

1

A car is designed to break the land speed record. The thrust exerted on the car is 230 kN at one instant of its motion. The mass of the car at this instant is 11 000 kg.

- (a) The acceleration of the car at this instant is 2.9 m s^{-2} .

Calculate the air resistance acting on the car.

air resistance = _____ N

(3)

- (b) The thrust on the car remains constant as the speed increases.

Explain why the acceleration decreases and eventually reaches zero.

(2)

- (c) A supersonic car is attempting to break the land speed record on a horizontal track. When it is travelling at 320 m s^{-1} , a small part **P** that is 1.5 m above the ground becomes detached from the car. The initial vertical velocity of **P** is 2.5 m s^{-1} in the upwards direction.

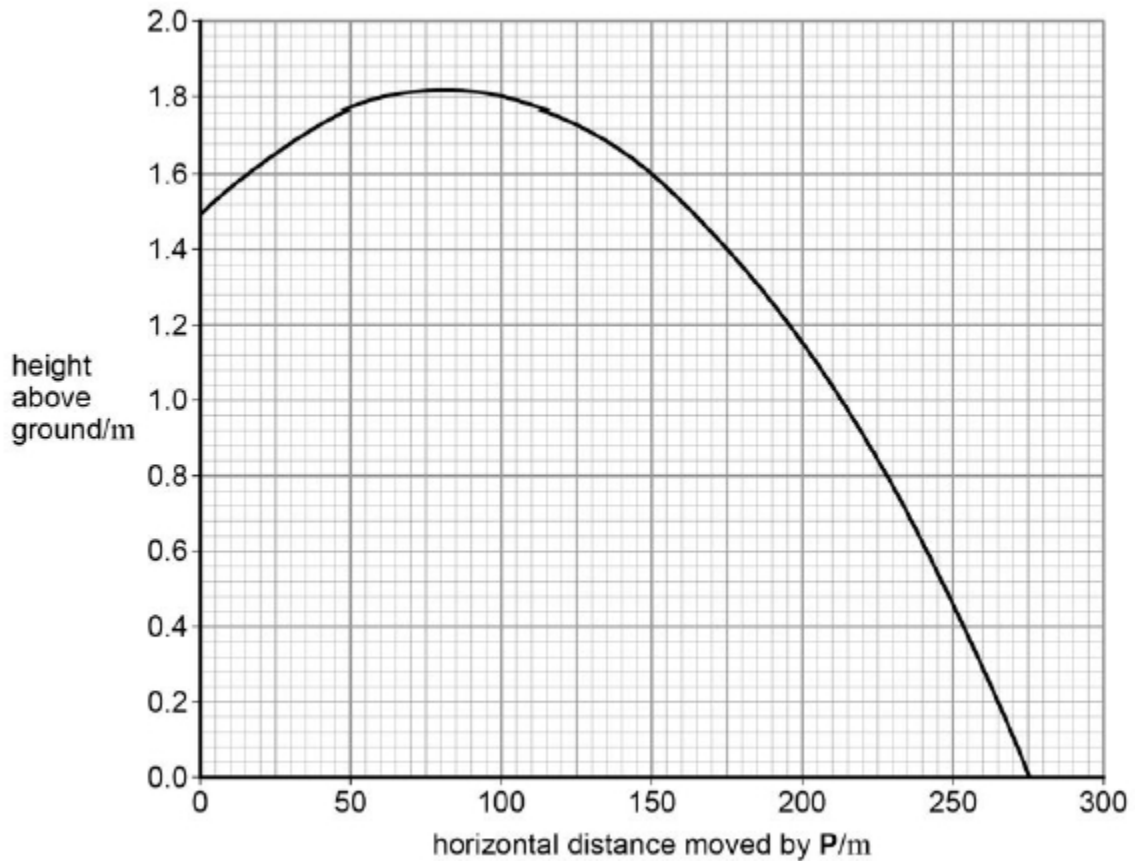
Calculate the time taken for the small part **P** to reach the ground.

Assume that air resistance has a negligible effect on the vertical motion.

time = _____ s

(2)

- (d) The graph below shows the path that **P** would follow from the instant that it became detached if there were no air resistance in the horizontal direction.



In practice, air resistance is not negligible in the horizontal direction.

