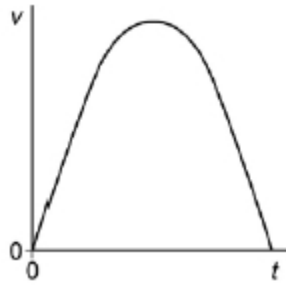
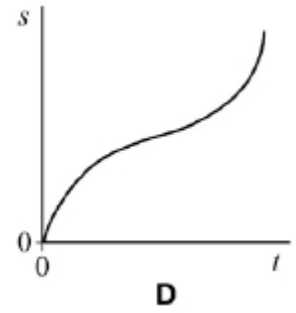
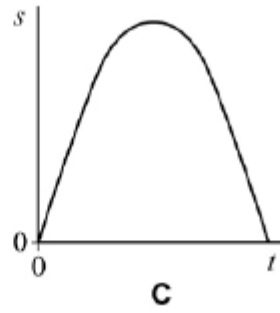
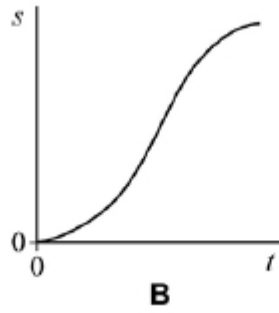
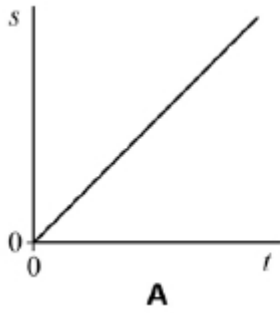


1

A body travels with speed v , which varies with time t as shown in the graph.



Which one of the graphs, **A** to **D**, shows how the distance s covered by the body varies with time t ?



A ☐

B ☐

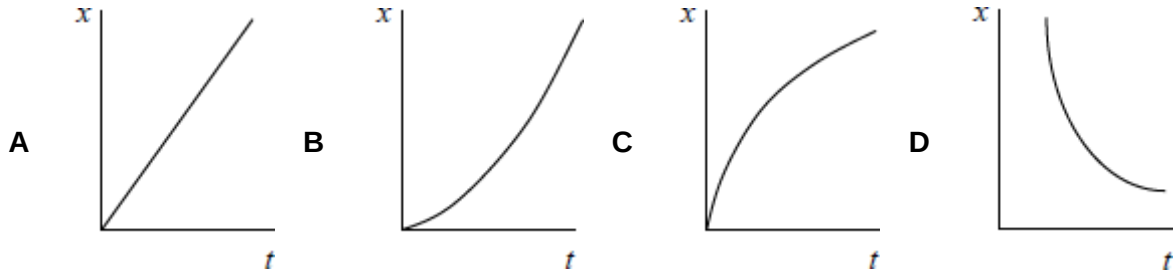
C ☐

D ☐

(Total 1 mark)

2

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

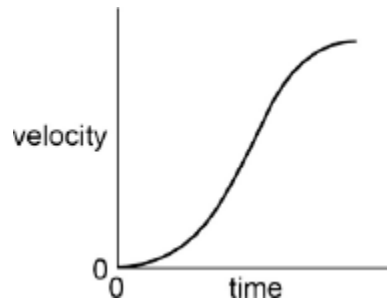


- A** ☐
- B** ☐
- C** ☐
- D** ☐

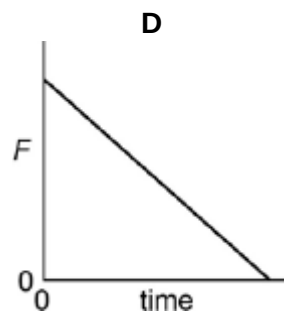
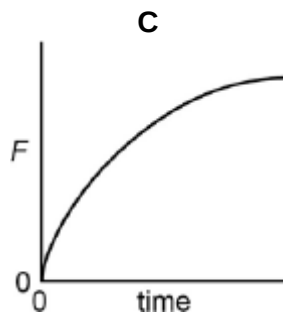
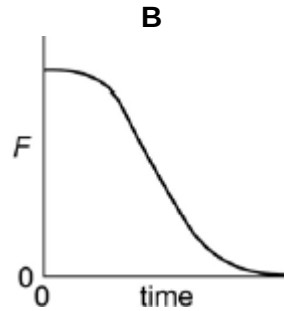
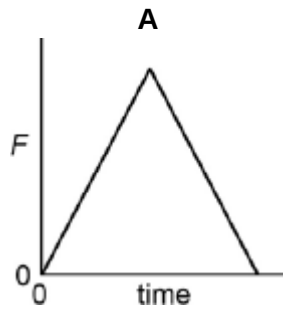
(Total 1 mark)

3

The velocity of a vehicle varies with time as shown by the following graph.



Which graph below represents how the resultant force F on the car varies during the same time?



