Revision – Mechanics (Year 12)

1.

(a) A plane has an air speed of 240 km h^{-1} due north. A wind is blowing at 90 km h^{-1} from east to west. Use a vector triangle to calculate the resultant velocity of the plane.

velocity = ... m s^{-1},

direction with respect to north = ... °

[4]

(b) The plane flies under these conditions for 10 minutes. Calculate the component of the displacement

1. due north,

displacement =..... km

2. due west.

displacement = ... km

[2]

2.

(a) Define acceleration.

.....

.....

.....[2]

(b) An aircraft of total mass 1.5×10^5 kg accelerates, at maximum thrust from the engines, from rest along a runway for 25 s before reaching the required speed for take-off of $65\,m\,s^{-1}$.
Assume that the acceleration of the aircraft is constant.

Calculate

(i) the acceleration of the aircraft

acceleration = ...$m\,s^{-2}$ [3]

(ii) the force acting on the aircraft to produce this acceleration

force = ... N [2]

(iii) the distance travelled by the aircraft in this time.

distance = ...m [2]

(c) The length of runways at some airports is less than the required distance for take-off by this aircraft calculated in **(b)(iii)**.
State and explain **one** method that could be adopted for this aircraft so that it could reach the required take-off speed on shorter runways.

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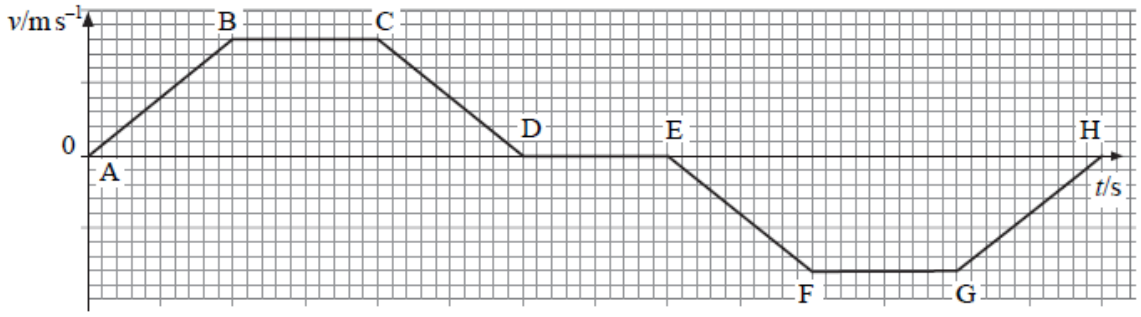
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3.

The graph below shows how the velocity of a toy train moving in a straight line varies over a period of time.



(a) Describe the motion of the train in the following regions of the graph.

AB .....

BC .....

CD .....

DE .....

EF .....

(5 marks)

(b) What feature of the graph represents the displacement of the train?

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(1 mark)

(c) Explain, with reference to the graph, why the distance travelled by the train is different from its displacement.

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(2 marks)

4.

Athlete A, competing in a 100 m race, crosses the finish line in a time of 10.2 s. At the start, the athlete accelerates uniformly to a top speed in 2.0 s and then remains at a constant speed for the remainder of the race.

(a) Calculate

(i) the average speed of the athlete over the full distance,

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(ii) the maximum speed of the athlete if the acceleration were 5.4 m s^{-2},