Draw, on the graph, a line to show the path that **P** would follow assuming that air resistance only affects motion in the horizontal direction.

(2)

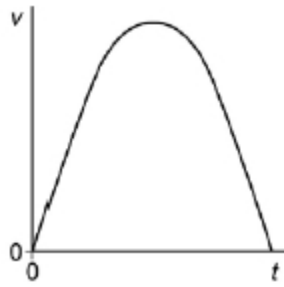
- (e) Explain your answer to part (d), including the reason why air resistance is negligible in the vertical direction.

(2)

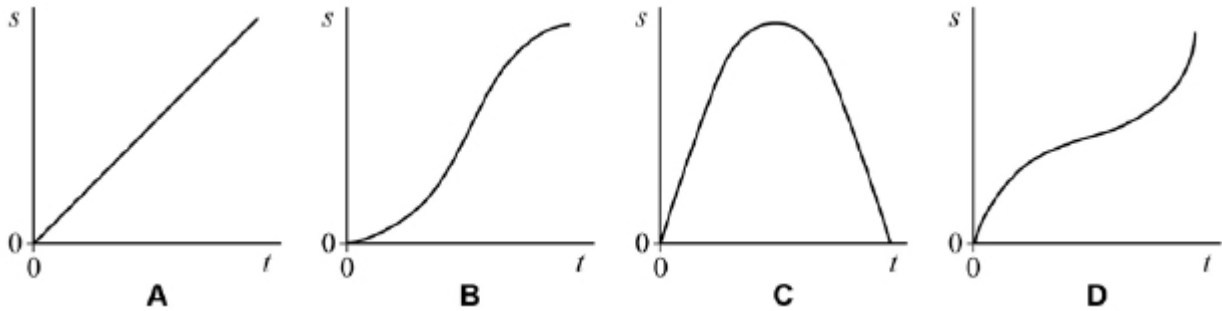
(Total 12 marks)

2

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)

3

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

A 10 m ☐

B 20 m ☐

C 25 m ☐

D 45 m ☐

(Total 1 mark)

4

The first section of a full-size stroboscopic photograph of a marble released from rest and in free fall is shown below. Every time the strobe light flashes an image of the marble is recorded. The time interval between successive flashes of the strobe light was 0.0435 s.

(a) This photograph can be used to find a value for the acceleration due to gravity g .

(i) Take measurements from the diagram below that can be used to find an accurate value for g .

(2)

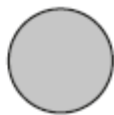
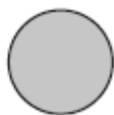
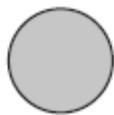
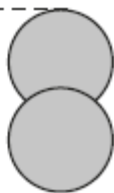
(ii) Calculate a value for g using your measurements from **(a)(i)**.

(2)

(b) Suggest why the duration of the flash of the strobe should be as short as possible.

(1)

position from
which marble
was released



(Total 5 marks)

5

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)

