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June 2024

IAL Physics WPH11 01

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Introduction

The unit WPH11 covers candidate's ability to understand and apply the physics involved in basic mechanics and properties of materials. The application of this knowledge in a range of familiar and unfamiliar contexts was examined.

There was a wide range of knowledge and skill demonstrated by candidates taking this paper. It was pleasing to see some excellent responses, particularly to some of the more challenging questions on topics such as moments and projectile motion.

Several questions asked for candidates to give explanations. While some candidates were able to answer these questions well, there was a fairly large proportion who were unable to include the detail needed to give complete answers, eg discussing a force instead of discussing the resultant force on an object.

Most candidates demonstrated a good ability to answer questions requiring calculations. However, in questions where candidates were asked to deduce an answer, it was common for candidates who calculated an appropriate value to just state their answer rather than compare their calculated value with a value given in the question.

Where diagrams were asked for, eg vector diagrams or free-body force diagrams, many candidates struggled – perhaps suggesting that more practice is needed for candidates at these skills.

The core practical task to describe the measurements needed to determine the Young Modulus of copper was assessed in question 16. While a fair proportion of candidates answered this well, many were vague when describing the measurements that were needed.

The standard of written English seen by the examiners in this paper did not, in most cases, cause any difficulty. Candidates were able to record their knowledge of the subject clearly, even if not in the best English. Apart from the * questions, where the structure of the candidates' responses was being assessed along with the physics, lack of skill in written English was not penalised, as long as the responses were clear and unambiguous.

It was clear that while most candidates have a broad idea of what is meant by most physics terms, many candidates need to improve their familiarity with physics terms and be able to apply these terms appropriately when giving explanations.

Question 11 (a)-(b)

Q11(a) was generally well answered, with most candidates correctly applying the equation for gravitational potential energy. A small proportion of candidates truncated their calculated answer from 417×10^6 J to 410×10^6 J instead of correctly rounding it to 420×10^6 J. Some candidates did not correctly convert answers between J and MJ.

The majority of candidates scored at least one mark on Q11(b), but many candidates did not apply conservation of energy and did not go on to score further marks. Some candidates tried to use a method which did not work, for example by trying to use the kinetic energy equation, work = force × distance or power = force × velocity. The correct unit was not always given.

11 A train moves up an inclined track at constant velocity. The train moves through a vertical height of 25 m.

(a) Show that the gravitational potential energy gained by the train is about 400 MJ.

mass of train = 1.7×10^6 kg

(2)

GPE = mgh

= $1.7 \times 10^6 \times 9.81 \times 25$

= 4.17×10^8 J

= 417 MJ ≈ 400 MJ (shown)

(b) The train's engine has an output power of 20 MW. The train takes a time of 35 s to move through the vertical height of 25 m.

Calculate the work done by the engine against resistive forces.

(3)

$P = \frac{W}{t}$

$P = \frac{F \times s}{t}$

$P = \frac{W}{t}$

W = Pt

= $20 \times 10^6 \times 35$

= 0.7×10^9 J

Work done = 0.7×10^9 J

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In Q11(a) this candidate showed a clear substitution into the equation for gravitational potential energy, and gave the answer to 3 significant figures, so gained both marks. To score the second mark, the answer needed to be given correctly to at least one more significant figure than the "show that" value given in the question.

In Q11(b) the candidate substituted into *W=Pt* which scored marking point 1, but they did not go on to use conservation of energy and so scored no further marks.

Question 12 (a)

Over 50% of candidates scored full marks on this question, with nearly four fifths of candidates gaining at least one mark.

The most common reason for scoring no marks was for candidates to use 3500 m^2 as the volume of the block of ice.

Some candidates treated the block of ice as a cylinder or sphere, which prevented them from scoring the first marking point, although they could go on to score some credit.

A small proportion of candidates calculated the weight of the block, but then went on to divide this by g and determine the mass of the block. Giving the mass as their final answer meant that marking point 3 was not scored.

The block of ice has a horizontal cross-sectional area of $3500\,m^2$.

(a) Calculate the weight of the block of ice.

density of seawater = $1.03 \times 10^3\,kg\,m^{-3}$

(3)

V = volume of displaced water = $3500\,m^2 \times 6.7\,m = 23450\,m^3$

~~$\rho = \frac{m}{V}$ so $m = \rho V = 1.03 \times 10^3\,kg/m^3 \times 23450 = 24153500\,kg$~~

Upthrust = weight of displaced sea water = $mg = \rho V g$

$= 1.03 \times 10^3 \times 23450\,m^3 \times 9.81 = 236945835\,N$

Weight of block of ice = upthrust = 236945835 N

Weight of block = 236945835 N

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Examiner Comments

This candidate calculated the volume of displaced water in the first line of their answer. Some candidates incorporated the volume calculation into a single calculation to determine the weight of the block, which was also a valid approach.

Many candidates, including this one, did not show separate working for use of W=mg and use of the density equation, instead jumping straight to mg=ρVg, which scored marking point 2.

In an ideal world, the answer would be given to the same number of significant figures as the data in the question, but this answer (with the correct unit included) was acceptable to score the final mark.

Question 12 (b)

Many candidates struggled to express themselves clearly in this question and were not clear about whether they were referring to, for example, the weight of the block/iceberg or the weight of displaced water. There was a clear misconception demonstrated by many candidates that the iceberg would float if weight is less than upthrust, rather than floating when weight is equal to upthrust. Some candidates wrote about drag, which was not relevant in the context of this question. A fair proportion of candidates described a change in density of the water, eg the weight is greater than the upthrust so the block of ice sinks, an approach which did not answer the question.

Approximately a quarter of all candidates scored at least one mark.

(b) An identical block of ice floats in water of a lower density than the seawater in (a). A larger volume of this block is below the surface of the water.

Explain why.

(2)

The upthrust is equal to the weight of displaced water. We know upthrust is equal to density x volume x g ($u = \rho v g$). As density is less, a larger volume has to be displaced to provide same upthrust.

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This candidate scored the first marking point in the first two lines. There were several valid methods to score this mark, by equating either the weight of the iceberg with the weight of displaced water, the weight of the iceberg with the upthrust, or the method seen here.

They go on to score marking point 2 in the second to last line.

