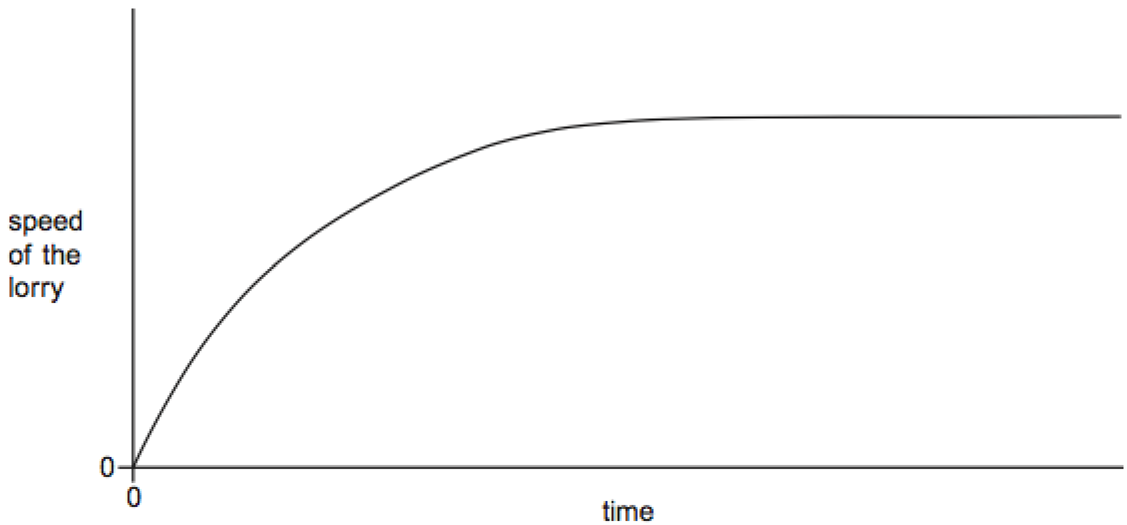
1 A fully-loaded lorry transporting water starts from rest and travels along a straight road. The figure is a graph showing how the speed of the lorry varies with time. The driving force on the lorry remains constant.

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:

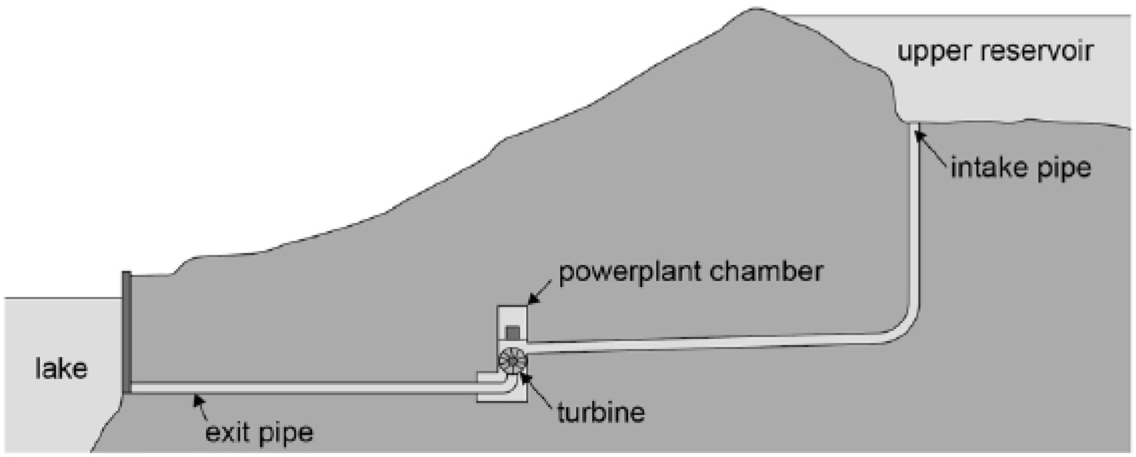
- the shape of the graph in the figure
- the effect of water loss on the initial gradient of the graph
- the effect of water loss on the final speed of the lorry.

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)

2 The diagram below shows a possible design for a pumped storage system used to generate electricity.



Water from the upper reservoir is to fall through a vertical distance of 90 m before reaching a powerplant chamber. The water rotates a turbine in the chamber that drives an electricity generator. After leaving the turbine, the water travels through an exit pipe to a lake.

(a) Show that the maximum possible speed of the water as it arrives at the turbine is about 40 $m\ s^{-1}$.

(2)

(b) The volume of water flowing into the turbine every second is 3.5 m^3.

Estimate the radius of the intake pipe that is required for the system.

pipe radius = ______________________ m

(2)

(c) The water leaves the powerplant chamber at a speed of 12 m s^{-1}.

Calculate the maximum possible power output of the turbine and generator.
Give an appropriate unit for your answer.

density of water = 1000 kg m^{-3}

Maximum power output = ________________ unit = ____________

(4)

(d) Energy losses are estimated to reduce the output power for the turbine and generator to 60% of the value you calculated in part **(c)**.

Explain **two** possible reasons for this energy loss.

