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AS LEVEL

Examiners' report

MATHEMATICS A

H230

For first teaching in 2017

H230/02 Summer 2022 series

Version 1

Contents

Introduction

Our examiners' reports are produced to offer constructive feedback on candidates' performance in the examinations. They provide useful guidance for future candidates.

The reports will include a general commentary on candidates' performance, identify technical aspects examined in the questions and highlight good performance and where performance could be improved. A selection of candidate answers are also provided. The reports will also explain aspects which caused difficulty and why the difficulties arose, whether through a lack of knowledge, poor examination technique, or any other identifiable and explainable reason.

Where overall performance on a question/question part was considered good, with no particular areas to highlight, these questions have not been included in the report.

A full copy of the question paper and the mark scheme can be downloaded from OCR.

Advance Information for Summer 2022 assessments

To support student revision, advance information was published about the focus of exams for Summer 2022 assessments. Advance information was available for most GCSE, AS and A Level subjects, Core Maths, FSMQ, and Cambridge Nationals Information Technologies. You can find more information on our website.

Paper 2 series overview

H230/02 is one of the two examination components for AS Level Mathematics A. The examination is structured in two sections. Section A: Pure Mathematics (this paper consists of eight questions allocated 50 marks) and Section B: Mechanics (this paper consists of four questions allocated 25 marks). All questions should be answered. Each section has a gradient of difficulty throughout the section and consists of a mix of short and long questions.

Three overarching themes are applied across all content.

1. Mathematical argument, language and proof

2. Mathematical problem solving

3. Mathematical modelling.

To do well on this paper, candidates need to be comfortable applying their knowledge and understanding to all three of these overarching themes, in both familiar and unfamiliar contexts.

Teachers and candidates are encouraged to remind themselves of the requirements expected from the 'command words' such as 'Determine', 'Show that', 'Hence', '**In this question you must show detailed reasoning' (DR)**, etc. These are fully explained in the specification. In the comments on individual questions there will be indications and examples of where not understanding these requirements resulted in marks not being given.

Competent use of a calculator is expected and encouraged when it does not conflict with the requirements of the 'command words'.

There was no evidence that time constraints led to a candidate underperforming.

OCR support

A student guide and a classroom poster to help reinforce the A Level Maths command words can be downloaded from the qualification website:
Exam hints for students and the A Level Maths command words poster A4 size

Candidates who did well on this paper generally did the following:	Candidates who did less well on this paper generally did the following:
• Calculated accurately and understood when exact calculations were needed, e.g., Questions 7 (a) and (b). • Demonstrated a competent algebraic technique. • Identified required methods readily. • Presented their work clearly. • Coped well with unstructured questions, e.g., Question 8 (b). • Interpreted modelling situations well, e.g., Question 12.	• Made careless errors in their calculations. • Lacked accuracy in their algebraic work, e.g., were prone to sign errors. Question 4 often illustrated this. • Did not understand the significance of the 'command words', so did not give sufficient indication of their reasoning in detailed reasoning, (**DR)** questions, e.g., Questions 2 and 11 (b). • Found it difficult to develop a suitable method to solve an unstructured question, e.g., Question 8 (b). • Understood mathematical terminology less well, e.g., Questions 3 and 5 (a).

Section A overview

This section comprises two thirds of the total marks, so candidates are encouraged to take this into account when considering how much time to allocate to it.

Question 1

1 Write the solution of the inequality $(x-2)(x+3) > 0$ using set notation. **[2]**

The majority of candidates correctly identified the critical values of 2 and -3, earning the first mark, but many did not write the solution using set notation. Those that did try to provide set notation used sloppy notation, e.g. $\{x : x < -3 \cup x > 2\}$ or confused ∪ and ∩. For this second mark, we only accepted an answer in the form written in the mark scheme.

Question 2

2 **In this question you must show detailed reasoning.**

Solve the equation $3x+1 = 4\sqrt{x}$. **[4]**

Assessment for learning

This question starts with the instruction '**In this question you must show detailed reasoning**'. This should be a warning to candidates to show sufficient evidence and detail in their solution. In this question candidates were therefore expected to show the method for solving the quadratic equation, not simply the roots stated from calculator work.

The method using the 'disguised quadratic' was more popular, with the correct values of *x* appearing quite often. Some candidates, however, did not provide values for *x* by squaring their quadratic solutions, instead taking the square root of them.

