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AS LEVEL

Examiners' report

MATHEMATICS A

H230

For first teaching in 2017

H230/02 Summer 2024 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 is also provided. The reports will also explain aspects that 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.

Paper 2 series overview

H230/02 is one of two exam components for AS Level Mathematics A. The component is structured in two sections, Section A: Pure Mathematics (this year's paper consists of eight questions allocated 50 marks) and Section B: Mechanics (this year's paper consists of three 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.

Previous years' reports have repeatedly emphasised the need for understanding of the 'command words' and this has again been an issue for some candidates. The 'command words' are explained in the specification (available from the OCR website). The instruction '**In this question you must show detailed reasoning**' (**DR**) occurred only once this year (in the final part of the last question) and many candidates did not provide sufficient working here. When this instruction is given, methods should be shown and this should be regularly reinforced with candidates (for more information, please see the commentary for Q11 (b) below). 'Determine' appeared often in this paper and although the calculator can be used effectively with this instruction, lack of justification marred some efforts. Again, individual question comments below are worth careful study.

In Question 5 (b) there was a request for exact working. While candidates found this question demanding, this request was either ignored or not understood by many. This continues to be something to be addressed (this is not the first time a request for exact working has been ignored by many candidates).

Candidates must be aware of the need to work to sufficient accuracy. For example, Question 2 (a) requested the angle be given correct to **1** decimal place and if 134° **only** was seen it did not get the answer mark. In the subject-specific marking instructions at the front of the mark scheme, instruction (f) provides further information about how flexible examiners will be about accuracy and this (along with the other instructions) is worth noting.

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

Candidates who did well on this paper generally:	Candidates who did less well on this paper generally:
• had a broad understanding of the specification and made sensible attempts at all the questions • worked to a sensible degree of accuracy, as requested and following the front cover rubric • were tidy and showed sufficient explanation • showed facility with algebra, simplifying sensibly (for example, in Question 3 and Question 8) • coped well with modelling questions and extended questions.	• showed generally limited understanding and struggled to provide good solutions to the more challenging questions (please see Question 5, Question 8 (c) and Question 11 for examples) • worked to a degree of accuracy that did not provide answers to the accuracy needed, e.g. **2** significant figures • were untidy and/or provided insufficient working • were less secure with algebraic manipulation, such as making sign errors or not simplifying effectively (for example, in Question 3 and Question 8) • found modelling questions and extended questions challenging.

Section A overview

This is a 1 hour 30 minute paper and Section A compromised 50 out of 75 marks. Candidates are urged to consider this when deciding how long to spend on this section.

Some questions specify how the answer should be given. For example, Question 2 requests an answer 'correct to **1** decimal place', Question 3 (b) says 'Give your answer in set notation', Question 4 (a) requests an 'equation', Question 5 (a) says 'Give your answer in the form ln$a$' and Question 5 (b) requests 'an exact constant'. Candidates need to pay attention to such detail.

Question 1 (a)

1 **(a)** Write $3x^2 + 24x + 5$ in the form $a(x+b)^2 + c$, where a, b and c are constants to be determined. **[3]**

This was well done, with many candidates given 3 marks. The most common errors involved c, with −16 + 5 = −11 as perhaps the most frequent. $\frac{-43}{3}$ occurred too. A few responses used $(x + 12)^2$ or $(x + 8)^2$.

Question 1 (b)

The finite region R is enclosed by the curve $y = 3x^2 + 24x + 5$ and the x-axis.

(b) State the inequalities that define R, including its boundaries. **[2]**

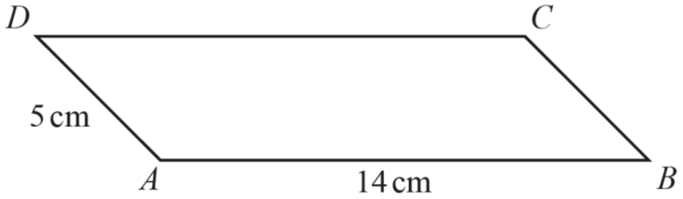
This part was found to be very challenging, with few fully correct solutions given. Many responses just gave $-7.785 \le x \le -0.214$ (or the exact values) as the answer, although this also appeared with other inequalities. It was not unusual to see R used in results; things like $R \ge 3x^2 + 24x + 5$ and $R \le x$. $x \le 0$ seemed to be confused with $y \le 0$ by some. Inequalities were given the wrong way round and/or strict.