1. ____

____

____

2. ____

____

____

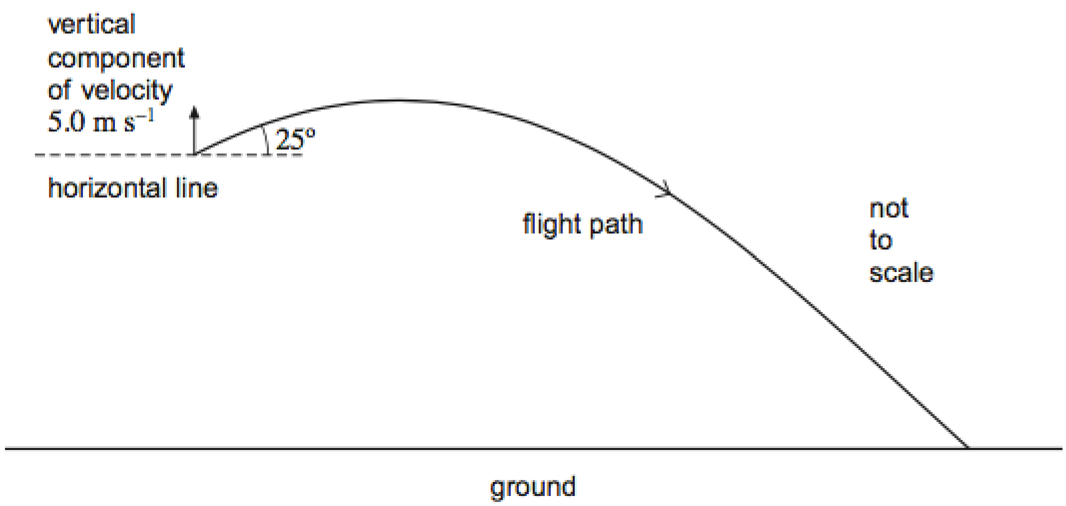
(2)

(Total 10 marks)

3 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.

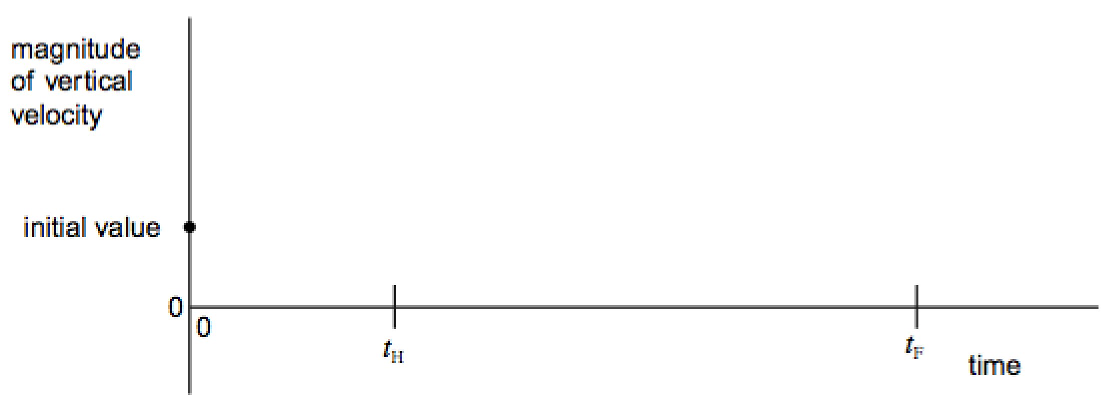
(1)

(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.

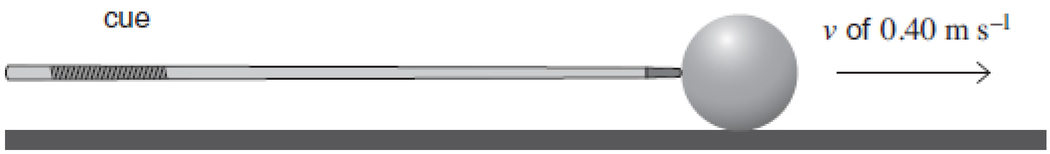
Figure 2



(2)

(Total 11 marks)

4 The diagram shows a cue striking a stationary snooker ball of mass 140 g. The contact time of the cue with the ball is 12 ms. The ball leaves the cue with a velocity *v* of 0.40 m s^{-1}



(a) Show that there is an impulse of about 6×10^{-2} N s when the cue is in contact with the snooker ball.

(2)

(b) Calculate the average force exerted by the cue on the snooker ball when they are in contact.

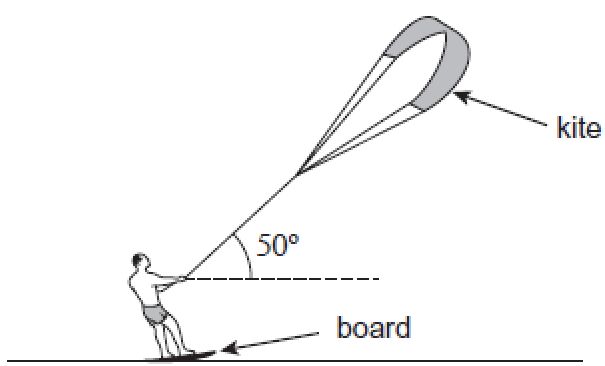
average force ____________________ N

(2)

(Total 4 marks)

5 **Figure 1** shows a kite boarder holding a line that is attached to a kite.

Figure 1



The wind blows the kite and the kite boarder moves at a constant speed across a level water surface. The tension in the line is 720 N and the line makes an angle of 50° to the horizontal.

(a) (i) Calculate the vertical component of the tension in the line.

vertical component of tension ____________________ N

(2)

(ii) The kite boarder has a mass of 58 kg.

Calculate the normal reaction of the board on the kite boarder.

normal reaction ____________________ N

(2)

(iii) Suggest how the answer to part **(a)(ii)** compares with the upthrust of the water on the board.