In the alternative method, $(3x + 1)^2 = 9x^2 + 1$ was not uncommon, likewise forgetting to square the 4 on the right-hand side of the given equation. The guidance in the mark scheme shows what we expected from candidates after their attempt to square before we allowed credit.

Exemplar 1

2

$3x + 1 = 4\sqrt{x}$

$3x + 1 = 4x^{\frac{1}{2}}$

$4x^{\frac{1}{2}} - 3x - 1 = 0$

$x^{\frac{1}{2}} = y \rightarrow 4y - 3y^2 - 1 = 0$

$y = 1 \quad y = \frac{1}{3}$

$x^{\frac{1}{2}} = 1 \quad x^{\frac{1}{2}} = \frac{1}{3}$

$x = \pm 1 \quad x = \pm\frac{1}{9}$

This exemplar illustrates well the point raised under 'Assessment for learning'. The quadratic equation here has seemingly been solved by calculator, (**BC)** and this is not sufficient in this question. Only the first 2 marks were given. Note the introduction of +/- in the final answers.

Question 3

3 Give a counter example to disprove the following statement.

If x and y are both irrational then $x+y$ is irrational. **[2]**

This question was not done well. Many candidates did not understand what an irrational number was, thinking that recurring decimals were irrational (⅓ + ⅔ = 1 was the most common example cited) or assuming that any square root was irrational (things like $4^{½} + 9^{½} = 5$ appeared). Fully correct solutions were very rare.

Question 4

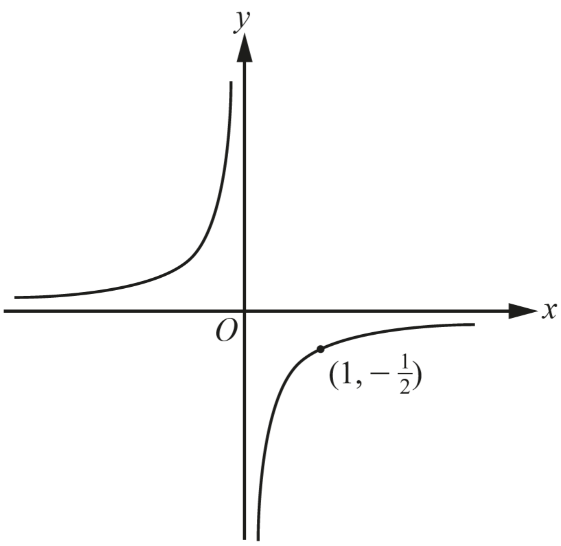
4 The circle $x^2+y^2-6x+4y+k=0$ has radius 5.

Determine the value of k. **[3]**

Generally, this was well attempted, with most candidates making some attempt to complete the square and gaining the first mark. Subsequently some struggled to set up an equation relating *k* and the radius correctly with confusion about whether to use 5 or 5^2. The method mark for the equation $-k + 13 = 5^2$ was dependent on the mark for attempting to complete the square. Sign errors were prevalent in this question.

Question 5 (a) (i)

5



The diagram shows a curve C for which y is inversely proportional to x. The curve passes through the point $\left(1,-\frac{1}{2}\right)$.

(a) **(i)** Determine the equation of the **gradient function** for the curve C. **[3]**

$y=\dfrac{k}{x}$ was quite well understood, and *k* then accurately found. Less successful attempts started by quoting $y=\dfrac{1}{x}$ or even $y = mx + c$. A few thought they had to find the equation of the tangent when asked for the gradient function. This request was overlooked.

Question 5 (a) (ii)

(ii) Sketch this **gradient function** on the axes in the Printed Answer Booklet. **[1]**

For those who plotted the correct type of graph, the requirements for a good graph mentioned in the mark scheme are worth noting. It is important to consider symmetry and draw asymptotes carefully.

Question 5 (b)

(b) The diagram indicates that the curve C has no stationary points.

State what feature of your sketch in part **(a)(ii)** corresponds to this. **[1]**

There were too many vague answers here. We only gave credit for graphs of the form $y = \frac{k}{x^2}$ and wanted candidates to simply focus on the graph not intersecting with the x-axis.

