Motion AS Revision Pack

Name:

Class:

Date:

Time: **338 minutes**

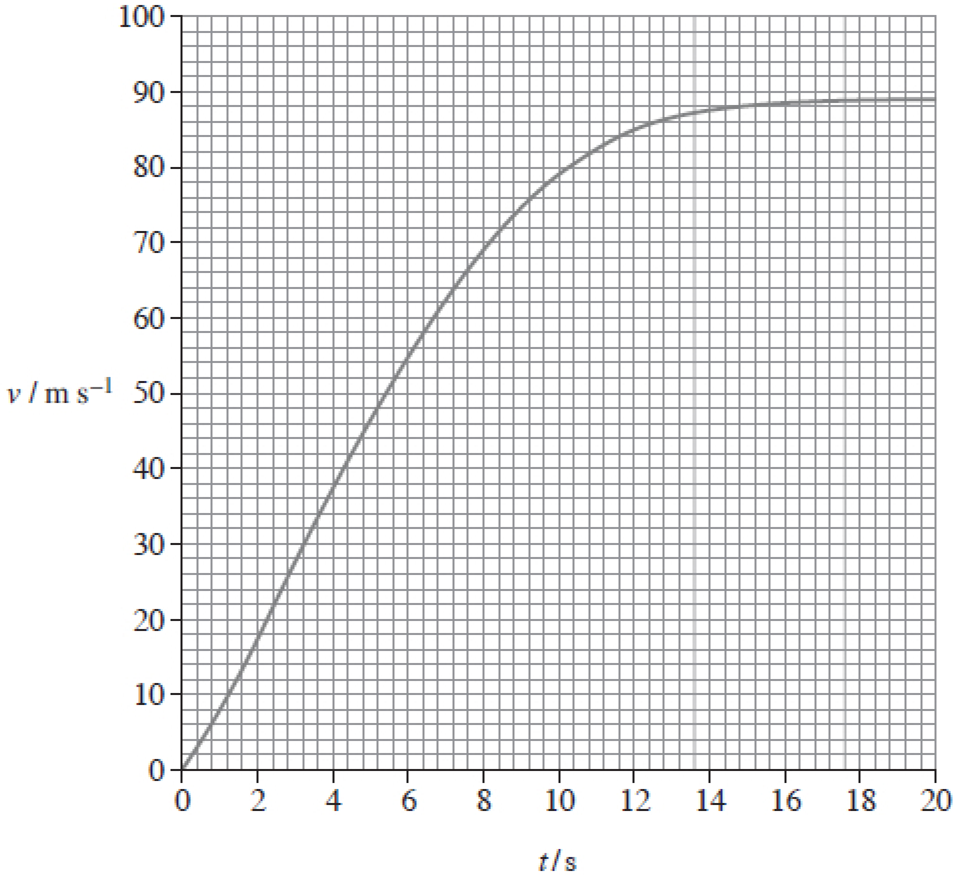
Marks: **295 marks**

Comments:

1 **Figure 1** shows the variation of velocity v with time t for a Formula 1 car during a test drive along a straight, horizontal track.

The total mass of the car and driver is 640 kg. The car engine provides a constant driving force of 5800 N.

Figure 1



(a) (i) Determine the distance travelled by the car during the first 10 s.

distance ____________________ m

(3)

(ii) Show that the instantaneous acceleration is about 4 m s^{-2} when t is 10 s.

(2)

(iii) Calculate the magnitude of the resistive forces on the car when t is 10 s.

resistive forces ____________________ N

(3)

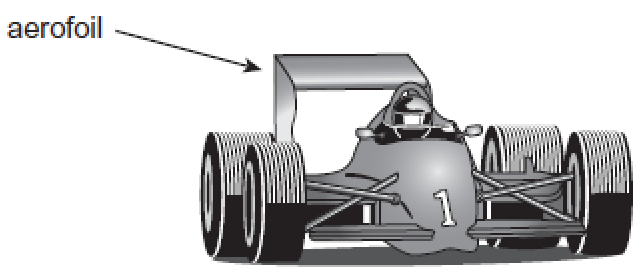
(iv) Calculate the power, in kW, of the car at the maximum speed during the test drive.

power ____________________ kW

(2)

(b) **Figure 2** shows the aerofoil that is fitted to a Formula 1 car to increase its speed around corners.

Figure 2



However, the aerofoil exerts an unwanted drag force on the car when it is travelling in a straight line so a Drag Reduction System (DRS) is fitted. This system enables the driver to change the angle of the aerofoil to reduce the drag.

The graph in **Figure 1** is for a test drive along a straight, horizontal track. Under the conditions for this test drive, the DRS was not in use and the engine produced a constant driving force.

Explain why the velocity varies in the way shown in the graph.

Go on to explain how the graph will be different when the DRS is in use and the driving force is the same.

The quality of written communication will be assessed in your answer.

(6)

(Total 16 marks)

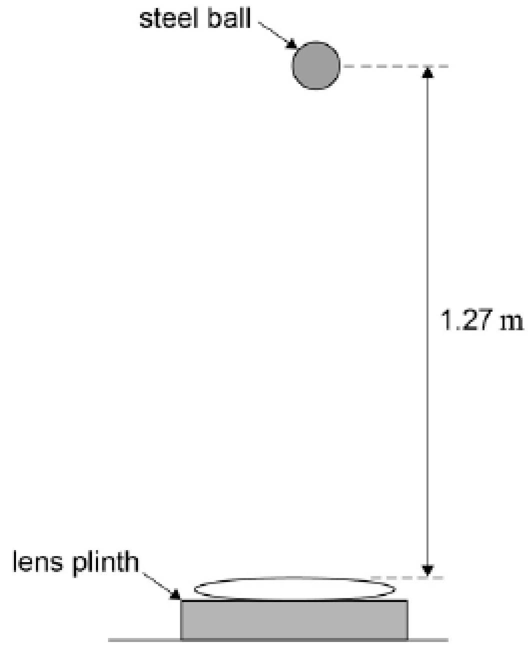
2 Spectacle lenses can be tested by dropping a small steel ball onto the lens, as shown in the figure below, and then checking the lens for damage.

A test requires the following specifications:

diameter of ball = 16 mm

mass of ball = 16 g

height of drop = 1.27 m



(a) Calculate the density of the steel used for the ball.

density = ____________________ kg m^{-3}

(3)

(b) In a test the ball bounced back to a height of 0.85 m.

Calculate the speed of the ball just before impact.

speed = ____________________ m s^{-1}

(2)

(c) Calculate the speed of the ball just after impact.

speed = m ____________________ m s^{-1}

(2)

(d) Calculate the change in momentum of the ball due to the impact.

momentum = m ____________________ kg m s^{-1}

(2)

(e) The time of contact was 40 ms. Calculate the average force of the ball on the lens during the impact.

average force = ____________________ N

(2)

(f) Explain, with reference to momentum, why the test should also specify the material of the plinth the lens sits on.

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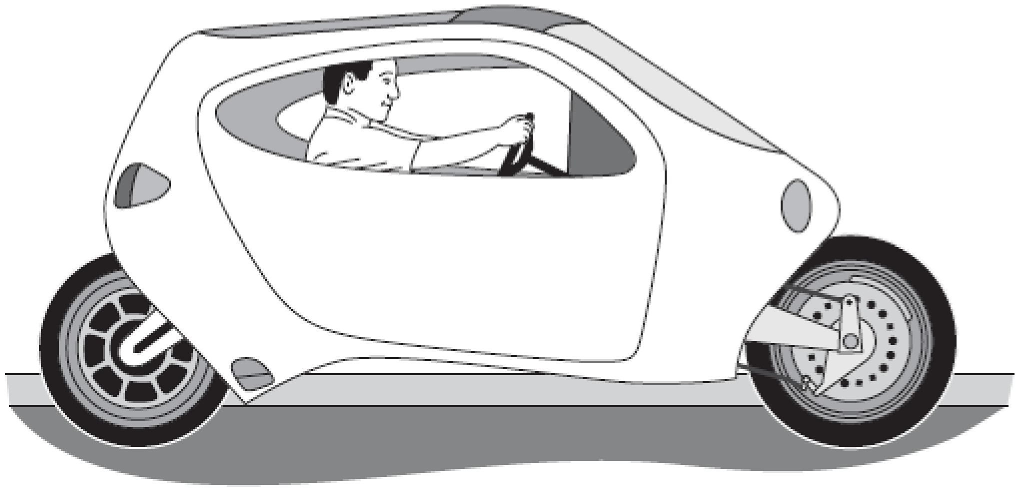
(2)

(Total 13 marks)

3 The diagram below shows an electric two-wheeled vehicle and driver.



(a) The vehicle accelerates horizontally from rest to 27.8 m s^{-1} in a time of 4.6 s. The mass of the vehicle is 360 kg and the rider has a mass of 82 kg.

(i) Calculate the average acceleration during the 4.6 s time interval.
Give your answer to an appropriate number of significant figures.

acceleration = ____________________ m s^{-2}

(2)

(ii) Calculate the average horizontal resultant force on the vehicle while it is accelerating.

resultant force = ____________________ N

(2)

(b) State and explain how the horizontal forward force on the vehicle has to change for **constant** acceleration to be maintained from 0 to 27.8 m s^{-1}.

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(3)

(c) The electric motors drive both wheels of the vehicle.

Add labelled force arrows to the diagram to show the horizontal forces acting on the vehicle when it is moving at a constant speed.

(2)

(d) The vehicle now accelerates to a constant speed of 55 m s^{-1}. The useful power output of the motors is 22 kW at this speed.

Calculate the horizontal resistive force acting on the vehicle.

horizontal resistive force = ____________________ N

(2)

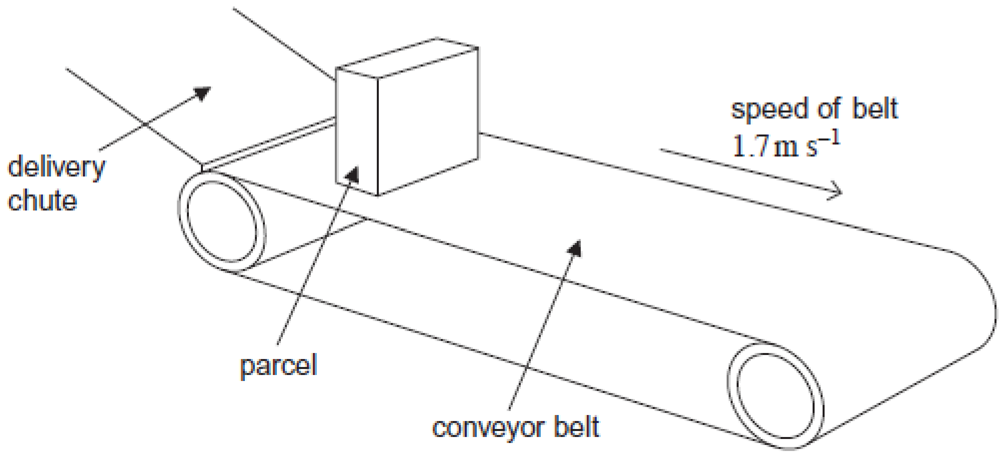
(Total 11 marks)

4 (a) A parcel of mass 15 kg drops from a delivery chute onto a conveyor belt as shown in **Figure 1**.

The belt is moving at a steady speed of 1.7 m s^{-1}.

The parcel lands on the moving belt with negligible speed and initially starts to slip. It takes 0.82 s for the parcel to gain enough speed to stop slipping and move at the same speed as the conveyor belt.

Figure 1



(i) Calculate the change in kinetic energy of the parcel during the first 0.82 s.

change in kinetic energy ____________________ J

(2)

(ii) The average horizontal force acting on the parcel during the first 0.82 s is 31 N.

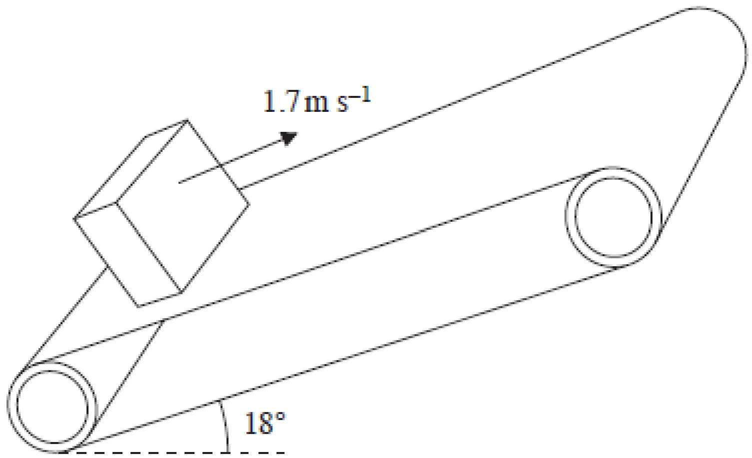
Calculate the horizontal distance between the parcel and the end of the delivery chute 0.82 s after the parcel lands on the conveyor belt. Assume that the parcel does not reach the end of the conveyor belt.

horizontal distance ____________________ m

(2)

(b) At a later stage the parcel is being raised by another conveyor belt as shown in **Figure 2**.