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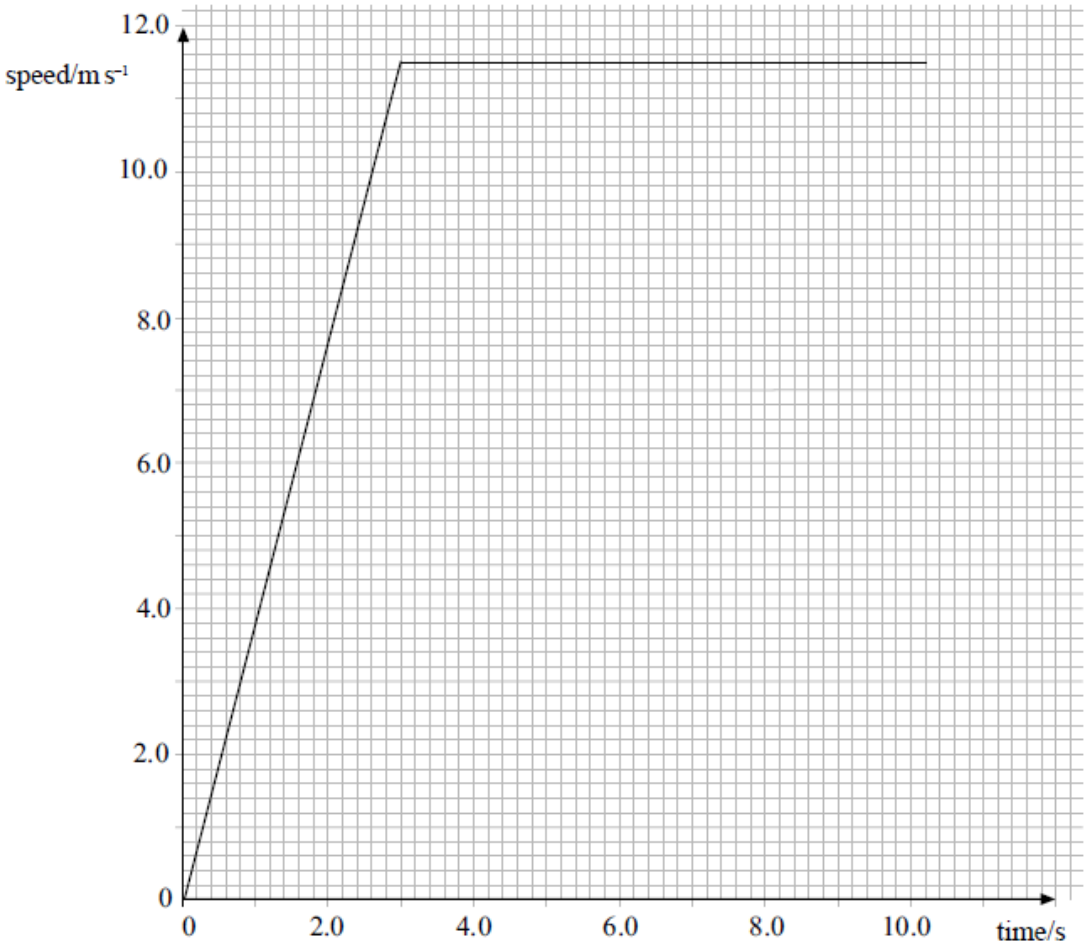
(iii) the distance travelled by the athlete whilst accelerating.

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(4 marks)

(b) The graph is a speed time graph for athlete B in the same race.



On the same axes, draw a speed-time graph for athlete A.

(c) Some time after the start of the race the two athletes are running at the same speed. Use your graph to determine

(i) the time at which this occurs,

.....

(ii) the distance covered by the athletes up to this time,

Athlete A: .....

.....

Athlete B: .....

.....

(iii) how far apart the athletes are at this time.

.....

(4 marks)

5.

(a) A cricketer throws a ball vertically upwards so that the ball leaves his hands at a speed of $25\,m\,s^{-1}$. If air resistance can be neglected, calculate

(i) the maximum height reached by the ball,

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.....

(ii) the time taken to reach maximum height,

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.....

(iii) the speed of the ball when it is at 50% of the maximum height.

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(4 marks)

(b) When catching the ball, the cricketer moves his hands for a short distance in the direction of travel of the ball as it makes contact with his hands. Explain why this technique results in less force being exerted on the cricketer's hands.

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(2 marks)

6.

(a) An egg of mass 5.8×10^{-2}kg is dropped from a height of 1.5 m onto a floor. Assuming air resistance is negligible, calculate for the egg

(i) the loss of potential energy,

.....

.....

(ii) the kinetic energy just before impact,

.....

(iii) the speed just before impact,

.....

.....

(iv) the momentum just before impact.

.....

(7 marks)

(b) On hitting the floor, the egg is brought to rest in a time of 0.010 s. Calculate the magnitude of the average decelerating force on the egg.

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(2 marks)

(c) The egg is now placed in a container that crumples on impact. Explain why this type of container makes it far less likely that the egg will break.

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(2 marks)

7.

Complete the table to show the missing physical quantity for each unit.

Unit	Physical quantity
$m\ s^{-1}$	Velocity
$m\ s^{-2}$	
$kg\ m^{-3}$	
$N\ m$	
$kg\ m\ s^{-1}$	
$N\ m\ s^{-1}$	

(5)

8.