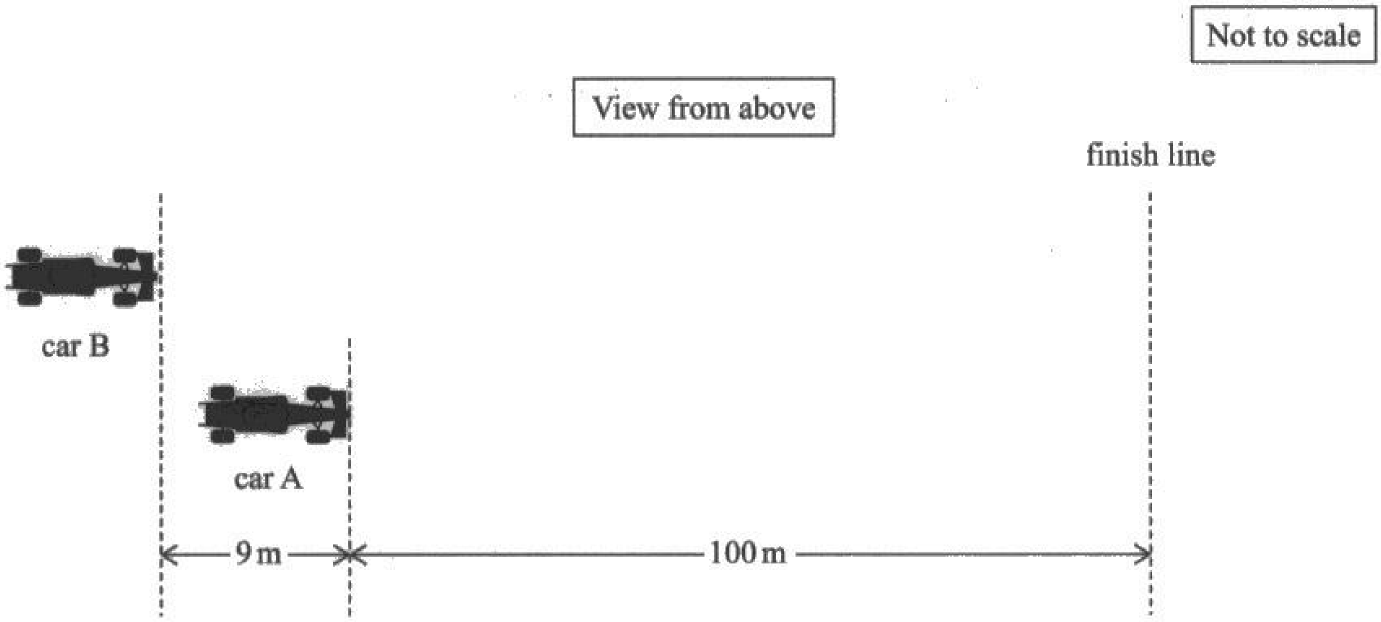
Question 13 (a)-(b)

In Q13(a) many candidates decided to "reverse engineer" the answer, taking the time of 1.1s and using it to show the distances travelled by both cars in that time and comparing these. As with the majority of "show that" type questions, to score the final mark, a value for the quantity stated needed to be given to one more significant figure than the value in the question. The reverse-engineering approach therefore limited candidates to a maximum of 2 marks on this question part. A relatively common mistake was for candidates to try to show that the cars were side by side at the finish line, which was not what was asked for.

There were many different valid approaches to Q13(b), but the most common approach was to calculate and compare the time taken for each car to finish the race. It is often the case in "deduce" questions that candidates need to make a comparison of values once they have completed their calculations. Some candidates did not make a valid comparison, despite having made appropriate calculations, which prevented them from scoring marking point 3. Some candidates did not include a unit with their calculated values, which prevented them from scoring marking point 2.

13 Two cars, A and B, are racing along a track.

Car A has a constant velocity of $93\,\text{m s}^{-1}$. At a particular instant, car A is 9 m ahead of car B, as shown.



At this instant, car B has a velocity of $93\,\text{m s}^{-1}$. Car B is accelerating with a constant acceleration of $14\,\text{m s}^{-2}$.

(a) Show that car A and car B are side by side after a time of about 1.1 s.

(3)

$S_A = 9 + V_A t = 9 + 93t$

$S_B = ut + \frac{1}{2}at^2 = 93t + \frac{1}{2} \times 14 \times t^2 = 93t + 7t^2$

$S_A = S_B$

$9 + 93t = 93t + 7t^2$

$t^2 = \frac{9}{7}$

$t = 1.13\ \text{s}$

(b) At the instant shown, car A is 100 m from the finish line.

Deduce whether car A reaches the finish line before car B.

(3)

$t = \frac{s}{v} = \frac{100}{93} = 1.08\ s$

$s_B = 93 \times 1.08 + \frac{1}{2} \times 14 \times 1.08^2 = 108.6\ m$

$100 + 9\ m > 108.6\ m \qquad 109 > 108.6$

$\therefore$ car A reaches the finish line before car B

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In Q13(a) this candidate's first line is an equation to determine the distance of car A from car B's initial position after time t.

In line 2, there is an equation to determine the distance travelled by car B in time t. Either of these lines on its own would have been enough to score marking point 1.

By equating these two statements in line 4, the candidate is using the difference in distances of 9 metres, and scores marking point 2.

The final answer of 1.13 s is given to one more significant figure than the value of 1.1 s given in the question, and so all 3 marks are scored.

In Q13(b) the candidate first calculates the time taken for A to cross the finish line as 1.08 s. This scores marking points 1 and 2.

The candidate then determines the distance travelled by car B in that time and compares the calculated distance with 109m, giving a valid conclusion, and scoring the final mark.

Question 14 (a)

Most candidates appeared to understand what the question was asking, although many candidates struggled to articulate a complete and unambiguous answer. A statement such as "weight = drag and upthrust" could be interpreted as meaning that weight = drag, and weight = upthrust. This would be incorrect, and so this did not score the mark. A more mathematically accurate description of "weight = drag + upthrust" was sufficient.

Some candidates answered the question by describing the conditions for Stokes' law to apply, (ie describing the grain of sand as small and spherical, with laminar flow) which did not gain any credit. Others described the time taken for the grain of sand to reach terminal velocity, which again did not answer the question.

14 A grain of sand quickly reaches terminal velocity when it falls into water.

(a) State why the grain of sand reaches terminal velocity.

