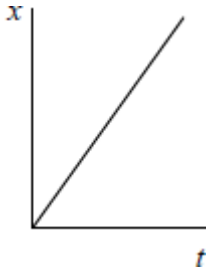
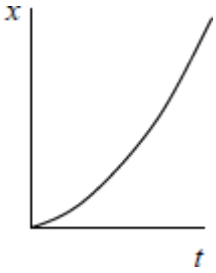
1 A car accelerates uniformly from rest along a straight road. Which graph shows the variation of displacement x of the car with time t?

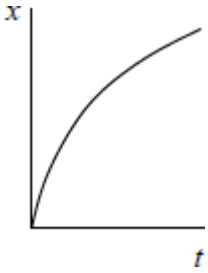
A



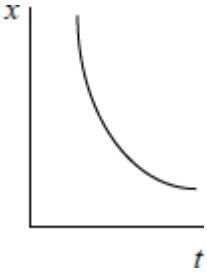
B



C



D



A ⬭

B ⬭

C ⬭

D ⬭

(Total 1 mark)

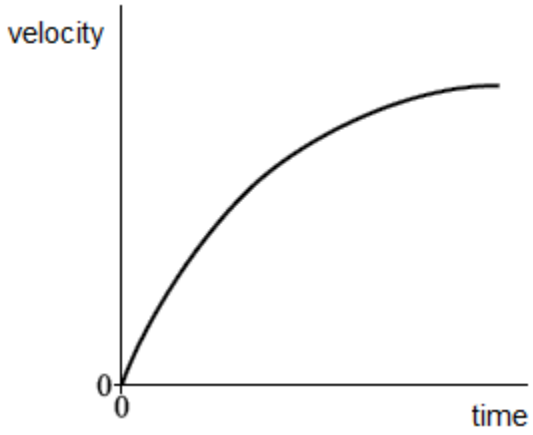
2 A girl jogs at 2.0 m s^{-1} in a straight line for 30 seconds, turns around and returns to her starting point 20 seconds later.

What is her average velocity and average speed?

	Average velocity/m s^{-1}	Average speed/m s^{-1}	
A	0 m s^{-1}	2.4 m s^{-1}	⬭
B	0 m s^{-1}	2.5 m s^{-1}	⬭
C	1.0 m s^{-1}	2.0 m s^{-1}	⬭
D	2.5 m s^{-1}	2.5 m s^{-1}	⬭

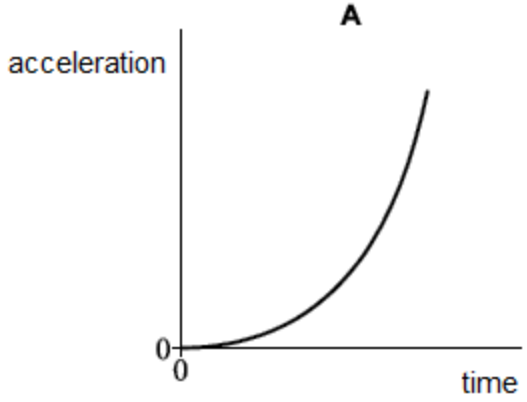
(Total 1 mark)

3 The velocity–time graph for a falling object is shown.

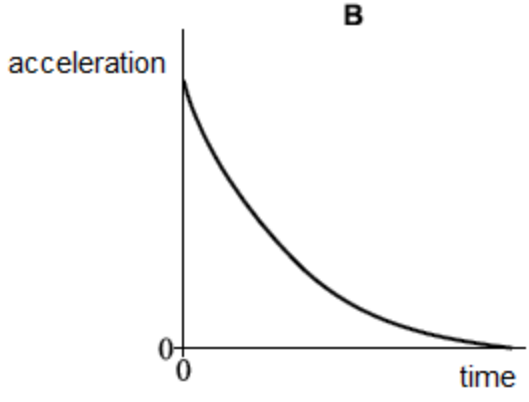


Which of the following shows the corresponding acceleration–time graph?

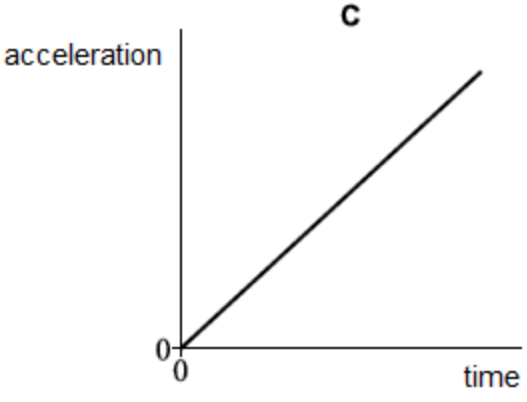
A



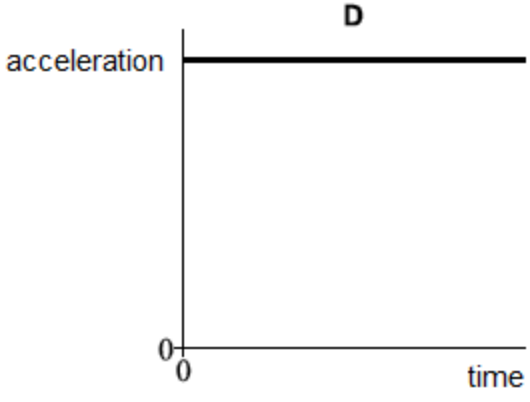
B



C



D



A ⬭

B ⬭

C ⬭

D ⬭

(Total 1 mark)

4 An object is dropped from a cliff. How far does the object fall in the third second? Assume that g = 10 m s^{-2}.

A 10 m ⬭

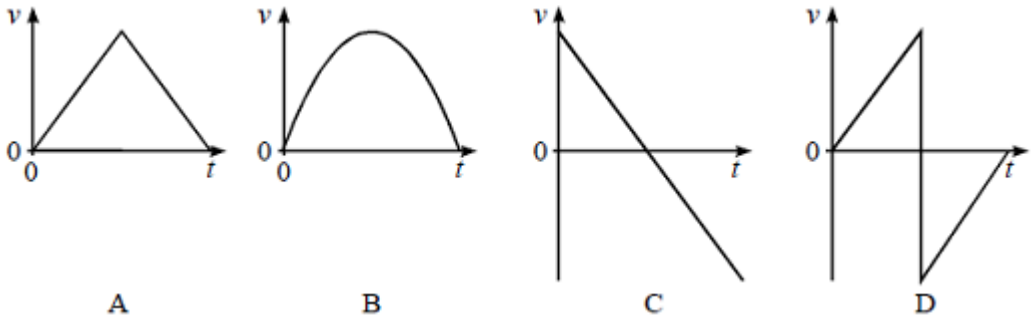
B 20 m ⬭

C 25 m ⬭

D 45 m ⬭

(Total 1 mark)

5 A perfectly elastic rubber ball falls vertically from rest and rebounds from the floor. Which one of the following velocity-time, *v*–*t*, graphs best represents the motion from the moment of release to the top of the first rebound?



