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EDEXCEL INTERNATIONAL A LEVEL MATHS: QUESTIONS BY TOPIC

Quadratic Functions (P1.2)

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

14 questions · 114 marks · Mark schemes included

Past papers January 2019 - June 2025 · 2 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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QUESTIONS

14 questions · 114 marks · 2 sub-topics

SUB-TOPIC P1.2a

COMPLETING THE SQUARE & SKETCHING QUADRATICS

Sub-topic P1.2a · 9 questions · 84 marks · lowest tariff first



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2.

$$f(x) = 11 - 4x - 2x^2$$

(a) Express $f(x)$ in the form

$$a + b(x + c)^2$$

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

(3)

(b) Sketch the graph of the curve C with equation $y = f(x)$, showing clearly the coordinates of the point where the curve crosses the y -axis.

(2)

(c) Write down the equation of the line of symmetry of C .

(1)

Question 2 continued

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Q2

(Total 6 marks)



Question 3 continued

(Total for Question 3 is 6 marks)



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2.

$$f(x) = 3 + 12x - 2x^2$$

(a) Express $f(x)$ in the form

$$a - b(x + c)^2$$

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

(3)

The curve with equation $y = f(x) - 7$ crosses the x -axis at the points P and Q and crosses the y -axis at the point R .

(b) Find the area of the triangle PQR , giving your answer in the form $m\sqrt{n}$ where m and n are integers to be found.

(4)

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Question 2 continued

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Question 2 continued

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(Total 7 marks)

Q2



Question 8 continued

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Question 8 continued

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Question 8 continued

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Q8

(Total 9 marks)



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5. The curve C has equation $y = f(x)$

Given that

- $f(x)$ is a quadratic expression
- the maximum turning point on C has coordinates $(-2, 12)$
- C cuts the negative x -axis at -5

(a) find $f(x)$

(4)

The line l_1 has equation $y = \frac{4}{5}x$

Given that the line l_2 is perpendicular to l_1 and passes through $(-5, 0)$

(b) find an equation for l_2 , writing your answer in the form $y = mx + c$ where m and c are constants to be found.

(3)

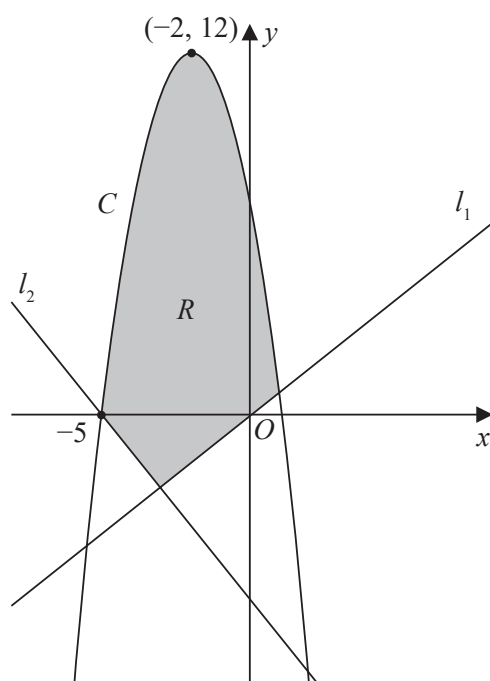


Figure 2

Figure 2 shows a sketch of the curve C and the lines l_1 and l_2

(c) Define the region R , shown shaded in Figure 2, using inequalities.

(2)

Question 5 continued

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Question 5 continued

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Question 5 continued

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(Total 9 marks)

Q5



Question 8 continued

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Question 8 continued

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Question 8 continued

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(Total 10 marks)

Q8



11.

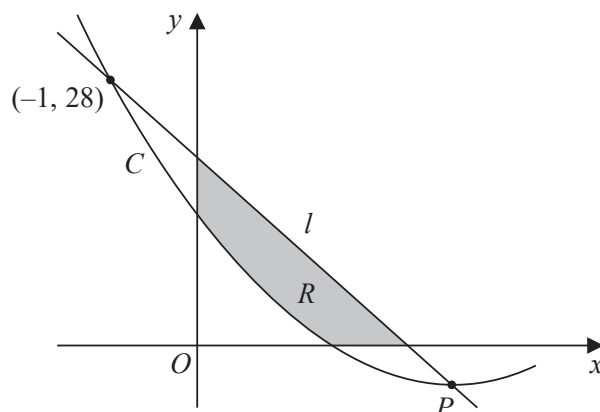


Figure 5

Figure 5 shows part of the curve C with equation $y = f(x)$ where

$$f(x) = 2x^2 - 12x + 14$$

(a) Write $2x^2 - 12x + 14$ in the form

$$a(x + b)^2 + c$$

where a , b and c are constants to be found.

(3)

Given that C has a minimum at the point P

(b) state the coordinates of P

(1)

The line l intersects C at $(-1, 28)$ and at P as shown in Figure 5.

(c) Find the equation of l giving your answer in the form $y = mx + c$ where m and c are constants to be found.

(3)

The finite region R , shown shaded in Figure 5, is bounded by the x -axis, l , the y -axis, and C .

(d) Use inequalities to define the region R .

(3)

Question 11 continued

Question 11 continued

(Total for Question 11 is 10 marks)

TOTAL FOR PAPER IS 75 MARKS



9.

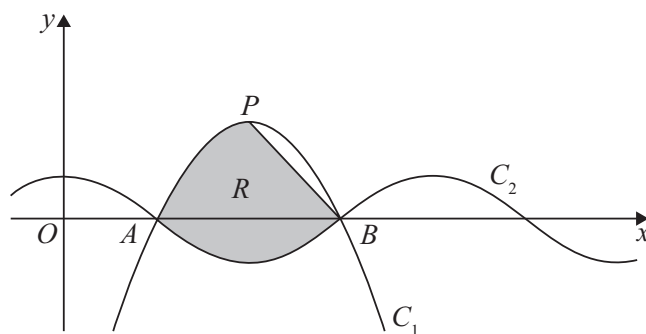


Figure 2

- (a) Express $6x - \frac{27}{4} - x^2$ in the form $a + b(x + c)^2$ where a , b and c are constants to be found.

(3)

Figure 2 shows part of a sketch of curve C_1 with equation

$$y = 6x - \frac{27}{4} - x^2$$

Given that the point P is the maximum point on C_1

- (b) state the coordinates of P

(2)

Figure 2 also shows part of a sketch of curve C_2 with equation

$$y = \cos(kx)$$

where k is a constant and x is measured in radians.

Given that C_1 and C_2 intersect on the x -axis at point A and at point B , as shown in Figure 2,

- (c) (i) state the x coordinate of B
 (ii) state the value of k
 (iii) state the period of C_2

(3)

The line segment L joins P and B .

The region R , shown shaded in Figure 2, is bounded by L , C_1 and C_2

- (d) Use inequalities to define R .

(5)



Question 9 continued

(Total for Question 9 is 13 marks)

TOTAL FOR PAPER IS 75 MARKS



9.

