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Structured Questions

Kinematics

Distance & Displacement / Speed & Velocity / Acceleration / Kinematic Equations / Motion Graphs / Projectile Motion / Fluid Resistance / Terminal Speed

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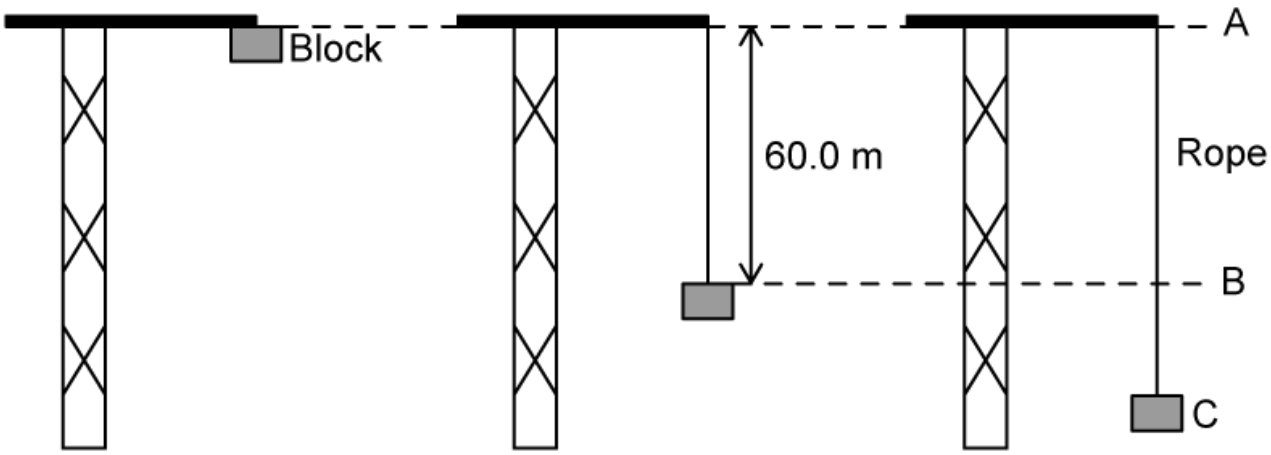
Total Marks **/50**

1 (a) One end of an elastic climbing rope is fixed to the top of a crane. The other end of the rope is connected to a block which is initially at position A. The block is released from rest. The mass of the rope is negligible.



The full length of the rope is 60.0 m. From position A to B, the block falls freely.

(i) State the block's acceleration between position A and B.

[1]

(ii) Describe how the velocity of the block changes between position A and B.

[1]

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(2 marks)

(b) Calculate the speed of the block at position B.

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(2 marks)

(c) At position B the rope starts to extend. Position C is the point at which the rope is fully extended. Describe the motion of the block between position B and C.

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(2 marks)

(d) Between position B and C the resultant force on the block changes, because the tension in the rope increases as the rope extends.

State and explain whether a SUVAT equation can be used to determine the distance the block falls between position B and C.