Assessment for learning

Candidates clearly found this topic difficult and many did not really seem to know what was expected. Teachers should be aware of this and consider how best to deliver the topic.

Question 2 (a)

2



The diagram shows a parallelogram *ABCD* where $AB = 14$ cm, $AD = 5$ cm and angle *DAB* is obtuse. The area of *ABCD* is 50 cm^2.

(a) Determine, in degrees, the size of angle *DAB*. Give your answer correct to **1** decimal place. **[3]**

Both methods outlined in the mark scheme were seen and applied well. Despite being told in the stem of the question (and shown in the diagram) that *DAB* was obtuse, quite a few candidates gave an acute angle as the final answer. The last mark required 134.4° or better to be seen.

Question 2 (b)

(b) Find the length, in centimetres, of the diagonal *BD*. Give your answer correct to **1** decimal place. **[2]**

Most candidates used the cosine rule here and gained marks, provided it was remembered correctly and correctly applied. We expected the cosine rule to be correct, so those who used sin*DAB* or omitted the '2' (for example) were given M0. Use of an acute angle (usually 45.6°) led to *BD* = 11.1 and again, reference to the diagram should suggest this is wrong; candidates should be encouraged to consider whether their answers are sensible in context. Only a very few used Pythagoras' theorem twice to find *BD*.

Question 3 (a)

3 The quadratic equation $kx^2 + 2kx + 2k = 3x - 1$, where k is a constant, has no real roots.

(a) Show that k satisfies the inequality

$4k^2 + 16k - 9 > 0$. **[4]**

There were a significant number of fully correct solutions to this problem, but also a fair number of attempts marred by sign errors at various stages in the working. These errors occurred either in the initial rearrangement, or subsequent algebraic work on $b^2 - 4ac$, or both. Use of $b^2 - 4ac > 0$ leading to the given answer was something examiners checked for (the mark scheme has the abbreviation '**AG**' ('answer given') to remind examiners that the answer is given), as was incorrect algebra leading to the answer. Weaker attempts applied $b^2 - 4ac$ to the left-hand side of the given equation and floundered.

Exemplar 1

3(a)

$kx^2 + 2kx + 2k = 3x - 1$

$\rightarrow kx^2 + 2kx - 3x + 2k - 1$

$\rightarrow kx^2 + (2k-3)x + (2k-1) = 0$

$a = k, \quad b = 2k-3, \quad c = 2k-1$

no real roots $\rightarrow b^2 - 4ac < 0$

$(2k-3)^2 - 4(k)(2k-1) < 0 \qquad (2k-3)(2k-3) = 4k^2 - 12k + 9$

$(4k^2 - 12k + 9) - (8k^2 + 4k) < 0 \qquad -4k(2k-1) = -8k^2 + 4k$

$-4k^2 - 16k + 9 < 0$

~~$\times(-1) \quad \times(-1)$~~

~~$4k^2 + 16k + 9 > 0$~~

$4k^2 + 16k - 9 > 0$

When an answer is given, examiners are conscious that candidates will sometimes finish their working with the correct answer, even though the working does not lead to it. Exemplar 1 is a case in point. There are sign errors in the working and full marks are not earned.

Question 3 (b)

(b) Hence find the set of possible values of k. Give your answer in set notation. **[2]**

For credit in this part we expected candidates to use the given inequality to obtain critical values and these were commonly found correctly. The question asked for set notation in the final answer and, as in previous years, we were quite strict in what we allowed. We needed to see 'curly' brackets, as is seen in the mark scheme. We accepted $k \in \{x : x > 0.5\} \cup \{x < -4.5\}$. Below are some examples of responses that were given B0FT.