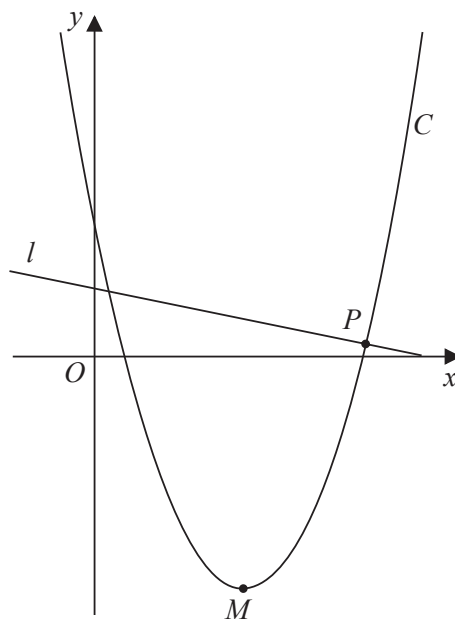
**Figure 3**

Figure 3 shows a sketch of the curve C with equation

$$y = \frac{1}{2}x^2 - 10x + 22$$

(a) Write $\frac{1}{2}x^2 - 10x + 22$ in the form

$$a(x + b)^2 + c$$

where a , b and c are constants to be found.

(3)

The point M is the minimum turning point of C , as shown in Figure 3.

(b) Deduce the coordinates of M

(2)

The line l is the normal to C at the point P , as shown in Figure 3.

Given that l has equation $y = k - \frac{1}{8}x$, where k is a constant,

(c) (i) find the coordinates of P

(ii) find the value of k

(6)

Question 9 continues on the next page

Question 9 continued



Question 9 continued



Question 9 continued

(Total for Question 9 is 14 marks)

TOTAL FOR PAPER IS 75 MARKS



SUB-TOPIC P1.2b

THE DISCRIMINANT & ROOTS OF QUADRATICS

Sub-topic P1.2b · 5 questions · 30 marks · lowest tariff first



4. Given that the equation

$$kx^2 + 6kx + 5 = 0 \quad \text{where } k \text{ is a non zero constant}$$

has no real roots, find the range of possible values for k .

(4)

(Total for Question 4 is 4 marks)



8. The straight line l has equation $y = k(2x - 1)$, where k is a constant.

The curve C has equation $y = x^2 + 2x + 11$

Find the set of values of k for which l does not cross or touch C .

(6)

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Question 8 continued

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Lined area for writing the answer to Question 8.

(Total 6 marks)

Q8

Mark box for Q8.



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

Solutions relying on calculator technology are not acceptable.

The equation

$$4(p - 2x) = \frac{12 + 15p}{x + p} \quad x \neq -p$$

where p is a constant, has two distinct real roots.

(a) Show that

$$3p^2 - 10p - 8 > 0 \quad (3)$$

(b) Hence, using algebra, find the range of possible values of p (3)

Question 6 continued

(Total for Question 6 is 6 marks)



9. The equation

$$\frac{3}{x} + 5 = -2x + c$$

where c is a constant, has no real roots.

Find the range of possible values of c .

(7)

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Question 9 continued

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Q9

(Total 7 marks)



10.

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

$$(k-1)x^6 + 4x^3 + (k-4) = 0 \quad \text{where } k \text{ is a constant}$$

- (a) Find the exact solutions to the given equation for $k = 4.5$ (3)
- (b) Find the set of possible values of k for which the given equation has no real roots. (4)

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 7 marks)

TOTAL FOR PAPER IS 75 MARKS



MARK SCHEMES

official mark schemes, in the same order as the questions



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.

Apply isw if possible if there is no contradiction so e.g. correct work leading to $x \leq -\frac{1}{4}, x \geq 2$ followed by $-\frac{1}{4} \geq x \geq 2$ can score full marks. If several different answers are offered, mark the final answer.

Particular cases and how to mark them:

Case 1

$$4x^2 - 3x + 7 \geq 4x + 9 \Rightarrow 4x^2 - 7x - 2 \geq 0$$

$$x = -\frac{1}{4}, 2 \Rightarrow x \leq -\frac{1}{4}, x \geq 2$$

Scores M0A0 M1A0

Case 2

$$4x^2 - 3x + 7 \geq 4x + 9 \Rightarrow 4x^2 - 7x - 2 \geq 0$$

$$\Rightarrow x \leq -\frac{1}{4}, x \geq 2$$

Scores M0A0M0A0

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.

B1 States gradient of l_1 is $-\frac{3}{4}$ but can be implied by further work. Eg sight of a gradient of $\frac{4}{3}$ in their equation for l_2 can also score this mark.
The value must be identified or used so it cannot just be awarded from a rearranged equation for l_1 . Circling the coefficient is acceptable but stating $-\frac{3}{4}x$ with no further work is B0.

M1 Attempts to find the gradient of the perpendicular line " $-\frac{3}{4}$ " $\rightarrow \frac{4}{3}$ and attempts to find the equation of l_2 . Look for $(y-6) = \frac{4}{3}(x-8)$ with both of the brackets correct. If they attempt using $y = mx + c$ then they must proceed as far as $c = \dots$

A1* $-\frac{14}{3}$ cso must be clearly stated as the y coordinate with no errors seen after achieving a correct equation for l_2 .

(c)

B1ft Finds the radius of the circle following through on their answer to (a). " $12 + \frac{14}{3}$ " is acceptable for this mark or it may be implied by their length of the arc. May be seen on the diagram or in other parts.

M1 Attempts to find the length of the arc with $\theta = 1.8$ and their $r = "12" + \frac{14}{3}$

A1 30 cao

(d)

M1 Attempts to find the area of the sector with $\theta = 1.8$ and their $r = "12" + \frac{14}{3}$

M1 **Adds the area of their sector with a correct method to find the area of the triangle.**

There are various ways to find the area of the triangle. They may find the lengths CD and DE using Pythagoras and proceed to find the area of the triangle:

$$\text{Eg } CD = \sqrt{6^2 + 8^2} = 10 \text{ and } DE = \sqrt{8^2 + \left(\frac{32}{3}\right)^2} = \frac{40}{3} \Rightarrow \text{Area} = \frac{1}{2} \times 10 \times \frac{40}{3} = \frac{200}{3}$$

Alternatively, via the shoelace method:

$$\text{Eg } \frac{1}{2} \begin{vmatrix} 0 & 12 \\ 8 & 6 \\ 0 & -\frac{14}{3} \\ 0 & 12 \end{vmatrix} = \frac{1}{2} \times \left(\left(8 \times -\frac{14}{3} \right) - (12 \times 8) \right) = \frac{200}{3}$$

A1 $\frac{950}{3}$ cao (accept $316\frac{2}{3}$ or $316.\dot{6}$ but not 316.7)



Question	Scheme	Marks
3(i)	Writes $\sqrt{180}$ as $6\sqrt{5}$ or $\sqrt{80}$ as $4\sqrt{5}$	M1
	Concludes working $\frac{6\sqrt{5}-4\sqrt{5}}{\sqrt{5}} = \frac{2\sqrt{5}}{\sqrt{5}} = 2$	A1
		(2)
(ii)	$\frac{4\sqrt{5}-5}{7-3\sqrt{5}} = \frac{4\sqrt{5}-5}{7-3\sqrt{5}} \times \frac{7+3\sqrt{5}}{7+3\sqrt{5}} = \dots$	M1
	$= \frac{28\sqrt{5}-35+12(\sqrt{5})^2-15\sqrt{5}}{49-9 \times 5}$	dM1
	$= \frac{25}{4} + \frac{13}{4}\sqrt{5}$	A1
		(3)
(5 marks)		
Notes: This is a non calculator question and all stages of working must be shown		

(i) Main method

M1: Writes $\sqrt{180}$ as $6\sqrt{5}$ or $\sqrt{80}$ as $4\sqrt{5}$.

