Examiners' Report

June 2010

GCE Physics 6PH01

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Introduction

Most candidates sitting this paper took the opportunity to demonstrate their understanding of the full range of topics in this unit. The majority showed good progression from GCSE. The responses for all questions, covered the full range allowable, with full marks being seen frequently for all question parts and indeed being the mode in many cases, including 6 and 7 mark calculation sections and one 3 mark explanation.

Having said this, full marks were less common for parts requiring explanation than they were for calculations. Candidates showed performance ranging from basic interpretations using simpler terminology and carrying out single step calculations, to full explanations with scientific terminology and carrying out unstructured calculations involving several steps.

Section A

In this part, candidates missed out any of the multiple choice questions very rarely indeed.

In increasing order of difficulty, the multiple choice questions were questions 10, 1, 8, 2, 3, 4, 6, 5, 7 and 9.

Questions 1, 8 and 10 were answered correctly by a sizeable majority, and questions 2 and 3 by a good majority. The rest got a minority correct response.

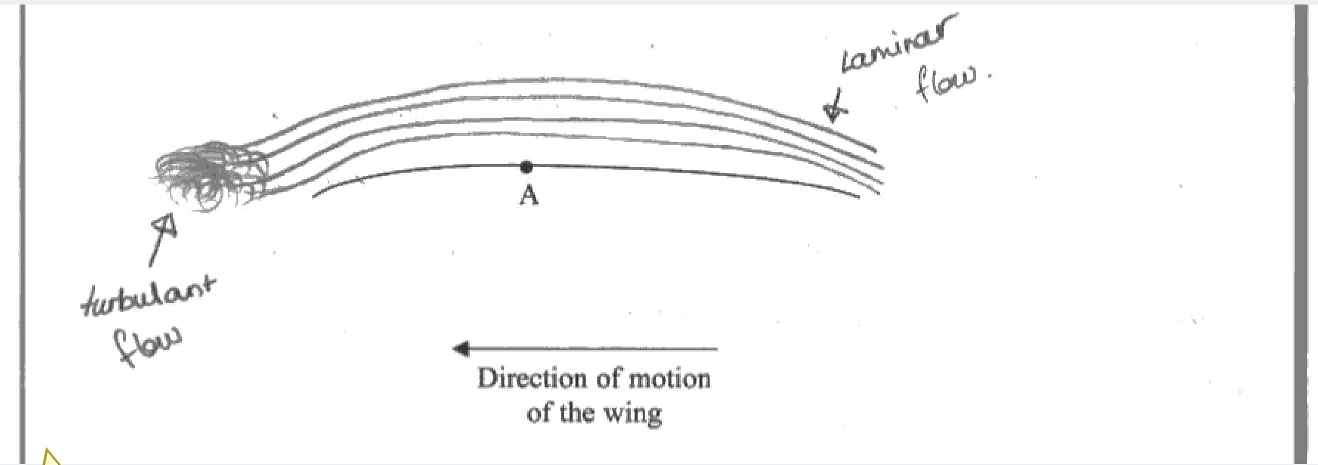
In some cases, a single incorrect choice was most popular. In question 2, many candidates chose C, although they all seemed to appreciate the importance of the direction of a force in question 17. In question 3, the most common incorrect answer was A, where candidates did not convert km to m. A very common response to question 4 was B, suggesting that candidates applied Newton's first law, but for a straight line path.

A frequent choice in question 5 was A, the units for force. In question 7 the most frequent response was B, taking no account of the greater speed attained by the bricks falling a greater distance. The great majority chose B in question 9, believing lift must be greater than weight to climb even though they were told the velocity was constant.

Question 11

Most candidates produced a diagram showing recognisable laminar and turbulent flow and got two marks. The drawings of turbulent flow were of quite variable quality, some candidates apparently thinking any messy scribble would be a suitable representation.

A sizeable minority drew the flow in the wrong direction and, if they did not add arrows, it had to be assumed they had the types of flows reversed. Others did not show the change at A as instructed, some even leaving it until after the portion of wing drawn.



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Examiner Comments

This candidate has labelled laminar and turbulent flow, but makes all the mistakes mentioned. The two types of flow are in the wrong order, te change is nowhere near A and the turbulent flow drawing is of poor quality.

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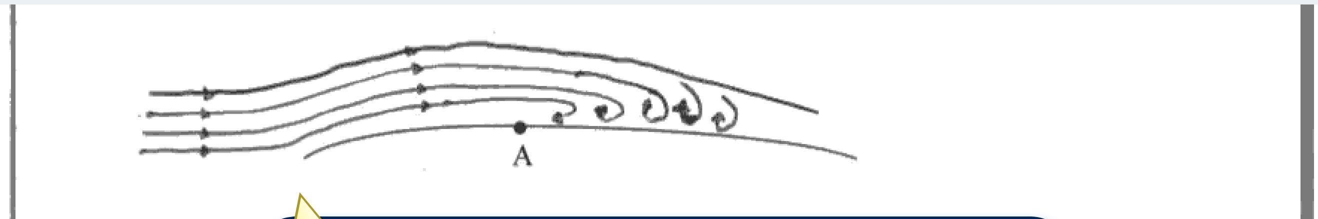
Examiner Tip

Pay careful attention to all the information given. For example, in this case the direction of movement was shown on the diagram and the point of change was clearly given as A, but both have been ignored.



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Examiner Comments

This is a good response and shows realistic turbulent flow as it would be seen in photographs of such a situation.

Question 12

Most candidates knew the difference between elastic and plastic in terms of the ability to return to the original shape, but quite often did not mention removal of the deforming force.

The second part of the question was tackled less successfully and often ignored. Many did not refer to a named material or object, or used a different one to illustrate each type of behaviour. Others, did not explain what caused the change in the type of deformation for a given material, i.e. increasing the force applied.

This question was clearly marked as one where quality of written communication (QWC) was assessed and in this paper that means that work must be clear and organised in a logical manner, using technical terminology where appropriate. References to 'stretching' and 'when released' would have been better in terms of applying or removing deforming forces.

A number of candidates used technical terminology relevant to the topic imprecisely or out of context. For example mentioning the elastic limit, but not linking it to a maximum force, extension, stress or strain. Rubber was frequently named as the material but was not a suitable example. Successful responses usually referred to a spring or to copper wire.

*12 Explain the difference between elastic deformation and plastic deformation. Use the behaviour of the same material or object to illustrate both types of deformation.

Elastic deformation is where the object obeys Hooke's law. For a given load, the extension of the material is proportional to the force applied. In elastic deformation once the force is removed the material will return to its original shape. However in plastic deformation, the material has passed its elastic limit (no longer obeys Hooke's law) so when the force is removed it is permanently deformed.