(Total 1 mark)

6 A lunar landing module is descending to the Moon's surface at a steady velocity of 10.0 m s^{-1}. At a height of 120 m a small object falls from its landing gear. Assuming that the Moon's gravitational acceleration is 1.60 m s^{-2}, at what speed, in m s^{-1} does the object strike the Moon?

A 22.0

B 19.6

C 16.8

D 10.0

(Total 1 mark)

7 A steel ball of weight W falls through oil. At a time **before** the ball reaches terminal velocity, the magnitude of the viscous resistance force on the ball is

A zero

B between zero and W

C equal to W

D greater than W

(Total 1 mark)

8 A roller coaster car is raised to a height of 65 m and released from rest.

What is the maximum possible speed of the car?

A 11 m s^{-1} ⬭

B 25 m s^{-1} ⬭

C 36 m s^{-1} ⬭

D 130 m s^{-1} ⬭

(Total 1 mark)

9 A car accelerates uniformly from rest to a speed of 100 km h^{-1} in 5.8 s.

(a) Calculate the magnitude of the acceleration of the car in m s^{-2}.

Acceleration = ...m s^{-2}

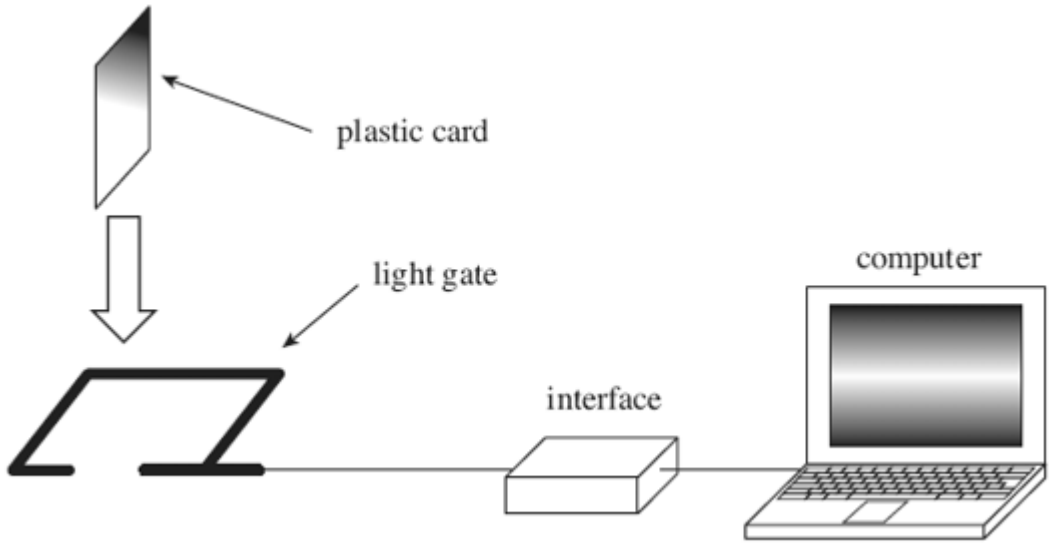
(3)

(b) Calculate the distance travelled by the car while accelerating.

Distance travelled = ...

(2)
(Total 5 marks)

10 A student measures the acceleration due to gravity, *g*, using the apparatus shown in the figure below. A plastic card of known length is released from rest at a height of 0.50m above a light gate. A computer calculates the velocity of the card at this point, using the time for the card to pass through the light gate.



(a) The computer calculated a value of 3.10 m s^{-1} for the velocity of the card as it travelled through the light gate. Calculate a value for the acceleration due to gravity, *g*, from these data.

answer = ... m s^{-2}

(2)

(b) The student doubles the mass of the card and finds a value for *g* that is similar to the original value. Use the relationship between *weight*, *mass* and *g* to explain this result.

.....

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(1)

(c) State and explain **one** reason why the card would give more reliable results than a table tennis ball for this experiment.

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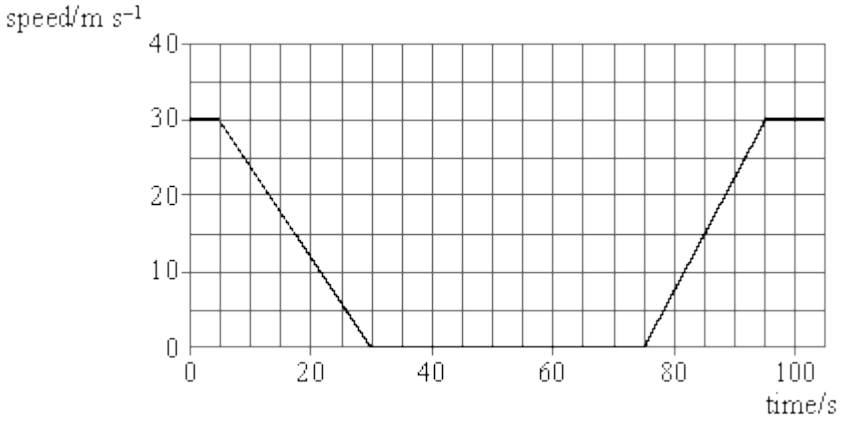
(2)
(Total 5 marks)

11 The diagram below shows a speed-time graph for a car that halts at traffic lights and then moves away.



(a) Use the graph to show that the car travels about 380 m whilst decelerating.

(2)

(b) Use the graph to calculate the acceleration of the car for the time interval from 75 s to 95 s.

Acceleration .....

(2)

(c) Calculate the total distance travelled by the car in the time interval 5 s to 95 s.

Distance travelled .....

(1)

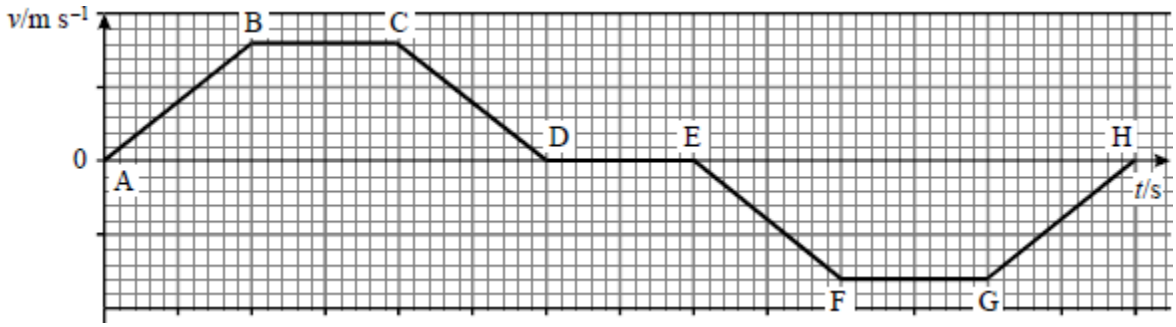
(d) A second car travels the same route without being halted at the traffic lights. The speed of this car is a constant 30 m s^{-1}.