Additional lines of working may be seen but they are not required for this mark

A1: Correct work leading to the answer 2. The M mark must have been awarded.

The solution shown in the main mark scheme is the minimum evidence required.

A valid alternative is $\frac{\sqrt{180}-\sqrt{80}}{\sqrt{5}} = \frac{6\sqrt{5}-4\sqrt{5}}{\sqrt{5}} = \left(\frac{6\sqrt{5}}{\sqrt{5}} - \frac{4\sqrt{5}}{\sqrt{5}}\right) = 6-4=2$

(i) Alt method I $\frac{\sqrt{180}-\sqrt{80}}{\sqrt{5}} = \frac{\sqrt{180}}{\sqrt{5}} - \frac{\sqrt{80}}{\sqrt{5}} = \sqrt{36} - \sqrt{16} = 6-4=2$

M1: Writes $\frac{\sqrt{180}}{\sqrt{5}}$ as $\sqrt{36}$ or $\frac{\sqrt{80}}{\sqrt{5}}$ as $\sqrt{16}$

Additional lines of working may be seen but they are not required

A1: Correct work leading to the answer 2. The solution shown below is the minimum evidence required

E.g. $\frac{\sqrt{180}}{\sqrt{5}} - \frac{\sqrt{80}}{\sqrt{5}} = \sqrt{36} - \sqrt{16} = 6-4=2$

(i) Alt method II $\frac{\sqrt{180}-\sqrt{80}}{\sqrt{5}} \times \frac{\sqrt{5}}{\sqrt{5}} = \frac{\sqrt{900}-\sqrt{400}}{5} = \frac{30-20}{5} = 2$

M1: Multiplies numerator and denominator by $\sqrt{5}$ and writes $\sqrt{180} \times \sqrt{5}$ as $\sqrt{900}$ or $\sqrt{80} \times \sqrt{5}$ as $\sqrt{400}$

A1: Correct work leading to the answer 2



Question Number	Scheme	Marks
8.(a)(i)	$4 + 12x - 3x^2 = a \pm 3(x + c)^2$ or $a + b(x \pm 2)^2$	M1
	Two of $16 - 3(x - 2)^2$ or two of $a = 16, b = -3, c = -2$	A1
	$16 - 3(x - 2)^2$	A1
	Coordinates $M = (2, 16)$	B1ft B1ft
		(5)
(b)	States or implies that l_2 has equation $y = "8"x + k$	M1
	Sets $4 + 12x - 3x^2 = "8"x + k$ and proceeds to 3TQ	dM1
	Correct 3TQ $3x^2 - 4x + k - 4 = 0$	A1
	Attempts to use $b^2 - 4ac = 0$ to find k	ddM1
	$k = \frac{16}{3} \Rightarrow y = 8x + \frac{16}{3}$	A1
		(5)
		(10 marks)

(a)(i)

M1 For attempting to complete the square. Look for $b = \pm 3$ or $c = \pm 2$ A1 Two correct constants or two correct integers from $16 - 3(x - 2)^2$ A1 $16 - 3(x - 2)^2$ ($16 - 3(2 - x)^2$ scores M1A1A0)**Alternative by comparing coefficients:**

$$a + b(x + c)^2 = a + b(x^2 + 2xc + c^2) = bx^2 + 2bcx + a + bc^2$$

$$bx^2 + 2bcx + a + bc^2 \equiv 4 + 12x - 3x^2$$

$$b = -3$$

$$2bc = 12 \Rightarrow c = -2$$

$$a - 12 = 4 \Rightarrow a = 16$$

Score M1 for expanding $a + b(x + c)^2$ and compare x^2 coefficients to find a value for b (NB this can be deduced directly and would score the M mark for $b = \pm 3$ as above)A1: Continues the process and compares x coefficients to find both $b = -3$ and $c = -2$ A1: $a = 16$

(a)(ii)

B1ft Either $x = 2$ or $y = 16$ but follow through on their $16 - 3(x - 2)^2$ where $a \neq 0$ B1ft Both $x = 2$ and $y = 16$ but follow through on their $(-c, a)$ from $a + b(x + c)^2$ where $b \neq \pm 1$ For correct or correct ft coordinates the wrong way round e.g. (16, 2) score SC B1 B0 but apply isw if the correct or correct ft answers are seen as $x = \dots, y = \dots$

(b)

M1 States or implies that l_2 has equation $y = "8"x + k, k \neq 0$ Follow through on their $y = \frac{a}{c}x + k$ or on $y = \left(\frac{y \text{ coordinate of their } M}{x \text{ coordinate of their } M} \right)x + k$ 

dM1 Sets $4 + 12x - 3x^2 = "8x" + k$ and proceeds to 3TQ

A1 Correct 3TQ $3x^2 - 4x + k - 4 = 0$ (The “= 0” may be implied by subsequent work)

ddM1 Attempts to use $b^2 - 4ac = 0$ to find k .

A1 $k = \frac{16}{3} \Rightarrow y = 8x + \frac{16}{3}$. Condone just $k = \frac{16}{3}$ if $y = 8x + k$ was mentioned as the equation for l_2

Alternative for part (b)

M1 Attempts to differentiate $4 + 12x - 3x^2$ ($x^n \rightarrow x^{n-1}$ at least once) and sets equal to their 8

dM1 Solves for x and proceeds to find the coordinates of point of contact

A1 Tangent meets curve at $\left(\frac{2}{3}, \frac{32}{3}\right)$ o.e.

ddM1 Substitutes their $\left(\frac{2}{3}, \frac{32}{3}\right)$ in their $y = "8"x + k$ to find k .

A1 $y = 8x + \frac{16}{3}$



Question Number	Scheme	Marks
11a	$2(x \pm \dots)^2$	B1
	$\dots(x \pm 3)^2 \dots$	M1
	$2(x-3)^2 - 4$	A1
		(3)
b	$(3, -4)$	B1ft
		(1)
c	$m = \frac{28 - -4}{-1 - 3} (= -8)$	M1
	$y - 28 = -8(x + 1)$	dM1
	$y = -8x + 20$	A1
		(3)
d	$y \leq -8x + 20$ and $y \geq 2x^2 - 12x + 14$ (or $y \geq 2(x-3)^2 - 4$)	B1ftB1ft
	$y \leq -8x + 20 \quad y \geq 2x^2 - 12x + 14 \quad y \geq 0, x \geq 0$	B1cso
		(3)
		(10 marks)

Note: answers may appear next to questions or on the diagram.

If there is a contradiction between the answer by the question/on the diagram and the main body of the work then the answer in the main body of the work takes precedence.

(a)

B1: $a = 2$ which may be stated or seen in the expression $2(x \pm \dots)^2$.

M1: $\dots(x \pm 3)^2 \dots$ may be implied by $b = \pm 3$. Accept unsimplified versions e.g. $\dots \left(x \pm \frac{12}{4}\right)^2 \dots$

A1: $2(x-3)^2 - 4$ isw following a correct expression (e.g. if they proceed to state incorrect values for a , b and/or c). If they just state the values then withhold this mark. Constants must be integers.

