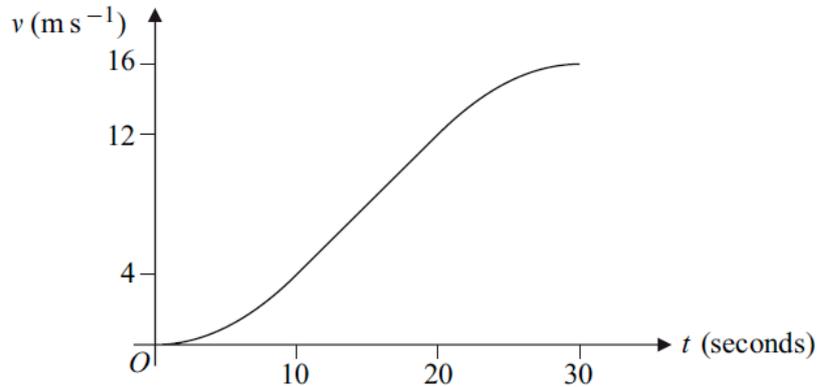


Mechanics 1 Kinematics Questions

- 2 A particle P moves with acceleration $(-3\mathbf{i} + 12\mathbf{j}) \text{ m s}^{-2}$. Initially the velocity of P is $4\mathbf{i} \text{ m s}^{-1}$.
- (a) Find the velocity of P at time t seconds. *(2 marks)*
- (b) Find the speed of P when $t = 0.5$. *(3 marks)*
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- 3 (a) A small stone is dropped from a height of 25 metres above the ground.
- (i) Find the time taken for the stone to reach the ground. *(2 marks)*
- (ii) Find the speed of the stone as it reaches the ground. *(2 marks)*
- (b) A large package is dropped from the same height as the stone. Explain briefly why the time taken for the package to reach the ground is likely to be different from that for the stone. *(2 marks)*
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- 6 A van moves from rest on a straight horizontal road.
- (a) In a simple model, the first 30 seconds of the motion are represented by three separate stages, each lasting 10 seconds and each with a constant acceleration.
- During the first stage, the van accelerates from rest to a velocity of 4 m s^{-1} .
- During the second stage, the van accelerates from 4 m s^{-1} to 12 m s^{-1} .
- During the third stage, the van accelerates from 12 m s^{-1} to 16 m s^{-1} .
- (i) Sketch a velocity–time graph to represent the motion of the van during the first 30 seconds of its motion. *(3 marks)*
- (ii) Find the total distance that the van travels during the 30 seconds. *(4 marks)*
- (iii) Find the average speed of the van during the 30 seconds. *(2 marks)*
- (iv) Find the greatest acceleration of the van during the 30 seconds. *(2 marks)*

- (b) In another model of the 30 seconds of the motion, the acceleration of the van is assumed to vary during the first and third stages of the motion, but to be constant during the second stage, as shown in the velocity–time graph below.



The velocity of the van takes the same values at the beginning and the end of each stage of the motion as in part (a).

- (i) State, with a reason, whether the distance travelled by the van during the first 10 seconds of the motion in **this** model is greater or less than the distance travelled during the same time interval in the model in part (a). *(2 marks)*
- (ii) Give one reason why **this** model represents the motion of the van more realistically than the model in part (a). *(1 mark)*
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1 A stone is dropped from a high bridge and falls vertically.

- (a) Find the distance that the stone falls during the first 4 seconds of its motion. *(3 marks)*
- (b) Find the average speed of the stone during the first 4 seconds of its motion. *(2 marks)*
- (c) State one modelling assumption that you have made about the forces acting on the stone during the motion. *(1 mark)*
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- 3 A car travels along a straight horizontal road. The motion of the car can be modelled as three separate stages.

During the first stage, the car accelerates uniformly from rest to a velocity of 10 m s^{-1} in 6 seconds.

During the second stage, the car travels with a constant velocity of 10 m s^{-1} for a further 4 seconds.

During the third stage of the motion, the car travels with a uniform retardation of magnitude 0.8 m s^{-2} until it comes to rest.

- (a) Show that the time taken for the **third** stage of the motion is 12.5 seconds. (2 marks)
- (b) Sketch a velocity–time graph for the car during the three stages of the motion. (4 marks)
- (c) Find the total distance travelled by the car during the motion. (3 marks)
- (d) State one criticism of the model of the motion. (1 mark)
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- 6 The points A and B have position vectors $(3\mathbf{i} + 2\mathbf{j})$ metres and $(6\mathbf{i} - 4\mathbf{j})$ metres respectively. The vectors \mathbf{i} and \mathbf{j} are in a horizontal plane.