Calculate the difference in journey time between the first and second cars.

Journey time difference .....

(3)
(Total 8 marks)

12 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)

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

.....

.....

(1)

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

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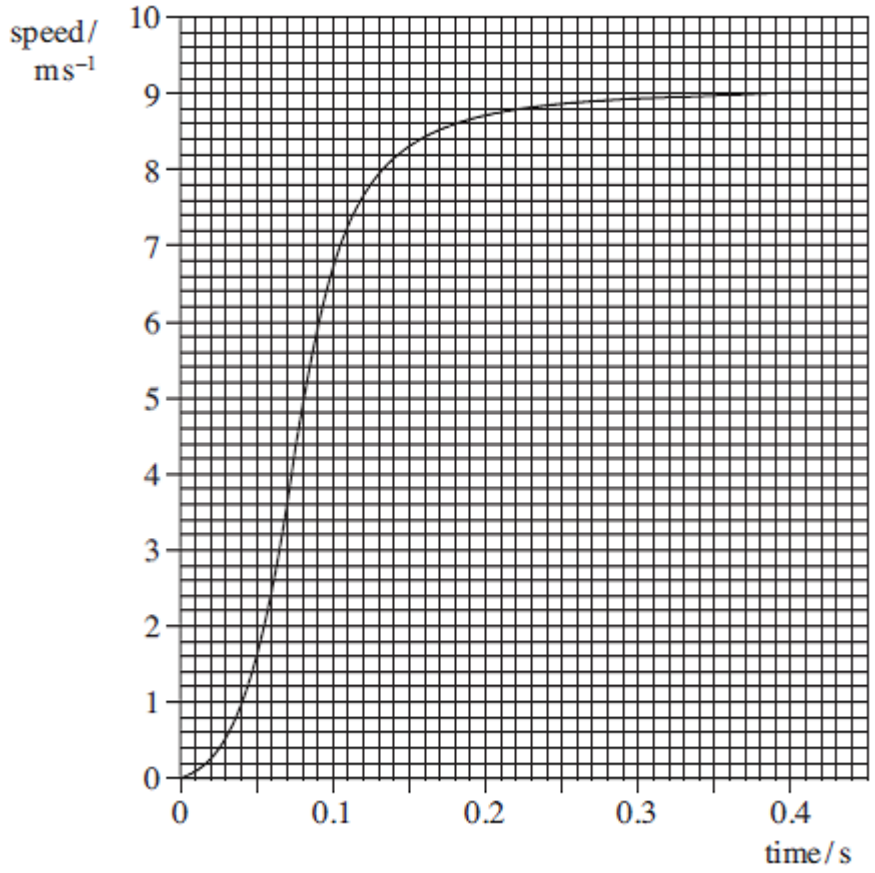
(2)
(Total 8 marks)

13 The figure below is a speed-time graph for a sprinter at the start of a race.



Determine the distance covered by the sprinter in the first 0.3 s of the race.

.....

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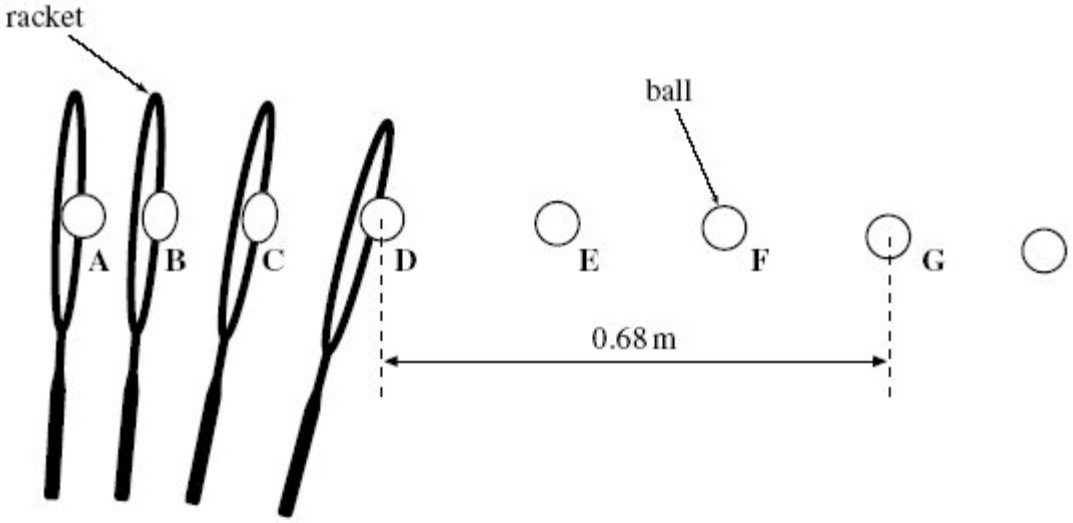
.....

.....

distance ..... m

(Total 3 marks)

14 A digital camera was used to obtain a sequence of images of a tennis ball being struck by a tennis racket. The camera was set to take an image every 5.0 ms. The successive positions of the racket and ball are shown in the diagram below.



(a) The ball has a horizontal velocity of zero at **A** and reaches a constant horizontal velocity at **D** as it leaves the racket. The ball travels a horizontal distance of 0.68 m between **D** and **G**.

(i) Show that the horizontal velocity of the ball between positions **D** and **G** in the diagram above is about 45 m s^{-1}.

(3)

(ii) Calculate the horizontal acceleration of the ball between **A** and **D**.

answer = ... m s^{-2}

(1)

(b) At **D**, the ball was projected horizontally from a height of 2.3 m above level ground.

(i) Show that the ball would fall to the ground in about 0.7 s.

(3)

(ii) Calculate the horizontal distance that the ball will travel after it leaves the racket before hitting the ground. Assume that only gravity acts on the ball as it falls.

answer = ... m

(2)

(iii) Explain why, in practice, the ball will not travel this far before hitting the ground.

.....