SC110 $2(x-3)-4$ (slip writing missing the squared on the bracket)

(b)

B1ft: $(3, -4)$ or e.g. $x = 3, y = -4$. Condone invisible brackets. Follow through from their part (a) so score for $(-b, c)$



(c)

M1: Attempts to find the gradient between their minimum point and $(-1, 28)$. Score for the expression $\frac{28 - (-4)}{-1 - (-3)}$ or equivalent. They must be subtracting the correct way round. Do not condone sign slips for this mark. If a value appears with no method (nor implied using their minimum point and $(-1, 28)$), then this mark cannot be scored (M0dM0A0)

May be part of the equation for l e.g. $\frac{28 - (-4)}{y - 28} = \frac{-1 - (-3)}{x + 1}$ or $\frac{28 - (-4)}{y + 4} = \frac{-1 - (-3)}{x - 3}$

dM1: Attempts to find the equation using their gradient. It is dependent on the previous method mark. Score for $y - 28 = -8(x + 1)$ or $y + 4 = -8(x - 3)$ but condone one sign slip substituting in the coordinates for x and y .
If they use $y = mx + c$ they must proceed as far as $c = \dots$

A1: $y = -8x + 20$

(d) Allow consistent use of either $\leq \geq$ or $< >$ Ignore use of and/or or equivalent notation for this question.

Note that $2x^2 - 12x + 14$ may be expressed as $2(x - 3)^2 - 4$

Allow the use of $f(x)$ instead of y but the use of R instead of y is not acceptable.

B1ft: One of

- $y \leq -8x + 20$ follow through on their part (c)
 - $y \geq 2x^2 - 12x + 14$ follow through on their part (b) so $2(x - 3)^2 - 4$
- May be part of an inconsistent set of inequalities e.g. $2x^2 - 12x + 14 < y \leq -8x + 20$

B1ft: Both

- $y \leq -8x + 20$ follow through on their part (c)
 - $y \geq 2x^2 - 12x + 14$ follow through on their part (b) so $2(x - 3)^2 - 4$
- May also be seen as $2x^2 - 12x + 14 \leq y \leq -8x + 20$

B1cso: $y \leq -8x + 20$ $y \geq 2x^2 - 12x + 14$ $y \geq 0, x \geq 0$ Do not isw for this mark.

Also accept $2x^2 - 12x + 14 \leq y \leq -8x + 20$ $y \geq 0, x \geq 0$

Accept inequalities $0 \leq x \leq p$ provided $p \geq \frac{5}{2}$
 $0 \leq y \leq q$ provided $q \geq 20$

Note: The equations may be written in alternative forms e.g. $8x + y \leq 20$ which is also acceptable



Question Number	Scheme	Marks
9(a)	$b = -1$	B1
	$\frac{9}{4} - (x-3)^2$	M1A1
		(3)
(b)	$\left(3, \frac{9}{4}\right)$	B1ftB1ft
		(2)
(c)(i)	$x = \frac{9}{2}$	B1
(ii)	$k = \frac{\pi}{3}$	B1
(iii)	6	B1
		(3)
(d)	$m = \frac{0 - \frac{9}{4}}{\frac{9}{2} - 3} = -\frac{3}{2}$	M1
	$y - 0 = -\frac{3}{2}\left(x - \frac{9}{2}\right)$ or $y - \frac{9}{4} = -\frac{3}{2}(x - 3)$	dM1
	$y = -\frac{3}{2}\left(x - \frac{9}{2}\right)$ or $y - \frac{9}{4} = -\frac{3}{2}(x - 3)$ o.e.	A1
	$y > \cos\left(\frac{1}{3}\pi x\right), y < 6x - \frac{27}{4} - x^2, y < -\frac{3}{2}x + \frac{27}{4}$	B1ftB1
		(5)
		(13 marks)

(a) **Note you may see values stated and an expression. The expression takes precedence.**

B1 $b = -1$ which may be embedded in their completed square form

M1 $\dots(x \pm 3)^2$ or may state $c = \pm 3$

A1 $\frac{9}{4} - (x-3)^2$ or $-(x-3)^2 + \frac{9}{4}$ or equivalent in the required form e.g. $-1(x-3)^2 + 2.25$ (must see the expression – cannot just state values for a , b and c). isw once a correct expression where a , b and c are single values within the expression are seen

(b) **May be seen on the diagram. If there is a contradiction then the main body of the work takes precedence.**

Note their a and c in part (a) must be single values to follow through in part (b)

Correct coordinates can be found in (b) and score B1ftB1ft without using their part (a)

B1ft One correct coordinate or follow through their part (a). Allow to be written as e.g. $x = 3$ or $y = \frac{9}{4}$ o.e.

B1ft $\left(3, \frac{9}{4}\right)$ o.e. or follow through their part (a) $(-c, a)$. Allow to be written as e.g. $x = 3$ and $y = 2.25$

(c)



(i)

B1 $\frac{9}{2}$ o.e. or condone $\left(\frac{9}{2}, 0\right)$ Ignore labelling but if the x coordinate of A is found as well then they must clearly identify $\frac{9}{2}$ as their final answer. Do not allow $\left(0, \frac{9}{2}\right)$

(ii)

B1 $\frac{\pi}{3}$ (must be exact)

(iii)

B1 6

(d)

M1 Attempts to find the gradient of l using their coordinates for P and B from (b) and (c).

The unsimplified expression is sufficient but do not allow sign slips.

May alternatively form two simultaneous equations and proceed to an equation in m . May use another letter. The equation in m (or a different variable for m) must be correct for their values, or implied by a correct value for m for their P and B . If only a value for m is seen you may need to check this is correct.

dM1 Attempts the equation of the straight line for l using their coordinates for P or B .

It is dependent on the previous method mark. The expression is sufficient. Condone one sign slip on substituting in their pair of coordinates. They do not need to rearrange to a particular form, but if they use $y = mx + c$ they must proceed as far as $c = \dots$

If using simultaneous equations it requires reaching values for both m and c (or other letters)

A1 Correct equation of l in any form

B1ft Any two correct inequalities in terms of y . (Do not accept in terms of e.g. R or e.g. C_1, l) following through if required on:

- their k in $\cos(kx)$
- and/or part (a) if they have used the completed square form of the quadratic.
- and/or their straight-line equation for l

Also allow if in terms of k . Condone inconsistent use of $< > /, , \dots$ for this mark.

May see e.g. $\cos\left(\frac{1}{3}\pi x\right) < y < -\frac{3}{2}x + 6.75$ which counts as two of the inequalities. One end

may be incorrect but allow the other end to still score for this mark if it would be correct as a single inequality.

B1 **All three correct inequalities in terms of y . (Do not accept in terms of e.g. R or e.g. C_1, l)**

Must consistently use $< >$ or $, \dots$ for this mark

May see e.g. $\cos\left(\frac{1}{3}\pi x\right) < y < -\frac{3}{2}x + 6.75$ which counts as two of the inequalities.

They must have substituted in the correct value for k so this mark cannot be scored following an incorrect value for k in (c)(ii) unless they restart.

If their part (a) answer is incorrect, they can still score full marks provided they use the given quadratic expression and not their incorrect completed square form.

Do not be concerned by any notation used to join the three inequalities or reference to AND/OR.