6

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}	☐

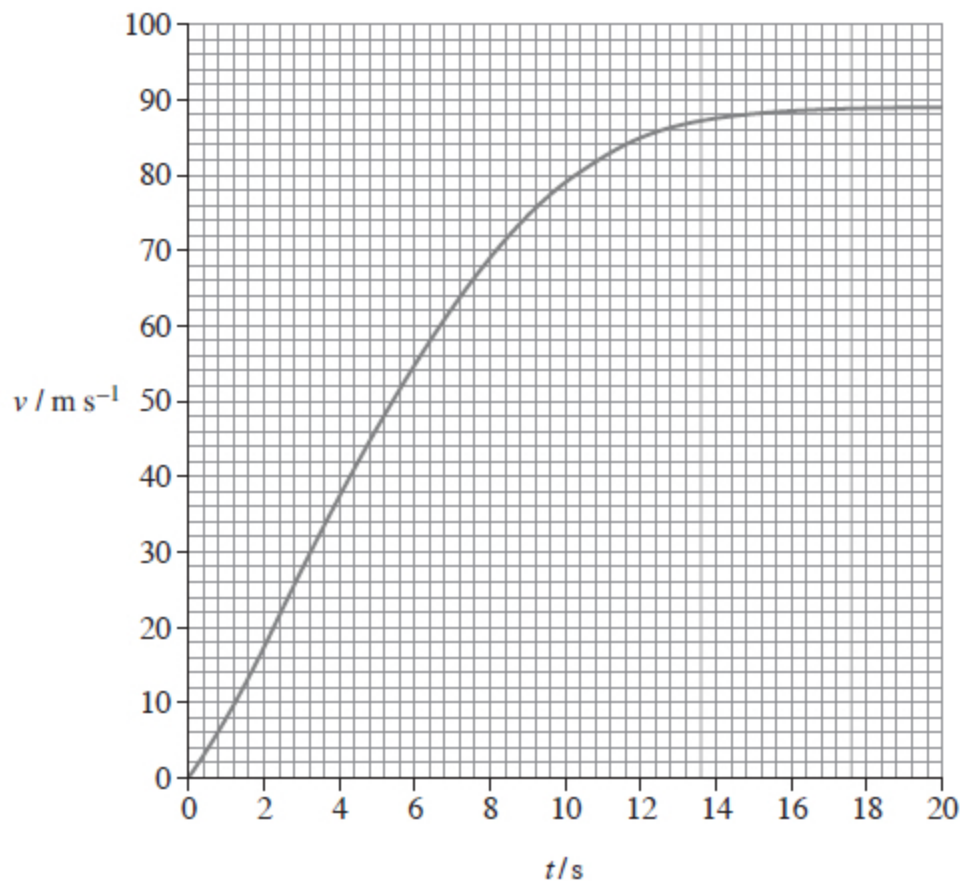
(Total 1 mark)

7

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)

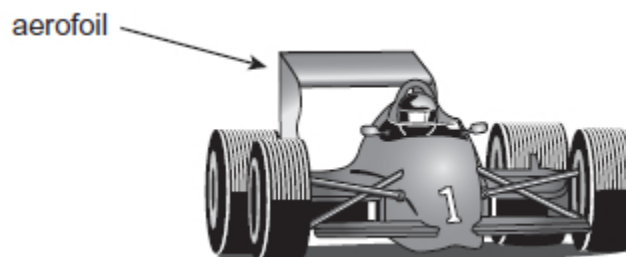
- (iv) Calculate the power, in kW, of the car at the maximum speed during the test drive.

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)

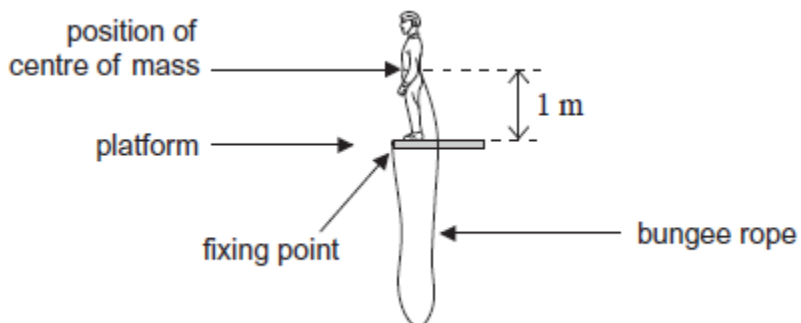
8

The diagram below shows a bungee jumper of mass 75 kg about to step off a raised platform. The jumper comes to a halt for the first time when his centre of mass has fallen through a distance of 31 m.

The bungee rope has an unextended length of 19 m and a stiffness of 380 N m^{-1} .

Ignore the effects of air resistance and the mass of the rope in this question.

Treat the jumper as a point mass located at the centre of mass.



- (a) (i) Calculate the extension of the bungee rope when the centre of mass of the jumper has fallen through 31 m.

extension _____ m

(1)

- (ii) Calculate the resultant force acting on the jumper when he reaches the lowest point in the jump.

resultant force _____ N

(2)

- (b) Calculate the extension of the rope when the jumper's acceleration is zero.

extension _____ m

(2)

- (c) The extension of the bungee rope is 5.0 m when the jumper's centre of mass has fallen through a distance of 25 m.

Use the principle of conservation of energy to calculate the speed of the jumper in this position.

speed _____ m s^{-1}

(4)

- (d) The bungee jump operator intends to use a bungee rope of the same unextended length but with a much greater stiffness. The rope is to be attached in the same way as before.

Explain, with reference to the kinetic energy of the jumper, any safety concerns that may arise as the jumper is slowed down by the new rope.

