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Examiners' Report
January 2011

GCE Physics 6PH01 01

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Introduction

There was a good range of performance in this paper, with all candidates having opportunities to demonstrate their understanding and show progression from GCSE, although candidates continue to show better performance with calculations than explanations. While there was an improvement in selecting and quoting relevant formulae to inform and support explanations, there was often a lack of precision in applying some of the physics terminology. Some candidates did not show sufficient clarity in setting out explanations to demonstrate fully their understanding of the situations being described.

Problems with significant figures in 'show that' questions, the use of 'gravity' instead of 'weight' and the use of g = 10 m s^{-2} were much more rare than in some previous series.

Section A

Performance was good on most multiple choice items in Section A, with many candidates at the higher grades giving 10 correct responses.

Questions 2 and 5 elicited over 90% correct responses, and 1, 7, 8, 9 and 10 over 75%. Just over half of the candidates answered questions 3 and 6 correctly.

In some cases the preferred incorrect answers are informative.

In question 3, candidates with an incorrect response rarely chose kW h or W s, but most often selected N m. The use of quantity algebra might help them to connect N m with J when defining work.

Candidates drawing a labelled diagram were more likely to get the correct answer to question 4, but sine was rarely chosen with or without diagrams.

Nearly half chose an incorrect answer to question 6, but they rarely chose answer A, answers B and C being of similar popularity. This indicates a poor general understanding of Newton's Third Law, apart from the forces being of equal magnitude and in opposite directions. Many candidates still need to learn that the forces act on different bodies and are the same type of force. This may be aided by learning more than the epigrammatic 'to every action there is an equal and opposite reaction' form of the law. Students might do better by learning about what happens 'when body A exerts a force on body B etc', and by practising with simple examples, such as in question 14 on the January 2009 6PH01 paper.

Candidates giving an incorrect response to question 8 nearly always chose A - ductile, showing a confusion (also seen in question 18) between compression and tension.

Question 9 saw about a fifth of candidates saying a ball bearing would fall faster through hotter oil and in question 10 a similar number indicated that they think work is a vector quantity.

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Examiner Tip

Make a two column table and list the properties of the forces in a Newton's third law pair that are the same in one column and the properties that are different in the other.

Question	Correct Responses
1	86%
2	95%
3	53%
4	71%
5	92%
6	55%
7	86%
8	79%
9	78%
10	75%

Question 11

Nearly all candidates showed that they could recognise Newton’s first and second laws of motion, with well over half getting at least 3 marks. By using imprecise wording, however, many lost one or more of the four marks available for stating the laws.

Marks were lost for the first law by making no reference to direction, which could be done by including ‘velocity’, ‘acceleration’ or ‘straight line’ in the statement, and for failing to specify ‘resultant’ force, often referring to an ‘external’ force only. Some candidates discussed equal forces rather than balanced forces.

The second law was commonly $F = ma$ in symbols or in words, without specifying ‘resultant’ force. Resultant was missed in the second law more frequently than in the first. Candidates using the formula sheet would have seen S$F = ma$, but sigma was not included nor was its significance explained.

A few candidates quoted Newton’s third law.

Many candidates satisfactorily linked the two laws, but in some cases they merely requoted one or the other or said that they both involved acceleration.

Most answers were structured clearly, stating first one law, then the next, and then comparing them. This helped to gain the last mark.

*11 During a lesson on Newton's laws of motion, a student says, "We don't really need to bother with Newton's first law because it is included in his second law".

State Newton's first two laws of motion and explain how Newton's second law includes the first law.

(5)

Newtons first law states that a force has to be applied on a object ~~for the~~ or the object will stay at a constant speed and newtons second law states that ~~the~~ Force equals mass times acceleration. The second law ~~can~~ includes the first law as if the force equal zero then the acceleration will be zero as the mass of the object will remain constant. This means without a force the speed will remain ~~the~~ constant as the acceleration is zero.

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Examiner Comments

This candidate is awarded 1 mark for Newton's second law (force = mass x acceleration) and one for the final comparison, but simply adding 'resultant' to force in lines 1 and 3 and saying constant velocity instead of speed, or saying constant speed in a straight line, allows 3 more marks to be obtained.

- Newtons First Law: A Body will remain at rest or in Equilibrium {moving at a constant ~~speed~~ velocity} so long as no external force is applied.
- Newtons Second Law: F = ma (Force = mass x acceleration)
- If a body is moving at a constant velocity ie zero acceleration. The Resultant Force acting on the body is zero ie The Body is in Equilibrium.
- ~~The body so~~ using F = ma ie if a = 0, F = 0.
- This has illustrated Newton's first law.

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Examiner Comments

This gets 3 marks, with a better final explanation than the previous example. Both laws need a reference to resultant force. 'In equilibrium' is used a bit variably, but the essential points are there.

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Examiner Tip

Learn full versions of Newton's laws of motion thoroughly so you can quote them accurately.

Question 12

Responses to this question often displayed a lack of focus on the question asked, lack of clarity in the language used and, unlike question 11, lack of structure in setting out explanations. Candidates should be reminded of the quality of written communication requirement that, 'Work must be clear and organised in a logical manner using technical wording where appropriate'.

Under a third of the candidature gained more than two marks, and the two marks most frequently awarded were for quoting relevant formulae.

Digressions frequently encountered by the examiners included references to the cost of weights (schools apparently can't afford many), the size of the force required to break the wire and making the experiment quicker to complete because it would break sooner. There were also many dissertations on the properties of copper as a ductile material or detailed descriptions of how to carry out the experiment.

Candidates who may well have realised that the wire described would maximise the extension for a given force and why that would be advantage often suggested it indirectly by rather vague references to making the extension visible or making it easier to measure. They didn't state that it would be easier to measure because the extension would be greater.

Candidates frequently quoted stress = force/area, but rarely mentioned that the area would be smaller, which could have led them on to increased stress and greater extension in a logical sequence. When they quoted strain = extension/length they usually suggested that a greater length would give a greater strain rather than that the same strain would entail a greater extension. Candidates did not all appreciate that the Young modulus is a constant and thought that the long, thin wire would increase it – even when they defined it as stress/strain and said strain would increase!

