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EDEXCEL INTERNATIONAL A LEVEL MATHS: QUESTIONS BY TOPIC

## Equations & Inequalities (P1.3)

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

17 questions · 115 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.

| QUESTION                                         | SOURCE                      | MARKS            | PAGE      |
|--------------------------------------------------|-----------------------------|------------------|-----------|
| <b>P1.3a SIMULTANEOUS EQUATIONS</b>              |                             | 5 Qs · 33 marks  | <b>2</b>  |
| 1. <b>Q8</b>                                     | IAL P1 (WMA11) October 2019 | 5                | <b>3</b>  |
| 2. <b>Q5</b>                                     | IAL P1 (WMA11) June 2019    | 7                | <b>5</b>  |
| 3. <b>Q5</b>                                     | IAL P1 (WMA11) January 2020 | 7                | <b>7</b>  |
| 4. <b>Q4</b>                                     | IAL P1 (WMA11) October 2020 | 7                | <b>9</b>  |
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| <b>P1.3b LINEAR &amp; QUADRATIC INEQUALITIES</b> |                             | 12 Qs · 82 marks | <b>15</b> |
| 6. <b>Q4</b>                                     | IAL P1 (WMA11) January 2019 | 3                | <b>16</b> |
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| 17. <b>Q3</b>                                    | IAL P1 (WMA11) October 2019 | 10               | <b>46</b> |



# QUESTIONS

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17 questions · 115 marks · 2 sub-topics

SUB-TOPIC P1.3a

## SIMULTANEOUS EQUATIONS

Sub-topic P1.3a · 5 questions · 33 marks · lowest tariff first



8. Solve, using algebra, the equation

$$x - 6x^{\frac{1}{2}} + 4 = 0$$

Fully simplify your answers, writing them in the form  $a + b\sqrt{c}$ , where  $a$ ,  $b$  and  $c$  are integers to be found.

(5)

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**Q8**

5. (a) Find, using algebra, all real solutions of

$$2x^3 + 3x^2 - 35x = 0$$

(3)

- (b) Hence find all real solutions of

$$2(y - 5)^6 + 3(y - 5)^4 - 35(y - 5)^2 = 0$$

(4)

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**Question 5 continued**

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**(Total 7 marks)**

**Q5**



5. (a) Find, using algebra, all solutions of

$$20x^3 - 50x^2 - 30x = 0$$

(3)

- (b) Hence find all real solutions of

$$20(y+3)^{\frac{3}{2}} - 50(y+3) - 30(y+3)^{\frac{1}{2}} = 0$$

(4)

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**Question 5 continued**

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**Q5**

**(Total 7 marks)**



4. Use algebra to solve the simultaneous equations

$$\begin{aligned}y - 3x &= 4 \\ x^2 + y^2 + 6x - 4y &= 4\end{aligned}$$

You must show all stages of your working.

(7)

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**Question 4 continued**

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**(Total 7 marks)**

Q4



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

- (a) Given that

$$2xy - 3x^2 = 50$$

and

$$y - x^3 + 6x = 0$$

show that

$$2x^4 - 15x^2 - 50 = 0 \quad (2)$$

- (b) Hence solve the simultaneous equations

$$2xy - 3x^2 = 50$$

$$y - x^3 + 6x = 0$$

Give your answers in fully simplified surd form. (5)

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**Q6**

SUB-TOPIC P1.3b

# LINEAR & QUADRATIC INEQUALITIES

Sub-topic P1.3b · 12 questions · 82 marks · lowest tariff first





**Question 4 continued**

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Q4

**(Total 3 marks)**



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

Solve the inequality

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

(4)



Question 1 continued

Lined area for writing the answer to Question 1.

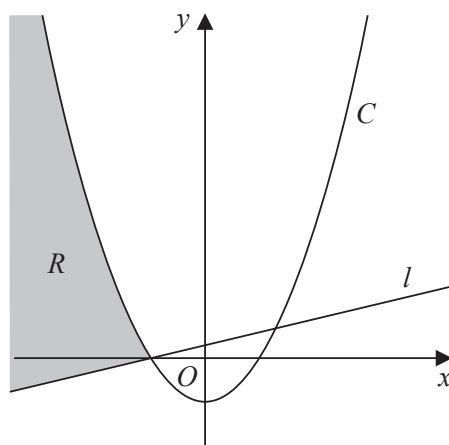
(Total for Question 1 is 4 marks)



**3. (i) Solve**

$$\frac{3}{x} > 4$$

(3)

$$(\dot{\mathbf{i}}\dot{\mathbf{i}})$$


### Figure 1

Figure 1 shows a sketch of the curve  $C$  and the straight line  $l$ .

The infinite region  $R$ , shown shaded in Figure 1, lies in quadrants 2 and 3 and is bounded by  $C$  and  $l$  only.

Given that

- $l$  has a gradient of 3
- $C$  has equation  $y = 2x^2 - 50$
- $C$  and  $l$  intersect on the negative  $x$ -axis

use inequalities to define the region  $R$ .

(3)

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Q3

**(Total 6 marks)**





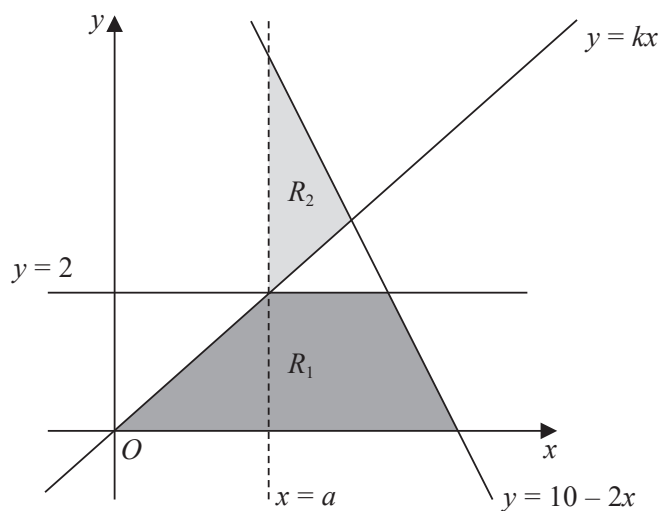
Question 2 continued

Lined area for writing the answer to Question 2.

(Total for Question 2 is 6 marks)



7.

**Figure 2**

The region  $R_1$ , shown shaded in Figure 2, is defined by the inequalities

$$0 \leq y \leq 2 \quad y \leq 10 - 2x \quad y \leq kx$$

where  $k$  is a constant.

The line  $x = a$ , where  $a$  is a constant, passes through the intersection of the lines  $y = 2$  and  $y = kx$

Given that the area of  $R_1$  is  $\frac{27}{4}$  square units,

(a) find

(i) the value of  $a$

(ii) the value of  $k$

**(4)**

(b) Define the region  $R_2$ , also shown shaded in Figure 2, using inequalities.

**(2)**


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Question 7 continued

Lined area for writing the answer to Question 7.

(Total for Question 7 is 6 marks)





Question 4 continued

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Lined area for writing the answer to Question 4.

(Total 7 marks)

Q4

Mark box for Q4.





Question 2 continued

Lined area for writing the answer to Question 2.

(Total for Question 2 is 7 marks)



6.

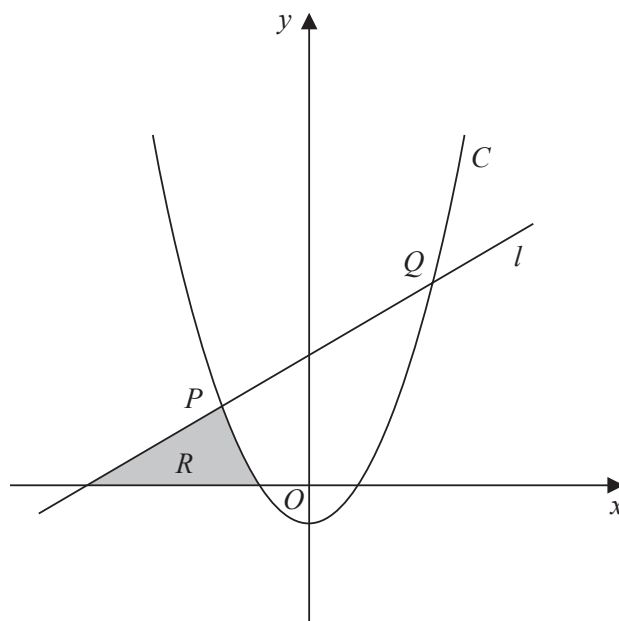


Figure 3

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

**Solutions relying on calculator technology are not acceptable.**

Figure 3 shows

- the line  $l$  with equation  $y - 5x = 75$
- the curve  $C$  with equation  $y = 2x^2 + x - 21$

The line  $l$  intersects the curve  $C$  at the points  $P$  and  $Q$ , as shown in Figure 3.

- (a) Find, using algebra, the coordinates of  $P$  and the coordinates of  $Q$ .

(4)

The region  $R$ , shown shaded in Figure 3, is bounded by  $C$ ,  $l$  and the  $x$ -axis.

- (b) Use inequalities to define the region  $R$ .

(3)

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Question 6 continued

Lined area for writing the answer to Question 6 continued.





(Total for Question 6 is / marks)



8.

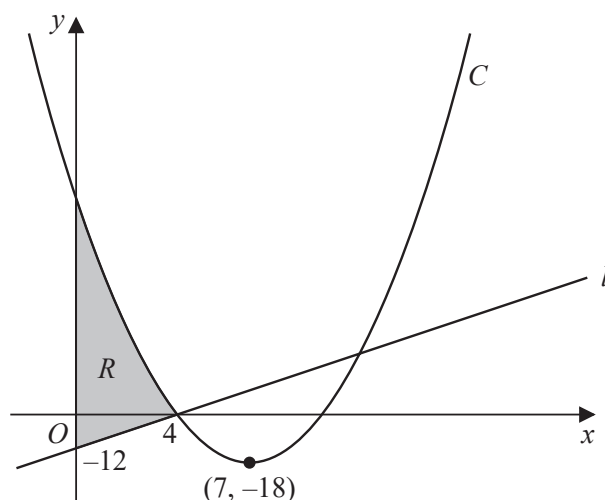


Figure 2

Figure 2 shows a sketch of the straight line  $l$  and the curve  $C$ .

Given that  $l$  cuts the  $y$ -axis at  $-12$  and cuts the  $x$ -axis at  $4$ , as shown in Figure 2,

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

(2)

Given that  $C$

- has equation  $y = f(x)$  where  $f(x)$  is a quadratic expression
- has a minimum point at  $(7, -18)$
- cuts the  $x$ -axis at  $4$  and at  $k$ , where  $k$  is a constant

- (b) deduce the value of  $k$ ,

(1)

- (c) find  $f(x)$ .

(3)

The region  $R$  is shown shaded in Figure 2.

- (d) Use inequalities to define  $R$ .

(2)

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Question 8 continued

Lined area for writing the answer to Question 8 continued.

**(Total for Question 8 is 8 marks)**



3.