Figure 2



This conveyor belt is angled at 18° to the horizontal and the parcel moves at a steady speed of 1.7 m s^{-1} without slipping.

Calculate the rate at which work is done on the parcel.

rate at which work is done ____________________ W

(3)

(Total 7 marks)

5 The world record for a high dive into deep water is 54 m.

(a) Calculate the loss in gravitational potential energy (gpe) of a diver of mass 65 kg falling through 54 m.

loss in gpe = ____________________ J

(2)

(b) Calculate the vertical velocity of the diver the instant before he enters the water. Ignore the effects of air resistance.

velocity = ____________________ ms^{-1}

(2)

(c) Calculate the time taken for the diver to fall 54 m. Ignore the effects of air resistance.

time = ____________________ s

(2)

(d) Explain, with reference to energy, why the velocity of the diver is independent of his mass if air resistance is insignificant.

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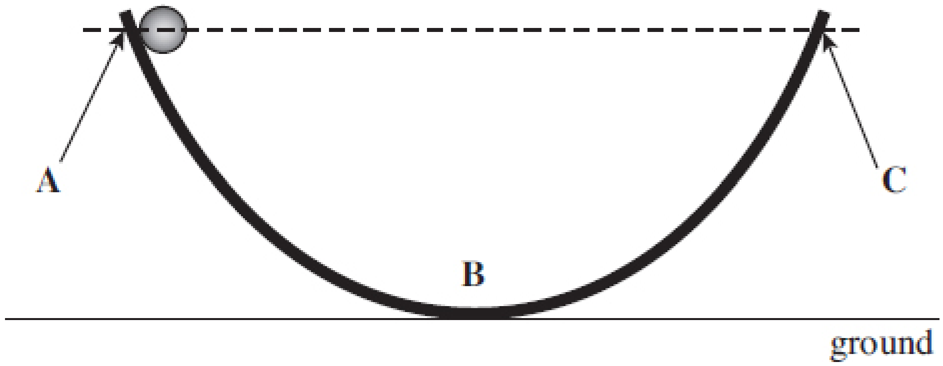
(3)

(Total 9 marks)

6 In the 17th century, when thinking about forces, Galileo imagined a ball moving in the absence of air resistance on a frictionless track as shown in **Figure 1**.

Figure 1



(a) Galileo thought that, under these circumstances, the ball would reach position **C** if released from rest at position **A**. Position **C** is the same height above the ground as **A**.

Using ideas about energy, explain why Galileo was correct.

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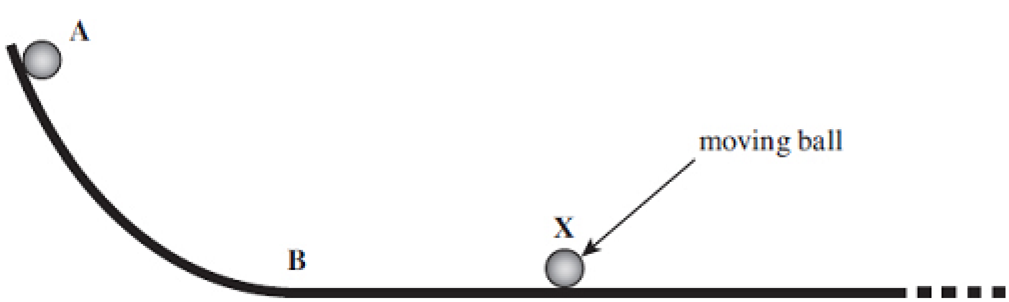
(3)

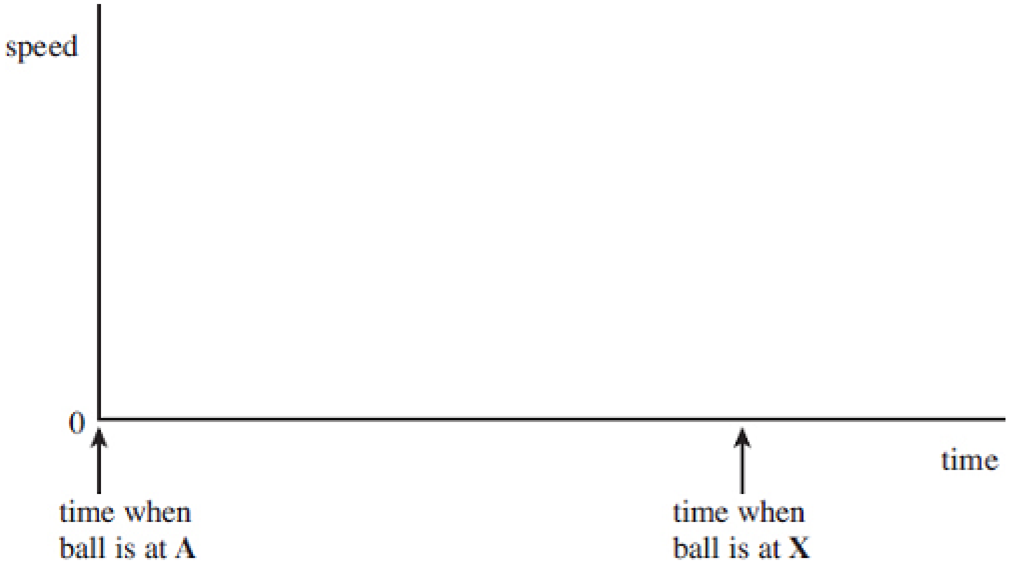
(b) Galileo then imagined that the track was changed, as shown in **Figure 2**.

Figure 2



The slope beyond **B** was now horizontal.

On the axes below, sketch a speed – time graph for the ball from its release at **A** until it reaches the position **X** shown in **Figure 2**. Indicate on your graph the time when the ball is at **B**.



(3)

(c) Newton later published his three laws of motion.

Explain how Newton's first law of motion is illustrated by the motion of the ball between **B** and **X**.

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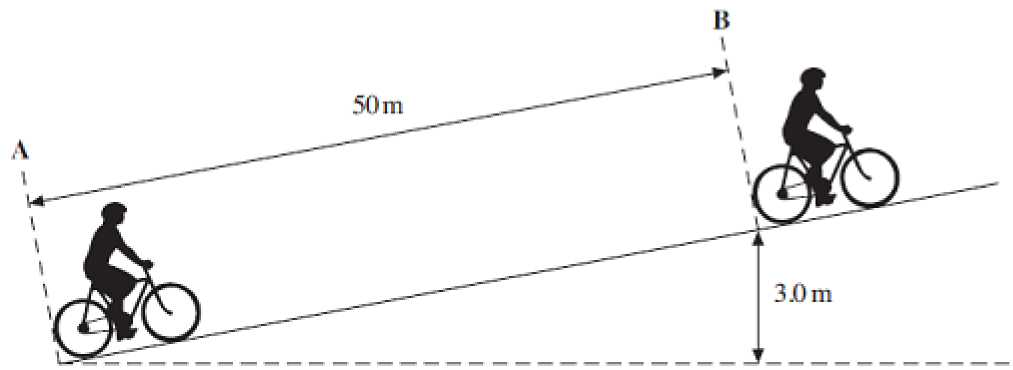
(2)
(Total 8 marks)

7 An 'E-bike' is a bicycle that is assisted by an electric motor. The figure below shows an E-bike and rider with a total mass of 83 kg moving up an incline.



(a) (i) The cyclist begins at rest at **A** and accelerates uniformly to a speed of 6.7 m s^{-1} at **B**. The distance between **A** and **B** is 50 m.
Calculate the time taken for the cyclist to travel this distance.

______________________ s

(2)

(ii) Calculate the kinetic energy of the E-bike and rider when at **B**. Give your answer to an appropriate number of significant figures.

______________________ J

(2)

(iii) Calculate the gravitational potential energy gained by the E-bike and rider between **A** and **B**.

______________________ J

(2)

(b) Between **A** and **B**, the work done by the electric motor is 3700 J, and the work done by the cyclist pedalling is 5300 J.

(i) Calculate the wasted energy as the cyclist travels from **A** to **B**.

_______________________ J

(2)

(ii) State **two** causes of this wasted energy.

Cause 1 ____

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Cause 2 ____

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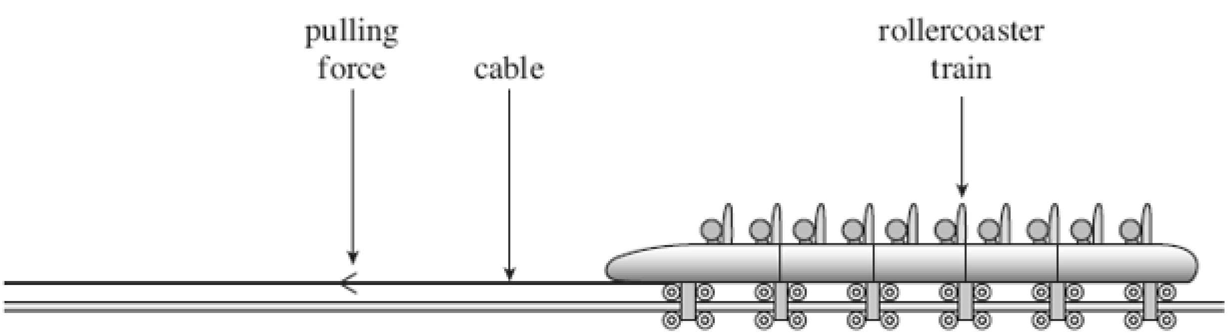
(2)

(Total 10 marks)

8 The figure below shows a rollercoaster train that is being accelerated when it is pulled horizontally by a cable.



(a) The train accelerates from rest to a speed of $58 ms^{-1}$ in 3.5 s. The mass of the fully loaded train is 5800 kg.

(i) Calculate the average acceleration of the train.

answer = _______________________ ms^{-2}

(2)

(ii) Calculate the average tension in the cable as the train is accelerated, stating an appropriate unit.

answer = ______________________

(3)

(iii) Calculate the distance the train moves while accelerating from rest to $58 ms^{-1}$.

answer = ______________________ m

(2)

(iv) The efficiency of the rollercoaster acceleration system is 20%.
Calculate the average power input to this system during the acceleration.

answer = ______________________ W

(3)

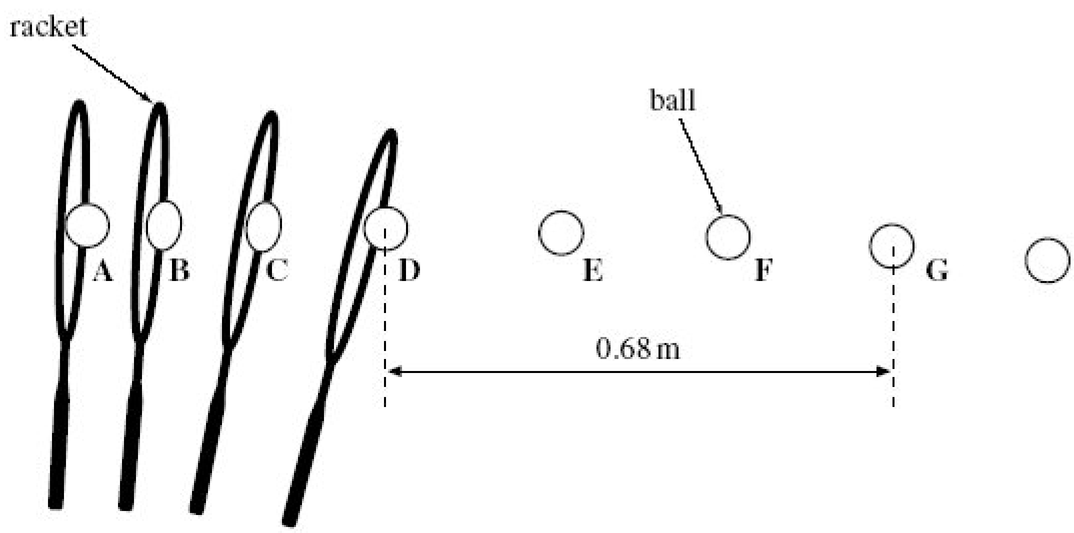
(b) After reaching its top speed the driving force is removed and the rollercoaster train begins to ascend a steep track. By considering energy transfers, calculate the height that the train would reach if there were no energy losses due to friction.

answer = ______________________ m

(3)

(Total 13 marks)

9 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.

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(2)

(Total 11 marks)

10 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.