So, while candidates often started well by quoting relevant formulae, they need to consider the variables in the formulae and the effect of changing them on the outcome. They just need to ask themselves questions like, "If I increase x, then will y increase or decrease?"

*12 Explain why the wire used when measuring the Young Modulus of copper in a school laboratory is long and thin.

(5)

a Long thin wire is used so that the students can see the breaking point of the wire is easily seen so the cross sectional value can be measured, as well as the extension of the wire being easily measured, and not too long before the wire snaps.

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Examiner Comments

This candidate focuses on breaking point, which is not required for the Young modulus, and how long it takes. Cross sectional area is mentioned, but its size isn't commented upon. It says the extension is easily measured, but not anything about what makes it easily measured, i.e. a larger extension.

Brittle materials have little to no plastic region, so soon after reaching their elastic limit they will fracture, whereas ductile materials have a large plastic region before fracture.

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Examiner Comments

This candidate gets 4 marks by quoting the relevant formulae and a bit of logical development: decreases area, so less force required, because stress = force/area. It also says extension is more easily read with a long wire, but doesn't say it is because the extension is greater.

Question 13(a)

The first words in part (a) were 'Use the graphs to help you', but many candidates felt able to proceed quite unaided, describing brittle in terms of shattering and ductile in terms of being drawn into wires which did not refer to features of the graphs.

About three quarters of candidates gained at least one mark, and usually lost the other through imprecise descriptions, most frequently referring to brittle as breaking with little deformation, omitting plastic, or failing to qualify the plastic deformation of ductile materials as significant in extent. Overall, more marks were awarded for brittle than ductile.

(a) Use the graphs to help you describe brittle and ductile behaviour.

(2)

Brittle materials break or crack with little deformation, which is why the line just stops instead of bending away. Ductile materials plastically deform which is why the line stars bending away and curving.

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Examiner Comments

This refers to the graph, but lacks some essential detail. It says brittle has little deformation, without specifying plastic, and doesn't describe the significant extent of plastic deformation for ductile.

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Examiner Tip

Practise definitions so they can be quoted to the required level of detail.

Brittle materials have little to no plastic region, so soon after reaching their elastic limit they will fracture, whereas ductile materials have a large plastic region before fracture.

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Examiner Comments

This is an example with the added level of detail, gaining full marks.

Question 13(b)

A good majority got both marks for part (b). The most frequent omission was to describe porcelain as brittle and errors included references to hardness, so it wouldn't dent, to malleability or ductility, so it could be reshaped, to hardness, so that the pieces would be large or to there being little elastic deformation, rather than little plastic deformation or just little deformation.

(b) In 2006, three Chinese vases, dating from the 17th Century, were smashed when a man fell down the stairs at the Fitzwilliam Museum in Cambridge. The vases were made of porcelain.

A restoration expert put the vases back together. She said, "It wasn't a difficult job. The museum collected all the pieces and they fitted back together perfectly."

Explain why it was possible to fit the pieces back together perfectly.

(2)

Porcelain is a tough and hard material which ~~stop~~ helped ~~x~~ reduced ~~x~~scratches and indentations so the broken peices were large and clean cuts making them easier to place back together.

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Examiner Comments

This chooses the wrong properties and refers to large pieces. Clean cut may indicate no change of shape, but is not clear enough.

THE PIECES WILL NOT HAVE DEFORMED PLASTICALLY, PORCELAIN IS VERY BRITTLE SO THE VASE WOULD HAVE SHATTERED INSTEAD of DENTS ETC. OCCURING. THE PIECES WOULD FIT BACK TOGETHER AS NO PLASTIC DEFORMATION ON VASE.

(Total for Question 13 = 4 marks)

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Examiner Comments

This states that the material is brittle and describes the effect to get full marks.

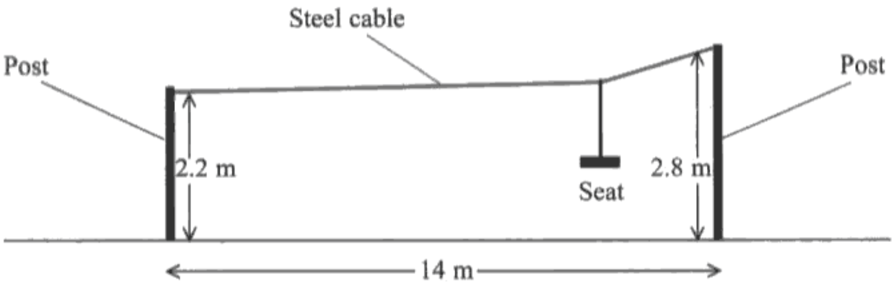
Question 14(a)

In part (a), three quarters gave a sensible assumption, but only about a fifth attempted the correct calculation based on conservation of energy, equating the decrease in gravitational potential energy to the gain in kinetic energy.

The majority of students attempted to use an equation of motion, usually $v^2 = u^2 + 2as$. These equations are for motion with uniform acceleration, which was not the case here, as shown by the two diagrams of the wire, and so were not appropriate. Candidates applying this equation used g = 9.81 m s^{-2} as the acceleration, which is another error as this acceleration was not in the direction of motion. Most used 0.6 m as *s*, but some used 14 m, which meant the path followed, the acceleration and the displacement were all in different directions.

This was similar to many responses in June 2010 for a bowling ball pendulum and candidates will need to get used to identifying which situations may be solved by equations of motion, which may be solved by conservation of energy and which may be solved by both.

14 A playground ride consists of a steel cable running at an angle between two posts of unequal height as shown in the diagram.



A child sits on the seat which moves on runners along the cable from the high end to the lower end.

(a) (i) Show that her maximum possible speed when she arrives at the lower post is about 3 m s^{-1}.