$\{k > 0.5\} \cup \{k < -4.5\}$

$\{k : k > 0.5 \text{ or } k < -4.5\}$

$\{k : k > 0.5 \cup k < -4.5\}$

$\{k : k > 0.5 , k < -4.5\}$

$(-\infty, -4.5) \cup (0.5, \infty)$.

We also saw $\cap$ used and incorrect inequality signs.

Question 4 (a)

4 (a) The curve $y = \sqrt{2x-1}$ is stretched by a scale factor $\frac{1}{4}$ parallel to the x-axis.

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

Clear thinking was needed here. Examiners saw a fair number of correct answers, however responses such as $y = \sqrt{\frac{1}{4}x - 1}$, $y = 4\sqrt{2x - 1}$, $y = \frac{1}{4}\sqrt{2x - 1}$, $y = \sqrt{8x - 4}$ and $y = \sqrt{\frac{1}{2}x - \frac{1}{4}}$ were also offered. An equation was requested, so '$y =$' was expected.

Question 4 (b)

(b) The curve $y = \sqrt{2x-1}$ is translated by the vector $\begin{pmatrix}-4\\0\end{pmatrix}$, and as a result, the point on the curve where $x = 5$ is transformed to the point P.

Find the coordinates of P. **[2]**

Rather than just dealing with the point where $x = 5$ and translating it, many candidates got into difficulty because they tried to find the equation of the curve after the translation and obtained an incorrect equation.

It was common for $y = \sqrt{2(x + 4) - 1}$ to appear and lead to $(5, \sqrt{17})$ as the answer.

Question 5 (a)

5 At the point P on the curve $y = e^{3x} - 21x - 8$ the gradient of the tangent is 3.

(a) Determine the x-coordinate of P. Give your answer in the form $\ln a$, where a is an integer to be determined. **[4]**

A lot of good responses lost the final mark because the answer was left as $\frac{1}{3}\ln 8$, ignoring the instruction to give the answer in the form ln*a*. Those who differentiated e^{3x} to $3xe^{3x}$, $3xe^{3x-1}$, e^{2x} or similar were given no marks. A small number set their differential equal to $-\frac{1}{3}$. Understanding of the log laws still needs strengthening. Some did not attempt differentiation, but started with things like $\ln y = \ln e^{3x} - \ln 21x - \ln 8$.

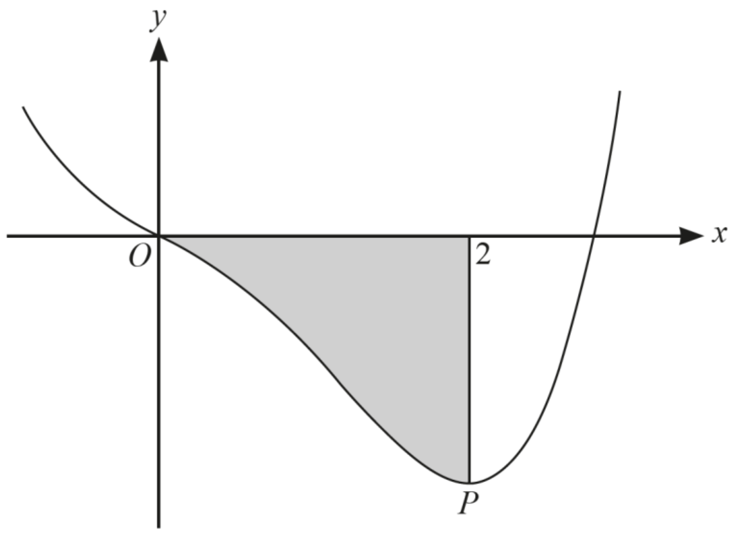
Question 5 (b)

(b) Hence determine the equation of the tangent at P. Give your answer in the form $y = 3x + c$ where c is an exact constant to be determined. **[3]**

This part was not well done. Those who did not find an *x* in **(a)** made no progress. Those who had an *x* often responded with a decimal, ignoring the request for an exact *c* (particularly those who had responded with $\frac{1}{3}\ln 8$ in the previous part).

