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EDEXCEL INTERNATIONAL A LEVEL MATHS: QUESTIONS BY TOPIC

Differentiation (P1.7)

International A Level Mathematics · P1: Pure Mathematics 1 (WMA11)

23 questions · 165 marks · Mark schemes included

Past papers January 2019 - June 2025 · 3 sub-topics

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HOW TO USE THIS BOOKLET

Questions are grouped by sub-topic and run from the lowest to the highest mark tariff, then oldest paper first.

Click any row below to jump straight to that sub-topic or question.

On every question page, click ANSWER in the top-right corner to jump to its mark scheme; < QUESTION brings you back.

A gold bar in the left margin marks exactly where the question sits on the original page.

Diagrams, graphs, grids and tables are printed exactly as they appear in the original papers.

Each question is filed under its main topic; longer questions may also test skills from other topics.

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P1.7a DIFFERENTIATING POWERS OF X		6 Qs · 41 marks	2
1. Q1	IAL P1 (WMA11) October 2023	5	3
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P1.7c INCREASING & DECREASING FUNCTIONS			

No questions on this sub-topic in the available past papers.



QUESTIONS

23 questions · 165 marks · 2 sub-topics

SUB-TOPIC P1.7a

DIFFERENTIATING POWERS OF X

Sub-topic P1.7a · 6 questions · 41 marks · lowest tariff first



1. Given that

$$y = 5x^3 + \frac{3}{x^2} - 7x \quad x > 0$$

find, in simplest form,

$$(a) \quad \frac{dy}{dx} \tag{3}$$

$$(b) \frac{d^2 y}{dx^2} \quad (2)$$

Question 1 continued

Lined area for writing the answer to Question 1.

(Total for Question 1 is 5 marks)



9.

In this question you must show all stages of your working.

Solutions relying on calculator technology are not acceptable.

A curve has equation

$$y = \frac{4x^2 + 9}{2\sqrt{x}} \quad x > 0$$

Find the x coordinate of the point on the curve at which $\frac{dy}{dx} = 0$

(6)

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Question 9 continued

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(Total 6 marks)

Q9



3.

In this question you must show all stages of your working.

Solutions relying on calculator technology are not acceptable.

$$y = x^3 + 96\sqrt{x} + 5 \quad x > 0$$

- (a) Find $\frac{dy}{dx}$, giving each term in simplest form.

(3)

- (b) Find the solution of the equation

$$\frac{d^2 y}{dx^2} = 0$$

writing the answer in the form 2^k where k is a constant.

(3)



Question 3 continued

Lined area for writing the answer to Question 3.

(Total for Question 3 is 6 marks)



6. (Solutions based entirely on graphical or numerical methods are not acceptable.)

Given

$$f(x) = 2x^{\frac{5}{2}} - 40x + 8 \quad x > 0$$

(a) solve the equation $f'(x) = 0$

(4)

(b) solve the equation $f''(x) = 5$

(3)

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Question 6 continued

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Q6

(Total 7 marks)



Question 7 continued

Lined area for writing the answer to Question 7.

(Total for Question 7 is 8 marks)



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- 7. In this question you must show all stages of your working.**
- Solutions relying on calculator technology are not acceptable.**

$$f(x) = 2x - 3\sqrt{x} - 5 \quad x > 0$$

(a) Solve the equation

$$f(x) = 9 \tag{4}$$

(b) Solve the equation

$$f''(x) = 6 \tag{5}$$

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Q7

SUB-TOPIC P1.7b

TANGENTS & NORMALS

Sub-topic P1.7b · 17 questions · 124 marks · lowest tariff first



2. In this question you must show all stages of your working.

Solutions relying on calculator technology are not acceptable.

A curve has equation

$$y = 3x^5 + 4x^3 - x + 5$$

The points P and Q lie on the curve.

The gradient of the curve at both point P and point Q is 2

Find the x coordinates of P and Q .

(5)

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Question 2 continued

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Lined area for writing the answer to Question 2.

(Total 5 marks)

Q2

Box for marking the question.



1. A curve C has equation

$$y = 2 + 10x^{\frac{1}{2}} - 2x^{\frac{3}{2}} \quad x > 0$$

- (a) Find $\frac{dy}{dx}$ giving your answer in simplest form.

(3)

- (b) Hence find the exact value of the gradient of the tangent to C at the point where $x = 2$ giving your answer in simplest form.

(Solutions relying on calculator technology are not acceptable.)

(2)

(Total for Question 1 is 3 marks)



4. The curve C has equation

$$y = \frac{2}{x} + 3x - 4 \quad x \neq 0$$

The straight line l has equation

$$y = kx + 2$$

where k is a constant.

(a) Show that l meets C when

$$(k-3)x^2 + 6x - 2 = 0$$

(2)

(b) Hence find the value of k for which l is a tangent to C

(3)

Question 4 continued

Lined area for writing the answer to Question 4.

(Total for Question 4 is 5 marks)



Question 2 continued

Lined area for writing the answer to Question 2.

(Total for Question 2 is 5 marks)



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Q1

Question 7 continued

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Lined area for writing the answer to Question 7.

(Total 6 marks)

Q7



Leave
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Q3

Question 1 continued

Lined area for writing the answer to Question 1.

(Total for Question 1 is 6 marks)



5. A curve has equation

$$y = \frac{x^3}{6} + 4\sqrt{x} - 15 \quad x \geq 0$$

- (a) Find $\frac{dy}{dx}$, giving the answer in simplest form.

(3)

The point $P\left(4, \frac{11}{3}\right)$ lies on the curve.

- (b) Find the equation of the normal to the curve at P . Write your answer in the form $ax + by + c = 0$, where a , b and c are integers to be found.

(4)

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Q5

3. The curve C has equation

$$y = \frac{5x^3 - 8}{2x^2} \quad x > 0$$

(a) Find $\frac{dy}{dx}$ writing your answer in simplest form.

(4)

The point $P(2, 4)$ lies on C .

(b) Find an equation for the tangent to C at P writing your answer in the form $ax + by + c = 0$, where a , b and c are integers.

(3)

Question 3 continued

Lined area for writing the answer to Question 3.

(Total for Question 3 is 7 marks)



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Q1

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Q1

Question 5 continued

Lined area for writing the answer to Question 5 continued.



Question 5 continued

Lined area for writing the answer to Question 5 continued.



Question 5 continued

Lined area for writing the answer to Question 5.

(Total for Question 5 is 8 marks)



8.

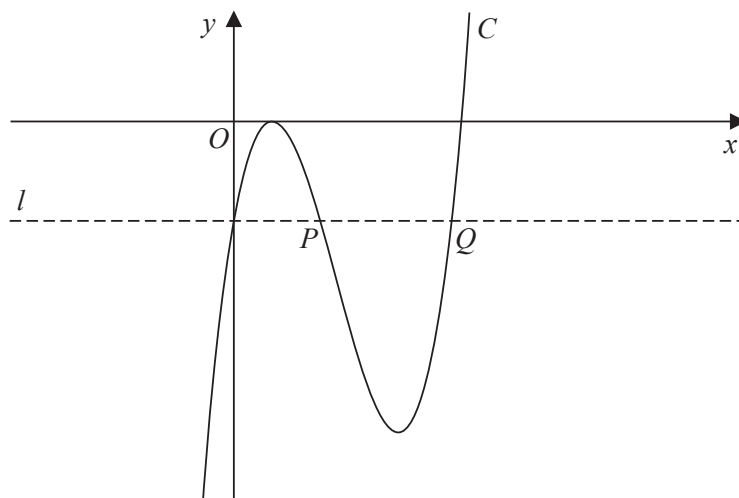


Figure 4

Figure 4 shows a sketch of part of the curve C with equation $y = f(x)$, where

$$f(x) = (3x - 2)^2 (x - 4)$$

- (a) Deduce the values of x for which $f(x) > 0$ (1)

- (b) Expand $f(x)$ to the form

$$ax^3 + bx^2 + cx + d$$

where a , b , c and d are integers to be found.

(3)

The line l , also shown in Figure 4, passes through the y intercept of C and is parallel to the x -axis.

The line l cuts C again at points P and Q , also shown in Figure 4.

- (c) Using algebra and showing your working, find the length of line PQ . Write your answer in the form $k\sqrt{3}$, where k is a constant to be found.

(Solutions relying entirely on calculator technology are not acceptable.)

(5)

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Q8

Question 10 continued

Lined area for writing the answer to Question 10.



Question 10 continued

Lined area for writing the answer to Question 10.

(Total for Question 10 is 10 marks)

TOTAL FOR PAPER IS 75 MARKS



8. The curve C has equation

$$y = (x - 2)(x - 4)^2$$

(a) Show that

$$\frac{dy}{dx} = 3x^2 - 20x + 32 \quad (4)$$

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Question 8 continued

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(Total 11 marks)

Q8



10.

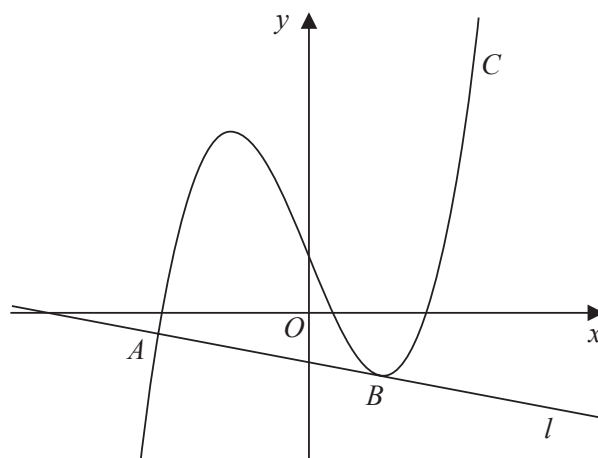
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Figure 5

Figure 5 shows a sketch of the curve C with equation

$$y = \frac{2}{7}x^3 + \frac{1}{7}x^2 - \frac{5}{2}x + k$$

where k is a constant.

(a) Find $\frac{dy}{dx}$

(2)

The line l , shown in Figure 5, is the normal to C at the point A with x coordinate $-\frac{7}{2}$

Given that l is also a tangent to C at the point B ,

(b) show that the x coordinate of the point B is a solution of the equation

$$12x^2 + 4x - 33 = 0$$

(4)

(c) Hence find the x coordinate of B , justifying your answer.

(2)

Given that the y intercept of l is -1

(d) find the value of k .

(4)

Question 10 continued

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Handwriting practice area with 30 horizontal lines.



Question 10 continued

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Lined area for writing the answer to Question 10 continued.



Question 10 continued

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Handwriting practice area with 30 horizontal lines.



Question 10 continued

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Lined area for writing the answer to Question 10.

Q10

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(Total 12 marks)

TOTAL FOR PAPER IS 75 MARKS

END



MARK SCHEMES

official mark schemes, in the same order as the questions



General Principles for Pure Mathematics Marking

(NB specific mark schemes may sometimes override these general principles)

Method mark for solving 3 term quadratic:

1. Factorisation

$(x^2 + bx + c) = (x + p)(x + q)$, where $|pq| = |c|$, leading to $x = \dots$

$(ax^2 + bx + c) = (mx + p)(nx + q)$, where $|pq| = |c|$ and $|mn| = |a|$, leading to $x = \dots$

2. Formula

Attempt to use correct formula (with values for a , b and c).

3. Completing the square

Solving $x^2 + bx + c = 0$: $(x \pm \frac{b}{2})^2 \pm q \pm c$, $q \neq 0$, leading to $x = \dots$

Method marks for differentiation and integration:

1. Differentiation

Power of at least one term decreased by 1. ($x^n \rightarrow x^{n-1}$)

2. Integration

Power of at least one term increased by 1. ($x^n \rightarrow x^{n+1}$)

Use of a formula

Where a method involves using a formula that has been learnt, the advice given in recent examiners' reports is that the formula should be quoted first.