May see an inequality in x . These can be ignored provided this range $1.5 < x < 4.5$ is included i.e. we would ignore $x < 5$ but not $x < 3$



Question Number	Scheme	Marks
8(a)(i)	$2\pi - \frac{2\pi}{3} = \frac{4\pi}{3}$	B1
	Area of sector = $\frac{1}{2} \times 3^2 \times \frac{4\pi}{3} = 6\pi \text{ (m}^2\text{)}$	M1A1
(ii)	Length of arc = $3 \times \frac{4\pi}{3} \Rightarrow$ Perimeter = $4\pi + 6 \text{ (m)}$	M1A1
		(5)
(b)	$\frac{1}{2} \times 3^2 \times \sin\left(\frac{2\pi}{3}\right) = \frac{9\sqrt{3}}{4} \text{ (m}^2\text{)}$	M1A1
		(2)
(c)	Eg $AB^2 = 3^2 + 3^2 - 2 \times 3 \times 3 \times \cos\left(\frac{2\pi}{3}\right) \Rightarrow AB^2 = 27 \Rightarrow AB = 3\sqrt{3} \text{ (m)}^*$	M1A1*
		(2)
(d)	$\frac{\sin BAC}{8} = \frac{\sin\left(\frac{\pi}{6}\right)}{3\sqrt{3}} \Rightarrow \sin BAC = \dots \text{ or } BAC = \dots$ $\sin BAC = \text{awrt } \frac{4\sqrt{3}}{9} \text{ or } BAC = \text{awrt } 0.88 \text{ (0.8785...)}$ Area $ABC = \frac{1}{2} \times 3\sqrt{3} \times 8 \times \sin\left(\pi - \frac{\pi}{6} - 0.88\right) (= 20.4896\dots)$ Total area = "18.8" + "3.90" + "20.5" = awrt 43 (m ²)	M1 A1 M1 dM1 A1
		(5)
		(14 marks)

If lengths or areas are found in other parts then credit can be awarded for these as long as they are referred to or used in the relevant part.

(a)(i)

B1 Finds the correct angle for the sector $AOBX$. They may find the minor sector first and then subtract from the area of the whole circle so may be implied from later work. They may also work in degrees. Sight of $\theta = \frac{4\pi}{3}$ on the diagram or within their working scores this mark.

M1 States or uses $\frac{1}{2}r^2\theta$ with $r = 3$ and $\theta = \frac{2\pi}{3}$ or $\theta = \frac{4\pi}{3}$ or the equivalent method working in degrees. May be implied by the correct answer, expression or awrt 9.42 or awrt 18.8
A1 $6\pi \text{ (m}^2\text{)}$ cao must be exact. Isw after a correct answer.

(ii)

M1 States or uses $r\theta$ with $r = 3$ and $\theta = \frac{2\pi}{3}$ or $\theta = \frac{4\pi}{3}$ or the equivalent method working in degrees. The addition of two radii to find the perimeter is not required for this mark. May be implied by the correct answer, expression or awrt 6.28 or awrt 12.6

A1 $4\pi + 6 \text{ (m)}$ cao must be exact. Isw after a correct answer.

(b)

M1 States or uses $\frac{1}{2}ab\sin C$ with $a = b = 3, \theta = \frac{2\pi}{3}$ (or may work in degrees). Alternatively, they may split the isosceles triangle into two right angled triangles including finding AB . Score for the overall method or awrt 3.90

A1 $\frac{9\sqrt{3}}{4} \text{ (m}^2\text{)}$ or exact equivalent. Isw after a correct answer



(c)

M1 Correct method (which may be seen in earlier work but referred to in (c)) by for example

- using the cosine rule with $a = b = 3, \theta = \frac{2}{3}\pi$
- splitting the isosceles triangle into two right angled triangles eg $2 \times 3 \times \sin\left(\frac{\pi}{3}\right)$
- using the sine rule such that $\frac{AB}{\sin\left(\frac{2\pi}{3}\right)} = \frac{3}{\sin\left(\frac{\pi}{6}\right)} \Rightarrow AB = \dots$

A1* $3\sqrt{3}$ (m) with no errors in their calculations. Minimum expected to see is a simplified expression for AB (or AB^2) which is not $3\sqrt{3}$. Eg via the cosine rule this would be either $AB^2 = 27$ or $AB = \sqrt{27}$ via the sine rule eg $\frac{3\sin\left(\frac{2\pi}{3}\right)}{\sin\left(\frac{\pi}{6}\right)}$ or via splitting the triangle up into

two right angle triangles $2 \times 3 \times \sin\left(\frac{\pi}{3}\right)$ oe. Accept alternative labelling for AB eg x

You do not need to see the exact values for the the trig functions within their working.

(d) **Beware there are many methods with incorrect working leading to 43 so you will need to check carefully that their method is sound.**

M1 Attempts to use the sine rule to find $\sin BAC$ or angle BAC . Award for the appropriate lengths and angles in the correct positions within a correct equation. Do not be concerned with the mechanics of the rearrangement, although it must be a solvable equation. Alternatively attempts to solve a quadratic in AC using the cosine rule.

$$(3\sqrt{3})^2 = AC^2 + 8^2 - 2 \times AC \times 8 \times \cos\left(\frac{\pi}{6}\right) \Rightarrow AC = \dots (= \sqrt{11} + 4\sqrt{3} = \text{awrt } 10.2)$$

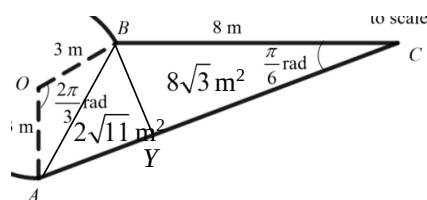
A1 Correct value for $\sin BAC$, angle BAC (awrt 0.88 or 50.3 in degrees) or AC

M1 Correct method to find the area of triangle ABC using either their angle ABC from $\pi - \frac{\pi}{6}$ - "BAC" or their length AC . May work in degrees.

dM1 Adds their (a)(i) + their (b) + their triangle ABC together to the find area of the pond. It is dependent on all of the previous method marks in (d) only

A1 awrt 43 (m^2) from a correct method. Also allow the exact answer $6\pi + 2\sqrt{11} + \frac{41}{4}\sqrt{3}$ oe

Alt (d) Forms two right angled triangles with the perpendicular to side AC from point B



M1 Height of the triangle ABC is $BY = 8\sin\left(\frac{\pi}{6}\right)$

A1 $BY = 4$ may be implied

M1 Attempts to find the area of triangle ABC . Usually this is by attempting to find length AC split into AY and YC eg $AY = \sqrt{(3\sqrt{3})^2 - 4^2}$ ($= \sqrt{11}$) and length $YC = 8\cos\left(\frac{\pi}{6}\right) = 4\sqrt{3}$

$$\Rightarrow \text{Area } ABC = \frac{1}{2} \times (\sqrt{11} + 4\sqrt{3}) \times 4. \text{ Score for the overall method condoning slips.}$$