(3)

(Total 12 marks)

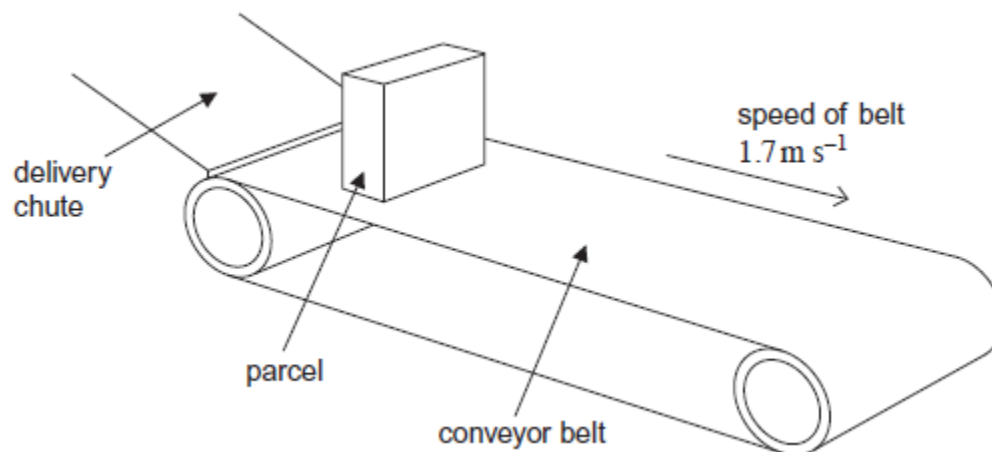
9

- (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.

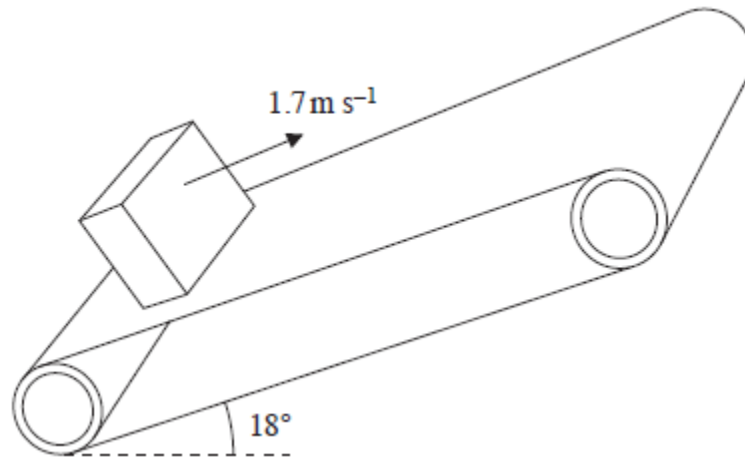
Calculate the horizontal distance between the parcel and the end of the delivery chute 0.82 s after the parcel lands on the conveyor belt. Assume that the parcel does not reach the end of the conveyor belt.

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)

10

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

$$d = kv^2$$

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)

11

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

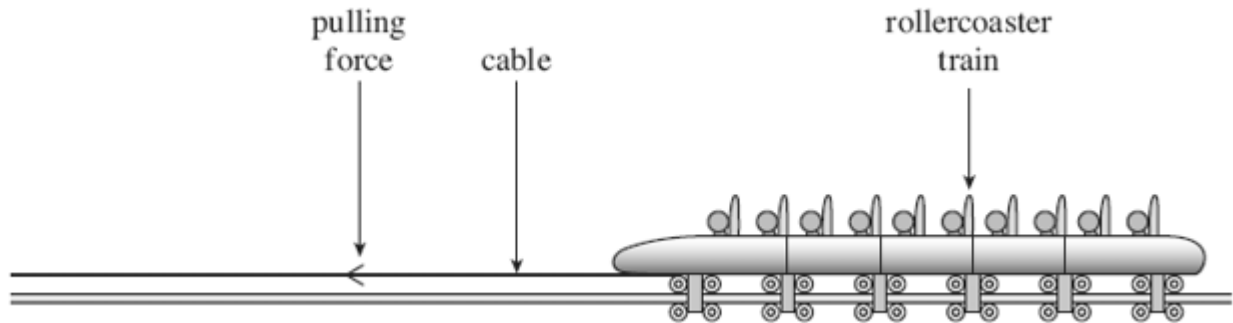
(2)