Question 5 (c)

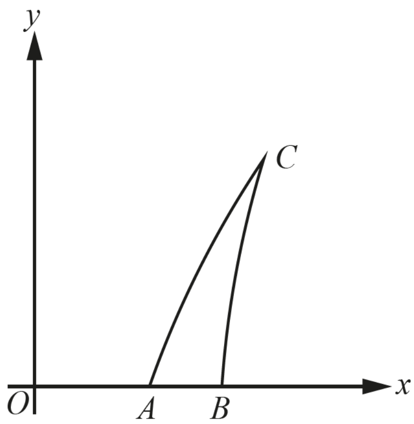
(c) The curve C is translated by the vector $\begin{pmatrix} -2 \\ 0 \end{pmatrix}$.

Find the equation of the curve after it has been translated. **[2]**

There were some good efforts at this part, but inevitably (x – 2) appeared in answers. $y = -\frac{1}{2x} - 2$ was seen also. We expected to see 'y =' in the final answer. Candidates should be encouraged to give their final answer in a more pleasing form $y = -\frac{1}{2(x+2)}$ rather than as $y = -\frac{0.5}{(x+2)}$. Some did not answer the question here and worked with the gradient function rather than the curve C.

Question 6 (a)

6



The shape ABC shown in the diagram is a student's design for the sail of a small boat.

The curve AC has equation $y = 2\log_2 x$ and the curve BC has equation $y = \log_2\left(x - \frac{3}{2}\right) + 3$.

(a) State the x-coordinate of point A. **[1]**

There were many correct answers in this part, although we occasionally saw $x = 2$.

Question 6 (b)

(b) Determine the x-coordinate of point B. **[3]**

Note the instruction 'Determine' here, so justification should be given for any results found, with appropriate working. There were quite a lot of good efforts at this part, isolating the log term and removing logs sensibly. The most common error was to try and split the $\log_2\left(x - \frac{3}{2}\right)$ term. Having done this the mark for removing logs was not given, so this approach scored 0/3.

Question 6 (c)

(c) By solving an equation involving logarithms, show that the x-coordinate of point C is 2. **[4]**

This proved more challenging than part (b), especially so when $2\log_2 x$ was not recognised as $\log_2 x^2$ at the start. The problem noted with $\log_2\left(x - \frac{3}{2}\right)$ in part (b) inevitably reappeared. Again, however, there were quite a few good solutions seen if the logarithm laws were understood. We expected $x = 2$ to be chosen as the required answer.

Question 6 (d)

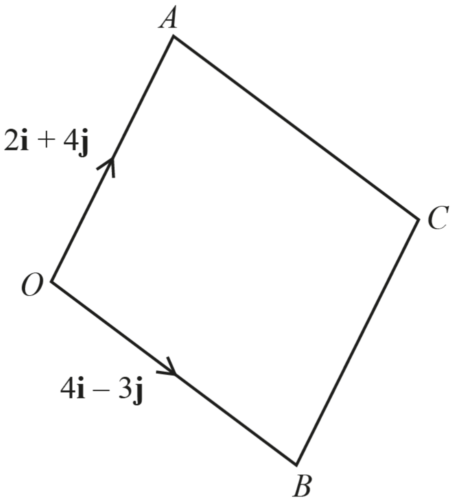
It is given that, correct to 3 significant figures, the area of the sail is 0.656 units^2.

(d) Calculate by how much the area is over-estimated or under-estimated when the curved edges of the sail are modelled as straight lines. **[4]**

This part was found to be more difficult, perhaps because it is slightly unusual. The area of the required triangle is easy to calculate using ½bh but some complicated attempts using the cosine rule and ½absinC were seen. Occasionally, the underestimation of 0.031 was not calculated. Candidates should be encouraged to read questions carefully and to check their answers to ensure they provide all the requested information.

Question 7 (a)

7



The diagram shows the parallelogram $OACB$ where $\overrightarrow{OA} = 2\mathbf{i} + 4\mathbf{j}$ and $\overrightarrow{OB} = 4\mathbf{i} - 3\mathbf{j}$.