(1)

Since the drag + upthrust = W

meaning the resultant force is 0

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Examiner Comments

Either of the statements given by this candidate would have scored this mark. Both are valid answers to the question. A statement that "the resultant force is 0" was relatively uncommon, with more candidates describing the relationship between drag, upthrust and weight at terminal velocity.

Question 14 (b)

The majority of candidates scored at least 1 mark on this question, with nearly 40% of candidates gaining full marks.

Candidates could calculate various quantities from the question and compare these. One of the more common approaches was to compare the drag force with the weight minus the upthrust, which was an alternative route to the example given on the mark scheme but was fully creditworthy.

Many candidates did not compare their calculated values in order to give a conclusion, which prevented them from scoring the third marking point.

(b) A spherical grain of sand has a weight of 4.3×10^{-5} N. The grain of sand displaces water with a weight of 1.5×10^{-5} N.

The terminal velocity of the grain of sand as it falls through the water is about 0.050 m s^{-1}.

Deduce whether Stokes' law applies to the grain of sand as it falls at terminal velocity.

viscosity of water = 1.2×10^{-3} Pa s
diameter of grain of sand = 1.5×10^{-3} m

(3)

$W = U + D$

$\Rightarrow D = W - U = (4.3 \times 10^{-5}) - (1.5 \times 10^{-5})$
$= 2.8 \times 10^{-5}$ N

$D = 6\pi r \eta v$
$= 6\pi \times 7.5 \times 10^{-4} \times 1.2 \times 10^{-3} \times 0.050$
$= 8.48 \times 10^{-7}$ N

∴ Since the values of both drag forces are not equal, Stokes' Law cannot be applied.

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This candidate calculated the value of drag using weight minus upthrust, and then calculated the value of drag using the Stokes' law equation. They went on to compare them ("the values of the drag forces are not equal") and give a valid conclusion, so scored all three marks.

Question 14 (c)

Just under half of all candidates scored both marks, with about 70% of candidates gaining at least one mark on this question.

There were many very clear and concise answers. However, some candidates lost their way by trying to account for all of the terms in the Stokes' law equation, but then didn't actually describe how the temperature of the water affects terminal velocity. Some candidates didn't specify whether they were referring to increasing or decreasing temperature, merely stating that temperature causes viscosity to decrease. This was not sufficient and so neither mark was scored in this case.

(c) Explain how the temperature of the water affects the terminal velocity of a grain of sand if Stokes' law does apply.

(2)

If temperature increases, viscosity of water decreases so terminal velocity increases, if temperature decreases, viscosity of water increases so terminal velocity decreases

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This candidate described the effect on viscosity and terminal velocity of both increasing the temperature of the water and decreasing the temperature of the water. Either approach on its own would have been enough to score both marks.

Question 15 (a)-(b)

Nearly all candidates gained at least 1 mark on this question, with about three quarters of candidates gaining 4 or 5 marks in total.

In Q15(a) it was very common to see a clearly laid-out answer, with conservation of momentum applied and a correct final answer. Some candidates did not give their answer to one more significant figure than the value given in the question, which prevented them from scoring the final mark. In the scenario given, both A and B had the same mass. Candidates who realised that this would cancel out the equation when conserving momentum could still score full marks if they simply subtracted the speed of B after the collision from the speed of A before the collision, to arrive at the correct answer.

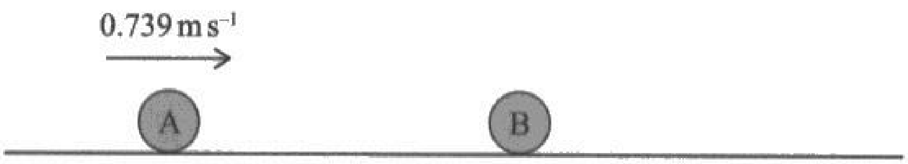
In Q15(b) most candidates scored at least one mark. A fair proportion of candidates only calculated the decrease in kinetic energy of ball A, rather than the total decrease in kinetic energy, which should have included ball B. Some candidates used the initial mass and velocity of ball A to calculate a value for the kinetic energy of A to more significant figures than the value given in the question. They then went on to use this value to answer the question. This was not an incorrect approach, and many of these candidates scored full marks on this question.

15 Two identical balls, A and B, collide. Ball B is initially at rest. After the collision, ball B moves off in the same direction as ball A.

The mass of each ball is 0.165 kg.

The initial velocity of ball A is 0.739 m s^{-1}. After the collision, the velocity of ball B is 0.691 m s^{-1}, as shown.

Before collision



After collision

(a) Show that the velocity of ball A immediately after the collision is about 0.05 m s^{-1}.

(3)

Total momentum before = total momentum after

$m_1v_1 + m_2v_2 = m_1v_1 + m_2v_2$

$0.165 \times 0.739 + 0.165 \times 0 = 0.165 \times v + 0.165 \times 0.691$

$\frac{(0.165 \times 0.739) - (0.165 \times 0.691)}{0.165} = v$

$v = 0.048 \text{ ms}^{-1}$

(b) Before the collision, the kinetic energy of ball A is 4.5×10^{-2} J, and the kinetic energy of ball B is zero.

Determine the decrease in total kinetic energy during the collision.

(2)

$E = \frac{1}{2} \times m \times v^2$

$= 0.5 \times 0.165 \times (0.048)^2$

$= 1.9 \times 10^{-4}$ J

Decrease

$45 \times 10^{-2} - 1.9 \times 10^{-4}$

$= 0.04481$

Decrease in total kinetic energy = 4.48×10^{-2} J

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In Q15(a), this candidate has clearly laid out the conservation of momentum calculation to arrive at the correct answer, which is given to one more significant figure than the "show that" value given in the question. They scored all 3 marks.

In Q15(b) the candidate has calculated the final kinetic energy of A, scoring marking point 1. However, they have then made the relatively common error of calculating the change in kinetic energy of ball A, rather than calculating the total change in kinetic energy of balls A and B, so they do not score the second mark.

Question 15 (c)

Approximately one in five candidates scored both marks on this question, with just over 50% of candidates gaining some credit.

Many candidates struggled to express themselves clearly when answering this question. There was often a particular lack of clarity when referring to the **resultant** force acting on ball A. It was reasonably common for candidates to just state that "every action has an equal and opposite reaction" which was not enough to score marking point 1. There was a reasonably common misconception that the resultant force on ball A decreased, which caused acceleration to decrease because *F=ma.* The correct description of this should have been that the resultant force on A was in the opposite direction to its motion, and therefore ball A decelerated.