(Total for Question 12 = 4 marks)

ResultsPlus

Examiner Comments

This candidate makes an incorrect reference to Hooke's law, but describes elastic and plastic deformation correctly, with reference to removing the deforming force. Elastic limit has been referred to, but incorrectly linked to Hooke's law and with no reference to a maximum force. No material has been named.

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Examiner Tip

Be sure to follow each part of a set of instructions. Underlining or highlighting can help you keep on track.

*12 Explain the difference between elastic deformation and plastic deformation. Use the behaviour of the same material or object to illustrate both types of deformation.

Elastic deformation is when the object returns to its original shape once the force exerted on it is removed. Plastic deformation is when an object has ~~been~~ had force exerted on it past its elastic limit and the shape is permanently distorted once the force is removed. For example in a spring when a load is attached, there is elastic deformation up to its elastic limit ie. the spring returns to its original shape. Once the load is greater than its elastic limit there is plastic deformation when the spring is permanently stretched.

(Total for Question 12 = 4 marks)

ResultsPlus

Examiner Comments

This candidate has tackled the question in a logical order with clear statements linked to each part of the question for full marks.

Question 13(a) (i)

The great majority found the component correctly. A few used sine instead of cosine or divided instead of multiplying. A few showed signs of confusing distance and speed.

(i) Show that the initial horizontal component of velocity for the droplet is about 1 m s^{-1}.

(2)

$0.4 \cos 70° = 0.137\ ms^{-1}$

ResultsPlus

Examiner Comments

This candidate has used distance to attempt to find the velocity component.

ResultsPlus

Examiner Tip

Be sure to distinguish clearly between distances and velocities in projectile questions.

Question 13(a) (ii)

Most candidates correctly found the vertical component and many went on to find the time of flight, but there were often problems with the final part. Those using appropriate equations of motion were sometimes confused in their use of initial and final velocity and a significant minority did not apply the acceleration due to gravity negatively.

A number either applied acceleration to the horizontal motion or did not apply it to the vertical motion. Some candidates, even when they drew a correct parabolic path, treated the motion as a straight line and attempted to find y by use of tangent in a right angled triangle with horizontal angle 70º.

Many candidates assumed the final vertical component of velocity was zero and used $v^2 = u^2 + 2as$. This condition was not implied in the question and may not always be assumed to be the case.

(ii) Calculate the vertical distance, y, to the insect if the droplet hits the insect.

(5)

$3.5 \sin 70 = 3.29$

$v = \frac{s}{t}$ $t = \frac{s}{v} = \frac{0.4}{1.2} = \frac{1}{3}$ s

$\frac{1}{3} \times 3.29 = 1.097$ m

≈ 1.1 m

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Examiner Comments

This example shows the vertical component and time of flight, although it could have been improved by naming the component as such.

The final calculation is simply speed multiplied by time and ignores acceleration for the vertical motion.

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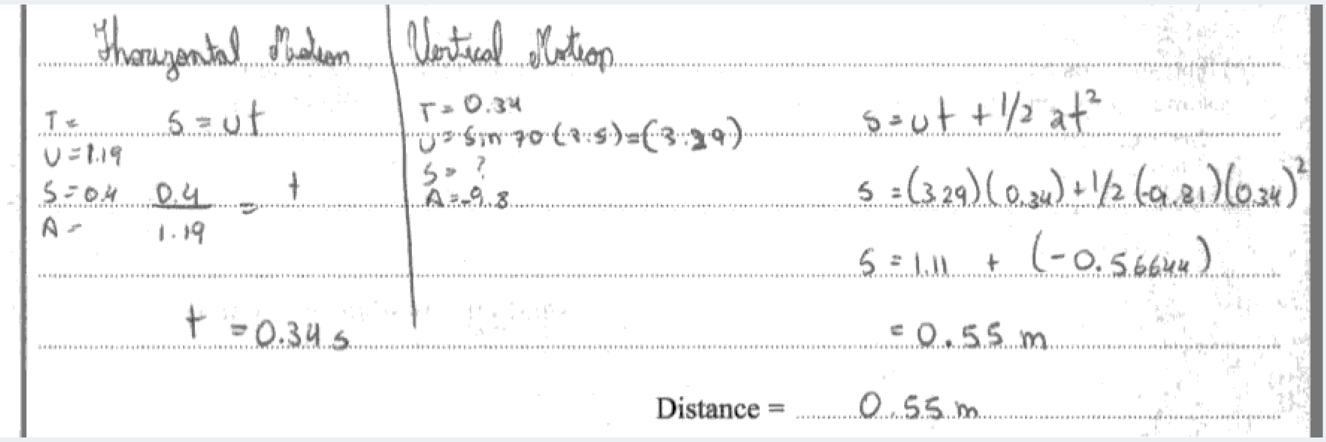
Examiner Tip

In projectile problems, be sure to separate motion clearly into horizontal motion, with no acceleration, and vertical motion, with constant acceleration.



Horizontal Motion

T =
U = 1.19
S = 0.4
A =

$s = ut$

$\frac{0.4}{1.19} = t$

$t = 0.34\,s$

Vertical Motion

T = 0.34
U = sin 70 (3.5) = (3.29)
S = ?
A = -9.8

$s = ut + \frac{1}{2}at^2$

$s = (3.29)(0.34) + \frac{1}{2}(-9.81)(0.34)^2$

$s = 1.11 + (-0.56644)$

$= 0.55\,m$

Distance = 0.55 m

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Examiner Comments

This candidate has very clearly separated horizontal and vertical motion and has set out the relevant *suvat* quantities before starting.