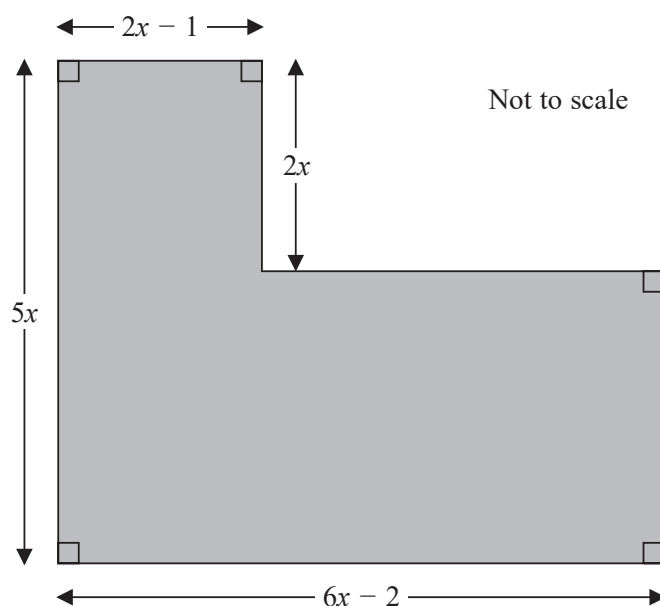
**Figure 1**

Figure 1 shows the plan of a garden. The marked angles are right angles.

The six edges are straight lines.

The lengths shown in the diagram are given in metres.

Given that the perimeter of the garden is greater than 29 m,

(a) show that  $x > 1.5$  m

**(3)**

Given also that the area of the garden is less than  $72 \text{ m}^2$ ,

(b) form and solve a quadratic inequality in  $x$ .

**(5)**

(c) Hence state the range of possible values of  $x$ .

**(1)**


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**Question 3 continued**

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**Question 3 continued**

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**(Total 9 marks)**

Q3



8.

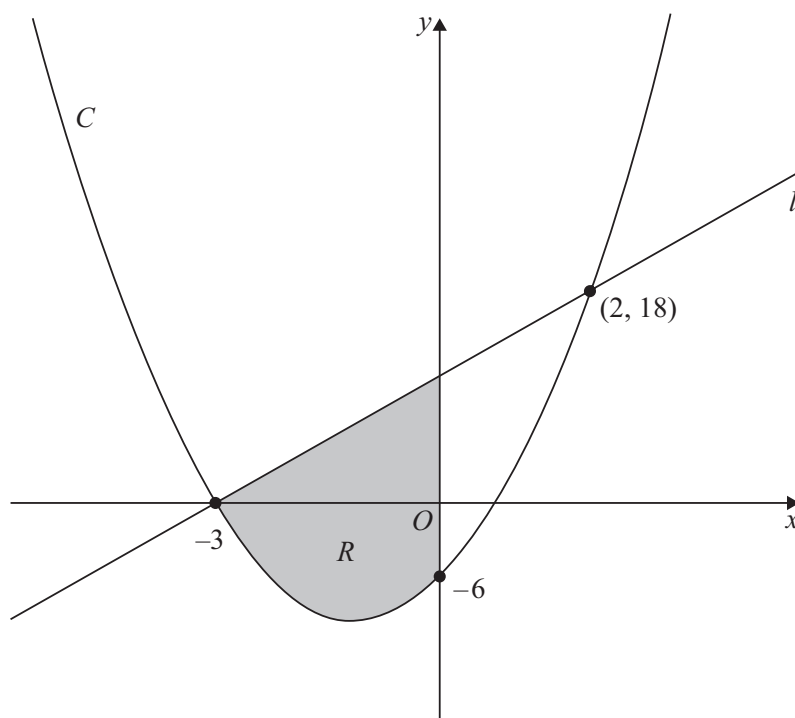


Figure 3

Figure 3 shows a sketch of a line  $l$  and a quadratic curve  $C$ .

Given that  $l$  passes through  $(-3, 0)$  and  $(2, 18)$

(a) find an equation for  $l$  in the form  $y = mx + c$  where  $m$  and  $c$  are constants.

(3)

Given that

- $C$  and  $l$  intersect at the points  $(-3, 0)$  and  $(2, 18)$
- $C$  crosses the  $y$ -axis at  $(0, -6)$

(b) find an equation for  $C$ .

(4)

The region  $R$ , shown shaded in Figure 3, is bounded by  $C$ ,  $l$  and the  $y$ -axis.

(c) Use inequalities to define  $R$ .

(2)

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Question 8 continued

Lined area for writing the answer to Question 8 continued.



Question 8 continued

Lined area for writing the answer to Question 8 continued.



Question 8 continued

Lined area for writing the answer to Question 8.

(Total for Question 8 is 9 marks)



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

Solutions relying on calculator technology are not acceptable.

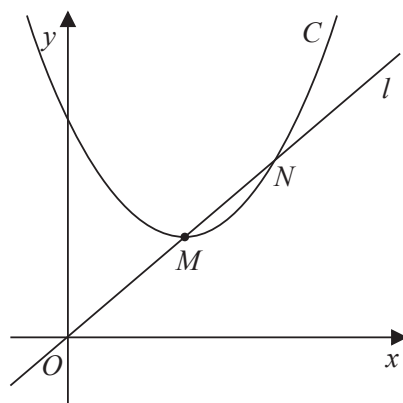


Figure 2

Figure 2 shows a sketch of the curve  $C$  with equation  $y = x^2 - 5x + 13$

The point  $M$  is the minimum point of  $C$ .

The straight line  $l$  passes through the origin  $O$  and intersects  $C$  at the points  $M$  and  $N$  as shown.

Find, showing your working,

(a) the coordinates of  $M$ , (3)

(b) the coordinates of  $N$ . (5)

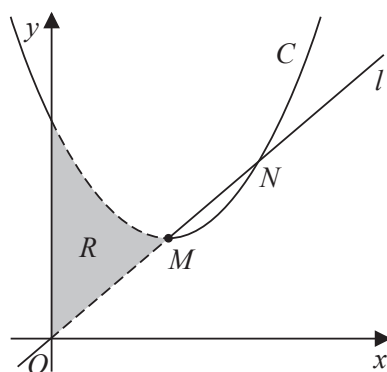


Figure 3

Figure 3 shows the curve  $C$  and the line  $l$ . The finite region  $R$ , shown shaded in Figure 3, is bounded by  $C$ ,  $l$  and the  $y$ -axis.

(c) Use inequalities to define the region  $R$ . (2)

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**(Total 10 marks)**

Q3



# MARK SCHEMES

official mark schemes, in the same order as the questions



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

(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.

| Question Number | Scheme                                                                                                                                 | Marks                                     |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------|
| <b>8</b>        | $x - 6x^{\frac{1}{2}} + 4 = 0$ $x^{\frac{1}{2}} = 3 \pm \sqrt{5} \text{ oe}$ $x = (3 \pm \sqrt{5})^2 \Rightarrow x = 14 \pm 6\sqrt{5}$ | M1 A1<br>M1 A1 A1<br><br><b>(5 marks)</b> |

M1 For attempting to solve an equation of the form  $y^2 - 6y + 4 = 0$  by completing the square or quadratic formula to reach at least one solution. There must be some working shown for this mark to be awarded, accept as a minimum identifying  $y = x^{\frac{1}{2}}$  and writing the quadratic in  $y$  before solutions.

A1  $\left(x^{\frac{1}{2}}\right) = 3 \pm \sqrt{5}$  Both required (though one may be later rejected) but need not be simplified, so accept  $\frac{6 \pm 2\sqrt{5}}{2}$

M1 For attempting to square a solution of the form  $p \pm q\sqrt{r}$  with 2 (out of 4) correct terms (may be implied by correct answers for their terms, but must have seen at least one solution for  $x^{\frac{1}{2}}$ )

A1  $x = 14 + 6\sqrt{5}$  **or**  $x = 14 - 6\sqrt{5}$  as an answer Accept equivalents for this mark.

A1  $x = 14 + 6\sqrt{5}$  **and**  $x = 14 - 6\sqrt{5}$  as answers, must be simplified.

Special Case: For candidates who show no initial working and write  $x^{\frac{1}{2}} = 3 \pm \sqrt{5}$  as their first step, M0A0M1A1A1 is possible if they go on to achieve correct answers

| Question Number | Scheme                                                                                                                                                            | Marks                               |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------|
| <b>8 Alt</b>    | $x + 4 = 6x^{\frac{1}{2}}$ $(x + 4)^2 = 36x$ $x^2 - 28x + 16 = 0 \Rightarrow (x - 14)^2 = 180 \Rightarrow x = 14 \pm \sqrt{180} \Rightarrow x = 14 \pm 6\sqrt{5}$ | M1 A1<br>M1 A1 A1<br><br><b>(5)</b> |

M1 Isolates the square root term and squares both sides.

A1 Correct squared expression,  $(x + 4)^2$  need not be expanded (as in scheme).

M1 Expands and solves the quadratic in  $x$  Note that candidates who square term by term will score no marks.

A1A1 As main scheme. Note for the final A both solutions must be fully simplified.



A1  $10\sqrt{2} + 10$  or  $10 + 10\sqrt{2}$  only. It cannot be awarded without sight of the correct intermediate line seen above

| Question Number | Scheme                                                                                                                                                                                                                                 | Marks                               |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------|
| <b>3.(a)</b>    | Attempts perimeter of garden = $2 \times 5x + 2 \times (6x - 2)$<br>Sets $2 \times 5x + 2 \times (6x - 2) > 29 \Rightarrow 22x > 33$<br>$\Rightarrow x > \frac{33}{22} \Rightarrow x > 1.5$ *                                          | M1<br>dM1<br>A1*<br>(3)             |
| <b>(b)</b>      | Attempts area of garden = $2x(2x - 1) + 3x(6x - 2)$<br>Sets $A < 72 \Rightarrow 22x^2 - 8x - 72 < 0$<br>Finds critical values $11x^2 - 4x - 36 \Rightarrow x = -\frac{18}{11}, 2$<br>Chooses inside region<br>$-\frac{18}{11} < x < 2$ | M1<br>A1<br>M1<br>ddM1<br>A1<br>(5) |
| <b>(c)</b>      | $1.5 < x < 2$                                                                                                                                                                                                                          | B1<br>(1)                           |
|                 |                                                                                                                                                                                                                                        | <b>(9 marks)</b>                    |

(a)

M1 An attempt at finding the perimeter of the garden.

Scored for sight of  $5x + 2x - 1 + 2x + 6x - 2 +$  additional term(s) involving  $x$

Individual lengths may not be seen so imply for sight of a total of  $ax + b$ , where  $a > 15$

dM1 Sets their  $P > 29$  and attempts to solve by proceeding to  $ax > c$

You may condone an attempt in which  $P = 29 \Rightarrow ax = c$

A1\* cso with at least one correct intermediate (simplified) line  $22x > 33$  or  $x > \frac{33}{22}$  before  $x > 1.5$  seen.

Condone an attempt in which you see  $P = 29 \Rightarrow x = 1.5$  before  $x > 1.5$  seen

Note that it is possible to start with  $x > 1.5$  and prove  $P > 29$  but for the A1\* to be scored there must be a final statement of the type "hence  $x > 1.5$ ". There is no requirement for any units

(b) **Mark part (b) and (c) together**

M1 For an attempt at finding the area of the garden. For this to be scored look for

The sum of two areas  $2x(2x - 1) + \dots x(6x - 2)$  condoning slips

The sum of two areas  $5x(2x - 1) + \dots x(\dots x \pm \dots)$  condoning slips

The difference between two areas  $5x(6x - 2) - 2x(\dots x \pm \dots)$  condoning slips.