Consider the board to have negligible mass.

____

____

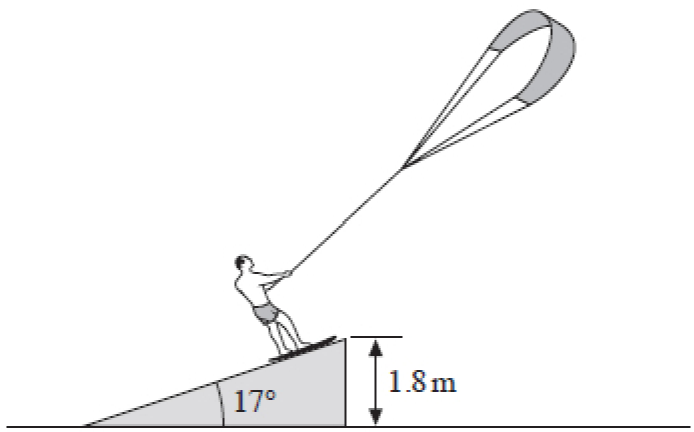
____

____

(2)

(b) **Figure 2** shows the kite boarder about to perform a jump using a ramp.

Figure 2



The end of the ramp is 1.8 m above the water surface. The kite boarder leaves the ramp at a velocity of 12 m s^{-1} and at an angle of 17° to the horizontal. The kite boarder lets go of the line at the instant he leaves the ramp.

Calculate the speed with which the kite boarder enters the water.

Assume that the kite boarder is a point mass and ignore the effects of air resistance.

speed ____________________ m s^{-1}

(4)

(Total 10 marks)

6 (a) Define the moment of a force about a point.

___

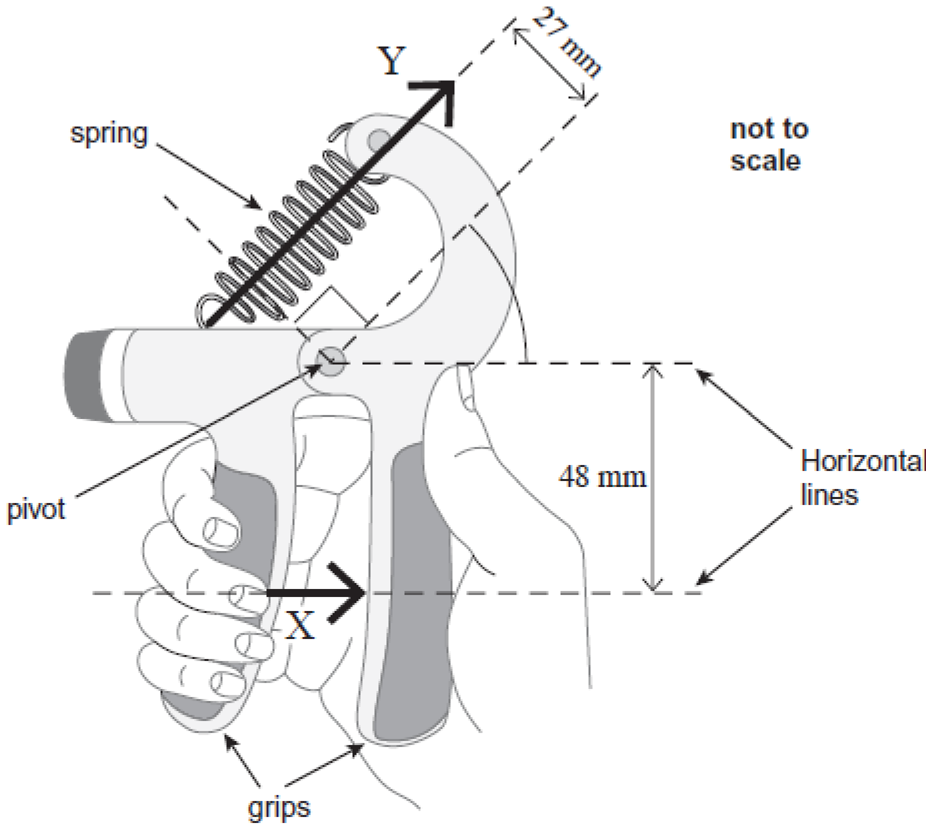
___

___

___

(2)

(b) The diagram shows a gripper which is used for hand strengthening exercises.



The diagram shows the gripper being squeezed. In this situation, the gripper is in equilibrium. The force produced by the fingers is equivalent to the single force **X** of magnitude 250 N acting in the direction shown above. A force, **Y**, is exerted by the spring which obeys Hooke's law.

(i) Calculate the moment of force **X** about the pivot. State an appropriate unit.

moment = ____________________ unit __________

(2)

(ii) Calculate force $\mathbf{Y}$.

force = ____________________ N

(2)

(iii) The extension of the spring is 15 mm.

Calculate the spring constant k of the spring. Give your answer in N m^{-1}.

spring constant = ____________________ N m^{-1}

(2)

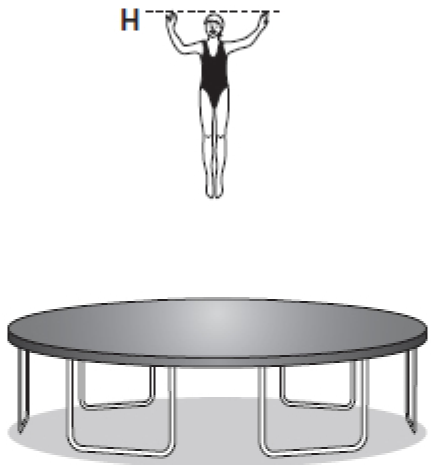
(iv) Calculate the work done on the spring to squeeze it to the position shown in the diagram.

work done = ____________________ J

(2)

(Total 10 marks)

7 The diagram shows a girl bouncing vertically on a trampoline. The highest point that she reaches is **H**.



Describe the energy changes involved as the girl bounces from position **H** and back to the same position shown in the diagram.