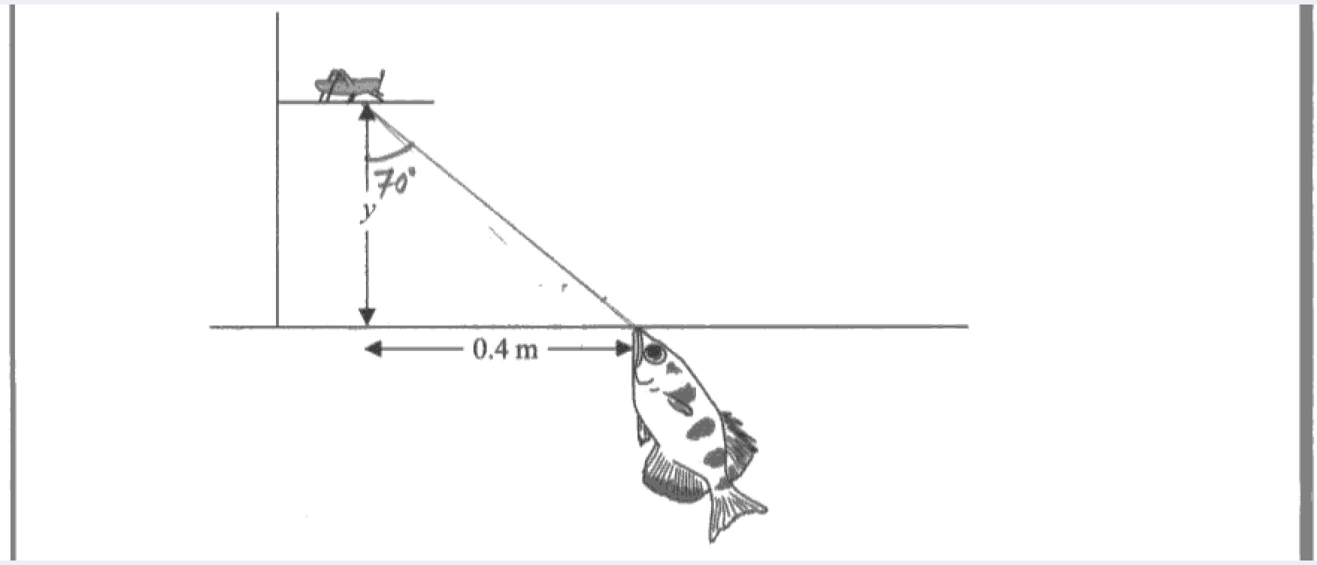
ResultsPlus

Examiner Tip

When using equations of motion, listing the suvat quantities can ensure you use the correct values and also helps when selecting which equation to use. Each equation has one quantity missing, so you know to use the equation with the three quantities you know and the one you want to find out!

Question 13(b)

About two thirds completed the diagram completely. Some missed it entirely, but most of the rest of the candidates drew a straight line, perhaps as part of their solution to part (a) (ii). The quality of some of the lines intended to be straight, suggested that some candidates may not have had rulers.



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Examiner Comments

This candidate has drawn a straight line rather than a curve and has also confused the angle to the vertical and the horizontal.

Question 14(a)

A bare majority completed this part fully. Many just found the product of density and volume and ignored the incorrect power of ten or just changed it! Correct answers often included a written statement that upthrust = weight of displaced liquid. Some candidates lost a mark by use of g = 10 N/kg instead of 9.81 N/kg.

(a) Show that the upthrust is about 8×10^{-4} N. (2)

$1300 \times (6.5 \times 10^{-8}) = 8.45$

$= 8 \times 10^{-4}$ N

ResultsPlus

Examiner Comments

This answer correctly calculates mass, although it doesn't say so, and uses the similarity of the value 8 to that in the question to equate it to the required value, ignoring the incorrect power of ten.

If mass = density x volume had been written down as the first step, the candidate might have remembered that g was required to find weight.

ResultsPlus

Examiner Tip

Write down formulae, before substituting the values.

(a) Show that the upthrust is about 8×10^{-4} N. (2)

volume of liquid displaced = volume of sphere = 6.5×10^{-8} m^3

mass of liquid displaced = density x volume = $1300 \times 6.5 \times 10^{-8} = 8.45 \times 10^{-5}$

upthrust = weight of liquid displaced

= mass x g = $8.45 \times 10^{-5} \times 9.81 = 8.28945 \times 10^{-4}$ N = 8×10^{-4} N (1sf)

ResultsPlus

Examiner Comments

This answer is very well set out, explaining what is being found at each stage.

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Examiner Tip

Set out your answers in clear stages, showing what is being found at each stage.

Question 14(b)

A majority of candidates selected the correct Stokes' law equation, substituted a force and other correct values, rearranged and solved it for viscosity.

Unfortunately, only about half of the candidates had calculated the viscous force using the upthrust they had just calculated and the weight which was given. Many simply used the upthrust or the weight alone. Candidates who used a diagram or wrote out something like weight = upthrust + drag were much less likely to make this error.

Some candidates thought v in $F = 6\pi r\eta v$ represented volume. Others substituted the density value for viscosity, calculated F using that and gave the result as their answer for viscosity.

A surprising number of candidates had remembered the equation for viscosity based on the difference in densities: $\eta = 2r^2g(\rho1 - \rho2)/9v$. In order to use it, they first had to calculate the density of the sphere using mass and volume, although some liked to make things even more complex and used radius rather than volume.

As in previous examinations, such as with the range formula for projectiles, candidates who successfully complete problems using material beyond the specification are given full credit. In this case, however, candidates taking that approach introduced many more opportunities for error and gave themselves much more work.

(b) The terminal velocity is found to be 4.6×10^{-2} m s^{-1}. Use this value to show that the viscosity of the liquid is about 2 kg m^{-1} s^{-1}.

(3)

$F = 6\pi\eta r v$

$F = 6 \times \pi \times 1300 \times 2.5 \times 10^{-3} \times 4.6 \times 10^{-2}$

$F = 2.81$ kg m^{-1} s^{-1}

ResultsPlus
Examiner Comments

This candidate has written the correct equation but thinks η is density and F is viscosity.

ResultsPlus
Examiner Tip

Be sure you know what the symbols stand for in the list of formulae and relationships.

(b) The terminal velocity is found to be 4.6×10^{-2} m s^{-1}. Use this value to show that the viscosity of the liquid is about 2 kg m^{-1} s^{-1}.

(3)

$F = 6\pi r \eta v$

$4.8 \times 10^{-3} = 6 \times \pi \times (2.5 \times 10^{-3}) \times \eta \times (4.6 \times 10^{-2})$

$4.8 \times 10^{-3} = 2.2 \times 10^{-3} \times \eta$

$\eta = \frac{(4.8 \times 10^{-3})}{(2.2 \times 10^{-3})} = 2.2 \text{ kg m}^{-1}\text{s}^{-1}$ (shown)

∴ The viscosity of the liquid is about 2 kg m^{-1}s^{-1}

ResultsPlus

Examiner Comments

Despite having calculated upthrust, this candidate has simply used weight as *F* rather than finding the difference of weight and upthrust.

ResultsPlus

Examiner Tip

Even if you haven't been asked to do it in the question, a diagram helps to visualize the forces.

(b) The terminal velocity is found to be 4.6×10^{-2} m s^{-1}. Use this value to show that the viscosity of the liquid is about 2 kg m^{-1} s^{-1}.

$F = 6\pi \eta r v$ (W − Upthrust = Viscous drag).

upthrust ↑ viscous drag ↑ ; weight ↓

$4.8 \times 10^{-3} - 8 \times 10^{-4} = 0.004 = 6\pi(\eta)(2.5 \times 10^{-3})(4.6 \times 10^{-2})$.