Normal marking procedure is as follows:

Method mark for quoting a correct formula and attempting to use it, even if there are small mistakes in the substitution of values.

Where the formula is not quoted, the method mark can be gained by implication from correct working with values, but may be lost if there is any mistake in the working.

Exact answers

Examiners' reports have emphasised that where, for example, an exact answer is asked for, or working with surds is clearly required, marks will normally be lost if the candidate resorts to using rounded decimals.

Answers without working

The rubric says that these may not gain full credit. Individual mark schemes will give details of what happens in particular cases. General policy is that if it could be done "in your head", detailed working would not be required. Most candidates do show working, but there are occasional awkward cases and if the mark scheme does not cover this, please contact your team leader for advice.



Question Number	Scheme	Marks
9.	$\frac{4x^2 + 9}{2\sqrt{x}} = \frac{4x^2}{2\sqrt{x}} + \frac{9}{2\sqrt{x}} = 2x^{\frac{3}{2}} + \frac{9}{2}x^{-\frac{1}{2}}$ $\left(\frac{dy}{dx}\right) = 3x^{\frac{1}{2}} - \frac{9}{4}x^{-\frac{3}{2}}$ $\left(\frac{dy}{dx}\right) = 3x^{\frac{1}{2}} - \frac{9}{4}x^{-\frac{3}{2}} = 0 \Rightarrow x^2 = \frac{3}{4} \Rightarrow x = \frac{\sqrt{3}}{2}$	M1 A1 M1 A1 M1 A1 (6) (6 marks)
Alt(I)	Quotient rule $u = 4x^2 + 9, u' = 8x, v = 2\sqrt{x}, v' = x^{-\frac{1}{2}}$ $\left(\frac{dy}{dx}\right) = \frac{2\sqrt{x} \times 8x - (4x^2 + 9) \times x^{-\frac{1}{2}}}{4x}$ $\left(\frac{dy}{dx}\right) = \frac{2\sqrt{x} \times 8x - (4x^2 + 9) \times x^{-\frac{1}{2}}}{4x} = 0 \Rightarrow x^2 = \frac{3}{4} \Rightarrow x = \frac{\sqrt{3}}{2}$	M1A1 M1A1 M1A1
Alt(II)	Product rule $u = 4x^2 + 9, u' = 8x, v = \frac{1}{2}x^{-\frac{1}{2}}, v' = \frac{1}{4}x^{-\frac{3}{2}}$ $\left(\frac{dy}{dx}\right) = (4x^2 + 9) \times \frac{1}{4}x^{-\frac{3}{2}} + 8x \times \frac{1}{2}x^{-\frac{1}{2}}$ $\left(\frac{dy}{dx}\right) = \frac{2\sqrt{x} \times 8x - (4x^2 + 9) \times x^{-\frac{1}{2}}}{4x} = 0 \Rightarrow x^2 = \frac{3}{4} \Rightarrow x = \frac{\sqrt{3}}{2}$	M1A1 M1A1 M1A1



- M1 Attempts to divide by $2\sqrt{x}$. Award for one correct term (including $\frac{9}{2x^2}$). Allow if they combine the two terms with a common denominator of 2, but the indices must have been processed.

If they use the quotient rule it is for selecting u and v and attempting to differentiate. Look for

$u = 4x^2 + 9, u' = \dots x, v = 2\sqrt{x}, v' = \dots x^{-\frac{1}{2}}$. If they use the product rule then it is for

$$u = 4x^2 + 9, u' = 8x, v = \frac{1}{2}x^{-\frac{1}{2}}, v' = \frac{1}{4}x^{-\frac{3}{2}}$$

- A1 $2x^{\frac{3}{2}} + \frac{9}{2}x^{-\frac{1}{2}}$ which may be left unsimplified but the indices must be processed. Using the product or quotient rule it is for having correct u' and v' .

- M1 Attempts to differentiate the expression written as a sum. Award for one power decreasing by one on one of their terms following through their sum and the indices must have been processed. Cannot be awarded if they just differentiate top and bottom of the fraction.

Using the quotient rule look for expressions of the form $\left(\frac{dy}{dx} = \right) \frac{2\sqrt{x} \times \dots x \pm (4x^2 + 9) \times \dots x^{-\frac{1}{2}}}{4x}$

Using the product rule look for expressions of the form $\left(\frac{dy}{dx} = \right) (4x^2 + 9) \times \dots x^{-\frac{3}{2}} + \dots x \times \frac{1}{2}x^{-\frac{1}{2}}$

- A1 $\left(\frac{dy}{dx} = \right) 3x^{\frac{1}{2}} - \frac{9}{4}x^{-\frac{3}{2}}$ which may be left unsimplified but the indices must be processed.

Using the quotient rule award for $\left(\frac{dy}{dx} = \right) \frac{2\sqrt{x} \times 8x - (4x^2 + 9) \times x^{-\frac{1}{2}}}{4x}$.

Using the product rule award for $\left(\frac{dy}{dx} = \right) (4x^2 + 9) \times \frac{1}{4}x^{-\frac{3}{2}} + 8x \times \frac{1}{2}x^{-\frac{1}{2}}$

- M1 Sets $\frac{dy}{dx} = 0$ and proceeds to $x^{\pm 2} = \dots$ or $x^{\pm 4} = \dots$ following a derivative in the form

$$\left(\frac{dy}{dx} = \right) Ax^{\frac{1}{2}} - Bx^{-\frac{3}{2}}, \quad A, B > 0 \quad (\text{which may be unsimplified}).$$

Using the quotient rule or product rule look to proceed from one of the forms above to $x^{\pm 2} = \dots$ or $x^{\pm 4} = \dots$

Rounded versions of the answer do not imply this mark. Do not be too concerned by the mechanics of their arrangement but we must see some attempt to carry out algebraic manipulation proceeding to the required form.

- A1 $(x =) \frac{\sqrt{3}}{2}$ or exact equivalent cso (Note that a correct exact answer can imply the final M1A1 but a rounded answer with no working such as awrt 0.87 is M0A0)

Withhold the final mark if $-\frac{\sqrt{3}}{2}$ is not rejected.



General Principles for Pure Mathematics Marking

(NB specific mark schemes may sometimes override these general principles)

Method mark for solving 3 term quadratic:

1. Factorisation

$(x^2 + bx + c) = (x + p)(x + q)$, where $|pq| = |c|$ leading to $x = \dots$

$(ax^2 + bx + c) = (mx + p)(nx + q)$, where $|pq| = |c|$ and $|mn| = |a|$ leading to $x = \dots$

2. Formula

Attempt to use correct formula (with values for a, b and c)

3. Completing the square

Solving $x^2 + bx + c = 0$: $(x \pm \frac{b}{2})^2 \pm q \pm c$, $q \neq 0$ leading to $x = \dots$

Method marks for differentiation and integration:

1. Differentiation

Power of at least one term decreased by 1 ($x^n \rightarrow x^{n-1}$)

2. Integration

Power of at least one term increased by 1 ($x^n \rightarrow x^{n+1}$)

Use of a formula

Where a method involves using a formula that has been learnt, the advice given in recent examiners' reports is that the formula should be quoted first.

Normal marking procedure is as follows:

Method mark for quoting a correct formula and attempting to use it, even if there are small mistakes in the substitution of values.

Where the formula is not quoted, the method mark can be gained by implication from correct working with values, but may be lost if there is any mistake in the working.

Exact answers

Examiners' reports have emphasised that where, for example, an exact answer is asked for, or working with surds is clearly required, marks will normally be lost if the candidate resorts to using rounded decimals.

Answers without working

The rubric says that these may not gain full credit. Individual mark schemes will give details of what happens in particular cases. General policy is that if it could be done "in your head", detailed working would not be required. Most candidates do show working, but there are occasional awkward cases and if the mark scheme does not cover this, please contact your team leader for advice.



(b)

M1 Uses the perpendicular gradient rule following through on their gradient from (a).
If a gradient is not given, follow through on their 'm'

M1 For the equation of a straight line with a **changed** gradient using $(6, -2)$.

So if (a) was $-\frac{3}{5}$, then $(y+2) = \frac{3}{5}(x-6)$ would score this. At least one bracket must be correct. If the form $y = mx + c$ is used they must proceed as far as finding c . They must either have shown their gradient and $(6, -2)$ substituted into $y = mx + c$ and rearrange (maybe with errors) to find c or if they show no working then their c must be correct.

A1 $y = \frac{5}{3}x - 12$ Allow exact equivalent values for their constants eg $y = \frac{10}{6}x - \frac{36}{3}$, $y = 1.6x - 12$,
 $y = \frac{5x}{3} - 12$ but do not allow equations such as $y = 1.67x - 12$. ISW after a correct equation in the correct form is found.



Question Number	Scheme	Marks
4.	When ---- represents $<$ or $>$ and ——— represents $\leq$ or $\geq$ Either $2y \leq x$ or $y \geq 2x - \frac{1}{8}x^2$ $2x - \frac{1}{8}x^2 = 0 \Rightarrow x = 16 \Rightarrow x < \dots$ or $x \leq \dots$ $x < 16$, $2y \leq x$ and $y \geq 2x - \frac{1}{8}x^2$	B1 M1 A1 (3) (3 marks)
Alt1	When ---- represents $\leq$ or $\geq$ and ——— represents $<$ or $>$ Either $2y < x$ or $y > 2x - \frac{1}{8}x^2$ $2x - \frac{1}{8}x^2 = 0 \Rightarrow x = 16 \Rightarrow x < \dots$ or $x \leq \dots$ $x \leq 16$, $2y < x$ and $y > 2x - \frac{1}{8}x^2$	B1 M1 A1 (3)

B1 Sight of $2y \leq x$ or $y \geq 2x - \frac{1}{8}x^2$. Either inequality is sufficient for B1 and they may be written in an equivalent correct form (see NB below)

NB Inequalities cannot be in terms of R

M1 Attempts to find the upper bound for x to define R . Solves to find where the quadratic intersects the x -axis and then uses their value to write $x < \dots$ or $x \leq \dots$. Use general principles for solving a quadratic equation (page 5). They do not need to find or state $x = 0$ and ignore any lower bound eg $0 < x < \dots$

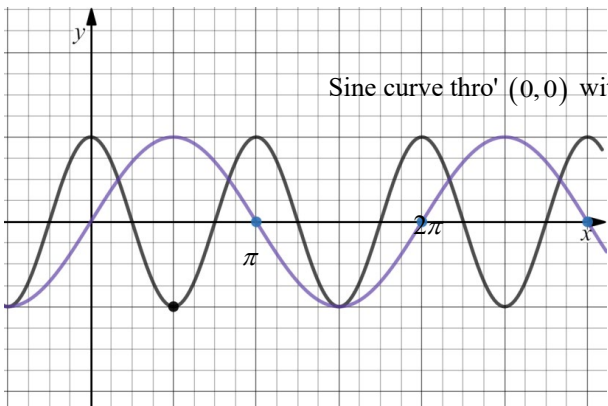
A1 $2y \leq x$, $y \geq 2x - \frac{1}{8}x^2$ and $x < 16$ (Allow $A \leq x < 16$ where $A \leq 12$).

Candidates may write more than one inequality for a particular boundary. In these cases mark the last one. Correct inequalities labelled on the graph are also acceptable, however, an inequality written below takes precedence.

NB You may see $y \leq \frac{x}{2}$ for $2y \leq x$ or even $2x - \frac{1}{8}x^2 \leq y \leq \frac{x}{2}$ oe

Alternatively, some candidates may express their inequalities involving a boundary for a dashed line using $\leq$ or $\geq$ and a boundary for a solid line using $<$ or $>$. It may not always be clear so mark positively. See Alt1



Question Number	Scheme	Marks
5. (a)	$\left(\frac{\pi}{2}, -1\right)$	B1 B1
(b)	 Sine curve thro' (0,0) with max/min of ± 1 Fully correct	(2) M1 A1
(c)	(i) 30 but follow through on $10 \times$ the number of their solutions $0 \rightarrow 2\pi$ (ii) 32	(2) B1ft B1 (2) (6 marks)

(a)

B1 Either coordinate correct. They may state the coordinates separately or condone the lack of brackets for this mark. (Accept the x -coordinate as 90° or awrt 1.57 radians for this mark) If only one coordinate is stated, it must be clear if it is the x or y coordinate.