(c) During the collision there is a resultant force on ball B from ball A.

Explain, in terms of Newton's laws, why ball A decelerates during the collision.

(2)

Ball A exerts a force ~~of to~~ on ball B. According to Newton's third law, ~~Ball B~~ ball B exerts an equal and opposite force on Ball A which is in opposite direction of motion of ball A. Therefore, a resultant force acts on ball A backwards. Thus according to Newton's ~~th~~ second law F=ma, ~~Ba~~ ball A decelerates.

(Total for Question 15 = 7 marks)

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The response from this candidate clearly lays out how Newton's third law applies to the collision, and then how Newton's second law applies to ball A, with a **resultant** force acting backwards and causing deceleration. This candidate scored both marks.

Question 16 (a)

There was a good spread of marks on this question, with over 80% of candidates scoring at least one mark, and around 25% of candidates scoring 5 or 6 marks. Many of the answers seen were very clearly written and demonstrated a good understanding of this practical task.

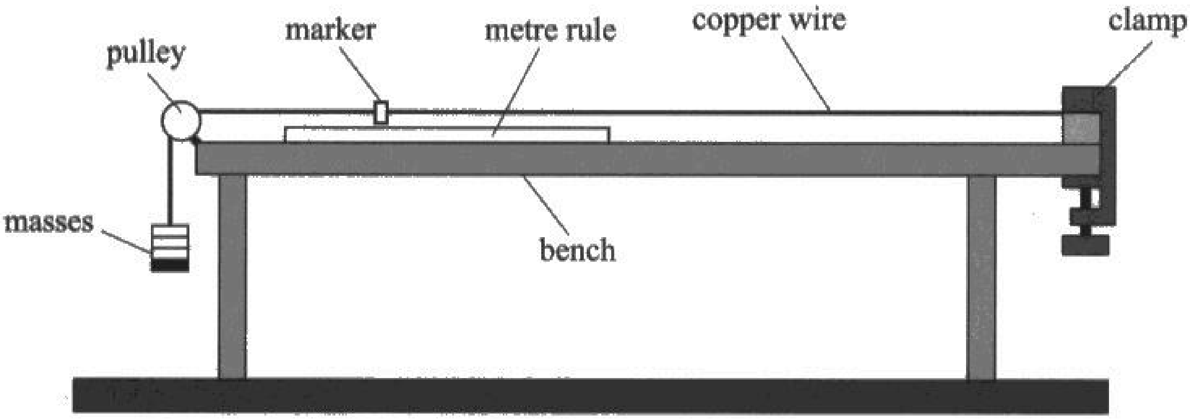
Many candidates were very good at defining any symbols they referred to when quoting the equations for stress, strain or the Young modulus. However, descriptions of how to measure the quantities needed had a tendency to be vague. For example, it was reasonably common for candidates to "measure the extension" without making it clear what they were actually measuring – they should have either measured the distance moved by the marker, or measured the original length and the new length and then calculated the difference.

Candidates could either take a graphical approach or a calculation-based approach to determine the Young modulus, and either approach could score full marks.

16 A student carried out an experiment to determine the Young modulus of copper.

*(a) The student clamped one end of a copper wire to the bench. The wire passed over a pulley and masses were added to the other end of the wire.

A metre rule was fixed to the bench and a marker fixed to the wire, as shown.



The student measured the diameter of the copper wire. $\frac{F}{A}$, $\frac{x}{\Delta x}$

Describe the other measurements that need to be made using this apparatus and how they will be used to determine the Young modulus of copper.

You should define the meanings of any symbols you use.

(6)

Young modulus = $\dfrac{\frac{F}{A}}{\frac{\Delta x}{x}} = \dfrac{Fx}{A\Delta x}$ = $\dfrac{\text{force} \cdot \text{length of wire}}{\text{cross-section area of wire} \times \text{extension of wire}}$.

Use the metre rule to measure the length of copper wire before to add the masses. Then use ~~Use~~ the metre rule to measure the total length of wire when add the masses. Use total length minus the original length to calculate the extension. Use a balance to measure the masses which must multiply the "g" to calculate the force act on the copper wire. Use the diameter ~~to~~ and formular $\pi(\frac{d}{2})^2$ to calculate the cross-seotion area of the wire. Make sure repeat this experience and take average of data, then calculate the Young modulus of the copper wire.

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The line of equations at the top of this candidate's response addresses both IC5 and IC6 on the mark scheme, giving a combined equation to determine the Young modulus and defining all symbols involved.

In line 2, the candidate measures the original length (IC1). They have then added masses and measured the new length and used this to determine the extension of the wire (IC2). Using a balance to determine the mass of the masses was not necessary but would lead to a more accurate final value for the Young modulus. This candidate has multiplied the mass by g to determine the force on the wire (IC3), and then described how the diameter can be used to calculate the cross-sectional area of the wire (IC4).

This response scored 6 marks.

Question 16 (b)

Slightly more than half of all candidates scored full marks on this calculation.

Some candidates treated the diameter as a radius when calculating the cross-sectional area of the wire. This prevented them from scoring the first marking point, but other marks could still be scored. Some candidates made power of ten errors when converting the diameter to metres. A proportion of candidates treated the diameter as an area, which prevented them from scoring further marks.

It is always worth encouraging candidates to think about how sensible their answer is after doing a calculation – if the answer to a question about stretching a wire in a laboratory comes out with an extension greater than the size of a typical laboratory, for example, then candidates ought to be checking their working to look for errors.

(b) Another student attaches a weight of 5.0 N to a copper wire of diameter 0.56 mm.

Calculate the extension of the wire.

length of wire = 2.5 m
Young modulus of copper = 1.1×10^{11} Pa

(4)

Cross-sectional Area = $\pi(d/2)^2$

$= \pi\left(\frac{5.6 \times 10^{-4}}{2}\right)^2 = 2.463 \times 10^{-7} m^2$

Young Modulus = $\frac{\text{Stress}}{\text{Strain}}$

$= \frac{F/A}{\Delta x / x}$

$\therefore \Delta x$ = extension
x = length of wire
F = Force
A = Area

$E = \frac{F x}{\Delta x \times A}$

extension = $\frac{\text{Force} \times \text{length}}{\text{Young Modulus} \times \text{Area}}$

$= \frac{5.0N \times 2.5m}{(1.1 \times 10^{11} Pa) \times (2.463 \times 10^{-7} m^2)} = 4.61 \times 10^{-4} m$

Extension = $4.61 \times 10^{-4} m$

(Total for Question 16 = 10 marks)

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This candidate has laid out their working clearly, calculating the cross sectional area, and then substituting their values into a re-arranged version of the Young modulus equation, which incorporates the stress and strain equations. This candidate scores all four marks.