$0.004 = 0.00217(\eta)$

$\eta = 1.845 \text{ kgm}^{-1}\text{s}^{-1} \approx 2 \text{ kgm}^{-1}\text{s}^{-1}$.

ResultsPlus

Examiner Comments

This candidate has summarised the forces in a diagram and in writing and has gone on to complete the problem successfully.

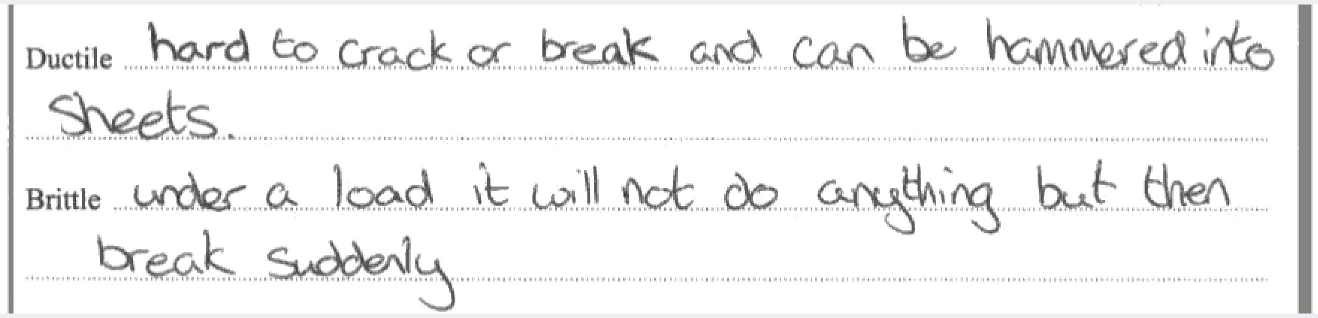
Question 14(c)

About three quarters of responses given, were correct. Most others suggested using the same sphere or same type of liquid although these would clearly be the same from the context of the question.

Question 15(a)

About three quarters of the candidates got at least one mark and slightly under a half got two marks. A significant proportion of the candidature clearly did not have a firm grasp of appropriate and specific terminology.

In many cases they seemed to think that ductile just meant a large force is required to break a material and brittle meant fracture occurs for a small force or just that a material breaks easily, perhaps thinking of what we would describe as fragile. Descriptions along the right lines often mentioned plastic deformation for ductile but did not mention a large amount, and for brittle they suggested that fracture occurred with no deformation at all rather than little or no plastic deformation. There was confusion with malleability and a number of candidates referred to ductile materials being moulded.


Ductile hard to crack or break and can be hammered into sheets.

Brittle under a load it will not do anything but then break suddenly

ResultsPlus

Examiner Comments

A typical 2 mark answer.

Ductile: it can withstand large plastic deformation without losing strength [illegible]
(easily shaped e.g. pulled into wires)

Brittle: undergo little or no plastic deformation, instead cracking/shattering

ResultsPlus
Examiner Comments

This candidate is describing the term malleable rather than ductile. The description for brittle may be based on the correct idea, but 'suddenly' is ambiguous and could refer to a specific time or a specific force, and, even if it does mean force, 'not do anything' would suggest no deformation at all rather than saying little or no plastic deformation.

ResultsPlus
Examiner Tip

Learn the definitions of the terms listed in the specification thoroughly. While that will not always be enough to get all the marks, it is a good start in every case.

Question 15(b)

While 90% clearly knew $W = mg$ and could substitute the values, only three quarters gave a fully correct answer. Most of those who went wrong made unit errors, possibly being confused by kN and thinking their kg answer was actually in grams. Some quoted the answer in N and some gave no unit. A small number lost a mark by use of g = 10 N/kg instead of 9.81 N/kg.

(b) The cover is also marked '35 kN'. This refers to the load it must be able to support.

Calculate the mass that would produce this load.

(2)

$\frac{F}{g} = m$ 35000 ÷ 9.81 = 3567.787971

Mass = 3567.8

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Examiner Comments

This candidate has omitted the unit and cannot get full credit.

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Examiner Tip

A physical quantity must have a magnitude and unit, so always check for units as you write answers and again at the end of the paper.

Question 16

Most candidates were able to choose the correct equations for all parts of this question, but failing to interpret the situation correctly led many to use the wrong distance and time in part (a) and part (b), probably getting 4 marks out of 6.

About half got at least the 4 marks, but the full 6 marks was actually the modal mark for the question, and gained by nearly a third. Some candidates drew a velocity-time graph to help visualize the situation.

In part (b), many candidates calculated the average velocity without realising that it was half of the maximum velocity. Most candidates who went wrong in part (a), were able to use the given ‘show that’ value or their own answer to fully answer part (c). Unit errors for acceleration and speed were sometimes seen.

(a) Show that the acceleration would be about 2 m s^{-2}.

(2)

5000000 m ↓ 1800 s ↓

s = 5000 km   t = 30 m   u = 0   a = ?

$s = ut + \frac{1}{2}at^2$

$a = \frac{s - ut}{\frac{1}{2}t^2}$ $a = \frac{5000000 - (0)(1800)}{0.5(1800)^2}$

$a = 3.086\ ms^{-2}$

(b) Calculate the maximum speed.

(2)

~~D = st~~

$t = \frac{5000000}{3600} = 1388\ ms^{-1}$

Speed = 1388 ms^{-1}

(c) Calculate the resultant force required to decelerate the train.

mass of train = 4.5×10^5 kg

(2)

$F = ma$

$f = 4.5 \times 10^5 \times 2$

$= 9 \times 10^5$

Force = 9×10^5 N

ResultsPlus
Examiner Comments

This candidate has set out the quantities sensibly and has chosen the correct time in part (a) but not the correct distance. The equation has been used correctly.

In (b), the wrong distance and time have both been used and the average velocity has been calculated rather than the maximum.

Part (c), has been completed correctly using the 'show that' value.