Question 6

6



The diagram shows the curve with equation $y = 5x^4 + ax^3 + bx$, where a and b are integers. The curve has a minimum at the point P where $x = 2$.

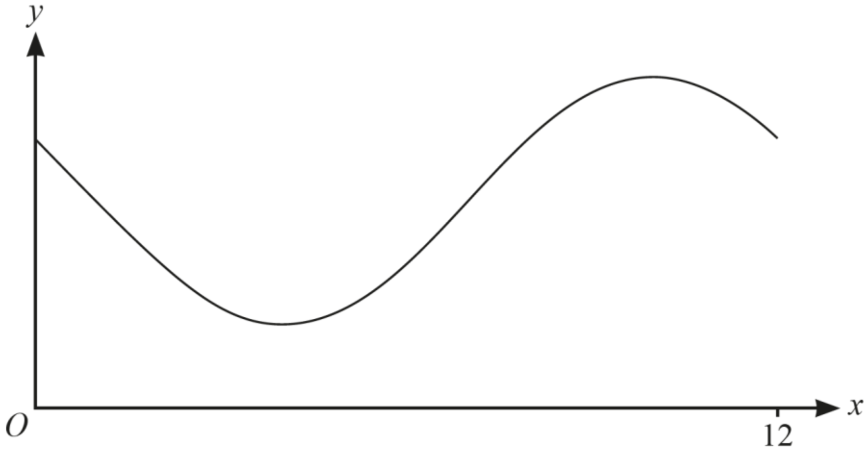
The shaded region is enclosed by the curve, the x-axis and the line $x = 2$.

Given that the area of the shaded region is 48 units^2, determine the y-coordinate of P. **[7]**

Those who recognised the need to differentiate and integrate generally did it well. A lot of candidates dropped 2 marks because they used 48 rather than -48 in their working. Quite a few unnecessarily found the second derivative; some then ignored it, but others substituted *x* = 2, set it to zero and obtained a value for *a*. The poorer efforts generally either didn't differentiate or didn't integrate, but most efforts gained at least 2 marks.

Question 7 (a) (i)

7



The diagram shows the curve with equation $y = 5 + 3\cos(30x + 60)°$, for $0 \leqslant x \leqslant 12$.

(a) **(i)** State the greatest value of y for points on the curve. **[1]**

There were many correct answers. We also saw 6.5, 1 and 6 occasionally.

Question 7 (a) (ii)

(ii) Determine the value of x for which this greatest value of y occurs. **[3]**

A lot of candidates obtained x = 10, many starting from the equation 8 = 5 + 3cos(30x + 60)° rather than just stating cos(30x + 60)° = 1 immediately. The command word 'Determine' indicated that we wanted to see justification of how x = 10 was obtained and sufficient evidence was required for full marks; a few just wrote x = 10 and were given M0. Some did not convincingly show the 360° idea and just got M1. The poorer efforts involved cos30x + cos60.

Question 7 (b)

There are two points on the curve for which the value of y is 7.

(b) Determine the values of x at these two points. **[5]**

This part stated 'Determine' again, so we expected to see sufficient justification of results and typically it was provided. There were a fair number of fully correct solutions given, but final answers of x = −0.394 and x = 8.39 were also not unusual. x = 8.4 were given A0 unless a better value was seen in the working; the 'exact' values of $\frac{42}{5}$ and $\frac{58}{5}$ (or equivalent) obtained from 312° and 408° respectively also both earned A0. Candidates should be encouraged to work to a sufficient degree of accuracy, given the front cover rubric. Again, efforts were seen involving cos30x + cos60.

Question 8 (a)

8 The points A and B have coordinates (4, 8) and (6, p) respectively, where p is a positive constant and $p \neq 8$.

(a) Find, in terms of p, the coordinates of the midpoint of AB. **[1]**

This was well done. A column vector gained B0, unless there was enough other working worthy of the B1.

