

Examiners' report

A LEVEL

MATHEMATICS B (MEI)

**OCR Level 3 Advanced GCE in
Mathematics B (MEI)**

H640

For first teaching in 2017

H640/03 Summer 2025 series

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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 responses is 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 [Teach Cambridge](#).

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Paper 3 series overview

This paper proved to be fairly accessible to all candidates and most candidates had sufficient time to attempt all the questions.

The paper has 2 sections:

Section A on Pure Mathematics (60 marks)

Section B on the Comprehension (15 marks)

In general, candidates found Section A more straightforward than Section B. Candidates were well prepared for questions involving calculations, but often didn't give sufficient detail to be awarded all of the available marks where an explanation was needed.

Candidates who did well on this paper generally:	Candidates who did less well on this paper generally:
- made a plan and structured their work clearly so it was easy to follow - made clear statements and showed their reasoning - showed all the steps in their working for 'show that' questions - justified their results fully - made good use of their calculators to check answers.	- used numerical examples rather than working with a general form - did not read the question carefully and missed out part of the response needed - made algebraic or arithmetic slips - missed out steps in working for 'show that' questions - did not pay attention to the degree of accuracy specified in a question.

Section A overview

Candidates were very successful on most of the questions in this section, with many candidates given nearly full marks on Questions 1 to 6. Question 7, involving mathematical modelling of exponential growth, Question 10, involving a 3D vector, and Question 11, involving a sequence defined using surds proved to be quite challenging for some candidates. Candidates who were successful in this section gave reasoned answers and fully justified their conclusions.

Question 1 (a) and (b)

- 1 (a) Find the first **three** terms in the binomial expansion of $(1 + 3x)^{\frac{1}{2}}$. [3]
- (b) State the range of values of x for which this expansion is valid. [1]

Most candidates were credited with full marks for this question and showed a good knowledge of the general binomial expansion and its range of values. Candidates who did less well did not use brackets and gave the 3rd term of the expansion as $\frac{\frac{1}{2}(\frac{1}{2}-1)}{2!} \times 3x^2$ rather than $\frac{\frac{1}{2}(\frac{1}{2}-1)}{2!} \times (3x)^2$.

The most common errors in writing the range of values of x were omitting the modulus bars (writing $x < \frac{1}{3}$) or using the wrong inequality sign (writing $|x| > \frac{1}{3}$).

Question 2

- 2 You are given that

$$f(x) = \frac{3}{x} \quad \text{on the domain } \{x : x \in \mathbb{R}, x \neq 0\}$$

$$g(x) = x - 1 \quad \text{on the domain } \{x : x \in \mathbb{R}\}.$$

Find $gf(x)$. You must state the domain.

[2]

Most candidates found the correct expression for $gf(x)$. Candidates who did less well in this question usually did not give a fully correct statement of the domain. They either excluded an incorrect value of x such as 1 or 3 or not did not state $x \in \mathbb{R}$.

Assessment for learning



Candidates are advised to take careful note of how the domains are written within a functions question as this will guide them in writing the domain for their answer. Since $g(x)$ is valid for all real values of x , the domain of $gf(x)$ is the same as the domain for $f(x)$ which is written in the question as $\{x : x \in \mathbb{R}, x \neq 0\}$.

Question 3 (a)

3 The straight line with equation $2x + y = 6$ crosses the x -axis at A and the y -axis at B.

- (a) Draw the line with equation $2x + y = 6$ on the grid in the Printed Answer Booklet. [1]

Most candidates drew the straight line correctly. A few candidates did not use a ruler, but produced a good freehand sketch.

Question 3 (b)

- (b) Determine the equation of the perpendicular bisector of AB. [6]

Many fully correct, well-planned responses were seen, and most candidates were given all 6 marks.

Candidates who did less well in the question did not formulate a clear plan and used either point A or B rather than the midpoint for the equation of the perpendicular or made an arithmetic error when finding the gradient of AB.