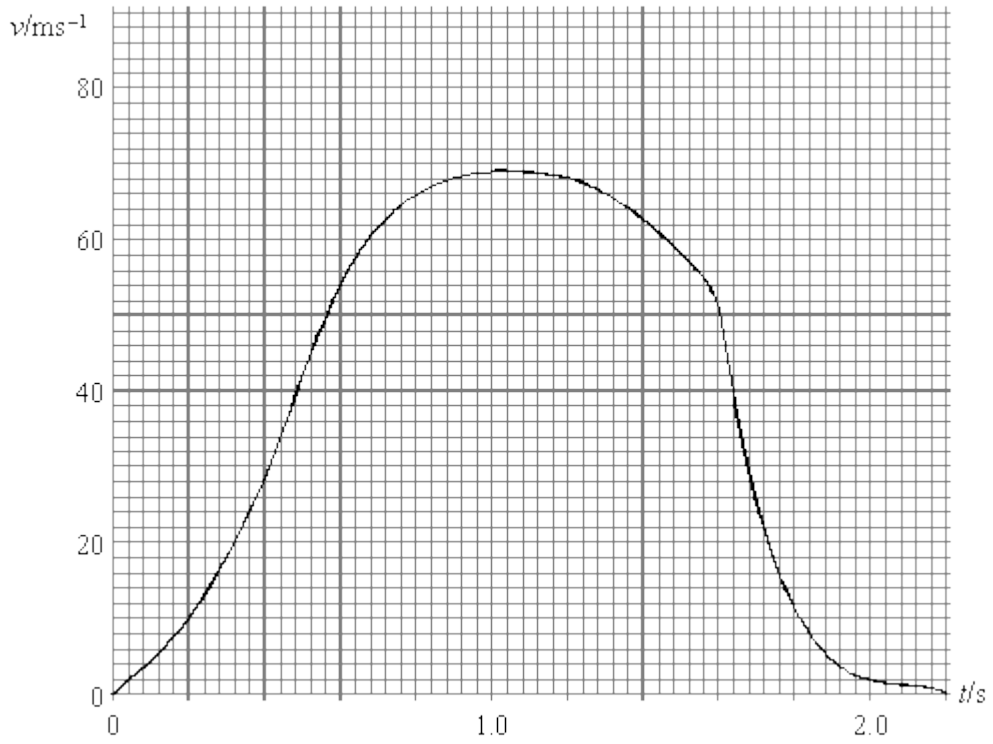
.....

.....

(2)

(Total 11 marks)

15 The graph below shows how the vertical component, *v*, of the velocity of a rocket varies with time, *t*, from its take-off on level ground to the **highest point of its trajectory**.



(a) Take readings from the graph to calculate the average vertical acceleration of the rocket from time $t = 0$ to time $t = 0.60$ s.

Average acceleration .....

(3)

(b) Use the graph to estimate the maximum height reached by the rocket.

Maximum height .....

(3)

(c) Assume that air resistance is negligible. Calculate the time taken for the rocket to fall from its maximum height back to the ground.

acceleration of free fall $g = 9.8$ m s^{-2}

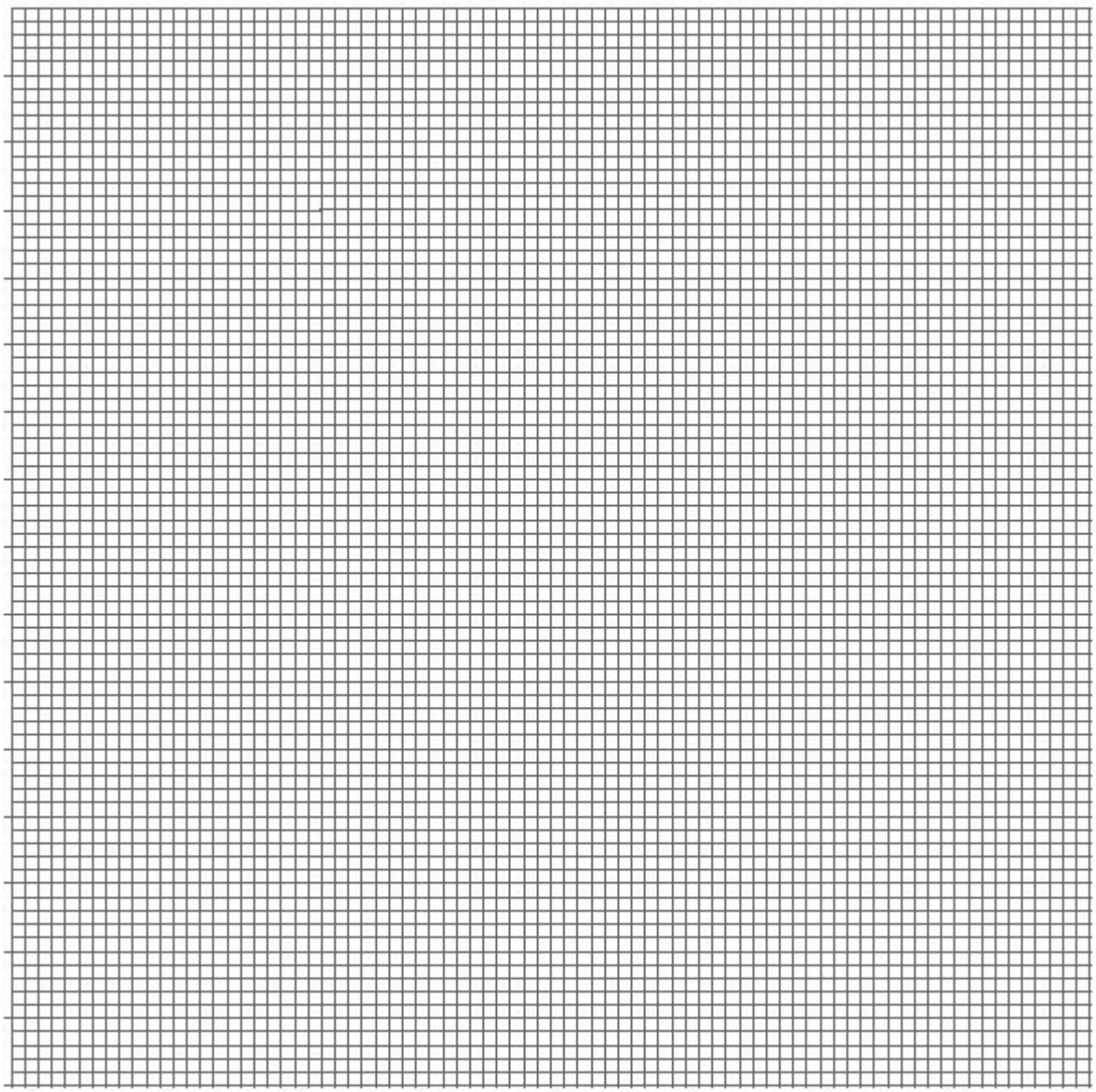
Time to fall to the ground .....