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

(3)

12

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 58ms^{-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 58ms^{-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)

13

The table below gives test data relating to three types of petrol driven car used commonly on roads in the UK.

car	A	B	C
mass / kg	1250	1340	1610
maximum power / kW	74	81	171
time, in second, taken to accelerate from 0 to 96 km per hour	10.9	12.5	6.9
fuel economy / litre per 100 km	7.7	5.0	9.1
maximum speed / km h ⁻¹	187	177	230

- (a) (i) Calculate the average acceleration, from rest, of car **A** during the test. Give your answer in m s⁻².

average acceleration _____ m s⁻²

(3)

- (ii) Calculate the resultant force required to make car **B** accelerate at 2.10 m s⁻².

force _____ N

(2)

- (b) Suggest reasons why the data given for car **C** may cause environmental and social concerns.

(3)

(Total 8 marks)

14

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)

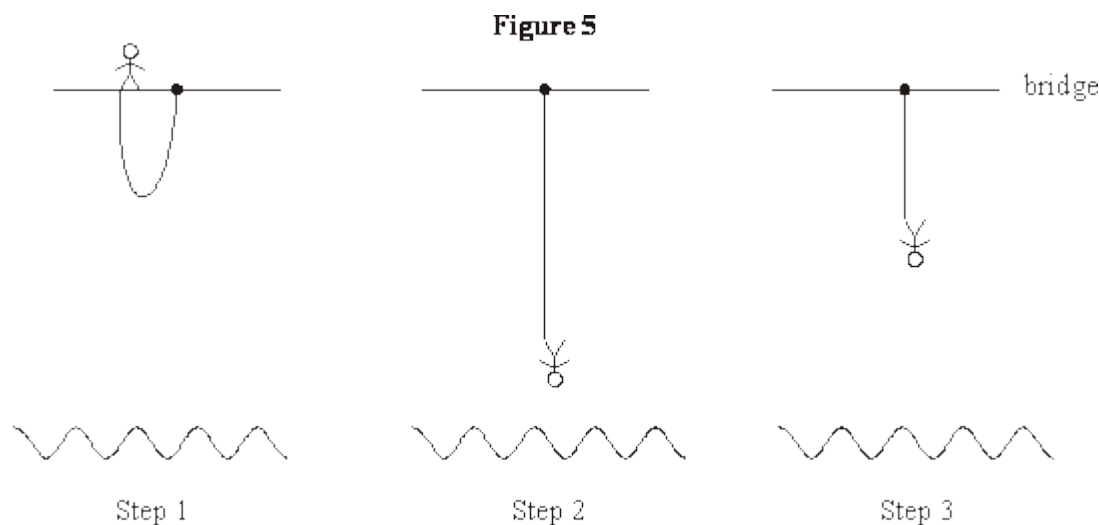
(Total 6 marks)

- (a) (i) Explain what is meant by the spring constant k of a spring.

- (ii) Give the unit of k .

(2)

- (b) The figure below shows the stages in a bungee jump.



In bungee jumping, the participant jumps from a high point attached to an elastic cord (step 1). After a period of free fall, the cord slows the fall of the jumper (step 2) with the system eventually undergoing oscillation (step 3).

A bungee jump is to be set up from a suspension bridge with the jumper of weight 700 N falling towards the river below. The roadway of the bridge is 76 m above the river surface. The bungee cord is adjusted so that the jumper just reaches the river surface at the bottom of the first oscillation.

The unstretched length of the elastic cord is to be 12 m.

- (i) Calculate the time taken before the cord begins to stretch.
- (ii) Show that, when jumping from the bridge to the river, the jumper loses about 53 kJ of gravitational potential energy.
- (iii) Calculate the extension of the cord when the jumper is at the bottom of the first oscillation.
- (iv) The gravitational potential energy is stored in the bungee cord. Calculate the spring constant of the cord.
- (v) Calculate the time period of oscillation of the jumper.

(12)

- (c) (i) Calculate the tension in the cord when the jumper comes to rest for the first time.
- (ii) Forces on astronauts and 'thrill seekers' are often specified in terms of the g force acting on the participants.

$1g$ is equivalent to an acceleration of 9.8 m s^{-2} .