Question 3 (c)

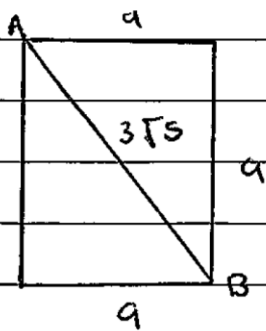
- (c) Points A and B are opposite vertices of a square of side a .

Determine the exact value of a . [3]

Candidates who made a sketch of the square were generally more successful with this question than those who did not. The most common mistake was to wrongly assume that AB was the side length of the square rather than the diagonal of the square. Drawing a clear diagram showing the information given in the question would have helped these candidates.

A few candidates did not take note of the command word 'exact' and gave their answer as a decimal rather than an exact surd.

Exemplar 1

3(c)		(distance of AB)
		$(0,6) \quad (3,0)$
		$\sqrt{(3-0)^2 + (0-6)^2}$
		$= 3\sqrt{5}$
		$a^2 + a^2 = (3\sqrt{5})^2$
		$2a^2 = 45$
		$a^2 = \frac{45}{2}$
		$a = \frac{\pm 3\sqrt{10}}{2}$
		As lengths are always positive
		$a = \frac{3\sqrt{10}}{2}$

This candidate drew a clear diagram which showed that AB is the diagonal of the square. They explained each step in their solution so it was easy to follow. They were given the first B1 for calculating the length of AB. They avoided algebraic slips by making a clear statement of Pythagoras' theorem for the side lengths of the square, which was given M1. They made sensible use of their calculator to simplify the final surd correctly for the final mark.

This response is given all 3 marks.

Question 4

4 The first term of a geometric sequence is 6.

The fourth term is $\frac{2}{9}$.

The sequence is infinite.

Find the sum of the associated series.

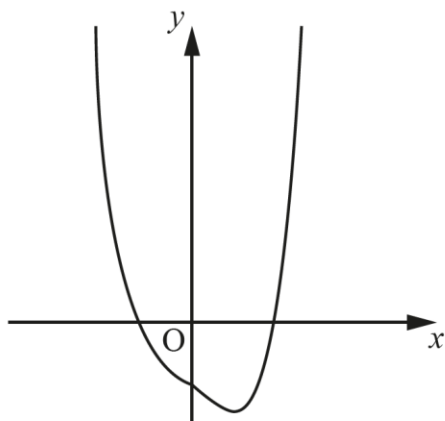
[3]

This question was generally well answered with most candidates connecting the 1st and 4th terms to form a correct equation for r . A few candidates worked out the value of r by inspection.

Candidates who did less well were unable to form a correct equation for r , often attempting to use the sum of terms or else writing $6r^4 = \frac{2}{9}$. A few candidates, after correctly finding r , found the sum of the first 4 terms instead of the sum to infinity and so were not given the final mark.

Question 5 (a)

5 The diagram shows the curve with equation $y = x^4 - 2^x$, for values of x close to zero.



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

Show that the equation $x^4 - 2^x = 0$ has a root which lies between 1 and 2.

[2]

Most candidates answered this question correctly and substituted the values of $x = 1$ and $x = 2$ into the equation and stated that the change of sign indicated a root.

Question 5 (b)

(b) Show that the equation $x^4 - 2^x = 0$ can be written in the form $x = 2^{0.25x}$ for positive values of x .

[1]

This question was well answered although a few candidates went a circuitous route involving logarithms. This question has the command phrase 'show that' which means candidates must give sufficient detail in their answers. A few candidates went straight from $x^4 = 2^x$ to the given answer which was not convincing enough to be given the mark. Examiners needed to see at least one step of working after the rearrangement.

Question 5 (c)

(c) Use the iterative formula $x_{n+1} = 2^{0.25x_n}$ with $x_0 = 0.4$ to determine a root of $x^4 - 2^x = 0$ to 2 decimal places.

[2]

Many fully correct answers were seen and candidates were generally careful to show their iterations. A minority of candidates did not give the root to the required level of accuracy and were not given the final mark.

Question 5 (d)

- (d) The diagram in the Printed Answer Booklet shows the line with equation $y = x$ and the curve with equation $y = 2^{0.25x}$.