(4)

60 kg. $E_{grav} = mgh$ $\quad 40 \times 9.81 \times 2.8 =$ ~~[illegible]~~

1098.72 J → gain in E_k = 1098.72 J

$1098.72 = \frac{40}{2} \times v^2 \quad \frac{1098.7}{20} = v^2 = 54.936$

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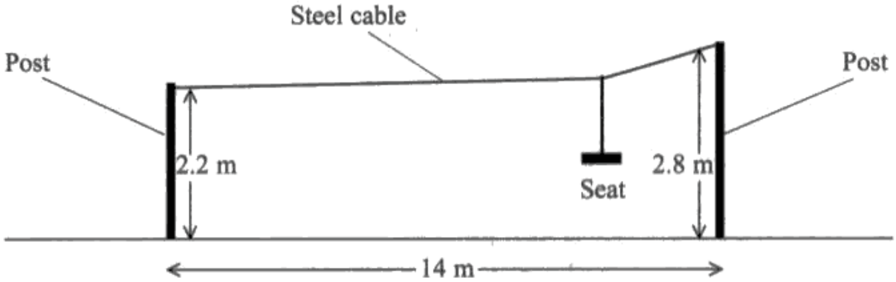
Examiner Comments

This candidate adopts the conservation of energy approach. Mass wasn't given, and isn't actually needed, but the candidate sensibly uses the mass quoted later. The candidate abandons the question when the answer isn't going to have the right magnitude. At this point it would have been worth working through the question to find the error. In this case it was using the wrong value for h. The assumption about mass is not sufficient, and the possible energy loss is not described and so no mark is awarded.



A child sits on the seat which moves on runners along the cable from the high end to the lower end.

(a) (i) Show that her maximum possible speed when she arrives at the lower post is about 3 m s^{-1}.

(4)

$2.8 - 2.2 = 0.6m$ $mgh = \frac{1}{2}mv^2$

$g = 9.81$ ~~m~~ $\times 9.81 \times 0.6 = \frac{1}{2}v^2$ ~~m~~

$9.81 \times 0.6 = \frac{1}{2}v^2$

$5.886 = \frac{1}{2}v^2$

$v^2 = 11.772$ $v = 3.4 ms^{-1}$

(ii) State an assumption that you have made.

(1)

that all the GPE (gravitational potential energy) is converted into kinetic energy.

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Examiner Comments

This example shows how it can be completed fully without requiring mass.

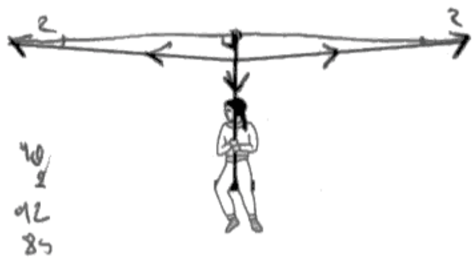
Question 14(b)

In part (b), a good majority labelled the downward force exerted by the girl and the seat ('weight' was accepted) and most of those also labelled tension with two appropriate arrows. Some candidates added an extra force, usually vertically upwards, sometimes labelled reaction.

A majority of candidates started the calculation by finding weight correctly, but some experienced difficulty with the trigonometric expressions, about a third completing it correctly. Mistakes in the calculation included using tangent instead of sine, and interpreting 2 sin 2° as sin 4°. The 'show that' answer given plainly reminded a number of candidates to divide by two at some stage. Clear diagrams appeared to help.

Please note that the number of arrows, or forces, need not correspond to the number of marks for a diagram.

(b) The diagram below shows the child at a point P where both sides of the cable make an angle of 2° to the horizontal.



(i) Add labelled arrows to the diagram to show the forces acting on the cable at the point P.

(2)

(ii) The total mass of the child and seat is 40 kg.

Show that the tension in the cable is about 6000 N.

(3)

m=40kg W= 392.4N

$\frac{392.4 \times \tan 88}{2} = \frac{11236.86579}{5618.43286}$

5618.43N ≈ 6000N

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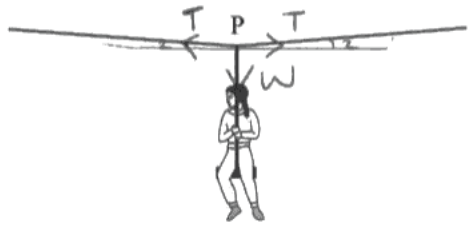
Examiner Comments

The diagram has the correct arrows, but needs force labels.
Weight has been calculated correctly, but then tangent has been used whereas tension is the hypotenuse of the relevant traingle of forces, so it should be sine.



(i) Add labelled arrows to the diagram to show the forces acting on the cable at the point P.

(2)

(ii) The total mass of the child and seat is 40 kg.

Show that the tension in the cable is about 6000 N.

(3)

$2(T\sin 2) = 40 \times 9.81$

$2(T\sin 2) = 392.4$

$T\sin 2 = 196.2$

$T = \dfrac{196.2}{\sin 2}$ $\quad T = 5621.86\text{ N}$

which is about 6000N.

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Examiner Comments

A well set out and fully correct example.

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Examiner Tip

It is worth drawing out a triangle of forces before attempting calculations like this.

Question 15(a)

In part (a), the great majority labelled the diagram correctly, drag being the most common omission. There were very few additional forces shown and little use of ‘gravity’ instead of ‘weight’.

Candidates usually gave part of the condition required, but often lost a mark through imprecise expression. They frequently made the ambiguous statement that weight must equal upthrust *and* drag, or said the forces must be equal, instead of using weight = upthrust + drag. Having related the sizes of the forces, they did not always state that this meant the forces were now in equilibrium or said there would be no acceleration. They were asked to *explain* and there were 2 marks, so candidates should expect to state a condition and a consequence of that condition.

15 (a) (i) A small solid particle is falling through water. Add labelled arrows to the diagram below to show the forces acting on the particle.

(3)

(ii) Explain the condition for the particle to fall at its terminal velocity.