You should consider the energy losses that occur during this motion.

____

____

____

____

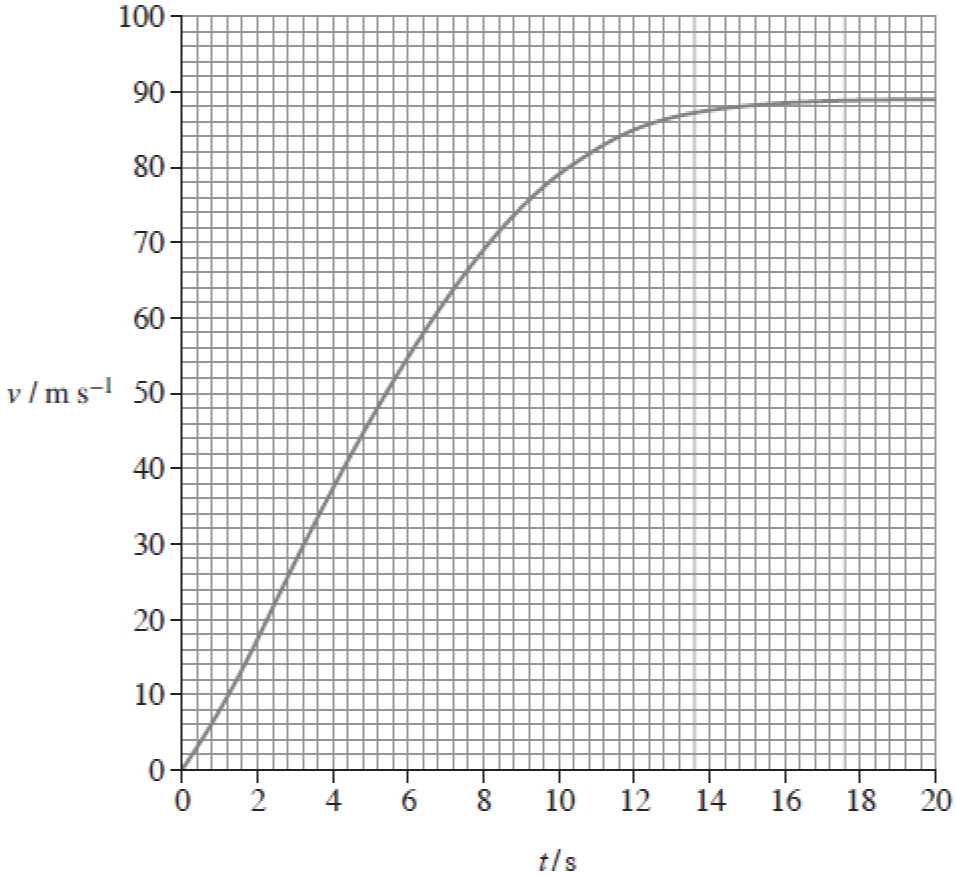
____

(Total 3 marks)

8 **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)

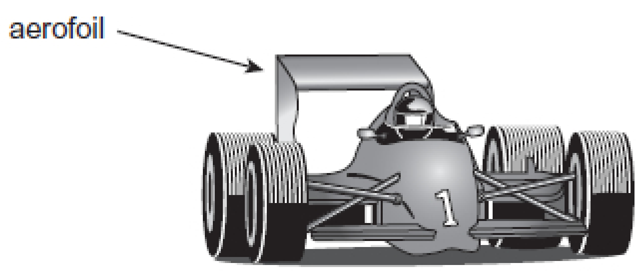
(iv) Calculate the power, in kW, of the car at the maximum speed during the test drive.

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.