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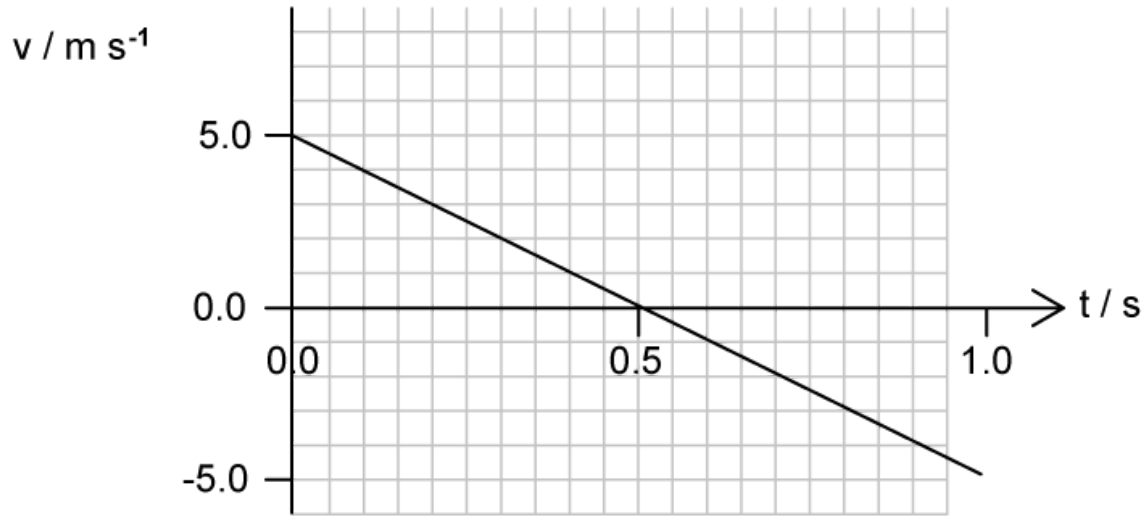
(2 marks)

2 (a) An experimenter throws a small object upwards. The graph shows the variation of velocity *v* with time *t* of the object.



Explain why the gradient of the graph between t = 0.0 s and t = 0.5 s is roughly 10 m s^{-2}.

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(2 marks)

(b) Use the graph to calculate the displacement of the object between t = 0 s and t = 0.5 s.

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(3 marks)

(c) State and explain the motion of the object at t = 0.5 s.

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(2 marks)

(d) The experimenter states that the velocity-time graph shows the object travels the same distance upwards and it does downwards.

Explain how the velocity-time graph shows the distance travelled by the object is the same upwards as it is downwards.

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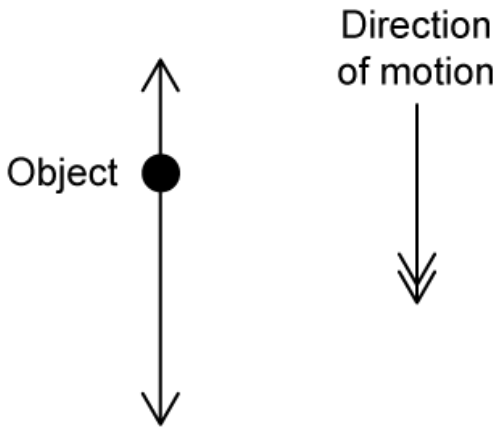
(2 marks)

3 (a) Examination questions on projectile motion often involves objects moving vertically through the atmosphere.



The object shown moves vertically downwards through the atmosphere.

Identify the two forces acting on the object and label them on the diagram.

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(2 marks)

(b) Often, a simplifying condition is assumed so that, in these cases, only a single force acts on objects as they move through the atmosphere.

(i) State the simplifying condition that is normally assumed.

[1]

(ii) Identify the force that is ignored under this simplifying condition.

[1]

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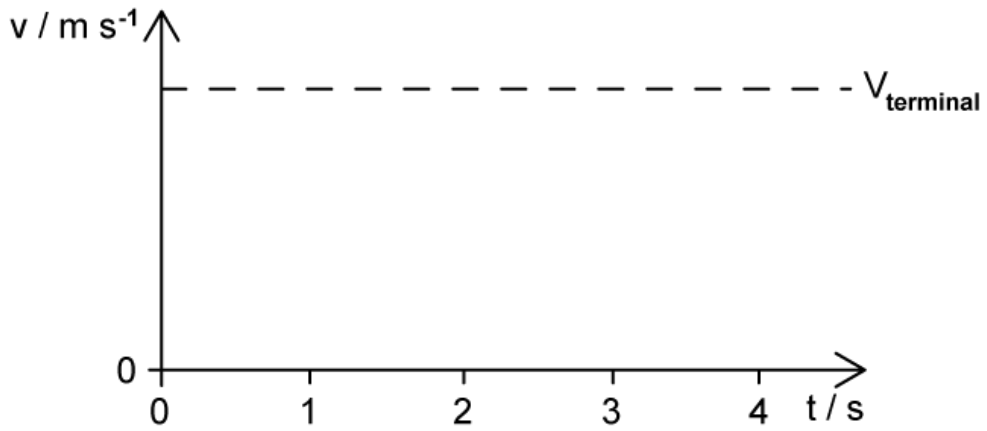
(2 marks)