Sketch a cobweb or staircase diagram, on the diagram in the Printed Answer Booklet, for the iterative formula $x_{n+1} = 2^{0.25x_n}$ starting with $x_0 = 0.4$. Show at least **two** iterations. [2]

Most candidates produced good quality staircase diagrams and were well prepared for this question.

Question 5 (e)

- (e) Show that the equation $x^4 - 2^x = 0$ can be written in the form $x = 4 \log_2 x$ for positive values of x . [1]

This question contains the command phrase 'show that'. Examiners needed to see at least one step of working after rearranging the equation to the form $x^4 = 2^x$ and a high number of fully correct answers were seen. The most common mistake was to take the log of each term in the equation $x^4 - 2^x = 0$ and write $\log_2(x^4) - \log_2(2^x) = 0$ which did not get given a mark as it is not convincingly from a correct process.

Question 5 (f)

- (f) In this question you must show detailed reasoning.

Show that the iteration $x_{n+1} = 4 \log_2 x_n$, with $x_0 = 1$, will **not** find a root of $x^4 - 2^x = 0$. [2]

Most candidates substituted $x_0 = 1$ into the iterative formula to find that $x_1 = 0$ and correctly commented that the iterative method would not work as $\log 0$ is undefined. A few candidates did not appreciate that $\log 0$ is undefined and did not earn the final mark.

Misconception

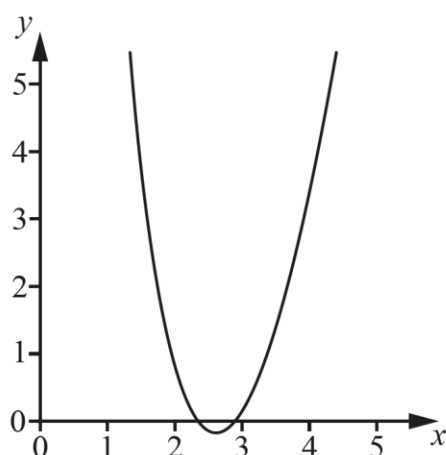


Logarithms are not distributive over addition and $\log(A + B) \neq \log A + \log B$.

$\log 0$ is undefined and is not 0.

Question 6 (a)

- 6** The diagram shows the curve with equation $y = f(x)$, where $f(x) = 13x - 34 \ln(x) - 1.5$ for $x > 0$.



- (a)** A student attempts to locate a root of $f(x) = 0$ by using a spreadsheet to calculate the values of $f(x)$ for positive integer values of x .

Explain why the student's method may lead to the conclusion that $f(x) = 0$ has no roots. [1]

Only around half of candidates were able to explain clearly why the student's method would not work to find the root. Candidates who answered this question well referred to the graph and stated that it shows that all for all integer values of x , $f(x)$ is positive and since there are two roots between the integers 2 and 3, there will be no sign change.

Common incorrect answers included 'because of the natural logarithm' or 'the roots are too close to a stationary point' or 'the roots are not at an integer value'.

Question 6 (b)

- (b)** Determine the exact value of the x -coordinate of the turning point of the curve. [2]

Most candidates answered this question well and correctly differentiated the function, set the derivative to 0 and solved to find the exact value of x . A few candidates were not able to differentiate the log term or else did not differentiate the constant term to give 0.

Candidates should pay attention to the command words 'determine' and 'exact'. The examiners expect to see some working to justify their answer and the final answer should be left as a fraction, not a rounded decimal.

Question 7 (a)

7 A group of scientists is studying how a population of insects grows in the laboratory.

At the start of the study, there are 48 insects.

At the end of the first month, there are 72 insects.

At the end of the second month, there are 108 insects.

The group develops two models, P and Q , to model the population.

The first model, P , is of the form $P_{t+1} = kP_t$, where k is a constant.

P_0 denotes the number of insects at the start of the study.

P_t denotes the number of insects at the end of month t , $t \geq 1$.

Model P fits the data for $t = 0, 1$ and 2 exactly.