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(2)

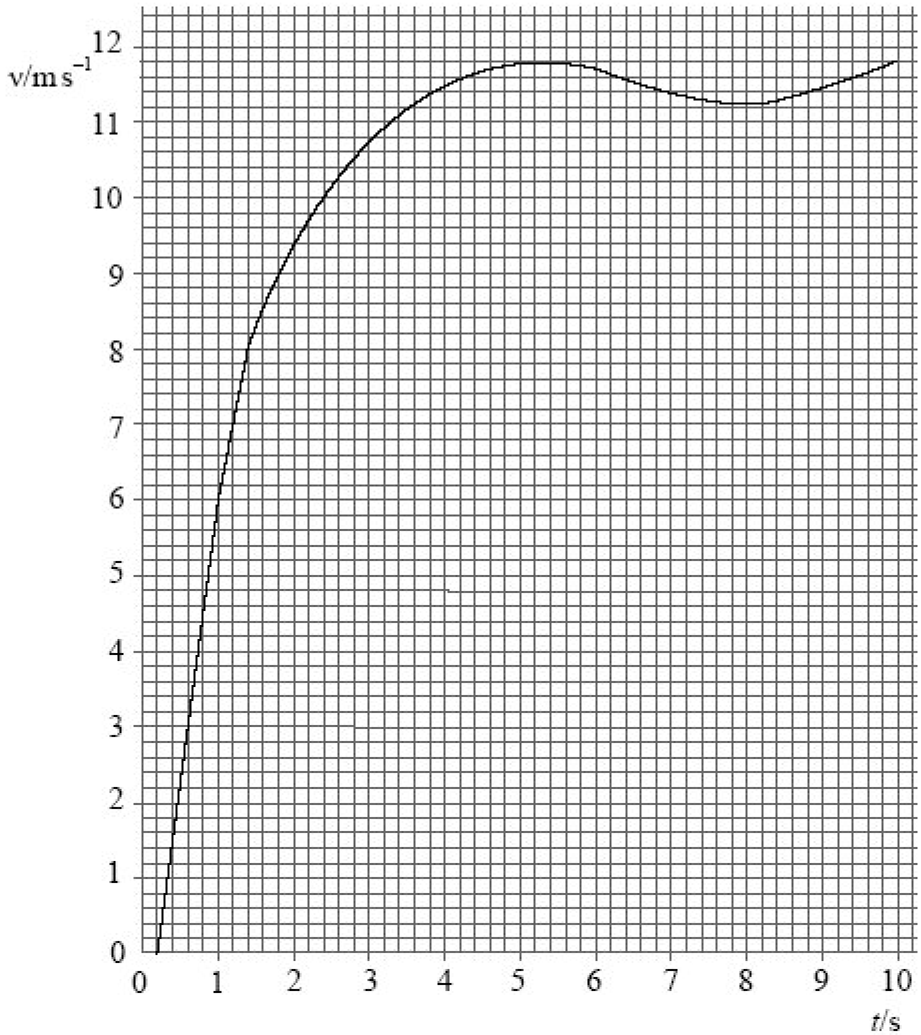
(ii) Use your graph to calculate the distance the car travelled after the lights turned red to when it stopped.

Answer ____________________ m

(4)

(Total 11 marks)

11 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.

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(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)

12 A supertanker of mass 4.0×10^8 kg, cruising at an initial speed of 4.5 m s^{-1}, takes one hour to come to rest.

(a) Assuming that the force slowing the tanker down is constant, calculate

(i) the deceleration of the tanker,

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(ii) the distance travelled by the tanker while slowing to a stop.

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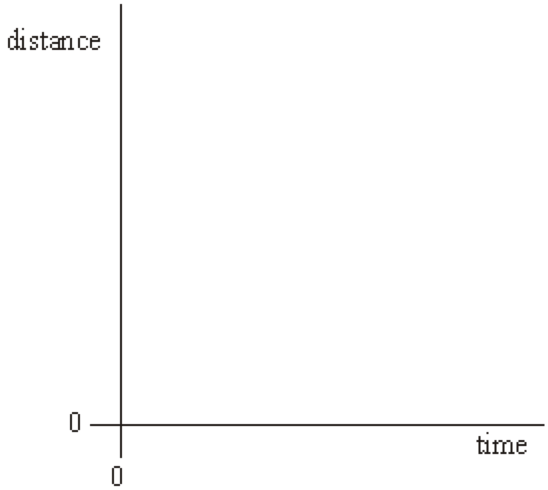
(4)

(b) Sketch, using the axes below, a distance-time graph representing the motion of the tanker until it stops.



(2)

(c) Explain the shape of the graph you have sketched in part (b).

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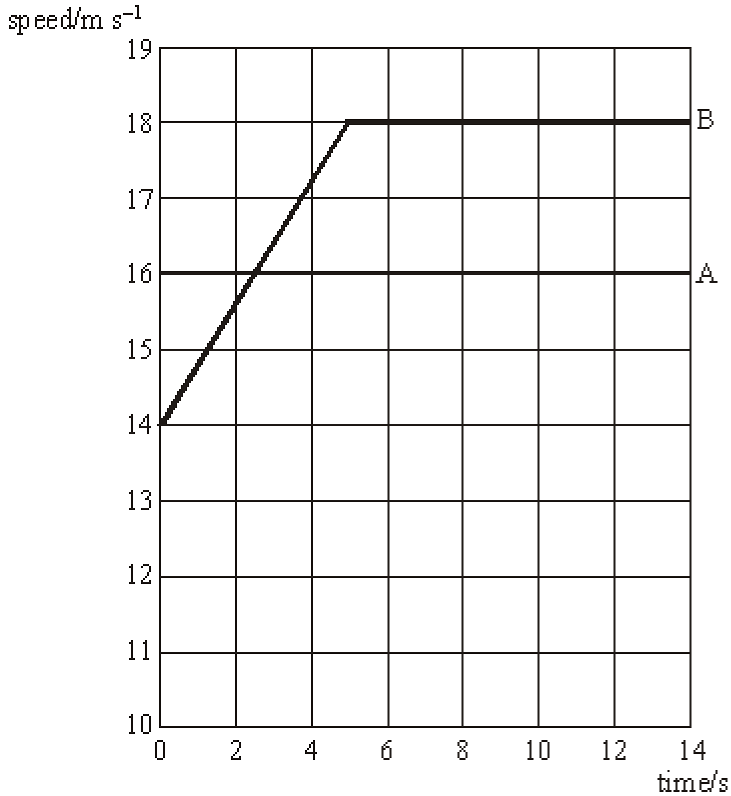
(2)
(Total 8 marks)

13 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: ______________________________

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(ii) car B: ______________________________

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(3)

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

(i) car A: ______________________________

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(ii) car B: ______________________________

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(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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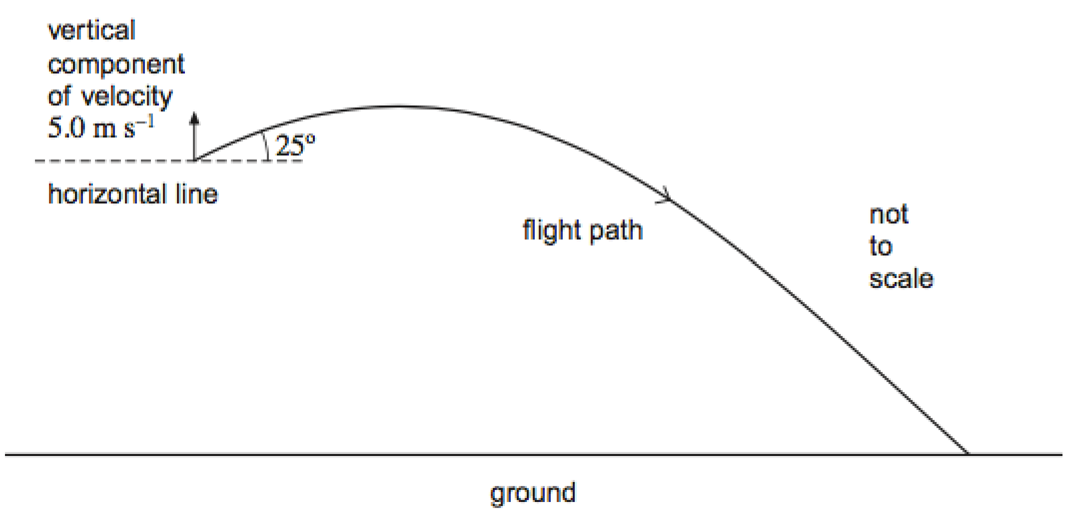
(3)

(Total 10 marks)

14 A projectile is launched some distance above the ground at an angle of 25° above the horizontal with a vertical component of velocity of 5.0 m s^{-1}. **Figure 1** shows the flight path of the projectile. The flight takes 1.3 s.

Ignore the effects of air resistance throughout this question.

Figure 1



(a) (i) Show that the initial speed of the projectile is about 12 m s^{-1}.

(2)

(ii) Calculate the horizontal component of velocity as the projectile hits the ground.

horizontal component of velocity = ____________________ m s^{-1}

(2)

(b) (i) Calculate the maximum height above the starting point reached by the projectile. Give your answer to an appropriate number of significant figures.

maximum height reached = ____________________ m

(2)

(ii) Calculate the total horizontal distance travelled by the projectile from its starting point.

horizontal distance = ____________________ m

(1)

(c) (i) Mark with an **A** on the flight path in **Figure 1** the position where the speed of the projectile is greatest.

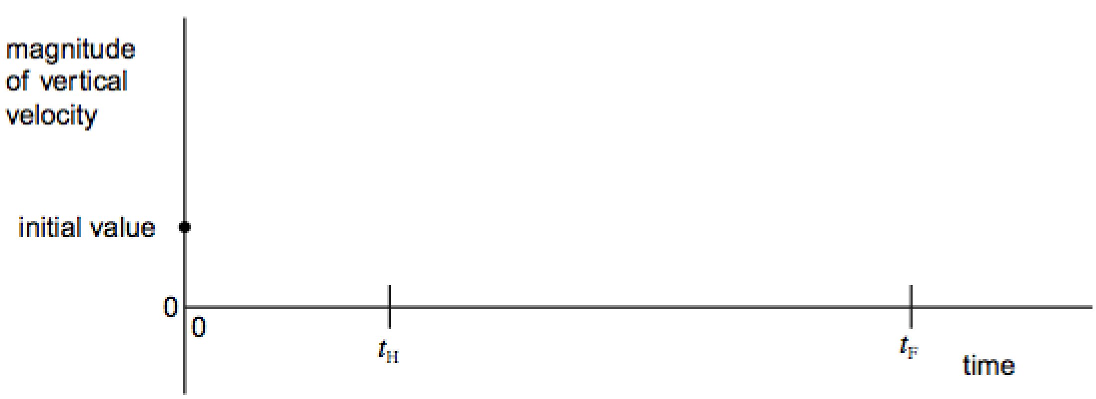
(1)

(ii) Mark with a **B** on the flight path in **Figure 1** the position where the speed of the projectile is least.

(1)

(iii) The projectile reaches its maximum height at time t_H and finishes its flight at time t_F. Draw on **Figure 2** a graph to show how the **magnitude** of the vertical component of velocity of the projectile varies with time. Numerical values are **not** required.

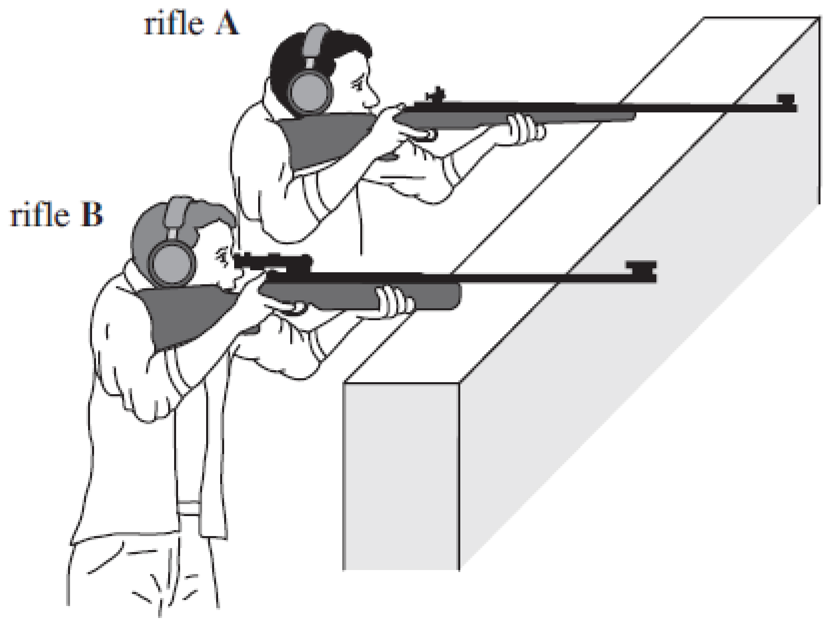
Figure 2



(2)

(Total 11 marks)

15 The diagram below shows two different rifles being fired horizontally from a height of 1.5 m above ground level.
Assume the air resistance experienced by the bullets is negligible.



(a) When rifle **A** is fired, the bullet has a horizontal velocity of 430 m s^{-1} as it leaves the rifle. Assume the ground is level.

(i) Calculate the time that the bullet is in the air before it hits the ground.

time ____________________ s

(2)

(ii) Calculate the horizontal distance travelled by the bullet before it hits the ground.

horizontal distance ____________________ m

(1)

(b) Rifle **B** is fired and the bullet emerges with a smaller horizontal velocity than the bullet from rifle **A**.

Explain why the horizontal distance travelled by bullet **B** will be less than bullet **A**.

