertical force is included in this model.

Teacher prompt / common error: The floor forces between the car and its contents are internal to the chosen system. Do not add a force of motion, an acceleration arrow or a second copy of the contents' weight. Arrow lengths are not assessed.



Directions shown; not to scale

4. Calculate the weight of the loaded lift car. [1 mark]

Answer / mark points: W = mg = 800 × 9.81 = 7848 N, or 7.85×10^3 N. [1]

Teacher prompt / common error: Weight is a force. Retain the unrounded value for later small resultant-force differences.

5. The cable tension is 8400 N. Calculate the resultant force on the lift car. State its direction. [1 mark]

Answer / mark points: F = T − W = 8400 − 7848 = +552 N, upwards. [1]

Teacher prompt / common error: The cable tension is an individual force, not the resultant.

6. Use your answer to question 5 to calculate the acceleration of the lift car. [1 mark]

Answer / mark points: a = F/m = 552/800 = +0.690 m s^{-2}, upwards. [1]

Teacher prompt / common error: Use the resultant from Q5, not 8400 N, in the second law.

7. The cable tension is adjusted so that it equals the weight of the lift car. The lift is moving upwards. Describe its subsequent motion and explain your answer. [2 marks]

Answer / mark points: Tension and weight balance, so resultant force and acceleration are zero. [1] The lift continues upwards at constant velocity. [1]

Teacher prompt / common error: Zero resultant force does not mean zero velocity or that no forces act.

8. The cable tension is reduced to 7000 N. Calculate the acceleration of the lift car. State its direction. [2 marks]

Answer / mark points: F = 7000 − 7848 = −848 N. [1] a = −848/800 = −1.06 m s^{-2}, downwards. [1]

Teacher prompt / common error: A negative sign denotes downward acceleration under the specified upward-positive convention.

9. The lift is still moving upwards when the cable tension is 7000 N. State how its speed changes. Use precise scientific language. [1 mark]

Answer / mark points: Its speed decreases; its positive upward velocity decreases linearly while the downward acceleration remains constant. [1]

Teacher prompt / common error: Speed decreases because acceleration is opposite to the present velocity, not because the cable tension is negative.

Continue your physics journey
Videos, practice and support for your next step
www.physicsuk.co.uk

2. Heavier lift load

10. Two further instrument cases, with a combined mass of 90.0 kg, are added. Calculate (i) the new total mass and (ii) the new weight of the lift car and its load. [2 marks]

Answer / mark points: (i) New mass = 800 + 90.0 = 890 kg. [1] (ii) Weight = 890 × 9.81 = 8730.9 N, or 8.73 × 10^3 N. [1]
Teacher prompt / common error: Use the new 890 kg mass in Q10–17. Keep guard digits in the weight.

11. Calculate the cable tension required to accelerate the loaded lift car upwards at 0.850 m s^{-2}. [2 marks]

Answer / mark points: T − mg = ma, hence T = m(g + a). [1] T = 890 × (9.81 + 0.850) = 9487.4 N, or 9.49 × 10^3 N. [1]
Teacher prompt / common error: For upward acceleration, tension exceeds weight by ma.

12. The cable has a safe maximum tension of 1.02 × 10^4 N. Determine whether it can accelerate the loaded lift car upwards at 1.80 m s^{-2}. Show your reasoning. [3 marks]

Answer / mark points: Use T = m(g + a) for upward acceleration. [1] Required T = 890 × (9.81 + 1.80) = 10332.9 N. [1] This exceeds the safe limit 10200 N, so the proposed acceleration is not safe. [1]
Teacher prompt / common error: The force-balance method, required tension, and justified safety decision are the three creditworthy outcomes. Do not count comparison and conclusion as two separate extra marks.

13. A pupil writes, 'The cable tension is 9.49 × 10^3 N, so this is the resultant force.' Explain why this is not correct. [2 marks]

Answer / mark points: Tension is only one of the external forces; the weight also acts downwards. [1] The resultant is their vector sum, T − W, not T alone. [1]
Teacher prompt / common error: Using the unrounded Q11 tension gives resultant 756.5 N upwards. Applying F = ma to an individual force is incorrect here.

Continue your physics journey
Videos, practice and support for your next step
www.physicsuk.co.uk

3. Return journey

14. The loaded lift car descends at constant velocity. Calculate the cable tension. [1 mark]

Answer / mark points: Constant velocity gives a = 0, hence T = mg = 8730.9 N, or 8.73×10^3 N. [1]

Teacher prompt / common error: Downward travel alone does not change the equilibrium condition.

15. While the loaded lift car is descending, the cable tension is 9.20×10^3 N. Calculate its acceleration. State how its speed changes. [3 marks]

Answer / mark points: F = 9200 − 8730.9 = +469.1 N. [1] a = 469.1/890 = +0.527 m s^{-2}, upwards. [1] The lift is moving downwards, so its speed decreases. [1] Its signed velocity is negative and increases linearly towards zero.

Teacher prompt / common error: With upwards positive, a downward-moving lift slowing down has increasing velocity but decreasing speed. Do not call a negative velocity a negative speed.

16. While the loaded lift car is descending, the cable tension is 7.60×10^3 N. Calculate its acceleration. State how its speed changes. [3 marks]

Answer / mark points: F = 7600 − 8730.9 = −1130.9 N. [1] a = −1130.9/890 = −1.27 m s^{-2}, downwards. [1] Its speed increases. [1] Its signed velocity becomes more negative and decreases linearly.

Teacher prompt / common error: Acceleration and velocity are both downward here. State the trend of signed velocity separately from the trend of speed.

17. A pupil writes, “The velocity is accelerating upwards” for the situation in question 15. Rewrite the statement correctly, describing acceleration and the change in signed velocity or speed. [2 marks]

Answer / mark points: The lift has an upward acceleration. [1] While it moves downwards, its upward-positive velocity increases linearly towards zero and its speed decreases. [1]

Teacher prompt / common error: Accept an equivalent statement that correctly distinguishes acceleration, signed velocity and speed. Velocity changes; it does not itself accelerate.

Closing review

With upwards positive, a descending lift has negative velocity. Upward acceleration makes that velocity increase towards zero and its speed decrease. Downward acceleration makes that velocity more negative and its speed increase.

Continue your physics journey

Videos, practice and support for your next step

www.physicsuk.co.uk