A ☐

B ☐

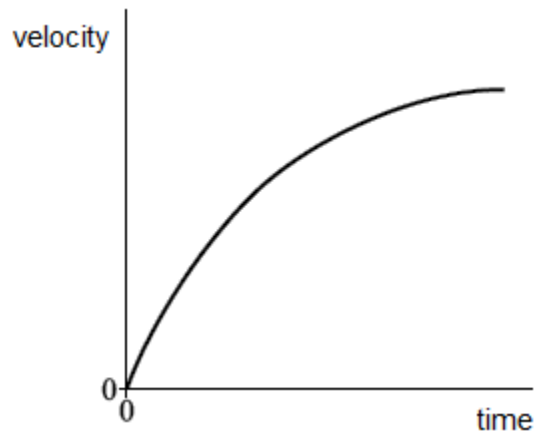
C ☐

D ☐

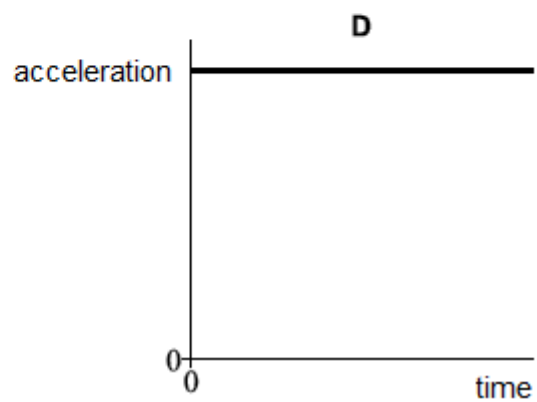
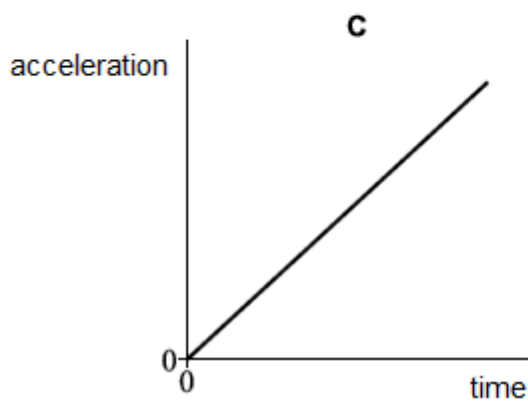
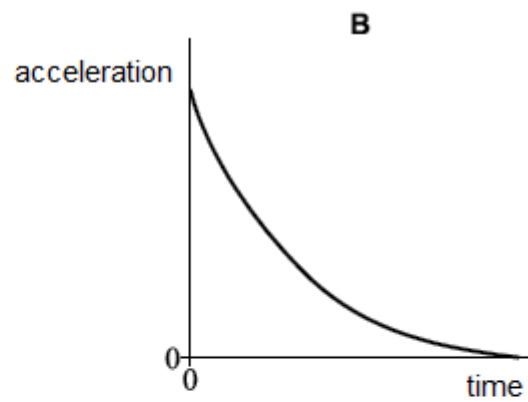
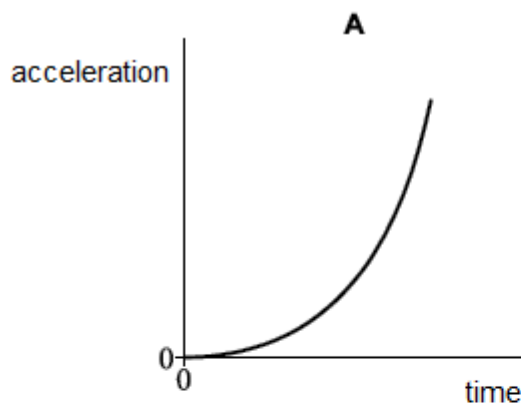
(Total 1 mark)

4

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



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



A

☐

B

☐

C

☐

D

☐

(Total 1 mark)

5

What is represented by the area under a force–displacement graph?

A rate of change of kinetic energy

☐

B change in momentum

☐

C work done

☐

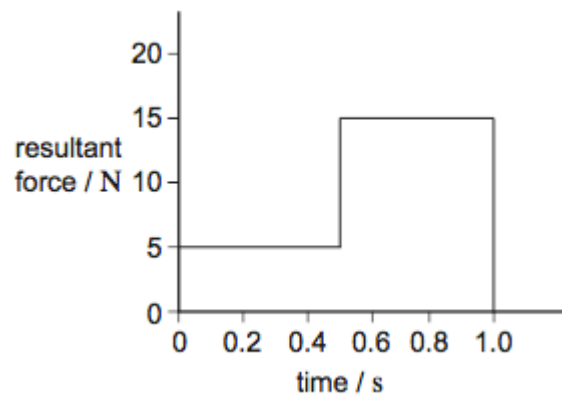
D acceleration

☐

(Total 1 mark)

6

The graph shows how the resultant force applied to an object of mass 2.0 kg, initially at rest, varies with time.



What is the speed of the object after 1.0 s?

A 2.5 m s⁻¹

B 5.0 m s⁻¹

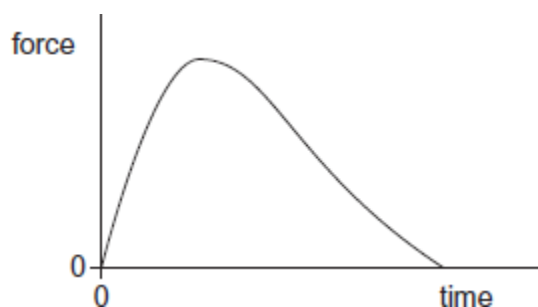
C 7.5 m s⁻¹

D 10 m s⁻¹

(Total 1 mark)

7

The graph shows how the force acting on a rocket varies with time.