Question 17 (a)-(c)

Approximately a fifth of candidates scored full marks on Q17.

Q17(a) was generally well answered. A minority of candidates did not give their answers to enough significant figures. A small number of candidates did not indicate which of their calculated values was the horizontal component and which was the vertical component. However, most candidates showed their working clearly and gave correct values to at least one more significant figure than the values stated in the question.

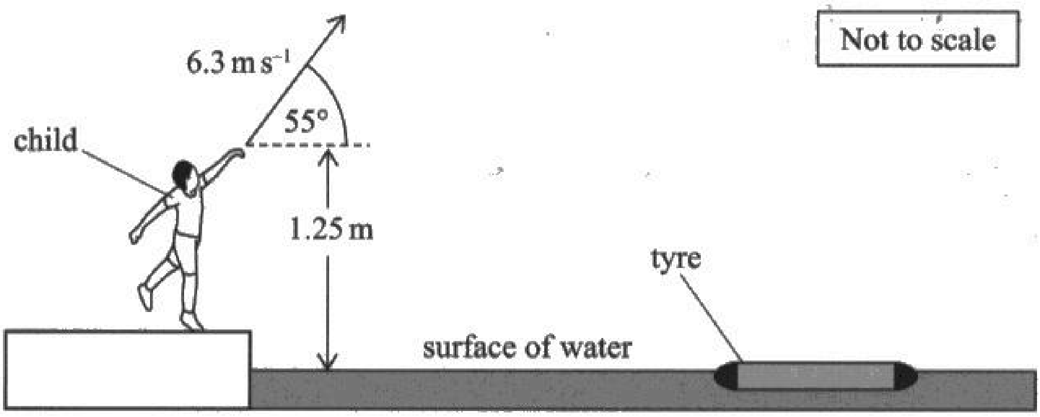
Q17(b) was also generally well answered. Some candidates took alternative, but valid, routes to answering the question, for example by calculating the time taken to reach maximum height and then calculating the maximum height using this equation. Most candidates remembered to add the 1.25m starting height of the stone.

Q17(c) proved to be more challenging than parts (a) and (b). There were a variety of valid approaches taken by candidates to answer this question. Common errors included calculating the time taken for the stone to return to its original height, and then using this time to determine the distance travelled by the stone. As with other "deduce" questions on this paper, there was a proportion of candidates who did either not give a valid comparison, or who did not give a valid conclusion and therefore did not score the final marking point. This mark could be scored even if mistakes had been made in the previous calculations.

17 A child is playing a game. The child is trying to get stones to land inside an old tyre floating on the water.

The child throws a stone at a speed of $6.3\,\text{m s}^{-1}$ and at an angle of 55° to the horizontal.

The stone leaves the child's hand at a height of 1.25 m above the surface of the water, as shown.



(a) Show that the vertical component of the stone's initial velocity is about $5\,\text{m s}^{-1}$ and that the horizontal component is about $4\,\text{m s}^{-1}$.

(2)

$6.3 \sin 55 = 5.2\,\text{ms}^{-1} = V_v$

$V_H = 6.3 \cos 55 = 3.6\,\text{ms}^{-1}$

(b) Show that the greatest height above the surface of the water reached by the stone is about 3 m.

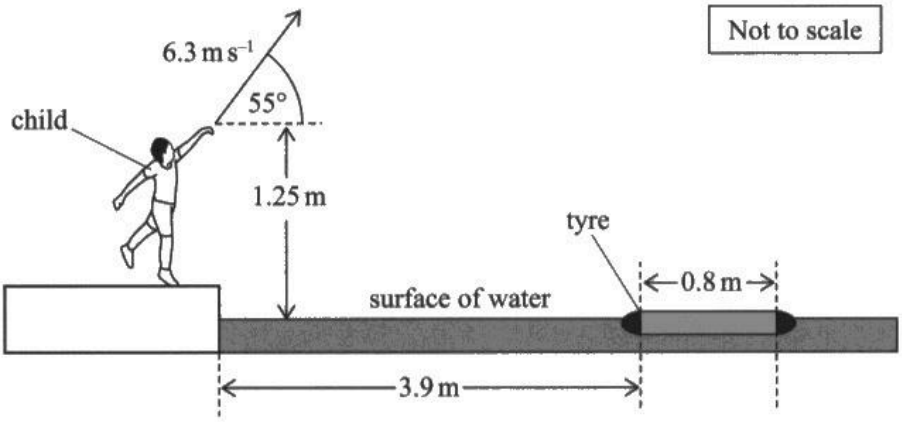
(3)

$s = ?\quad u = 5.2\quad v = 0\quad a = -9.81$

$v^2 = u^2 + 2as \Rightarrow s = \frac{v^2 - u^2}{2a}\qquad s = \frac{0^2 - 5.2^2}{2(-9.81)} = 1.38\,\text{m}$

$1.25 + 1.38 = 2.6\,\text{m}$

(c) The inside of the tyre is 0.8 m in diameter and is 3.9 m from the side of the water, as shown.



Deduce whether the stone thrown by the child lands inside the tyre.

(4)

$s_H = V_H t$ $\qquad s = -1.25 \quad u = 5.2 \quad v = ? \quad a = -9.81 \quad t = ?$

$s_H = 3.6 \times 1.26 = \underline{4.54\,m}$ $\qquad \uparrow s = ut + \frac{1}{2}at^2$

$-1.25 = 5.2t + \frac{1}{2}(-9.81)t^2$

$0 = 1.25 + 5.2t + 4.9t^2$

$t = 1.26s$

~~4.54m~~ 3.9m < 4.54m < 4.7m ∴ lands inside tyre

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Examiner Comments

In Q17(a) the candidate has clearly shown the vertical (V_v) and horizontal (V_h) values to one more significant figure than the values given in the question. Both marks are scored.

