M1 Dynamics of a Particle: exam questions

10 questions · 30 marks · full mark schemes

Name _____ Date _____ Score / 30

- F = ma in a straight line; connected particles over pulleys; tow-bars; lifts.
- Try every question before you look at the mark schemes. They start after the questions: M marks for method, A marks for accuracy, B marks for a correct result on its own.
- Online, with more practice: alevelmathrevision.com/alevel-frontend/units/m1/dynamics-questions

1. **2 marks · warm-up**

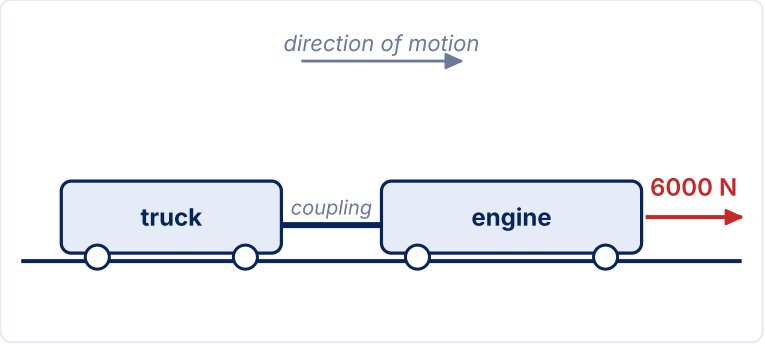
Find the weight of a $5\ \text{kg}$ mass. (Take $g = 9.8\ \text{m s}^{-2}$)

2. **3 marks · standard**

A box of mass $20\ \text{kg}$ rests on the floor of a lift. The lift is descending and decelerating at $1.5\ \text{m s}^{-2}$. Find the normal reaction force on the box.

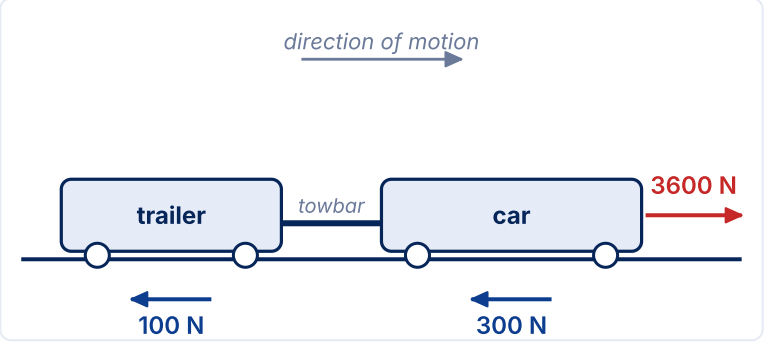
3. 3 marks · standard

An engine of mass $2000\ \text{kg}$ pulls a truck of mass $1000\ \text{kg}$ along a straight horizontal track. There are no resistances to motion and the system accelerates at $2\ \text{m s}^{-2}$. Find the tension in the coupling between the engine and the truck.



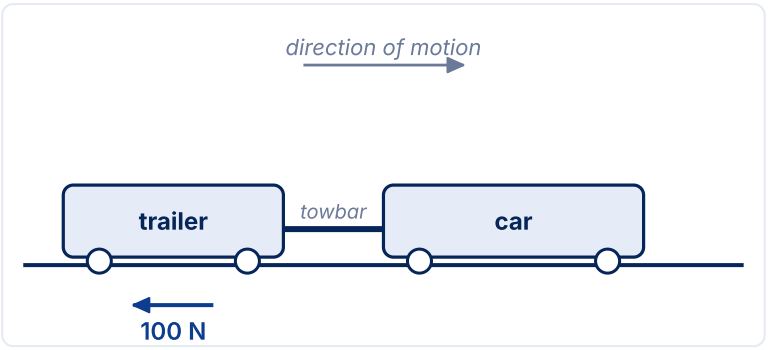
4. 3 marks · standard

A car of mass $1200\ \text{kg}$ pulls a trailer of mass $400\ \text{kg}$. The resistances to motion are $300\ \text{N}$ on the car and $100\ \text{N}$ on the trailer. The driving force of the car is $3600\ \text{N}$. Find the acceleration of the system.



5. 3 marks · standard

A car of mass $1200\ \text{kg}$ pulls a trailer of mass $400\ \text{kg}$ along a straight horizontal road by a light horizontal towbar. The resistance to motion of the trailer is $100\ \text{N}$ and the system accelerates at $2\ \text{m s}^{-2}$. Find the tension in the towbar.

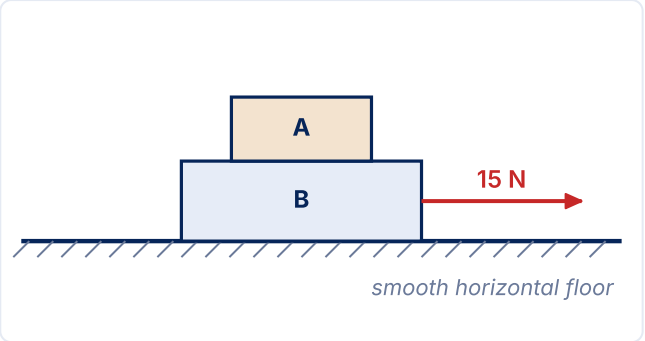


6. 3 marks · standard

A helicopter of mass $2500\ \text{kg}$ is lifting a rescue harness of mass $50\ \text{kg}$. The helicopter accelerates vertically upwards at $2\ \text{m s}^{-2}$. Find the tension in the cable lifting the harness.