(2)

weight upthrust and drag must be equal to each other

So can the particle can move a constant acceleration

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Examiner Comments

A correct diagram, but it then suggests that weight, upthrust and drag should equal each other, which would not balance the forces. More care needs to be taken in a comparison of forces like this, and an equation would be useful.

(ii) Explain the condition for the particle to fall at its terminal velocity.

(2)

Upthrust and viscous drag must be equal to the particles weight

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Examiner Comments

This repeats a fairly common mistake, saying weight equals upthrust AND drag. It should say weight = upthrust PLUS drag.

Question 15(b)(i-iii)

For (b)(i) about half gave a sensible line and almost all completed a recognisable diagrammatic representation of the definition of turbulent flow in part (ii).

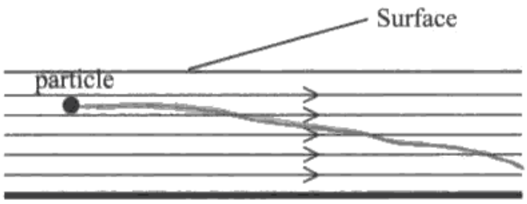
A good majority described the difference between laminar and turbulent flow for part (iii). Those failing to get this mark sometimes described laminar simply as smooth or streamlined, neither of which is sufficient. Some stated that laminar flow is in straight lines, when they possibly meant parallel. Others said that the velocity is the same everywhere, which rather misses the point of considering a gradation of speeds between adjacent layers of fluid, when they meant that the velocity at a point remains the same over time.

(b) Flowing water can be used to move solid particles from one place to another.

(i) The diagram below shows water moving horizontally with a laminar flow.

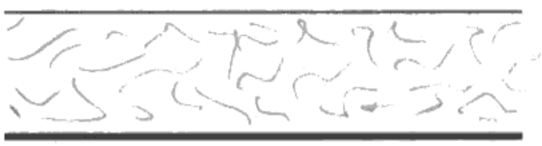
Add to the diagram to show the path of the particle falling through this water flow.

(1)



(ii) Complete the diagram below to show water moving with turbulent flow.

(1)



(iii) Describe the difference between laminar and turbulent flow.

(1)

Laminar flow is ~~were~~ were a fluid is slow steadily at a slow speed where the paths of water move in a straight line with the steadily velocity where as turbulent flow is where a fluid is flowing fast and the paths of water are broken and everywhere

(iv) Suggest why turbulent flow may be used to move small solid particles.

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Examiner Comments

The diagrams are satisfactory. The descriptions are linked to speed of flow, whereas speed is an indicator of which type of flow to expect rather than a property of the flow. Steady velocity needs to refer to the water at a particular point.

(iii) Describe the difference between laminar and turbulent flow.

(1)

Laminar flow is a smooth straight flow, whereas turbulent flow is mixed up and churning

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Examiner Comments

Laminar is described as smooth and straight, neither of which is sufficient. It should describe the flow as having parallel layers. The turbulent description needs to say what is mixed up.

(iii) Describe the difference between laminar and turbulent flow.

(1)

laminar flow – Velocity at every point is the same, everything moves in the same direction

Turbulent flow – has various different velocities at different points and different Directions

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Examiner Comments

When this says velocity at every point IS the same, it should say velocity at any point REMAINS the same. The turbulent description needs to refer to the velocity changing at a given point.

Question 15(b)(iv)

About a third got a mark for part (iv), even when they had a good clue from correct diagrams for parts (i) and (ii). Candidates often just linked turbulent flow to higher speeds and suggested an increased force pushing the particle.

(iv) Suggest why turbulent flow may be used to move small solid particles.

(1)

~~The~~ Because turbulent flow ~~f~~ at high speed moving the solid particles quicker ie. the current is stronger.

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Examiner Comments

This only refers to an assumed greater speed of flow and implies a greater force (stronger current). It needs to include a suggestion of some vertical component of force and/or motion.

(iv) Suggest why turbulent flow may be used to move small solid particles.

(1)

The constant change in direction of the lines would keep the particle higher up for longer instead of it going diagonally ~~down~~ downwards at a constant rate.

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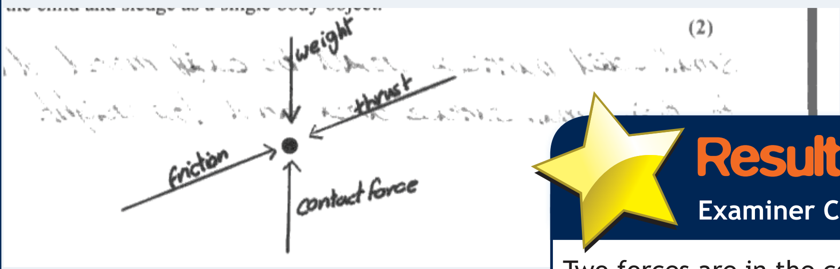
Examiner Comments

This makes a sensible suggestion, and refers appropriately to the earlier digrams.

Question 16(a)

Candidates usually recognised the difference between a question asking them to add labelled arrows to a diagram and one asking for a free body diagram and drew arrows from the point given in part (a). A few may have been misled by the 2 marks and only showed 2 forces, usually weight and friction or weight and normal contact force. The rest felt no such restriction on the number of forces and frequently included 4 in different directions, only a sixth getting the diagram correct. Many who added weight, friction (or air resistance) and normal contact force correctly added an additional force down the slope, often labelled thrust or resultant. While weight was usually in the correct direction, many students thought they needed all the forces to be vertical or horizontal, while others drew all forces parallel or perpendicular to the slope. These candidates may have been thinking of components. Thinking of 'normal contact force' rather than 'reaction' may help students to get the direction right.