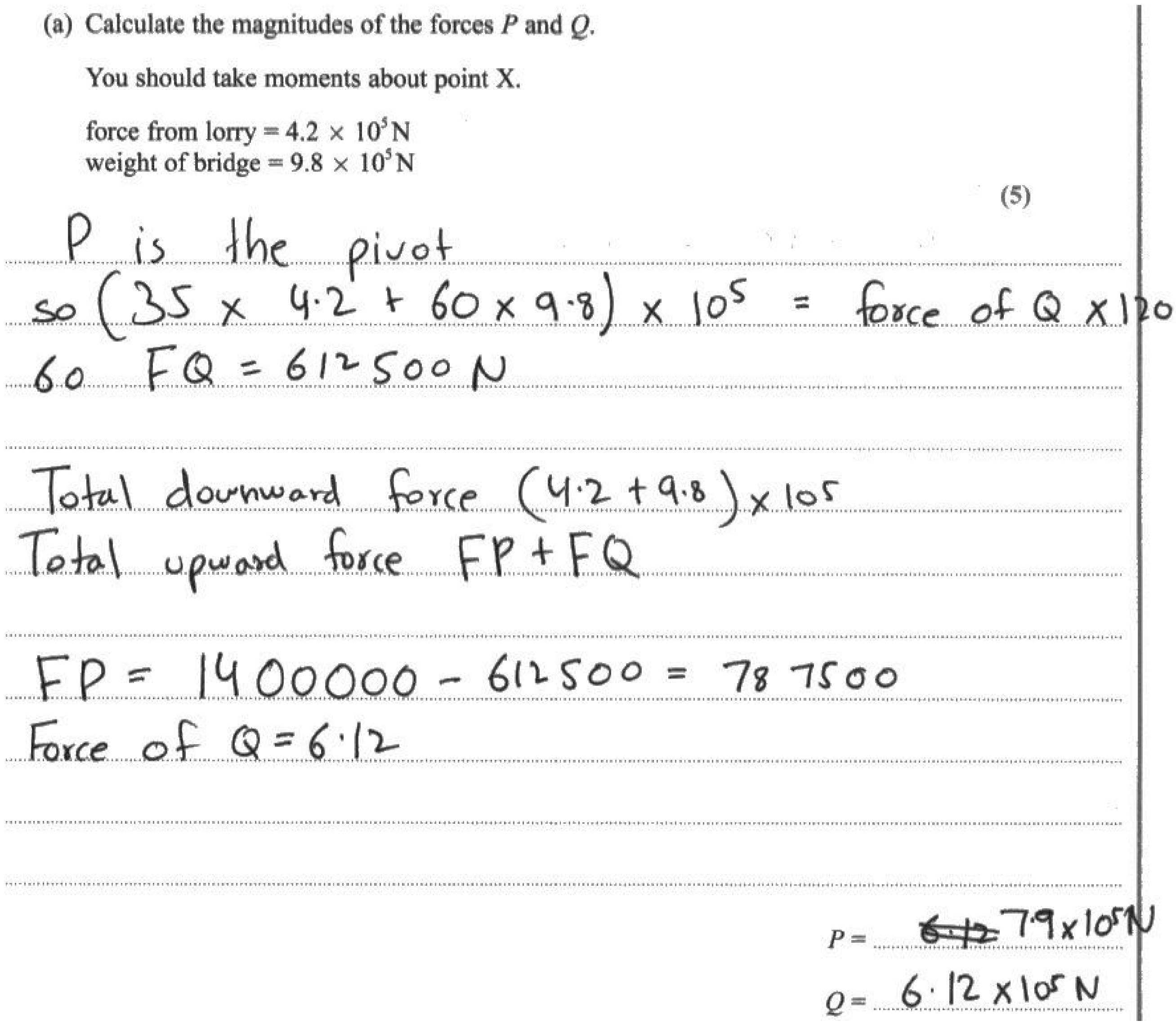
In Q17(b) the candidate has used the appropriate suvat equation to determine the change in height, and added the initial height to arrive at the correct answer, scoring all marks.

In Q17(c), in the central column of the answer space, the candidate calculates the time taken until the stone lands in the water of 1.26s. The left end of the first two lines show that the speed × this time is 4.5m. This distance is then compared with the distances either side of the tyre, and the relevant conclusion is given. This response scores 4 marks.

Question 18 (a)

The majority of candidates were able to score at least one mark on this question, for using the equation for the moment of a force. Just under half of all candidates scored all 5 marks.

Some candidates forgot to include a unit in their answers, a mistake which could lead to a maximum mark of 4. Some candidates took moments about positions other than point X. It was possible to score full marks by taking this approach, but answers attempted in this way often made errors when solving as a simultaneous equation.



(a) Calculate the magnitudes of the forces P and Q.

You should take moments about point X.

force from lorry = 4.2×10^5 N
weight of bridge = 9.8×10^5 N

(5)

P is the pivot
so $(35 \times 4.2 + 60 \times 9.8) \times 10^5$ = force of Q $\times 120$
so FQ = 612500 N

Total downward force $(4.2 + 9.8) \times 10^5$
Total upward force FP + FQ

FP = 1400000 − 612500 = 787500
Force of Q = 6.12

$P =$ ~~6.12~~ 7.9×10^5 N

$Q =$ 6.12×10^5 N

ResultsPlus Examiner Comments

This candidate has correctly determined F_Q and then applied Newton's first law to determine the value of F_P, scoring all 5 marks.

Question 18 (b)

Many candidates struggled on this question, with over 40% scoring no marks.

Some candidates took a more mathematical approach to answering the question, which tended to work well for them. Some candidates did not realise that this was a question about moments, and instead attempted to answer in terms of Newton's third law, which gained no credit. Others referred to conservation of momentum which was also not correct. It was reasonably common for candidates to attempt to describe that at equilibrium the sum of all moments is zero, but to describe this incompletely by stating something such as "at equilibrium the moment is zero" – which was not sufficient to score marking point 3.

(b) Explain why force Q increases as the lorry moves across the bridge.

(5)

The ~~to~~ moment of lorry is the distance from lorry to original ~~point~~ point X the weight of lorry. ~~the~~ Define P is original point. When lorry moves across the bridge, the distance from lorry to P ~~is~~ increases, thus the moment of lorry increases. ~~So~~ ~~if~~ Due to moment of lorry + moment of weight of bridge = moment of ~~fo~~ Q, and the distance from Q to P is constant. So the force Q is increased to keep this system is equilibrium, ~~which means the total~~

ResultsPlus Examiner Comments

This candidate scored 4 marks.