Question 8 (b)

(b) Find, in terms of p, the gradient of the line AB. **[1]**

Many correct answers appeared. $m = \Delta x/\Delta y$ was used by some.

Question 8 (c)

The perpendicular bisector of AB intersects the positive x-axis at the point where $x = \frac{7}{5}p$.

(c) Determine the x-coordinate of this point of intersection. **[5]**

This part proved very challenging, perhaps because of the algebra involved. Very few fully correct answers were seen. The B1FT was often given, although some candidates missed it because the signs were changed on both the numerator and denominator of the reciprocal. The M1 for an attempt at the equation of the perpendicular bisector was also often given, but what to do next seemed to prove elusive to many. The alternative method using gradients only was rarely seen.

Exemplar 2

8(c)

$y = \dfrac{-1}{\frac{p-8}{2}}$ $\qquad \dfrac{-1}{1} \times \dfrac{2}{p-8} = \dfrac{-2}{p-8}$

Bisector: $y = \left(\dfrac{-2}{p-8}\right)x + c$

$\dfrac{8+p}{2} = \dfrac{-10}{p-8} + c$

$c = \dfrac{8+p}{2} + \dfrac{10}{p-8}$

$c = \dfrac{p^2-64}{2(p-8)} + 20$

$c = \dfrac{p^2-44}{2(p-8)}$

$y = \dfrac{p-8}{2}x + c$

$8 = \dfrac{4p-32}{2} + c$

$c = 8 - 2p + 16$

$c = -2p + 24$

$\dfrac{-2}{p-8}x + \dfrac{p^2-44}{2(p-8)} = \dfrac{p-8}{2}x - 2p + 24$

This exemplar earns the initial B1FT M1, as did many. Following that, the candidate finds the equation of the line *AB* and tries to solve this simultaneously with the equation of the perpendicular bisector. This ineffective continuation appeared on several occasions.

Section B overview

Section B compromises 25 out of 75 marks. Candidates are urged to consider this when deciding how long to spend on Section B out of their total 1 hour 30 minutes.

Last year's report mentioned that most questions do not require the units to be stated in the final answer, but that it is sensible for candidates to get into the habit of always providing them. There was evidence this year that this comment has been taken on board.

Most candidates now use g = 9.8 as provided on the front cover rubric, but we still see 9.81 being used in a few scripts.

Question 9 (a)

9 A particle P of mass 2.5 kg is in equilibrium under the action of three horizontal forces

$\mathbf{F}_1 = \begin{pmatrix} 3 \\ -7 \end{pmatrix}$N, $\mathbf{F}_2 = \begin{pmatrix} -5 \\ 10 \end{pmatrix}$N and $\mathbf{F}_3$.

(a) Find the force $\mathbf{F}_3$. **[2]**

There were a lot of correct answers to this question. Marks were lost by some for simple arithmetical errors or for using $\mathbf{F_1} + \mathbf{F_2} = \mathbf{F_3}$.

Question 9 (b)

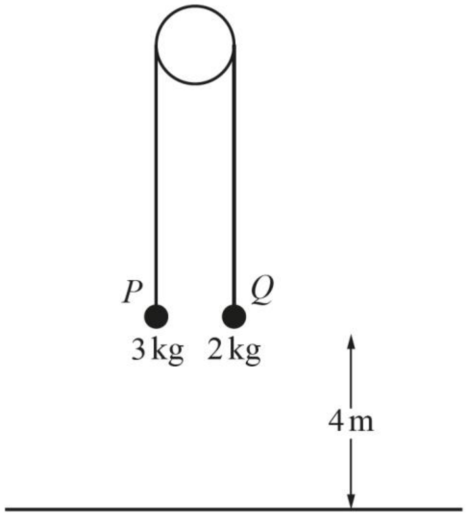
The force $\mathbf{F}_3$ is changed to $\begin{pmatrix} 8 \\ 1 \end{pmatrix}$N.