7. 3 marks · standard

Block A of mass $2\ \text{kg}$ rests on Block B of mass $3\ \text{kg}$, which rests on a smooth horizontal floor. A horizontal force of $15\ \text{N}$ is applied to Block B. Assuming Block A does not slip on Block B, find the acceleration of the system.



8. 3 marks · harder

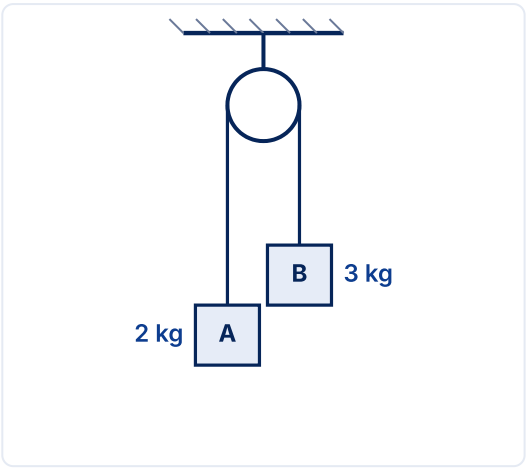
A helicopter of mass $2500\ \text{kg}$ is lifting a rescue harness of mass $50\ \text{kg}$, which hangs below it on a cable. The helicopter and harness accelerate vertically upwards at $2\ \text{m s}^{-2}$. Find the total upward lift force produced by the helicopter's rotors.

9. 3 marks · harder

A lift of mass $M\ \text{kg}$ is being raised by a cable. The tension in the cable is $12000\ \text{N}$. The lift accelerates upwards at $1.5\ \text{m s}^{-2}$. Find the value of M to the nearest integer.

10. 4 marks · harder

Two particles A ($2\ \text{kg}$) and B ($3\ \text{kg}$) are connected by a light inextensible string over a smooth pulley. They are released from rest. After 2 seconds, the string breaks. Find the velocity of particle A at the instant the string breaks.



Answers and worked solutions

Question 1 — 2 marks

1. M1 for applying $W = mg = 5 \times 9.8$.
2. A1 for calculating $49\ \text{N}$.

Question 2 — 3 marks

1. M1 for recognising that decelerating downwards means the acceleration is upwards: $a = 1.5\ \text{m s}^{-2}$ upwards.
2. M1 for setting up the equation: $R - mg = ma \implies R - 20(9.8) = 20(1.5)$.
3. A1 for calculating $R = 196 + 30 = 226\ \text{N}$.

Question 3 — 3 marks

1. M1 for isolating the truck and applying $F = ma$.
2. M1 for setting up $T = m_{\text{truck}} \times a = 1000 \times 2$.
3. A1 for calculating $T = 2000\ \text{N}$.

Question 4 — 3 marks

1. M1 for finding the net force on the entire system: $F_{net} = 3600 - 300 - 100 = 3200\ \text{N}$.
2. M1 for applying $F = ma$ to the whole system: $3200 = (1200 + 400)a$.
3. A1 for finding $a = 2\ \text{m s}^{-2}$.

Question 5 — 3 marks

1. M1 for considering the forces acting only on the trailer.
2. M1 for setting up the equation: $T - 100 = 400a \implies T - 100 = 400(2)$.
3. A1 for calculating $T = 900\ \text{N}$.

Question 6 — 3 marks

1. M1 for writing the equation of motion for the harness: $T - mg = ma$.
2. M1 for substituting the values: $T - 50(9.8) = 50(2)$.
3. A1 for calculating $T = 490 + 100 = 590\ \text{N}$.

Question 7 — 3 marks

1. M1 for treating A and B as a single combined particle of mass $5\ \text{kg}$.
2. M1 for applying $F = ma$: $15 = 5a$.
3. A1 for finding $a = 3\ \text{m s}^{-2}$.

Question 8 — 3 marks

1. M1 for writing the equation of motion for the whole system: $L - (M + m)g = (M + m)a$.
2. M1 for substituting the values: $L - 2550(9.8) = 2550(2)$.
3. A1 for calculating $L = 24990 + 5100 = 30090\ \text{N}$.

Question 9 — 3 marks

1. M1 for writing the equation of motion: $T - Mg = Ma \implies 12000 - 9.8M = 1.5M$.
2. M1 for rearranging to isolate M: $11.3M = 12000$.
3. A1 for calculating $M = 1061.94... \approx 1062\ \text{kg}$ (Accept 1060 kg).

Question 10 — 4 marks

1. M1 for setting up equations to find acceleration: $3g - T = 3a$ and $T - 2g = 2a$.
2. M1 for calculating $a = \frac{g}{5} = 1.96\ \text{m s}^{-2}$.
3. M1 for applying $v = u + at$ for the first 2 seconds.
4. A1 for finding $v = 0 + 1.96(2) = 3.92\ \text{m s}^{-1}$.

More dynamics of a particle practice with instant feedback: alevelmathrevision.com/alevel-frontend/units/m1/dynamics-questions
Our own original questions, written and checked by A Level Math Revision. Independent, not affiliated with Pearson Edexcel.