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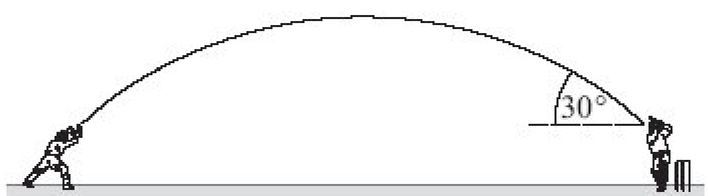
(3)

(Total 6 marks)

16 **Figure 1** shows the flight of a cricket ball hit by a batsman at 30° to the horizontal at a speed of 22 m s^{-1}. The ball reached a fielder without bouncing and was caught at the same height as it was hit. The effect of air resistance on the cricket ball is negligible.

Figure 1



(a) (i) Calculate the vertical speed of the ball at the instant it left the bat.

vertical speed ____________________ m s^{-1}

(1)

(ii) Show that the ball was in the air for about 2.2 s.

(3)

(iii) How far did the ball travel horizontally before it was caught?

distance ____________________ m

(1)

(b) (i) A tennis ball is about the same size as a cricket ball but has a lower mass.
By considering the energy changes that take place, explain why a tennis ball hit at the same speed and angle as the cricket ball would be unlikely to reach the fielder without bouncing.

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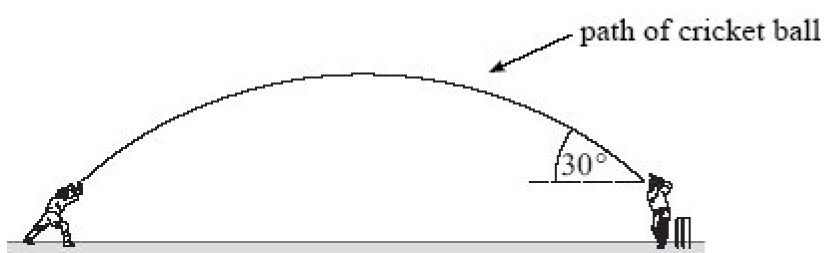
(3)

(ii) Draw on **Figure 2** the path you would expect a tennis ball to follow when hit at the same speed and angle as the cricket ball.

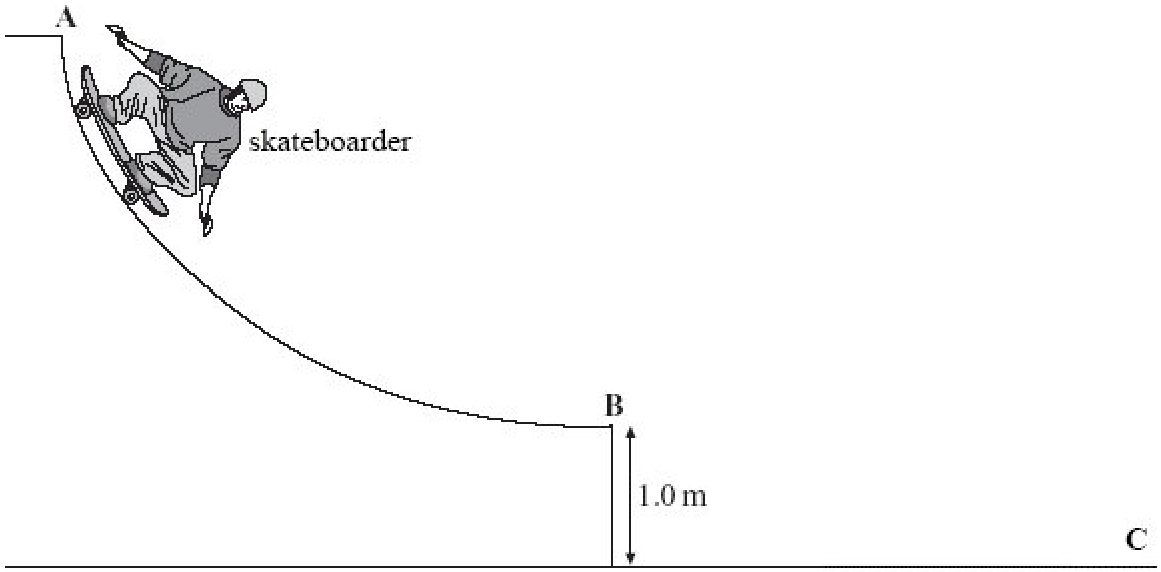
Figure 2



(2)

(Total 10 marks)

17 The figure below shows a skateboarder descending a ramp.



The skateboarder starts from rest at the top of the ramp at **A** and leaves the ramp at **B** horizontally with a velocity *v*.

(a) State the energy changes that take place as the skateboarder moves from **A** to **B**.

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(2)

(b) In going from **A** to **B** the skateboarder's centre of gravity descends a vertical height of 1.5 m. Calculate the horizontal velocity, *v*, stating an assumption that you make.

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(3)

(c) Explain why the acceleration decreases as the skateboarder moves from **A** to **B**.

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(2)

(d) After leaving the ramp at **B** the skateboarder lands on the ground at **C** 0.42 s later.

Calculate for the skateboarder

(i) the horizontal distance travelled between **B** and **C**,

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(ii) the vertical component of the velocity immediately before impact at **C**,

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(iii) the magnitude of the resultant velocity immediately before impact at **C**.

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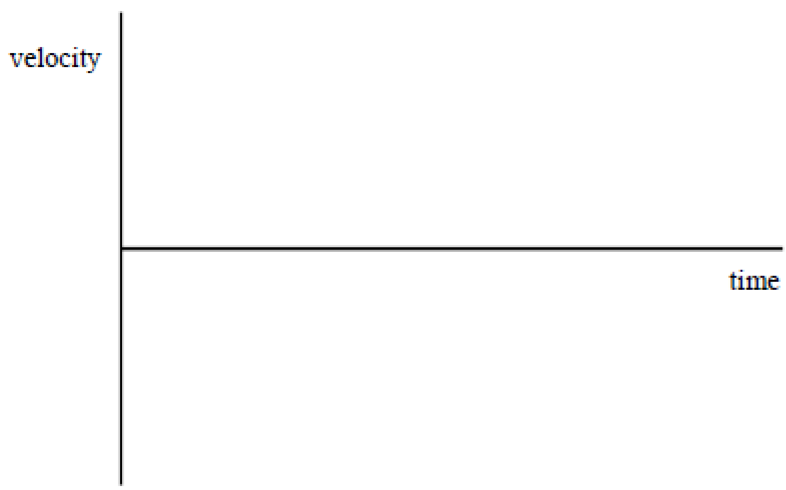
(5)

(Total 12 marks)

18 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,

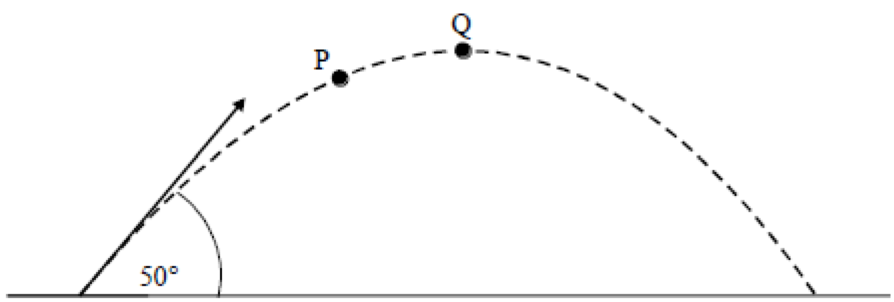


(4)

(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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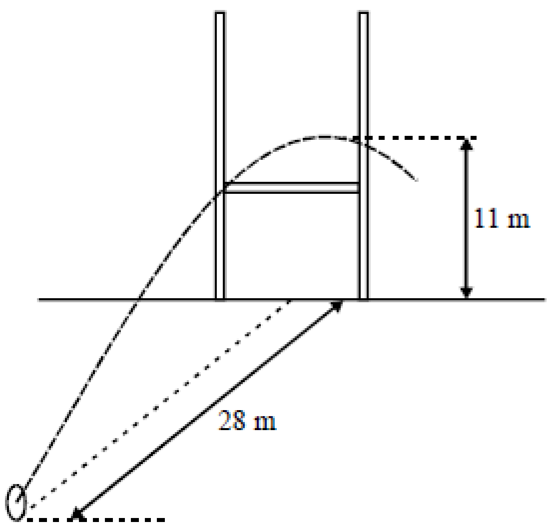
(4)
(Total 13 marks)

19 A rugby ball is kicked towards the goal posts shown in the diagram below from a position directly in front of the posts. The ball passes over the cross-bar and between the posts.



(a) The ball takes 1.5 s to reach a point vertically above the cross-bar of the posts.

(i) Calculate the ball's horizontal component of velocity, v_h. Ignore air resistance.

v_h ______________________

(2)

(ii) The ball reaches its maximum height at the same time as it passes over the crossbar. State the vertical component of velocity when the ball is at its maximum height.

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(1)

(iii) The ball's maximum height is 11 m. Calculate, v_v, the vertical component of velocity of the ball immediately after it has been kicked. Ignore the effects of air resistance.

acceleration due to gravity, g = 9.8 m s^{-2}

v_v ______________________

(3)

(b) (i) Determine the magnitude of the initial velocity, v, of the ball immediately after it is kicked.

v ____________________

(3)

(ii) Determine the angle above the horizontal at which the ball was kicked.

Angle ____________________

(1)

(c) State and explain at what instant the ball will have its maximum kinetic energy.

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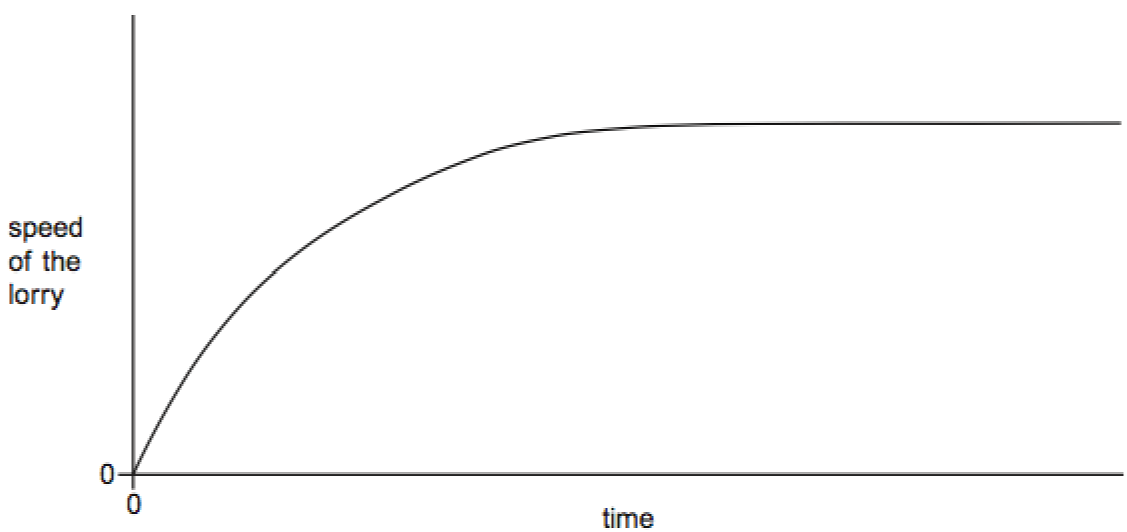
(2)

(Total 12 marks)

20 A fully-loaded lorry transporting water starts from rest and travels along a straight road. The figure is a graph showing how the speed of the lorry varies with time. The driving force on the lorry remains constant.

The total resistive force acting on the lorry increases with both speed and mass of the lorry. A large proportion of the mass of the lorry is due to the water which it is carrying.



A similar lorry, also loaded with water, has the same initial mass. However, at the instant it begins to move, a large leak develops and all the water leaks out during the time covered by the graph.

Discuss how the speed–time graph will be different from that shown in the figure.

Your answer should include an explanation of:

- the shape of the graph in the figure
- the effect of water loss on the initial gradient of the graph
- the effect of water loss on the final speed of the lorry.

You may draw on the figure to help you with your answer.

The quality of your written communication will be assessed in your answer.

(Total 6 marks)

21 The driver of a car travelling with a velocity, *v*, along a level road, applies the brakes. The brakes lock and the car skids to a stop. The skidding distance, *d*, is given by

$$d = kv^{\circ}$$

where *k* is a constant.