On line 3, the answer refers to "The distance from lorry to P increases, thus the moment of lorry increases" scoring marking points 1 and 2. The equation on line 5 is equivalent to the sum of moments remaining zero, and scores marking point 3. The candidate did not mention that the moment about X due Q increases, so did not score marking point 4. However, they did mention that the distance from Q to P is constant so Q increases, scoring the fifth marking point.

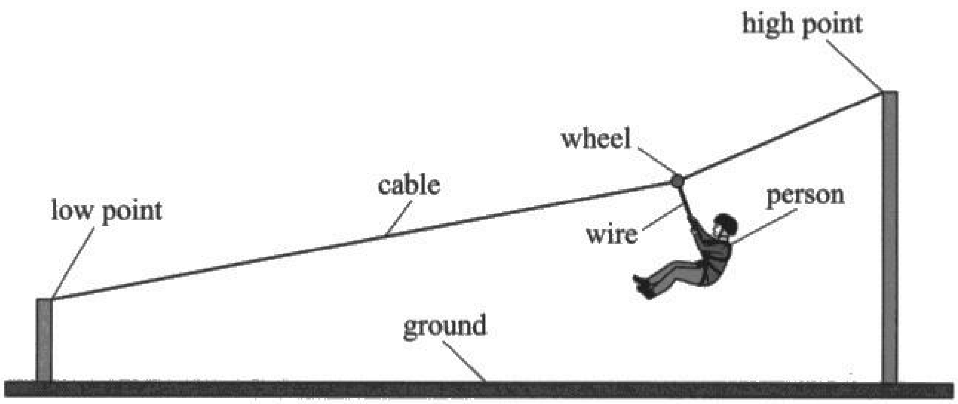
Question 19 (a)

Approximately nine out of ten candidates gained at least one mark on this free-body force diagram, but less than a fifth managed to score all 3 marks.

Some candidates drew two force arrows representing the tension in the cable, rather than representing the forces on the person. Some of these responses still scored a mark for correctly drawing a weight arrow on their diagram. It was relatively common for candidates to either not label their force arrows at all, or to use non-standard abbreviations to name the forces.

19 A 'zip-line' consists of a cable fixed at two points, one higher than the other.

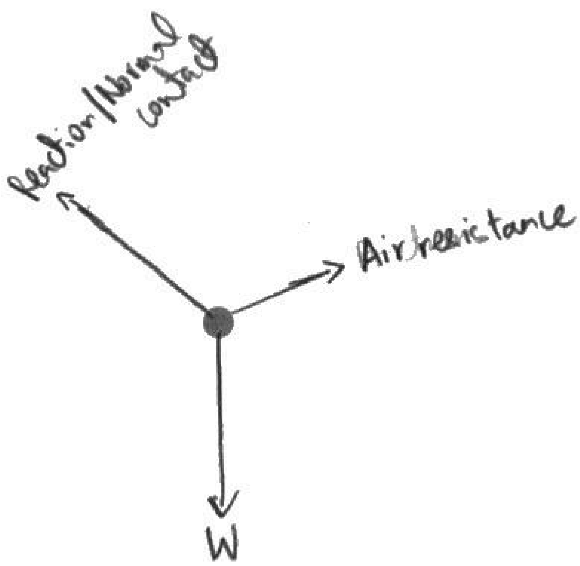
A person hangs from a wire attached to a wheel, as shown. The wheel can move along the cable. The wheel moves the person along the cable.



(a) In the position shown, the person is accelerating.

Complete the free-body force diagram below to show the three forces acting on the person in this position.

(3)



ResultsPlus
Examiner Comments

This response scored 3 marks.

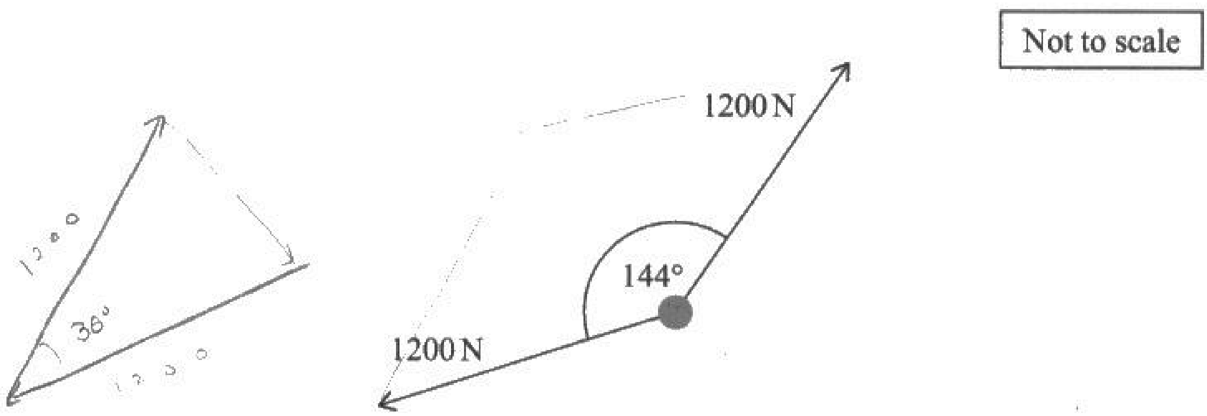
The force of the wire on the person could also be labelled as the normal contact force, as in this example, or tension.

Question 19 (b)(i)

Candidates who took a valid approach to this question had a tendency to score both marks, so only a very low proportion of candidates scored 1 mark. Many candidates correctly used the cosine rule to arrive at their answer.

Candidates struggled to get started on this question. Many candidates found it useful to add to the given diagram, or to draw their own diagram, to help them arrive at the correct calculation needed.

(b) At a particular instant, the tension in the cable is 1200 N and the angle formed by the cable at the wheel is 144°, as shown.



(i) Show, by calculation, that the force on the wheel from the cable is about 740 N.

(2)

$(F_w)^2 = 1200^2 + 1200^2 - 2(1200)(1200)\cos 36$

$F_w = \sqrt{5.5\times10^5}$

$= 741.6$ N

ResultsPlus
Examiner Comments

This response scored both marks. The candidate has drawn a vector triangle at the top left. This on its own is not worth credit, but it may have helped the candidate to apply the cosine rule and arrive at the correct answer.