B1 For $\left(\frac{\pi}{2}, -1\right)$ or $x = \frac{\pi}{2}, y = -1$ Allow $\left[\frac{\pi}{2}, -1\right]$

SC $\left(-1, \frac{\pi}{2}\right)$ B1B0 (coordinates the wrong way round)

(b)

M1 For a sketch of a sine curve with at least one cycle starting at (or going through) the origin with the same maximum/minimum y -values as the $\cos 2x$ curve.
 Condone poor/incorrect period and poor symmetry
 Condone turning points appearing V shaped for this mark. If drawn on a separate diagram the maximum and minimum must appear to be ± 1 according to their axes and a complete cycle must be in the positive domain. Condone slight inaccuracies of the amplitude of their sine curve.



- A1 A correct sketch of $\sin x$ between $-\frac{\pi}{2}$ and 3π . Labelling where the graph crosses the x -axis is not required. Turning points must appear curved. If multiple attempts are drawn and it is not clear which is their final attempt then withhold the A1.

Do not accept linear looking graphs so unless it is a clear V shape at one maximum or minimum then allow any curvature at the turning points. As a guide the curve should not go diagonally across the square either side of turning points. See graph on the right showing what is not acceptable. Where the graph crosses the x -axis, it must be within half a square of the correct points



(c) (i)

- B1ft 30 or follow through on $10 \times$ the number of their solutions between 0 and 2π (where 2π should be on the graph - see mark scheme for position). The question said hence or otherwise so they may get B1 for 30 even if their graph does not suggest that number of solutions.

(ii)

B1 32

Question Number	Scheme	Marks
6.(a)	$f'(x) = 5x^{\frac{3}{2}} - 40$ Attempts $5x^{\frac{3}{2}} - 40 = 0 \Rightarrow x^{\frac{3}{2}} = \dots$ $x = 4$	M1A1 M1 A1 cao (4)
(b)	$f''(x) = \frac{15}{2}x^{\frac{1}{2}} = 5$ $\Rightarrow x^{\frac{1}{2}} = \dots \Rightarrow x = \dots^2$ $x = \frac{4}{9}$	M1 M1 A1 (3) (7 marks)

(a)

M1 For reducing the power by one on either x term ($x^{\frac{5}{2}} \rightarrow x^{\frac{3}{2}}$ or $-40x \rightarrow -40$)

A1 Correct (but may be unsimplified) $[f'(x)] = 5x^{\frac{3}{2}} - 40$

M1 Attempts to solve their $f'(x) = 0 \Rightarrow x^{\frac{3}{2}} = \dots$ by making their $x^{\frac{3}{2}}$ the subject. Their $f''(x)$ must be a changed function. This can be implied by their final answer. If their $f'(x) = 0$ is of the form $f'(x) = Ax^B + Cx^D$ then this mark can be awarded for taking a factor out eg. $x^B(A + Cx^{D-B})$ and doing the same as above on the terms in their bracket.

A1 $x = 4$ cao (do not accept ± 4)

(b)

M1 For reducing the power by one on one of their terms in $f'(x)$ and setting their $f''(x) = 5$

M1 For a correct method leading to $x = \dots$ from an equation of the form $Ax^{\frac{1}{2}} = 5$.
Eg for $\frac{15}{2}x^{\frac{1}{2}} = 5$ either makes $x^{\frac{1}{2}}$ the subject and squares or squares both sides and makes x the subject. This can be implied by their final answer. Do not allow slips on the power.

A1 $x = \frac{4}{9}$ or exact equivalent

The question states that solutions based entirely on graphical or numerical methods are not acceptable. Therefore if no differentiation is shown then this will score no marks.



Question Number	Scheme	Marks
7.(a)	Attempts $\frac{\sin \angle ACB}{6.5} = \frac{\sin 35}{4.7}$ $\angle ACB = \text{awrt}(52 \text{ or } 53)^\circ$ or $\text{awrt}(127 \text{ or } 128)^\circ$ $\angle ACB = 127.5^\circ$	M1 A1 A1
(b)	Eg $\frac{(AC)}{\sin "17.5^\circ"} = \frac{6.5}{\sin "127.5^\circ"} \text{ or } = \frac{4.7}{\sin 35^\circ}$ $\left[\frac{(CD)}{\sin "75^\circ"} = \frac{4.7}{\sin "127.5^\circ"} \Rightarrow (CD) = \dots \Rightarrow (AC) + (CD) \right] = \text{awrt } 8.2$ Total length of wood = $8.1 + 6.5 + 4.7 + 4.7 = \text{awrt } 24.1$	M1 A1 A1 (3) (6 marks)
Alt1(a)	$\cos 35 = \frac{AC^2 + 6.5^2 - 4.7^2}{2 \times 6.5 \times AC} \Rightarrow AC^2 - 13 \cos(35)AC + 20.16 = 0 \Rightarrow AC = \dots$ $\cos \angle ACB = \frac{AC^2 + 4.7^2 - 6.5^2}{2 \times AC \times 4.7} \text{ oe}$	M1

(a)

M1 Uses the sine rule with the angles and sides in the correct positions.

Alternatively they may use the cosine rule on ACB and then solve the subsequent quadratic to find AC and then use the cosine rule again

A1 $\angle ACB = \text{awrt}(52 \text{ or } 53)^\circ$ or $\text{awrt}(127 \text{ or } 128)^\circ$ A1 $\angle ACB = 127.5^\circ$ only

Question	Scheme	Marks
7(a)(i)	$f(x) = 2x^3 - kx^2 + 14x + 24 \Rightarrow (f'(x) =) 6x^2 - 2kx + 14$	M1A1
	$(f''(x) =) 12x - 2k$	A1ft
(ii)		(3)
(b)	$6x^2 - 2kx + 14 = 12x - 2k \Rightarrow 6(5)^2 - 2k(5) + 14 = 12(5) - 2k \Rightarrow k = \dots$	M1
	$k = 13$	A1
		(2)
(c)	$k = 13 \Rightarrow 6x^2 - 38x + 40 = 0 \Rightarrow x = \dots$	M1
	$x = \frac{4}{3} \Rightarrow y = 12\left(\frac{4}{3}\right) - 2 \times 13$ or $y = 6\left(\frac{4}{3}\right)^2 - 2 \times 13 \times \left(\frac{4}{3}\right) + 14$	M1
	$x = \frac{4}{3}, y = -10$	A1
		(3)
		Total 8

Notes:

In part (a), penalise the inclusion of “+ c” on either derivative only once on the first occurrence.

(a)(i)

M1: For $x^3 \rightarrow \dots x^2$ or $x^2 \rightarrow \dots x$ or $14x \rightarrow 14$

A1: Correct simplified first derivative. The “ $f'(x) =$ ” is not required.

Do not allow x^1 for x .

Isw can be applied once a correct simplified derivative is seen.

(ii)

A1ft: Correct simplified second derivative. Follow through their first derivative

The “ $f''(x) =$ ” is not required.

Isw can be applied once a correct simplified second derivative is seen. **Must follow M1**

(b)

M1: Sets $f'(x) = f''(x)$, substitutes $x = 5$ and solves a linear equation in k to find a value for k .

May substitute $x = 5$ into $f'(x)$ and $f''(x)$ first, then equate and solve for k .

A1: $k = 13$

(c)

M1: Substitutes their k into the equated $f'(x) = f''(x)$ and solves the resulting 3TQ to obtain at least one value for x by any means including a calculator.

M1: Substitutes their x (not 5) and their k into $f'(x)$ or $f''(x)$ to find a value for y .

May be implied by their values so you may need to check.

A1: Correct coordinates. May be seen as $x = \dots, y = \dots$ or as a coordinate pair but condone missing brackets

e.g. $\frac{4}{3}, -10$. Award this mark as soon as the correct values are seen.

Allow a “made up” k in (c).



Note if they have a contradiction between what is stated and what is written on the graph then the graph takes precedence.

(c)

M1 Attempts to set $3x + 4 = -\frac{k}{x} + k$ and proceeds to a 3TQ in x on one side of the equation but terms do not need to be collected ($=0$ may be omitted).

A1 Correct quadratic seen $3x^2 + (4 - k)x + k = 0$ with the x terms collected together or implied by their values for a , b and c

M1 Attempts to use their values in $b^2 - 4ac \dots 0$ ($= k^2 - 20k + 16$) to find the critical values where ... is = or an inequality.

Dependent upon having $a = 3$ with both b and c expressions in k .

The solution of the quadratic in k ($= 10 \pm 2\sqrt{21}$) must be by allowable methods but allow decimal answers. As a minimum a quadratic in k must have been produced but it is acceptable to then state the critical values from their calculator. awrt19.2 / awrt0.8. You may need to check these on your calculator using their values of a , b and c .

dM1 Uses $b^2 - 4ac < 0$ OR $b^2 - 4ac \leq 0$ and selects inside region for their critical values. It is dependent upon both previous M's. Condone if a different variable to k is used.

A1 Accept any of $10 - 2\sqrt{21} < k < 10 + 2\sqrt{21}$ or exact equivalent expressions such as $10 - \sqrt{84} < k < 10 + \sqrt{84}$ or Allow $10 + 2\sqrt{21} > k > 10 - 2\sqrt{21}$ or expressions such as $\{k : 10 - 2\sqrt{21} < k < 10 + 2\sqrt{21}\}$,

Must be in terms of k (Not x or any other variable)

ALLOW ' $10 - 2\sqrt{21} < k$ AND $k < 10 + 2\sqrt{21}$ ' (or equivalent) but

DO NOT ALLOW ' $10 - 2\sqrt{21} < k$ OR $k < 10 + 2\sqrt{21}$ '

Question Number	Scheme	Marks
7. (a)	$2x - 3\sqrt{x} - 5 = 9 \Rightarrow 2x - 3\sqrt{x} - 14 = 0$ and treats as quadratic equation $\Rightarrow (2\sqrt{x} - 7)(\sqrt{x} + 2) = 0 \Rightarrow (\sqrt{x} =) \frac{7}{2}, (-2)$ $\Rightarrow x = \left(\frac{7}{2}\right)^2 = \frac{49}{4}$	M1 A1 dM1 A1 (4)
(b)	$(f'(x) =) 2 - \frac{3}{2}x^{-\frac{1}{2}}$	B1

General Principles for Core Mathematics Marking*(But note that specific mark schemes may sometimes override these general principles).***Method mark for solving 3 term quadratic:****1. Factorisation** $(x^2 + bx + c) = (x + p)(x + q)$, where $|pq| = |c|$, leading to $x = \dots$ $(ax^2 + bx + c) = (mx + p)(nx + q)$, where $|pq| = |c|$ and $|mn| = |a|$, leading to $x = \dots$ **2. Formula**

Attempt to use the correct formula (with values for a, b and c).

3. Completing the squareSolving $x^2 + bx + c = 0$: $\left(x \pm \frac{b}{2}\right)^2 \pm q \pm c = 0$, $q \neq 0$, leading to $x = \dots$ **Method marks for differentiation and integration:****1. Differentiation**Power of at least one term decreased by 1. ($x^n \rightarrow x^{n-1}$)**2. Integration**Power of at least one term increased by 1. ($x^n \rightarrow x^{n+1}$)**Use of a formula**

Where a method involves using a formula that has been learnt, the advice given in recent examiners' reports is that the formula should be quoted first.

Normal marking procedure is as follows:

Method mark for quoting a correct formula and attempting to use it, even if there are small errors in the substitution of values.Where the formula is not quoted, the method mark can be gained by implication from correct working with values, but may be lost if there is any mistake in the working.**Exact answers**

Examiners' reports have emphasised that where, for example, an exact answer is asked for, or working with surds is clearly required, marks will normally be lost if the candidate resorts to using rounded decimals.