(a) For a car travelling at a speed of 30 ms^{-1}, *d* is 45 m. Calculate the value of *d* when the car is travelling at 15 ms^{-1}.

d ____________________ m

(2)

(b) The mass of the car and its passengers is 700 kg. Calculate the average skidding force that would bring the car to a stop from an initial speed of 30 ms^{-1} in a skidding distance of 45 m.

average skidding force ____________________ N

(4)

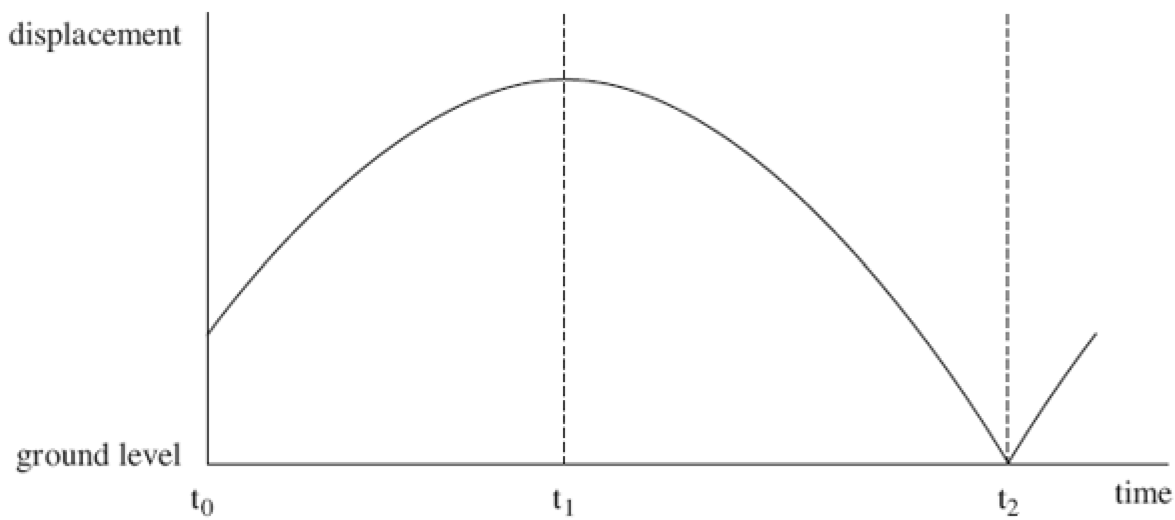
(c) By considering the equations for kinetic energy and the skidding distance, discuss how the heat generated when the car skids is related to *d*.

(3)

(Total 9 marks)

22 A boy throws a ball vertically upwards and lets it fall to the ground. **Figure 1** shows how displacement relative to the ground varies with time for the ball.

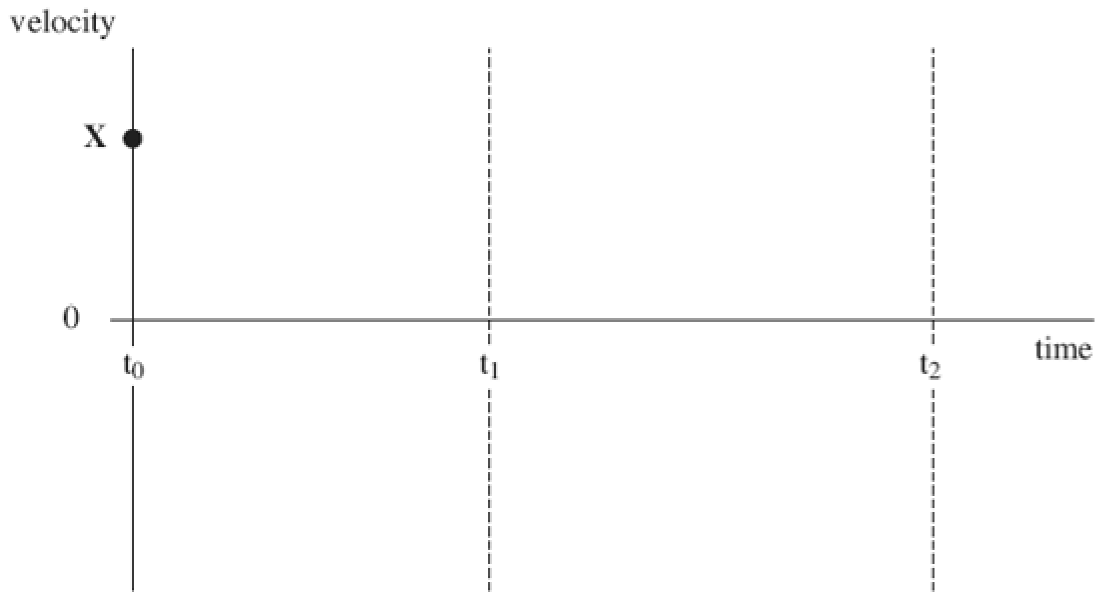
Figure 1



(a) (i) State which feature of a displacement-time graph represents the velocity.

(1)

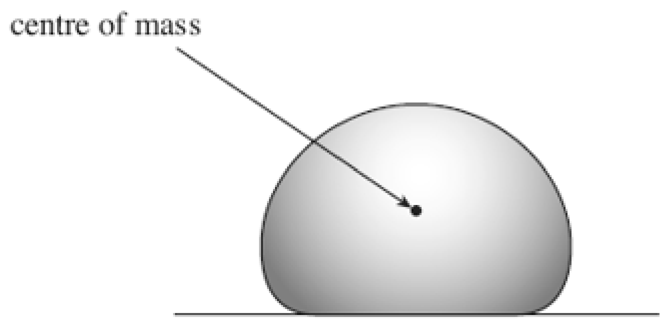
(ii) On the axes below, draw the shape of the velocity-time graph for the ball between t_0 and t_2. The starting point is labelled **X**.



(3)

(b) **Figure 2** shows the ball deforming as it contacts the ground, just at the point where it is stationary for an instant and has reached maximum deformation.

Figure 2



(i) Explain how Newton's third law of motion applies to **Figure 2**.

____

____

____

____

(2)

(ii) Explain why there is a resultant upward force on the ball in **Figure 2**.

(2)

(Total 8 marks)

23 A car of mass 1300 kg is stopped by a constant horizontal braking force of 6.2 kN.

(a) Show that the deceleration of the car is about 5 m s^{-2}.

(3)

(b) The initial speed of the car is 27 m s^{-1}.
Calculate the distance travelled by the car as it decelerates to rest.

distance travelled ____________________ m

(3)

(Total 6 marks)

24 (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)

(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.

(2)

(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.

(2)

(Total 11 marks)

25 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.

____

____

____

____

____

____

(3)

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

____

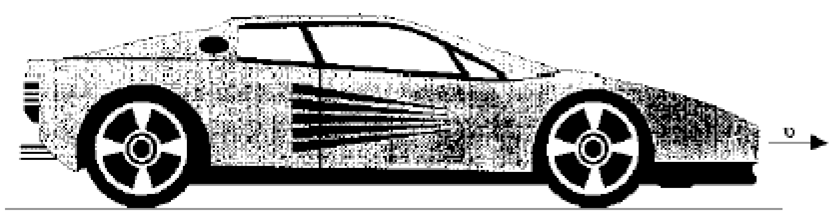
____

____

____

(2)
(Total 5 marks)

26 The diagram shows a car travelling at a constant velocity along a horizontal road.



(a) (i) Draw and label arrows on the diagram representing the forces acting on the car.

(ii) Referring to Newton's Laws of motion, explain why the car is travelling at constant velocity.

____

____

____

____

(5)

(b) The car has an effective power output of 18 kW and is travelling at a constant velocity of 10 m s^{-1}. Show that the total resistive force acting is 1800 N.

____

____

____

(1)

(c) The total resistive force consists of two components. One of these is a constant frictional force of 250 N and the other is the force of air resistance, which is proportional to the square of the car's speed.

Calculate

(i) the force of air resistance when the car is travelling at 10 m s^{-1},

____

____

(ii) the force of air resistance when the car is travelling at 20 m s^{-1},

____

____

(iii) the effective output power of the car required to maintain a constant speed of 20 m s^{-1} in a horizontal road.

____

____

____

(4)

(Total 10 marks)

27 The Thrust SSC car raised the world land speed record in 1997. The mass of the car was 1.0×10^4 kg. A 12 s run by the car may be considered in two stages of constant acceleration. Stage one was from 0 to 4.0 s and stage two 4.0 s to 12 s.

(a) In stage one the car accelerates from rest to 44 m s^{-1} in 4.0 s. Calculate the acceleration produced and the force required to accelerate the car.

____

____

____

____

(b) In stage two the car continued to accelerate so that it reached 280 m s^{-1} in a further 8.0 s. Calculate the acceleration of the car during stage two.

____

____

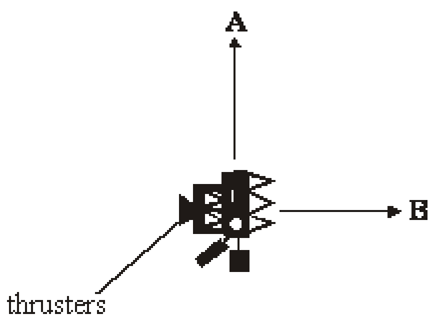
(c) Calculate the distance travelled by the car from rest to reach a speed of 280 m s^{-1}.

____

____

(Total 6 marks)

28 The diagram below shows a spacecraft that initially moves at a constant velocity of 890 m s^{-1} towards **A**.



To change course, a sideways force is produced by firing thrusters. This increases the velocity towards **B** from 0 to 60 m s^{-1} in 25 s.

(a) The spacecraft has a mass of 5.5 × 10^4 kg. Calculate:

(i) the acceleration of the spacecraft towards **B**;

Acceleration ____________________

(1)

(ii) the force on the spacecraft produced by the thrusters.

Force on spacecraft ____________________

(2)

(b) Calculate the magnitude of the resultant velocity after 25 s.

Magnitude of resultant velocity ____________________

(2)

(c) Calculate the angle between the initial and final directions of travel.

Angle ____________________

(1)

(Total 6 marks)

29 **Figure 1** shows a graph of velocity against time for an aircraft of mass 2.8×10^4 kg landing on a stationary aircraft-carrier.

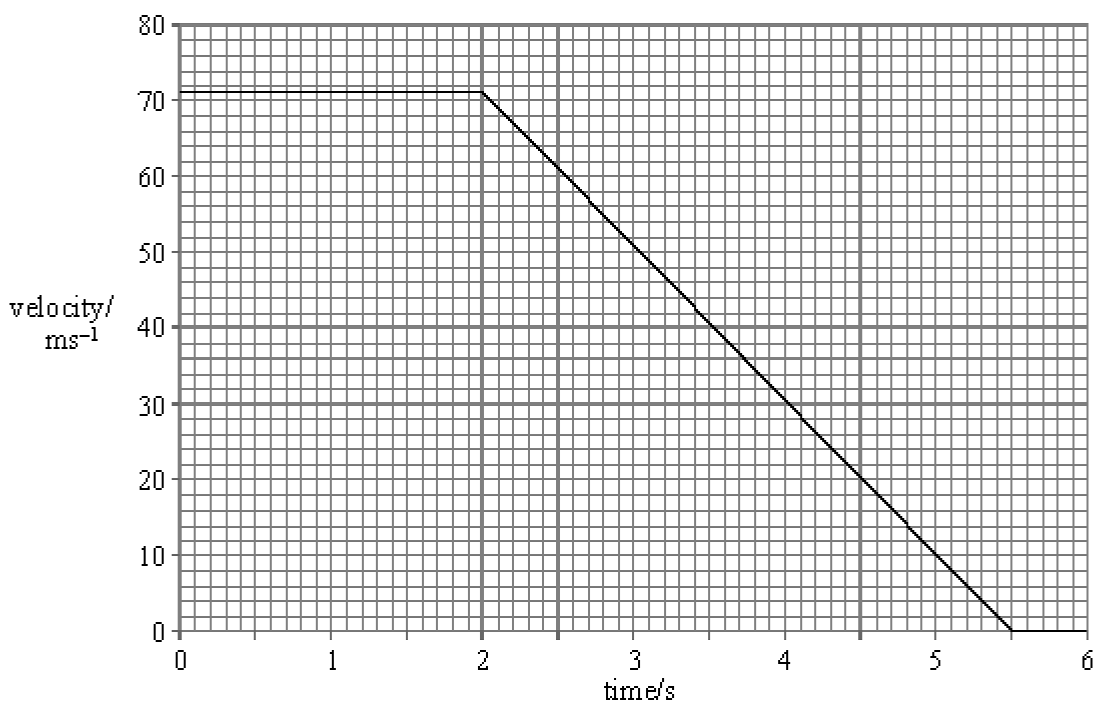


Figure 1

(a) (i) Calculate the initial kinetic energy of the aircraft.

Initial kinetic energy ____________________

(2)

(ii) Show that the deceleration of the aircraft is about 20 m s^{-2}.

(3)

(iii) Calculate the decelerating force acting on the aircraft.

Force ____________________

(2)

(b) A steam catapult is used to enable aircraft to take off from the ship. The catapult accelerates the aircraft from rest to its take-off speed of 71 m s^{-1} in a distance of 62 m.

Calculate the acceleration of the aircraft.

Acceleration ____________________

(2)

(c) In level flight, the pilot sets the course to be 80 m s^{-1} due north. There is a wind blowing from east to west at 20 m s^{-1}. Find, by scale drawing or otherwise, the resultant velocity of the aircraft.