(b) Find the acceleration of P, giving your answer in column vector form. **[2]**

This question was also well attempted, with many correct answers. The most common error was to use $8\mathbf{i} + \mathbf{j} = 2.5\boldsymbol{a}$. Also sometimes given was $\sqrt{6^2 + 4^2} = 2.5\boldsymbol{a}$, with no vector equation.

Question 10 (a)

10



Two small balls P and Q, of masses 3 kg and 2 kg respectively, are attached to the ends of a light inextensible string. The string passes over a smooth fixed pulley. The balls are held at a height of 4 m above a horizontal floor, with the string taut. The parts of the string which are not in contact with the pulley are vertical (see diagram).

The system is set in motion in such a way that P moves vertically downwards.

(a) Determine the tension in the string immediately after the system is set in motion. **[4]**

This part was successfully done by many. The need to use Newton's Second law was well recognised and the correct answer was often seen. Most found a first and then T. We still saw equations like $3g - T = T - 2g$ with no mention of a, but these seemed less common than in the past.

Question 10 (b)

The initial downward speed of P is $4.2\,\text{m s}^{-1}$ and when P reaches the floor it is immediately brought to rest. It is given that Q does not reach the pulley in the subsequent motion.

(b) Find the speed of P as it hits the floor. **[2]**

The use of $v^2 = u^2 + 2as$ was widespread. Substituting $a = 9.8$ was the most common mistake. A few forgot to take the square root.

Question 10 (c)

(c) Determine the time, after the start of the motion, at which Q reaches its greatest height above the floor. **[4]**

Attempts at this part were less successful. To calculate t_1, using $s = ut + ½at^2$ was prevalent, but $a = 9.8$ again appeared. Giving $t_1 = 0.8$ or 0.80 resulted in A0, unless anything more accurate was seen. Some found t_1 and gave it as their final answer.

Some candidates recalculated v using $u = 0$ and used this new value in their working for t_1 and t_2, rather than the value found in **(b)**.

Occasionally $s = ut + ½at^2$ was attempted with $s = 8$.

Question 10 (d)

(d) State what it would mean about the accelerations of the balls if the string could not be assumed to be inextensible. **[1]**

Hardly any candidates referred to the magnitude of the acceleration. Please refer to the mark scheme's appendix for what we were expecting and examples of what was and was not accepted.

Question 11 (a)

11 A man P runs in a straight line from O to A, leaving O at time $t = 0$. At time t seconds his velocity $v\,\mathrm{m\,s^{-1}}$ is given by $v = 5 + 0.003t^2$.

Another man Q runs from O to A at a constant speed of $7.08\,\mathrm{m\,s^{-1}}$, starting 5 seconds after P.

(a) Show that the times T s when P and Q are the same distance from O satisfy the equation

$$T^3 - 2080T + 35400 = 0.$$ **[5]**

The need to integrate to find s_p was appreciated by many and often these were the only 2 marks given. A few tried $s_p = vt$. For Q, $s_Q = 7.08t$ was more common than the correct result. Because the final answer was given, examiners looked for a convincing argument leading to it; a sudden appearance of 35.4 in the working that looked as if it had been worked back from the given answer could not be given marks. For the final mark we wanted to see exactly what was given on the question paper (correctly obtained), so T rather than t and '= 0'.

Question 11 (b)