(a) A car of mass m is travelling in a straight line along a horizontal road at a speed u when the driver applies the brakes. They exert a constant force F on the car to bring the car to rest after a distance d.

(i) Write down expressions for the initial kinetic energy of the car and the work done by the brakes in bringing the car to rest.

Kinetic energy .....

Work done .....

(1)

(ii) Show that the base units for your expressions for kinetic energy and work done are the same.

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(2)

(b) A car is travelling at 13.4 m s^{-1}. The driver applies the brakes to decelerate the car at 6.5 m s^{-2}. Show that the car travels about 14 m before coming to rest.

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(3)

(c) On another occasion, the same car is travelling at twice the speed. The driver again applies the brakes and the car decelerates at 6.5 m s^{-2}. The car travels just over 55 m before coming to rest. Explain why the braking distance has more than doubled. You may be awarded a mark for the clarity of your answer.

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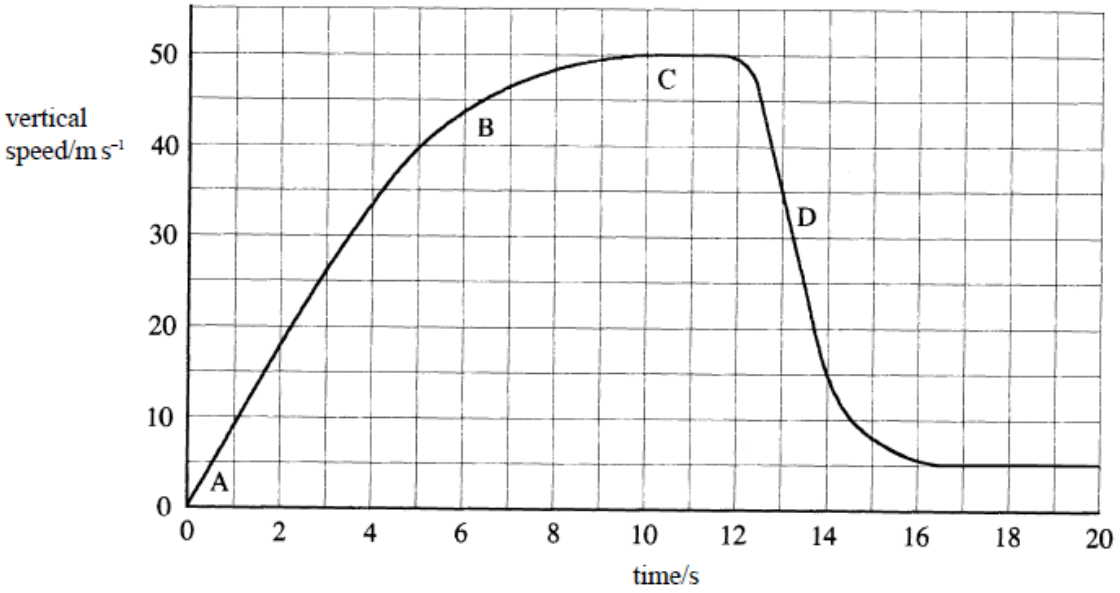
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(4)

Question 9 is on the next page.

9.

The graph shows how the vertical speed of a parachutist changes with time during the first 20 s of his jump. To avoid air turbulence caused by the aircraft, he waits a short time after jumping before pulling the cord to release his parachute.



(a) Regions A, B and C of the graph show the speed before the parachute has opened. With reference to the forces acting on the parachutist, explain why the graph has this shape in the region marked

(i) A, ...

.....

.....

.....

(ii) B, ...

.....

.....

(iii) C. .....

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.....

.....

(6 marks)

(b) Calculate the maximum deceleration of the parachutist in the region of the graph marked D, which shows how the speed changes just after the parachute has opened. Show your method clearly.

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(2 marks)

(c) Use the graph to find the total vertical distance fallen by the parachutist in the first 10 s of the jump. Show your method clearly.

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(4 marks)

(d) During his descent, the parachutist drifts sideways in the wind and hits the ground with a vertical speed of 5.0 $m\,s^{-1}$ and a horizontal speed of 3.0 $m\,s^{-1}$. Find

(i) the resultant speed with which he hits the ground,

.....

.....

.....

(ii) the angle his resultant velocity makes with the vertical.

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(2 marks)

10.

(a) (i) Define acceleration.

.....