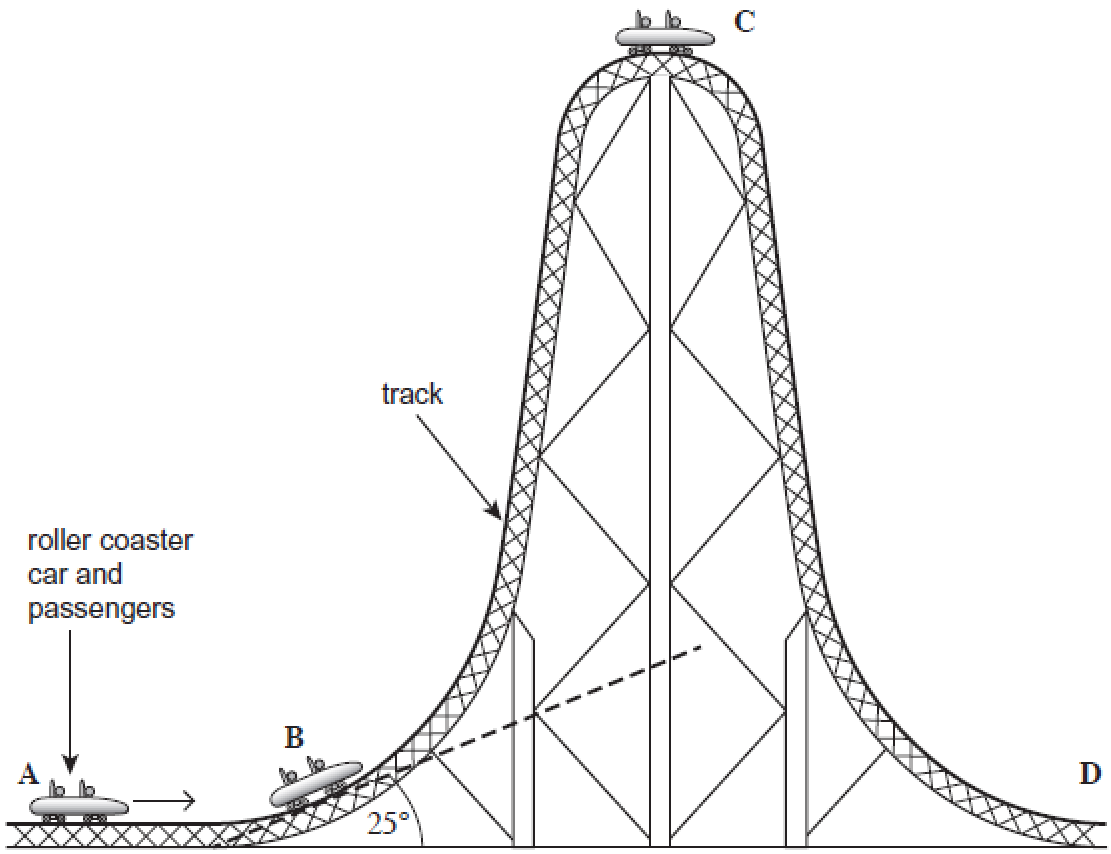
Explain why the velocity varies in the way shown in the graph.

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)

9 The following figure shows a roller coaster car which is accelerated from rest to a speed of 56 m s^{-1} on a horizontal track, **A**, before ascending the steep part of the track. The roller coaster car then becomes stationary at **C**, the highest point of the track. The total mass of the car and passengers is 8300 kg.



(a) The angle of the track at **B** is 25° to the horizontal. Calculate the component of the weight of the car and passengers acting along the slope when the car and passengers are in position **B** as shown in the image above.

component of weight ____________________ N

(2)

(b) (i) Calculate the kinetic energy of the car including the passengers when travelling at 56 m s^{-1}.

kinetic energy ____________________ J

(2)

(ii) Calculate the maximum height above **A** that would be reached by the car and passengers if all the kinetic energy could be transferred to gravitational potential energy.

maximum height ____________________ m

(2)

(c) The car does not reach the height calculated in part (b).

(i) Explain the main reason why the car does not reach this height.

____

____

____

____

(2)

(ii) The car reaches point **C** which is at a height of 140 m above **A**. Calculate the speed that the car would reach when it descends from rest at **C** to its original height from the ground at **D** if 87% of its energy at **C** is converted to kinetic energy.

speed ____________________ m s^{-1}

(2)

(Total 10 marks)

10 The units of physical quantities can be expressed in terms of the fundamental (base) units of the SI system. In which line in the table are the fundamental units correctly matched to the physical quantity?

	Physical quantity	Fundamental units	
A	charge	$A\ s^{-1}$	○
B	power	$kg\ m^2\ s^{-3}$	○
C	potential difference	$kg\ m^2\ s\ A^{-1}$	○
D	energy	$kg\ m^2\ s^{-1}$	○

(Total 1 mark)

11 Which of the following is a scalar quantity?

A kinetic energy ○

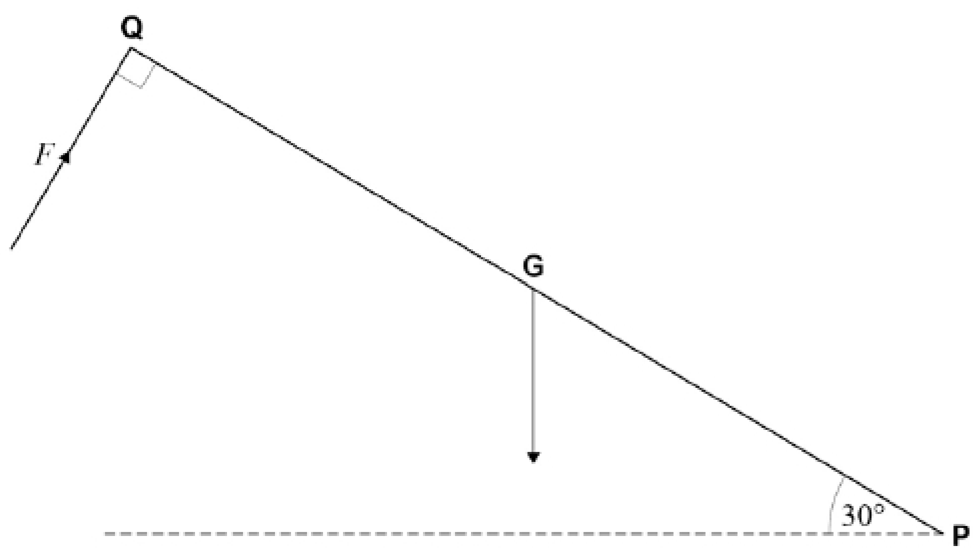
B momentum ○

C force ○

D acceleration ○

(Total 1 mark)

12 A car bonnet, represented by **QP**, of mass 12 kg is pivoted at **P**. Its weight acts at **G** where **QG** = **GP** = 1.0 m.