Question Number	Scheme	Marks
1	$y = 2 + 10x^{\frac{1}{2}} - 2x^{\frac{3}{2}}$	
(a)	$\frac{dy}{dx} = 5x^{-\frac{1}{2}} - 3x^{\frac{1}{2}}$	M1 A1 A1
		(3)
(b)	$x = 2 \Rightarrow \frac{dy}{dx} = \frac{5}{\sqrt{2}} - 3\sqrt{2}$	M1
	$\frac{5}{\sqrt{2}} - 3\sqrt{2} = \frac{5}{2}\sqrt{2} - 3\sqrt{2} = -\frac{1}{2}\sqrt{2}$	A1
		(2)
		(5 marks)

(a) Mark (a) and (b) together.

M1: For ANY one of: $10x^{\frac{1}{2}} \rightarrow \dots x^{-\frac{1}{2}}$ or $-2x^{\frac{3}{2}} \rightarrow \dots x^{\frac{1}{2}}$ or $2 \rightarrow 0$

A1: For one simplified term e.g. either $10x^{\frac{1}{2}} \rightarrow 5x^{-\frac{1}{2}}$ or $-2x^{\frac{3}{2}} \rightarrow -3x^{\frac{1}{2}}$

A1: $\left(\frac{dy}{dx} = \right) 5x^{-\frac{1}{2}} - 3x^{\frac{1}{2}}$. Allow e.g. $\left(\frac{dy}{dx} = \right) \frac{5}{\sqrt{x}} - 3\sqrt{x}$. The “ $\frac{dy}{dx} =$ ” is not required. Condone “+ 0” as part of their answer.

There must be no other terms e.g. “+ c” or e.g. $\left(\frac{dy}{dx} = \right) 2 + 5x^{-\frac{1}{2}} - 3x^{\frac{1}{2}}$ but apply isw if possible once a correct simplified derivative with no extra terms is seen.

(b)

M1: For an attempt to substitute $x = 2$ fully into their $\frac{dy}{dx}$ which is not y e.g. it must be a “changed” function which could even come from integration.

All that is required is the substitution so allow for e.g. $5(2)^{-\frac{1}{2}} - 3(2)^{\frac{1}{2}}$

This mark may be implied by their answer or e.g. a decimal answer of awrt -0.7 following a correct derivative.

Do **not** allow this mark if they have e.g. $\left(\frac{dy}{dx} = \right) 5x^{-\frac{1}{2}} - 3x^{\frac{1}{2}} + c$ in part (a) **AND** subsequently go on to try and establish a value for “c” using $x = 2$.

A1: $-\frac{1}{2}\sqrt{2}$ or exact simplified equivalent e.g. $-\frac{1}{\sqrt{2}}$, $-0.5\sqrt{2}$, $-2^{-\frac{1}{2}}$, $-2^{-0.5}$ **following at least one intermediate line of working.**

E.g. $\frac{5}{\sqrt{x}} - 3\sqrt{x} = \frac{5}{\sqrt{2}} - 3\sqrt{2} = -\frac{1}{\sqrt{2}}$ scores M1A0



Question Number	Scheme	Marks
1.	$\int \left(\frac{1}{2}x^3 + \frac{3}{\sqrt{x}} - 4 \right) dx = \frac{1}{2} \times \frac{x^4}{4} + 3 \times \frac{x^{\frac{1}{2}}}{\frac{1}{2}} - 4x + c$ $= \frac{1}{8}x^4 + 6x^{\frac{1}{2}} - 4x + c$	M1, A1 A1, A1 (4 marks)

M1: For raising any correct index by 1. So, award for $x^3 \rightarrow x^4$, $x^{-\frac{1}{2}} \rightarrow x^{\frac{1}{2}}$ or $-4 \rightarrow -4x$ (allowing $-4x^1$)
The index must be processed and not left, for example, as x^{3+1}

A1: For **two** of $\frac{1}{2} \times \frac{x^4}{4}$, $+3 \times \frac{x^{\frac{1}{2}}}{\frac{1}{2}}$, $-4x$ (allowing $-4x^1$) correct simplified or correct unsimplified.

A1: For **two** of $\frac{1}{8}x^4$, $+6x^{\frac{1}{2}}$, $-4x$ correct and in simplest form.

Accept forms such as $0.125x^4$, $+6\sqrt{x}$ and $-4x^1$ and $+ -4x^1$

A1: Fully correct, and simplified with $+c$ all on a single line. Accept simplified equivalents (see above)

Ignore any spurious notation such as $\int \frac{1}{8}x^4 + 6x^{\frac{1}{2}} - 4x + c$ or $\frac{1}{8}x^4 + 6x^{\frac{1}{2}} - 4x + c \, dx$

If they go on, however, and multiply for example by 8 then it is A0 or integrate again it is A0.
They can do this in one line for full marks

General Principles for Pure Mathematics Marking

(NB specific mark schemes may sometimes override these general principles)

Method mark for solving 3 term quadratic:

1. Factorisation

$(x^2 + bx + c) = (x + p)(x + q)$, where $|pq| = |c|$ leading to $x = \dots$

$(ax^2 + bx + c) = (mx + p)(nx + q)$, where $|pq| = |c|$ and $|mn| = |a|$ leading to $x = \dots$

2. Formula

Attempt to use correct formula (with values for a, b and c)

3. Completing the square

Solving $x^2 + bx + c = 0$: $(x \pm \frac{b}{2})^2 \pm q \pm c$, $q \neq 0$ leading to $x = \dots$

Method marks for differentiation and integration:

1. Differentiation

Power of at least one term decreased by 1 ($x^n \rightarrow x^{n-1}$)

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Answers without working

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Question Number	Scheme	Marks
7.(a)	Attempts $\frac{dy}{dx} = 4x$ at $x = 2$ At $x = 2$ gradient of tangent = 8	M1 A1 (2)
(b)	$(y_Q =) 2(2+h)^2 + 5$ Gradient $PQ = \frac{\text{their } y_Q - 13}{2+h-2}$ $\left(= \frac{8h+2h^2}{h} \right) = 8+2h$	B1 M1 A1 (3)
(c)	States as $h \rightarrow 0$ Gradient $PQ \rightarrow 8 =$ Gradient of tangent	B1 (1) (6 marks)

(a)

M1 Attempts to find the value of $\frac{dy}{dx} = ax$, $a > 0$ at $x = 2$

A1 For 8. No need to state this is the gradient.

(b)

B1 $(y_Q =) 2(2+h)^2 + 5$ M1 Attempts $\pm \frac{y_Q - y_P}{x_Q - x_P}$ condoning slips, but must be a genuine attempt at y_Q A1 Gradient is $8+2h$ (with no errors seen)

(c)

B1 States as $h \rightarrow 0$ Gradient $PQ \rightarrow 8 =$ Gradient of tangent (oe)There should be reference to “limit” or “as h tends to 0” (words or symbols) and linked to part (a) (so same gradient, or showing the answers agree). But be generous with the explanation beyond these constraints.

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2. Formula

Attempt to use correct formula (with values for a , b and c).

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Attempt to use correct formula (with values for a , b and c).

3. Completing the square

Solving $x^2 + bx + c = 0$: $(x \pm \frac{b}{2})^2 \pm q \pm c$, $q \neq 0$, leading to $x = \dots$

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Answers without working

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Question Number	Scheme	Marks
3. (a)	$x^2 - 5x + 13 = (x - 2.5)^2 - 2.5^2 + 13 = (x - 2.5)^2 + 6.75$ Coordinates $M = (2.5, 6.75)$	M1 A1
(b)	Attempts the equation of l using their M $y = \frac{6.75}{2.5}x$ ($y = 2.7x$) Attempts to solve their $y = 2.7x$ with $y = x^2 - 5x + 13$ $\Rightarrow 2.7x = x^2 - 5x + 13 \Rightarrow x^2 - 7.7x + 13 = 0 \Rightarrow (x - 2.5)(x - 5.2) = 0$ $x = 5.2$ oe Coordinates $N = (5.2, 14.04)$	M1 M1 A1 dM1 A1
(c)	States two of $y < x^2 - 5x + 13$, $y > 2.7x$, $0 \leq x < 2.5$ States all three of $y < x^2 - 5x + 13$, $y > 2.7x$, $0 \leq x < 2.5$	M1 A1ft
		(10 marks)

(a)

 M1 For attempting to complete the square. Look for $(x - 2.5)^2$

 A1 $(x - 2.5)^2 + 6.75$ or for correctly extracting $x = 2.5$ as the x coordinate.

 A1 $M = (2.5, 6.75)$ or $\left(\frac{5}{2}, \frac{27}{4}\right)$

(b)

 M1 Uses their M to find an equation for l . Look for a correct attempt at the gradient, so $y = \frac{6.75}{2.5}x$ or

 $y - 6.75 = \frac{6.75}{2.5}(x - 2.5)$

 M1 Depends on having made an attempt (not necessarily correct) to use O and M to find the equation of l . Attempts to solve their equation for l with $y = x^2 - 5x + 13$ Look for a full attempt leading to $x = \dots$

Correct answers following a correct simplified quadratic is fine for the method.

 A1 $x = 5.2$ or equivalent such as $x = \frac{26}{5}$

 dM1 Depends on second M mark. Substitutes their $x = 5.2$ into either equation to find $y = \dots$ If a y value follows an x value with no clearly incorrect working, then allow as an attempt.

 A1 Coordinates $N = (5.2, 14.04)$ oe such as $\left(\frac{26}{5}, \frac{351}{25}\right)$. Allow this to be written separately.

(c)

 M1 States any two of $y < x^2 - 5x + 13$, $y > 2.7x$, $0 \leq x < b$ where $2.5 \leq b \leq 5.2$

 Also allow the first two combined, or with loose inequalities, e.g $2.7x \leq y \leq x^2 - 5x + 13$

 Also allow either $\leq$ or $<$ on the left hand end of $0 \leq x < 2.5$ due to the y -axis.

 Use of R instead of y is M0

 A1ft States all three inequalities. Same conditions as above, follow through on their $2.7x$ from (b) and 2.5

Allow part (a) to be attempted via finding minimum point

 M1 For setting $\frac{dy}{dx} = ax + b = 0$ and finding a value for x , or for stating $x_{min} = -b/2a = \dots$

 A1 $x = 2.5$

 A1 $M = (2.5, 6.75)$

Note: Answer with no working score M0A0A0

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2. Formula

Attempt to use correct formula (with values for a, b and c)

3. Completing the square

Solving $x^2 + bx + c = 0$: $(x \pm \frac{b}{2})^2 \pm q \pm c$, $q \neq 0$ leading to $x = \dots$

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Power of at least one term decreased by 1 ($x^n \rightarrow x^{n-1}$)

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Question Number	Scheme	Marks
1.	$\int (2x-5)(3x+2)(2x+5) \, dx$ $(2x-5)(3x+2)(2x+5) = (6x^2 - 11x - 10)(2x+5) = \dots$ $= 12x^3 + 8x^2 - 75x - 50$ $\int (2x-5)(3x+2)(2x+5) \, dx = 3x^4 + \frac{8}{3}x^3 - \frac{75}{2}x^2 - 50x + c$	M1 A1 M1, A1ft, A1 (5 marks)

M1: Attempts to multiply out. Look for an attempt to multiply two brackets together to form a quadratic before the result is combined with the third bracket.

Condone slips and it may be left unsimplified but it must lead to an expression that could be simplified to the form $ax^3 + bx^2 + cx + d$ where $a, b, c, d \neq 0$

Condone an answer appearing without an intermediate step only if it is of the form (or can be expressed in the form) $12x^3 + px^2 + qx \pm 50$ where $p, q \neq 0$

A1: For $12x^3 + 8x^2 - 75x - 50$ but allow this unsimplified with the terms uncollected

M1: For an attempt to integrate scored for $\int x^n dx \rightarrow x^{n+1}$, $n \neq 0$, on any term in x following an attempt to expand. The index must be processed, i.e. $x^3 \rightarrow x^4$ and not x^{3+1} . Can be scored following a quadratic expansion, so when $a = 0$

A1ft: Correct follow through on any **two terms** of their $ax^3 + bx^2 + cx + d$.