(ii) State why acceleration is a vector quantity.

.....

.....

(2 marks)

(b) State what feature of a velocity-time graph may be used to calculate

(i) acceleration,

.....

(ii) displacement.

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(2 marks)

(c) The graph in **Figure 1** shows how the displacement of a runner from a fixed point, along a straight track, varies with time.

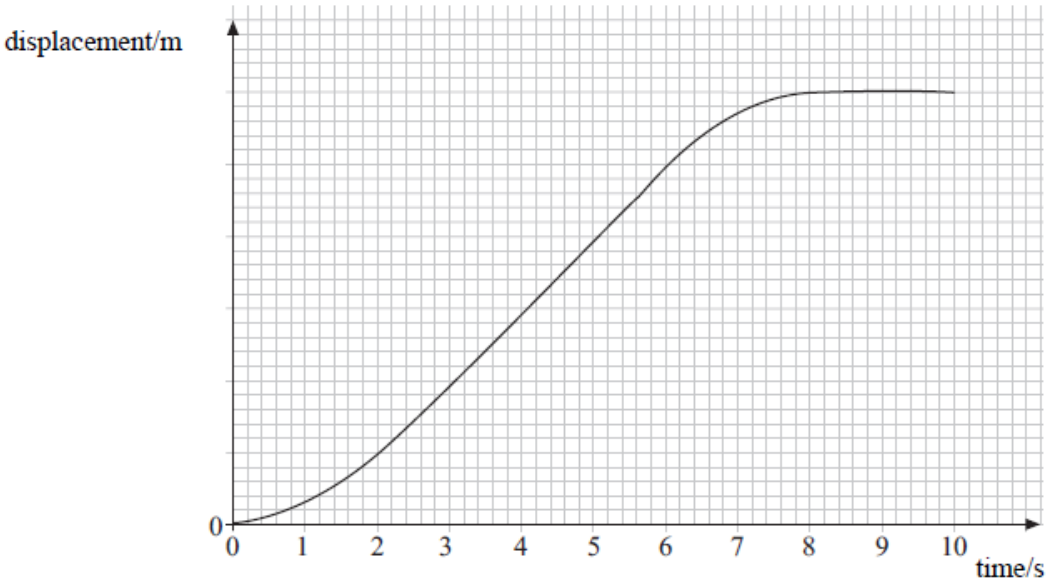


Figure 1

Without calculation, sketch on the grid in **Figure 2** a graph to show how the velocity of the same runner varies over the same period. The time scales are the same on both graphs.

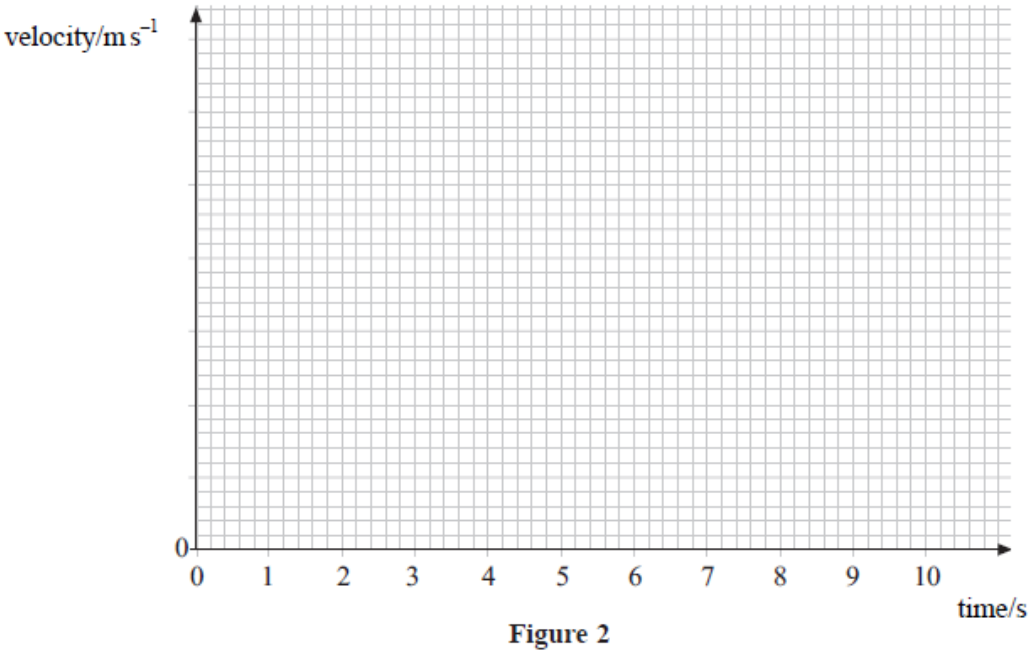
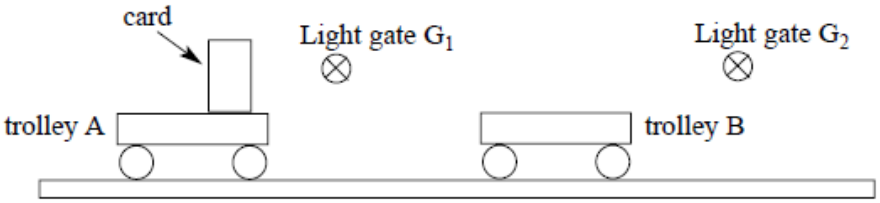