A1 A "correct and simplified" equality or inequality, condoning  $< \leftrightarrow \leq \leftrightarrow =$  Eg.  $22x^2 - 8x - 72 < 0$  oe

M1 A valid attempt to find the critical values of their 3TQ. Allow factorisation, formula, completion of square or use of calculator. If a calculator is used then the answer(s) must be correct for their 3TQ. Condone candidates who fail to state the negative root of their quadratic.

ddM1 Dependent upon both M's. For choosing the inside region for their critical values. Condone  $< \leftrightarrow \leq$

Condone for this mark replacing a negative root with 0, 0.5 or 1.5. So accept for example one of either  $1.5 < x < 2$ ,  $0 < x < 2$  or  $0.5 < x < 2$

A1  $-\frac{18}{11} < x < 2$  Allow  $0 < x < 2$  or  $0.5 < x < 2$  due to context. Allow alternative notation. See below

(c)



| Question Number | Scheme                                                                                                                                                                                                   | Marks                                  |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------|
| 1.              | $\int \left( \frac{8}{3}x^3 - \frac{1}{2}x^{\frac{1}{2}} - 5 \right) dx = \frac{8}{3} \times \frac{x^4}{4} - \frac{1}{2} \times 2x^{\frac{1}{2}} - 5x + c$ $= \frac{2}{3}x^4 - x^{\frac{1}{2}} - 5x + c$ | M1 A1<br><br>A1 A1<br><b>(4 marks)</b> |

M1 For raising a power of  $x$  by 1 seen at least once (i.e.  $x^n \rightarrow x^{n+1}$ ) or  $-5 \rightarrow -5x$ .  
The index does not have to be processed for this mark.

Award following incorrect manipulations eg  $-\frac{1}{2\sqrt{x}} \rightarrow \dots x^{\frac{1}{2}} \rightarrow \dots x^{\frac{3}{2}}$

A1 For two of  $\frac{8}{3} \times \frac{x^4}{4}$ ,  $-\frac{1}{2} \times 2x^{\frac{1}{2}}$ ,  $-5x^1$  correct (unsimplified).

This may be implied by a correct simplified answer. May be seen on different lines. Indices must be processed. Ignore any spurious notation for any of the A marks.

A1 For two of  $\frac{2}{3}x^4$ ,  $-x^{\frac{1}{2}}$ ,  $-5x$  correct and in simplest form. Accept forms such as  $\frac{2x^4}{3}$  and  $-\sqrt{x}$

Condone  $-5x^1$ ,  $-1x^{\frac{1}{2}}$  but not  $-\frac{5x}{1}$ . Correct terms may be seen on different lines. Allow  $\frac{2}{3}$  to be written as  $0.\dot{6}$  or  $0.6666\dots$  only (must be exact)

A1 Fully correct **on one line**, and simplified with  $+c$ . Accept simplified equivalents (see above)

| Question Number | Scheme                                                                              | Marks            |
|-----------------|-------------------------------------------------------------------------------------|------------------|
| <b>2 (a)</b>    | $3^{3x} = (3^x)^3 = y^3$                                                            | B1<br>(1)        |
| <b>(b)</b>      | $\frac{1}{3^{x-2}} = \frac{1}{3^x \times 3^{-2}} = \frac{9}{y}$                     | M1 A1<br>(2)     |
| <b>(c)</b>      | $\frac{81}{9^{2-3x}} = \frac{9^2}{9^{2-3x}} = 9^{2-(2-3x)} = 9^{3x} = 3^{6x} = y^6$ | M1 A1<br>(2)     |
|                 |                                                                                     | <b>(5 marks)</b> |

**Note: Correct answer in any part implies full marks for that part**

(a)

B1  $y^3$  Condone  $(y)^3$ . Ignore once correct answer seen.

(b)

M1 For correct application of the addition/subtraction law so award for eg:

$$\frac{1}{3^x \times 3^{-2}} \text{ or } \frac{1}{3^x \div 3^2} \text{ or } \frac{1}{\left(\frac{3^x}{3^2}\right)} \text{ or } \frac{1}{y \times 3^{-2}} \text{ or } \frac{3^2}{3^x} \text{ or sight of } 9 \text{ or } \frac{1}{y} \text{ oe}$$

A1 For  $\frac{9}{y}$  or  $9y^{-1}$  but NOT expressions that still contain  $\div$  or fractions within fractions or  $3^2 y^{-1}$ . Ignore once correct answer seen.

(c)

M1 For simplifying the indices to expressions of the form  $9^{\dots}$  or  $3^{\dots}$  (not as a denominator) so award for  $9^{3x}$ ,  $(9^x)^3$ ,  $3^{6x}$ ,  $(3^x)^6$ , or  $k \times y^6$ ,  $k \neq 0$  which must come from correct working. Also allow unsimplified equivalent expressions of the final answer eg  $\frac{1}{y^{-6}}$  as long as it is in terms of  $y$

A1  $y^6$  only (not eg  $\frac{1}{y^{-6}}$ ). Ignore once correct answer seen. Condon  $(y)^6$

Note: In all parts they may work from  $y = 3^x$  and manipulate both sides to the given answer which is acceptable.

Eg part (b):  $y = 3^x \Rightarrow y \times 3^{-2} = 3^{x-2}$  (M1)  $\Rightarrow \frac{1}{y \times 3^{-2}} = \frac{1}{3^{x-2}} \Rightarrow \frac{9}{y} = \frac{1}{3^{x-2}}$  (A1)

Eg part (c):  $y = 3^x \Rightarrow y^{-6} = 3^{-6x} \Rightarrow 81y^{-6} = 3^{4-6x}$  (M1)  $\Rightarrow 81y^{-6} = 9^{2-3x} \Rightarrow \frac{81}{9^{2-3x}} = y^6$  (A1)



| Question | Scheme                                                                                                                                                                                                                                                                                                              | Marks                             |
|----------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------|
| 2(a)     | $b = 2$<br>$\dots \pm \dots (x \pm 3)^2$<br>$(f(x) =) 21 - 2(x - 3)^2$                                                                                                                                                                                                                                              | B1<br><br>M1<br><br>A1            |
|          |                                                                                                                                                                                                                                                                                                                     | (3)                               |
| (b)      | $R \text{ is } (0, -4) \text{ or } "h" = 4$<br>$f(x) - 7 = 14 - 2(x - 3)^2 \Rightarrow x = \dots \quad \text{or} \quad f(x) - 7 = -4 + 12x - 2x^2 \Rightarrow x = \dots$<br>$(\text{NB } x = 3 \pm \sqrt{7})$<br>$\text{Area} = \frac{1}{2} \times ("3 + \sqrt{7}" - ("3 - \sqrt{7}")) \times "4"$<br>$= 4\sqrt{7}$ | B1<br><br>M1<br><br>dM1<br><br>A1 |
|          |                                                                                                                                                                                                                                                                                                                     | (4)                               |
|          |                                                                                                                                                                                                                                                                                                                     | (7 marks)                         |

## Notes

(a)

**B1**  $b = 2$  implied from their expression or stated. Eg look for  $-2(x \pm \dots)^2$ Beware of expressions such as  $21 + 2(x - 3)^2$  which would be B0**M1** Sight of  $(x \pm 3)^2$ **A1**  $21 - 2(x - 3)^2$ . Condone  $21 - 2(x + -3)^2$  or they may state the values for  $a, b$  and  $c$ . If there is a contradiction between what appears to be their final expression and values for  $a, b$  or  $c$  which are incorrectly stated afterwards then treat this as isw.

(b)

**B1**  $R \text{ is } (0, -4) \text{ or } "h" = 4$  (The coordinate may be seen on a diagram as a point of their triangle or quadratic so allow just  $-4$  rather than the full coordinate to be indicated on the  $y$ -axis). It may also be implied by their working.**M1** Attempts to solve  $f(x) - 7 = 0$ 

Score for an attempt to solve a 3TQ of the form:

 $-2x^2 + 12x + C = 0$  where  $C \neq 3$  or  $A - 2(x - 3)^2 = 0$  where  $A \neq 21$ or if they use their part (a)  $"a" - "b"(x + "c")^2 = 0 \Rightarrow d - "b"(x + "c")^2 = 0$  where  $d \neq a$ 

(It must have a different  $y$  intercept to the given  $f(x)$  or their  $f(x)$  from part (a) but the coefficients of  $x$  and  $x^2$  must remain the same.)

Condone slips in their working. They should be solving their quadratic using either the formula or completing the square. (usual rules for solving). Allow to be solved directly from a calculator. If only the roots are written, then these will need to be checked.

**dM1** Fully correct method for the area of their triangle. It is dependent on the previous method mark.

Score for values embedded in  $\frac{1}{2} \times (\beta - \alpha) \times "y\text{-intercept}"$  where  $\alpha, \beta$  are the roots of their 3TQ.

This should be  $\frac{1}{2} \times (2 \times \sqrt{\dots}) \times "y\text{-intercept}"$  oe

Alternatively, if their quadratic has a negative  $y$ -intercept they may find the area of a large right-angled triangle and subtract the area of the small right-angled triangle. Look for expressions of the form:

$$\frac{1}{2} \times \beta \times "y\text{-intercept}" - \frac{1}{2} \times \alpha \times "y\text{-intercept}"$$

They may even attempt finding all the lengths of the triangle, applying the cosine rule to find an angle and then applying the area sine rule. (See diagrams below).

Alternatively, they may apply the shoelace method:

$$\frac{1}{2} \left| (3 + \sqrt{7}) \times 0 + (3 - \sqrt{7}) \times (-4) + 0 \times 0 - (0 \times (3 - \sqrt{7}) + 0 \times 0 + (-4) \times (3 + \sqrt{7})) \right| = 4\sqrt{7} \text{ oe}$$

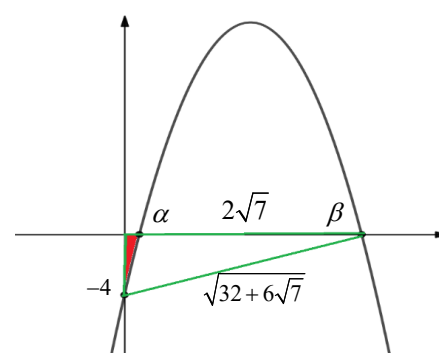
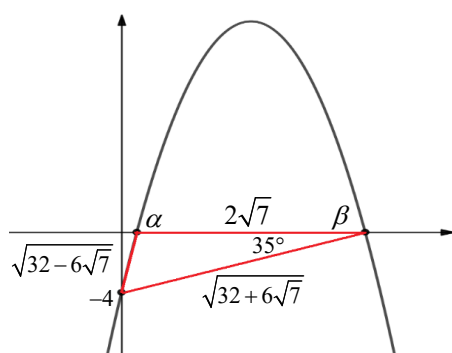
You may see other credit worthy methods so if in doubt send to review.

**A1**  $4\sqrt{7}$  Cao (Allow e.g.  $= 2\sqrt{28}, \sqrt{112}$ ). They may work in decimals and state the correct exact answer of  $4\sqrt{7}$  which can score full marks **if it follows from a correct method**.