Alternatively, they may attempt the cosine rule to find $AC \Rightarrow \text{Area } ABC = \dots$

dM1A1 Follows main scheme



Question Number	Scheme	Marks
9(a)	$\frac{1}{2}x^2 - 10x + 22 = \frac{1}{2}(x \pm \dots)^2 \pm \dots$ or states $a = \frac{1}{2}$	B1
	$\frac{1}{2}x^2 - 10x + 22 = \frac{1}{2}(x \pm 10)^2 \pm \dots$ or states $a = \frac{1}{2}$ and $b = \pm 10$	M1
	$\frac{1}{2}x^2 - 10x + 22 = \frac{1}{2}(x - 10)^2 - 28$	A1
		(3)
(b)	("10", "-28")	B1ftB1ft
		(2)
(c)(i)	Gradient of tangent = 8	B1
	$\frac{dy}{dx} = x - 10 = 8 \Rightarrow x = \dots$	M1
	$x = 18, y = 4$	A1A1
(c)(ii)	$k - \frac{1}{8} \times "18" = "4" \Rightarrow k = \frac{25}{4}$	dM1A1
		(6)
(d)	One of $x \dots "10"$ or y ,, $"\frac{25}{4}" - \frac{1}{8}x$ or $y \dots \frac{1}{2}x^2 - 10x + 22$	B1ft
	Two of $x \dots "10"$ or y ,, $"\frac{25}{4}" - \frac{1}{8}x$ or $y \dots \frac{1}{2}x^2 - 10x + 22$	B1ft
	All three of $x \dots 10, y$,, $\frac{25}{4} - \frac{1}{8}x$ and $y \dots \frac{1}{2}x^2 - 10x + 22$	B1
		(3)
		(14 marks)

(a) If there is a contradiction between the embedded values of a , b and c within their expression and their stated values then the embedded values take precedence.

B1 Achieves $\frac{1}{2}x^2 - 10x + 22 = \frac{1}{2}(x \pm \dots)^2 \pm \dots$ or states that $a = \frac{1}{2}$

M1 Deals correctly with the first two terms of $\frac{1}{2}x^2 - 10x + 22$

Scored for $\frac{1}{2}x^2 - 10x + 22 = \frac{1}{2}(x \pm 10)^2 \pm \dots$ or states that $a = \frac{1}{2}$ & $b = \pm 10$ (may be found using symmetry by finding the roots)

A1 $\frac{1}{2}x^2 - 10x + 22 = \frac{1}{2}(x - 10)^2 - 28$ (cannot just be the stated values). Do not isw if for example they attempt to multiply by 2 to achieve integer values

This may also be done by equating coefficients using the expanded form

$a(x+b)^2 + c = ax^2 + 2abx + ab^2 + c$ but the marks can be applied in the same way



(b)

B1ft One of the coordinates of $(10, -28)$ or follow through one of their $(-b, c)$ from (a).

B1ft $(10, -28)$ or follow through their $(-b, c)$ from (a). Accept $x = "10"$, $y = "-28"$. Condone lack of bracketing as long as the intention as to which coordinate is which is clear.

(c)(i)

B1 Gradient of tangent = 8 (stated or implied)

M1 Differentiates $\frac{1}{2}x^2 - 10x + 22$ to achieve a derivative of the form $px + q$ and sets equal to 8.

They then proceed to find a value for x .

Alternatively, sets $8x + \alpha = \frac{1}{2}x^2 - 10x + 22$, proceeds to a quadratic in x , sets the

discriminant = 0 and solves to find α . They then use this value of α in their original equation to solve and find x

A1 $x = 18$

A1 $y = 4$

(c)(ii)

dM1 Sets $k - \frac{1}{8} \times "18" = "4"$ and proceeds to find a value for k . It is dependent on the method mark

in (i)

A1 $k = \frac{25}{4}$ oe

(d) Ignore any references to OR or AND (or equivalent use of set notation)

Note that $\frac{1}{2}x^2 - 10x + 22$, y , $"\frac{25}{4} - \frac{1}{8}x"$ is acceptable and counts as two of the required

inequalities in part (d)

Use of strict or inclusive inequalities must be consistent for all of their inequalities on the last mark only

B1ft One of $x \dots "10"$ (or $"10"$, x , d where d is at least 18) or y , $"\frac{25}{4} - \frac{1}{8}x"$ or

$y \dots \frac{1}{2}x^2 - 10x + 22$ follow through on their minimum point or their k . Allow if l is still in terms of k

B1ft Two of $x \dots "10"$ (or 10 , x , d where d is at least 18) or y , $"\frac{25}{4} - \frac{1}{8}x"$ or

$y \dots \frac{1}{2}x^2 - 10x + 22$ follow through on their minimum point or their k . Allow if l is still in terms of k

B1 All three of $x \dots 10$ (or 10 , x , d where d is at least 18), y , $\frac{25}{4} - \frac{1}{8}x$ and

$y \dots \frac{1}{2}x^2 - 10x + 22$. Condone the additional minimum interval (or greater) -28 , y , 5



Question Number	Scheme	Marks
4	$kx^2 + 6kx + 5 = 0$	
	$b^2 - 4ac = (6k)^2 - 4 \times k \times 5$	M1
	$b^2 - 4ac = (6k)^2 - 4 \times k \times 5 \dots 0 \Rightarrow k \dots$	dM1
	$k < \frac{5}{9}$	A1
	$0 < k < \frac{5}{9}$	A1
		(4 marks)

M1: Attempts to use $b^2 - 4ac$ for the given quadratic with $b = 6k$, $a = k$ and $c = 5$.

May be seen as part of the quadratic formula or may be implied by an attempt to solve e.g. $b^2 = 4ac$

Condone attempts where the "6" isn't squared e.g. $6k^2 - 4 \times k \times 5$ but the k must be squared.

dM1: Dependent upon the previous M mark, it is for setting $b^2 - 4ac \dots 0$ leading to a non-zero value for k from an "equation" of the form $\alpha k^2 - \beta k \dots 0$

Condone any of e.g. "=", "<", ">" etc. for "...". for this mark.

A1: For obtaining an upper limit for k of $\frac{5}{9}$ (not just the value) but condone $k \leq \frac{5}{9}$ which may be

implied by e.g. $0 < k < \frac{5}{9}$ or $0 < k \leq \frac{5}{9}$. Allow exact equivalents for $\frac{5}{9}$ e.g. $\frac{10}{18}$ etc. Condone the use

of x for this mark so allow e.g. $x \leq \frac{5}{9}$, $x < \frac{5}{9}$ Allow 0.5 for $\frac{5}{9}$

Allow the inequalities to be on separate lines e.g. $k < \frac{5}{9}$
 $k > 0$



Question Number	Scheme	Marks
8.	Equates $y = k(2x-1)$ and $y = x^2 + 2x + 11 \Rightarrow k(2x-1) = x^2 + 2x + 11$ $\Rightarrow x^2 + (2-2k)x + 11+k (=0)$ Attempts "$b^2 - 4ac$"... $0 \Rightarrow (2-2k)^2 - 4(11+k) \dots 0$ and proceeds to critical values Critical values of $(k =) 5, -2$ No roots so $b^2 - 4ac < 0$ so choose inside region $-2 < k < 5$	M1 A1 M1 A1 M1 A1 (6) (6 marks)

M1 Attempts to equate $y = k(2x-1)$ and $y = x^2 + 2x + 11 \Rightarrow k(2x-1) = x^2 + 2x + 11$

A1 $x^2 + (2-2k)x + 11+k (=0)$ oe

Correct quadratic or correct values of a , b and c . The terms should be collected on one side of the equation and the x terms must have been collected together in a bracket. Condone a missing " $=0$ ". This mark may be implied by values of a , b and c used in later work.