(c) Terminal velocity is only attained if both forces act on the object.

State and explain the magnitude of the resultant force on the object if it moves at its terminal velocity.

(2 marks)

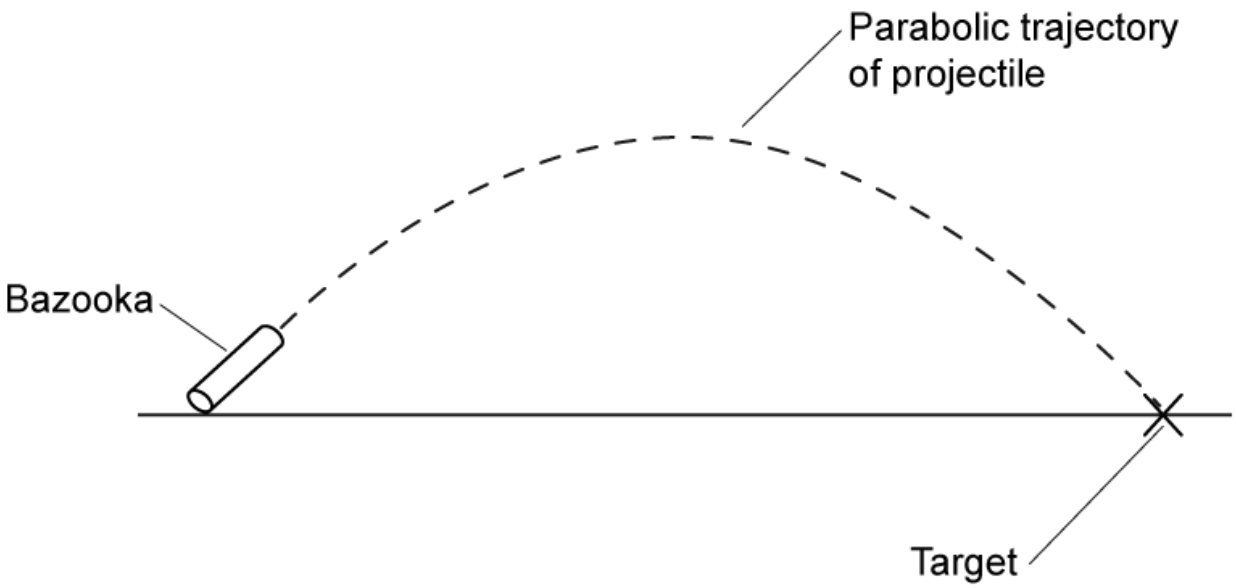
(d) Sketch a graph on the axes provided to show an object that is released from rest at t = 0 s and falls vertically through the atmosphere, attaining terminal velocity, $v_{terminal}$ after t = 4 s.