**Note**

$$f(x) + 7 = 0 \Rightarrow 28 - 2(x - 3)^2 \text{ or } 10 + 12x - 2x^2 \Rightarrow x = 3 \pm \sqrt{14} \Rightarrow \text{Area} = \frac{1}{2} \times (2\sqrt{14}) \times 10 = 10\sqrt{14}$$

would score B0M1M1A0



$$\text{Large triangle} = 6 + 2\sqrt{7} = 11.29\dots$$

$$\text{Small triangle} = 6 - 2\sqrt{7} = 0.708\dots$$

| Question          | Scheme                                                                                                                                                                                                                                                                                                                                                   | Marks                 |
|-------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|
| <b>3(a)</b>       | $\frac{1}{2} \times 3^2 \times \alpha = 7.2 \Rightarrow \alpha = \dots \text{ or } \frac{1}{2} \times 3^2 \times 1.6 = 7.2 \Rightarrow \alpha = 1.6$ $\alpha = 1.6^*$                                                                                                                                                                                    | M1<br>A1*             |
|                   |                                                                                                                                                                                                                                                                                                                                                          | <b>(2)</b>            |
| <b>(b)(i)</b>     | $\text{Angle } COA = \frac{1}{2}(2\pi - 1.6) (= 2.34\dots) \quad (\approx 134^\circ)$ $\text{Area } COA = \frac{1}{2} \times 5 \times 3 \sin("2.34") \quad (= 5.38\dots)$ $\text{Total Area} = 2 \times \frac{1}{2} \times 5 \times 3 \sin("2.34") + 7.2$ $= 18 \text{ (cm}^2\text{)} \quad \text{Awrt } 18 \text{ (cm}^2\text{)} \text{ (Ans = 17.96)}$ | M1<br>M1<br>dM1<br>A1 |
| <b>(ii)</b>       | $\text{Arc } AB = 3 \times 1.6 (= 4.8)$ $(AC^2 =) 5^2 + 3^2 - 2 \times 5 \times 3 \cos("2.34")$ $\text{Total perimeter} = 2 \times \sqrt{5^2 + 3^2 - 2 \times 5 \times 3 \cos("2.34")} + 3 \times 1.6$ $= \text{Awrt } 19.6 \text{ (cm)}$                                                                                                                | B1<br>M1<br>dM1<br>A1 |
|                   |                                                                                                                                                                                                                                                                                                                                                          | <b>(8)</b>            |
| <b>Alt (b)(i)</b> | $AB = 2 \times 3 \sin 0.8$ $ON = 3 \cos 0.8$ $\text{Total Area} = \frac{1}{2}(5 + ON) \times AB + 7.2 - \frac{1}{2} \times 3 \cos 0.8 \times 2 \times 3 \sin 0.8$ $= 18 \text{ (cm}^2\text{)} \quad \text{Awrt } 18 \text{ (cm}^2\text{)} \text{ (Ans = 17.96)}$                                                                                         | M1<br>M1<br>dM1<br>A1 |
|                   |                                                                                                                                                                                                                                                                                                                                                          | <b>(10 marks)</b>     |

**Notes****(a)**

**M1** Uses a correct sector area formula and 7.2 to find the value for  $\alpha$ . They should show the values embedded in the equation and proceed to find a value for  $\alpha$ .

Alternatively, substitutes in  $\alpha = 1.6$  into the area of a sector formula and achieves 7.2.

**A1\*** Correct proof starting with  $\frac{1}{2} \times 3^2 \times \alpha = 7.2$  and at least one intermediate line of working and no

errors. Eg  $\frac{1}{2} \times 3^2 \times \alpha = 7.2 \Rightarrow \alpha = \frac{7.2}{4.5} = 1.6$  scores M1A1

Alternatively, they must conclude that  $\alpha = 1.6$  or if there is a preamble then there should be some form of completion which could be a tick, QED etc.

If they use a different variable such as  $\theta$  they must state/link somewhere that  $\alpha = 1.6$



| 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



**Do NOT allow solutions that rely on huge jumps. The M marks must be awarded as above.**

For example

$$\frac{\sqrt{180} - \sqrt{80}}{\sqrt{5}} = \frac{(\sqrt{180} - \sqrt{80}) \times \sqrt{5}}{\sqrt{5} \times \sqrt{5}} = \frac{30 - 20}{5} = 2 \text{ scores M0 A0}$$

without sight of  $\sqrt{180} \times \sqrt{5}$  as  $\sqrt{900}$  or  $\sqrt{80} \times \sqrt{5}$  as  $\sqrt{400}$  o.e.

Or

$$\frac{\sqrt{180} - \sqrt{80}}{\sqrt{5}} = \frac{2\sqrt{5}}{\sqrt{5}} = 2 \text{ scores M0 A0 without sight of } \sqrt{180} \text{ as } 6\sqrt{5} \text{ or } \sqrt{80} \text{ as } 4\sqrt{5}$$

(ii)

**Main method**

**M1:** Correct attempt to rationalise. Look for attempt at multiplying numerator and denominator by  $7 + 3\sqrt{5}$   
The multiplications need not be carried out for this mark.

**dM1:** It is dependent upon the previous mark. Scored for

- Correct expression for denominator (without surds) Accept as shown, or as  $7^2 - 3^2 \times 5$  or just 4
- and attempts to multiply out the numerator with the sight of 4 terms . Condone slips here. See \*\*\*

**A1:** Correct answer any way around. Allow  $6.25 + 3.25\sqrt{5}$

Do NOT allow in the form  $\frac{25 + 13\sqrt{5}}{4}$  but accept if followed by "hence  $a = \frac{25}{4}, b = \frac{13}{4}$  "

(ii) **Alt method**

**M1:** Sets  $\frac{4\sqrt{5} - 5}{7 - 3\sqrt{5}} = a + b\sqrt{5} \Rightarrow 4\sqrt{5} - 5 = (a + b\sqrt{5})(7 - 3\sqrt{5})$  and attempts to set up simultaneous

equations in  $a$  and  $b$ . FYI the correct equations are  $7a - 15b = -5, 7b - 3a = 4$

**dM1:** Attempts to solve their equations. They must have at least one correct equation

**A1:** Correct answer. Must be  $\frac{25}{4} + \frac{13}{4}\sqrt{5}$  and not **just** values of  $a$  and  $b$

The following solution is a minimally acceptable solution for 3 marks, the first M1 being implied.

$$\frac{4\sqrt{5} - 5}{7 - 3\sqrt{5}} = \frac{(4\sqrt{5} - 5) \times (7 + 3\sqrt{5})}{4} = \frac{28\sqrt{5} - 35 + 60 - 15\sqrt{5}}{4} = \frac{13}{4}\sqrt{5} + \frac{25}{4} \quad ***$$



| Question Number | Scheme                                                                                                                                                                              | Marks                                  |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------|
| 1.              | $\int \frac{2}{3}x^3 - \frac{1}{2x^3} + 5 \, dx = \frac{2}{3} \times \frac{x^4}{4} - \frac{1}{2} \times \frac{x^{-2}}{-2} + 5x + c$ $= \frac{1}{6}x^4 + \frac{1}{4}x^{-2} + 5x + c$ | M1 A1<br><br>A1 A1<br><b>(4 marks)</b> |

M1 For raising any power by 1 eg.  $x^3 \rightarrow x^4$ ,  $x^{-3} \rightarrow x^{-2}$ ,  $5 \rightarrow 5x$  or eg.  $x^3 \rightarrow x^{3+1}$

A1 For two of  $\frac{2}{3} \times \frac{x^4}{4}$ ,  $-\frac{1}{2} \times \frac{x^{-2}}{-2}$ ,  $+5x$  correct (un-simplified). Accept  $5x^1$

This may be implied by a correct simplified answer

A1 For two of  $\frac{1}{6}x^4$ ,  $+\frac{1}{4}x^{-2}$ ,  $+5x$  correct and in simplest form. Accept forms such as  $\frac{x^4}{6}$ ,  $\frac{1}{4x^2}$ ,

CONDONE  $+\frac{0.25}{x^2}$  but NOT  $\frac{1/4}{x^2}$ ,  $\frac{5x}{1}$ ,  $-\left(-\frac{1}{4}x^{-2}\right)$

A1 Fully correct and simplified with  $+c$  all on one line. Accept simplified equivalents (see above) and ignore any spurious notation. ISW after a correct simplified answer is achieved.

A common mistake is writing  $-\frac{1}{2x^3} = -2x^{-3} \rightarrow -x^{-2}$  this can still get the method mark for increasing the power by 1.



| Question Number | Scheme                                                                                                                                                                                                                                                                                                                                              | Marks                                                   |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------|
| 2.              | <p>Attempts both sides as powers of 3 <math>\frac{3^x}{3^{4y}} = 3^3 \times 3^{0.5} \Rightarrow 3^{x-4y} = 3^{3.5}</math></p> <p>Sets powers equal and attempts to makes y the subject :<br/> <math>x - 4y = 3.5 \Rightarrow y = \dots</math></p> $y = \frac{1}{4}x - \frac{7}{8}$                                                                  | <p>M1</p> <p>dM1</p> <p>A1</p> <p>(3)<br/>(3 marks)</p> |
| Alt1            | <p>Multiplies by <math>3^{4y}</math> first:</p> <p>Attempts both sides as powers of 3 <math>3^x = 27\sqrt{3} \times 3^{4y} \Rightarrow 3^x = 3^{3.5+4y}</math><br/> (Addition law on RHS)</p> <p>Sets powers equal and makes y the subject <math>x = 3.5 + 4y \Rightarrow y = \dots</math></p> $y = \frac{1}{4}x - \frac{7}{8}$                     | <p>M1</p> <p>dM1</p> <p>A1</p>                          |
| Alt2            | <p>Divides by <math>27\sqrt{3}</math> first:</p> <p>Attempts both sides as powers of 3 <math>\frac{3^x}{3^{4y} \times 27\sqrt{3}} = 1 \Rightarrow 3^{x-4y-3.5} = 3^0</math><br/> (Subtraction law on LHS)</p> <p>Sets powers equal and makes y the subject <math>x - 3.5 - 4y = 0 \Rightarrow y = \dots</math></p> $y = \frac{1}{4}x - \frac{7}{8}$ | <p>M1</p> <p>dM1</p> <p>A1</p>                          |
| Alt3            | <p>Takes logs of both sides</p> <p>Eg Base 3: <math>\log_3 \left( \frac{3^x}{3^{4y}} \right) = \log_3 (27\sqrt{3})</math></p> $\log_3 3^x - \log_3 3^{4y} = \log_3 27\sqrt{3}$ $x - 4y = 3.5 \Rightarrow y = \dots$ $y = \frac{1}{4}x - \frac{7}{8}$                                                                                                | <p>M1</p> <p>dM1</p> <p>A1</p>                          |



- M1 Attempts to use the subtraction law on the LHS and the addition law on the RHS to achieve a form of  $3^{\dots} = 3^{\dots}$

Condone errors writing  $27\sqrt{3}$  as a single power of 3 but it must be clear what the two indices are before adding if they make an error ( $27 = 3^a$  and  $\sqrt{3} = 3^b$  so  $27\sqrt{3} = 3^{a+b}$ )

A common mistake is to write  $27\sqrt{3} \Rightarrow \sqrt{9} \times \sqrt{3} \times \sqrt{3} = 3^2$  which can be condoned and they can still get M1M1A0.

They may rearrange the equation first so look for attempts at the appropriate index laws being applied (see alternatives). In Alt2 allow the RHS=1.

They may use logs on both sides (the most likely would be base 3 - see Alt3) To score M1 they would need to take logs and then apply the laws of logs to either add or subtract.

- dM1 Dependent upon the previous M mark, it is for an attempt to make  $y$  the subject. For this mark follow through their power for  $27\sqrt{3}$  but they must have 3 terms in their equation relating to the powers and they cannot “lose” one in the rearrangement. (i.e  $ax + by + c = 0$  or where  $a, b, c \neq 0$ ) Do not award this mark if they rearrange to make  $x$  the subject. Condone sign slips only.