Calculate the maximum g force that acts on the jumper.

- (iii) Hardened thrill seekers prefer their sports to generate $3g$ or more. Without carrying out detailed calculations, suggest the changes that would need to be made to the cord in order to produce a greater g force for the 700 N jumper.

(6)

(Total 20 marks)

16

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)

Mark schemes

1

- (a) resultant force = $11\,000 \times 2.9 = 31900 \text{ (N)}$ ✓

resultant force = thrust – air resistance

OR

$$31\,900 = 230\,000 - \text{air resistance} \checkmark$$

$$198\,000 \text{ (N)} \checkmark$$

3

- (b) Air resistance increases with speed so resultant force decreases with speed ✓

Eventually air resistance = thrust (so no acceleration) ✓

2

- (c) Time to reach maximum height = $2.5/9.8 = 0.255 \text{ s}$ ✓

$$\text{maximum height} = 1.5 + 4.9 \times 0.255^2 = 1.82 \text{ m} \checkmark$$

Time to reach ground from maximum height = 0.61 s giving total time = 0.87 s ✓

OR

$$-1.5 = 2.5t - 0.5 \times 9.8 \times t^2 \checkmark$$

rearrange quadratic gives $4.9t^2 - 2.5t - 1.5 = 0$ and

$$\text{solution } t = \frac{2.5 \pm \sqrt{2.5^2 + 4 \times 4.9 \times 1.5}}{2 \times 4.9} \checkmark$$

Giving solutions 0.86 or – 0.35 hence time = 0.86 s ✓

Allow credit for alternative routes

3

- (d) Starts at 2.5 m s^{-1} and maximum height same but reached earlier ✓

Maximum range no more than 175 m ✓

2

- (e) Motion unchanged vertically / maximum height of P is unchanged: air resistance decelerates P horizontally so less distance travelled. (both points needed) ✓

Air resistance increases with speed: speed is low vertically but very high horizontally (both points needed) ✓

2

[12]

R

3

C

[1]

4

- (a) (i) maximum distance from 1st to 5th image = 139 mm (allow 138 to 140mm) ✓

Any other correctly measured distance(s), to provide additional data, but do not allow the distance from 1st to 2nd image (as this is too small).

Alternatively allow a repeat measurement of the maximum distance for this mark. ✓

E.g. 1st to 4th image distance = 79 mm, 1st to 3rd image distance = 34 mm (allow ± 1 mm on these values)

*If a candidate measures distances which do not go back to the first image the initial velocity, u , will not be zero. Use of the 'suvat' equations is then considerably more complicated. A mark can still be awarded, **provided** the candidate illustrates how g can be calculated **or** correctly calculates g from this value in **(a)(ii)**.*

If the printing process in your centre alters the scale of this diagram, measure the values on your printed papers and mark the scripts accordingly. (Send details to the moderator).

If the candidate is visually impaired and is using a modified paper that alters the scale of this diagram, measure the values on the printed paper and mark the script accordingly.

2

- (ii) Evidence of correct number of time intervals to match the distance used.(e.g Using distance from 1st to 5th marble with 4 time intervals, time = 0.174 s) ✓

Value of $g = 9.18$ or 9.2 m s^{-2} (based on 139 mm and 0.174 s)

*Allow ecf from value of time in **(a)**, and ecf from incorrect measurements in **(b)**, but to allow ecf candidate **must** show workings of the calculation and not just state a value for g*

(Allow also 918 or 920 cm s^{-2} and 9180 or 9200 mm s^{-2}) Answer must have correct unit ✓

*Allow this mark based on a correct calculation from just one measurement of distance in **(a)(i)***

No sf penalty

2

- (b) So image is sharp / less blurred / image is well defined
OR

Any answer referring to 'motion blurring'

Allow reference to 'image' or 'marble'

1

[5]

5

C

[1]

7

- (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 $640 \times$ their 7aii
5800-2560 or 5800-($640 \times$ 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

Higher maximum velocity on graph
 Same initial acceleration / gradient on graph

6
 [16]

8

(a) (i) 11 (m)

B1
 1

(ii) Use of $F = k\Delta L$ or $W = mg$
 Allow use of $\Delta L = 12 \text{ m}$

C1

3400 (N)

A1
 2

(b) Sets $mg = k\Delta L$

C1

1.9 (m)