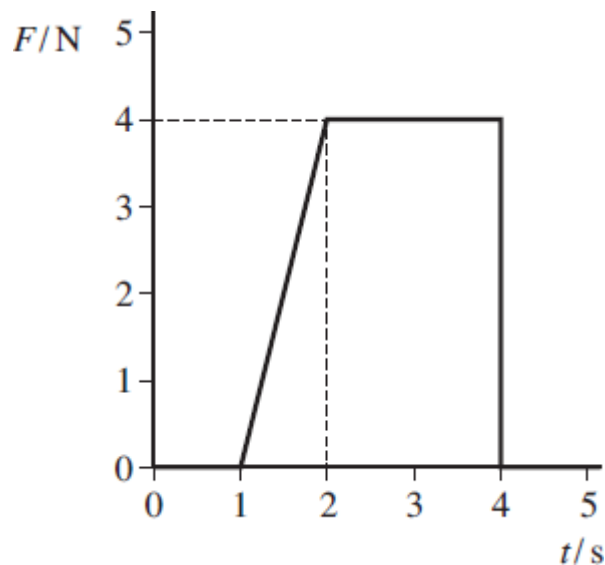
Which one of the following is represented by the area under the graph?

- A distance travelled
- B gain in kinetic energy
- C change in velocity
- D change in momentum

(Total 1 mark)

8

The graph shows how the resultant force, F , acting on a body varies with time, t .



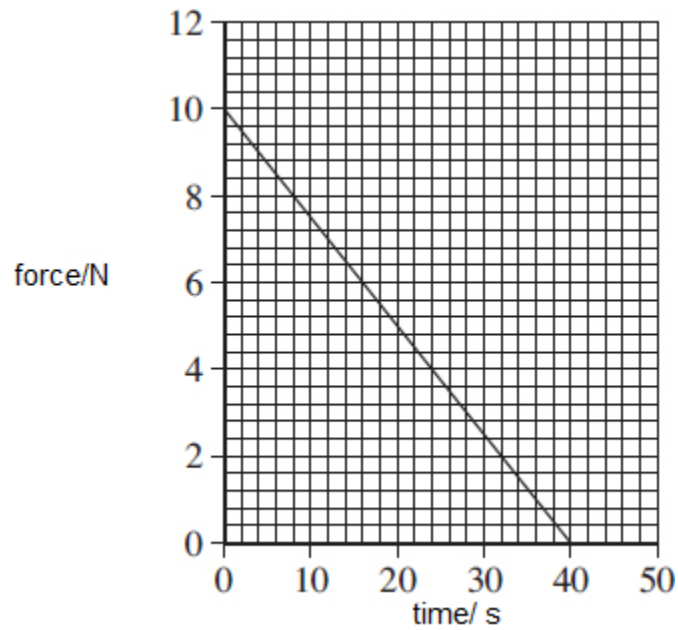
What is the change in momentum of the body over the 5 s period?

- A 2N s
- B 8N s
- C 10N s
- D 12N s

(Total 1 mark)

9

The graph shows how the force acting on a body changes with time.



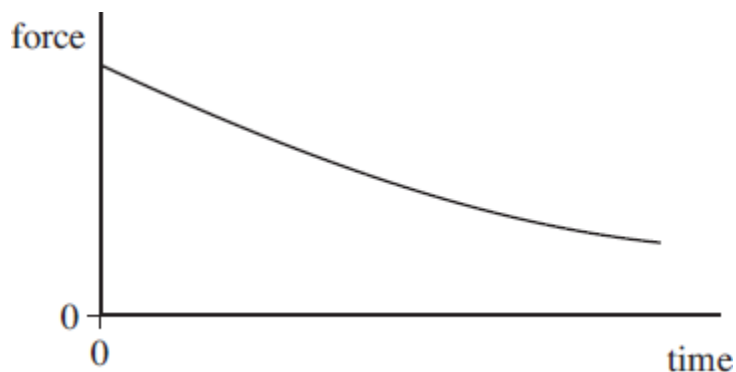
The body has a mass of 0.25 kg and is initially at rest. What is the speed of the body after 40 s assuming no other forces are acting?

- A** 200 ms⁻¹
- B** 400 ms⁻¹
- C** 800 ms⁻¹
- D** 1600 ms⁻¹

(Total 1 mark)

10

A ball is released so that it falls vertically. The graph shows how the resultant force acting on the ball changes with time.



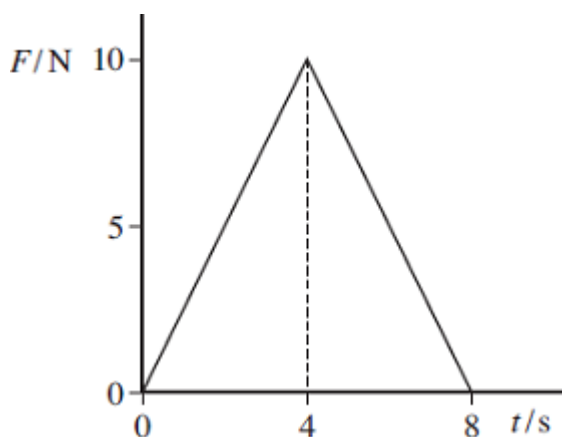
Which one of the following is represented by the area under the graph?

- A distance travelled
- B gain in kinetic energy
- C acceleration
- D impulse

(Total 1 mark)

11

A ball of mass 2.0 kg , initially at rest, is acted on by a force F which varies with time t as shown by the graph.



