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SOLUTIONS
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OCR A A Level Dynamics: F = ma solutions

Matching solutions and teaching prompts for the class review

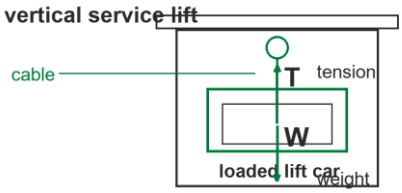
Specification points covered

- 3.2.1(a) Apply Newton's second law, F = ma.
- 3.2.1(b) Define the newton as the unit of force.
- 3.2.1(c) Understand weight of an object, W = mg.
- 3.2.1(d) Define and identify tension, normal contact force, upthrust and friction.
- 3.2.1(e) Draw and interpret free-body diagrams.

Teaching focus

Start every calculation by identifying the system, the forces and the direction of the resultant force. Model the distinction between an individual force, a resultant force and an acceleration.

1. Initial journey: lift car and cable



1. Define one newton. [1 mark]

Answer / mark points: One newton is the force that gives a 1 kg mass an acceleration of 1 m s^{-2}.

Teacher prompt / common error: The definition needs both the 1 kg mass and the 1 m s^{-2} acceleration. A newton is a unit of force.

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

Answer / mark points: Total mass = 680 kg + 120 kg = 800 kg.

Teacher prompt / common error: This establishes the system mass before any force calculation. Do not add forces in newtons to a mass in kilograms.

3. In the blank space below, draw a free-body diagram for the loaded lift car. Ignore air resistance. Label all forces acting on the lift car. [2 marks]

Answer / mark points: A correct free-body diagram has tension, T, vertically upward and weight, W, vertically downward. Do not include a 'force of motion' or an acceleration arrow.

Teacher prompt / common error: For full credit, arrows must represent forces on the lift car: tension upward and weight downward. Motion and acceleration are not forces.

1. Initial journey continued

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

Answer / mark points: $W = mg = 800 \times 9.81 = 7848\ N = 7.85 \times 10^3\ N$ (3 s.f.).
Teacher prompt / common error: Weight is a force, measured in N. Use W = mg, not W = m / g.

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

Answer / mark points: Resultant force = 8400 - 7848 = 552 N upwards.
Teacher prompt / common error: Tension must be compared with weight. The resultant force is not equal to the tension alone.

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

Answer / mark points: F = ma, so a = 552 / 800 = 0.690 m s^{-2} upwards (3 s.f.).
Teacher prompt / common error: Use the resultant force from question 5 in F = ma. Retain the direction.

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: The lift continues upwards at constant velocity. Tension and weight balance, so the resultant force is zero and the acceleration is zero.
Teacher prompt / common error: Constant velocity means zero acceleration and therefore zero resultant force; it does not mean 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: Resultant force = 7848 - 7000 = 848 N downwards. a = 848 / 800 = 1.06 m s^{-2} downwards (3 s.f.).
Teacher prompt / common error: With upward as positive, the acceleration could be written as -1.06 m s^{-2}. A stated downward direction is essential.

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 upward velocity decreases linearly, so the lift slows down. The acceleration is downwards, opposite to the direction of motion.
Teacher prompt / common error: Preferred language: upward velocity decreases linearly. Do not accept ‘the velocity accelerates’.

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. (ii) $W = mg = 890 \times 9.81 = 8731\ N = 8.73 \times 10^3\ N$ (3 s.f.).
Teacher prompt / common error: Both the total mass and W = mg are creditworthy. The added cases increase the weight as well as the mass.

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

Answer / mark points: $T - W = ma$. $T = W + ma = 8730.9 + (890 \times 0.850) = 9487.4\ N = 9.49 \times 10^3\ N$ (3 s.f.).
Teacher prompt / common error: For upward acceleration, tension exceeds weight by ma. Award marks for the force balance and correct tension.

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: Required $T = W + ma = 8730.9 + (890 \times 1.80) = 1.033 \times 10^4$ N. This is greater than 1.02×10^4 N, so the cable cannot accelerate the lift at 1.80 m s^{-2} safely.
Teacher prompt / common error: For three marks expect the required tension, comparison with the safe maximum and a clear conclusion.

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 one force acting upward. The resultant force is the vector sum of all forces; here it is the difference between the tension and the weight. Only a non-zero resultant force produces acceleration.
Teacher prompt / common error: Model the distinction: tension is an individual force; resultant force is the combined effect of every force.

3. Return journey

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

Answer / mark points: Constant velocity means zero acceleration and zero resultant force. The cable tension equals the weight: $T = 8.73 \times 10^3$ N (3 s.f.).

Teacher prompt / common error: The direction of motion does not change the force balance for constant velocity: acceleration and resultant force are both zero.

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: Resultant force = 9200 - 8730.9 = 469.1 N upwards. a = 469.1 / 890 = 0.527 m s^{-2} upwards. Its downward velocity decreases linearly, so it slows down.

Teacher prompt / common error: The acceleration is upward while the lift moves down. Therefore the downward velocity decreases linearly; the lift slows down.

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: Resultant force = 8730.9 - 7600 = 1130.9 N downwards. a = 1130.9 / 890 = 1.27 m s^{-2} downwards. Its downward velocity increases linearly, so it speeds up.

Teacher prompt / common error: The acceleration and motion are both downward, so the downward velocity increases linearly; the lift speeds up.

17. A pupil writes, 'The velocity is accelerating upwards' for the situation in question 15. Rewrite this statement using correct scientific language. [2 marks]

Answer / mark points: For example: 'The lift has an upward acceleration. Because it is moving downwards, its downward velocity decreases linearly.'

Teacher prompt / common error: A quantity can increase, decrease or remain constant. Acceleration describes the rate of change of velocity; it is not something velocity does.

Closing review

When an object moves upwards while its acceleration is downwards, its upward velocity decreases. When it moves downwards while its acceleration is upwards, its downward velocity decreases.
Use 'increases', 'decreases' or 'stays the same' for a quantity; use 'accelerates' only to describe a change in velocity.