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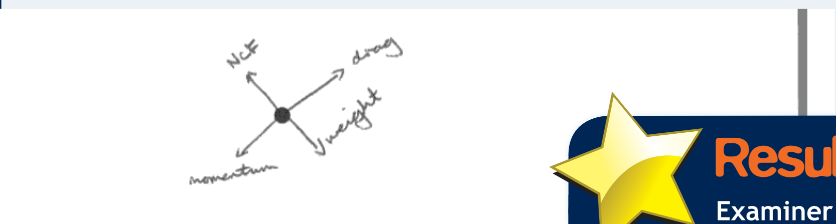
Examiner Comments

Two forces are in the correct direction, but none are shown correctly with force arrows leaving the point. Each pair is along the same line of action, but this is not a necessary condition for forces.



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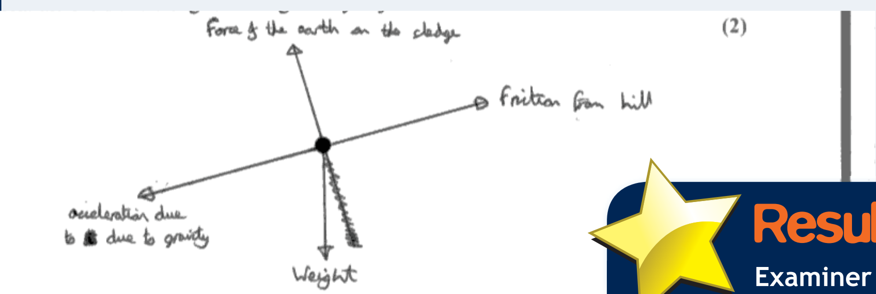
Examiner Comments

This has drag and NCF correct, but has weight in the opposite direction to NCF instead of vertical. An additional effect down the slope has been added.



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Examiner Comments

This has the three correct forces and all in the correct direction. There is an additional arrow, labelled acceleration, which should not be added to a free body force diagram. In addition, without details of the speed, it isn't possible to determine whether it is accelerating or travelling at constant velocity.

Question 16(b)(c)

In part (b), a majority selected an appropriate equation, although some rearranged it incorrectly. Some tried to use $v = u + at$, but they generally calculated the average velocity from 11 m / 4.9 s first and didn't double it. A large majority used their acceleration or the 'show that' value to find the force, although some used $g = 9.81$ m s^{-2} as the acceleration.

In part (c), the majority found the correct component of the adult's force, but rarely did any subtract the resultant force to find the resistive force. Again, clear diagrams appeared to help.

Candidates had little difficulty in applying work = force x distance and dividing this by time for power, but there was a fairly high incidence of using the wrong force, either the correct answer to (c) (i), 200 N, or the answer to (b) (ii). Units were sometimes given as N s^{-1}.

A fair proportion used $P = Fv$, which is not required by the specification. With some irony, while using average velocity was a problem in (b) (i), candidates tended to go astray here by calculating and using the final velocity. Although the calculations should involve exactly the same quantities (188 N x 11 m / 4.9 s), those not using $P = Fv$ were less likely to go astray.

(b) The child and sledge are pulled across level ground by an adult.

(i) They are pulled 11 m from rest in 4.9 s.

Show that the average acceleration is about 1 m s^{-2}.

(2)

11m 4.9s $\frac{\Delta V}{\Delta t}$ =

$\frac{11}{4.9}$ = 2.25 m/s $\frac{2.25}{4.9}$ = 0.46 m/s²

(ii) The child and sledge have a combined mass of 40 kg.

Calculate the average resultant force on the child and sledge.

(2)

40kg F=Ma

40kg x 1 m/s²

=

Average resultant force = 40N

(c) The force applied by the adult is 200 N at an angle of 20° to the horizontal.

(i) Calculate the average resistive force acting while the sledge is being pulled.

(2)

200N 20 200N F=ma

200 Cos 20 40kg ucosθ

200 Cos 20

187.96N

Average resistive force = 187.94N

(ii) Calculate the average power developed by the adult in pulling the sledge 11 m.

(3)

power = Wd/t 200x 11 =

2200 W / 4.9s

Average power = 448.98 W

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Examiner Comments

This attempts to find acceleration using change in speed/time, but the speed used is the average rather than the final speed.
in part (c) the resultant force isn't used to find resistive force and, although the correct equations are used, the wrong force is used when calculating power.

(b) The child and sledge are pulled across level ground by an adult.

(i) They are pulled 11 m from rest in 4.9 s.

Show that the average acceleration is about 1 m s^{-2}.

(2)

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

$11 = 12.005a$

$\frac{11}{12.005} = a = 0.916 \text{ ms}^{-2}$

about 1 ms^{-2}

(ii) The child and sledge have a combined mass of 40 kg.

Calculate the average resultant force on the child and sledge.

(2)

$F = ma$

$40 \times 0.916 = 36.7\text{ N}$

Average resultant force = 36.7 N

(c) The force applied by the adult is 200 N at an angle of 20° to the horizontal.

(i) Calculate the average resistive force acting while the sledge is being pulled.

(2)

Horizontal component of Force applied

$= 200 \cos 20 = 188\text{ N}$

$188 - 36.7 = 151\text{ N}$

Average resistive force = 151 N

(ii) Calculate the average power developed by the adult in pulling the sledge 11 m.

(3)

Work done = Force × distance

$200 \cos 20 \times 11 = 2067\text{ J}$

$\frac{\text{work done}}{\Delta \text{time}} = \text{Power}$ $\quad \frac{2067}{4.9} = 422\text{ W}$

Average power = 422 W

ResultsPlus

Examiner Comments

This is a good example of a fully correct answer.

Question 17(a)(i-ii)

Few problems were seen in (a) (i) and (ii), with over 90% getting both marks.

(a) (i) Show that the initial horizontal component of the fluid's velocity is about 5 m s^{-1}. (1)

$\cos(50) \times 7.5 = 4.82$

(ii) Show that the initial vertical component of the fluid's velocity is about 6 m s^{-1}. (1)

$\cos(30) \times 7.5 = 6.495$

ResultsPlus
Examiner Comments

This candidate completes part (i) but then, instead of using sine, uses cosine of the other angle but subtracts from 90 incorrectly. It should be cos 40 in part (ii).