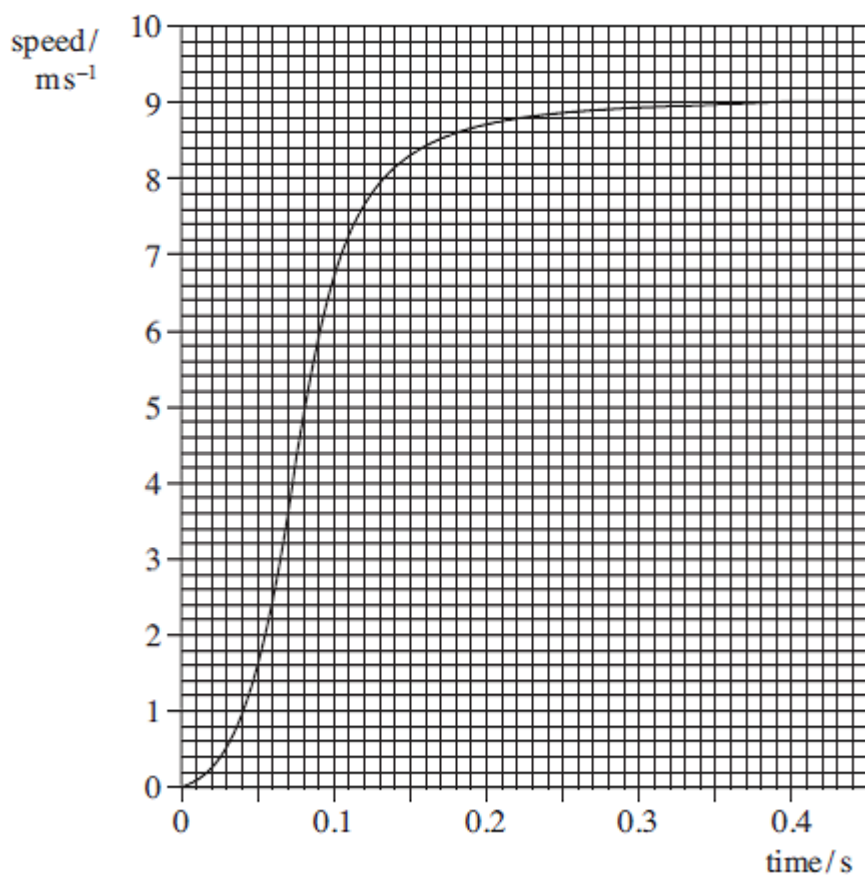
What is the velocity of the ball after 8.0 s ?

- A 20 ms^{-1}
- B 40 ms^{-1}
- C 80 ms^{-1}
- D 160 ms^{-1}

(Total 1 mark)

12

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



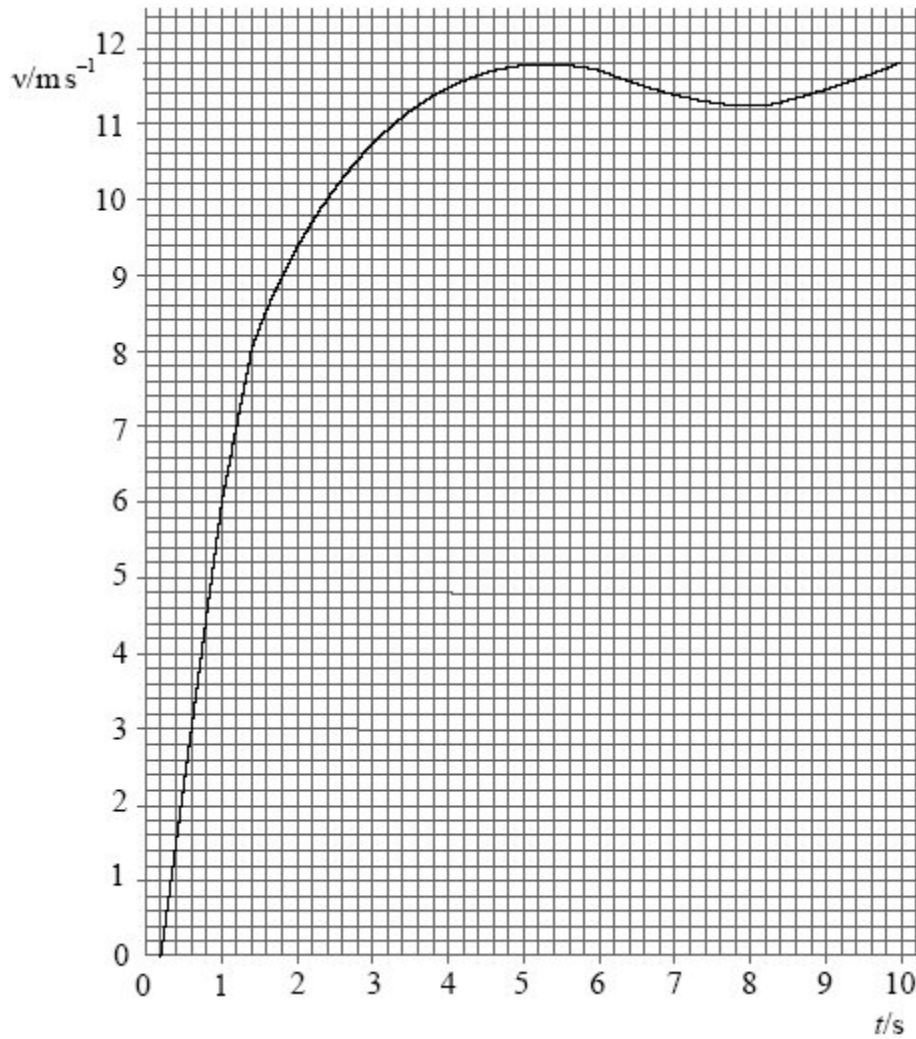
Determine the distance covered by the sprinter in the first 0.3 s of the race.

distance _____ m

(Total 3 marks)

13

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.