(a) Show that $\cos AOB = -\frac{2\sqrt{5}}{25}$. **[5]**

I**OA**I and I**OB**I were correctly found by many, and often less successful attempts could obtain **AB** and its length. Most realised the triangle *AOB* was not right angled and attempted the cosine rule. It is good practice for candidates to be in the habit of showing surd simplification even if the calculator is used to do the relevant work. Exact working was expected for full credit. Those who just used $AOB = \tan^{-1}(4/2) + \tan^{-1}(3/4)$ to get 100.3° and their calculator with this to try and show the given result scored 0 marks.

Question 7 (b)

(b) Hence find the exact value of $\sin AOB$. **[2]**

Many candidates did not seem to understand what exact value meant as far as an acceptable solution was concerned. So often we saw sin100.3° given as a decimal only. Exact working was uncommon.

Assessment for learning

Candidates should be reminded of what is required when an **exact value** is requested in a question. See section 2d of the specification for a list of command word explanations.

Question 7 (c)

(c) Determine the area of $OACB$. **[2]**

Less successful attempts simply found **|OA|** x **|OB|**. Those who found the area of the triangle *AOB* sometimes struggled to find $\sin AOB$ or forgot to double their answer. They did not have to use exact values in this part.

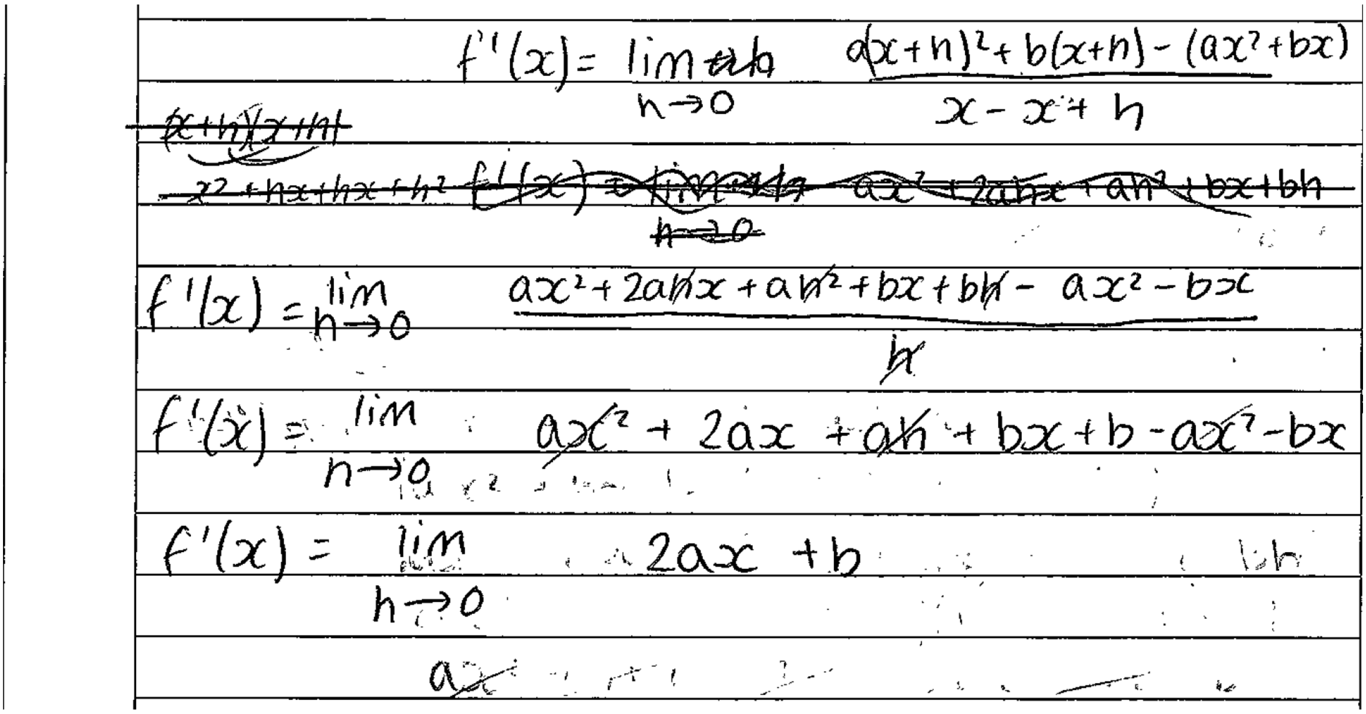
Question 8 (a)

8 **(a)** The quadratic polynomial $ax^2 + bx$, where a and b are constants, is denoted by $\mathrm{f}(x)$.