Figure 2

(4 marks)

11.

The simplified diagram shows an experimental arrangement to investigate the collision of two trolleys.



In the experiment, trolley A is travelling at speed v. It collides with and sticks to, the initially stationary trolley B.

(a) State the measurements you would need to take so that you could determine the speed of

(i) trolley A before the collision,

.....

.....

(ii) trolleys A and B after the collision.

.....

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(3 marks)

(b) Explain how you would verify that momentum was conserved in this collision, indicating what other measurements would be required.

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(2 marks)

(c) State and explain what you would do to minimise the effects of friction on the motion of the trolleys.

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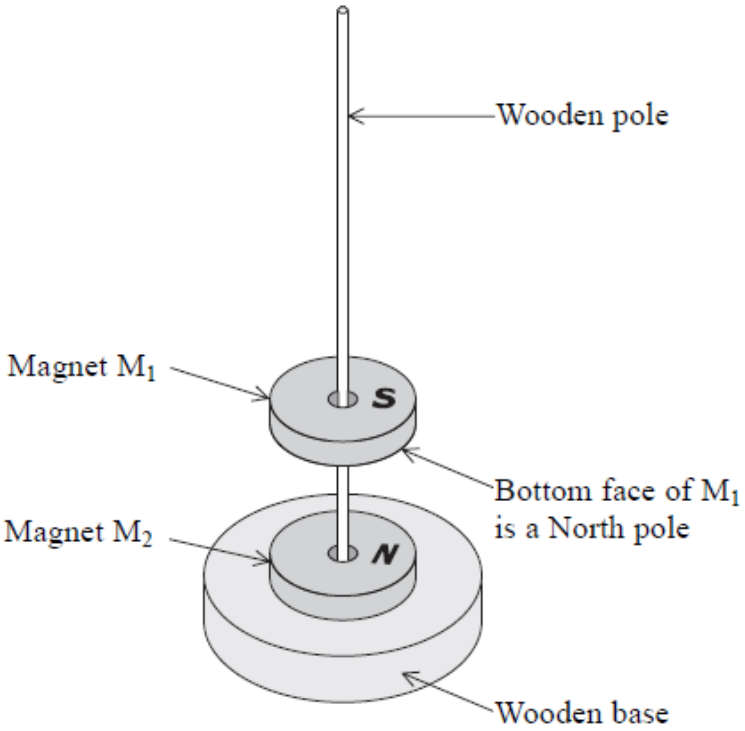
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(2 marks)

12.

The diagram shows two magnets, M_1 and M_2, on a wooden stand. Their faces are magnetised as shown so that the magnets repel each other.



(a) Draw a fully labelled free-body force diagram for the magnet M_1 in the space below.

(2)

(b) The table gives the three forces acting on the magnet M_2. For each force on M_2 there is a corresponding force known as its 'Newton's third law pair'. In each case state

(i) the body on which this corresponding force acts,

(ii) the direction of this corresponding force.

Force on M_2	Body on which corresponding force acts	Direction of the corresponding force
Contact		
Magnetic		
Weight		

(6)

13.

A ball bearing is released into a tall cylinder of clear oil. The ball bearing initially accelerates but soon reaches terminal velocity.

(a) By considering the forces acting on the ball bearing, explain its motion.

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(3 marks)

(b) How would you demonstrate that the ball bearing had reached terminal velocity?