M1 Attempts " $b^2 - 4ac$ " where $a = \pm 1$, $b = \pm 2 \pm 2k$, $c = \pm 11 \pm k$ to achieve a 3TQ and proceeds to find critical values. Condone arithmetical slips in the rearrangement to a 3TQ. Usual rules for solving a quadratic apply. You may see " $b^2 \dots 4ac$ ".
FYI " $b^2 - 4ac = 4k^2 - 12k - 40$ " (Be careful that this may result from incorrect working which loses the A marks that follow)

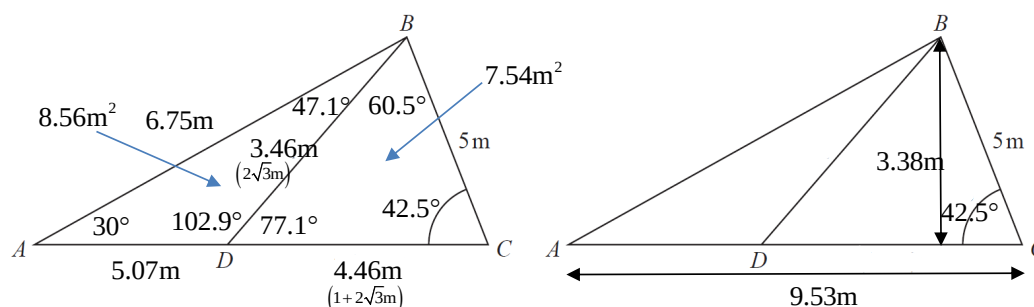
A1 Correct critical values $(k =) 5, -2$ **MUST HAVE COME FROM CORRECT WORKING**

M1 Finds inside region for their critical values. May be awarded for eg $-2 \leq k \leq 5$ or $-2 \leq k < 5$. Allow this mark if another variable is used.

A1 $-2 < k < 5$ oe such as $k \in (-2, 5)$ cso
Note that $-2 < x < 5$ is A0



(b) Note there are a variety of different methods to finding the area of triangle ABC



B1: $\theta = \text{awrt } 42^\circ$ seen or implied. Accept 42.5. May work in radians (awrt 0.73/0.74 radians)

M1: Attempts to find AB , AD or AC using a correct method. Angles and lengths must be in the correct positions in the relevant formula or formulae. Condone slips in any rearrangement, calculations and substituting in $x = 2\sqrt{3}$ provided the method is correct. Condone working in radians provided the angles are consistently in degrees or radians within the expression or formula.

A1: awrt 6.75/6.76 or awrt 9.53/9.54 or awrt 5.07/5.08 (may be implied by further work).

dM1: Correct full method to find the total area (the expression is sufficient. It is dependent on the previous method mark. Condone use of incorrectly rounded angles/slips and may work in radians.

$$\text{e.g. Area} = \frac{1}{2} \times 5 \times 6.75 \times \sin\left(\pi - \frac{\pi}{6} - 0.74\right)$$

May find the areas of the two separate triangles ABD and BDC and add them together.

$$\text{e.g. Area} = \frac{1}{2} \times 5.07 \times 6.75 \times \sin 30 + \frac{1}{2} \times 4.46 \times 5 \times \sin 42.5$$

Use the diagrams above to help with the various methods. Invisible brackets may be implied by further work or their answer.

Note that if, as part of their method to find the total area, they find angle ADB but incorrectly deduce this as an acute angle then this is dM0

A1: awrt 16.1 m^2 (condone lack of units)



Question Number	Scheme	Marks
6a	$4(p-2x) = \frac{12+15p}{x+p}$	M1
	$8x^2 + 4px + 12 + 15p - 4p^2 (=0)$	
	e.g. $a=8, b=4p, c=12+15p-4p^2$ $(4p)^2 - 4 \times 8 \times (12+15p-4p^2) (>0)$	dM1
	$3p^2 - 10p - 8 > 0 \quad *$	A1*
		(3)
b	e.g. $(p-4)(3p+2) (=0) \Rightarrow 4, -\frac{2}{3}$	M1
	$p < -\frac{2}{3} \text{ or } p > 4$	M1A1
		(3)
		(6 marks)

Allow part (b) to follow on from (a) without any labelling of specific parts

(a)

M1: Multiplies by $(x+p)$, multiplies out the brackets and collects terms on one side.

Condone slips and the omission of $=0$, but there must be an $\dots x^2$ term.

May be implied by further work e.g. their attempt at the discriminant.

dM1: Attempts $b^2 - 4ac$ for their quadratic in x with their b and their c both being in terms of p .

The values/expressions for a , b and c for their quadratic in x must be embedded in the correct positions in the expression but condone invisible brackets and sign slips miscopying. It is dependent on the previous method mark.

Condone for this mark if they work in terms of x instead of p provided the coefficients were actually those in terms of p from their original quadratic. i.e.

$$8x^2 + 4px + 12 + 15p - 4p^2 = 0 \Rightarrow a=8, b=4p, c=12+15p-4p^2$$

$$\Rightarrow (4x)^2 - 4 \times 8 \times (12+15x-4x^2) (>0) \text{ (they have just written } x \text{ instead of } p \text{ which is fine)}$$

A1*: Achieves $3p^2 - 10p - 8 > 0$ with all stages of working shown:

- Multiplying out $(p-2x)(x+p)$
- Collecting terms on one side of an equation ($=0$ may be implied)
- Finding the discriminant
- At least one intermediate stage of working between the discriminant and the final answer

There must be no errors seen including invisible brackets but condone a missing trailing bracket if it does not alter the processing. e.g. $(4p)^2 - 4 \times 8 \times (12+15p-4p^2)$

Condone the >0 appearing for the first time in their final answer, provided an incorrect inequality has not been used in earlier working.

Do not withhold this mark if they state e.g. " $b^2 - 4ac = 0$ " as part of their working.



(b)

M1: Attempts to find critical values by solving the given quadratic by either

- factorising (do not accept $(p-4)(p+\frac{2}{3})$ unless they have divided both sides of the inequality/equation by 3 first)
- completing the square $3\left(p-\frac{5}{3}\right)^2 \pm \dots \Rightarrow (p=) \dots$
- quadratic formula

Usual rules apply (see general marking principles for guidance). May be in another variable. Allow this mark to be scored if seen in (a).

This mark cannot be awarded from directly using a calculator and stating the roots.

M1: Attempts to find the outside region for their critical values. May use another variable e.g. x

May be implied by $p \leq -\frac{2}{3}$, $p \geq 4$ or incorrect use of inequalities e.g. $4 < p < -\frac{2}{3}$

This is **not** dependent on the first method mark so if a calculator has been used then this mark can still be scored.

A1: $p < -\frac{2}{3}$ or $p > 4$ (or equivalent). (may appear on separate lines). Isw once a correct

answer is seen, provided there is no contradiction and no part of the range is rejected.

This can only be scored provided both previous method marks have been awarded.