Velocity of aircraft: magnitude ____________________

direction ____________________

(3)

(Total 12 marks)

30 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;

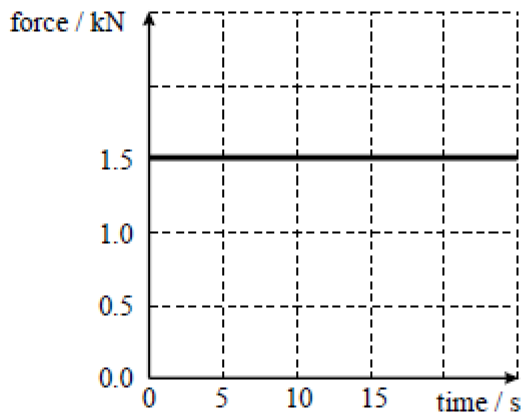
(2)

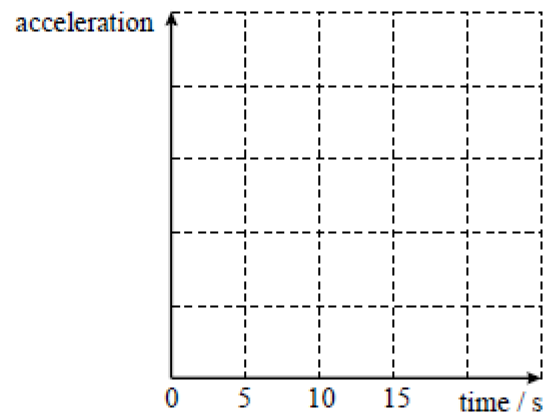
(iv) the distance travelled by the motor car in the first 15 s of the motion.

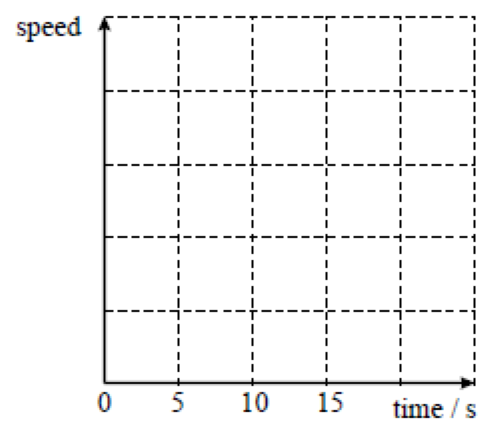
(1)

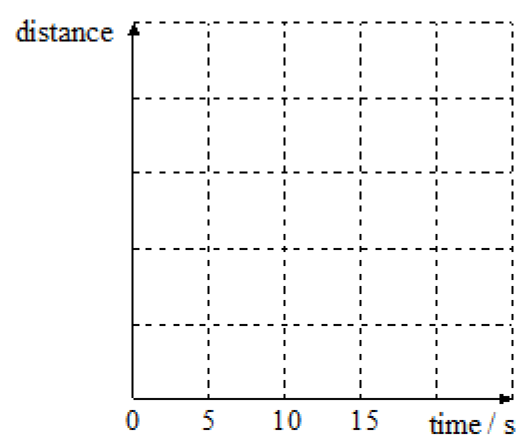
(b) The diagrams below show the graph of force against time together with three incomplete sets of axes. Sketch on these axes the corresponding graphs for acceleration, speed and distance travelled for the first 15 seconds of the car's motion.

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 (a) (i) Attempt to determine area under curve
Number of “large” squares (22 ± 1)
or distance per square = 20 (large) or 0.8 (small)
435 ± 10 (m)

Zero marks for use of suvat

3

(ii) Tangent to curve seen drawn at 10 s
Gradient of tangent = 4.2 (allow 3.5 – 4.5) (m s^{-2})

Zero marks for use of suvat

2

(iii) 640 × 4 or 2560 or 640 × their 7aii
5800-2560 or 5800-(640 × their 7aii)
3200 (3240) (N)

3

(iv) 89 (read off from graph) cnao
520 (516) (kW)

If answer is in W, then unit must be given

2

(b) The marking scheme for this question includes an overall assessment for the quality of written communication (QWC). There are no discrete marks for the assessment of QWC but the candidate's QWC in this answer will be one of the criteria used to assign a level and award the marks for this question.

Descriptor – an answer will be expected to meet most of the criteria in the level descriptor.

Level 3 – good
-claims supported by an appropriate range of evidence;
-good use of information or ideas about physics, going beyond those given in the question;
-argument is well structured with minimal repetition or irrelevant points;
-accurate and clear expression of ideas with only minor errors of grammar, punctuation and spelling.
Level 2 – modest
-claims partly supported by evidence;
-good use of information or ideas about physics given in the question but limited beyond this;
-the argument shows some attempt at structure;
-the ideas are expressed with reasonable clarity but with a few errors of grammar, punctuation and spelling.
Level 1 – limited
-valid points but not clearly linked to an argument structure;
-limited use of information about physics;
-unstructured;
-errors in spelling, punctuation and grammar or lack of fluency.
Level 0
-incorrect, inappropriate or no response.

Allow named resistive forces e.g. air resistance, drag, friction.

Allow thrust for driving force.

Explanation of velocity variation:

Car accelerates / Velocity increases because driving force is larger than resistive forces

Maximum acceleration at start

Resistive forces are zero at start

Resistive forces increase with increasing velocity

Drag proportional to velocity-squared

Resultant force decreases with increasing velocity

Acceleration decreases with increasing velocity

Terminal velocity reached when resultant force is zero / resistive forces balance the driving force

Explanation of change with DRS in use:

Resistive forces reduced (because air resistance / drag) is reduced

Resultant force is non-zero for longer time

Acceleration occurs over longer time

Terminal velocity reached in longer time

Higher terminal velocity achieved

Higher maximum velocity on graph
Same <u>initial</u> acceleration / gradient on graph

6
[16]

2 (a) m = 16 g = 0.016 kg   r = 0.008 m

Use of $V = 4/3\,\pi\,r^3$ to give $V = 4/3\,\pi\,(0.008)^3$

$= 2.1 \times 10 - 6$ m^3✓

The first mark is for calculating the volume

1

Use of density = m / V   to give density = 0.016 / 2.1 × 10^{-6}✓

The second mark is for substituting into the density equation using the correct units

1

Density = 7.4 × 10^3 kg m^{-3} ✓

The final mark is for the answer.

1

(b) Use of $v^2 = u^2 + 2as$ to give v^2 = 2 (9.81) (1.27) ✓

(allow use of $mg\Delta h = ½ mv^2$)

v^2 = 25 (24.9)

The first mark is for using the equation

1

v = 5.0 (m s^{-1}) ✓

The second for the final answer

1

(c) Use of v2 = u2 + 2as to give 0 = u^2 + 2 (-9.81) (0.85) ✓

The first mark is for using the equation

1

u^2 = 17 (16.7)

u = 4.1 m s^{-1} ✓

The second for the final answer

1

(d) Change in momentum = mv + mu = 0.016 × 5 + 0.016 × 4.1✓

The first mark is for using the equation

1

= 0.15 (0.146) kg m s^{-1} ✓

The second for the final answer

1

(e) Use of Force = change in momentum / time taken

= 0.15 / 40 × 10^{-3}✓

The first mark is for using the equation

1

= 3.6 N ✓

The second for the final answer

1

(f) Impact time can be increased if the plinth material is not stiff✓

Alternative

A softer plinth would decrease the change in momentum of the ball (or reduce the height of rebound) ✓

1

Increased impact time would reduce the force of the impact. ✓

Smaller change in momentum would reduce the force of impact ✓

1

[13]

3 (a) (i) *(a =(v-u) / t)*

= 27.8 (−0) / 4.6 = 6.04 ✓

= <u>6.0</u> (ms^{-1}) ✓

no need to see working for the mark

2 sig fig mark stands alone

2

(ii) (*F = ma*)

= (360 + 82) × 6.0(4) ✓ (allow CE from (i))

= 2700 (N) ✓ (2670 N or 2652 N)

F = 442 × (i)

1 mark may be gained if mass of rider is ignored giving answer 2200N from 2175N

2

(b) (forward force would have to) increase ✓

air resistance / drag increases (with speed) ✓

<u>driving / forward</u> force must be greater than resistive / drag force ✓

no mark for wind resistance

(so that) <u>resultant / net</u> force stayed the same / otherwise the <u>resultant / net</u> force would decrease ✓

4max3

(c) <u>horizontal</u> force arrows on both wheels towards the <u>right</u> starting where tyre meets road or <u>on the axle</u> labelled driving force or equivalent ✓

ignore the actual lengths of any arrows

ignore any arrows simply labelled 'friction'

a <u>horizontal</u> arrow to the <u>left</u> starting <u>anywhere</u> on the vehicle labelled drag / air resistance

no mark for wind resistance, resistance or friction force

the base of an arrow is where the force is applied

2

(d) ($F = P / v$)
= 22 000 / 55 ✓ Condone 22 / 55 for this mark
= 400 ✓ (N)

2

[11]

4

(a) (i) Use of $KE = \frac{1}{2} m v^2$

C1

21.7 (J)

A1

2

(ii) Use of $W = Fs$

Allow 1 mark for use of suvat or F=ma

C1

0.70 (m)

A1

2

(b) Use of $\Delta E_p = mg\Delta h$

C1

Correct sub for h (1.7 sin 18°)

C1

77.3 (W)
OR
Use of $P=Fv$
Correct sub for F (mg sin 18°) or v (1.7 sin 18°)
77.3 (W)

A1

3

[7]

5 (a) *($E_p = mg\Delta h$)*

$= 65 \times 9.81 \times 54$ ✓

$= 3.44 \times 10^4 = 3.4 \times 10^4$ (J) ✓ (34433)

max 1 if g =10 used (35100 J)

Correct answer gains both marks

2

(b) $v = \sqrt{\frac{2\,Ep}{m}}$ OR $v = \sqrt{\frac{2 \times 34433}{65}}$ ✓ $= 33$ (32.55 ms^{-1}) ✓ ecf 1(a)

allow 32 (32.3) for the use of 34000
allow 32.6

OR correct use of $v^2 = 2\,g\,s$

don't penalise g = 10 (32.863)

2

(c) (s =1 / 2 gt^2 or other kinematics equation)

$t = \sqrt{\frac{2s}{g}}$ OR $t = \sqrt{\frac{2 \times 54}{9.81}}$ ✓ $= 3.318 = 3.3$ (s) ✓

With use of g= 9.8 or 9.81 or 10 and / or various suvat equations,
expect range 3.2 to 3.4 s.
No penalty for using g= 10 here.

ecf from 1(b) if speed used

2

(d) (all G)PE (lost) is transferred to KE
no (GP)E transferred to 'heat' / 'thermal' / internal energy
OR ✓

Must imply that <u>all</u> GPE is transferred to KE. E.g. accept 'loss of
GPE is gain in KE' but not: 'loses GPE and gains KE'.

(therefore) $mg\Delta h \; \frac{1}{2}mv^2$ ✓
mass cancels. ✓

Accept 'm's crossed out

3

[9]

6 (a) *GPE* to *KE* to *GPE* ✓

no energy lost (from system) / no <u>work done</u> against resistive forces ✓

initial *GPE* = final (*GPE*) / initial (*GPE*) = final *GPE*

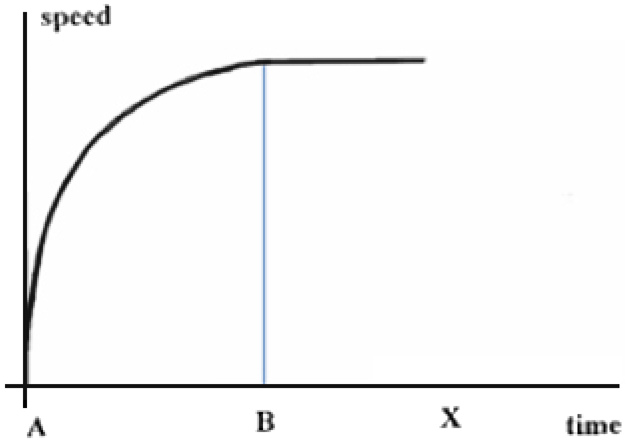
OR *h* = *GPE /mg* and these are all constant so *h* is the same ✓

3

(b) Initial curve with decreasing gradient and reaching constant maximum speed before X and maintaining constant speed up to X ✓

B labelled in correct place ✓

B labelled in correct place **AND** constant speed maintained for remainder of candidates graph and line is straight ✓



3

(c) (first law) ball travels in a straight line at a constant speed / constant velocity / (maintains) uniform / no change in motion / zero acceleration ✓

there is no (external) **unbalanced / resultant** force acting on it ✓

2

[8]

7 (a) (i) *(s = ½(u + v) t) t = 2s/v* ✓ (correct rearrangement, either symbols or values)

(= 100/6.7) = 15 ✓ (s) (14.925)

or alternative correct approach

2

(ii) ($KE = 1/2mv^2 = ½ \times 83 \times 6.7^2$) = 1900 ✓ (1862.9 J)