(a) Find the value of k .

[1]

Most candidates found the correct value of k . The main error arose from substituting values incorrectly or from slips in the algebraic manipulation resulting in an answer of $\frac{2}{3}$.

Question 7 (b)

(b) Use model P to predict the number of insects at the end of month 3.

[1]

Nearly all candidates found the correct value of 162.

Question 7 (c) (i)

The second model, Q , is of the form $Q = 48e^{0.4t}$, where t is the time, in months, after the start of the study and Q denotes the number of insects at time t .

(c) (i) By considering the given data on the number of insects when $t = 1$ and $t = 2$, assess whether model Q fits the data for these times.

[2]

Nearly all candidates were given both marks here and very few incorrect answers were seen.

Question 7 (c) (ii)

- (ii) Show that model Q implies that the rate of growth of the population is proportional to the population at any time t . [2]

Most candidates realised that 'rate of growth' meant they should differentiate and were given 1 mark. Candidates who answered this question well then went on to say that since $\frac{dQ}{dt} = 0.4Q$, the rate of growth was in proportion to the population. Candidates who did less well found the wrong constant of proportionality or else just commented that the population growth was exponential.

Question 7 (c) (iii)

- (iii) Show that, for integer values of t with $t > 1$, the population predicted by model Q will always be lower than the population predicted by model P . [3]

Candidates who did well in this question showed that the multiplier for model Q ($e^{0.4} = 1.49 \dots$) was lower than the multiplier for model P (1.5) and commented that both models had the same starting values. A few candidates gave a fully correct well-constructed algebraic argument.

Candidates who did less well did not comment on the starting value or were unable to find a multiplier for model Q . A number of candidates just listed values for both models for consecutive months and then stating this showed that model Q would always be lower than P .

Question 8 (a), (b) and (c)

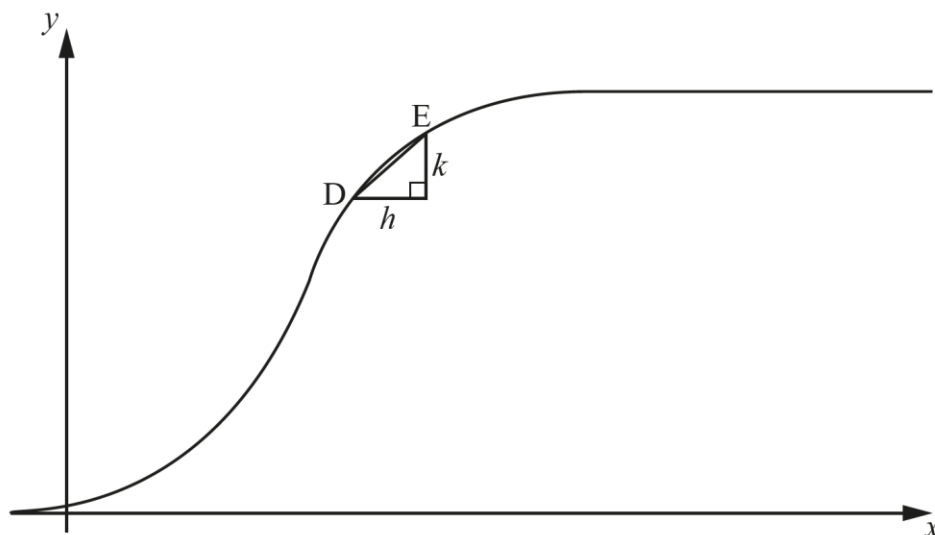
8 The diagram below shows the graph of y as a function of x .

Point D is the fixed point on the graph where $x = 10$.

Point E is the point on the graph where $x = 10 + h$ where h denotes a small increase in x .

The values of y at points D and E differ by k .

The value of the gradient of chord DE is $\frac{k}{h}$.



The screenshot below shows a spreadsheet used to find the gradient of DE for different values of h . The contents of some of the cells are not shown in the screenshot.