(a) (i) Show that the initial horizontal component of the fluid's velocity is about 5 m s^{-1}. (1)

7.5, 50, 4.8

$\cos 50 \times 7.5 = 4.8 \text{ m s}^{-1}$

(ii) Show that the initial vertical component of the fluid's velocity is about 6 m s^{-1}. (1)

$\sqrt{7.5^2 - 4.8^2} = 5.76 \text{ m s}^{-1}$

$\tan 50 \times 4.8 = 5.72 \text{ m s}^{-1}$ $\sin 50 \times 7.5 = 5.74 \text{ m s}^{-1}$

ResultsPlus
Examiner Comments

This candidate calculates the answer in part (ii) in several different ways, but they all work.

Question 17(a)(iii)

In (a) (iii), the majority set out on the route of considering vertical and horizontal motion independently, finding the time to the highest point and going on to find the range. A proportion of those using this method failed to double the time to the highest point.

Errors included using $v^2 = u^2 + 2as$ and giving the height found as the final answer, reversing the components, using 7.5 m s^{-1} instead of one of the components and applying acceleration to the horizontal motion.

Some candidates used a single range equation, but some of these lost a lot of marks by not quoting or completing it correctly.

(iii) Use these values to calculate the maximum horizontal distance travelled by the fluid. Assume the fluid leaves the bottle at ground level. (4)

u = 5.7 v = 0 a 9.81 s = ? t ? ↑ vertically

v = u + at 0 = 5.7 + -9.81 t 9.81t = 5.7 t = 0.58s seconds to reach top

→ u = 4.8 v = 4.8 a = 0 s = ? t = 5.8s

s = ut + ½at² ½at² = 0 s = ut s = 5.7 × 0.585

distance travelled at half way = s = 3.34 m

3.34m So maximum horizontal distance = 2 × 3.34 = 6.68 m

Maximum distance = 6.68 m

ResultsPlus

Examiner Comments

This candidate adopts the correct general approach, but makes some errors. The vertical velocity is used to calculate time to maximum height, and this is doubled later for the full flight, and the horizontal component is quoted, but the vertical component is used again in the distance calculation.

(iii) Use these values to calculate the maximum horizontal distance travelled by the fluid. Assume the fluid leaves the bottle at ground level. (4)

u = 5.7 v = 0 a 9.81 s = ? t ? ↑ vertically

v = u + at 0 = 5.7 + -9.81 t 9.81t = 5.7 t = 0.58s seconds to reach top

→ u = 4.8 v = 4.8 a = 0 s = ? t = 5.8s

s = ut + ½at² ½at² = 0 s = ut s = 5.7 × 0.585

distance travelled at half way = s = 3.34 m

3.34m So maximum horizontal distance = 2 × 3.34 = 6.68 m

Maximum distance = 6.68 m

ResultsPlus

Examiner Comments

This is set out well, including all the values and with the relvant equations. Unfortunately the time to maximum height wasn't doubled to find the full time of flight.

Question 17(b)(i)

For the (b) (i) calculation, three quarters got credit for using the kinetic energy equation. Many of those who did not get this mark forgot to substitute using velocity squared. About a half got the second mark. Those who did not usually neglected to square velocity, used the wrong mass or the wrong velocity or calculated kinetic energy separately for the mass before and the mass after and found the difference. Quite a few gave N as the unit.

(b) (i) Calculate the total amount of kinetic energy transferred to the fluid.

total mass of bottle, contents and sweets before the experiment = 2.24 kg
total mass of bottle, contents and sweets after the experiment = 0.79 kg

(2)

2.24
− 0.79
1.45

ke = ½ mv²
ke 0.5 x 1.45 x 7.5
= 5.4375 J

Kinetic energy = 5.4375 J

ResultsPlus
Examiner Comments

Although the formula has been quoted correctly, once substituted this only includes velocity, not velocity squared.

(2)

B: $E_k = \frac{1}{2}mv^2 = \frac{1}{2} \times 2.24 \times 7.5^2$
= 63 J

63 − 22.22 =

A: $E_k = \frac{1}{2} \times 0.79 \times 7.5^2 = 22.22$ J

Kinetic energy = 40.78 J

ResultsPlus
Examiner Comments

This candidate gets credit for using the kinetic energy formula, but has used two masses to calculate energy separately and subtracted one value from the other. As part of the 2.24 kg and the 0.79 kg don't move at all, this value has no meaning.
The difference in mass should have been found before carrying out the calculation.

Question 17(b)(ii-iii)

In (b) (ii) and (b) (iii), answers were often reversed in comparison to those required and only a quarter gained any marks. For example, air resistance was very often quoted in (ii) when it was a possible cause in part (iii). Many candidates used inaccuracies in measurements or rounding errors as explanations. The key to this part was that the initial speed had been calculated as 7.5 m s^{-1} using the measured range and assuming all the liquid leaving the bottle had this velocity. Considering measured mass and calculated velocity, as they were used to find kinetic energy, might have been a good way to start. Kinetic energy would be too large if either was too large, and the context and photograph suggest a range of velocities and spilled liquid affecting the mass. Kinetic energy would be too small if either was too small, and the context suggests velocity.

(ii) Give a reason why your value of kinetic energy might be higher than the true value.

(1)

Because energy is lost through sound.

(iii) Explain why your value of kinetic energy might be lower than the true value.

(2)

Because the speed of some parts of the fluid are going faster than others only one part was measured

ResultsPlus

Examiner Comments

This has the basic idea for both reasons, but in the wrong order. The answer to (iii) would get the mark if it was given for part (ii). Energy lost through sound is a bit imprecise for a part (iiii) answer, but it would identify the calculated energy being less than the original energy.

not all of the liquid would have travelled the distance used

(iii) Explain why your value of kinetic energy might be lower than the true value.

(2)

because the fluid would have taken the path of a parabolic curve

ResultsPlus

Examiner Comments

This does give a correct answer for part (ii), but the answer ot part (iii) is not relevant.