2 sf ✓

2

(iii) GPE = 83 × 9.81 × 3.0 ✓ penalise use of 10, allow 9.8

= 2400 (2443 J) ✓ do not allow 2500 (2490) for use of g = 10

2

(b) (i) 5300 + 3700 (or 9000 seen)

or – 2443 – 1863 (or (–) 4306 seen) ✓

= 4700 (J) ✓ (4694) ecf from parts aii & aiii

2

(ii) mention of friction and appropriate location given ✓

mention of **air** resistance (or drag) ✓

do not allow energy losses or friction within the motor

do not allow energy losses from the cyclist

must give a **cause** not just eg 'heat loss in tyres'

2

[10]

8 (a) (i) $\left(a = \frac{v-u}{t}\right) = \frac{58}{3.5}$ ✓ = 17 (m s^{-2}) ✓

2

(ii) (F = ma) = 5800 × 16.57 ecf (a)(i) ✓

= 96000 ✓

allow 98600 or 99000 for use of 17

N ✓

3

(iii) $\left(s = \frac{1}{2}(u+v)t\right) = \frac{1}{2} \times 58 \times 3.5$ ✓

= 100 (101.50, 102, accept 101 m) ✓

or use of $v^2 = u^2 + 2as$ (= 101 m. 98.9 for use of 17) 2

or $s = ut + \frac{1}{2}at^2$ (= 101.7, use of 17 gives 104) (ecf from (a)(i))

2

(iv) ($W = Fs$) (a)(ii) × (a)(iii) or use of $\frac{1}{2}mv^2$ ✓ (= 13.6 to 14.7)

$\left(P = \frac{Fs}{t}\right) = \frac{96106 \times 101.5}{3.5}$ ✓ = 2.8M (W) ecf (a)(ii), (a)(iii)

or use of $P = \frac{Fv}{2}$ their answer × 5 ✓ = 14,000,000 = 14 M (W)

3

(b) $\frac{1}{2}(m)\,v^2 = (m)\,g\,(\Delta)\,h$ **or** (loss of) KE = (gain in) PE ✓

allow their work done from (iv) used as KE

$h = \frac{1}{2}\frac{v^2}{g}$ **or** $h = \frac{1}{2} \times \frac{58^2}{9.81}$ ✓

accept use of kinematics equation

= 170 ✓

3

[13]

9

(a) (i) $v = \frac{s}{t}$ **(1)**

t = 0.015 (s) or 15 (ms) **(1)**

0.68/0.015 **(1)** (= 45)

3

(ii) $\left(a = \frac{\Delta v}{\Delta t} = \frac{45.3}{0.015}\right)$ = 3000 (m s^{-2}) (3022) **(1)**

1

(b) (i) $s = (ut) = \frac{1}{2}gt^2$ or $t = \sqrt{\frac{2s}{g}}$ **(1)**

correct substitution seen = $\sqrt{\frac{2 \times 2.3}{9.81}}$ **(1)**

0.68 to 0.69 correct answer to more than one dp seen **(1)**

3

(ii) ($s = vt$) = 45(.3) × 0.685 or 0.7 **(1)**

= 30.6 to 32 **(1)** (m)

2

(iii) mention of air resistance or drag **(1)**

causing **horizontal** deceleration or 'slowing down' **(1)**

2

[11]

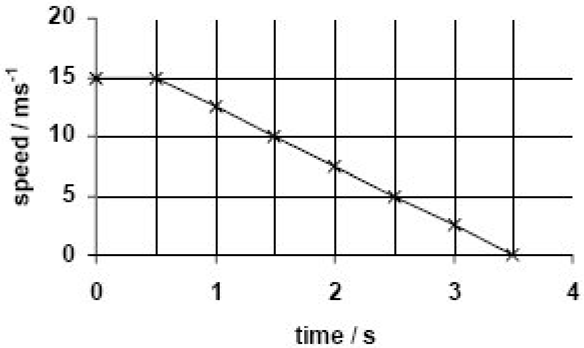
10 (a) axes labelled correctly with correct units shown **(1)**

suitable scales **(1)**

6 points plotted correctly **(1)**

all points plotted correctly **(1)**

both sections of line drawn correctly **(1)**



5

(b) (i) the gradient (of the slope section) represents the deceleration/ calculates 5 m s^{-2} **(1)**

(deceleration is uniform because) the gradient is constant/ line is straight **(1)**

(ii) distance travelled = area under line (0 to 3.5 s or 0.5 to 3.5 s) **(1)**

(= 15.0 × 0.5) = 7.5 m in first 0.5 s **(1)**

(= 0.5 × 15.0 × 3.0) or s = ½(u + v)t, etc) = 22.5 m (from 0.5s to 3.5s) **(1)**

(= ½(0.5 + 3.5) × 15 gets all three method marks) (total distance travelled = 7.5 + 22.5) = 30m **(1)**

6

[11]

11 (a) the sprinter takes time to react to the starting pistol **(1)**

B1

1

(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]

12 (a) (i) (use of $a = \frac{\Delta v}{\Delta t}$ gives) $a = \frac{4.5}{3600}$ **(1)**

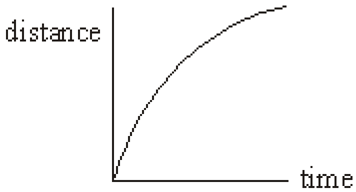
$=1.25 \times 10^{-3}$ ms^{-2} **(1)**

(ii) (use of $v^2 = u^2 + 2as$ gives) $0 = 4.5^2 - 2 \times 1.25 \times 10^{-3} \times s$ **(1)**

$$s\left(= \frac{20.25}{2.5 \times 10^{-3}}\right) = 8.1 \times 10^3 \text{ m}$$ **(1)**

4

(b) increasing curve **(1)**
correct curve **(1)**



1

(c) gradient (slope) of graph represents speed **(1)**
hence graph has decreasing gradient **(1)**

2

[8]

13 (a) (i) car A: travels at constant speed **(1)**

(ii) car B: accelerates for first 5 secs (or up to 18 m s^{-1}) **(1)**
then travels at constant speed **(1)**

3

(b) (i) car A: distance = 5.0 × 16 **(1)**
= 80 m **(1)**

(ii) car B: (distance = area under graph)
distance = [5.0 × ½ (18 + 14)] **(1)**
= 80 m **(1)**

4

(c) car B is initially slower than car A (for first 2.5 s) **(1)**
distance apart therefore increases **(1)**
cars have same speed at 2.5 s**(1)**
after 2.5 s, car B travels faster than car A (or separation decreases) **(1)**

max 3

[10]

14 (a) (i) (using $\sin 25° = V_V/V$
$V = V_V / \sin 25°$)
=5.0/sin25° ✓
11.8 (m s^{-1}) ✓
(working and answer is required)

Look out for cos 65° = sin 25° in first mark.

Also calculating the horizontal component using cos 25° followed by Pythagoras is a valid approach.

Working backwards is not acceptable.

2

(ii) (using tan 25° = V_V / V_H)
$V_H = V_V$ /tan 25° ✓
= 5 / tan 25° =11(m s^{-1}) ✓ (10.7m s^{-1})
Or (using cos 25° = V_H / V)
$V_H = V$ cos 25° ✓ = 11.8 cos 25° = 11 (m s^{-1}) ✓ (10.7 m s^{-1})
Or (using $V_H^2 + V_V^2 = V^2$)
$V_H^2 + 5^2 = 11.8^2$ ✓ (0r 12^2)
V_H = 11 (m s^{-1}) ✓ (10.7 m s^{-1})

Note 1/cos 65° = sin 25°

and tan 25° = 1/ tan 65°

Rounding means answers between 10.7 and 11 m s^{-1} are acceptable

2

(b) (i) (using $v^2 = u^2 + 2as$ with up being positive
$0 = 5.0^2 + 2 \times -9.81 \times s$)
s = 1.3 (m) ✓ (1.27 → 1.28 m)
or (loss of KE = gain of PE
$\frac{1}{2} \cancel{m} v^2 = \cancel{m} g h$
½ 5.0^2 =9.81 × h)
h = 1.3 (m) ✓ (1.27 → 1.28 m)

quoted to 2 sig figs ✓

for the sig fig mark the answer line takes priority. If a choice of sig figs given and not in answer line – no sig fig mark

Sig fig mark stands alone provided some working is shown

2

(ii) (using $s = (u + v)t/2$) or horizontal distance = speed × time)
s = 11 × 1.3 = 14 (m) ✓ (using 10.7 gives the same answer)

allow CE s = (aii) × 1.3 but working must be seen

1

(c) (i) **A** marked at the point of landing or immediately before ✓

*The **A** or its marked position must not be further to the left than the 'c' in the word 'scale'*

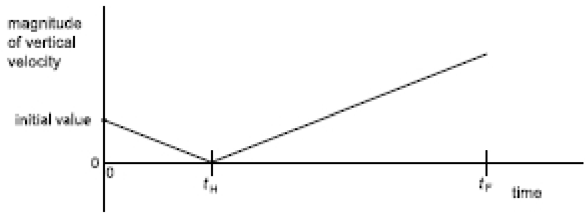
1

(ii) **B** marked at the maximum height of the path ✓

*The **B** must lie vertically between the 'r' and 'a' in the word 'resistance above figure 2.*

1

(d) <u>straight</u> line from point given down to point t_H on the axis ✓
<u>straight</u> line starting where first line stops (t_H) but with opposite gradient to the first line ✓



(A measure of accuracy for the second mark) The second line must end (t_H) between the height of the vertical axis and half this height.

Obviously straight lines drawn by hand are acceptable.

2

[11]

15 (a) (i) $\left(s = \frac{1}{2}gt^2\right)$

Allow g=10 (0.5477)

$1.5 = \frac{1}{2}9.81t^2$ OR $t = \sqrt{\frac{2s}{g}}$ OR $t = \sqrt{\frac{2 \times 1.5}{9.81}}$ ✓

(= 0.553) = 0.55 (s) ✓

0.6 gets 2 marks only if working shown. 0.6 on its own gets 1 mark.

2

(ii) ($s = v\,t$ = 430 × 0.553 = 237.8 =) 240 (m) ✓
ecf a(i)

1

(b) their vertical motion is independent of their horizontal motion
OR <u>downward</u> / <u>vertical</u> acceleration is the same for both
OR acceleration <u>due to gravity</u> is the same for both
OR <u>vertical</u> speed / velocity is the same for both ✓

Allow 'time is constant'
Don't allow 'similar'

(bullets A and B will be in the air) for the same time ✓

(Horizontal acceleration is zero and thus horizontal) distance is proportional to <u>horizontal</u> speed **OR** $s = ut$ where u is the <u>horizontal</u> velocity ✓

'velocity smaller so distance smaller' is not sufficient

3

[6]

16 (a) (i) vertical speed = 22 sin 30 = 11 m s^{-1} **(1)**

C1

(ii) use of $v = u + at$ or substitution **(1)**

B1

or any correct alternative using equations of motion
working leading to 1.12 s **(1)**

B1

working showing that it is doubled for up and down **(1)**

B1

(iii) 41.9 – 43m **(1)**

B1

5

(b) (i) **max 3 from**

tennis ball doesn't travel as far because:

tennis ball has lower KE when hit **(1)**

B1

tennis ball has a rougher surface so more friction/air
resistance) **(1)**

B1

(although)rate of energy loss to air (initially) is
the same **(1)**

B1

tennis ball loses KE quicker **(1)**

B1

(ii) sketch showing significantly lower height and range **(1)**

M1

acceptable flight path initially same (for short
distance then always below cricket ball path° **(1)**

A1

5

[10]

17 (a) potential energy to kinetic energy **(1)**
mention of thermal energy and friction **(1)**

2

(b) (use of ½ $mv^2 = mgh$ gives) ½ $v_h^2 = 9.81 \times 1.5$ **(1)**
$v_h = 5.4(2)\text{ms}^{-1}$ **(1)**
(assumption) energy converted to thermal energy is negligible **(1)**

3

(c) component of weight down the slope causes acceleration **(1)**
this component decreases as skateboard moves further down the slope **(1)** air resistance/friction increases (with speed) **(1)**

2

(d) (i) distance (= 0.42 × 5.4) = 2.3m **(1)**
(2.27m)

(allow C.E. for value of v_h from (b))

(ii) $v_v = 9.8 \times 0.42$ **(1)**
= 4.1(l) m s^{-1} **(1)**

(iii) $v^2 = 4.1^2 + 5.4^2$ **(1)**
$v = 6.8$ m s^{-1} **(1)**
(6.78 m s^{-1})

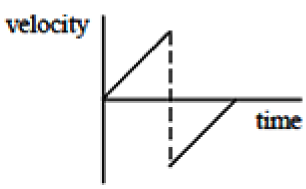
(allow C.E. for value of v_h from (b))

5

[12]

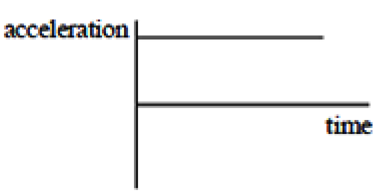
18 accept mirror image for (a) and (b)

(a)



straight line sloping up **(1)**
sudden change to negative velocity **(1)**
smaller negative velocity **(1)**
same gradient as positive line **(1)**

(b)



constant value shown **(1)**

(5)