	A	B	C	D	E
1	h	$10+h$	y	k	gradient
2	1	11	1992.8	197.5937	197.594
3	0.1		1817.54	22.33784	
4	0.01	10.01	1797.46	2.259142	225.914
5	0.001	10.001	1795.43	0.226167	226.167
6	0.0001	10.0001	1795.22	0.022619	226.192
7	0.00001	10.00001	1795.2	0.002262	226.195
8					

(a) Write down the value for cell B3. [1]

(b) Find the value for cell E3. Give your answer to 3 decimal places. [1]

(c) Deduce, to 1 decimal place, the value of the gradient of the graph at D. [1]

Many candidates were given all 3 marks in this question. The most common error was to not use the correct degrees of accuracy in parts (b) and (c).

In part (c), a few candidates appeared not understand that the question was asking for the limit that the gradient in the last column was tending to, and did not give an answer.

Question 9 (a)

9 The function $f(x)$ is defined on all real numbers by $f(x) = x^3 + e^{3x}$.

(a) Differentiate $x^3 + e^{3x}$. [2]

This part was with almost all candidates able to correctly differentiate the function. Where there were errors, it usually came from writing the derivative of the second term as $3xe^{3x}$.

Question 9 (b)

(b) Write down the coordinates of the point where the curve $y = f(x)$ crosses the y -axis. [1]

This question was also well answered. It is worth noting that when a question asks for coordinates, the full pair should be written down. Just giving the answer of 1 is insufficient unless it is clearly given that $x = 0$ and $y = 1$.

The most common error seen was substituting $x = 0$ into $f'(x)$, leading to an incorrect answer of (0,3).

Question 9 (c)

(c) Find the gradient of the curve of the inverse function, $y = f^{-1}(x)$, at the point where it crosses the x -axis. [2]

This question proved more challenging for candidates with only a few knowing the relationship between the gradient of the function at a point and the corresponding point on the inverse function. Instead, the most common correct method came from using implicit differentiation.

Many wrong attempts led from attempting to rearrange $f(x)$, using logarithms to find the inverse function. Not many candidates used sketches to try and collect their thoughts, but where they did, it was often successful in leading them to the correct answer.

Question 10

- 10 The magnitude of the vector $\begin{pmatrix} 4 \\ -1 \\ x \end{pmatrix}$ is an integer.

Determine all possible **integer** values of x .

[6]

Many candidates were given 4 marks on this question, but fewer candidates attempted to fully justify that they had found all possible integer values. The command word 'determine' means that some justification should be given for the results found, and in this question the examiners were looking for a justification of how a candidate knows they have found all possible integer values.

Candidates quickly realised they needed to find a square number equal to $17 + x^2$ and most proceeded to find this by trial and improvement. The setting out of this work was often unclear or else no method at all was shown. The better responses showed specific substitutions into $17 + x^2$ in a structured fashion. Many did not rule out further values after $x = \pm 8$ by not recognising that adjacent squares differed by more than 17.

Higher performing candidates used an algebraic approach and from $17 + x^2 = m^2$ used the difference of two squares method in conjunction with the 2 factors of 17 to give simultaneous equations for m and x .

Once the solution of $x = 8$ was found, most candidates recognised the negative solution to be awarded the final B1.

Exemplar 2

10	$4^2 + (-1)^2 + x^2 = y^2 \quad (\text{let } y = \text{magnitude})$
	$16 + 1 + x^2 = y^2$
	$y^2 = x^2 + 17$
	$y = \sqrt{x^2 + 17}$
	trial: square numbers + 17, where result is another square number
	$3^2 + 17 = 42 \quad \times$
	$8^2 + 17 = 81 \quad \checkmark \quad 81 = 9^2$
	$(-8)^2 + 17 = 81 \quad \checkmark$
	$x = 8 \text{ and } -8$

This candidate has found a correct relationship for the magnitude of the vector and has realised that $x^2 + 17$ must be a square number which is credited first two B marks. The response shows a couple of trials which is sufficient for the M1 mark. The candidate has not justified why they need look no further, so this is given A0.

The two correct answers of 8 and -8 are given the last two B marks. This response is given 5 marks out of 6 marks.