Use differentiation from first principles to determine, in terms of a, b and x, an expression for $\mathrm{f}'(x)$. **[4]**

This was generally well answered, with many realising what was required to do differentiation from first principles. Examiners checked the algebra carefully and there were quite a few common errors. For example, $-(ax^2 + bx)$ becoming $-ax^2 + bx$, h^2 appearing rather than ah^2 and spurious division by h. Often the 'correct' result appeared.

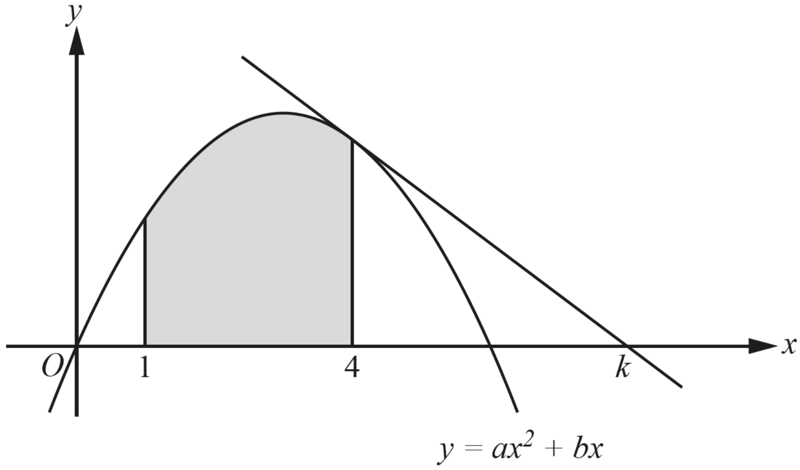
Exemplar 2



This exemplar illustrates the point that the correct result often appeared, but the preceding algebra is not accurate. This solution scored M1 only.

Question 8 (b)

(b)



The diagram shows the quadratic curve $y = ax^2 + bx$, where a and b are constants. The shaded region is enclosed by the curve, the x-axis and the lines $x = 1$ and $x = 4$.

The tangent to the curve at $x = 4$ intersects the x-axis at the point with coordinates $(k, 0)$.

Given that the area of the shaded region is 9 units^2, and the gradient of this tangent is $-\frac{3}{4}$, determine the value of k. **[7]**

Many candidates earned the first 3 method marks here, most integrating correctly, a few making a sign error when evaluating the limits. Less successful was recognising where the second equation in a and b came from, and hence not finding their values. Those who managed this often produced a complete solution, but not all provided the correct method to find k. Some thought $y = 2ax + b$ was the equation of the tangent. Only a few started this question by differentiating $y = ax^2 + bx$ rather than integrating it.

Section B overview

This section comprises one third of the total marks, so candidates are encouraged to take this into account when considering how much time to allocate to it.

Virtually all candidates used g = 9.8 as instructed.

Question 9

9 Two forces $(3\mathbf{i}+2\mathbf{j})$ N and $\mathbf{F}$ N act on a particle P of mass 4 kg.

Given that the acceleration of P is $(-2\mathbf{i}+3\mathbf{j})\,\mathrm{m\,s^{-2}}$, calculate $\mathbf{F}$. **[2]**

A straightforward question to start the Mechanics section. It was often fully correct. A few made sign errors and less successful attempts applied **F** = *m***a** using the magnitudes of the vectors.

Question 10

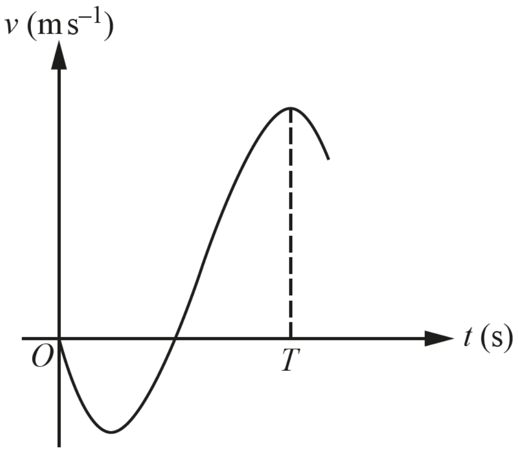
10 A small ball B is projected vertically upwards from a point 2 m above horizontal ground. B is projected with initial speed $3.5\,\mathrm{m\,s^{-1}}$, and takes t seconds to reach the ground.