Must be in terms of p

Accept e.g. $p < -\frac{2}{3}$, $p > 4$, $p < -\frac{2}{3}$ $p > 4$ $\left\{ p : p < -\frac{2}{3} \cup p > 4 \right\}$ or variations of

these. Accept $\left(-\infty, -\frac{2}{3}\right)$, $(4, \infty)$

Do not accept e.g. $p < -\frac{2}{3}$ and $p > 4$ $\left\{ p : p < -\frac{2}{3} \cap p > 4 \right\}$ or variations of these

Do not accept $\left(-\infty, -\frac{2}{3}\right]$, $[4, \infty)$ $p \leq -\frac{2}{3}$, $p \geq 4$ $4 < p < -\frac{2}{3}$

Question Number	Scheme	Marks
8 (a)	States $y = 4$	B1 (1)
(b)	States (16,9) only	B1 (1)
(c)	$k \leq 4, k = 9$	B1, B1 (2)
(d) (i)	$a = 6$	B1
(ii)	$y = f(x - 3)$	B1 (2)
		(6 marks)

(a)

B1 $y = 4$ only. May be written on a new graph

(b)

B1 (16,9) condone lack of brackets and must be the only answer (or clearly their final answer). May be written on a graph again.

(c)

B1 Sight of either one of $k \leq 4, k = 9$ Must be in terms of k . Ignore any others for this markB1 Both of $k \leq 4, k = 9$ ONLY Where several inequalities or equations are given only mark what appears to be their final answer for the $k = \dots$ and their final answer for $k \leq \dots$ Ignore any inequalities which are within $k \leq 4$ SC $y \leq 4, y = 9$ (They never write in terms of k so score B1B0)

(d)(i)

B1 $a = 6$ (6 on its own is sufficient). Also allow $(y =) f(x) - 6$ and isw if they proceed to state $a = -6$ B1 $y = f(x - 3)$ Also accept $y = -f(x) + 6$, $y = f(x + 4) - 9$ or even rearrangements such as $f(x) = 6 - y$ Do not accept combinations of different transformations as the question asked for a single transformation.

Question Number	Scheme	Marks
9.	$\frac{3}{x} + 5 = -2x + c$ Multiplies through by x $3 + 5x = -2x^2 + cx \Rightarrow \pm 2x^2 \dots\dots (= 0)$ and writes in quadratic form $\Rightarrow 2x^2 + (5 - c)x + 3 (= 0)$ oe Attempts " $b^2 - 4ac$ " = $(5 - c)^2 - 24$ Attempts " $b^2 - 4ac$ " = $0 \Rightarrow (5 - c)^2 - 24 = 0 \Rightarrow c = \dots$ $(c =) 5 \pm 2\sqrt{6}$ oe Attempt at inside region $5 - 2\sqrt{6} < c < 5 + 2\sqrt{6}$ oe	M1 A1 M1 dM1 A1 M1 A1 (7) (7 marks)

- M1 Attempts to multiply through by x and moves all terms to one side. This may be implied by later work. Condone one term not being multiplied by x for this mark but all four terms must be on one side. You do not have to see the " $=0$ ".
- A1 Correct quadratic with the terms in x factorised, or correct values of a , b and c . Accept the equivalent form where terms have been collected on the other side. The " $=0$ " is not needed for this mark and ignore the use of any inequalities.
- M1 Attempts $b^2 - 4ac$ using their values. You may see " $b^2 \dots 4ac$ ". It is sufficient to see the values substituted in correctly for this mark and you can condone invisible brackets. They must have achieved a quadratic in x to calculate the discriminant so do not allow if eg a is their coefficient of x^{-1} but do allow this mark if they have a quadratic from incorrect working.
- dM1 Attempts to solve their $b^2 - 4ac = 0$ to find at least one of the critical values for c . Must have achieved a quadratic in c . Apply general marking principles for solving a quadratic. This is dependent on the previous method mark and may be implied by solutions correct to 1dp for their quadratic.
- A1 Correct critical values $(c =) 5 \pm \sqrt{24}$ or exact equivalent of the form $\frac{a \pm \sqrt{b}}{c}$ (the critical values may appear within inequalities)
- M1 Finds inside region for their critical values. They may draw a diagram but they must proceed to an $\dots < c < \dots$ (allow use of $\leq$ for one or both inequalities for this mark and they may even be separate statements) May be in terms of x or any other variable for this mark.



A1 $5 - 2\sqrt{6} < c < 5 + 2\sqrt{6}$ Must be in terms of c and must be exact

Accept others such as $5 - \sqrt{24} < c < 5 + \sqrt{24}$, $c > 5 - 2\sqrt{6}$ AND $c < 5 + 2\sqrt{6}$ $c > 5 - 2\sqrt{6}, c < 5 + 2\sqrt{6}$

$5 + 2\sqrt{6} > c > 5 - 2\sqrt{6}$, $\{c : 5 - 2\sqrt{6} < c < 5 + 2\sqrt{6}\}$, $\frac{10 - \sqrt{96}}{2} < c < \frac{10 + \sqrt{96}}{2}$

Do NOT accept $c > 5 - 2\sqrt{6}$ OR $c < 5 + 2\sqrt{6}$



Question Number	Scheme	Marks
10	$(k-1)x^6 + 4x^3 + (k-4) = 0$	
(a)	$3.5x^6 + 4x^3 + 0.5 = 0 \Rightarrow 7x^6 + 8x^3 + 1 = 0$ $\Rightarrow (x^3 + 1)(7x^3 + 1) = 0$ $\Rightarrow x^3 = -1, \quad x^3 = -\frac{1}{7}$ $\Rightarrow x = -1, \quad x = -\frac{1}{\sqrt[3]{7}}$	M1 A1 A1 (3)
(b)	Attempts $b^2 - 4ac = 16 - 4(k-1)(k-4)$ $= 20k - 4k^2$ Solves $b^2 - 4ac < 0 \Rightarrow 4k(5-k) < 0 \Rightarrow k < 0, \quad k > 5$	M1 A1 dM1 A1 (4) (7 marks)

(a)

M1: Substitutes in $k = 4.5$ (allowing a minor slip) and attempts to solve a quadratic in x^3 . Ignore reference to any complex roots. Allow solutions via calculator to find values for x^3 but directly to x is M0. Essentially this mark is for recognising the quadratic in x^3 and attempting to solve it.

A1: For **both** values for x^3 . Allow for, e.g. $y = \dots$ if they substituted $y = x^3$ but if they used $x = x^3$ then they need to return to x^3 before accessing the mark.

A1: $x = -1, \quad x = -\frac{1}{\sqrt[3]{7}}$ and no other real solutions. Condone alternative forms such as $\sqrt[3]{-\frac{1}{7}}$ or $\left(-\frac{1}{7}\right)^{\frac{1}{3}}$ for $-\frac{1}{\sqrt[3]{7}}$ and isw after a correct answer. Ignore complex roots.

(b)

M1: Attempts $b^2 - 4ac = 16 - 4(k-1)(k-4)$ condoning slips.

A1: Correct expanded and simplified expression for $b^2 - 4ac$ (may be implied if they divide through by 4 before simplifying). (Do not be concerned about the inequality or equality for this mark.)

dM1: Attempts to find the region for $b^2 - 4ac < 0$ following through on their roots to an expression with negative k^2 coefficient (allow if there were slips solving) - must be choosing the outside region. They must have obtained two values for k . Condone „ instead of $<$ and condone poor notation such as $5 < k < 0$ for this mark only.

A1: $k < 0, k > 5$ Accept with “or” or “and” between. Accept set or interval notation

[e.g. $k \in (-\infty, 0) \cup (5, \infty)$] (must use union). Do not allow x or another variable, though.