(c) (i) vertically down at P **(1)**

(ii) vertically down at Q **(1)**

(iii) along tangent at P **(1)**

(iv) along tangent at Q **(1)**

(4)

(d) horizontal component of velocity at Q = 15 cos 50° **(1)** = 9.64 m s^{-1} **(1)**

momentum at Q = 0.15 × 9.64 = 1.45 **(1)** N s (or kg m s^{-1}) (horizontally) **(1)**

(4)

[13]

19 (a) (i) $v = s / t$ **C1**

19 (18.7) m s^{-1} **A1**

(ii) zero tolerate missing unit **B1**

(iii) $v^2 = (u^2) + 2as$ $v = u + at^2$ $s = ut + 1 / 2at^2$ **C1**

$v = \sqrt{(2 \times 9.8 \times 11)}$ **C1**

15 m s^{-1} / 14.7 m s^{-1} **A1**

(b) (i) use of Pythagoras **C1**

$18.7^2 + 14.7^2 = v^2$ **OR** $v^2 = \sqrt{(\text{their (a)(i)}^2 + \text{their (a)(iii)}^2)}$ **C1**

24 (23..7 or 23.8) ms^{-1} **ecf** **A1**

OR velocities drawn correctly to scale **C1**

suitable scale used and quoted **M1**

23 – 25 m s^{-2} **A1**

(ii) 38° to 39° 37° to 40° for scale drawing

ecf $\tan^{-1} \dfrac{\text{their (a)(iii)}}{\text{their (a)(i)}}$ **B1**

(c) when kicked / when landing has max KE

B1

has no PE at this point / has max speed and KE = ½mv^2

B1

or loses energy because of (work done against) air resistance

B1

total energy greatest just after it's been kicked

B1

[12]

20

High Level – Good to Excellent
The relationship between the acceleration and the gradient of the graph or how it changes should be given including the reason why the initial acceleration would remain the same. Also a reference to terminal velocity should be made and an explanation of why the terminal speed is greater.
The information presented as a whole should be well organised using appropriate specialist vocabulary. There should only be one or two spelling or grammatical errors for this mark.

6 marks = 6 points given from the descriptor list but at least one must come from each Group.

5 marks = 5 points given from the descriptor list but at least one must come from each Group.

5 - 6

Intermediate Level – Modest to Adequate
The relationship between the acceleration and the gradient of the graph or how it changes should be given. Also something should be said about the initial acceleration being the same and/or the terminal velocity being larger. With this restriction marks can come from any marking point that is clearly given.
The grammar and spelling may have a few shortcomings but the ideas must be clear.

4 marks = 4 points from the descriptor list but at least one must come from two Groups.

3 marks = 3 points from the descriptor list but at least one must come from two Groups.

3 - 4

Low Level – Poor to Limited
Any two valid statements that cover any of the parts given below.
There may be many grammatical and spelling errors and the information may be poorly organised.

2 marks = any 2 points from the descriptor list with no restriction on which Group they come from

1 mark = any point from the descriptor list

1 - 2

The description expected in a competent answer should include:

First Group:

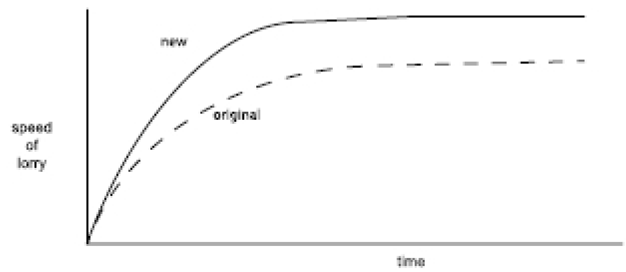
1. the acceleration is the gradient of the graph (or the link between acceleration and gradient is clearly made)
2. the acceleration is greatest initially / (continuously) decreases
3. a constant final velocity / terminal velocity is shown by the graph becoming horizontal / flat.

Second Group:

4. initial acceleration or the initial gradient is the same or only slightly greater (as initially the mass is the same)
5. *a* = *F/m* (in words or symbols)

Third Group:

6. at the end / eventually / at terminal velocity *resistance force = drive force*
7. resistance force is now less at the same speed (because mass is less)
8. speed will be higher or graph has higher line (this may come from the figure)
9. in the middle of the graph the acceleration will be greater.



[6]

21

(a) $K = \frac{45}{30^2} (= \frac{45}{900} = 0.05)$ or $\frac{d}{45} = \frac{15^2}{30^2} (= \frac{1}{4})$

d = 11.25 (m)

C1

A1

2

(b) rearrangement or substitution into $v^2 = u^2 + 2as$ or $s = \frac{v+u}{2}t$

C1

$a = (-)10$ or $t = 3.0$

A1

allow use of more than one equation of motion provided it gives a deceleration or time

use of *F* = *ma* or *Ft* = *mv* − *mu* (−)7000 (N)

C1

A1

4

(c) mention of $E_K = \frac{1}{2}mv^2$

B1

allow a mark for kinetic

all used to heat brakes / surroundings

B1

energy to 'heat'

since both ke and d are proportional to V^2

B1

d must be proportional to heat generated or to the kinetic energy

B1

E = md / 2 k gains two marks

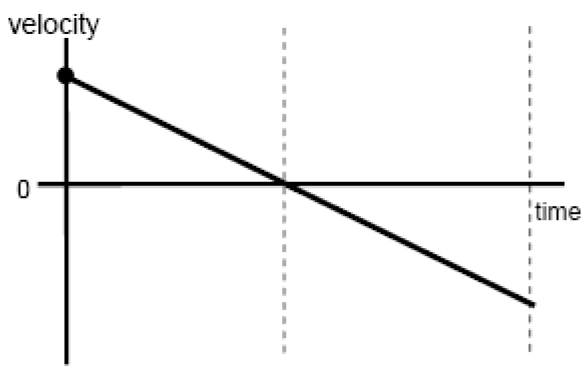
3 max

[9]

22 (a) (i) gradient (allow 'slope'/' **steepness of the line**') ✓

1

(ii)



single straight line sloping down from X to t_2 ✓

passes through zero at t_1 ✓

increases to a maximum negative value at t_2
(ignore all lines beyond t_2)
or allow line from zero at t_1 to a positive velocity at
t_2 greater than the initial velocity ✓

3

(b) (i) **ball** exerts **force on ground and** ground exerts force (on ball)/reaction ✓

and **these** forces are **equal** and **opposite** ✓

2

(ii) recognise that the downward force is the weight of the ball (accept gravity) ✓

recognition that the upward/reaction force (on the ball) is greater than the downward force on the ball ✓

2

[8]

23 (a) a force/1300 (condone power of ten error)

C1

6200 ÷ 1300

C1

4.77 (m s^{-2})

A1

3

(b) use of suitable kinematic equation

C1

eg distance = $27^2/(2 \times 4.8)$ correct sub

C1

76/76.4 m/72.9 from *a* = 5/75.9 from *a* = 4.8

A1

3

[6]

24 (a) (i) $E_p = mg\Delta h$ **(1)**
$= 5.8 \times 10^{-2} \times 9.8(1) \times 1.5 = 0.85$ J ✓

(ii) 0.85 J **(1)**
(allow C.E. for value of E_p from (i))

(iii) (use of $E_k = ½mv^2$ gives) $0.85 = 0.5 \times 5.8 \times 10^{-2} \times v^2$ **(1)**
(allow C.E. for answer from (ii))
($v^2 = 29.3$) $v = 5.4$ m s^{-1} **(1)**

(iv) (use of $p = mv$ gives) $p = 5.8 \times 10^{-2} \times 5.4$ **(1)**
(allow C.E. for value of v from (iii))
= 0.31 N s **(1)**

7

(b) $\left(\text{use of } F = \frac{\Delta(mv)}{\Delta t} \text{ gives}\right) F = \frac{0.31}{0.010}$ **(1)**

(allow C.E. for value of p from (iv))

= 31 N **(1)**

[or $a = \frac{5.4}{0.010}$ = 540 (m s^{-2}) **(1)**

F = 5.8 × 10^{-2} × 540 = 31 N **(1)**]

2

(c) egg effectively stopped in a longer distance **(1)**
hence greater time and therefore less force on egg **(1)**
[or takes longer to stop

hence force is smaller as $F = \frac{\Delta(mv)}{t}$

[or acceleration reduced as it takes longer to stop
thus force will be smaller]

[or some energy is absorbed by container
less absorbed by egg]

2

[11]

25 (a) ball bearing accelerates at first as resultant force is downwards **(1)**
resistive force increases with speed **(1)**
when resultant force on ball is zero, terminal velocity reached **(1)**

3

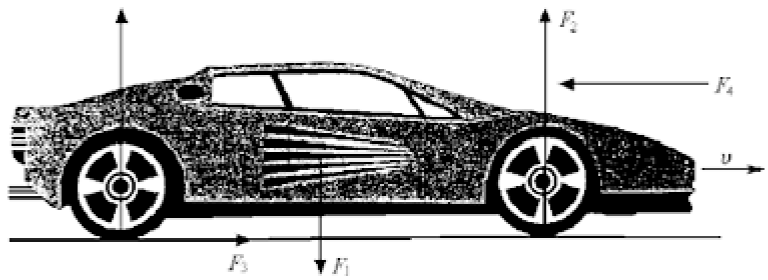
The Quality of Written Communication marks are awarded for the quality of answers tothis question.

(b) show ball bearing takes same time **(1)**
to travel equal distances **(1)**
[or measure velocity at different points **(1)** with appropriate method **(1)**]

2

[5]

26 (a) (i)



F_1 weight / mg **(1)**
F_2 reaction or normal contact force **(1)**
F_3 driving force **(1)**
F_4 friction or air resistance **(1)**

(ii) zero acceleration **(1)**
zero resultant force **(1)**

The Quality of Written Communication marks were awarded primarily for the quality of answers to this part.

(max 5)

(b) ($P = Fv$ gives) $18 \times 10^3 = F \times 10$ **(1)** (and $F = 1.8 \times 10^3$ N)

(1)

(c) (i) $1800 - 250 = 1.6 \times 10^3$ N **(1)** (1.55×10^3 N)

(ii) force = $4 \times 1.55 \times 10^3 = 6.2 \times 10^3$ N **(1)**
(allow e.c.f. from (i))

(iii) total force = 6200 + 250(N) **(1)** (= 6.45×10^3 (N))
($P = Fv$ gives) $P = 6.45 \times 10^3 \times 20 = 1.3 \times 10^5$ W **(1)** (1.29×10^5 W)
(allow e.c.f. for value of total force)

(4)

[10]

27

(a) $a = \dfrac{44}{4.0} = 11$ ms^{-2} **(1)**

$F = ma = 1.1 \times 10^5$ N **(1)**

(b) $\Delta v = 236$ m s^{-1}

$a = \dfrac{236}{8.0} = 29.5$ m s^{-2} **(1)**

(c) $s_{one} = v_{av} \times t = \left(\frac{44+0}{2}\right) \times 4.0 = 88$ m **(1)**

$s_{two} = v_{av} \times t = \left(\frac{280+44}{2}\right) \times 8.0$ **(1)** = 1296 (m) **(1)**

total distance = 1384 m **(1)**

[6]

28 (a) (i) 2.4 m s^{-2}

B1

1

(ii) $F = ma$

C1

132 000 N (ecf from (i))

A1

2

(b) final speed = $(890^2 + 60^2)^{1/2}$

C1

892 m s^{-1} (cao) (allow 890 m s^{-1} as final answer but 892 must be seen in working)

A1

2

(c) $\tan^{-1}$ 60/890 or $\sin^{-1}$ 60/892 = 3.9° (3.86)°
or $\cos^{-1}$(890/892) = 3.8 (4)°
or $\sin^{-1}$ 60/890 =3.9° (3.86)° if ecf from (b)

B1

1

[6]

29 (a) (i) $\frac{1}{2} mv^2 = \frac{1}{2} \times 2.8 \times 10^4 \times 71^2$

C1

$= 7.1 \times 10^7$ J

A1

2

(ii) decel = gradient of graph or $a = (v\text{-}u)/t$ or $\Delta v/\Delta t$ or evidence on graph

B1

= (71-0)/(3.5 – 0)

B1

= 20.3 [m s^{-2}]

B1

3

(iii) [$F=ma$] = $2.8 \times 10^4 \times 20.3$

C1

=568 kN

A1

2

(b) $v^2 = u^2 + 2as$

$a = v^2/2s = 71^2/124$ or alt process

= 41 m s^{-2} [40.6]

C1 A1

2

(c) drawing correct, scale clearly stated, wind speed line>+ 2 cm **or** one

B1

correct calculation

speed 82/83/82.5 m s^{-1} [80 – 84 if drawn]

B1

course 14° [12 – 16] west of north [346°]

B1

3

[12]

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

B1 **(1)**

(ii) ($v = u + at$) = 0 + 1.76 × 15

C1

= 26.4 m s^{-1}
allow e.c.f. from (i)

A1 **(2)**

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

C1

= 49.5 m
allow e.c.f. from (i)

A1 **(2)**

(iv) t doubles so s quadruples = 4 × 49.5 ~ 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]