Find the value of t. **[3]**

The 'direct' method written out on the scheme was obviously quicker than considering the motion in various parts but seemed to be less popular. Those who tried to apply it often did not appreciate that the initial velocity was not in the same direction as the displacement and acceleration. Note the quadratic here could be done by calculator (**BC)**. Those who did it by considering the motion up and the motion down, for example, often got full marks but a complete method for what we requested was needed to gain any credit. If a relevant time was omitted, no marks were given.

Question 11 (a)

11



A particle P moves along the x-axis. At time t seconds, where $t \geqslant 0$, the velocity of P in the positive x-direction is $v \text{ m s}^{-1}$. It is given that $v = t(t-3)(8-t)$.

P attains its maximum velocity at time T seconds. The diagram shows part of the velocity-time graph for the motion of P.

(a) State the acceleration of P at time T. **[1]**

Many correct values. A few gave an expression for the acceleration rather than the required value.

Question 11 (b)

(b) In this question you must show detailed reasoning.

Determine the value of T. **[5]**

Candidates generally knew how to answer this question. It is another detailed reasoning (**DR) question** so, as in Question 2, we wanted to see how the quadratic equation had been solved. Many did not provide this evidence so 3/5 was a common mark. We also expected to see a valid reason for the rejection of $T = {}^4/_3$.

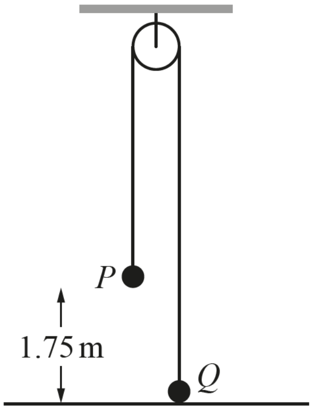
Question 11 (c)

(c) Find the total distance that P travels between times $t = 0$ and $t = T$. **[3]**

Most candidates realised this part required v to be integrated. Many did not use the calculator to do this despite the instruction being 'Find'. The most common error was to do this with limits 6 and 0, but the combination of 6 and ${}^4/_3$ and ${}^4/_3$ and 0 was also seen. When doing definite integrals on the calculator it is wise, time permitting, for candidates to type in the relevant details twice to hopefully avoid careless errors.

Question 12 (a)

12



Particles P and Q, of masses 4 kg and 6 kg respectively, are attached to the ends of a light inextensible string. The string passes over a smooth fixed pulley. The system is in equilibrium with P hanging 1.75 m above a horizontal plane and Q resting on the plane. Both parts of the string below the pulley are vertical (see diagram).

(a) Find the magnitude of the normal reaction force acting on Q. **[1]**

Correct answers were rare here, with 6*g* the value generally given.

Question 12 (b)

The mass of P is doubled, and the system is released from rest. You may assume that in the subsequent motion Q does not reach the pulley.

(b) Determine the magnitude of the force exerted on the pulley by the string before P strikes the plane. **[5]**

In this part many just gained the first 3 marks, applying Newton's Second Law to both particles and calculating *a* and *T*. Few realised that the magnitude of the force exerted on the pulley by the string was 2*T*. One examiner mentioned that when teaching this topic, they got students to draw the tensions acting downwards from the pulley as well as the tensions acting upwards just in case this sort of question came up! In this type of question, a good diagram of the forces involved is to be encouraged.