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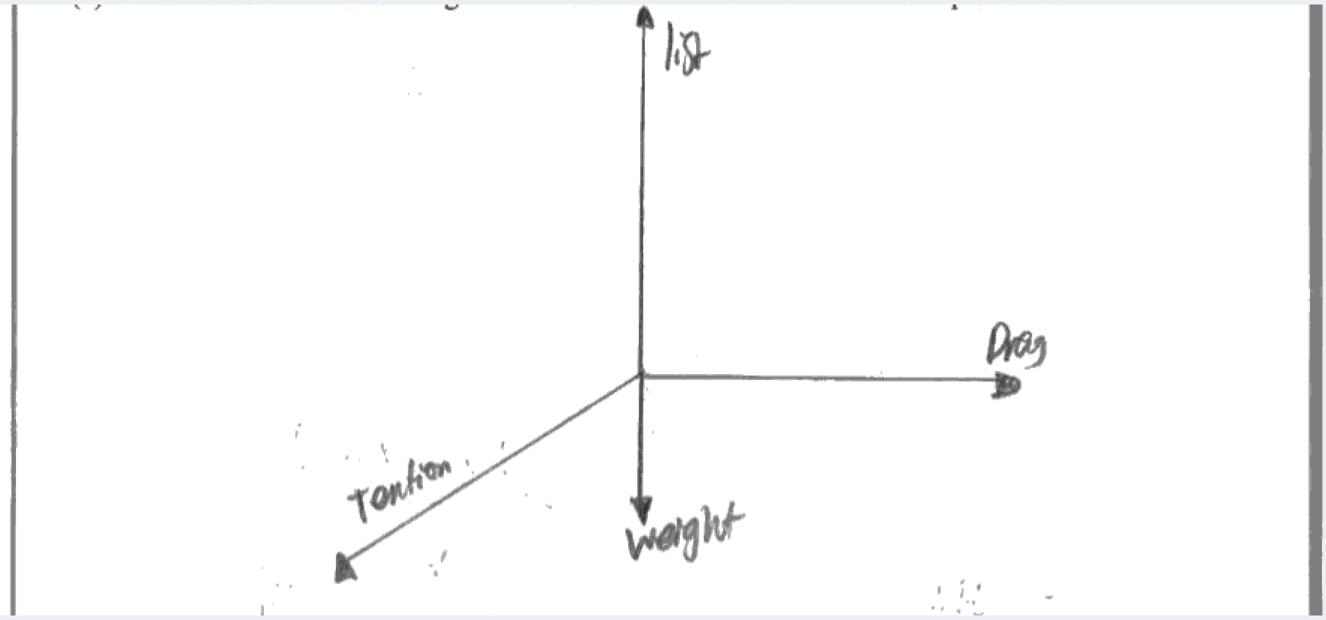
Examiner Tip

Read the question carefully!

Question 17

(a)

Candidates rarely drew a correct polygon of vectors. Many just repeated the diagram of the kite without the girl. Some attempted a triangle, but ignored the 'tip-to-tail' rule and effectively added the magnitudes of lift and weight. A few drew a trapezium but as a mirror image or rotated through 90º.



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Examiner Comments

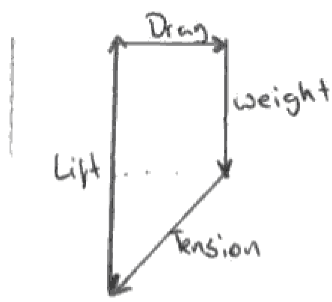
A typical diagram which just copies that in the question.

ResultsPlus
Examiner Comments

This candidate has attempted to draw a closed polygon of forces, but weight does not follow the 'tip-to-tail' rule and is effectively added to lift. There is no evidence of a ruler.

ResultsPlus
Examiner Tip

To show forces in equilibrium, keep the directions the same and make sure the tip of each force joins the tail of the next one. A ruler always helps!



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Examiner Comments

A correct version.

(b)

Most candidates seemed to know the technique required to find the tension, but many went astray through using either the lift only or the weight only as the vertical force, and some used the sum rather than the difference. This was not always connected with the diagram in (a), with correct working sometimes following an incorrect diagram and vice versa. Overall the magnitude was done slightly more successfully than the angle, some being happy to write 'downwards' or similar. Occasionally the '°' for degrees was omitted.

(b) The lift is 4.3 N, the drag is 6.0 N and the weight is 0.44 N.

Calculate the tension in the string. State its magnitude and direction from the horizontal.

(4)

$4.3 + 0.44 = 4.74\,N$

$4.74^2 + 6^2 = x^2$

$x = 7.65\,N$

$\tan x = \dfrac{4.74}{6} = 38.3°$

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Examiner Comments

The vertical force is incorrect, although all of the working is correct given that initial error. Other candidates used 4.3 N or 0.44 N only.

vertical component of T = $4.3 - 0.44 = 3.86$ N

horizontal component of T = 6 N

$\sqrt{6^2 + 3.86^2} = 7.13$ N magnitude (2dp)

$\tan\theta = \frac{6}{3.86}$ $\tan^{-1} 1.55 = 57.25°$

$90 - 57.25 = 32.75°$ direction

ResultsPlus

Examiner Comments

Following a correct diagram, this example has been concluded successfully.

(c)

Candidates nearly always used work = force x distance, perhaps prompted by the formula sheet, but forgot the longer ‘work = force x distance in the direction of the force’. Consequently, the force used was most frequently the answer from part (b) rather than the drag force of 6 N. Some candidates went to the trouble of finding the horizontal component of the tension – usually managing to get back to 6 N! Having obtained a value for work, most applied power = energy / time, although some substituted another numerical value on the page, e.g. 2.0, instead of calculating the time. Candidates using the off-specification ‘power = force x velocity’ were credited fully, but they usually repeated the error of using the incorrect force. There were unit errors between J, N and W.

(c) (i) The wind speed decreases so the girl flying this kite walks into the wind at a constant speed of 2.0 m s^{-1} to maintain the forces shown. Calculate the work done by the girl as she walks 25 m.

(2)

ΔW = F Δs

7.13N x 25 = 178.25J

Work done = 178.25J

(ii) Calculate the rate at which work is done by the girl.

(2)

P = ΔW / t

D / (s t) 25 / 2 = 12.5

178.25 / 12.5s = 14.26

Rate at which work is done = 14 Js

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Examiner Comments

This candidate has used the tension as the force rather than the drag. Part (ii) has been worked through correctly, allowing for the error carried forward, but has written Js as the unit rather than J s^{-1}.

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Examiner Tip

Expect to need to calculate work when the direction of motion is not along the line of the force. Check the directions before carrying out the calculation.

$W = Fs$ $s = 25$ $mg\Delta h = \frac{1}{2}mv^2 = Fs$

$7{\cdot}13 \cos 32{\cdot}7 = 6{\cdot}0N$

$6 \times 25 = 150$ Nm (J)

Work done = 150 J

(ii) Calculate the rate at which work is done by the girl.

(2)

$P = \frac{W}{t} = \frac{150}{t}$ $v = \frac{s}{t}$ $t = \frac{s}{v} = \frac{25}{2} = 12{\cdot}5s$

$P = \frac{150}{12{\cdot}5} = 12W$

Rate at which work is done = 12 W

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Examiner Comments

This candidate has made some extra work calculating the horizontal component of tension, but it shows a careful consideration of the relative directions of the force and movement.