What force, F, acting perpendicular to **QP** as shown, is required to hold the bonnet at 30° to the horizontal?

A 29 N

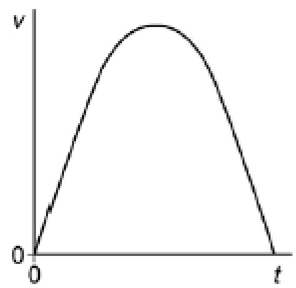
B 51 N

C 59 N

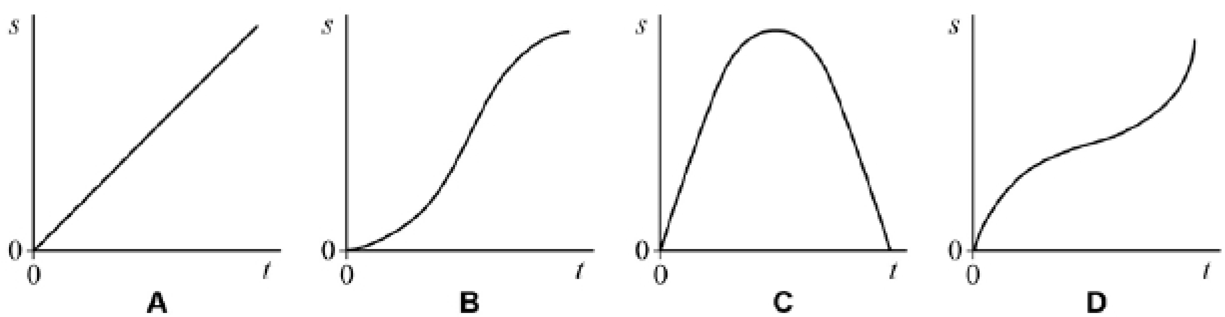
D 136 N

(Total 1 mark)

13 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)

14 A body of mass 4 kg falls vertically through the air.

What is the acceleration of the body when the magnitude of the air resistance is 30 N?

A	$17.3\ \mathrm{m\ s^{-2}}$	⬭
B	$7.7\ \mathrm{m\ s^{-2}}$	⬭
C	$2.3\ \mathrm{m\ s^{-2}}$	⬭
D	$0.4\ \mathrm{m\ s^{-2}}$	⬭

(Total 1 mark)

15 A stone of mass 0.4 kg is projected horizontally at a speed of $6.0\ \mathrm{m\ s^{-1}}$ from the top of a wall, 5.0 m above the surrounding ground. When it arrives at the ground its speed is $10\ \mathrm{m\ s^{-1}}$.

How much energy is lost by the stone in falling through the air?

A	2.4 J	⬭
B	6.8 J	⬭
C	12.8 J	⬭
D	14.4 J	⬭

(Total 1 mark)

Mark schemes

1

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:

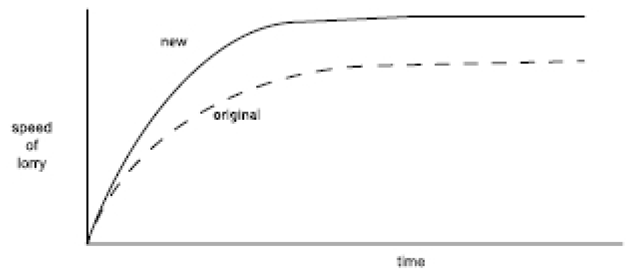
1. the acceleration is the gradient of the graph (or the link between acceleration and gradient is clearly made)
2. the acceleration is greatest initially / (continuously) decreases
3. a constant final velocity / terminal velocity is shown by the graph becoming <u>horizontal / flat</u>.

Second Group:

4. initial acceleration or the initial gradient is the same or only <u>slightly</u> 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]

2 (a) E_k E_p or $v = \sqrt{2gh}$ ✓

$= \sqrt{2 \times 9.81 \times 90}$

$= 42.0$ (m s^{-1}) ✓

First mark for realising energy transformation from GPE to KE.

Second mark for correct answer.

2

(b) calculation of area of pipe (=0.0833 m^2) ✓

radius = $\sqrt{\frac{0.0833}{\pi}}$ = 0.16 (m) ✓

2

(c) mass of water / s = 3500 kg ✓

energy available per second = $0.5 \times 3500 \times (42^2 - 12^2)$ ✓

= 2.8 ✓ MW ✓

4

(d) heat / mechanical friction in turbines ✓

friction at walls of pipes / turbulence ✓

electrical heating in wires ✓

*Do **not** allow (friction) bald.*

Seat of loss must be clear.