Condone one of a, b, c, d being 0. Can be scored following a quadratic expansion, so when $a = 0$
The terms must now have been collected

A1: $3x^4 + \frac{8}{3}x^3 - \frac{75}{2}x^2 - 50x + c$ or exact equivalent including the $+ c$

I am happy to accept terms like $\frac{8}{3x^{-3}}$ for $\frac{8}{3}x^3$

Ignore/condone spurious additional notation such as $\int 3x^4 + \frac{8}{3}x^3 - \frac{75}{2}x^2 - 50x + c$

Do not ISW if candidates proceed say to multiply by 6 to get rid of the fractional terms.



Question Number	Scheme	Marks
2.(a)	Attempts $A = \frac{1}{2}ab \sin C \Rightarrow 100 = \frac{1}{2} \times 25 \times 15 \sin BAC$ $\sin \theta^\circ = \frac{8}{15}$	M1 A1 (2)
(b)	$(BC^2) = 15^2 + 25^2 - 2 \times 15 \times 25 \times \cos \theta^\circ$ where $\theta^\circ = \arcsin \frac{8}{15}$ $BC^2 = 15^2 + 25^2 - 2 \times 15 \times 25 \times \cos(180 - \text{their '32.2'}) \Rightarrow BC = \dots$ $BC^2 = 1484.4 \dots \Rightarrow BC = \text{awrt } 38.5 \text{ cm}$ cso	M1 dM1 A1 (3) (5 marks)

(a)

M1: Attempts to use the area formula " $A = \frac{1}{2}ab \sin C$ " with the given information (condoning slips)
The angle used **should** be θ , BAC , CAB or A with or without any degrees symbol but condone, for this mark only, a direct substitution into the formula to achieve $100 = \frac{1}{2} \times 25 \times 15 \sin C$

A1: Achieves $\sin \theta^\circ = \frac{8}{15}$ or **exact** equivalent fraction such as $\frac{200}{375}$, $\frac{100}{187.5}$ in the form $\frac{a}{b}$ or $0.5\dot{3}$

Condone answers such as $\theta = \arcsin \frac{8}{15}$ or $\sin \theta^\circ = \frac{8 \text{ cm}^2}{15 \text{ cm}^2}$

Allow θ to be BAC , CAB or $A \rightarrow a$ with or without any degrees symbol.

Allow C to be just "changed" to θ or any of the above for both marks. E.g.

$$100 = \frac{1}{2} \times 25 \times 15 \sin C \Rightarrow \sin \theta^\circ = \frac{8}{15} \quad \text{ISW after sight of } \sin \theta^\circ = \frac{8}{15}$$

Note that finishing with $\sin C = \frac{8}{15}$ is A0 but allow all marks to be scored in (b) following this.

(b)

M1: Attempts to use the cosine rule. Ignore the lhs and allow using an acute angle found using part (a)

Look for $15^2 + 25^2 - 2 \times 15 \times 25 \times \cos \theta^\circ$ where $\cos \theta^\circ$ is found using their $\sin \theta^\circ$ from part (a)

So allow for $15^2 + 25^2 - 2 \times 15 \times 25 \times \cos 32.2^\circ$ It can be implied by an answer for BC of 14.7 cm

Their angle must be correct to the nearest degree for their $\sin \theta^\circ = \frac{8}{15}$. Hence marks can only be achieved in part (b) if their $-1 \leq \sin \theta^\circ \leq 1$.

You may see sight of an exact $\cos \theta^\circ$ being used. E.g. if $\sin \theta^\circ = \frac{8}{15}$ look for $\cos \theta^\circ = \left(\pm\right) \frac{\sqrt{161}}{15}$

dM1: Full use of the cosine rule (with lhs correct) and an obtuse angle used (correct to the nearest degree) leading to a value for BC . The obtuse angle must be correct for their part (a), that is $(180 - \text{their '32.2'})$

A1: CSO $BC = \text{awrt } 38.5 \text{ cm}$. Condone missing units

SPECIAL CASE

Solutions using radians are possible. So a "correct" solution would be

$$BC^2 = 15^2 + 25^2 - 2 \times 15 \times 25 \times \cos(\pi - 0.5625) \Rightarrow BC = 38.5 \text{ for M1 dM1 A0}$$

The angle θ given in this question is measured in degrees so this is not a completely correct solution.



General Principles for Pure Mathematics Marking

(But note that specific mark schemes may sometimes override these general principles).

Method mark for solving 3 term quadratic:

1. Factorisation

$(x^2 + bx + c) = (x + p)(x + q)$, where $|pq| = |c|$, leading to $x = \dots$

$(ax^2 + bx + c) = (mx + p)(nx + q)$, where $|pq| = |c|$ and $|mn| = |a|$, leading to $x = \dots$

2. Formula

Attempt to use correct formula (with values for a , b and c).

3. Completing the square

Solving $x^2 + bx + c = 0$: $(x \pm \frac{b}{2})^2 \pm q \pm c$, $q \neq 0$, leading to $x = \dots$

Method marks for differentiation and integration:

1. Differentiation

Power of at least one term decreased by 1. ($x^n \rightarrow x^{n-1}$)

2. Integration

Power of at least one term increased by 1. ($x^n \rightarrow x^{n+1}$)

Use of a formula

Where a method involves using a formula that has been learnt, the advice given in recent examiners' reports is that the formula should be quoted first.

Normal marking procedure is as follows:

Method mark for quoting a correct formula and attempting to use it, even if there are small mistakes in the substitution of values.

Where the formula is not quoted, the method mark can be gained by implication from correct working with values, but may be lost if there is any mistake in the working.

Exact answers

Examiners' reports have emphasised that where, for example, an exact answer is asked for, or working with surds is clearly required, marks will normally be lost if the candidate resorts to using rounded decimals.

Answers without working

The rubric says that these may not gain full credit. Individual mark schemes will give details of what happens in particular cases. General policy is that if it could be done "in your head", detailed working would not be required. Most candidates do show working, but there are occasional awkward cases and if the mark scheme does not cover this, please contact your team leader for advice.



General Principles for Core Mathematics Marking

(But note that specific mark schemes may sometimes override these general principles).

Method mark for solving 3 term quadratic:1. Factorisation

$(x^2 + bx + c) = (x + p)(x + q)$, where $|pq| = |c|$, leading to $x = \dots$

$(ax^2 + bx + c) = (mx + p)(nx + q)$, where $|pq| = |c|$ and $|mn| = |a|$, leading to $x = \dots$

2. Formula

Attempt to use correct formula (with values for a , b and c).

3. Completing the square

Solving $x^2 + bx + c = 0$: $(x \pm \frac{b}{2})^2 \pm q \pm c$, $q \neq 0$, leading to $x = \dots$

Method marks for differentiation and integration:1. Differentiation

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Question Number	Scheme	Marks
1	$\int \left(8x^3 - 6\sqrt{x} - \frac{2}{5x^3} \right) dx = 2x^4 - 4x^{\frac{3}{2}} + \frac{1}{5x^2} + c$	M1 A1A1A1
		(4 marks)

M1 Increases the power by one on one of the terms in x

Must be for any one of $x^3 \rightarrow x^4$ $x^{\frac{1}{2}} \rightarrow x^{\frac{3}{2}}$ $x^{-3} \rightarrow x^{-2}$. Indices do not need to be processed for this mark. e.g. $x^3 \rightarrow x^{3+1}$ is fine.

A1 One term of $2x^4 - 4x^{\frac{3}{2}} + \frac{1}{5x^2}$ (may be unsimplified but indices must be processed)

A1 Any two terms of $2x^4 - 4x^{\frac{3}{2}} + \frac{1}{5x^2}$ (may be unsimplified but indices must be processed). Terms may appear as a list or be on different lines.

A1 $2x^4 - 4x^{\frac{3}{2}} + \frac{1}{5x^2} + c$ or simplified equivalent (including the constant of integration) all on one line.

e.g. accept $2x^4 - 4(\sqrt{x})^3 + 0.2x^{-2} + c$ but do not accept $\frac{0.2}{x^2}$ or $\frac{\frac{1}{5}}{x^2}$ for $\frac{1}{5x^2}$

isw once a correct answer is seen but withhold if there is any spurious notation e.g. an integral sign or dx



Question Number	Scheme	Marks
2(a)	Gradient = $\frac{8-5}{7\sqrt{3}-(-2\sqrt{3})}$ o.e.	M1
	e.g. $\Rightarrow \frac{3}{9\sqrt{3}} \times \frac{\sqrt{3}}{\sqrt{3}} = \frac{\sqrt{3}}{9}$	A1
		(2)
(b)	$\frac{1}{9}\sqrt{3} \rightarrow -\frac{9}{\sqrt{3}}$	B1ft
	$y-5 = -\frac{9}{\sqrt{3}}(x+2\sqrt{3})$	M1
	$y = -3\sqrt{3}x - 13$	A1
		(3)
		(5 marks)

(a) Note $\frac{1}{9}\sqrt{3}$ with no working seen is M0A0

M1 Finds a correct expression for the gradient between A and B **which must not be of the form** $p\sqrt{3}$ where p is a rational constant e.g. $\frac{3}{9\sqrt{3}}$

We are not allowing sign slips when substituting in the coordinates for this mark. May subtract the other way round which is fine as long as it is consistent i.e. $\frac{5-8}{-2\sqrt{3}-7\sqrt{3}}$

Allow any version of the final answer which is not of the form $p\sqrt{3}$ where p is a rational constant to score.

May alternatively form two simultaneous equations ($5 = -2\sqrt{3}m + c$ and $8 = 7\sqrt{3}m + c$) and proceed to e.g. $\frac{8-5}{7\sqrt{3}-(-2\sqrt{3})}$ or e.g. $\frac{3}{9\sqrt{3}}$ which must not be of the form $p\sqrt{3}$ where p is a rational constant.

Note working leading to e.g. $3 = m \times 9\sqrt{3} \Rightarrow m = \frac{\sqrt{3}}{9}$ is M0A0 (it is not of an allowable form before achieving the required answer)

A1 $p\sqrt{3}$ where p is a rational constant which does not have to be simplified e.g. $\frac{1}{9}\sqrt{3}$ or $\frac{\sqrt{3}}{9}$ or $\frac{3}{27}\sqrt{3}$ or $\frac{27}{243}\sqrt{3}$. It must come from a correct method and evidence of rationalising the denominator seen (they cannot just use their calculator)

Minimum working required e.g. $\frac{3}{9\sqrt{3}} \times \frac{\sqrt{3}}{\sqrt{3}} = \frac{\sqrt{3}}{9}$ or e.g. $\frac{3}{9\sqrt{3}} = \frac{3\sqrt{3}}{27} \left(= \frac{\sqrt{3}}{9} \right)$ is M1A1

Allow e.g. $\frac{3}{9\sqrt{3}} = \frac{1}{3\sqrt{3}} = \frac{\sqrt{3}}{9}$ to score M1A1 (cancelling first before rationalising)



(b) Full marks can be scored in this part even if insufficient working is shown in part (a) to find the correct gradient.

B1ft Correct perpendicular gradient to l_1 or follow through the negative reciprocal of their gradient from part (a), which may be an earlier form rather than their final answer.
May be implied by further work. Do not withhold this mark if they have a correct unsimplified expression for the perpendicular gradient, but make manipulation or transcription errors in further work.