- A1  $y = \frac{1}{4}x - \frac{7}{8}$  or exact simplified equivalent eg  $y = \frac{2x-7}{8}$ ,  $y = 0.25x - 0.875$

DO NOT ACCEPT  $y = \frac{x - \frac{7}{2}}{4}$  or  $y = \frac{x - 3.5}{4}$



| Question         | Scheme                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Marks      |
|------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|
| 1                | $4x^2 - 3x + 7 \geq 4x + 9$ $\Rightarrow 4x^2 - 7x - 2 \dots 0 \Rightarrow (4x+1)(x-2) \dots 0 \Rightarrow x = \dots$ <p style="text-align: center;">or</p> $\Rightarrow 4x^2 - 7x - 2 \dots 0 \Rightarrow x = \frac{-(-7) \pm \sqrt{(-7)^2 - 4(4)(-2)}}{2 \times 4} \Rightarrow x = \dots$ <p style="text-align: center;">or</p> $\Rightarrow 4x^2 - 7x - 2 \dots 0 \Rightarrow 4\left(x^2 - \frac{7}{4}x - \frac{1}{2}\right) \dots 0 \Rightarrow 4\left(\left(x - \frac{7}{8}\right)^2 - \left(\frac{7}{8}\right)^2 - \frac{1}{2}\right) \dots 0 \Rightarrow x = \dots$ | <b>M1</b>  |
|                  | $x = -\frac{1}{4}, 2$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |            |
|                  | $x \leq -\frac{1}{4}, \quad x \geq 2$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |            |
|                  | $x \leq -\frac{1}{4} \text{ or } x \geq 2 \text{ oe}$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |            |
|                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |            |
|                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | <b>(4)</b> |
| <b>(4 marks)</b> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |            |

**Notes:**

**M1:** Gathers terms to one side and solves their 3TQ which is not  $4x^2 - 3x + 7 = 0$  to obtain at least one critical value for  $x$ . Allow by factorisation, the quadratic formula or completing the square. Do not be concerned about the inequality symbol for the first two marks and the "...0" can be implied.

Note that  $4x^2 - 7x - 2 \dots 0 \Rightarrow \left(x + \frac{1}{4}\right)(x - 2) \dots 0 \Rightarrow x = \dots$  scores M0

For completing the square, the conditions for their  $4x^2 - 7x - 2 \dots 0$  are as follows:

Either  $4x^2 - 7x - 2 \dots 0 \Rightarrow 4\left(x^2 + bx + c\right) \dots 0$  then as general guidance

Or  $4x^2 - 7x - 2 \dots 0 \Rightarrow \left(2x - \frac{7}{4}\right)^2 \pm q \pm 2 \dots 0 \Rightarrow x = \dots$

**A1:** Both correct critical values. Allow unsimplified but must be single fractions e.g. allow  $-\frac{2}{8}, \frac{16}{8}$

These values may be seen embedded in their final answer but the **first M1 must have been scored**.

**M1:** Chooses the outside region for their 2 critical values. Allow with < and > for this mark.

Condone poor notation e.g.  $-\frac{1}{4} \geq x \geq 2$  or e.g.  $-\frac{1}{4} > x > 2$  or e.g.  $2 < x < -\frac{1}{4}$

**A1:** Correct solution only – **depends on all previous marks**. Allow e.g.  $x \leq -\frac{1}{4}, x \geq 2$  ;

$x \leq -\frac{1}{4}$  and  $x \geq 2$  ;  $\left(-\infty, -\frac{1}{4}\right], [2, \infty)$  ;  $\left(-\infty, -\frac{1}{4}\right)$  or  $[2, \infty)$  ;  $\left(-\infty, -\frac{1}{4}\right]$  and  $[2, \infty)$

Do **not** allow  $-\frac{1}{4} \geq x \geq 2$  ;  $x \leq -\frac{1}{4} \cap x \geq 2$  ;  $\left(-\infty, -\frac{1}{4}\right) \cap [2, \infty)$

Allow unsimplified constants but must be single fractions e.g. allow  $-\frac{2}{8}, \frac{16}{8}$  as above.



**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 square**Solving  $x^2 + bx + c = 0$ :  $\left(x \pm \frac{b}{2}\right)^2 \pm q \pm c = 0$ ,  $q \neq 0$ , 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**

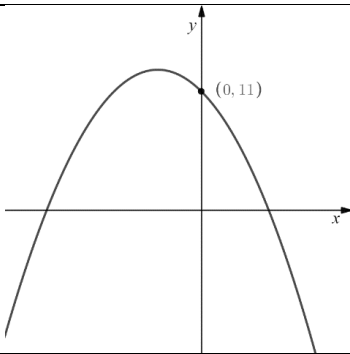
$$4x^2 - 3x + 7 \geq 4x + 9 \Rightarrow 4x^2 - 7x - 2 \geq 0$$

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

Scores M0A0M0A0



| Question                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Scheme                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Marks                    |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|
| 7(a)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | $0 = 10 - 2x \Rightarrow x = 5$ or $y = 2, y = 10 - 2x \Rightarrow x = 4$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | <b>B1</b>                |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | <p><b>Examples:</b></p> $\frac{1}{2} \times 2(5 + 4 - a) = \frac{27}{4} \text{ or } \frac{1}{2} \times 2\left(5 + 4 - \frac{2}{k}\right) = \frac{27}{4}$ <p>Trapezium<br/>or</p> $\frac{1}{2} \times 2a + \frac{1}{2} \times 2(5 - a + 4 - a) = \frac{27}{4} \text{ or } \frac{1}{2} \times 2 \times \frac{2}{k} + \frac{1}{2} \times 2\left(5 - \frac{2}{k} + 4 - \frac{2}{k}\right) = \frac{27}{4}$ <p>Triangle + Trapezium<br/>or</p> $\frac{1}{2} \times 2a + 2(4 - a) + \frac{1}{2} \times 1 \times 2 = \frac{27}{4} \text{ or } \frac{1}{2} \times 2 \times \frac{2}{k} + 2\left(4 - \frac{2}{k}\right) + \frac{1}{2} \times 1 \times 2 = \frac{27}{4}$ <p>Triangle + Rectangle + Triangle<br/>or</p> $\frac{1}{2} \times 5 \times 2 + \frac{1}{2}(4 - a) \times 2 = \frac{27}{4} \text{ or } \frac{1}{2} \times 5 \times 2 + \frac{1}{2}\left(4 - \frac{2}{k}\right) \times 2 = \frac{27}{4}$ <p>2 Triangles</p> | <b>M1</b>                |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | $\Rightarrow k = \frac{8}{9}, a = \frac{9}{4}$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | <b>A1</b><br><b>A1ft</b> |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | <b>(4)</b>               |
| (b)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Two of $y \geq \frac{8}{9}x, y \leq 10 - 2x, x > \frac{9}{4}$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | <b>M1</b>                |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | All three of $y \geq \frac{8}{9}x, y \leq 10 - 2x, x > \frac{9}{4}$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | <b>A1</b>                |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | <b>(2)</b>               |
| <b>(6 marks)</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                          |
| <b>Notes:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                          |
| <p><b>(a)</b><br/> <b>B1:</b> Correct x intercept for <math>y = 10 - 2x</math> or correct x coordinate for intersection of <math>y = 2</math> with <math>y = 10 - 2x</math>. May be seen on the diagram or in a sketch or implied by their working.<br/> <b>M1:</b> Correct method for area and sets equal to <math>\frac{27}{4}</math> to form an equation in <math>a</math> or <math>k</math>. The <math>2 \times \frac{1}{2}</math> may be implied. May use e.g. trapezium, triangle + trapezium, triangle + rectangle + triangle or 2 triangles. See above for some examples. Note that with a correct “5” and “4” the area is <math>9 - a</math> or <math>9 - \frac{2}{k}</math>.<br/> <b>A1:</b> Correct value for <math>a</math> or <math>k</math> as a single value not a calculation.<br/> <b>A1ft:</b> Correct values for <math>a</math> and <math>k</math>. Correct values or follow through using <math>ak = 2</math> from their first value to the second <b>provided the M1 is scored</b>. Allow exact equivalents or exact ft equivalents so if correct allow e.g. <math>k = 0.\dot{8}</math>, <math>a = 2.25</math> or <math>2\frac{1}{4}</math></p> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                          |

| Question Number | Scheme                                                                                                        | Marks          |
|-----------------|---------------------------------------------------------------------------------------------------------------|----------------|
| <b>2(a)</b>     | $f(x) = 11 - 4x - 2x^2$<br>$\Rightarrow \dots - 2(2x + x^2) \dots$ or $\Rightarrow \dots - 2(2x + x^2 \dots)$ | B1             |
|                 | $\dots(2x + x^2) \Rightarrow \dots((x+1)^2 \pm \dots)$                                                        | M1             |
|                 | $(f(x) =) 13 - 2(x+1)^2$                                                                                      | A1             |
|                 |                                                                                                               | <b>(3)</b>     |
| <b>(b)</b>      |                             | M1             |
|                 |                                                                                                               | A1             |
|                 |                                                                                                               | <b>(2)</b>     |
| <b>(c)</b>      | $x = -1$                                                                                                      | B1ft           |
|                 |                                                                                                               | <b>(1)</b>     |
|                 |                                                                                                               | <b>Total 6</b> |
| <b>Alt(a)</b>   | $a + b(x^2 + 2cx + c^2) = 11 - 4x - 2x^2$                                                                     | B1             |
|                 | $b = -2$                                                                                                      |                |
|                 | $2bc = -4 \Rightarrow c = \dots (=1)$                                                                         | M1             |
|                 | $a + bc^2 = -4 \Rightarrow a = \dots (=13)$<br><br>$(f(x) =) 13 - 2(x+1)^2$                                   | A1             |

**(a)**B1:  $b = -2$ M1: Attempts to complete the square on  $x^2 \pm 2x$  so score for  $(x \pm 1)^2 \pm \dots$  or alternatively attempts to compare coefficients to find a value for  $c$ .Condone  $11 - 4x - 2x^2 \Rightarrow \dots - 2(2x - x^2) \dots \Rightarrow -2(x \pm 1)^2 \pm \dots$ A1:  $13 - 2(x+1)^2$ . If  $a$ ,  $b$  and  $c$  are stated and there is a contradiction then mark their final expression. Condone  $13 + -2(x+1)^2$  or just the values of  $a$ ,  $b$  and  $c$  being stated.

(b)

M1:  $\cap$  shape anywhere on a set of axes Cannot be a part of other functions (eg a cubic).  
See examples below

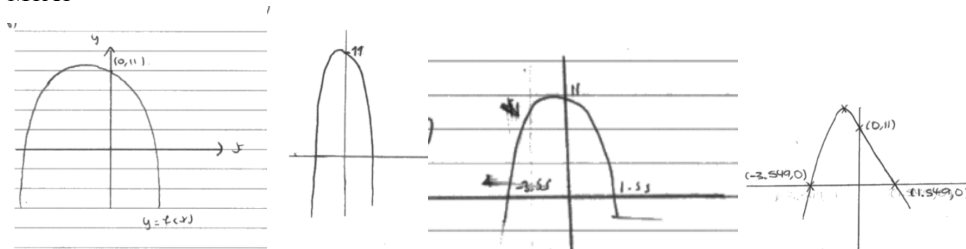
A1: Correct shape that cuts  $x$ -axis once either side of the origin, maximum in quadrant 2 and  $y$  intercept  $(0, 11)$  or 11 marked on  $y$ -axis. Condone  $(11, 0)$  if the intercept is in the correct place. Do not be concerned with any labelled  $x$ -intercepts. Condone aspects of the graph which may appear linear (but not a  $\wedge$  shape). Its line of symmetry must appear to the left of the origin and its curve should broadly appear symmetrical about this line. Ignore  $x$ -intercepts or the maximum stated.

The  $y$ -intercept may be stated underneath their graph instead, but if there is a contradiction between the graph and what is marked on the graph then the graph takes precedence.

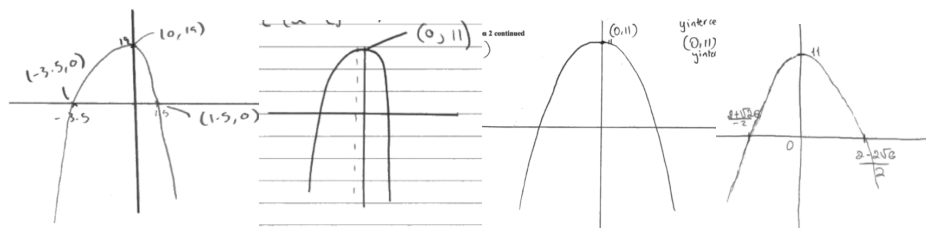
Do not accept graphs which appear to be symmetrical about the  $y$ -axis.