(2)

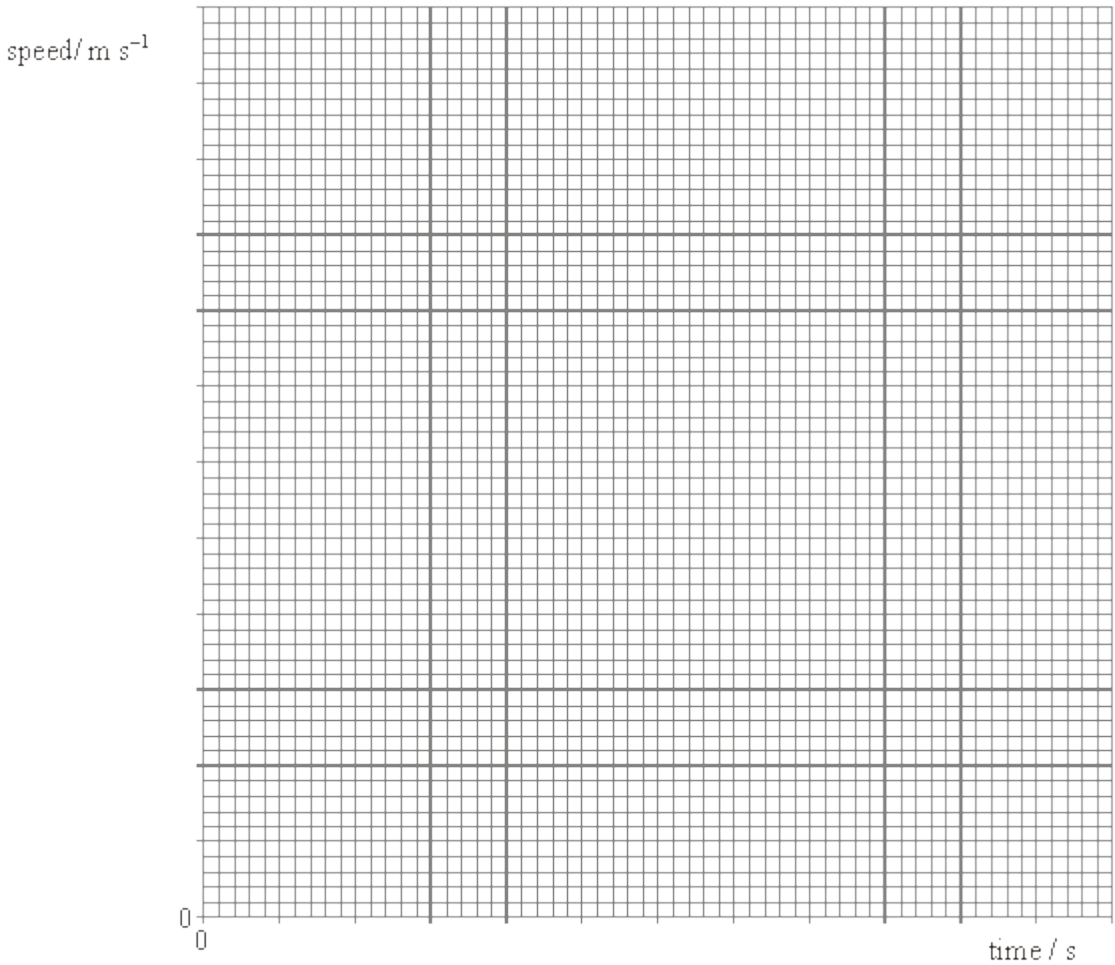
(Total 10 marks)

14

A car accelerates from rest to a speed of 26 m s^{-1} . The table shows how the speed of the car varies over the first 30 seconds of motion.

time/ s	0	5.0	10.0	15.0	20.0	25.0	30.0
speed/ m s ⁻¹	0	16.5	22.5	24.5	25.5	26.0	26.0

(a) Draw a graph of speed against time on the grid provided.



(3)

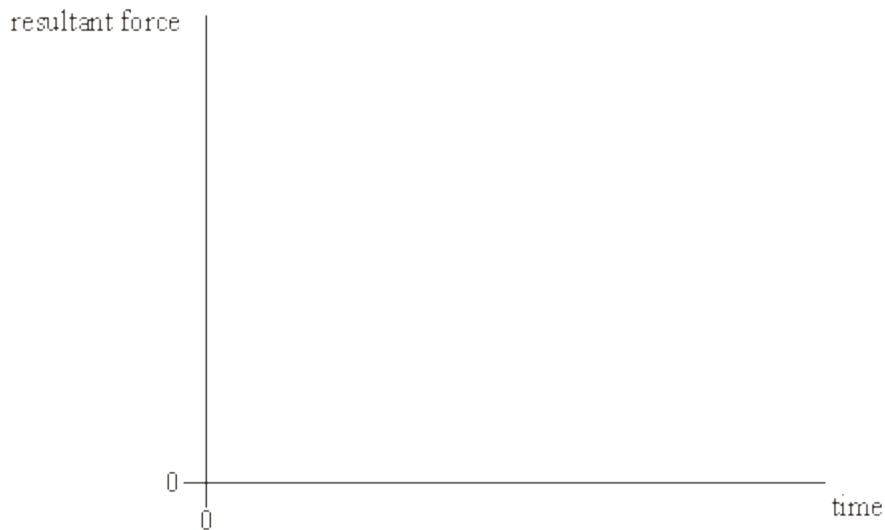
(b) Calculate the average acceleration of the car over the first 25 s.

(2)

- (c) Use your graph to estimate the distance travelled by the car in the first 25 s.