Max 2

[10]

3 (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
½ ~~m~~ v^2 = ~~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)
$s = 11 \times 1.3 = 14$ (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'*

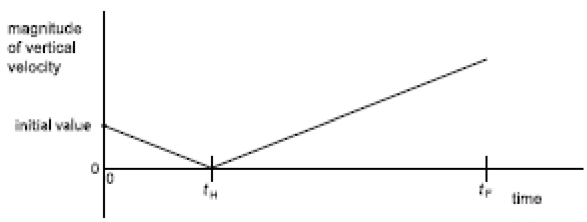
1

(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]

4 (a) $F\Delta t = \Delta p$ (or stated in words)
$\Delta p = 0.14 \times 0.4$ or 0.056

Accept use of F = ma with / in FΔt

Accept $4.67 \times 12 \times 10^{-3} = 0.056$

2

(b) $0.056 / 12 \times 10^{-3}$ or $0.06 / 12 \times 10^{-3}$
4.7 (4.67) (N)

Condone power of 10 error in t for C1 mark

Allow 1 sf answer of 5 (N) for 0.06 (kg m s^{-1})

2

[4]

5 (a) (i) 720 sin 50° or 720 cos 40°
550 (552) (N)

2

(ii) 58 × 9.81 or 569 seen
19 (N)

Allow 569-(their (a)(i) for 2 marks

2

(iii) Upthrust is same as normal reaction (or same as their (a)(ii)
Newton's 2nd or 3rd Law or Archimedes' Principle reason
given

2

(b) u_h = 12 cos 17° or 11.5 (m s^{-1}) seen
u_v = 12 sin 17° or 3.5 (m s^{-1}) seen
Use of $v^2 = u^2 + 2as$ with either 3.5 or 1.8 or v_v = 6.9 (m s^{-1})
13.4 (m s^{-1})

OR

Initial KE = 0.5 × 58 × 12^2 or 4176 (J) seen
ΔGPE = 58 × 9.81 × 1.8 or 1024 (J) seen
or v = √(2 × 9.81 × 1.8) or 5.9 (m s^{-1}) seen
Final KE = 5200 (J) or v = √(2.KE/m)
13.4 (m s^{-1})

Allow valid suvat arguments that use time of flight

4

[10]

6 (a) (moment =) Force x <u>perpendicular</u> distance ✓
<u>between line of action</u> (of force) <u>and pivot / point ✓</u>

both marks need to be clear − avoid bod
if the force is named specifically (e.g. weight) mark the work but give a maximum of 1 mark
ignore extra material such as law of moments

2

(b) (i) moment = 250 × 0.048 = 12 ✓ (allow 12000 for this mark)

only allow answers in other units if consistent e.g. 1200 N cm

N m ✓ (stand alone mark if no number is present but only for N mm, N cm and N m)

no working shown can gain full marks if answer and unit are consistent
newton should be upper case if a symbol and metre should be in lower case (but only penalise if it is very obviously wrong)

2

(ii) *Y* × 0.027 = 12 OR Y = 12 / 0.027 ✓
(allow use of 12 and 27 for this mark)
= 440 (N) ✓ (444.4 N) CE from (i)

Y = (i) / 0.027
treat power of 10 error as an AE
note 450 N is wrong
1 sig fig is not acceptable

2

(iii) *(k = F / ΔL)*
= 444.4 / 0.015 ✓ CE from (ii)
= 3.0×10^4 (Nm^{-1}) ✓ (29630 Nm^{-1})

k = (ii) / 0.015

treat power of 10 error as an AE

using 440 gives 2.9×10^4 (Nm^{-1})

1 sig fig is not acceptable

2

(iv) W (= ½ $F\,\Delta L$) = ½ × 444.4 × 0.015
Or
W (= ½ $k\,\Delta L^2$) = ½ × 29630 × 0.015^2 ✓
(give this mark for seeing the digits only ie ignore powers of 10 and allow CE from (ii) or (iii) as appropriate
= 3.3 (J) ✓ (3.333 J)

W = ½ × (ii) × 0.015

W = ½ × (iii) × 0.015^2

treat power of 10 error as an AE

if either equation misses out the ½ no marks

common CE is to use F = 250 N which can be used giving W = 1.9 J

2

[10]

7 GPE to KE and / or elastic potential (and reverse)

Energy is lost due to work done on air / trampoline

Work done by child (on trampoline) makes up for energy losses

No B1 mark for an incorrect energy change

Accept air resistance for an energy loss

[3]

8 (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]

9 (a) 8300 × 9.81 OR = 81423 ✓
(8300 × 9.81 sin 25)
= 3.4×10^4 (N) ✓ (34 411 N) ecf from first line unless g not used

msin25 gets zero

Penalize use of g = 10 <u>here only</u>
(35 077 N)
Allow 9.8 in any question

Correct answer only, gets both marks for all two mark questions

2

(b) (i) ($E_k = ½mv^2$)
= ½ × 8300 × 56^2 ✓
= 1.3×10^7 (J) ✓ (13 014 400) allow use of 8300 only

In general: Penalise transcription errors and rounding errors in answers

2

(ii) *mgh* = KE (13 014 400) for *mgh* allow GPE or E_p
OR 13 014 400 / 81 423 ✓
h = 160 (m) ✓ (159.8) ecf 1bi

Allow use of suvat approach

2

(c) (i) (work done) by friction \ drag \ air resistance \ resistive forces ✓
(energy converted) to internal \ thermal energy ✓

Allow 'heat'

2

(ii) 0.87 x (8300 x 9.81 x 140 = 9 917 000) OR $v = \sqrt{\left[\frac{2 \times (9\,917\,000)}{8300}\right]}$ ✓
= 49 (= 48.88 ms^{-1}) ✓

87% of energy for 140m or 160m only for first mark.
Use of 160 (52.26) and / or incorrect or no % (52.4) gets max 1 provided working is shown

Do not credit suvat approaches here

2

[10]

10 B

[1]

11 A

[1]

12 B

[1]

13 B

[1]

14 C

[1]

15 B

[1]

