Please check the examination details below before entering your candidate information

Candidate surname	Other names

Pearson Edexcel International Advanced Level

Centre Number

Candidate Number

Wednesday 10 October 2018

Morning (Time: 2 hours 30 minutes) | Paper Reference **WMA01/01**

Core Mathematics C12

Advanced Subsidiary

You must have:
Mathematical Formulae and Statistical Tables (Blue)

Total Marks

Candidates may use any calculator allowed by the regulations of the Joint Council for Qualifications. Calculators must not have the facility for symbolic algebra manipulation, differentiation and integration, or have retrievable mathematical formulae stored in them.

Instructions

- Use **black** ink or ball-point pen.
- If pencil is used for diagrams/sketches/graphs it must be dark (HB or B). Coloured pencils and highlighter pens must not be used.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions and ensure that your answers to parts of questions are clearly labelled.
- Answer the questions in the spaces provided – *there may be more space than you need.*
- You should show sufficient working to make your methods clear. Answers without working may not gain full credit.
- When a calculator is used, the answer should be given to an appropriate degree of accuracy.

Information

- The total mark for this paper is 125.
- The marks for **each** question are shown in brackets – *use this as a guide as to how much time to spend on each question.*

Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over

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1. (i) Given that $125\sqrt{5} = 5^a$, find the value of a.

(2)

(ii) Show that $\dfrac{16}{4 - \sqrt{8}} = 8 + 4\sqrt{2}$

You must show all stages of your working.

(3)

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Question Number	Scheme	Notes	Marks
1(i) **Way 1**	$125\sqrt{5}=5^3\times5^{\frac{1}{2}}=5^{3+\frac{1}{2}}$	Writes $125\sqrt{5}=5^p\times5^q$ with at least one of $p=3$ or $q=\dfrac{1}{2}$ and adds their p and q	M1
	$=5^{3\frac{1}{2}}$ or $a=3\frac{1}{2}$ or 3.5	Sight of $a=3\frac{1}{2}$ or 3.5 or $5^{3\frac{1}{2}}$	A1
	Note that some candidates are treating the 125 as $\sqrt{125}$ and then writing $\sqrt{125}$ as $5\times5^{\frac{1}{2}}$ which leads to $a=2$. This is M0 as they are not writing 125 as a power of 5.		
			(2)
Way 2	$125\sqrt{5}=5^a\Rightarrow\log_5 125\sqrt{5}=\log_5 5^a$ $\Rightarrow\log_5 125\sqrt{5}=a\log_5 5$	Takes logs base 5 of both sides and uses power rule i.e. $\log_5 5^a=a\log_5 5$ or $\log_5 5^a=a$	M1
	$=5^{3\frac{1}{2}}$ or $a=3\frac{1}{2}$ or 3.5	Sight of $a=3\frac{1}{2}$ or 3.5 or $5^{3\frac{1}{2}}$	A1
			(2)
Way 3	$125\sqrt{5}=5^a\Rightarrow\log 125\sqrt{5}=\log 5^a$ $\Rightarrow\log 125\sqrt{5}=a\log 5$	Takes logs **to the same base** of both sides and uses the power rule correctly.	M1
	$=5^{3\frac{1}{2}}$ or $a=3\frac{1}{2}$ or 3.5	Sight of $a=3\frac{1}{2}$ or 3.5 or $5^{3\frac{1}{2}}$	A1
			(2)
Way 4	$125\sqrt{5}=5^a\Rightarrow\left(125\sqrt{5}\right)^2=\left(5^a\right)^2$ $125\sqrt{5}=5^a\Rightarrow 78125=5^{2a}$ $2a=\log_5 78125$ or $\log 78125=2a\log 5$	Squares both sides and takes log base 5 or takes logs in a different base and uses the power rule correctly	M1
	$=5^{3\frac{1}{2}}$ or $a=3\frac{1}{2}$ or 3.5	Sight of $a=3\frac{1}{2}$ or 3.5 or $5^{3\frac{1}{2}}$	A1
			(2)
	Correct answer in (i) with no incorrect working scores both marks		
	Note that in (i) if they take logs both sides incorrectly e.g. $125\sqrt{5}=5^a\Rightarrow\log 125\times\log\sqrt{5}=a\log 5$ **this scores M0.**		