- (a) A particle moves from A to B with constant velocity $(\mathbf{i} - 2\mathbf{j}) \text{ m s}^{-1}$. Calculate the time that the particle takes to move from A to B . (3 marks)
- (b) The particle then moves from B to a point C with a constant acceleration of $2\mathbf{j} \text{ m s}^{-2}$. It takes 4 seconds to move from B to C .
- (i) Find the position vector of C . (4 marks)
- (ii) Find the distance AC . (2 marks)
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- 2 A lift rises vertically from rest with a constant acceleration.

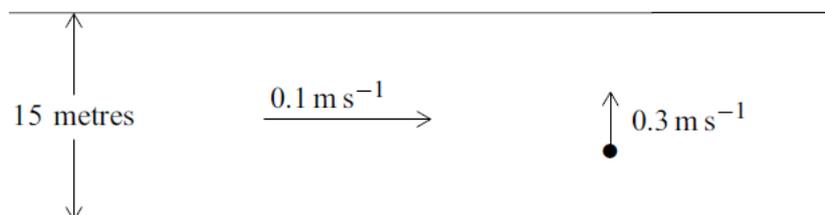
After 4 seconds, it is moving upwards with a velocity of 2 m s^{-1} .

It then moves with a constant velocity for 5 seconds.

The lift then slows down uniformly, coming to rest after it has been moving for a total of 12 seconds.

- (a) Sketch a velocity–time graph for the motion of the lift. (4 marks)
- (b) Calculate the total distance travelled by the lift. (2 marks)
- (c) The lift is raised by a single vertical cable. The mass of the lift is 300 kg. Find the maximum tension in the cable during this motion. (4 marks)

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- 5 A girl in a boat is rowing across a river, in which the water is flowing at 0.1 m s^{-1} . The velocity of the boat relative to the water is 0.3 m s^{-1} and is perpendicular to the bank, as shown in the diagram.



- (a) Find the magnitude of the resultant velocity of the boat. *(2 marks)*
- (b) Find the acute angle between the resultant velocity and the bank. *(3 marks)*
- (c) The width of the river is 15 metres.
- (i) Find the time that it takes the boat to cross the river. *(2 marks)*
- (ii) Find the total distance travelled by the boat as it crosses the river. *(2 marks)*
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- 8 A particle is initially at the origin, where it has velocity $(5\mathbf{i} - 2\mathbf{j}) \text{ m s}^{-1}$. It moves with a constant acceleration $\mathbf{a} \text{ m s}^{-2}$ for 10 seconds to the point with position vector $75\mathbf{i}$ metres.

- (a) Show that $\mathbf{a} = 0.5\mathbf{i} + 0.4\mathbf{j}$. *(3 marks)*
- (b) Find the position vector of the particle 8 seconds after it has left the origin. *(3 marks)*
- (c) Find the position vector of the particle when it is travelling parallel to the unit vector \mathbf{i} . *(6 marks)*
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- 1 A ball is released from rest at a height h metres above ground level. The ball hits the ground 1.5 seconds after it is released. Assume that the ball is a particle that does not experience any air resistance.

- (a) Show that the speed of the ball is 14.7 m s^{-1} when it hits the ground. *(2 marks)*
- (b) Find h . *(2 marks)*
- (c) Find the distance that the ball has fallen when its speed is 5 m s^{-1} . *(3 marks)*
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5 An aeroplane flies in air that is moving due east at a speed of $V \text{ m s}^{-1}$. The velocity of the aeroplane relative to the air is 150 m s^{-1} due north. The aeroplane actually travels on a bearing of 030° .

(a) Show that $V = 86.6 \text{ m s}^{-1}$, correct to three significant figures. *(2 marks)*

(b) Find the magnitude of the resultant velocity of the aeroplane. *(3 marks)*

8 A boat is initially at the origin, heading due east at 5 m s^{-1} . It then experiences a constant acceleration of $(-0.2\mathbf{i} + 0.25\mathbf{j}) \text{ m s}^{-2}$. The unit vectors \mathbf{i} and \mathbf{j} are directed east and north respectively.

(a) State the initial velocity of the boat as a vector. *(1 mark)*

(b) Find an expression for the velocity of the boat t seconds after it has started to accelerate. *(2 marks)*

(c) Find the value of t when the boat is travelling due north. *(3 marks)*

(d) Find the bearing of the boat from the origin when the boat is travelling due north. *(6 marks)*