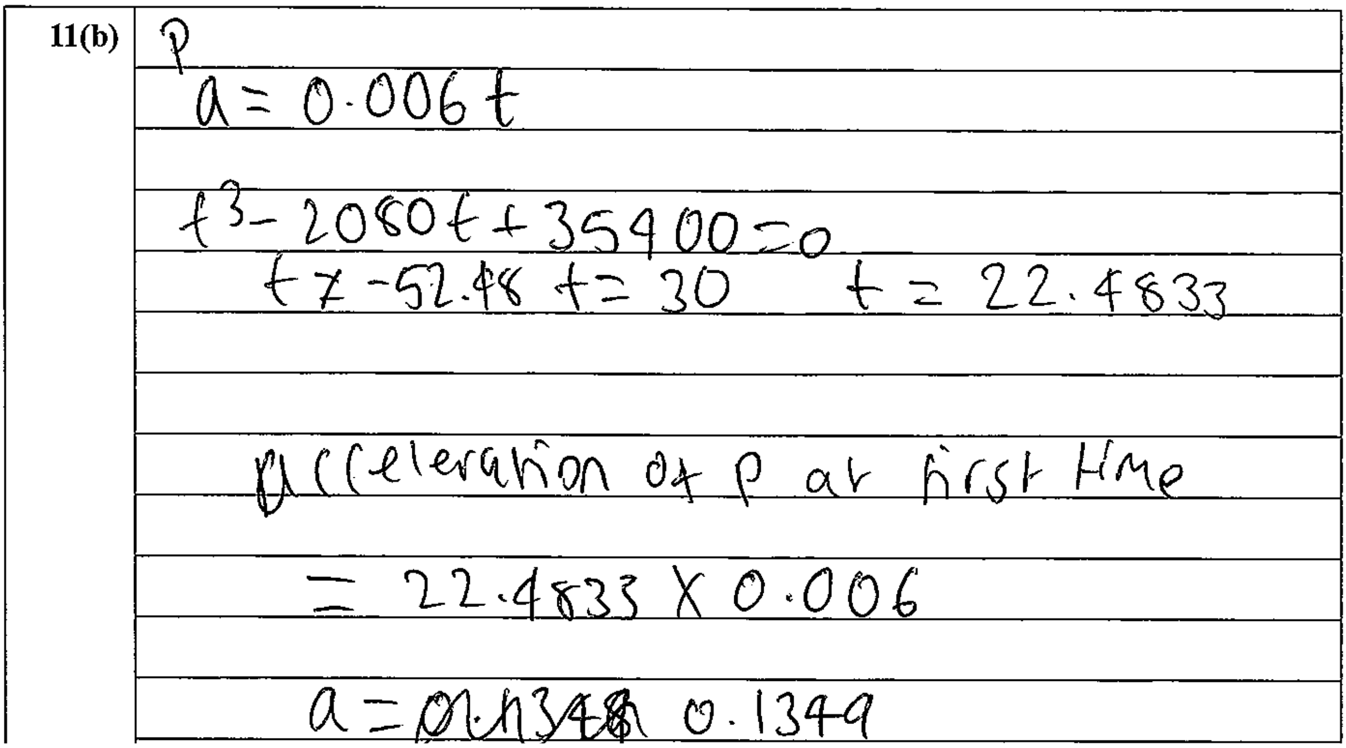
(b) In this question you must show detailed reasoning.

As they run from O to A there are two times at which P and Q are the same distance from O. The second of these is when $T = 30$.

Find the acceleration of P at the first of these times. **[5]**

This part requested detailed reasoning, so we expected to see the method clearly presented; in very many cases this did not happen. As soon as candidates see this instruction they should think carefully about how they are going to use the calculator (see Exemplar 3 below and its commentary). To gain the M mark (and so potentially the next 2 marks also), we wanted to see clear evidence of factorising or long division. For the A mark allocated to T = 22.5, we wanted to see how this value had been obtained, for example evidence of the quadratic formula. Many candidates just gained the last 2 marks, as seen in Exemplar 3 below.

Exemplar 3



11(b)

P

$a = 0.006t$

$t^3 - 2080t + 35400 = 0$

$t = -52.48 \quad t = 30 \quad t = 22.4833$

acceleration of P at first time

$= 22.4833 \times 0.006$

$a =$ ~~0.1348~~ 0.1349

Exemplar 3 shows how many candidates obtained T = 22.5, by just using their calculator to solve the cubic given in **(a)**. This is not sufficient following a 'show detailed reasoning' request and earned M0. Note that the last B mark could still be given in such cases.

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