(2)
(Total 8 marks)

16 A car is travelling on a level road at a speed of 15.0 m s^{-1} towards a set of traffic lights when the lights turn red. The driver applies the brakes 0.5 s after seeing the lights turn red and stops the car at the traffic lights. The table below shows how the speed of the car changes from when the traffic lights turn red.

time/s	0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5
speed/m s^{-1}	15.0	15.0	12.5	10.0	7.5	5.0	2.5	0.0

(a) Draw a graph of speed on the y-axis against time on the x-axis on the grid provided.



(5)

(b) (i) State and explain what feature of the graph shows that the car's deceleration was uniform.

.....

.....

.....

.....

(2)

(ii) Use your graph to calculate the distance the car travelled after the lights turned red to when it stopped.

Answer ..... m

(4)
(Total 11 marks)

17 **Figure 1** shows the speed-time graph for a swimmer performing one complete cycle of the breast stroke.

Figure 1

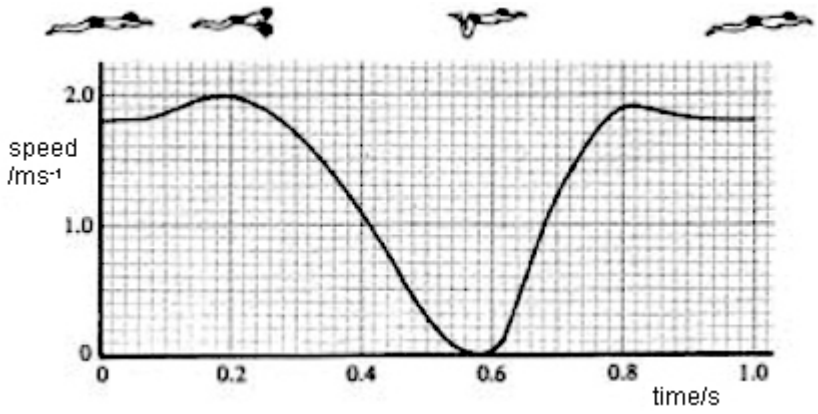
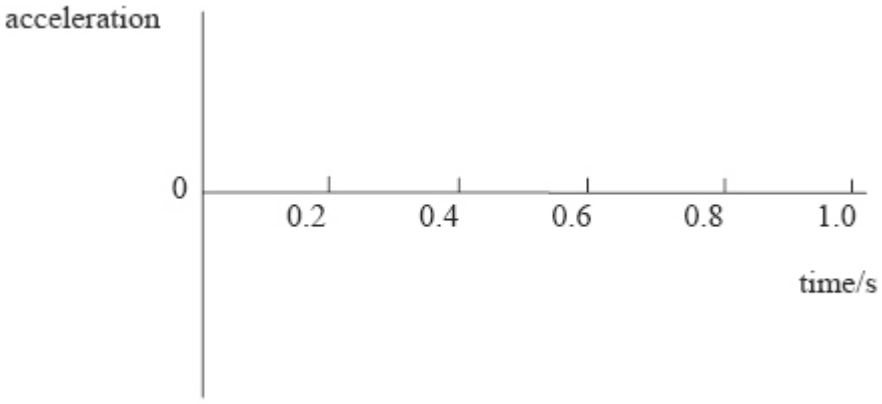


Figure 2



(a) (i) Find the acceleration of the swimmer at time 0.65 s.

acceleration .....

(ii) Sketch, on the axes in **Figure 2**, a graph to show how the acceleration of the swimmer varies with time for the same time interval. You are not required to make any further calculations but your graph should show relative values.

(4)

(b) Use the graph in **Figure 1** to estimate the distance travelled by the swimmer in one complete cycle of the stroke. Show your working clearly.

distance travelled ..... m

(4)
(Total 8 marks)

18 (a) (i) Define acceleration.

.....

(ii) State why acceleration is a vector quantity.

.....

.....

(2)

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

(i) acceleration,

.....

(ii) displacement.

.....

(2)

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

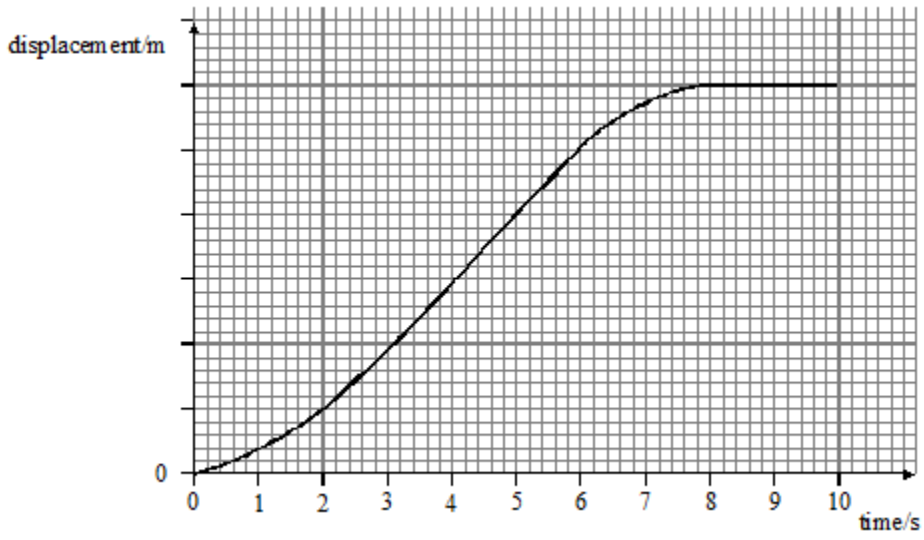


Figure 1

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.