A1
 2

(c) Correct use of $W = \frac{1}{2}k\Delta L^2$ or $\frac{1}{2}F\Delta L$
 $\Delta L = 5 \text{ m}$

C1

Correct use of $\Delta GPE = mg\Delta h$
 $\Delta h = 25 \text{ m}$

C1

States or uses $(mg\Delta h) - (\frac{1}{2} k\Delta L^2) = \frac{1}{2}mv^2$

C1

19 (m s^{-1}) cnao

A1
 4

- (d) Same kinetic energy when rope begins to stretch

B1

More work done per unit extension / stops in shorter distance

"Shorter time" gets no credit

B1

Increases force on jumper (increasing the risk of injury)

B1

3

[12]

9

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

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 ($1.7 \sin 18^\circ$)

C1

77.3 (W)

OR

Use of $P = Fv$

Correct sub for F ($mg \sin 18^\circ$) or v ($1.7 \sin 18^\circ$)

77.3 (W)

A1

3

[7]

10

(a) $K = \frac{45}{30^2} (= \frac{45}{900} = 0.05)$ or $\frac{d}{45} = \frac{15^2}{30^2} (= \frac{1}{4})$
 $d = 11.25 \text{ (m)}$

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]

11

- (a) $(E_p = mg\Delta h)$
 $= 65 \times 9.81 \times 54$ ✓
 $= 3.44 \times 10^4 = 3.4 \times 10^4 \text{ (J)}$ ✓ (34433)
max 1 if $g = 10$ used (35100 J)
Correct answer gains both marks

2

- (b) $v = \sqrt{\frac{2E_p}{m}}$ 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 $v^2 = 2gs$
don't penalise $g = 10$ (32.863)

2

- (c) $(s = 1/2 gt^2 \text{ or other kinematics equation})$
 $t = \sqrt{\frac{2s}{g}}$ 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 all 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]

12

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

2

- (ii) $(F = ma) = 5800 \times 16.57$ ecf (a)(i) ✓
 $= 96000$ ✓

allow 98600 or 99000 for use of 17

$$(iii) \quad (s = \frac{1}{2}(u + v)t) = \frac{1}{2} \times 58 \times 3.5 \checkmark$$

$$= 100 \text{ (101.50, 102, accept 101 m) } \checkmark$$

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

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

2

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

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

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

3

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

allow their work done from (iv) used as KE

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

accept use of kinematics equation

$$= 170 \checkmark$$

3

[13]

13

(a) (i) divides a speed (from the table) by 10.9

C1

converts speed to m s^{-1} (26.7)

C1

2.4/2.45/2.5 (m s^{-2})

A1

3

(ii) multiples 2.10 by a mass from the table

C1

2810 (N)

A1

2

(b) **any two from**

fuel consumption is high

B1

emissions will also be high

B1

max speed is very high

B1

any one from

wasteful of resources

B1

links high emissions to global warming/specified environmental issue

B1

road safety implications of high speed

B1

max3

[8]

14

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

C1

$6200 \div 1300$

C1

$4.77 \text{ (m s}^{-2}\text{)}$

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]

15

- (a) (i) $k = \text{force/extension}$ (1)

- (ii) N m^{-1} (1)

2

- (b) (i) $s = ut + \frac{1}{2} at^2$ or alt used (1)

$$t^2 = 12/4.9 \text{ (1)}$$

$$1.6 \text{ s (1)}$$

- (ii) weight $\times$ height change seen (1)

$$53200 \text{ J (1)}$$

- (iii) $76 - 12 = 64 \text{ m (1)}$

12

- (iv) $\frac{1}{2} kx^2 = \text{energy stored}$ seen (1)

$$k = 2 \times 53200 / (64)^2 \text{ (1)}$$

$$25.9 \text{ N (1)}$$

- (v) $T = 2\pi\sqrt{(k/m)}$ seen (1)

$$\text{subst (1)}$$

$$1.2 \text{ s (1)}$$

- (c) (i) $F = kx$ seen **(1)**
 $= 25.9 \times 64 = 1660 \text{ N}$ **(1)**
- (ii) $1660/700$ seen **(1)**
 2.4 g **(1)**
- (iii) stiffer cord **(1)**
less elongation so longer natural length **(1)**

6

[20]

16

A

[1]