Examples

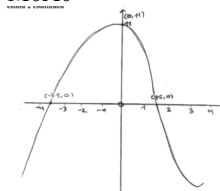
M1A1



M1A0



M0A0



(c)

B1ft: Correct equation seen in part (c) (follow through their numeric  $c$  so allow  $x = -c$ ).

| Question Number | Scheme                                                                                                                                                                        | Marks          |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------|
| 3(i)            | $\sqrt{8} = 2\sqrt{2}$ seen anywhere in the solution (see notes)                                                                                                              | B1             |
|                 | $(x + \sqrt{2})^2 + (3x - 5\sqrt{8})^2$ $= x^2 + 2x\sqrt{2} + 2 + 9x^2 - 30x\sqrt{8} + 25 \times 8$                                                                           | M1             |
|                 | $= 10x^2 - 58x\sqrt{2} + 202$                                                                                                                                                 | A1             |
|                 |                                                                                                                                                                               | (3)            |
| (ii)            | $\sqrt{3}(4y - 3\sqrt{3}) = 5y + \sqrt{3}$ $\Rightarrow 4\sqrt{3}y - 9 = 5y + \sqrt{3}$ $\Rightarrow 4\sqrt{3}y - 5y = 9 + \sqrt{3}$                                          | M1             |
|                 | $\Rightarrow y = \dots \text{ or } \Rightarrow ky = \dots$ <p>eg <math>y = \frac{9 + \sqrt{3}}{4\sqrt{3} - 5}</math> or <math>"23"y = "9 + \sqrt{3}"</math></p>               | dM1            |
|                 | $y = \frac{9 + \sqrt{3}}{4\sqrt{3} - 5} \times \frac{4\sqrt{3} + 5}{4\sqrt{3} + 5} \Rightarrow y = \frac{\dots}{"23"}$                                                        | ddM1           |
|                 | $y = \frac{57}{23} + \frac{41}{23}\sqrt{3} \text{ (or } y = 2\frac{11}{23} + 1\frac{18}{23}\sqrt{3})$                                                                         | A1             |
|                 |                                                                                                                                                                               | (4)            |
|                 | <b>(ii) Alternative 1:</b>                                                                                                                                                    |                |
|                 | $\sqrt{3}(4p + 4q\sqrt{3} - 3\sqrt{3}) = 5(p + q\sqrt{3}) + \sqrt{3}$ $\Rightarrow 4p\sqrt{3} + 12q - 9 = 5p + 5q\sqrt{3} + \sqrt{3}$ $\Rightarrow 4p = 5q + 1, 12q - 9 = 5p$ | M1<br>dM1      |
|                 | $\Rightarrow 4p = 5q + 1, 12q - 9 = 5p$ $\Rightarrow p = \dots, q = \dots$                                                                                                    | ddM1           |
|                 | $y = \frac{57}{23} + \frac{41}{23}\sqrt{3} \text{ (or } y = 2\frac{11}{23} + 1\frac{18}{23}\sqrt{3})$                                                                         | A1             |
|                 |                                                                                                                                                                               | <b>Total 7</b> |

Note solutions relying on calculator technology are not acceptable.

(i)

B1: May be stated in the margin or seen/implied anywhere in the solution.

**It does not need to be explicitly stated.**

Eg. sight of  $30\sqrt{8} \rightarrow 60\sqrt{2}$  is fine as is  $(3x - 5\sqrt{8})^2 \rightarrow \dots x^2 - 60\sqrt{2} + \dots$

M1: Expands both brackets so look for:

$$x^2 + ax\sqrt{2} + 2 + bx^2 - cx\sqrt{8} + d \text{ or } x^2 + ax\sqrt{2} + 2 + bx^2 - cx\sqrt{2} + d$$

where  $a, b, c$  and  $d$  are non-zero. **The  $x$  terms do not need to be collected to score this mark.**

A1:  $10x^2 - 58x\sqrt{2} + 202$  or equivalent isw after a correct answer.  $58\sqrt{2}x$  is acceptable



Eg  $x^2 + 2x\sqrt{2} + 2 + 9x^2 - 30x\sqrt{8} + 25 \times 8 \Rightarrow 10x^2 - 58x\sqrt{2} + 202$  scores B1M1A1  
as  $\sqrt{8} = 2\sqrt{2}$  is correctly seen by the correct collection of the terms.

Eg  $x^2 + 2x\sqrt{2} + 2 + 9x^2 - 30x\sqrt{8} + 25 \times 8 \Rightarrow 10x^2 - 60x\sqrt{2} + 202$  scores B0M1A0  
as  $\sqrt{8} = 2\sqrt{2}$  is not correctly seen or implied as the coefficient of  $x$  is incorrect

**(ii) On EPEN this is M1A1M1A1 we are marking this M1M1M1A1**

M1: Attempts to multiply out and isolates the two  $y$  terms on one side of the equation.  
**Condone sign slips only in their rearrangement.**

dM1: Attempts to make  $y$  or  $ky$  the subject (where  $k$  is an integer or fraction which would simplify to an integer). Score for  $y = f(x)$  or  $ky = g(x)$  where the function includes  $\sqrt{3}$  but it cannot be scored for directly proceeding to  $y = \frac{57}{23} + \frac{41}{23}\sqrt{3}$  or  $y = \frac{57 + 41\sqrt{3}}{23}$ .

It is dependent on the previous method mark.

Note  $y(4\sqrt{3} - 5) = 9 + \sqrt{3} \Rightarrow y = \frac{57}{23} + \frac{41}{23}\sqrt{3}$  is M1dM0ddM0A0

ddM1: Proceeds to  $y = \dots$  with a rational denominator. The denominator does not need to be simplified. It is dependent on the previous method mark. They must have shown the step of either rationalising the denominator or showing how they achieve  $ky = \dots$  and proceeds to  $y = \dots$

A1: Correct answer in the correct form with all stages of working seen

- Collects  $y$  terms on one side of the equation
- Makes  $y$  the subject
- Rationalises and proceeds to the correct answer. Somewhere in their solution they will have had to have multiplied two brackets involving surds together and they must have shown this being multiplied out (calculators are not allowed)

eg  $\frac{9 + \sqrt{3}}{4\sqrt{3} - 5} \times \frac{4\sqrt{3} + 5}{4\sqrt{3} + 5} = \frac{36\sqrt{3} + 45 + 12 + 5\sqrt{3}}{23}$

Condone solutions with invisible brackets to score full marks, provided the general method is sound and the answer has not just come from a calculator or incorrect working.

Do not accept  $y = \frac{57 + 41\sqrt{3}}{23}$

---  
**Alt(ii)1 (main scheme alternative)**

M1: Substitutes  $y = p + q\sqrt{3}$  expands, collects terms. Condone sign slips.

dM1: Compares rational/irrational parts to form two equations. It is dependent on the previous method mark.

ddM1: Solves 2 linear equations in  $p$  and  $q$  using an acceptable method. They cannot just state the values. Condone slips in their working. It is dependent on the previous method mark.

A1:  $y = \frac{57}{23} + \frac{41}{23}\sqrt{3}$  (or  $y = 2\frac{11}{23} + 1\frac{18}{23}\sqrt{3}$ ) with full working shown.

--  
**Alt(ii)2 Squaring and completing the square**

M1: Squares both sides and multiplies out brackets (condone slips)  
eg.  $(48y^2 - 72\sqrt{3}y + 81 = 25y^2 + 3 + 10\sqrt{3}y)$

dM1: Rearranges to form a 3TQ = 0 ( $23y^2 - 82\sqrt{3}y + 78 = 0$ ). It is dependent on the previous method mark.

### 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 | Scheme                                                                                                                                                                                                                   | Marks          |
|----------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------|
| 5(a)     | $\frac{1}{2} \times 6^2 \times 1.3 = \dots$                                                                                                                                                                              | M1             |
|          | $= 23.4 \text{ (m}^2\text{)}$                                                                                                                                                                                            | A1             |
|          |                                                                                                                                                                                                                          | (2)            |
| (b)      | $12.2^2 = 6^2 + 10.8^2 - 2 \times 6 \times 10.8 \cos(\angle ABE)$                                                                                                                                                        | M1             |
|          | $\cos(\angle ABE) = \frac{6^2 + 10.8^2 - 12.2^2}{2 \times 6 \times 10.8} \left( = \frac{19}{648} \right)$<br>$\angle ABE = 1.54$                                                                                         | A1             |
|          |                                                                                                                                                                                                                          | (2)            |
| (c)      | Area $ABE = \frac{1}{2} \times 10.8 \times 6 \sin(\angle ABE)$                                                                                                                                                           | M1             |
|          | Area $BCD = \frac{1}{2} \times 6 \cos(\pi - 1.3 - "1.54") \times 6 \sin(\pi - 1.3 - "1.54")$<br>or e.g.<br>Area $BCD = \frac{1}{2} \times 6 \sin(\pi - 1.3 - "1.54") \times \sqrt{6^2 - (6 \sin(\pi - 1.3 - "1.54"))^2}$ | M1             |
|          | Total area = $60.9 \text{ m}^2$                                                                                                                                                                                          | A1             |
|          |                                                                                                                                                                                                                          | (3)            |
|          |                                                                                                                                                                                                                          | <b>Total 7</b> |

**Notes:**(a) **Marks for part (a) must be seen in part (a)****M1:** Attempts to evaluate  $\frac{1}{2}r^2\theta$  with  $r = 6$  and  $\theta = 1.3$  or equivalent e.g.  $\frac{\theta}{360} \times \pi \times 6^2$  with  $\theta = 1.3 \times \frac{180}{\pi}$  which may be implied by use of e.g.  $74^\circ$  or  $75^\circ$ **A1:** Correct value. Allow equivalent values e.g.  $\frac{117}{5}$ ,  $23\frac{2}{5}$ .

Condone lack of units but if any are given they should be correct. Correct answer only scores both marks.

(b)

**M1:** Correct numerical application of the cosine rule for the required angle.**A1:** For awrt 1.54

(c)

**Allow equivalent work in degrees.****M1:** Correct method for area  $ABE$  e.g.  $\frac{1}{2} \times 10.8 \times 6 \sin(\text{their } \angle ABE)$ **M1:** Correct method for area  $BCD$ Must be a correct method including the  $\frac{1}{2}$ Note that  $CD$  may be found using the sine rule e.g.  $\frac{6}{\sin \frac{\pi}{2}} = \frac{CD}{\sin(\pi - 1.3 - "1.54")} \Rightarrow CD = \dots$ Note that  $BC$  may be found using the sine rule e.g.  $\frac{6}{\sin \frac{\pi}{2}} = \frac{BC}{\sin\left(1.3 + "1.54" - \frac{\pi}{2}\right)} \Rightarrow BC = \dots$ Having found  $CD$  or  $BC$  as above,  $BC$  or  $CD$  may be found using Pythagoras.

In such cases the trigonometry must be correct for their values.