(2)

- (d) Using the axes below, sketch a graph to show how the resultant force acting on the car varies over the first 30 s of motion.



(2)

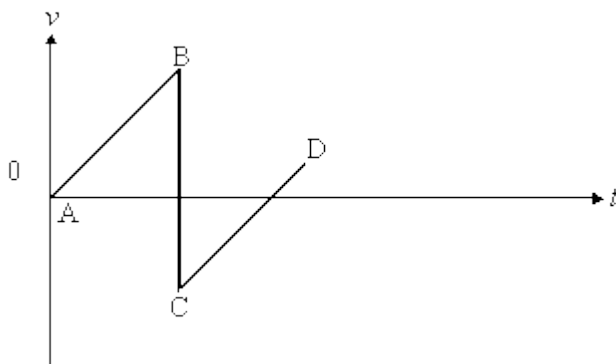
- (e) Explain the shape of the graph you have sketched in part (d), with reference to the graph you plotted in part (a).

(2)

(Total 11 marks)

15

The diagram shows the velocity-time graph for a vertically bouncing ball, which is released above the ground at A and strikes the floor at B. The effects of air resistance have been neglected.



- (a) (i) What does the gradient of a velocity-time graph represent?

- (ii) Explain why the gradient of the line CD is the same as line AB.

- (iii) What does the area between the line AB and the time axis represent?

- (iv) State why the velocity at C is negative.

- (v) State why the speed at C is less than the speed at B.

(5)

- (b) The ball has a mass of 0.15 kg and is dropped from an initial height of 1.2 m. After impact the ball rebounds to a height of 0.75 m.

Calculate

- (i) the speed of the ball immediately before impact,

(ii) the speed of the ball immediately after impact,

(iii) the change in momentum of the ball as a result of the impact,

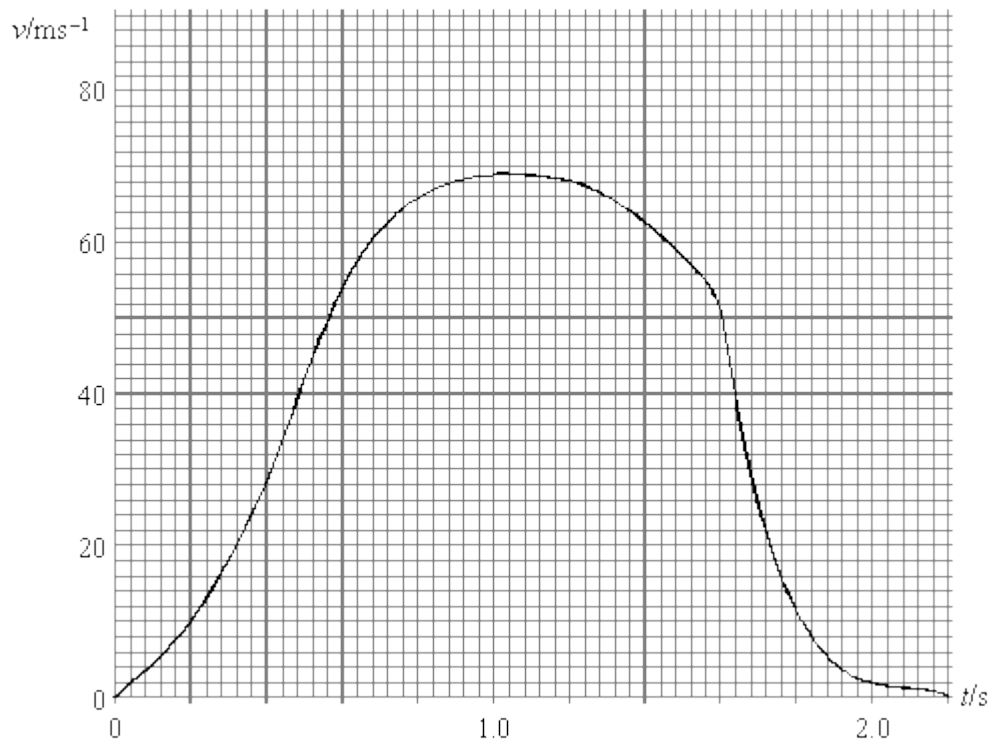
(iv) the magnitude of the resultant average force acting on the ball during impact if it is in contact with the floor for 0.10 s.

(8)

(Total 13 marks)

16

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 $g = 9.8 \text{ m s}^{-2}$

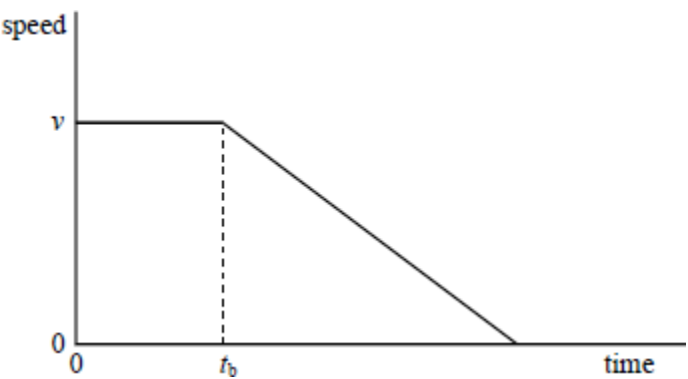
Time to fall to the ground _____

(2)

(Total 8 marks)

17

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

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

where a 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 $v/\text{km h}^{-1}$	speed $v/\text{m s}^{-1}$	stopping distance s/m	$\frac{s}{v}/\text{sec}$
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 _____