M1 Attempts to find the equation of the perpendicular line through A using a changed gradient. Allow one sign slip on the coordinates. If they use $y = mx + c$ then they must proceed as far as $c = \dots$ (you do not need to check the mechanics of the rearrangement of this)

A1 $y = -3\sqrt{3}x - 13$ o.e. e.g. $y = -\frac{9}{\sqrt{3}}x - 13$ isw once a correct equation of the required form is found.



Question Number	Scheme	Marks
3(a)	$58^2 = a + 5^3 \times b, \quad 65^2 = a + 10^3 \times b \Rightarrow a = \dots, \text{ or } b = \dots$	M1
	$a = 3241, \quad b = 0.984$	A1A1
		(3)
(b)	e.g. $85^2 = "3241" + "0.984" \times T^3 \Rightarrow T = \dots$	M1
	$(T =) \text{awrt } 15.9$	A1
		(2)
		(5 marks)

If the equation is misread and used consistently throughout the question with either indices of 2 or 3 e.g. $P^3 = a + bt^2$ or e.g. $P^2 = a + bt^2$ then only allow the M marks to be scored. The equation must be seen.

Note candidates who work with 58000 and 65000 in (a) and 85000 in (b) can score maximum (a) M0A0A0 (b) M1A1 for 15.9

(a) Note that correct values for a and b scores full marks.

M1 Forms two simultaneous equations in a and b (at least one equation must be correct) and proceeds to find a value for a (must be positive) or a value for b (which may be directly from a calculator).
May see e.g. $3364 = a + 125b$ or e.g. $4225 = a + 1000b$
You do not need to check the mechanics of any rearrangement.

A1 One of $a = 3241, b = 0.984$ (or $\frac{123}{125}$) (may be embedded in the equation)

A1 $a = 3241, b = 0.984$ (or $\frac{123}{125}$) (may be embedded in the equation) isw once the correct values paired correctly with a and b are seen.

SC $b = 3241, a = 0.984$ (wrongly paired) score M1A1A0

(b) Note candidates who work with 58000 and 65000 in (a) and 85000 in (b) can score maximum (a) M0A0A0 (b) M1A1 for 15.9

Note awrt 15.9 with no working is M0A0

M1 Forms a correct equation for their a and their b and proceeds to find a value for T
Condone use of 3240 (3241 to 3sf)

If their a is 3 241 000 000 (or 3 240 000 000 to 3sf) and b is 984 000 condone miscopying/transcription errors provided the intention was clear to use these.

A1 awrt 15.9 following a correct equation seen. isw if they subsequently round to e.g. 16
Allow awrt 15.9 using 85000 if their a is 3 241 000 000 (or 3 240 000 000 to 3sf) and b is 984 000



Question Number	Scheme	Marks
4(i)(a)	ay^3	B1
		(1)
(i)(b)	$\frac{5}{(3a^{1-x})^{-2}} = \frac{45}{\dots}$	B1
	$(\dots a^{1-x})^{-2} = a^{-2} \times a^{2x}$	M1
	$= \frac{45a^2}{y^2}$	A1
		(3)
(ii)(a)	e.g. $3^{4t+2} = (3^{2t})^2 \times 9 = 9p^2$ (see notes)	M1
	$\Rightarrow 27 \times p^2 + 3 = 82 \times p \Rightarrow 27p^2 - 82p + 3 = 0$ *	A1*
		(2)
(ii)(b)	Solves the quadratic $\Rightarrow 3, \frac{1}{27}$	B1
	$(3')^2 = 3$ or $9' = 3 \Rightarrow t = \frac{1}{2}$	M1
	or	
	$(3')^2 = \frac{1}{27} \Rightarrow 3' = \frac{1}{3\sqrt{3}} \Rightarrow t = -\frac{3}{2}$ or $9' = \frac{1}{27} \Rightarrow t = -\frac{3}{2}$	A1
	$(t =) \frac{1}{2}, -\frac{3}{2}$	
		(3)
		(9 marks)

Check answers by the questions but if there is a contradiction between by the question and the main body of the text then the main body of the text takes precedence

(i)

(a)

B1 ay^3 or y^3a Condone $a(y)^3$. Do not isw and do not accept e.g. $a \times y^3$ or e.g. a^1y^3 (b) **Note a correct answer with no working can score full marks in this part only**B1 Correct coefficient of 45. Sight of 45 can imply this mark but do not allow e.g. $-45, \frac{1}{45}, \frac{45}{9}$ M1 Uses index laws to proceed from $(a^{1-x})^{-2} \rightarrow$ e.g. $\left(\frac{a}{a^x}\right)^{\pm 2}$ or $\frac{a^2}{y^2}$ or $a^{-2} \div a^{-2x}$

If they write as a product then look for $(a^{1-x})^{-2} \rightarrow$ e.g. $(a \times a^{-x})^{\pm 2}$ or $a^2 \times y^{-2}$ or $a^{-2} \times a^{2x}$ (i.e. the signs of the indices cannot be the same)

Do not be concerned with any coefficients which are not in the indices. e.g. $5a^2 \div 3y^2$ is M1

Do not penalise if they make subsequent errors or they have multiple attempts. Score for sight of the expression. Do not be concerned as to whether it is on the numerator or denominator of the fraction.

A1 $\frac{45a^2}{y^2}$ or simplified equivalent including e.g. $\frac{45y^{-2}}{a^{-2}}, 45a^2y^{-2}$ but not $45\left(\frac{a}{y}\right)^2$. isw once a correct answer is seen.



(ii) Mark (a) and (b) together**(a)**M1 Using the power law on 3^{4t+2} It requires one of the following to be **seen** in their solution:

$$3^{4t+2} \rightarrow \left[(3^2)^{2t} \text{ or } (3^{2t})^2 \text{ or } (9)^{2t} \text{ or } (9^t)^2 \right] \times \left[3^2 \text{ or } 9 \right] \quad \text{or} \quad 3^{4t+2} = 9^{2t+1}$$

Do not accept e.g. $3^{4t+2} = 9p^2$ or e.g. $3^{4t} \times 9 = 9p^2$ as they do not explicitly show the power law being applied.Do not accept 81^t and do not accept valid expressions appearing from incorrect stages of working e.g. $3^{4t+2} = 9^{2t+2} = 9^{2t} \times 9$ M0A0*Note they may multiply out the brackets first leading to 3^{4t+3} so we would need to see

$$3^{4t+3} \rightarrow \left[(3^2)^{2t} \text{ or } (3^{2t})^2 \text{ or } (9)^{2t} \text{ or } (9^t)^2 \right] \times \left[3^3 \text{ or } 27 \right] \quad \text{or} \quad 3^{4t+3} = 9^{2t+1.5}$$

Do not be concerned with the rest of the equation for this mark.

If arithmetical slips result in not achieving one of the required forms above then M0A0*

A1* Proceeds to the given answer with no errors seen.

Their solution requires at least one intermediate stage of working which involves multiplying out the brackets (which may have been done earlier) before proceeding to the given answer.

$$\text{e.g. } 3\left(9 \times (3^{2t})^2 + 1\right) = 82p \Rightarrow 27p^2 + 3 = 82p \Rightarrow \text{given answer}$$

If they attempt to work backwards then send to review.**(b)** Condone poor labelling provided the intention is clearB1 3 and $\frac{1}{27}$ M1 Attempts to find a value for t using one of their roots. May use logarithmic methods to solve to find a value e.g. $9^t = 3 \Rightarrow t = \log_9 3 = \dots$ If using logarithms, the expression should be correct for their roots. May be implied by a correct value for t for one of their roots. You may need to check this.A1 $(t =) \frac{1}{2}$ and $-\frac{3}{2}$ o.e. This mark can only be scored following **sight of correct roots** to the given quadratic in p 

Question Number	Scheme	Marks
5(a)	$x^n \rightarrow x^{n-1}$	M1
	$\left(\frac{dy}{dx} = \right) 12x^2 - \frac{2}{x^2}$	A1
		(2)
(b)	$12x^2 - \frac{2}{x^2} = -5 \Rightarrow \dots \Rightarrow 12x^4 + 5x^2 - 2 = 0 *$	M1A1*
		(2)
(c)	$12x^4 + 5x^2 - 2 = 0 \Rightarrow (4x^2 - 1)(3x^2 + 2) = 0 \Rightarrow x^2 = \frac{1}{4} \rightarrow x = \frac{1}{2} \quad (x > 0)$	M1
	$y = 4\left(\frac{1}{2}\right)^3 + \frac{2}{\left(\frac{1}{2}\right)} + 9 = \dots \left(= \frac{27}{2} \right)$	M1
	$k = \frac{27}{2} + 5 \times \frac{1}{2} = \dots$ $k = 16$	dM1 A1
		(4)
		(8 marks)

(a)

M1 Decreases the power by one on at least one of the terms in x to achieve a term with a correct index. i.e. $x^3 \rightarrow x^2$ or $x^{-1} \rightarrow x^{-2}$. The indices do not need to be processed for this mark. e.g. $x^{-1} \rightarrow x^{-1-1}$

A1 $12x^2 - \frac{2}{x^2}$ or $12x^2 - 2x^{-2}$. Do not accept unsimplified equivalent expressions e.g. $12x^2 + -2x^{-2}$ isw if a correct answer is seen but they then attempt to e.g. divide by 2 afterwards

(b) Marks in (b) cannot be awarded for work done or seen in (c)

M1 Sets their $\frac{dy}{dx}$ of the form $ax^2 + \frac{b}{x^2}$ equal to -5 and attempts to rearrange to a 3-term quadratic in $x^2 = 0$. They must multiply through by x^2 and collect all 3 terms on one side of an equation (condone omission of $= 0$). It cannot be awarded for proceeding directly to the given answer in one step. (They may use an alternative letter so condone $y = x^2$ so they proceed to a 3-term quadratic in that variable instead)
Condone sign slips only for this mark.

A1* Achieves the given answer with no errors seen and at least one intermediate stage of working. Must see " $= 0$ " on their final line. Condone if the order is different to the printed answer, provided all terms are on one side $= 0$

(c) Note that M0M1dM1A0 is possible. Work labelled as (b) must be used in (c) to score

M1 Solves the **given** quadratic in x^2 by factorising, completing the square or using the formula to find a positive value for x^2 and proceeds to find a positive value for x (usual rules apply). They cannot just solve the quadratic in x^2 (or the quartic) directly using a calculator. If they just state the root(s) then it is M0



Note that $12x^4 + 5x^2 - 2 = 0 \Rightarrow \left(x^2 + \frac{2}{3}\right)\left(x^2 - \frac{1}{4}\right) = 0 \Rightarrow x^2 = \dots$ is M0 (the factorised version must match the quartic)

Condone poor labelling of x^2 as x if they then go on to square root

e.g. $12x^4 + 5x^2 - 2 = 0 \Rightarrow (3x + 2)(4x - 1) = 0 \Rightarrow x = \frac{1}{4} \Rightarrow x = \frac{1}{2}$

Do not be concerned if they achieve other incorrect roots.

- M1 Attempts to substitute their positive value of x (they must not be substituting in x^2) into the original equation to find a value for y . Condone miscopying and arithmetical slips provided the intention is clear. May be implied by a correct value for y but not if labelled as k

Whilst not dependent on the first M, it is dependent on an attempt to solve the given quartic (however poorly including via use of a calculator) and using their positive value of x (not x^2) from this. It cannot be for using their positive value of x from an incorrect quartic.

Ignore if they repeat this process for more than one x value, which may be negative.

- dM1 Uses their pair of x and y to find a value for k . Condone slips. It is dependent on the previous method mark. Ignore if they repeat this process for more than one pair. May be implied by $k = 16$ provided the correct root is found and the previous method mark has been scored.

- A1 $k = 16$ only (this can only be scored provided all method marks in this part have been awarded)

Alt(c) Using curve = tangent

- M1: As above in main scheme and notes

- M1: Sets $4x^3 + \frac{2}{x} + 9 = k - 5x$ and substitutes in their positive value of x . Condone slips if the attempt at the substitution is seen. (Must be seen or used in (c) to score or if there is a lack of labelling they must be attempting to find k not attempting to achieve the quartic in (b)). If the substitution is not explicitly seen then you will need to check this for their positive value of x .