Do **not** allow mixing of degrees and radians e.g.  $180 - 1.3 - "1.54"$  for  $\pi - 1.3 - "1.54"$ **A1:** Correct total area. Allow awrt 60.9 (Condone lack of units)**Some values for reference:**Angle  $DBC = 0.300\dots(17.1\dots^\circ)$ , Angle  $BDC = 1.27\dots(72.7\dots^\circ)$ ,  
Area  $ABE = 32.38\dots$ , Area  $BCD = 5.083\dots$ ,  $CD = 1.77\dots$ ,  $BC = 5.73\dots$ 

| Question | Scheme                                                                                                                                                                                                                                                                                             | Marks   |
|----------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|
| 6(a)     | $y - 5x = 75, y = 2x^2 + x - 21$<br>$\Rightarrow 2x^2 + x - 21 = 5x + 75$<br>$\Rightarrow 2x^2 - 4x - 96 = 0$ or e.g. $x^2 - 2x - 48 = 0$<br>or<br>$\Rightarrow y = 2\left(\frac{y-75}{5}\right)^2 + \frac{y-75}{5} - 21$<br>$\Rightarrow 2y^2 - 320y + 10350 = 0$ or e.g. $y^2 - 160y + 5175 = 0$ | M1      |
|          | $x^2 - 2x - 48 = 0 \Rightarrow (x-8)(x+6) = 0 \Rightarrow x = -6, 8$                                                                                                                                                                                                                               | dM1     |
|          | $x = -6 \Rightarrow y = 45$ or $x = 8 \Rightarrow y = 115$                                                                                                                                                                                                                                         | dM1     |
|          | $P(-6, 45)$ and $Q(8, 115)$                                                                                                                                                                                                                                                                        | A1      |
|          |                                                                                                                                                                                                                                                                                                    | (4)     |
| (b)      | e.g. $y \leq 2x^2 + x - 21, y - 5x \leq 75, y \geq 0, x \leq -3.5$<br><br>$x \leq a$ where $-3.5 \leq a < 3$<br>(or $a \leq x \leq b$ where $a \leq -15, -3.5 \leq b \leq 3$ )                                                                                                                     | M1A1A1  |
|          |                                                                                                                                                                                                                                                                                                    | (3)     |
|          |                                                                                                                                                                                                                                                                                                    | Total 7 |

**Notes:**

(a)

**Note that solutions relying on calculator technology are not acceptable so a complete method must be shown.**

**M1:** Equates the line and the curve and rearranges to obtain a 3TQ in  $x$

Alternatively eliminates  $x$  to obtain a 3TQ in  $y$

**dM1:** Solves their 3TQ to obtain at least one value for  $x$  or  $y$  by an acceptable method e.g. factorisation, formula or completing the square. They cannot just state the roots without seeing a correct line of intermediate working.

We will condone e.g.  $2x^2 - 4x - 96 = 0 \Rightarrow x = \frac{4 \pm \sqrt{(-4)^2 - 4(2)(-96)}}{2 \times 2} = -6, 8$

But e.g.  $2x^2 - 4x - 96 = 0 \Rightarrow x = \frac{4 \pm \sqrt{-4^2 - 4(2)(-96)}}{2 \times 2} = -6, 8$  scores M0 as it suggests an incorrect

formula but allow recovery e.g.  $2x^2 - 4x - 96 = 0 \Rightarrow x = \frac{4 \pm \sqrt{-4^2 - 4(2)(-96)}}{2 \times 2} = \frac{4 \pm \sqrt{784}}{4} = -6, 8$  and

condone a missing trailing bracket e.g.  $x = \frac{4 \pm \sqrt{(-4)^2 - 4(2)(-96)}}{2 \times 2} = -6, 8$

If they factorise do **not** accept  $2x^2 - 4x - 96 = 0 \Rightarrow (x+6)(x-8) = 0 \Rightarrow x = -6, 8$

**Depends on the previous method mark.**

**dM1:** Uses at least one  $x$  value to find at least one  $y$  value (or vice versa) using either of the given equations.

**Depends on the FIRST method mark and depends on having solved a 3TQ in  $x$  or  $y$ .**

May be implied by their values. You may need to check (for both equations).

**A1:** All correct. Must be correctly paired but ignore any labelling regarding  $P$  and  $Q$ , just look for the correct paired values. This may be explicit as a coordinate pair or implied by e.g.  $x = 8, y = 115$ .

Condone coordinates written without brackets e.g.  $-6, 45$

**Depends on all previous marks so 1011 is not possible.**



Candidates who show no working for solving their 3TQ can score a maximum 1010

Correct answers with no working scores no marks.

(b) Allow strict or non-strict inequalities and allow a mixture for the first 2 marks.

**M1:** Obtains at least 2 of the required inequalities e.g. 2 of:

$$y \leq 2x^2 + x - 21, y - 5x \leq 75, y \geq 0, x \leq a \text{ where } -3.5 \leq a < 3$$

Allow equivalents e.g.  $y < 5x + 75$

Allow e.g.  $0 \leq y \leq 2x^2 + x - 21$  or e.g.  $0 < y < 5x + 75$  each of which would count as 2 correct inequalities.

Do **not** allow e.g.  $R \leq 2x^2 + x - 21$

**A1:** Any 3 of the 4 required inequalities.

**A1:** All correct and consistent. For consistency, the inequalities for  $y$  must be either all strict or all non-strict.

The restriction on  $x$  will depend on their chosen  $x$  value. For example

$$y \geq 0, y \leq 5x + 75, y \leq 2x^2 + x - 21, x < 0 \text{ scores full marks}$$

$$y \geq 0, y \leq 5x + 75, y \leq 2x^2 + x - 21, x < -3.5 \text{ scores M1A1A0}$$

If there are extra **incorrect** inequalities then score A0

| Question Number | Scheme                                                                                          | Marks            |
|-----------------|-------------------------------------------------------------------------------------------------|------------------|
| <b>8(a)</b>     | $y = 3x + "c"$ or $y = "m" x - 12'$                                                             | M1               |
|                 | $y = 3x - 12$                                                                                   | A1               |
|                 |                                                                                                 | <b>(2)</b>       |
| <b>(b)</b>      | $k = 10$                                                                                        | B1               |
|                 |                                                                                                 | <b>(1)</b>       |
| <b>(c)</b>      | E.g. $y = A(x-4)(x-10)$ or $y = C(x-7)^2 - 18$                                                  | M1               |
|                 | E.g. $-18 = A(7-4)(7-10) \Rightarrow A = \dots$<br>Or $0 = C(4-7)^2 - 18 \Rightarrow C = \dots$ | dM1              |
|                 | $y = 2(x-4)(x-10)$ , $y = 2(x-7)^2 - 18$ o.e.                                                   | A1               |
|                 |                                                                                                 | <b>(3)</b>       |
| <b>(d)</b>      | Two of $y > 3x - 12$ , $y < 2(x-4)(x-10)$ , $x > 0$ , $x < 4$                                   | M1               |
|                 | E.g. $3x - 12 < y < 2(x-4)(x-10)$ , $0 < x < 4$                                                 | A1               |
|                 |                                                                                                 | <b>(2)</b>       |
|                 |                                                                                                 | <b>(8 marks)</b> |

(a)

**M1:** Attempts form  $y = mx + c$  with  $m$  or  $c$  correct. May be implied by e.g.  $m = 3$  (or  $\frac{12}{4}$ ) or  $c = -12$

**A1:**  $y = 3x - 12$ . A full correct equation is required including “ $y =$ ”. Condone  $\frac{12}{4}$  for 3.

(b)

**B1:**  $k = 10$ . Condone  $x = 10$  and condone  $(10, 0)$

(c)

**M1:** Attempts an equation of the form  $(y =) A(x-4)(x-10)$  or  $(y =) C(x-7)^2 - 18$

Condone with  $A, C = 1$  or any other constant.

It is possible they could try with an attempt to use all three coordinates.

The “ $y =$ ” is not needed unless the equation is attempted as e.g.  $y + 18 = C(x-7)^2$

**dM1:** Full attempt at equation with an attempt at finding  $A$  or  $C$ . **Depends on the first mark.**

E.g.  $y = A(x-4)(x-10)$  and uses  $x = 7, y = -18$  to find  $A$  or  $y = C(x-7)^2 - 18$  and uses  $x = 4$  or  $x = 10$  when  $y = 0$  to find  $C$

**A1:**  $(y =) 2(x-4)(x-10)$ ,  $(y =) 2(x-7)^2 - 18$  o.e. e.g.  $(y =) 2(x-7)^2 - 18$

The “ $y =$ ” is **not** required here, just look for a correct expression.

(d)

**M1:** Two of  $y > 3x - 12$ ,  $y < 2(x-4)(x-10)$ ,  $x > 0$ ,  $x < 4$  Accept with  $\leq \leftrightarrow <$  and  $\geq \leftrightarrow >$

Follow through their answers to part (a) and part (c) provided (a) is linear and (c) is quadratic.

Do not allow e.g.  $R > 3x - 12$ ,  $R < 2(x-4)(x-10)$  etc. but allow  $f(x)$  for  $y$ .



**A1:** Fully defines region correctly (**not ft here**).

E.g.  $3x - 12 < y < 2(x - 4)(x - 10)$ ,  $0 < x < 4$  (or  $x > 0, x < 4$ )

Or e.g.  $y > 3x - 12$ ,  $y < 2(x - 4)(x - 10)$ ,  $x > 0$ ,  $x < 4$

The right hand side of the inequality  $0 < x < 4$  may be larger. Accept  $0 < x < p$  as long as

$$4 \leq p \leq \frac{23}{2}$$

Allow **consistent** use of  $> \leftrightarrow \geq$  for all of their inequalities.

| Question Number | Scheme | Marks            |
|-----------------|--------|------------------|
| <b>9(a)</b>     | $\pi$  | B1               |
|                 |        | <b>(1)</b>       |
| <b>(b)(i)</b>   | 3      | B1               |
|                 |        | <b>(1)</b>       |
| <b>(ii)</b>     | 5      | B1               |
|                 |        | <b>(1)</b>       |
| <b>(iii)</b>    | 201    | B1               |
|                 |        | <b>(1)</b>       |
|                 |        | <b>(4 marks)</b> |

(a)

**B1:** Period is  $\pi$  (radians) but condone  $180^\circ$  or just 180

(b)(i)

**B1:** 3

(ii)

**B1:** 5

(iii)

**B1:** 201



## 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

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                                                 |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------|
| <b>1.(a)</b>    | $\frac{dy}{dx} = \frac{1}{8} \times 3x^2 - 24 \times -\frac{1}{2} x^{-\frac{3}{2}}$ $\frac{dy}{dx} = \frac{3}{8} x^2 + 12x^{-\frac{3}{2}}$        | M1<br><br>A1 A1<br><br><b>(3)</b>                     |
| <b>(b)</b>      | $\left. \frac{dy}{dx} \right _{x=4} = \frac{3}{8} \times 4^2 + 12 \times 4^{-\frac{3}{2}} = (7.5)$ $y + 3 = 7.5(x - 4) \Rightarrow y = 7.5x - 33$ | M1<br><br>M1 A1<br><br><b>(3)</b><br><b>(6 marks)</b> |

(a)

M1 For reducing a correct power by one on either  $x$  term. Allow for either  $x^3 \rightarrow x^{3-1}$  or  $x^{-\frac{1}{2}} \rightarrow x^{-\frac{1}{2}-1}$

So this **cannot** be awarded for  $\frac{24}{x^{0.5}} \rightarrow \frac{24}{0.5x^{-0.5}}$

A1 One term of  $\frac{3}{8} x^2 + 12x^{-\frac{3}{2}}$  correct and simplified

A1  $\frac{dy}{dx} = \frac{3}{8} x^2 + 12x^{-\frac{3}{2}}$  or exact simplified equivalent such as  $\frac{dy}{dx} = \frac{3}{8} x^2 + \frac{12}{x\sqrt{x}}$ .

ISW after a correct answer. There is no need to see the  $\frac{dy}{dx}$

(b)

M1 For attempting to find the value of their  $\frac{dy}{dx}$  at  $x = 4$ .