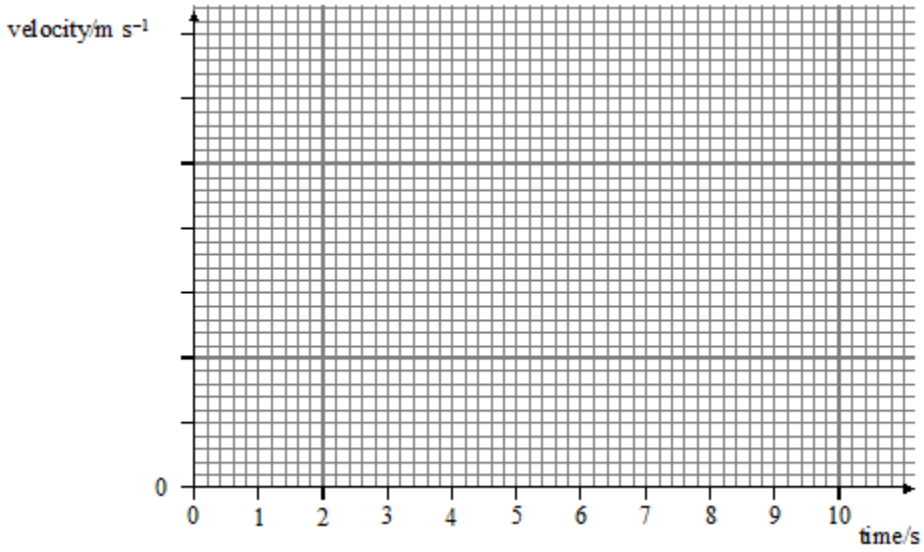
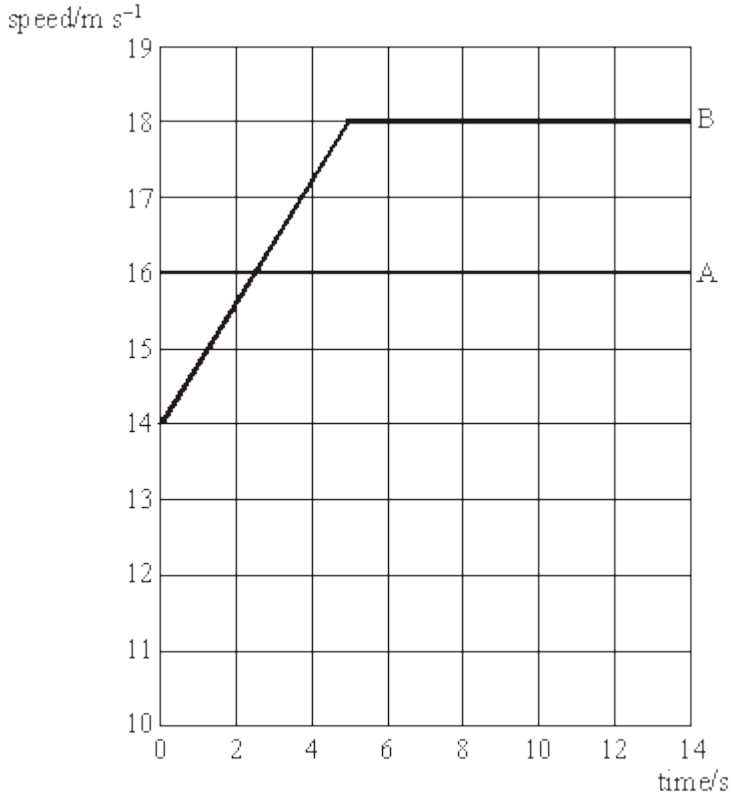


Figure 2

(4)
(Total 8 marks)

19 The graph represents the motion of two cars, A and B, as they move along a straight, horizontal road.



(a) Describe the motion of each car as shown on the graph.

(i) car A: .....

.....

(ii) car B: .....

.....

(3)

(b) Calculate the distance travelled by each car during the first 5.0 s.

(i) car A: .....

.....

.....

(ii) car B: .....

.....

.....

(4)

(c) At time t = 0, the two cars are level. Explain why car A is at its maximum distance ahead of B at t = 2.5 s

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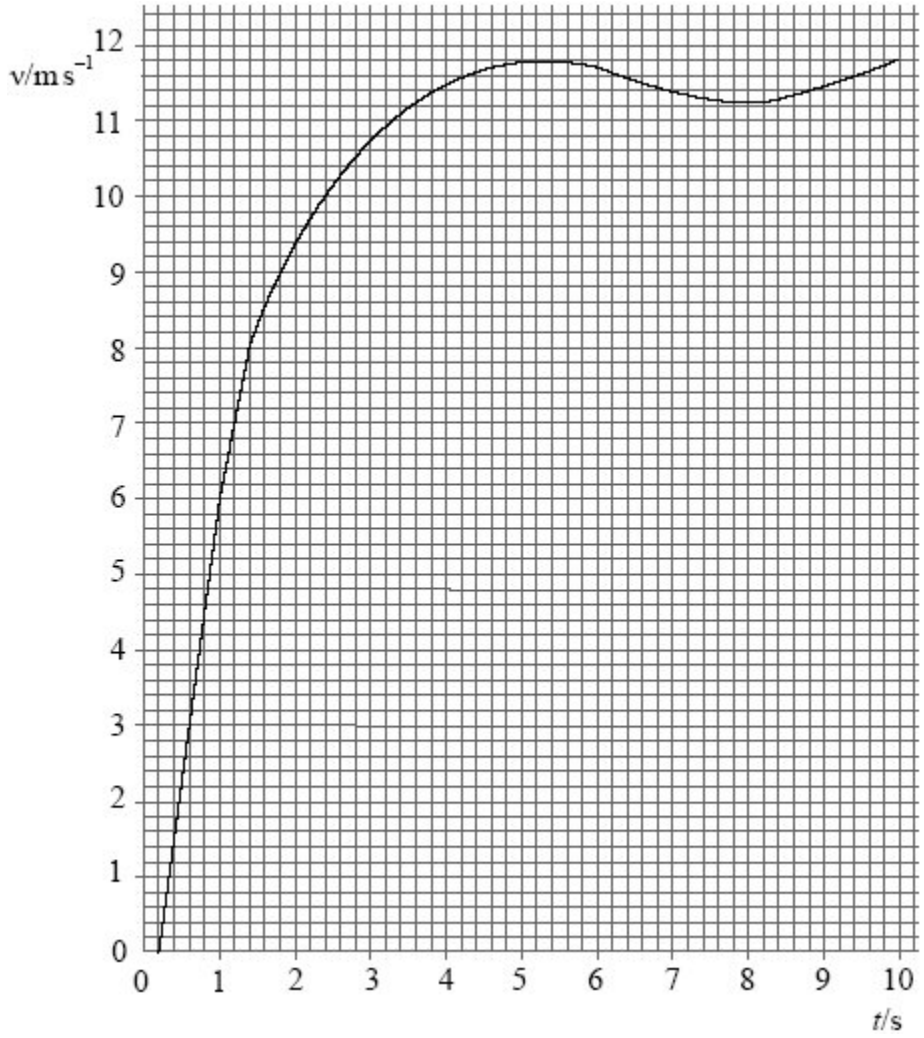
(3)
(Total 10 marks)

20 The diagram below shows the variation of the speed, *v,* of a sprinter with time, *t,* from the time the starting pistol is fired until the sprinter reaches the finishing line during a 100 m sprint.