- dM1: Proceeds to find a value for k . You do not need to check the mechanics of the rearrangement as long as a value is achieved. It is dependent on the previous method mark. May be implied by $k = 16$ provided the correct root is found and the previous method mark has been scored.

- A1 $k = 16$ only (this can only be scored provided all method marks have been awarded)



Question Number	Scheme	Marks
	$(f''(x)) = \frac{3}{4}x^{-\frac{3}{2}}$ Attempts $\frac{3}{4}x^{-\frac{3}{2}} = 6 \Rightarrow x^{-\frac{3}{2}} = 8 \Rightarrow x = \frac{1}{4}$	M1 A1 dM1 A1 (5) (9 marks)

- (a) Note calculators in this question are not acceptable so answers on their own or roots without working score 0 marks.

M1 **Way One:** Sets $2x - 3\sqrt{x} - 5 = 9 \Rightarrow 2x - 3\sqrt{x} - 14 = 0$ and attempts to solve a 3TQ quadratic in $\sqrt{x}$ or sets eg $u = \sqrt{x}$ and attempts to solve a 3TQ in u ($2u^2 - 3u - 14 = 0$). See general guidance for solving a quadratic. Condone use of other variables including $x = \sqrt{x}$.

Condone slips in their rearrangement to achieving a 3TQ quadratic and proceeding to find a value but the method must be sound. To score they must either

- show the factorised form of their quadratic eg $(2u - 7)(u + 2)$
- show embedded values in the quadratic formula
- show their method completing the square

Way Two: Sets $2x - 14 = 3\sqrt{x}$ oe and attempts to square leading to a 3TQ quadratic on one side of an equation. Condone slips when multiplying out eg $(2x - 14)^2$ and rearranging their equation but their method must be sound.

Note: $2x - 14 = 3\sqrt{x} \Rightarrow 4x^2 - 196 = 9x$ would be M0.

A1 **Way One:** $(\sqrt{x} =) \frac{7}{2}$ or eg $(u =) \frac{7}{2}$ Ignore any reference to the -2 . Condone $x = \frac{7}{2}$

Note the roots do not imply M1A1

Way Two: $4x^2 - 65x + 196 = 0$ oe (the terms should be collected on one side of the equation, but condone lack of $= 0$)

dM1 **Way One:** Attempts to find one value for x . Condone 4 or squaring -2

Way Two: Attempts to find one value for x by solving their quadratic (see general guidance for solving a quadratic). To score they must either

- show the factorised form of their quadratic eg $(4x - 49)(x - 4)$
- show embedded values in the quadratic formula
- show their method completing the square



Question Number	Scheme	Marks
10	$y = \frac{2}{3}x^3 - 25x - \frac{56}{x} + \frac{194}{3}$	
(a)	$\frac{dy}{dx} = 2x^2 - 25 + \frac{56}{x^2}$ Finds $\frac{dy}{dx}\bigg _{x=2} = 2 \times 4 - 25 + \frac{56}{4} = -3$ Equation of tangent $y + 8 = -3(x - 2) \Rightarrow y = -3x - 2$ *	M1, A1 dM1 ddM1, A1* (5)
(b)	Sets $2x^2 - 25 + \frac{56}{x^2} = -3$ $x^4 - 11x^2 + 28 = 0$ $(x^2 - 4)(x^2 - 7) = 0 \Rightarrow x^2 = ..$ $x = \sqrt{7} \text{ only}$	M1 dM1, A1 ddM1 A1 (5) (10 marks)

This is a non-calculator question so you must see evidence for all calculations/marks

(a)

M1: Correctly differentiates two of the four terms. The indices must be processed

So, look for two of $\frac{2}{3}x^3 \rightarrow \frac{2}{3} \times 3x^2$, $-25x \rightarrow -25$, $-\frac{56}{x} \rightarrow +\frac{56}{x^2}$, $+\frac{194}{3} \rightarrow 0$

A1: Correct differentiation. Allow un-simplified

dM1: Substitutes $x = 2$ into their $\frac{dy}{dx}$ (to find the gradient of the tangent).

Allow values to be embedded following the M mark E.g. $2 \times 2^2 - 25 + \frac{56}{4}$

It is dependent upon the previous M mark, so there must be some correct differentiation.

If there is no working for this, it is implied by a correct value for their $\frac{dy}{dx}$

ddM1: Dependent upon both previous M's.

For a correct method of finding the equation of the tangent at (2, -8).

Look for $y + 8 = \frac{dy}{dx}\bigg|_{x=2} (x - 2)$

If the form $y = mx + c$ is used it must proceed as far as $c = ...$

A1*: CSO: $y = -3x - 2$ following the award of previous M's and A.

This is a given answer so all aspects must be correct.



(b)

M1: Sets their $\frac{dy}{dx} = -3$ **to form an equation in x**

At least one term must have been differentiated correctly for this to be awarded

dM1: Multiplies by x^2 to form a 3-term quadratic equation in x^2 . Terms need not be on the same side of the = sign. Allow equivalents, so an equation in t where $t = x^2$

It is dependent upon a 'correct' starting point of $-3 = px^2 + q + \frac{r}{x}$

A1: Correct 3 TQ = 0 in x^2 . The '= 0' may be implied by subsequent work. Allow equivalents

ddM1: Solves via an appropriate method to find a value for x^2 other than 4. Dependent upon the previous dM1.

Allow factorisation (usual way of applying this, i.e first and last terms) and formula to find x^2
Examples of allowable work:

For an equation of the type $2x^4 - 22x^2 + 56 = 0$

E.g. 1: Via factorisation look for $(2x^4 - 8)(x^2 - 7) = 0 \Rightarrow x^2 = \dots$

E.g. 2: Via the formula condone $x^2 = \frac{22 \pm \sqrt{(-22)^2 - 4 \times 2 \times 56}}{4}$ (a fully correct numerical version of the quadratic formula) leading to 7 and 4.

If there is an error E.g. $x^2 = \frac{22 \pm \sqrt{-22^2 - 4 \times 2 \times 56}}{4}$ it can only be awarded if recovered to

$x^2 = \frac{22 \pm \sqrt{36}}{4}$ or $x^2 = \frac{22 \pm 6}{4}$ before the roots 7 and 4 are given

E.g. 3: $x^4 - 11x^2 + 28 = 0 \Rightarrow (x^2 - 7)(x^2 - 4) = 0 \Rightarrow x = \pm\sqrt{7}$ as the $x^2 =$ can be implied

E.g. 4: $x^4 - 11x^2 + 28 = 0$ Let $t = x^2$, $t^2 - 11t + 28 = 0 \Rightarrow (t - 7)(t - 4) = 0 \Rightarrow t = 7, 4$

Examples of work that will NOT score marks:

E.g.1 $2x^4 - 22x^2 + 56 = 0 \Rightarrow x^2 = 4, 7$ (No method seen)

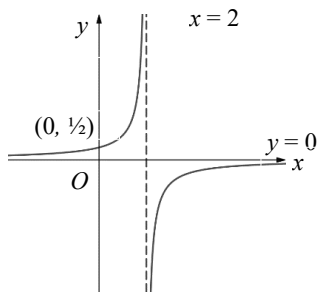
E.g.2 $x^4 - 11x^2 + 28 = 0$ Let $t = x^2$, $t^2 - 11t + 28 = 0 \Rightarrow t = 7$ (No factorisation)

E.g.3 $x^4 - 11x^2 + 28 = 0$, $x^2 = \frac{11 \pm \sqrt{(-11)^2 + 4 \times 1 \times 28}}{2} \Rightarrow x^2 = 7$ (Incorrect formula)

E.g 4 Using num-solv on TI-36XPro, $x^4 - 11x^2 + 28 = 0$ followed by $x = \sqrt{7}$

A1: $x = \sqrt{7}$ ONLY following the previous marks.

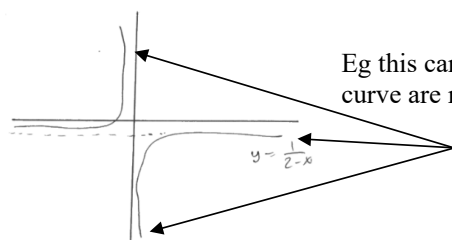


Question	Scheme	Marks
7(a)	 B1 Negative reciprocal shape B1 Intercept at $\left(0, \frac{1}{2}\right)$ B1 $x=2, y=0$	B1B1B1
		(3)
(b)	$4x+k = \frac{1}{2-x} \Rightarrow (4x+k)(2-x)=1 \Rightarrow 8x+2k-4x^2-kx-1(=0) \text{ oe}$ $4x^2+(k-8)x+1-2k=0$ $a=4, b=k-8, c=1-2k \quad \text{or} \quad a=-4, b=8-k, c=2k-1$ $(k-8)^2-4 \times 4(1-2k)(>0) \text{ oe}$ $k^2-16k+64-16+32k>0 \Rightarrow k^2+16k+48>0^*$	M1 A1 M1 A1*
		(4)
(c)	$k^2+16k+48=0 \Rightarrow (k+12)(k+4)=0 \Rightarrow k=...$ $k=-12, -4$ $k<-12 \text{ or } k>-4$	M1 A1 M1A1
		(4)
		(11 marks)

Notes

(a)

- B1** Negative reciprocal shape (top left/bottom right sections) in any position on a set of axes with no clear vertical or horizontal ‘overlaps’.
- Condone slips of the pen as long as there is not a clear turning point, but it should not curve back on itself. If there are several attempts, then mark the last one. If there are contradictions between points stated in the text and any on the graph, then the graph takes precedence.



Eg this can score B1 for the correct shape. The ends of their curve are regarded as a slip of the pen

B1 Intercept at $\left(0, \frac{1}{2}\right)$ and no others. Allow $\frac{1}{2}$ to be marked on the y -axis and condone $\left(\frac{1}{2}, 0\right)$ if the intercept is in the correct place. Cannot be awarded without a sketch.

B1 $x = 2$ and $y = 0$ and no other asymptotes. Do not allow “ x -axis” as an asymptote. Do not award without a sketch.

(b) Mark (b) and (c) together

M1 Sets line = curve, multiplies by $(2 - x)$, attempts to expand and collects terms on one side of the equation. Condone the absence of $=0$.

A1 Correct equation unsimplified with all terms on one side, condone the absence of $=0$. This may be implied by later work such as their values of a , b and c substituted in to $b^2 - 4ac$ and full marks can be awarded in this question if $=0$ is never seen.

M1 Attempts discriminant in terms of k using their a , b and c from their 3TQ. Sight of these terms embedded in $b^2 - 4ac$ is sufficient for this mark. Condone invisible brackets and ignore the use of $>$, $<$ or $=$ for this mark.

A1* Correctly multiplies out their expression for the discriminant, sets > 0 and proceeds to the given answer with no errors including any omission of brackets in their work.
They must have used a correct inequality on at least the previous line before their final answer or stated $b^2 - 4ac > 0$ somewhere in their working.

(c)

M1 Solves the given quadratic to obtain 2 values for k . See guidance on solving quadratics. They may just write the roots down from their calculator which is acceptable.

A1 $-12, -4$

M1 Attempts ‘outside regions’ so this may include $\leq$ or $\geq$ are condoned for this mark.
 $-4 < k < -12$ would imply this mark. Ignore if in terms of x for this mark. Cannot be scored from a diagram.