Question 11 (a)

11 The n th term of a sequence is defined by $a_n = \frac{1}{\sqrt{n+1}-1} - \frac{1}{\sqrt{n+1}+1}$, for $n \geq 1$.

(a) Prove that every term in the sequence, a_n , is a rational number. [3]

This was generally done quite well, with most candidates able to rationalise the denominators and show the sequence can be written as $\frac{2}{n}$.

The command word is 'prove', so candidates are expected to give a high level of mathematical detail in their answers. Many did not gain the final mark for not mentioning that n is an integer, hence $\frac{2}{n}$ must be rational. Some candidates just said $\frac{2}{n}$ is rational because n is rational without explaining how they knew it was rational.

Misconception



A number in the form $\frac{a}{b}$ is only rational if both variables a and b are known to be rational. In this question, n is the n th term of a sequence, so as part of their proof candidates should make clear that, by definition, n is an integer and since 2 is also an integer, $\frac{2}{n}$ is rational.

Question 11 (b)

(b) Determine whether the sequence is increasing, decreasing or neither. [2]

Performance on this question was mixed, with many candidates just listing the first few terms of the sequence and concluding it was a decreasing sequence without actually referring to the general term.

Higher performing candidates generally made a correct statement about the limit of $\frac{2}{n}$ as n tended to infinity, or showed it was a decreasing sequence by finding the difference between two successive general terms. A few candidates differentiated $\frac{2}{x}$ (as an implied associated function) and stated a correct conclusion.

Section B overview

This comprehension on the Trisectrix of Maclaurin proved quite difficult for many candidates although most candidates did attempt all of the questions. Many candidates did not use the correct inequality signs and had work that was difficult to follow. Higher performing candidates produced well-reasoned and clearly laid out answers and paid careful attention to whether an inequality should be strict or not.

Question 12 (a)

12 (a) Show that for the point on the curve where $x = 0$, $\frac{3a-x}{a+x} \geq 0$ as given in line 10. [1]

Most candidates earned this mark. The most common slips were to not compare their value with 0 or to wrong simplify $\frac{3a}{a}$ to $2a$.

Question 12 (b)

(b) Use the equation of the curve given in line 8 to show that for all points on the curve where $x \neq 0$, $\frac{3a-x}{a+x} \geq 0$ as given in line 10. [1]

Many candidates attempted this question but did not produce a complete argument.

More successful candidates stated that since $y^2 \geq 0$ and $x^2 > 0$ then $\frac{3a-x}{a+x}$ must also be positive or 0. The most common error was to assume that $x^2 \geq 0$ rather than the strict $x^2 > 0$. Other candidates did not mention y^2 at all and so did not complete their argument.

Misconception



Candidates need to be careful with the difference between a 'non-negative number' ($n \geq 0$) and a 'positive number' ($n > 0$).

Question 12 (c)

(c) Show that it follows that $3a-x \geq 0$ and $a+x > 0$, as given in lines 10 and 11, for values of $a > 0$. [3]

Few fully correct responses were seen. The highest performing candidates usually correctly identified that $a+x \neq 0$ and then stated that since $\frac{3a-x}{a+x} \geq 0$ either $3a-x \geq 0$ and $a+x > 0$ OR $3a-x \leq 0$ and $a+x < 0$. They then showed the negative cases led to a contradiction.

Many candidates did earn the first B1 for stating that $a+x \neq 0$ but did not produce a fully complete justification for $3a-x \geq 0$ and $a+x > 0$.

Exemplar 3

12(c)	$\therefore \frac{3a-x}{a+x} \geq 0$
	$\therefore 3a-x \geq 0$, as $\frac{0}{a+x} = 0$, so $3a-x \geq 0$ //
	$\therefore a+x > 0$, as $\frac{3a-x}{0} = \text{no answer}$
	and if $\frac{3a-x}{a+x} \geq 0$, $a+x$ can't be a negative value
	$\therefore a+x > 0$ //

This response was given B1 for recognising that $a + x$ cannot equal 0.