Score for sight of embedded 4's followed by an answer. Condone slips

If no calculations are seen then only award if the value is correct for their  $\frac{dy}{dx}$

M1 For correct method of finding the equation of the tangent at  $(4, -3)$  using their numerical  $\left. \frac{dy}{dx} \right|_{x=4}$

Condone one error on the sign of the 4 and  $-3$  within the tangent formula.

If the form  $y = mx + c$  is used they must proceed as far as  $c = \dots$

It cannot be awarded from a made-up gradient

A1  $y = 7.5x - 33$  or exact equivalent in the form  $y = mx + c$ . ISW after a correct answer.

If the form  $y = mx + c$  is used they must get correct  $m$  and  $c$  and write

$y = 7.5x - 33$  oe .....  
.....

NB. If a calculator is used to find  $\left. \frac{dy}{dx} \right|_{x=4} = 7.5$  **without sight of**  $\frac{dy}{dx} = \frac{3}{8} x^2 + 12x^{-\frac{3}{2}}$  then you may allow the final two marks in (b) for correct method to find a correct tangent.



| Question Number                                                                                                                                                                                                                                                                                                                                                      | Scheme                                                                                                                                                                                                             | Marks            |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------|
| <b>8(a)</b>                                                                                                                                                                                                                                                                                                                                                          | $m = \frac{18-0}{2- -3}$                                                                                                                                                                                           | M1               |
|                                                                                                                                                                                                                                                                                                                                                                      | $y - 18 = \frac{18}{5}(x - 2)$ or e.g. $y = \frac{18}{5}(x + 3)$<br>or<br>$18 = \frac{18}{5}(2) + c \Rightarrow c = \dots$ or e.g. $0 = \frac{18}{5}(-3) + c \Rightarrow c = \dots$                                | dM1              |
|                                                                                                                                                                                                                                                                                                                                                                      | $y = \frac{18}{5}x + \frac{54}{5}$                                                                                                                                                                                 | A1               |
|                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                                    | <b>(3)</b>       |
| <b>(b)</b>                                                                                                                                                                                                                                                                                                                                                           | Examples:<br>$y = ax^2 + bx - 6$<br>$y = (x + 3)(px + q)$<br>$y = ax^2 + bx + c, (0, -6), (2, 18), (-3, 0) \Rightarrow a = \dots$ or $b = \dots$ or $c = \dots$<br>NB $a = \frac{14}{5}, b = \frac{32}{5}, c = -6$ | M1               |
|                                                                                                                                                                                                                                                                                                                                                                      | Full method to find all constants.<br>E.g. Solves $9a - 3b - 6 = 0$ and $4a + 2b - 6 = 18 \Rightarrow a = \dots, b = \dots$                                                                                        | dM1              |
|                                                                                                                                                                                                                                                                                                                                                                      | Either $a = \frac{14}{5}$ or $b = \frac{32}{5}$<br>$y = \frac{14}{5}x^2 + \frac{32}{5}x - 6$                                                                                                                       | A1<br>A1         |
|                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                                    | <b>(4)</b>       |
| <b>(c)</b>                                                                                                                                                                                                                                                                                                                                                           | $\frac{14}{5}x^2 + \frac{32}{5}x - 6 < y < \frac{18}{5}x + \frac{54}{5}, \quad x < 0$                                                                                                                              | M1 A1ft          |
|                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                                    | <b>(2)</b>       |
|                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                                    | <b>(9 marks)</b> |
| <b>Notes</b>                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                    |                  |
| <b>(a)</b>                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                                                                    |                  |
| <b>M1:</b> Attempts gradient = $\frac{18-0}{2- -3}$ .<br>Condone 1 sign/copying slip only if a correct formula is seen or implied.<br>Alternatively solves two simultaneous equations, e.g. $18 = 2m + c$ and $0 = -3m + c$ to find $m$ or $c$ .                                                                                                                     |                                                                                                                                                                                                                    |                  |
| <b>dM1:</b> Full attempt at equation of the line using $(-3, 0)$ or $(2, 18)$ with values correctly placed.<br>If they use $y = mx + c$ they must proceed as far as finding a value for $c$ .<br>If they use e.g. $\frac{y}{18-0} = \frac{x+3}{2- -3}$ both M's can be scored together.<br>Condone 1 sign/copying slip only if a correct formula is seen or implied. |                                                                                                                                                                                                                    |                  |
| <b>A1:</b> $y = \frac{18}{5}x + \frac{54}{5}$ o.e.                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                    |                  |

(b)

**M1:** Uses a method that finds one of the unknowns leaving an equation in two unknowns.

- States equation is  $y = ax^2 + bx - 6$  (the most common)
- States equation is  $y = (x+3)(px+q)$ ,  $p \neq 1$  or e.g.  $y = a(x+3)(x+b)$
- States equation is  $y = ax^2 + bx + c$  and uses all 3 coordinates to find one unknown

**dM1:** Uses all three coordinates to find all three unknowns. Condone slips with substitution provided the intention is clear.**A1:** Two correct unknowns found.**A1:** Correct equation. E.g.  $y = \frac{14}{5}x^2 + \frac{32}{5}x - 6$  or  $y = (x+3)\left(\frac{14}{5}x - 2\right)$  or  $y = \frac{14}{5}(x+3)\left(x - \frac{5}{7}\right)$ but not e.g.  $C = \dots$ Note that attempts at e.g.  $y = x^2 + bx - 6$  score no marks as there are insufficient unknowns.

(c)

**M1:** Uses two of the three required inequalities. Two may be combined as seen in the scheme.Accept  $\leq \leftrightarrow <$ . Follow through on their equations for  $l$  and  $C$ . $\frac{14}{5}x^2 + \frac{32}{5}x - 6 < y < \frac{18}{5}x + \frac{54}{5}$  would count as 2 correct inequalities.Do **not** allow inequalities in terms of  $R$  e.g.  $\frac{14}{5}x^2 + \frac{32}{5}x - 6 < R < \frac{18}{5}x + \frac{54}{5}$ **A1ft:** Correct definition of  $R$  using their equations for  $l$  and  $C$ .E.g.  $y \geq \frac{14}{5}x^2 + \frac{32}{5}x - 6, y \leq \frac{18}{5}x + \frac{54}{5}, x \leq 0$  with inequalities used consistently.If applying ft, their equations must be appropriate e.g.  $y = mx + c$ ,  $m, c \neq 0$  for  $l$  and a 3 term quadratic expression for  $C$ .If they have a lower limit of  $-3$  on the restriction on  $x$  e.g.  $-3 \leq x \leq 0$  this is fine as long as it is consistent. If their lower limit is less than  $-3$  then the left hand inequality can be strict or non-strict i.e. consistency is not required.This mark should be withheld if any extra incorrect inequalities are given e.g. if they impose an extra restriction on  $y$  vertically then  $-\frac{338}{35} \leq y \leq \frac{54}{5}$  would be correct (for correct (a) and (b))

but anything narrower than this would not.

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

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$(x^2 + bx + c) = (x + p)(x + q)$ , 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. ( $x^n \rightarrow x^{n+1}$ )

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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.

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| Question Number | Scheme                                                                                                                                                    | Marks                               |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------|
| <b>1.(a)</b>    | Sets $\frac{1}{2}r^2 \times 1.25 = 15 \Rightarrow r^2 = 24$<br>$\Rightarrow r = \sqrt{24}$ or $2\sqrt{6}$ (only)                                          | M1<br>A1<br>(2)                     |
| <b>(b)</b>      | Attempts $s = r\theta = 2\sqrt{6} \times 1.25$<br>Attempts $P = 2r + r\theta = 2 \times 2\sqrt{6} + 2\sqrt{6} \times 1.25$<br>$= \frac{13\sqrt{6}}{2}$ oe | M1<br>dM1<br>A1<br>(3)<br>(5 marks) |

(a)

M1 Uses  $A = \frac{1}{2}r^2\theta$  in an attempt to find  $r$ A1  $r = \sqrt{24}$  or  $2\sqrt{6}$  only (oe) (isw after a correct answer is seen) Withhold the A if  $r = \pm 2\sqrt{6}$  is given.

(b)

M1 Uses the formula  $s = r\theta$  with their  $r$  and  $\theta = 1.25$  in an attempt to find the arc length.dM1 For applying  $P = 2r + r\theta$  their  $r$  and  $\theta = 1.25$  in an attempt to find the perimeter.A1  $\frac{13\sqrt{6}}{2}$  (isw after a correct answer is seen). Accept  $6.5\sqrt{13}$  (oe simplest forms)

| Question Number | Scheme                                                                                        | Marks                    |
|-----------------|-----------------------------------------------------------------------------------------------|--------------------------|
| <b>2. (a)</b>   | $1.85 = 2a + b$ and $3.45 = 7a + b$<br>Solves simultaneously to get $a = 0.32, b = 1.21$ (oe) | M1 A1<br>dM1 A1<br>(4)   |
| <b>(b)</b>      | States 1.21 m or 121 cm (oe)                                                                  | B1ft<br>(1)<br>(5 marks) |

(a)

M1 For either  $1.85 = 2a + b$  or  $3.45 = 7a + b$ A1 For both  $1.85 = 2a + b$  and  $3.45 = 7a + b$ dM1 Solves simultaneously to get a value for  $a$  and a value for  $b$ A1  $a = 0.32, b = 1.21$  or equivalent fractions. May be seen in the equation.

(b)

B1 ft States 1.21 m or 121 cm (oe including units). Correct answer or follow through on their **positive**  $b$   
Alt part (a)M1 Attempts  $\frac{3.45 - 1.85}{7 - 2}$  Allow from attempts at use of arithmetic series, or from incorrect indexing. SoE.g.  $1.85 = 3a + b, 3.45 = 8a + b \Rightarrow a = \dots$  or  $a_n = a + (n-1)d, a_1 = 1.85, a_6 = 3.45 \Rightarrow a = \dots$  gain this mark.A1  $a = 0.32$  (may be called  $d$  if using AS)dM1 Full correct method to find  $b$  E.g substitutes their  $a = 0.32$  into either **correct** equation (with correct indexing), or in " $a_n = a + (n-1)d$ " finds " $a$ " ( $= 1.53$ ) and expands to find  $b = "a" - "d"$ .A1  $a = 0.32, b = 1.21$ 

| Question Number | Scheme                                                                                                                                                                                                                                                                                                        | Marks                           |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------|
| <b>3. (a)</b>   | $x^2 - 5x + 13 = (x - 2.5)^2 - 2.5^2 + 13 = (x - 2.5)^2 + 6.75$<br>Coordinates $M = (2.5, 6.75)$                                                                                                                                                                                                              | M1 A1<br>A1<br>(3)              |
| <b>(b)</b>      | Attempts the equation of $l$ using their $M$ $y = \frac{6.75}{2.5}x$ ( $y = 2.7x$ )<br>Attempts to solve their $y = 2.7x$ with $y = x^2 - 5x + 13$<br>$\Rightarrow 2.7x = x^2 - 5x + 13 \Rightarrow x^2 - 7.7x + 13 = 0 \Rightarrow (x - 2.5)(x - 5.2) = 0$<br>$x = 5.2$ oe<br>Coordinates $N = (5.2, 14.04)$ | M1<br>M1<br>A1<br>dM1 A1<br>(5) |
| <b>(c)</b>      | States two of $y < x^2 - 5x + 13$ , $y > 2.7x$ , $0 \leq x < 2.5$<br>States all three of $y < x^2 - 5x + 13$ , $y > 2.7x$ , $0 \leq x < 2.5$                                                                                                                                                                  | M1<br>A1ft<br>(2)<br>(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 pointM1 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