Question 18(a)

Over half the candidates gained half the marks, but only one sixth gained 5 or more. The stem stated that the situation was about energy transfer, but many candidates did not devote much, or any, of their answer to a discussion of energy.

In many cases the only marks were for describing whether or not the ball would reach the girl's nose. Many other candidates gave too much of their answer to repeated descriptions of energy transfer from kinetic to gravitational potential energy. There were 6 marks, but few candidates showed signs of trying to make sure they made 6 points, for example using bullet points.

(a) Explain this demonstration and the need for these instructions.

(6)

If any additional force is applied to the pendulum the ball will have more kinetic energy whilst travelling as the potential energy was increased. This will result in the ball travelling further and will hit the girl as it returns in the pendulum motion assuming no external force is applied.

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Examiner Comments

This candidate has only discussed the second part of the question, not explaining the demonstration and only using the key term 'energy' twice. There are not 6 separate points, whether on the mark scheme or not.

ResultsPlus
Examiner Tip

For an explanation with many marks, there will usually be more marking points in the mark scheme than marks available. You should try to make as many clear points as there are marks, perhaps using bullet points. You then could add a spare in case one of yours misses the mark!

- As the ball swings gravitational potential energy is transferred to kinetic energy
- Because some energy will be lost due to air resistance and friction in the wire although the ball starts touching her nose when it swings back it won't ~~[illegible]~~ touch / hit her.
- At the top of its swing the kinetic energy will be transferred back into gravitational potential energy (and then back again as it falls).
- The instructions are needed as if she pushed it the ball will have extra kinetic energy so will hit her. If she moves forward she will be too close and it will also hit her.

ResultsPlus

Examiner Comments

This answer is well-structured, using bullet points to help this, even though the marks don't follow the bullet points, being 1 for the first, 2 for the second, none for the third and 3 for the last.

In this demonstration, the bowling ball is given gravitational potential energy when it is lifted up, and this energy is transferred to kinetic energy when the ball is released. This means that halfway through a swing ~~the ball will~~ the KE of the ball will be equal to the GPE it started with due to the conservation of energy, and also the ball will reach exactly the same height it was released from after an entire swing is complete. The instruction to not move your face is to demonstrate that the ball will reach exactly the same height, and the instruction to not push the ball is because the ball would then have more KE that it could then convert into GPE, and so the ball would reach slightly higher and hit the student in the face.

ResultsPlus

Examiner Comments

This answer shows a good, logical structure, describing the demonstration and addressing each point of the instructions.

Question 18(b)

A slight majority of candidates gained full marks, with most calculating the gpe correctly but slipping up with the speed. A surprising number made unit errors, quoting energy in N. Some candidates incorrectly applied equations of uniformly accelerated motion rather than conservation of energy.

(i) Calculate the gravitational potential energy gained by the ball.

(2)

$E_{grav} = mg\Delta h$

$= 7.0 \times 9.81 \times (1.5 - 0)$

$= 103.005 \simeq 103\ N$ (3sf)

Gravitational potential energy = 103 N

(ii) Calculate the speed of the ball at the bottom of its swing.

(2)

$E_{grav} = E_k$

$\therefore mg\Delta h = \frac{1}{2}mv^2$

$103.005 = \frac{1}{2}mv^2$

$\therefore \sqrt{\frac{2 \times 103.005}{7.0}} = v$

$\therefore v = 5.424942396$

$v \simeq 5.4\ ms^{-2}$ (2sf)

Speed = $5.4\ ms^{-2}$

ResultsPlus

Examiner Comments

This is set out well and has been worked through correctly but has unit errors in both parts.

Question 19(a)

Many candidates do not seem to be familiar with the difference between graphs of length versus force and graphs of extension versus force for this type of context, because they thought this did not obey Hooke's law because it did not pass through the origin.

A large minority got 2 marks and two thirds at least 1 mark, but many thought that Hooke's law is shown if force is proportional to length, rather than extension or change in length. Some clouded the issue by referring to change in extension.

(a) Explain whether the spring obeys Hooke's law.

(2)

yes the spring does obey hooke's law because a graph of length against force has produced a straight line with a positive gradient which shows they are directly proportional.

ResultsPlus
Examiner Comments

This candidate is suggesting force is proportional to length rather than extension.

ResultsPlus
Examiner Tip

Learn the meanings of the symbols. $F = k\,\Delta x$ refers to a change in length.

(a) Explain whether the spring obeys Hooke's law.

(2)

It does as the line is straight with a constant gradient. Extension is proportional to force.

ResultsPlus
Examiner Comments

This answers well by describing an observation (straight line) and then by explaining its significance (extension α force).

Question 19(bc)

Candidates generally found the correct spring constant, but many simply divided the force at a point by the length at that point instead of finding the change in length.

$k = \frac{F}{\Delta x}$ $\frac{1.4}{50 \times 10^{-3}}$

$\frac{1.4}{0.05}$ $28\ \mathrm{Nm}$

$\simeq 20$

ResultsPlus

Examiner Comments

This candidate has written Δx, but has treated it as length rather than extension.

$F = ke$ $k = F/e = 1.6/(51-41)\times 10^{-2} = 1.6/0.1 = 16\ \mathrm{Nm^{-1}}$

ResultsPlus

Examiner Comments

This response makes it clear that a change in length is being used.

Candidates usually selected the correct equations for these parts, but very frequently failed to convert cm to m, even though they had done so in part (b).

(i) Calculate the force that must be applied to the spring to get it into the tin.

(2)

$F = kx$

$F = 16 \times (41 - 9)$

$= 512\,N$

Force = 512 N

(ii) Calculate the energy stored in the spring when it is compressed to fit into the tin.

(2)

$E = \frac{1}{2} F.x$

$E = \frac{1}{2} \times 512 \times (41 - 9)$

$= 8192\,J$

Energy = 8192 J.

ResultsPlus

Examiner Comments

In this answer the lengths have been left in cm in both parts.

ResultsPlus

Examiner Tip

Remember to convert to SI base units for calculations. For derived units use them without prefixes, e.g. kJ must be converted to J, MW to W etc. Mass is the only base unit which has a prefix, kg.

(i) Calculate the force that must be applied to the spring to get it into the tin.

(2)

extension = 41 − 9 = 32cm = 0·32m

F = ke

= 16 × 0·32

= 5·12N

Force = 5·12N

(ii) Calculate the energy stored in the spring when it is compressed to fit into the tin.

(2)

energy stored = ½Fx = ½ × force × extension

= ½ × 5·12 × 0·32

= 0·8192J

= 0·82J (2sf)

Energy = 0·82J

ResultsPlus

Examiner Comments

The extension has been found and converted to m in this answer.