(ii)	$\dfrac{16\left(4+\sqrt{8}\right)}{\left(4-\sqrt{8}\right)\left(4+\sqrt{8}\right)}$	Multiply numerator and denominator by $\pm\left(4+\sqrt{8}\right)$ or equivalent e.g. $\pm\left(4+2\sqrt{2}\right)$ Note that this statement is sufficient. This mark may be implied by a correct expression in the numerator and 16 – 8 or a full expansion in the denominator.	M1
	$=\dfrac{16\left(4+2\sqrt{2}\right)}{16-8}$	$=\pm\dfrac{\cdots}{16-8}$ or $=\pm\dfrac{\cdots}{8}$ or $=\pm\dfrac{\cdots}{16+4\sqrt{8}-4\sqrt{8}-8}$ **But must follow M1**	A1
	$=8+4\sqrt{2}$ * Fully correct proof with an intermediate line with 16 – 8 or 8 or a full correct expansion seen in the denominator and $\sqrt{8}=2\sqrt{2}$ used (**does not need to be explicitly stated**). Note that in this question we **are allowing recovery** from invisible brackets so that starting with e.g. $\dfrac{16\left(4+\sqrt{8}\right)}{4-\sqrt{8}\left(4+\sqrt{8}\right)}, \dfrac{16}{4-\sqrt{8}}\times\dfrac{4+\sqrt{8}}{4+\sqrt{8}}$, should **not** be penalised.		A1
			(3)

(ii)	**An alternative is to cancel 2 throughout then the scheme follows the same pattern:**		
	$\dfrac{16}{\left(4-\sqrt{8}\right)}=\dfrac{16}{4-2\sqrt{2}}=\dfrac{8}{2-\sqrt{2}}$		
	$=\dfrac{8\left(2+\sqrt{2}\right)}{\left(2-\sqrt{2}\right)\left(2+\sqrt{2}\right)}$	Multiply numerator and denominator by $\pm\left(2+\sqrt{2}\right)$. Note that this statement is sufficient. This mark may be implied by a correct expression in the numerator and 4 – 2 or a full expansion in the denominator.	M1
	$=\dfrac{8\left(2+\sqrt{2}\right)}{4-2}$	$=\pm\dfrac{\cdots}{4-2}$ or $=\pm\dfrac{\cdots}{2}$ or $=\pm\dfrac{\cdots}{4+2\sqrt{2}-2\sqrt{2}-2}$ **But must follow M1**	A1
	$=8+4\sqrt{2}$ * Fully correct proof with an intermediate line with 4 – 2 or 2 or a full correct expansion seen in the denominator and $\sqrt{8}=2\sqrt{2}$ used. Note that in this question we **are allowing recovery** from invisible brackets so that starting with e.g. $\dfrac{8\left(2+\sqrt{2}\right)}{2-\sqrt{2}\left(2+\sqrt{2}\right)}, \dfrac{8}{2-\sqrt{2}}\times\dfrac{2+\sqrt{2}}{2+\sqrt{2}}$, should **not** be penalised.		A1
			(3)

	Alternative for (ii)		
	$\left(8+4\sqrt{2}\right)\left(4-\sqrt{8}\right)=...$	Attempt to expand to at least 3 terms	M1
	$=32-8\sqrt{8}+16\sqrt{2}-4\sqrt{16}$	All terms correct	A1
	$=16 \therefore \dfrac{16}{4-\sqrt{8}}=8+4\sqrt{2}$	Obtains 16 correctly with a conclusion which could be as shown or allow just a tick, #, QED etc.	A1
			Total 5

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2. Use algebra to solve the simultaneous equations

$$x + y = 5$$

$$x^2 + x + y^2 = 51$$

You must show all stages of your working.