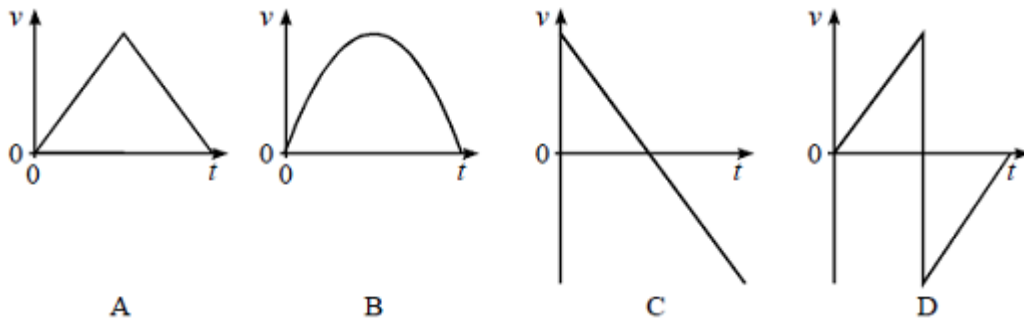
(ii) the magnitude of the deceleration, a .

(4)

(Total 13 marks)

18

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)

19

A horizontal force of 1.5 kN acts on a motor car of mass 850 kg that is initially at rest.

(a) Calculate:

(i) the acceleration of the motor car;

(1)

(ii) the speed of the motor car after 15 s;

(2)

(iii) the distance travelled by the motor car in the first 7.5 s of the motion;

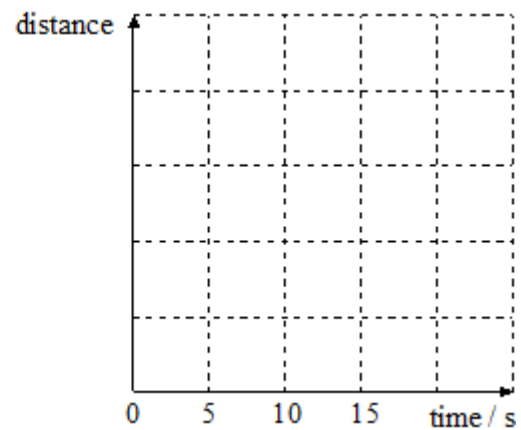
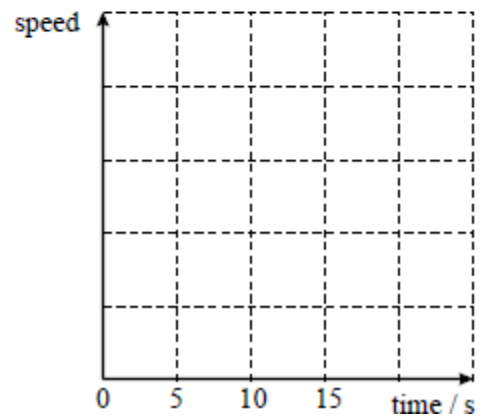
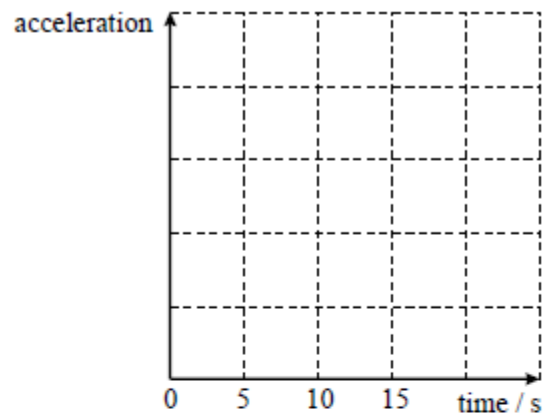
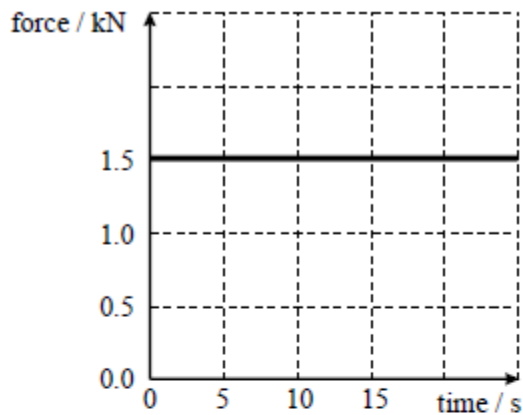
(2)

(iv) the distance travelled by the motor car in the first 15 s of the motion.

(1)

- (b) The diagrams below show the graph of force against time together with three incomplete sets of axes. Sketch on these axes the corresponding graphs for acceleration, speed and distance travelled for the first 15 seconds of the car's motion.

You should include labels for the axes and any known numerical values.



(4)

- (c) In practice the resultant force exerted on the motor car will not be constant with time as suggested by the force-time graph. Air resistance is one factor that affects the resultant force acting on the vehicle.

- (i) Suggest how the force-time graph will change when air resistance is taken into account. Explain your answer. You may wish to sketch a graph to illustrate your answer.

(3)

- (ii) Explain why the vehicle will eventually reach a maximum speed even though the motorist keeps the accelerator pedal fully depressed.