Question 19(d)

This question evinced a most encouraging set of responses, giving the great majority of candidates the chance to show their ability. Over half of the cohort got the full three marks and three quarters got two out of three. This gave candidates the opportunity to demonstrate that they could set out a logical explanation, going from physical causes to a final effect in a sensible sequence. Stronger candidates often included more than the three points needed for full marks, covering up to the full 6 possibilities in the mark scheme. Even candidates who made an incorrect initial assumption developed their arguments logically. Well done!

Explain the effect this has on the speed at which the spring leaves the tin.

(3)

two decreasing the ~~Len~~ internal length would causes the spring to have a higher speed. as the spring is more compressed, when releasing & the spring the force is much high therefore higher speed.

ResultsPlus
Examiner Comments

This is a rare example where lack of clarity of expression has cost a mark in this question. The candidate states ‘the force is much high’. This question was marked for Quality of Written Communication, but even if it wasn’t, failing to say ‘higher’ would cost the final mark because it is not a clear comparison.

ResultsPlus
Examiner Tip

When comparing situations, be sure to use comparative terms such as ‘higher’, ‘more’ etc rather than terms like ‘high’, ‘a lot of’ etc.

Explain the effect this has on the speed at which the spring leaves the tin.

(3)

If the internal length of the tin is less, the spring would have to be compressed more. This means a greater force would be required to compress it. This in turn would mean more elastic strain energy is stored in the spring. Assuming a 100% energy transfer, then the spring would have more kinetic energy, which implies the speed at which the spring leaves the tin is greater.

ResultsPlus
Examiner Comments

This fairly typical answer straightforwardly and logically mentions 5 of the 6 available points.

Question 20(a)

Even though this was the most difficult part, nearly a third of the cohort got 2 of the 3 marks and a good majority got at least 1 mark. While candidates often knew which of Newton's laws to apply to which part of the explanation (the 1 mark), the detail in applying them was often insufficient. They would use Newton's first law to explain why the car moved, but rarely mention that it accelerated or link it to it starting to move or refer to a resultant or unbalanced force. With Newton's third law the objects being acted upon and the directions of the forces were often unclear. Candidates who started by clearly stating the laws were at an advantage.

> When the air is not released, all forces acting on the car are in equilibrium, and thus the car doesn't move. However as soon ~~at~~ as the air is released, its reaction force propels the car forwards.

ResultsPlus
Examiner Comments

This answer starts off by attempting to ask a question which has not been asked, which is why it isn't moving at first. (This could have been a prepared answer to another question, and would have needed to refer to the car remaining stationary rather than saying 'doesn't move' anyway.) The answer mentions a reaction force, a vague reference to Newton's third law, but needs to identify both forces in the pair to get the explanation mark. It refers to the force in such a way as could imply it is a new force, but fails to state that it is unbalanced. Similarly, it may have been intended to suggest that as the force 'propels the car' it starts to move, but this is not unambiguous.

ResultsPlus
Examiner Tip

In questions like this about Newton's first law, be sure to mention a resultant force and an acceleration. Contrariwise, when explaining stationary objects mention the absence of a resultant force and explain that there is no acceleration.

ResultsPlus
Examiner Tip

Answer the question on the page, not the one you learned from practice papers.

Newton's first law states every object will remain in its state of rest or uniform motion in a straight line unless made to change by a resultant force acting on it. The releasing of air provides a force causing the car to change from rest to motion. Newton's third law states when ~~force~~ object A exerts a force on object B, ~~&~~ then B will exert an equal and opposite force on object B. The balloon releasing the air is exerting a force to the left on the air as it escapes, therefore the air exerts an equal and opposite force on the car to the right, hence creating a resultant force on the car putting it in motion.

ResultsPlus

Examiner Comments

This candidate states each law correctly and then carefully applies it point by point to the context, even though the required contextual link to 'resultant' force comes rather late.

ResultsPlus

Examiner Tip

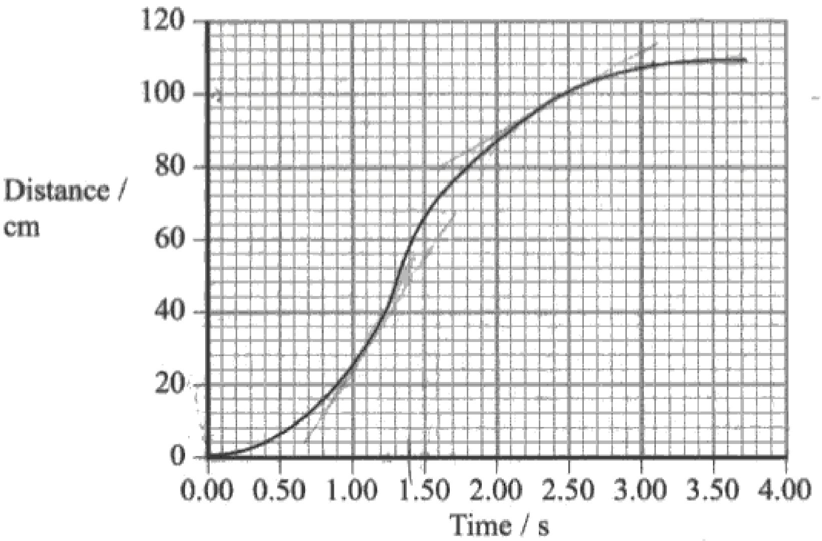
Learn the laws you need to apply carefully. While the statement itself may not get marks, writing the relevant law as part of your answer can help to apply it in context.

Question 20(b)

About a fifth of the candidates got the full 6 marks and this was again the modal mark. Over half gained at least half marks. Candidates generally knew that a gradient was required, but they did not always draw the tangent at the correct place and could therefore not get a value within the required range. Some candidates just used values of distance and time from the graph, finding an average speed. There were some very small triangles used and some tried to use the area under the graph. Several drew multiple tangents but did not make it clear which was being used.

In drawing their own graph, candidates usually realised that there was a maximum speed and often that it then fell to zero, although not always, but frequently didn't place the maximum speed at the correct time, either from the original graph or from where they placed their tangent. Some candidates marked the maximum speed correctly on their graph and occasionally a candidate would find the speed at several times to get a more precise shape, although candidates were not expected to derive the shape fully.

(b) The following distance-time graph is obtained for the car.