Question 18(a)(i)

(a) (i) While three quarters got some credit, often for mentioning a straight line, only half got two marks. Many of these said ‘force is proportional to length’ rather than ‘force is proportional to extension’ or ‘force is proportional to change in length’. This is another example where candidates would do well to simply learn a law off by heart. For (a) (i), having ‘force is directly proportional to extension’ in mind would have helped many.

A significant minority thought it didn’t follow Hooke’s law because the line didn’t pass through the origin. They should be familiar with length vs force and extension vs force graphs and know the difference. It was somewhat disappointing that so few candidates incorporated this into their correct references to extension being proportional to force.

(a) (i) Explain whether the results follow Hooke’s law.

(2)

Yes they do, because the line is straight therefore, the length and the force put on is directly proportional. It has not reached the limit of proportionality yet.

ResultsPlus

Examiner Comments

This identifies a straight line, but links force to length rather than extension. Saying 'the force put on' is somewhat ambiguous as it could mean the force added each time or the total force.

(2)

The results do follow Hooke's law because the graph is a straight line which means Force is directly proportional to Length (or Extension).

ResultsPlus

Examiner Comments

This may not be deliberate, but candidates must choose their answer and not leave it to the examiner. This candidate should choose extension.

Question 18(a)(ii)

For (a) (ii), about three quarters of candidates who attempted this related stiffness to the gradient, although a fair proportion simply used two values from the graph and did not find the extension. A number of candidates did not read the graph values accurately enough and some used particularly small triangles. Scaling problems were usually eliminated because of the 'show that' answer.

A number of candidates did not attempt this part. It might be that they were put off by length being used, or perhaps they didn't recognise the term *stiffness*, although it is in the specification.

(ii) Show that the stiffness of the Slinky is about 0.7 N m^{-1}.

(3)

$F = k\Delta x$

$\frac{0.3\text{N}}{2.0} = 0.15\text{Nm}^{-1}$ $\frac{0.5\text{N}}{2.3} = 0.22\text{Nm}^{-1}$

$\frac{0.7\text{N}}{2.55} = 0.27\text{Nm}^{-1}$

ResultsPlus
Examiner Comments

This candidate has used Force/length rather than Force/extension. They have also done it for three pairs of values and obtained different results, which helps to illustrate that it is not the same as the gradient.

$F = ke$ $K = \frac{F}{E}$ $F = 0.8$ $E = (270 \times 10^{-2}) - (160 \times 10^{-2})$

$E = 1.1$

$\frac{0.8}{1.1} = 0.72\text{Nm}^{-1}$

ResultsPlus
Examiner Comments

This example clearly shows how extension has been calculated and goes on to find the correct answer.

Question 18(a)(iii)

Part (a) (iii) saw about three quarters identifying and using a correct formula, but there were again problems with not using an extension and misreading the scale and additional problems with cm and m. Directly calculating area from the graph usually resulted in the inclusion of an extra quantity of energy equal to the original length x the force chosen from an extra rectangle on the graph.

(iii) Calculate the elastic strain energy stored in the Slinky when the applied force is 0.70 N.

(3)

$E_{el} = F\Delta x$

$= 0.7 \times 257 = 179.9\ N$

Elastic strain energy = 179.9 N

ResultsPlus
Examiner Comments

This candidate has used force x extension, forgetting the factor of 1/2. A length has also been used, rather than an extension.

ResultsPlus
Examiner Tip

Do use the formula sheet to check - that's what it's there for.

$E_{el} = \frac{1}{2} F \Delta x$

$= 0.5 \times 0.7 \times 2.6$

$= 0.91\ J$

Elastic strain energy = 0.91 J

ResultsPlus
Examiner Comments

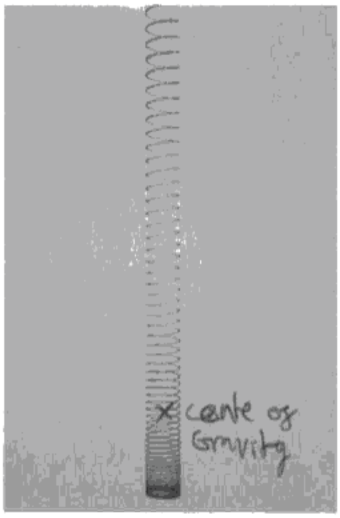
This uses the correct formula, but again uses length rather than extension. At F = 0.7 N the extension is 1.0 m.

Question 18(b)(i-ii)

Part (b) highlighted a lot of confusion between force and energy. For example, in part (i), some thought the spring was stretched more because gravitational potential energy increased as height increased. Some thought the Slinky stretched more at the top because the hand was pulling it up from the top and others unfortunately thought the bottom was supported by the ground. A majority managed to make some link with increased force at the top or having to support all the coils below.

Many candidates did not seem familiar with the centre of gravity of an irregular object, often placing it precisely in the centre or at the very bottom in (b) (ii).

(b) The photograph shows part of the Slinky hanging from a person's hand.



(i) Explain why the coils are extended more at the top than the bottom.

(2)

Because the coils at the top are under strain from the mass of the rest of the slinky.

(ii) Mark and label the approximate position of the centre of gravity of the Slinky on the photograph above.

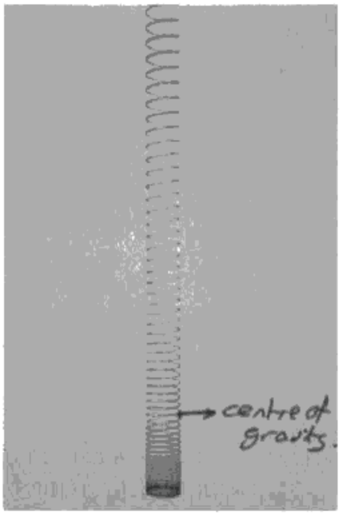
(1)

ResultsPlus

Examiner Comments

This states that the top coils are supporting more of the slinky, but doesn't link it to a greater force. The centre of gravity is in a sensible position.

(b) The photograph shows part of the Slinky hanging from a person's hand.