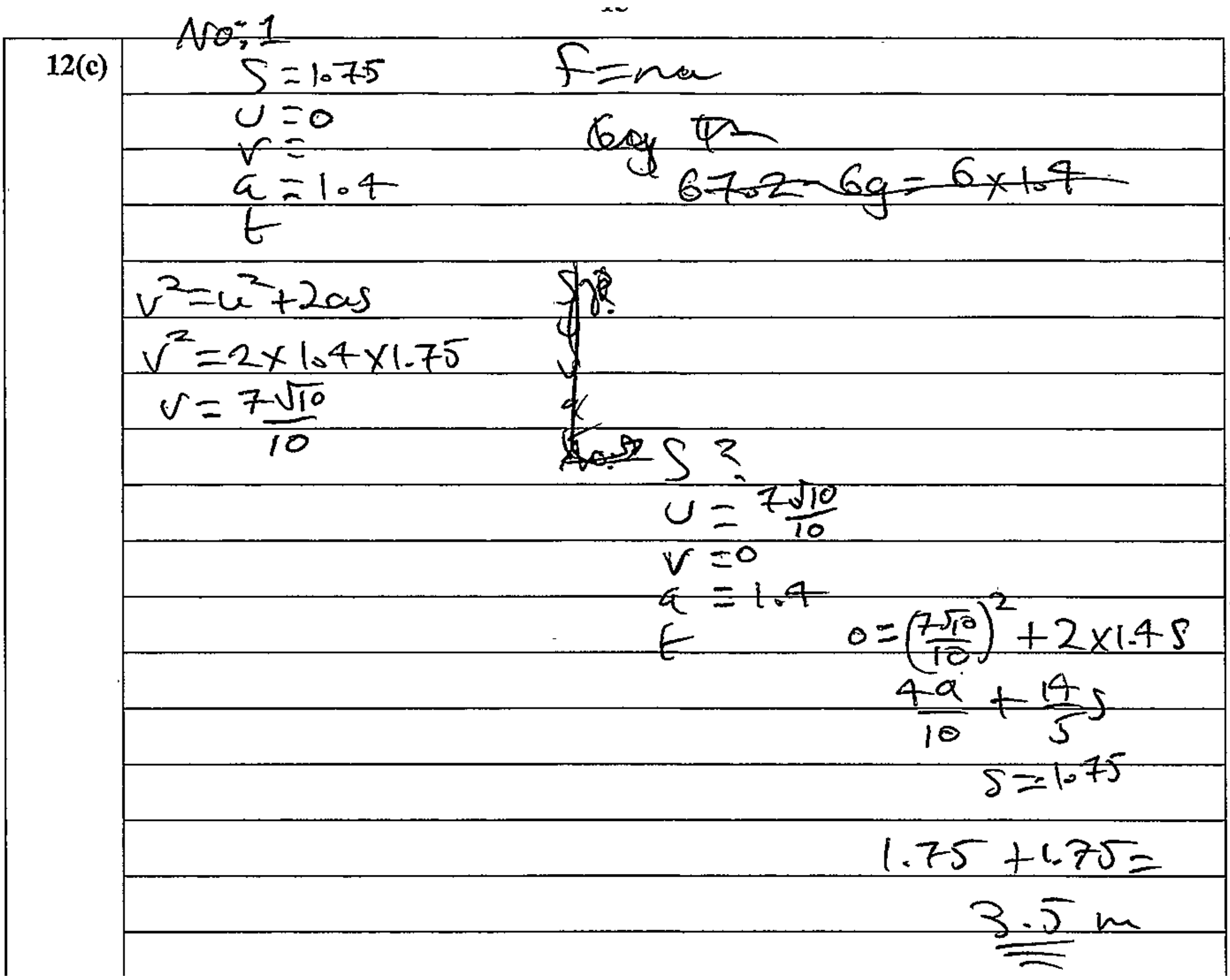
Those who considered the system as a whole, which is to be discouraged, often did not score full marks . If they succeeded in finding *a* sensibly, they did not then show clarity when trying to find *T*.

Question 12 (c)

(c) Determine the total distance travelled by Q between the instant when the system is released and the instant when Q first comes momentarily to rest. **[4]**

Many struggled with this question. The most common error was not understanding that the acceleration of *Q* changed when *P* hit the floor. 9.8 or their answer to part (b) was used in both stages of the motion. Finding the velocity of *Q* at the instant when *P* hits the floor was critical to solving this problem. A few good efforts lost the final mark by giving the answer as 2 x (0.25) + 1.75.

Exemplar 3



This exemplar illustrates the above comment about acceleration. This candidate uses the acceleration found in part (b) of $1.4 ms^{-2}$ in both stages of the motion.

Question 12 (d)

When this motion is observed in practice, it is found that the total distance travelled by Q between the instant when the system is released and the instant when Q first comes momentarily to rest is less than the answer calculated in part **(c)**.

(d) State **one** factor that could account for this difference. **[1]**

Many correctly cited 'air resistance' or 'friction at the pulley'.

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