(2)

(Total 15 marks)

Mark schemes

1	B			[1]
2	B			[1]
3	A			[1]
4	B		[1]	
5	C		[1]	
6	B		[1]	
7	D			[1]
8	C			[1]
9	C			[1]
10	D			[1]
11	A			[1]
12	clear attempt to use area under graph/statement that distance is equivalent to area under graph			
		C1		
	38 to 40 squares/1 square is equivalent to 0.05 m			
		C1		
	1.9 to 2.0 m			
		A1		
				[3]
13	(a) the sprinter takes time to react to the starting pistol (1)			
		B1		

(b) attempt using tangent **(1)**

C1

acceleration about 0.74 (0.68 – 0.80) **(1)**

A1

m s⁻² **(1)**

B1

3

(c) appreciation that area under the graph **(1)**

C1

distance per square = 1m **(1)** or clear use of scale in correct approach

C1

total squares = 10 – 10.8 **(1)**

C1

distance correct 10.1 – 10.6m **(1)** (unit essential)

A1

4

or alternative method using triangle and trapezium

(d) use a velocity sensor **or** record time to reach set distances **(1)**

M1

detail about frequency at which data is collected **(1)**

sensor placed so that athlete runs toward it

plot distance time graph and measure gradient at different times

A1

2

[10]

14

(a) scales **(1)**

six points correctly plotted **(1)**

trendline **(1)**

3

(b) average acceleration = $\frac{26}{25}$ **(1)**

= 1.0(4) ms⁻² (1)

(allow C.E. for incorrect values used in acceleration calculation)

2

(c) area under graph **(1)**

= 510 ± 30 m **(1)**

2

(d) (graph to show force starting from y-axis)

decreasing (not a straight line) **(1)**

to zero (at end of graph) **(1)**

2

(e) (since) gradient of a velocity-time graph gives acceleration **(1)**

first graph shows acceleration is decreasing **(1)**

2

[11]

15

(a) (i) acceleration **(1)**

(ii) both represent acceleration of free fall
[or same acceleration] **(1)**

(iii) height/distance ball is dropped from above the ground
[or displacement] **(1)**

(iv) moving in the opposite direction **(1)**

(v) kinetic energy is lost in the collision
[or inelastic collision] **(1)**

5

(b) (i) $v^2 = 2 \times 9.81 \times 1.2$ **(1)**
 $v = 4.9 \text{ m s}^{-1}$ **(1)** (4.85 m s⁻¹)

(ii) $u^2 = 2 \times 9.81 \times 0.75$ **(1)**
 $u = 3.8 \text{ m s}^{-1}$ **(1)** (3.84 m s⁻¹)

(iii) change in momentum = $0.15 \times 3.84 - 0.15 \times 4.85$ **(1)**
 $= -1.3 \text{ kg m s}^{-1}$ **(1)** (1.25 kg m s⁻¹)

(allow C.E. from (b) (i) and (b)(ii))

(iv) $F = \frac{1.3}{0.10}$ **(1)**
 $= 13 \text{ N}$ **(1)**

(allow C.E. from (b)(iii))

16

- (b) clear attempt to estimate area under the curve

A1

allow ecf for height

2

[8]

17

- (ii) column D: 1.3(5) 1.72 2.02 2.39 2.73 3.08
(all values correct to 2 or 3 sig figs ± 0.1) **(1)**

2

- (c) graph of $\frac{s}{v}$ against v [or v against $\frac{s}{v}$] **(1)**

axes labelled correctly **(1)** (column D vs column B or A)

appropriate scales **(1)**

at least four points plotted correctly to 1 square **(1)**

acceptable straight line **(1)**

[note: if chosen graph gives a curve (e.g. s against v) then candidate can only score 2nd, 3rd and 4th marks]

5

- (d) (i) (intercept) $t_b = 0.66 \text{ s}$ **(1)** (values in range 0.6 to 0.7 accepted)

- (ii) gradient = (any triangle e.g. $(3 - 1) / (30 - 4.5)) = 7.8 \times 10^{-2} \text{ (s}^2\text{m}^{-1})$ **(1)**
[other answers, if consistent with graph, acceptable]

gradient = $(1 / 2a)$ **(1)**

gives $a = 6.4 \text{ m s}^{-2}$ **(1)** (values in range 6.1 to 6.7 accepted)
(allow C.E. for value of gradient)

[if column D vs column A used, gradient = 0.022

use of conversion factor gives gradient = $0.078 \text{ (s}^2\text{m}^{-1})$]

[if graph of v against $\frac{s}{v}$, gradient = 12.8 m s^{-2}

= $2a$ for first two marks]

4

[13]

18

D

[1]

19

- (a) (i) (acceleration = F / m) 1.76 m s^{-2}

B1

(1)

- (ii) $(v = u + at) = 0 + 1.76 \times 15$

C1

= 26.4 m s^{-1}

allow e.c.f. from (i)

A1

(2)

- (iii) $(s = ut + 0.5 at^2) = 0.5 \times 1.76 \times 7.5^2$

C1

= 49.5 m

allow e.c.f. from (i)

A1

(2)

(iv) t doubles so s quadruples = $4 \times 49.5 \sim 200$ m
[or equivalent]

B1

(1)

(b) acceleration graph correct: same shape as $F-t$;
1.8 (1.76) identifiable on axis

B1

speed graph correct: straight line through origin to
identifiable 26 m s^{-1}
at 15 s

B1

distance graph correct: shape parabolic; both calculated points
identifiably marked

B1

all axes labelled with unit

B1

(4)

(c) (i) total force decreases as time increases [or appropriate graph]

B1

(because) speed increase leads to drag force increase

B1

total thrust is sum of engine force – drag (frictional force)

B1

(3)

(ii) forward thrust = friction force

B1

so (total thrust = 0) and acceleration = 0

B1

(2)

[15]