(i) Explain why the coils are extended more at the top than the bottom.

(2)

There is more mass acting down wards near the top of the slinky which counteracts the elastic energy stored. This causes the extension.

(ii) Mark and label the approximate position of the centre of gravity of the Slinky on the photograph above.

(1)

ResultsPlus

Examiner Comments

This candidate has indicated that a greater mass of the slinky is below the upper coils but fails to link extension to force, trying to explain in terms of energy instead.
The centre of gravity is not on the central axis of the coil, although it is positioned at a sensible vertical position.

Question 18(b)(iii)

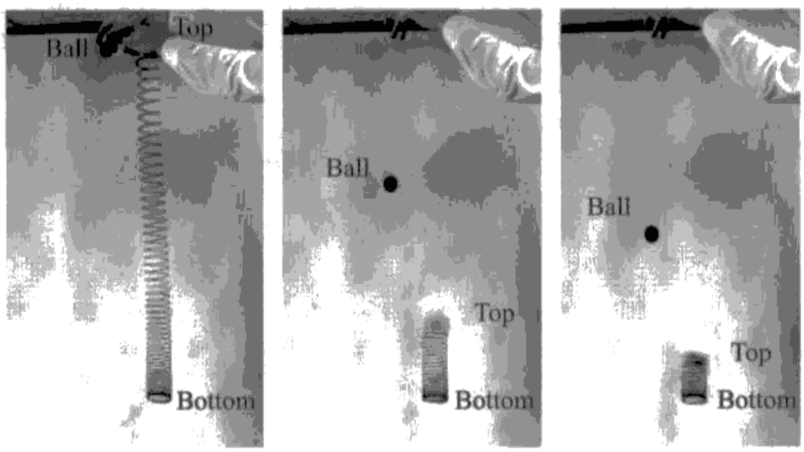
In (b) (iii) the majority linked the ball to the action of gravity only and about a third successfully compared this to the additional effect of elasticity on the Slinky, but they were far more likely to do so in terms of energy than force. Despite a clear instruction to consider forces, forces were not mentioned at all, unless it was to talk of strain energy pulling the spring down.

Candidates who mentioned weight (or gravitational potential energy) for the ball and tension (or elastic potential energy) for the Slinky did not always also mention the gravitational effect on the Slinky to establish a full comparison. A small proportion who correctly compared the forces went on to mention the effect of the extra force, i.e. an increased acceleration of the top coils.

There was sometimes reference to less air resistance for the Slinky, and a number of candidates thought compressive forces were acting.

For the final part candidates were only asked to make a suggestion of a cause rather than to explain it, but few mentioned that there was an upwards force as well as a downwards force or simply invoked Newton's first law to say that the forces must be balanced. Some suggested that the bottom coils had to wait for the top coils to catch up.

(iii) A ball is dropped from the same height, and at the same time, as the top of the Slinky is released. The three photographs below show what happens.



*(1) By considering the forces acting on the top coils of the Slinky, explain why they fall faster than the ball.

(3)

The forces acting on top coils is larger than of acting on the ball, because there is stored elastic strain energy in the Slinky which pulls the the top coils downwards, at the same it is being pulling gravitational force of Earth, while the ball only acts in the ~~affect of~~ effect of gravitational force of Earth only. Thus ~~it~~ the top coils fall faster than the ball.
Besides, the weight of the bottom coils also pull the top coils down.

(2) Suggest why the bottom coils remain in the same position in the three photographs.

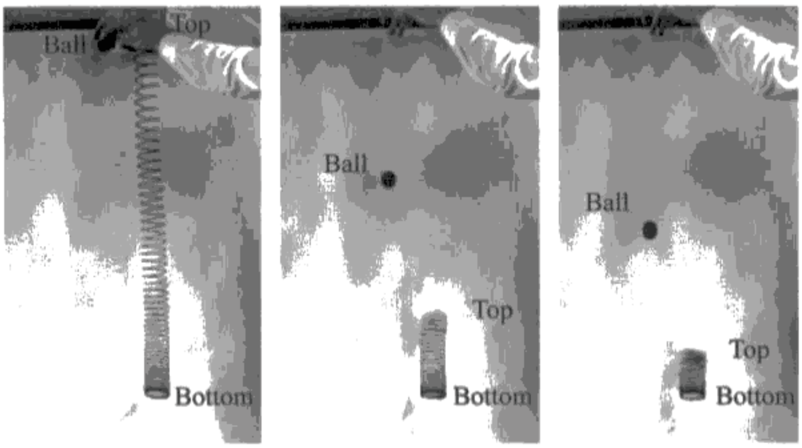
(1)

Their energy inside Slinky is used to do work to recover the Slinky's shape instead of being transferred as kinetic energy to fall down wards.

ResultsPlus

Examiner Comments

1 This is an example of an answer mixing energy and force. It says the elastic strain energy pulls coils downwards, showing confusion between force and energy. It does identify weight as the sole force acting on the ball. It just quotes 'falls faster' and doesn't relate this to acceleration.
2 This may have some relevance, but doesn't explain the question in any way.



*(1) By considering the forces acting on the top coils of the Slinky, explain why they fall faster than the ball.

(3)

The forces acting on the ball is weight. However acting on the ~~spr~~ slinky is the weight of the top coils plus the extension force from the spring. This gives an overal larger resultant downwards force for the slinky than the ball.

(2) Suggest why the bottom coils remain in the same position in the three photographs.

(1)

The reaction force of the extension pulls the top and bottom together upon release. ~~Due~~ The bottom stays ~~st~~ still as the reaction force there is equal to mg

ResultsPlus

Examiner Comments

1 This example does describe the forces correctly, but doesn't link it to acceleration.
2 This does describe an upwards force balancing weight, although it is called a reaction force, which is not clear. It would be quite satisfactory if it said, for example, tension.

Paper Summary

Candidates who used clear diagrams and set out their data in problems performed more consistently in calculations.

Those who were able to quote the required laws directly and concisely had a clear advantage in applying them to new situations.

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