The response was not given any further marks as the response does not explore the possibility that **both** $3a - x$ **and** $a + x$ could be negative. Instead, the candidate has assumed that $3a - x$ is positive.

This response was given 1 mark out of 3 marks.

Question 12 (d)

(d) Hence find, in terms of a where $a > 0$, the range of values of x for points on the curve

$$y^2 = \frac{x^2(3a-x)}{a+x}.$$

[1]

Candidates often realised that the denominator leads to $x > -a$ but did not go on to find the fully correct range of $-a < x \leq 3a$.

Some candidates wrote their final answer as $3a \geq x > -a$ which, although not wrong, is not a preferred way of expressing an inequality.

Question 12 (e)

(e) Find the equation of the asymptote to the curve.

[1]

Most candidates gave the correct equation of the asymptote.

Question 13

13 Use $\tan(A+B) = \frac{\tan A + \tan B}{1 - \tan A \tan B}$, with suitable choices for A and B , to show that

$$\tan 3\theta = \frac{t(3-t^2)}{1-3t^2}, \text{ where } t = \tan \theta, \text{ as given in line 25.} \quad [3]$$

This question was well answered and many candidates were confident in working with trigonometric identities. Candidates usually started by writing $\tan 2\theta = \frac{2t}{1-t^2}$ or $\tan 3\theta = \frac{\tan 2\theta + \tan \theta}{1 - \tan 2\theta \tan \theta}$ and were given the B mark. They then formed the correct expression for $\tan 3\theta$ and simplified this correctly to reach the required result.

A few candidates were unable to make any progress as they tried to work with $\tan(1.5\theta + 1.5\theta)$.

Question 14 (a)

14 (a) Draw and label a suitable triangle on the diagram in the **Printed Answer Booklet** to show that $\tan \theta = \frac{y}{x}$, as given in line 30. [1]

Many fully correct diagrams were seen. The most common errors were to not draw a right-angled triangle or to not label the triangle.

Question 14 (b)

(b) Subtract $x = \frac{a(3-t^2)}{1+t^2}$ from $3a$ to show that $3a - x = \frac{4at^2}{1+t^2}$. [1]

Many candidates correctly formed the expression for $3a - x$ and correctly simplified it to the given answer.

Question 14 (c)

- (c) Find an expression, in terms of
- a
- and
- t
- , for
- $a + x$
- .

[1]

More successful candidates wrote down $a + \frac{a(3-t^2)}{1+t^2}$ and simplified it to $\frac{4a}{1+t^2}$. Some candidates left their answer in a not simplified form and so were not given the mark. Other candidates made no progress as they tried to start from $3a$.

OCR support



The specification states that are expected that candidates will simplify algebraic and numerical expressions when giving their final answers, even if the examination question does not explicitly ask them to do so. For more information on the presentation of answers and command words, see section 2d of the OCR Mathematics B [specification](#).

Question 14 (d)

- (d) Hence, or otherwise, show that the parametric equations given in lines 29 and 31 are equivalent to $y^2 = \frac{x^2(3a-x)}{a+x}$, as claimed in lines 8 and 33.

[2]

The command phrase for this question is 'hence or otherwise'. Some higher performing students recognised that this command phrase meant they should use their previous answers to help them. These candidates used the 'hence method' which proved to be very efficient. They showed their

expressions for $3a - x$ and $a + x$ from parts a) and b) could be divided to give $\frac{3a-x}{a+x} = \frac{\frac{4at^2}{1+t^2}}{\frac{4a}{1+t^2}} = t^2$ and then used the fact that $t^2 = \frac{y^2}{x^2}$.

Most other successful candidates worked with the parametric equation for x to make t^2 the subject and then used this to show the given equation. A few other candidates made the start of a sensible plan but made algebraic slips.

This was a challenging final question for the paper and many candidates struggled with the required algebraic manipulation.

Assessment for learning



When a question contains the command phrase 'hence, or otherwise,' candidates should try and use their work from previous part(s) to answer the question. In general, this command phrase is signposting a suitable starting point or a more straightforward method.

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