Examiner reports

1 The question gave rise to a good spread of marks. It was a question that tested the organisational skills of the students. Those that responded to the bullet points and gave physical justification for their ideas scored very well. Others often missed out the first bullet point in which they could have recorded some basic physics. They then gave an answer like, 'it would end up going faster', but only justified this statement by repeating back words from the question like, 'because it leaks water and the driving force is the same'. The other approach by weaker responses was to have an idea about the final speed but then repeat this idea in several different alternative sentences. Middle range responses did try to work through logically but just slipped up on one or two issues. For example they said the second lorry had less water so would accelerate more initially. However the question points to the lorries having the same initial mass. Another common misconception was that the terminal velocity is a fixed value that both lorries had to achieve. So the student may correctly say that as the mass is less the acceleration is more but then they would reach the wrong conclusion that it achieves the same terminal velocity but quicker. Finally there was the usual problems associated with using incorrect terms. Moves rapidly, accelerates, increases its acceleration are all used to describe the initial movement of the first lorry. Then later instead of referring to the acceleration reducing many students talked about the lorry decelerating or even going backwards.

3 (a) (i) The answers seen split clearly into two groups. The largest of which scored the mark because they could resolve a vector into its components. The smaller group did not score because they thought the question could be approached through the equations of motion.

(ii) Slightly fewer scored full marks compared to those in 2(a)(i) because, although just as many used a vector rather than an equation of motion approach, there was more opportunity for things to go wrong. There was more data to choose from with the velocity and the vertical component of velocity both available.

(b) (i) A majority of students performed well choosing the correct equation of motion to obtain the correct answer. There were a number of students who used the wrong equation and / or data. Also equal numbers scored one mark either by answering with a wrong answer given to two significant figures or by giving the correct answer but not using two significant figures.

(ii) Again the vast majority had no problem with this question especially when an error carried forward was allowed. Those who got it wrong normally wanted to include a non-zero acceleration and used the value of 'g'.

(c) These questions were generally answered very well.

(d) The overall correct shape was achieved by a majority of students. Some students did not realise that the lines on the graph needed to be straight because of the constant acceleration due to gravity. An equal number seemed to guess at the answer and had the maximum speed at the time corresponding to the maximum height.

4 Both parts were answered well.

5

(a) Part (i) was correctly answered by over 85% of students. Almost all students knew that the weight of the kite boarder was necessary in part (ii), but only half realised that it needed to be subtracted from the answer to part (i). Most students struggled with part (iii), with only about 20% of students gaining full marks. Sketched force diagrams, which would have aided the comprehension of the system, were rarely seen.

(b) This question was challenging to students, with only about 20% gaining full credit. There were two valid methods to solving this question: using suvat equations or considering energy changes.

6

The moments component of this question was answered relatively well but students ran into difficulties in calculating the work done on a spring. The definition required in (a) split the students into three equal groups. The weakest group could get as far as saying that a moment is a force times a distance. The next group made the addition that it is the perpendicular distance to the pivot without defining what the line is perpendicular to. The last group got the whole definition correct by adding in the line of action of the force.

A vast majority got (b)(i) correct. Even the small cohort who chose to work in non-SI units did so without error. The most significant error seen was to give the unit of moment as N m^{-1} rather than Nm.

(b)(ii) was again answered well. Weaker students had issues in a number of ways. Some wanted to use a force of 250 N taken from the diagram. Again, using the diagram, others wanted to incorporate the 45 degree angle in some trigonometrical expression. The final group had issues over powers of 10. Students who did not work in SI units tended to feature more in this group.

Students performed well on (b)(iii) but (b)(iv) highlighted cracks in their knowledge. Most did not appreciate that the average force on a spring being squeezed is half the maximum force. Most used the equation work done equals force times distance and left out the factor of one half. The other problem encountered was students inability to choose the correct data to substitute from previous sections of the question.

7

The majority of answers were limited to describing energy changes. Very few students considered energy losses, even though this was explicit in the question. Almost no answers addressed how the girl would return to the same height.

8

(a) No credit was given in parts (i) or (ii) for using suvat equations, as the acceleration is not constant. Evidence of “counting squares” for part (i) and a tangent for part (ii) were expected to be seen. A majority of students comfortably coped with parts (iii) and (iv).

(b) Students found this question very accessible, with just over 50% gaining at least four marks. Answers of the highest quality showed a detailed understanding of the effect of the DRS on the duration of the acceleration. A common misconception was that the initial acceleration would be greater and therefore the start of the graph would be steeper.

9 (a) The number of mistakes on this question was surprising. Most candidates knew it was something to do with 'cos' or 'sin' but they resolved incorrectly. Common errors included resolving the mass rather than the weight (8300sin25), finding the wrong component (mg cos25), incorrect trigonometry (mg / sin25) or simply calculating the weight without resolving (8300 × 9.81). Plenty of practice and assessment on resolution of forces on inclined planes is needed for many students.

(b) (i) These presented few problems apart from an occasional power of ten error or use of weight instead of mass.

(ii) As above.

(c) (i) There were lots of really good answers on this question with correct descriptions of energy transformations and mention of friction and 'thermal energy'.

However, some mentioned the appropriate force (friction, drag, etc.) but not the form of energy (internal, 'thermal', 'heat') and vice versa. Some candidates do not know the difference between a form of energy and the process that causes the transformation: 'kinetic energy is converted to friction' being a typical comment.

(ii) This was generally well done, but some used 160 m instead of 140 m.

Some candidates used a 'suvat' equation but this is incorrect physics due to the fact that the acceleration is not constant. Students must first identify if a situation involves constant velocity, uniform acceleration or changing acceleration. If the acceleration is changing, the kinematics equations used at AS will not be applicable.