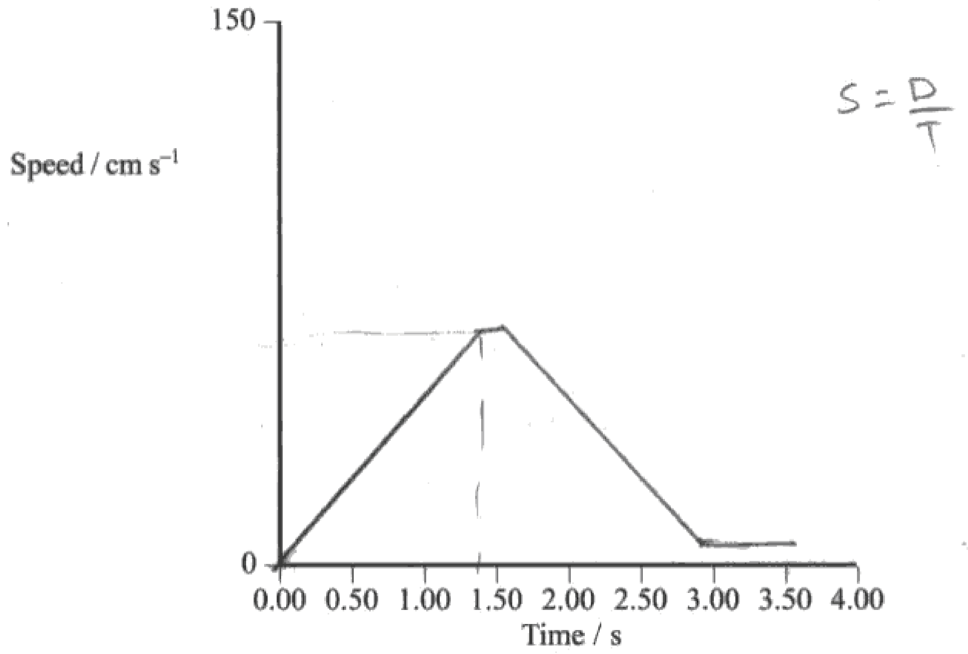
$S = \frac{D}{T}$

(i) Show that the maximum speed reached is between 100 and 150 cm s^{-1}.

(3)

$S = \frac{D}{T}$ $\frac{40-20}{1 \cdot 25} = \frac{dy}{dx} = $ Speed

(ii) Sketch the shape of the corresponding speed-time graph on the axes below. (3)



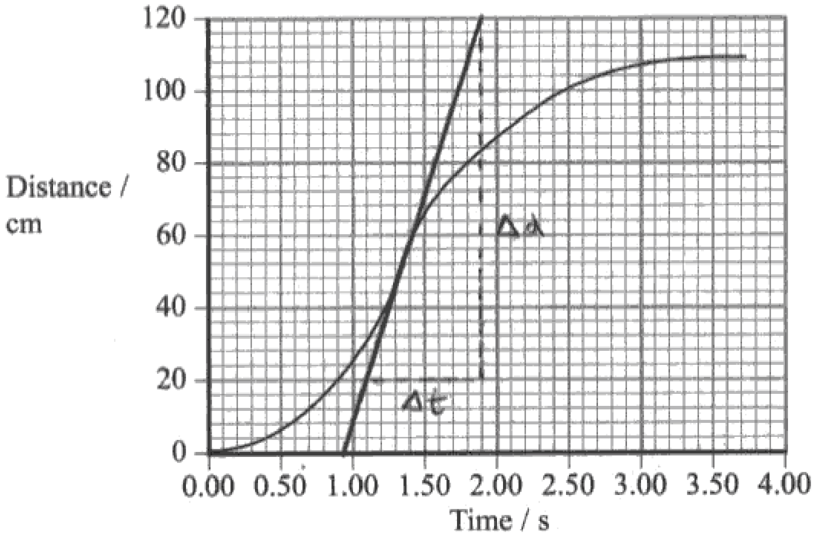
ResultsPlus
Examiner Comments

This candidate has drawn two tangents. They appear to have used the first, but forgotten to find the difference in time for the denominator. A triangle would have made this clearer. The graph in part (ii) follows the required general pattern at the correct times, except it obstinately levels off above zero at about 3.00 s.

ResultsPlus
Examiner Tip

Draw large triangles from tangents when calculating gradients.

(b) The following distance-time graph is obtained for the car.



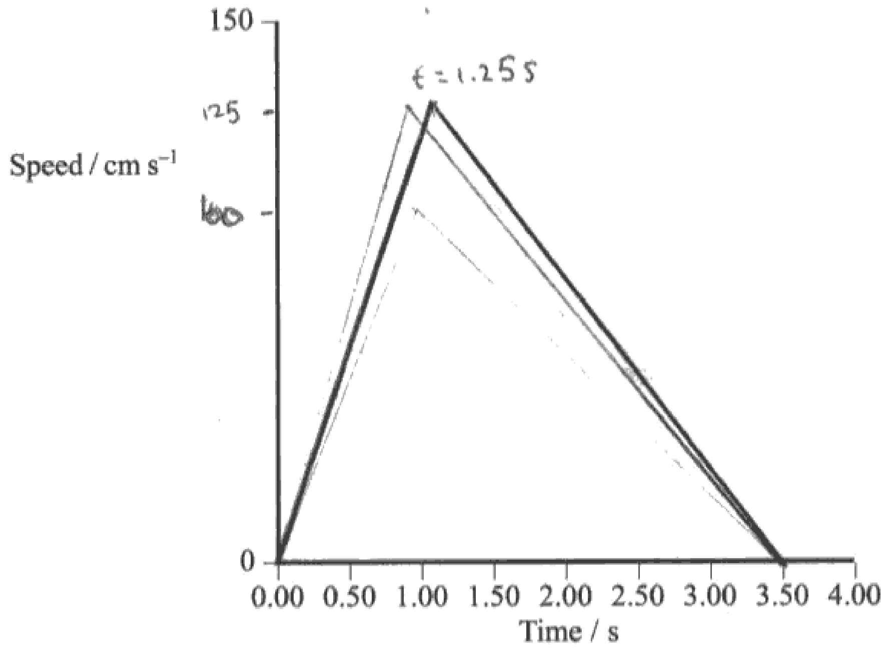
(i) Show that the maximum speed reached is between 100 and 150 cm s^{-1}.

(3)

$s = \frac{d}{t} = \frac{\Delta d}{\Delta t} = \frac{1.20 - 0.20}{1.90 - 1.10}$

$= \frac{1}{0.8} = 1.25 \text{ ms}^{-1} = 125 \text{ cm s}^{-1}$

(ii) Sketch the shape of the corresponding speed-time graph on the axes below. (3)



ResultsPlus Examiner Comments

The tangent is large and the gradient clearly set out in the answer as the change in distance divided by the change in time. A suitable scale has been added to the speed axis in the second graph and the relevant time and speed have been clearly indicated.

ResultsPlus Examiner Tip

Be sure you know which gradients and areas to use with graphs of motion.

Grade boundaries

Grade	Max. Mark	A	B	C	D	E	N
Raw boundary mark	80	60	53	46	40	34	28

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