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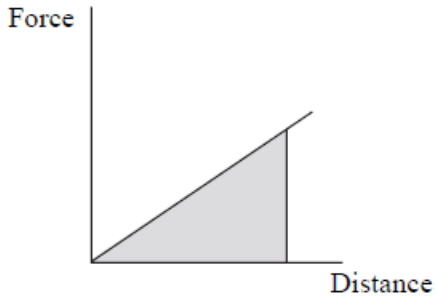
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(2 marks)

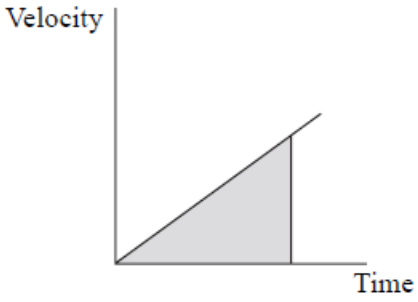
14.

Name the physical quantity represented by the area under each of the following graphs.
Give your answers in the table below.

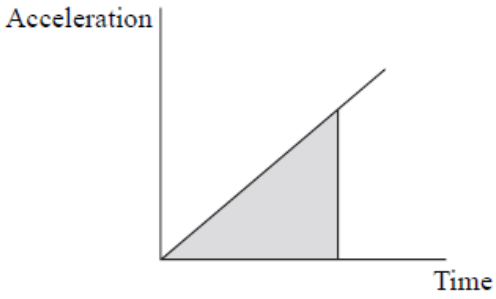
(i)



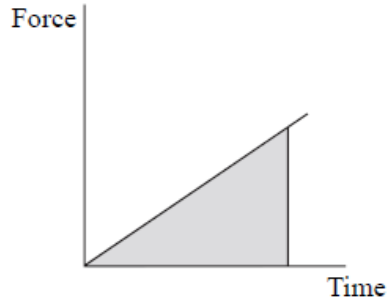
(ii)



(iii)



(iv)

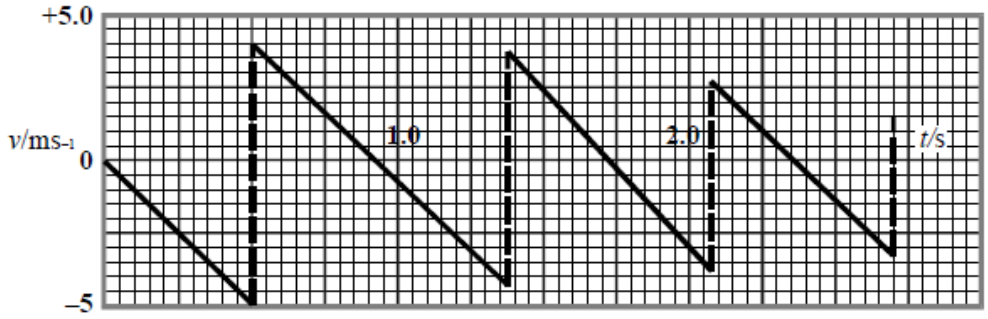


Graph	Physical quantity represented by area under graph
(i)	
(ii)	
(iii)	
(iv)	

(4)

15.

The diagram shows a velocity-time graph for a ball bouncing vertically on a hard surface.



At what instant does the graph show the ball to be in contact with the ground for the third time?

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(2)

The downwards-sloping lines on the graph are straight. Why are they straight?

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(2)

Calculate the height from which the ball is dropped.

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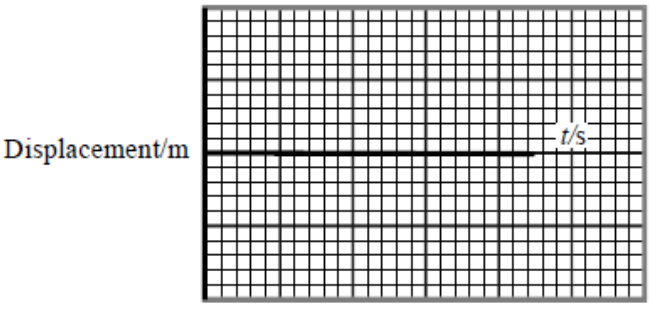
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Height = ...

(3)

Sketch a displacement-time curve on the axes below for the first second of the motion.



(3)

What is the displacement of the ball when it finally comes to rest?

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(1)