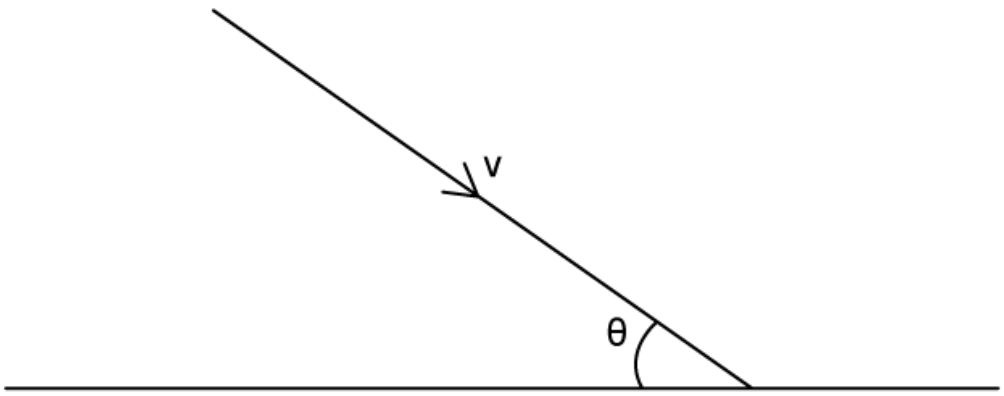
The line corresponding to $v_{terminal}$ is included as guidance.

(3 marks)

4 (a) Projectiles follow parabolic trajectories. One such trajectory is shown for a projectile fired from a bazooka.



The projectile lands on its target with a final velocity *v* that can be represented as shown.



(i) Draw and label the direction of the horizontal and vertical components of the final velocity *v* on the diagram.

[2]

(ii) Write the magnitude of each component in terms of the angle to the horizontal, θ.

[2]

(4 marks)

(b) The initial horizontal velocity given to the projectile is 3.5 m s^{-1}. Air resistance can be ignored.

(i) State the final horizontal velocity of the projectile.

[1]

(ii) Explain your answer to part (i).

[1]

(2 marks)

(c) The final vertical velocity of the projectile is 3.8 m s^{-1}.

Calculate the magnitude of the final velocity, v.

(3 marks)

(d) The horizontal distance between the bazooka and the target is 27 m.

Calculate the time taken for the projectile to reach the target.

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(3 marks)

5 (a) The following quantities are used to describe the motion of an object:

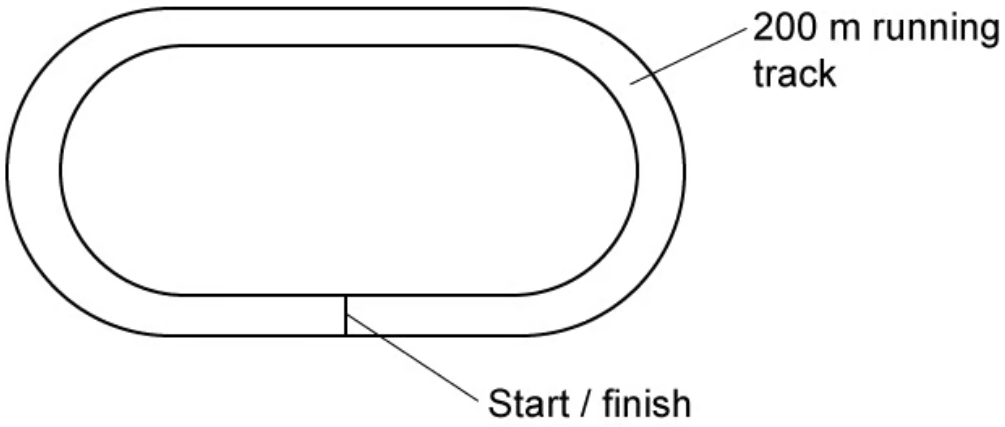
Distance Acceleration Velocity Displacement Speed

Complete the table by placing a tick (✓) in the correct column to indicate whether each of the quantities are scalars or vectors.

Quantity	Vector	Scalar
Distance		
Acceleration		
Velocity		
Displacement		
Speed		

(5 marks)

(b) A runner completes a full lap of a 200 m running track in a time of 63.4 s.



Calculate the average speed of the runner over the entire lap.

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(3 marks)

(c) State the average velocity of the runner over the entire lap and explain your answer.

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(3 marks)

(d) Define instantaneous velocity.

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(1 mark)