(a) Explain why the graph does not go through the origin.

.....

.....

(1)

(b) Determine the acceleration of the sprinter 3.5 s after the start of the race.
Give an appropriate unit for your answer.

acceleration .....

(3)

(c) What distance was covered in the first 2.0 s of the race?

distance .....

(4)

(d) Describe briefly how the data for the sprinter's velocity–time graph shown in the diagram above could have been collected.

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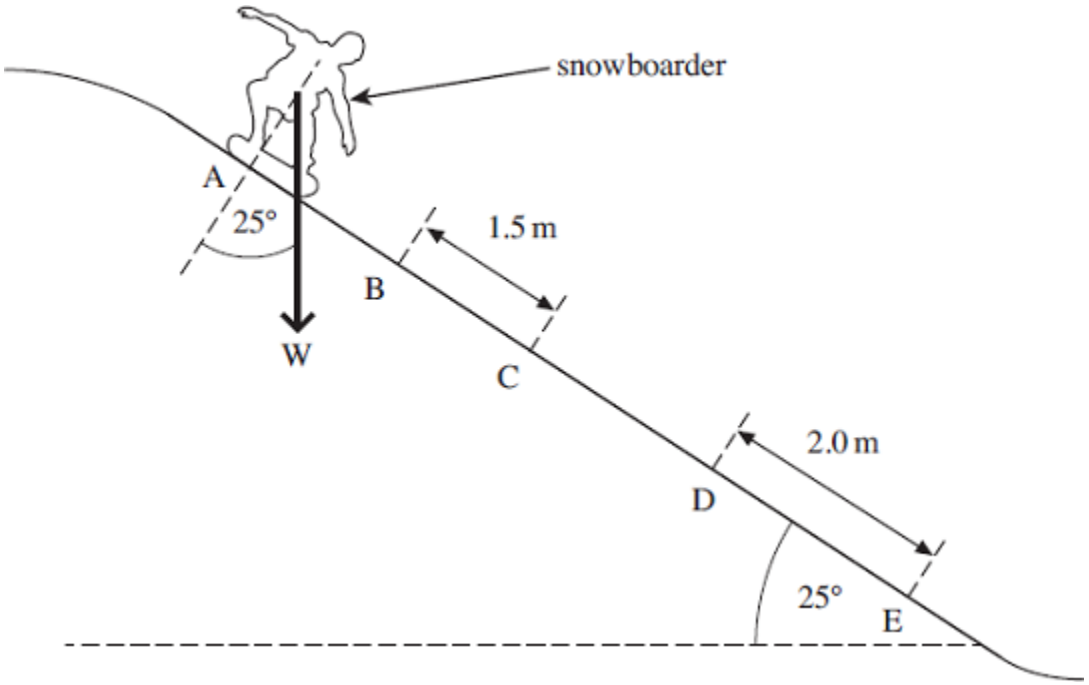
(2)
(Total 10 marks)

21 A snowboarder slides down a slope, as shown in the diagram below. Between **B** and **C** her acceleration is uniform.



(a) The snowboarder travels 1.5 m from B to C in a time of 0.43 s and her velocity down the slope at C is 5.0 ms^{-1}.

Calculate her velocity down the slope at B.

velocity = ... ms^{-1}

(3)

(b) The combined mass of the snowboarder and snowboard is 75 kg and the angle of the slope is 25°

(i) Calculate the component of the weight of the snowboarder and snowboard acting down the slope.

weight component = ... N

(2)

(ii) At D the snowboarder has reached a constant velocity. She moves a distance of 2.0 m at constant velocity between D and E.

Calculate the work done against resistive forces as she moves from D to E.

work done = ... J

(1)

(c) State and explain what happens to the gravitational potential energy lost between D and E.

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(3)
(Total 9 marks)

22 A ball is dropped and rebounds vertically to less than the original height.

For this first bounce only, sketch graphs of

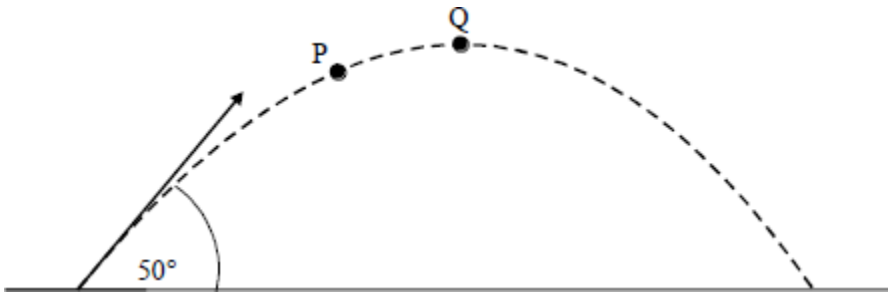
(a) the velocity of the ball plotted against time,

(4)

(b) the acceleration of the ball plotted against time.

(1)

(c)



The ball is then thrown at an angle to the horizontal and follows the trajectory shown in the diagram.

Mark on the diagram the directions of

(i) the acceleration vector at P,

(ii) the acceleration vector at Q,

(iii) the momentum vector at P,

(iv) the momentum vector at Q.

(4)

(d) The mass of the ball is 0.15 kg and the initial direction makes an angle of 50° to the horizontal. Calculate the magnitude of the momentum of the ball at Q when it is projected with an initial speed of 15 m s^{-1}. Neglect the effects of air resistance.

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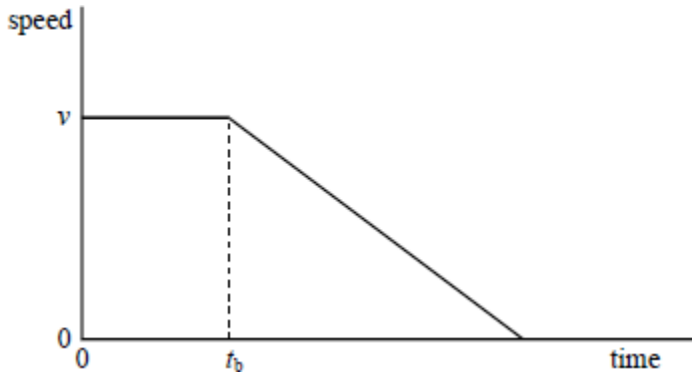
(4)
(Total 13 marks)

23 The driver of a car sees an obstruction ahead and applies the brakes at time t_b later, bringing the car to a halt. The graph shows how the speed of the car varies with time.



The stopping distance, s, of the car which was travelling at speed v before the driver applied the brakes, can be represented by the equation

$$s = t_b + \frac{v^2}{2a},$$

where α is the magnitude of the deceleration of the car (assumed constant).