A1 Accept any of ‘ $k < -12, k > -4$ ’, ‘ $k < -12$ or $k > -4$ ’, ‘ $\{k : k < -12 \cup k > -4\}$ ’, ‘ $\{k : -\infty < k < -12 \cup -4 < k < \infty\}$ ’ or their equivalent expressions
Must be in terms of k . (Not x or any other variable)

DO NOT ALLOW ‘ $k < -12$ and $k > -4$ ’, ‘ $-12 > k > -4$ ’, ‘ $-4 < k < -12$ ’

Note: These inequalities without any working score full marks in (c)



Question	Scheme	Marks
8(a)	$y = (x-2)(x^2 - 8x + 16) \Rightarrow y = x^3 - 8x^2 + 16x - 2x^2 + 16x - 32 \Rightarrow$ $y = x^3 \pm \dots x^2 \pm \dots x \pm 32$ $= x^3 - 10x^2 + 32x - 32$ $\frac{dy}{dx} = 3x^2 - 20x + 32^*$	M1 A1 M1A1*
		(4)
(b)	$x = 6 \Rightarrow y = (6-2)(6-4)^2 = 16$ $\frac{dy}{dx} = 3(6)^2 - 20(6) + 32 = 20$ $y - "16" = "20"(x - 6)$ $y = 20x - 104$	B1 B1 M1 A1
		(4)
(c)	$3x^2 - 20x + 32 = "20" \Rightarrow 3x^2 - 20x + 12 = 0$ $3x^2 - 20x + 12 = 0 \Rightarrow (3x-2)(x-6) = 0 \Rightarrow x = \dots$ $\alpha = \frac{2}{3}$	M1 dM1 A1
		(3)
		(11 marks)

Notes**(a)****M1** Attempts to multiply out the three brackets, condoning slips in their working.Usually $y = (x-2)(x^2 - 8x + 16) \Rightarrow y = x^3 - 8x^2 + 16x - 2x^2 + 16x - 32 \Rightarrow x^3 \pm \dots x^2 \pm \dots x \pm 32$ Score for expressions of the form $x^3 \pm \dots x^2 \pm \dots x \pm 32$. Middle terms do not need to be collected.**A1** $x^3 - 10x^2 + 32x - 32$ If they do not collect terms together until after differentiating, A1 can be awarded by subsequent work. You would have to see the individual differentiated terms collected rather than implied by the final answer.**They must have attempted to multiply out the brackets for this mark.****M1** $x^n \rightarrow x^{n-1}$ correct on one term so either $\dots x^3 \rightarrow \dots x^2$ $\dots x^2 \rightarrow \dots x$ $Ax \rightarrow A$ $B \rightarrow 0$ **A1*** Correct proof with no errors including omission of brackets. At some point they should have had $y = \dots$ and their final line should finish with $\frac{dy}{dx} = 3x^2 - 20x + 32$ including the $\frac{dy}{dx}$ but the terms on the rhs can be in any order.

Alternative method: Product rule - Note the order of marking

2nd M1 $\left(\frac{dy}{dx} = \right) (x-2) \times A(x-4) \pm B(x-4)^2$ applies the product rule. Look for this form or equivalent.

1st A1 $\left(\frac{dy}{dx} = \right) (x-2) \times 2(x-4) + (x-4)^2$

1st M1 $\left(\frac{dy}{dx} = \right) 2x^2 - 8x - 4x + 16 + x^2 - 8x + 16 \Rightarrow 3x^2 - 20x + 32$ attempts to multiply out and collect terms to form a 3TQ

2nd A1* $\frac{dy}{dx} = 3x^2 - 20x + 32$ * with no errors

M1 $y = (x-2)(x^2 - 8x + 16) \Rightarrow y = x^3 \pm \dots x^2 \pm \dots x \pm 32$ (does not require middle terms to score M1)

A1 $y = x^3 - 10x^2 + 32x - 32$ oe

M1 $\int (3x^2 - 20x + 32) dx = x^3 - 10x^2 + 32x + C$ look for correct index on one term

A1* deduce that $C = -32$ and conclude $\frac{dy}{dx} = 3x^2 - 20x + 32$ with no errors seen

(b)

B1 16 is identified as the y coordinate. Beware that $\frac{d^2y}{dx^2} = 16$ when $x = 6$

B1 20 is identified as the gradient. Eg $\frac{dy}{dx} = 20$, $m = 20$, $g = 20$ or may be used within their equation for the tangent.

M1 Correct straight line method $y - "16" = "20"(x - 6)$ using:

- their value of y from substituting in $x = 6$ into $y = (x-2)(x^2 - 8x + 16)$ or $y = \dots$ from (a)
- their gradient found from substituting $x = 6$ into $\frac{dy}{dx} = 3x^2 - 20x + 32$. This cannot be a changed gradient (eg gradient of a normal)

If they use $y = mx + c$ they must proceed as far as $c = \dots$

A1 $y = 20x - 104$ cao

(c)

M1 Equates $3x^2 - 20x + 32$ with their 20 and collects terms to obtain a 3TQ. Condone slips in their rearrangement.

dM1 Attempts to solve their 3TQ (see general guidance for solving quadratics). If they just state the roots then you may need to check these on a calculator. It is dependent on the previous method mark.

A1 $\alpha = \frac{2}{3}$ (allow $x = \dots$) Ignore sight of 6. Answer on its own scores full marks.

(Note that values of 4, $\frac{8}{3}$ imply they have solved $3x^2 - 20x + 32 = 0$ which is 0 marks)

Question	Scheme	Marks
10(a)	$\frac{dy}{dx} = \frac{6}{7}x^2 + \frac{2}{7}x - \frac{5}{2}$	M1 A1
		(2)
(b)	At $x = -\frac{7}{2}$, $\frac{dy}{dx} = \frac{6}{7}\left(-\frac{7}{2}\right)^2 + \frac{2}{7}\left(-\frac{7}{2}\right) - \frac{5}{2} = \dots (= 7)$	M1
	So at B we know $\frac{dy}{dx} = -\frac{1}{7}$	M1
	hence $\frac{6}{7}x^2 + \frac{2}{7}x - \frac{5}{2} = -\frac{1}{7}$	dM1
	$\Rightarrow 12x^2 + 4x - 35 = -2 \Rightarrow 12x^2 + 4x - 33 = 0^*$	A1*
		(4)
(c)	E.g. $12x^2 + 4x - 33 = 0 \Rightarrow (2x - 3)(6x + 11) = 0 \Rightarrow x = \dots$	M1
	From graph we can see the x coordinate is positive, so $x = \frac{3}{2}$ at B	A1
		(2)
(d)	Equation of l is $y = -\frac{1}{7}x - 1$	M1
	Finds coordinates of A $x = -\frac{7}{2} \Rightarrow y = -\frac{1}{7} \times -\frac{7}{2} - 1 = \left(-\frac{1}{2}\right)$	dM1
	Substitutes $x = -\frac{7}{2}$, $y = -\frac{1}{2}$ into $y = \frac{2}{7}x^3 + \frac{1}{7}x^2 - \frac{5}{2}x + k \Rightarrow k = \dots$	ddM1
	$k = \frac{5}{4}$ CSO	A1
		(4)
(12 marks)		

(a)

M1: Finds $\frac{dy}{dx}$, look for at least two terms correct. They do not need to be simplified.

A1: Correct derivative, need not be simplified. ISW after a correct answer

(b) Marks cannot be retrospectively awarded from work in (d)

M1: Substitutes $-\frac{7}{2}$ into their $\frac{dy}{dx}$ to find the gradient of C at A

M1: Applies perpendicular condition to their gradient to find gradient at B

dM1: Equates $\frac{dy}{dx}$ to the gradient of the normal at B, depends on first M mark and a changed gradient.

A1*: Reaches the given equation with any correct intermediate line shown following $\frac{6}{7}x^2 + \frac{2}{7}x - \frac{5}{2} = -\frac{1}{7}$



(c)

M1: Any valid method to solve the quadratic, factorisation, completing square, formula or calculator may be used (implied by one correct answer). This may be awarded for work in (b)

A1: Correct coordinate $x_B = \frac{3}{2}$ given with reason. See scheme. The reason should reference the sketch, e.g.

E.g. cannot be $-\frac{11}{6}$ as that is negative, condone reasons like "because B is positive"

(d) Marks cannot be awarded from work in (b), but allow the transfer of answers. E.g. $y = -\frac{1}{7}x - 1$

Explanation of Main method:

Find equation for l , then find coordinates for A or B, then sub coordinates into equation for C to find k

M1: Uses their gradient of l and intercept -1 to form the equation of l .

The gradient must a result of a changed $\frac{dy}{dx}$ at $x = -\frac{7}{2}$. It cannot be just made up

dm1: Finds the coordinates of either A or B using the equation for l and either $x_A = -\frac{7}{2}$ or $x_B = \frac{3}{2}$

$$\text{FYI } x = -\frac{7}{2} \Rightarrow y = -\frac{1}{7} \times -\frac{7}{2} - 1 = \left(-\frac{1}{2}\right) \text{ and } x = \frac{3}{2} \Rightarrow y = -\frac{1}{7} \times \frac{3}{2} - 1 = \left(-\frac{17}{14}\right)$$

ddM1: A full method to solve for k . This involves substituting the coordinates of A or B in the equation for

curve C. E.g. See scheme but can also use $x = \frac{3}{2}$ $y = -\frac{17}{14}$ into $y = \frac{2}{7}x^3 + \frac{1}{7}x^2 - \frac{5}{2}x + k \Rightarrow k = \dots$

A1: CSO $k = \frac{5}{4}$

Explanation of Alt method:

Use the x coordinate for A or B in the equation for C to find the y coordinate for A or B in terms of k .

Then use the gradient and point A or B to form an equation for l in terms of k . Use the fact that the intercept of l is -1 to form and solve an equation in k

Alt I (d)	At A $y = \frac{2}{7}\left(-\frac{7}{2}\right)^3 + \frac{1}{7}\left(-\frac{7}{2}\right)^2 - \frac{5}{2}\left(-\frac{7}{2}\right) + k = \dots \left(= k - \frac{7}{4}\right)$	M1
	Equation of l is $y - \left(k - \frac{7}{4}\right) = -\frac{1}{7}\left(x + \frac{7}{2}\right)$ or y intercept is $-\frac{1}{7} \times \frac{7}{2} + k - \frac{7}{4}$	dm1
	$\Rightarrow y = -\frac{1}{7}x + k - \frac{9}{4} \Rightarrow k - \frac{9}{4} = -1 \Rightarrow k = \dots$	ddM1
	$k = \frac{5}{4}$	A1

M1: Substitutes $x = -\frac{7}{2}$ or $x = \frac{3}{2}$ into the equation for C and finds the y coordinate in terms of k .

This cannot be scored if they substitute any value for y (except for the correct value which would mean that we would be using the main method).

FYI at B the y coordinate is $k - \frac{69}{28}$

dm1: Uses their gradient for normal at A (or tangent at B) and their y coordinate to find an equation of the

line l or to find an expression for the intercept. For use of B expect $y - \left(k - \frac{69}{28}\right) = -\frac{1}{7}\left(x - \frac{3}{2}\right)$



ddM1: Sets their intercept to -1 and solves for k .

A1: $k = \frac{5}{4}$

Explanation of Alt II (d)

Find the equation for l (as in main method) but then equate with the equation for C . Use the fact that the equation formed has a root of either $3/2$ or $-7/2$ to set up and solve an equation in k .

M1: For an attempt at the equation for l . Score for $y = -\frac{1}{7}x - 1$

dM1: Equate equation for l with equation for C and use the fact that a root of this equation is known.

For example $-\frac{1}{7}x - 1 = \frac{2}{7}x^3 + \frac{1}{7}x^2 - \frac{5}{2}x + k \Rightarrow 4x^3 + 2x^2 - 33x + 14k + 14 = 0$

Set $g\left(\pm\frac{3}{2}\right) = 0$ or $g\left(\pm\frac{7}{2}\right) = 0$ where $g(x) = 4x^3 + 2x^2 - 33x + 14k + 14$ to form an equation in k

ddM1: As above but sets $g\left(\frac{3}{2}\right) = 0 \Rightarrow k = \dots$ $g\left(-\frac{7}{2}\right) = 0 \Rightarrow k = \dots$ which must lead to a value for k

A1: $k = \frac{5}{4}$