Question 19 (b)(ii)

Many candidates struggled with drawing a vector diagram. Many responses were left blank, and a fair number of candidates drew an arrow to represent the force from the wire but got no further. Of those candidates who did draw a vector triangle, many started the 800 N arrow and the 740 N arrow starting from the same point, rather than drawing the arrows tip to tail. Some candidates did not attempt a vector diagram, instead using trigonometry to calculate their answer, an approach which scored a mark if their answer was correct.

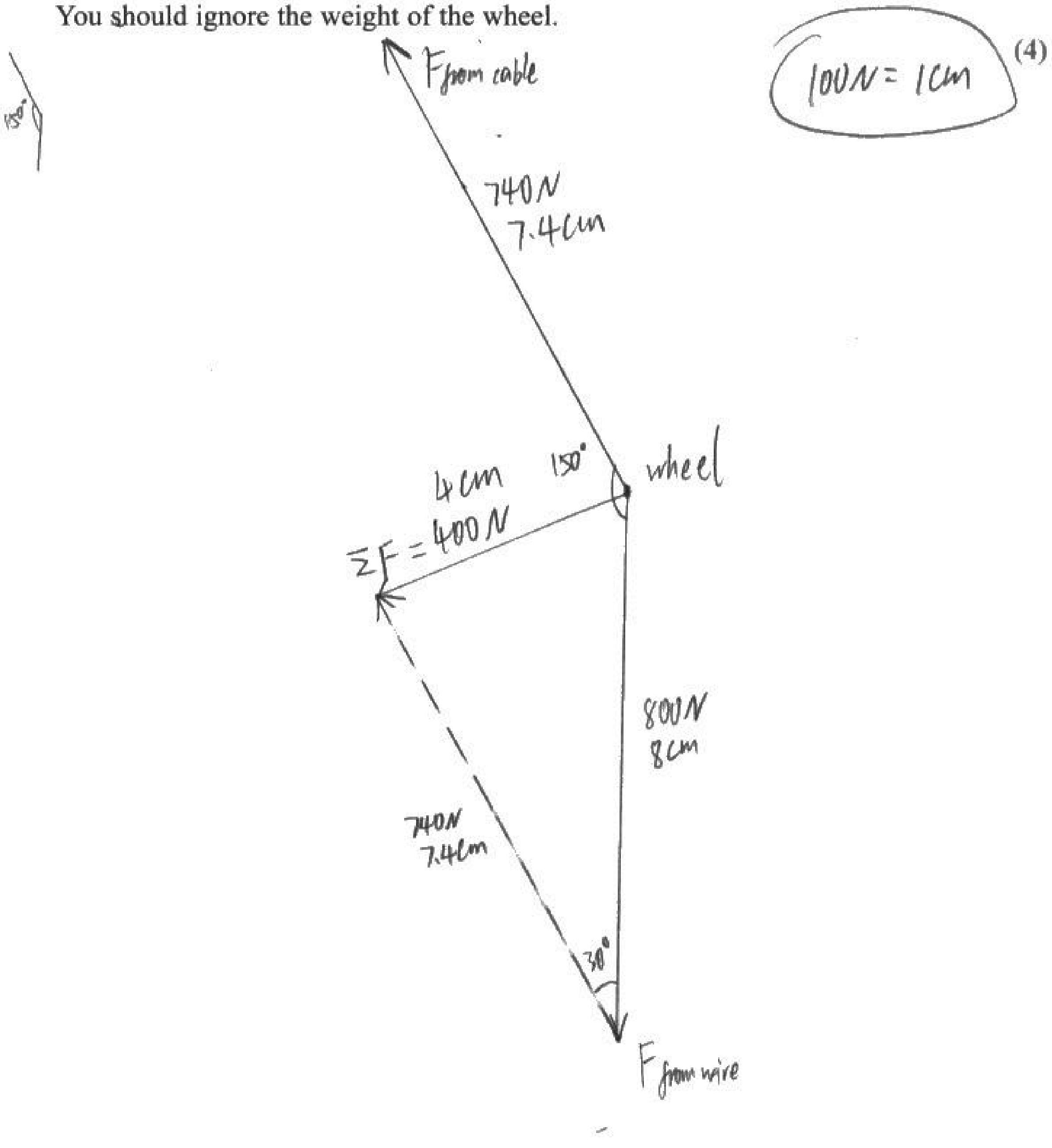
(ii) There is a force on the wheel from the wire of 800 N.

The angle between the force from the cable and the 800 N force from the wire is 150°.

Determine the magnitude of the resultant force on the wheel using a scaled vector diagram.

You should ignore the weight of the wheel.

(4)



Resultant force on the wheel = 400N

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This candidate scored all four marks on this question.

Constructing (or beginning to construct) a parallelogram did not prevent the marks for the vector triangle being scored. The arrows forming the triangle are all clearly labelled and are pointing in the correct relative directions.

Question 19 (c)

It was very rare for candidates to score all three marks on this question. Those who described the change from gravitational potential energy to kinetic energy often scored marking points 1 and 2, but very few candidates went on to note that this assumed that air resistance was negligible.

(c) People take turns at moving along the zip-line from the high point to the low point. The people are initially at rest at the high point.

Explain why the speeds of people with different masses are always about the same when they reach the low point.

(3)

~~g~~ gravitational potential energy = kinetic energy.

~~gp~~ $mgh = \frac{1}{2}mv^2$

The masses cancel out, g and $\frac{1}{2}$ constant.

v depends on $\sqrt{h}$

h is the vertical height which is the same for all the people. so speed is the same.

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Examiner Comments

This is a typical example of a candidate scoring 2 marks. Simply equating the equation for gravitational potential energy and kinetic energy was enough to score the first marking point.

As with most candidates, there is no mention that air resistance must be negligible for the argument to hold true.

Paper Summary

Based on their performance on this paper, candidates should:

- Emphasise the importance of understanding and clearly defining basic terms and quantities to ensure candidates receive credit for concepts they comprehend.
- Practice applying principles in a variety of different contexts to boost confidence and problem-solving skills.
- Thoroughly read and re-read questions and their answers to reduce the risk of misunderstandings and inconsistencies.
- Be reminded of the importance of giving a correct unit with a calculated answer to a question.
- Ensure when answering "deduce" questions, that they emphasise the importance of comparing their calculated value to data from the question in order to arrive at a valid conclusion.

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