(a) State what distance is represented by each of the terms

$vt>_b$

$\frac{v^2}{2a}$ .....

(2)

(b) The table includes data on stopping distances of cars. Column C gives the total stopping distance for a car travelling at each of the speeds shown in column A.

column A	column B	column C	column D
speed v/km h^{-1}	speed v/m s^{-1}	stopping distance s/m	$\frac{s}{v}$/sec
32	8.9	12	
48		23	
64		36	
80		53	
96		73	
112		96	

(i) Complete column B,

(ii) In column D, calculate each of the corresponding values of $\frac{s}{v}$.

(2)

(c) The equation for s can be rearranged as $\frac{s}{v} = t_b + \frac{v}{2a}$.

From the data you have calculated, plot a suitable graph to verify this equation.

(One sheet of graph paper should be provided)

(5)

(d) From your graph determine the value of

(i) t_b .....

(ii) the magnitude of the deceleration, a.

.....

.....

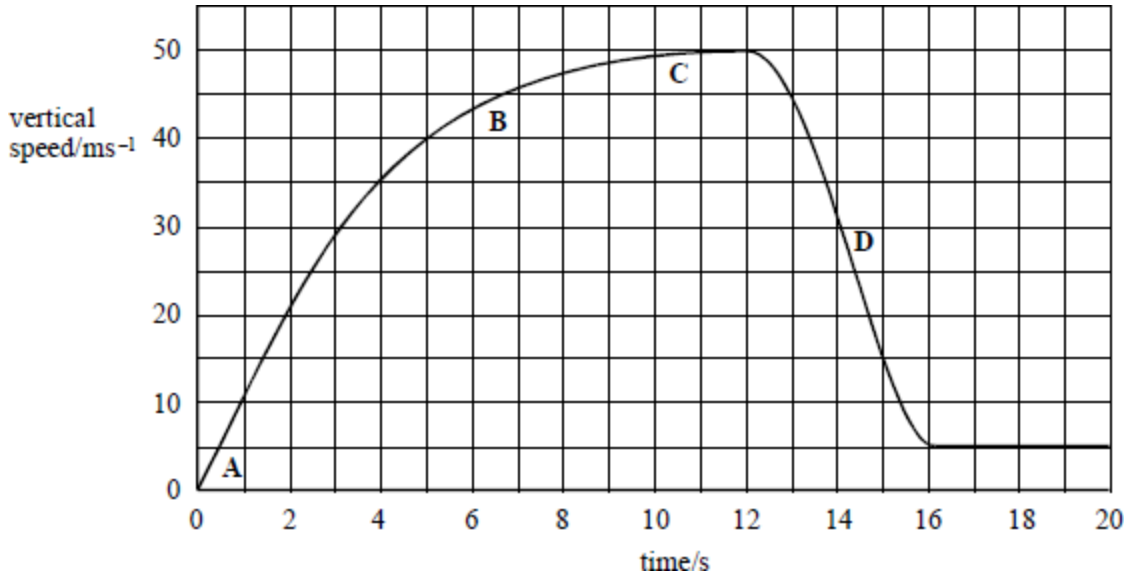
.....

.....

.....

(4)
(Total 13 marks)

24 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, ...

.....

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.....

(iii) C, ...

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(6)

(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)

(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)

(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.

.....

.....

(2)
(Total 14 marks)

25 (a) Indicate with ticks (✓) in the table below which of the quantities are vectors and which are scalars.

	Velocity	**Speed**	**Distance**	**Displacement**
vector				
scalar				

(2)

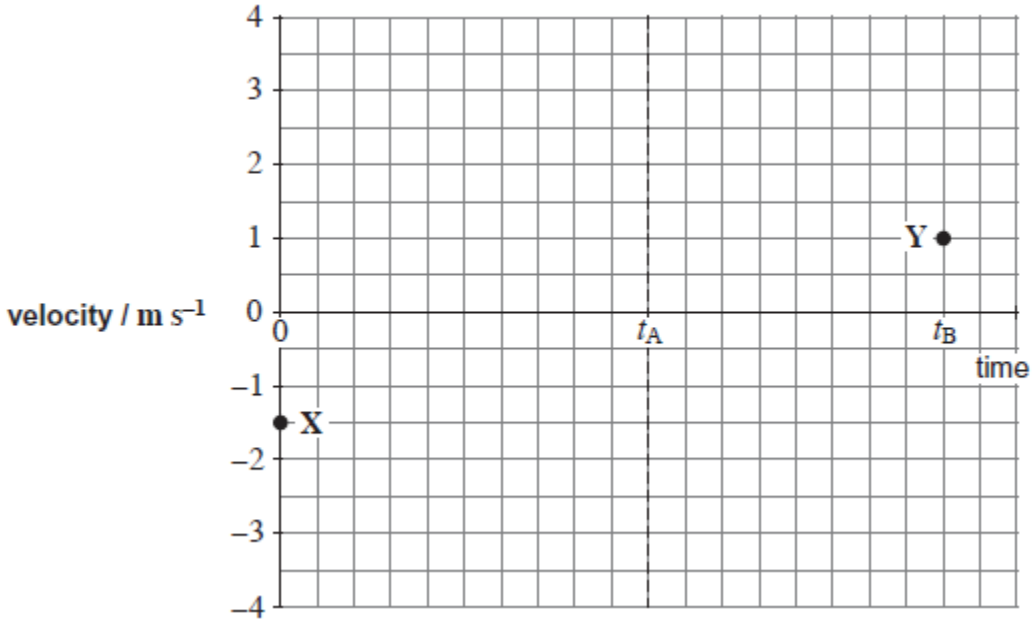
(b) A tennis ball is thrown vertically downwards and bounces on the ground. The ball leaves the hand with an initial speed of 1.5 m s^{-1} at a height of 0.65 m above the ground. The ball rebounds and is caught when travelling upwards with a speed of 1.0 m s^{-1}.

Assume that air resistance is negligible.

(i) Show that the speed of the ball is about 4 m s^{-1} just before it strikes the ground.

(3)

(ii) The ball is released at time $t = 0$. It hits the ground at time t_A and is caught at time t_B. On the graph, sketch a velocity–time graph for the vertical motion of the tennis ball from when it leaves the hand to when it returns. The initial velocity **X** and final velocity **Y** are marked.



(3)

(c) In a game of tennis, a ball is hit horizontally at a height of 1.2 m and travels a horizontal distance of 5.0 m before reaching the ground. The ball is at rest when hit.

Calculate the initial horizontal velocity given to the ball when it was hit.

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

(3)

(Total 11 marks)