(7)

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Question Number	Scheme	Notes	Marks
2	$x+y=5 \quad x^2+x+y^2=51$		
	$y=5-x \Rightarrow x^2+x+(5-x)^2=51$ **or** $x=5-y \Rightarrow (5-y)^2+(5-y)+y^2=51$	Attempts to rearrange the linear equation to $y=\ldots$ or $x=\ldots$ and attempts to fully substitute into the second equation.	M1
	$2x^2-9x-26=0$ or $2y^2-11y-21=0$	Collect terms together to produce a 2 or 3 term quadratic expression = 0. The '= 0' may be implied by later work.	M1
		Correct quadratic equation in x or y	A1
	$(2x-13)(x+2)=0 \Rightarrow x=\ldots$ or $(2y+3)(y-7)=0 \Rightarrow y=\ldots$	Attempt to factorise and solve or complete the square and solve or uses a correct quadratic formula **for a 3 term quadratic and obtains at least one value of *x* or *y*. Dependent on both previous method marks.** (May be implied by their values)	**d**M1
	$x=6.5,\ x=-2$ or $y=-1.5,\ y=7$	Correct answers for either both values of x or both values of y (possibly un-simplified)	A1 cso
	Substitutes their x into their $y=5-x$ or Substitutes their y into their $x=5-y$	Substitute at least one value of x to find y or vice versa. You may need to check if the substitution is not shown explicitly.	M1
	$x=6.5\left(\text{or}\frac{13}{2}\right),\quad x=-2$ and $y=-1.5\left(\text{or}-\frac{3}{2}\right),\quad y=7$	Fully correct solutions and simplified. Coordinates do **not** need to be paired.	A1 cso
	Note that some candidates solve their quadratic in *y* and call these *x* and so the values will be the wrong way round. In such cases the final 2 A marks can be witheld.		
			(7)
			Total 7

Note that the following is an incorrect method but the final method mark is still available:

$$x+y=5 \Rightarrow x^2+y^2=25$$
$$x^2+y^2=25,\ x^2+x+y^2=51 \Rightarrow x=26$$

Scores M0M0A0dM0A0

But then

$$x=26 \Rightarrow y=5-26=-21$$

Scores M1A0

Leave blank

3. Given that $y = 2x^3 - \dfrac{5}{3x^2} + 7, \quad x \neq 0,$ find in its simplest form

(a) $\dfrac{\mathrm{d}y}{\mathrm{d}x}$,

(3)

(b) $\int y \,\mathrm{d}x$.

(4)

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Question Number	Scheme	Notes	Marks
3(a)		$x^n \to x^{n-1}$ seen at least once. Allow $7 \to 0$ as evidence.	M1
		$3\times 2x^2$ **or** $-2\times\frac{-5}{3}x^{-3}$ (One correct term unsimplified or simplified)	A1
	$6x^2+\frac{10}{3x^3}$	Fully correct answer on one line $6x^2+\frac{10}{3x^3}$ or $6x^2+\frac{10}{3}x^{-3}$ Allow $3\frac{1}{3}$ or $3.\dot{3}$ (clear dot over the 3) for $\frac{10}{3}$ (If $+c$ is present score A0) Do **not** allow 'double decker' fractions e.g. $\frac{3\frac{1}{3}}{x^3}$	A1
			(3)
(b)	$\frac{x^4}{2}+\frac{5}{3x}+\ldots$	$x^n \to x^{n+1}$ seen at least once. Allow $7 \to 7x$ as evidence. **But an attempt to integrate their answer to part (a) is M0**	M1
		$2\frac{x^4}{4}$ **or** $\frac{-5}{3}\times\frac{x^{-1}}{-1}$ (one of the first 2 terms correct unsimplified or simplified)	A1
		$2\frac{x^4}{4}$ **and** $\frac{-5}{3}\times\frac{x^{-1}}{-1}$ (both of the first 2 terms correct unsimplified or simplified)	A1
	$\frac{x^4}{2}+\frac{5}{3x}+7x+c$	Fully correct answer on one line including the $+c$. For $\frac{5}{3x}$ allow $\frac{5}{3}x^{-1}$ or $1\frac{2}{3}x^{-1}$ or $1.\dot{6}x^{-1}$ or $\frac{1.\dot{6}}{x}$ (clear dot over the 6). Do not allow x^1 for x. Do **not** allow 'double decker' fractions e.g. $\frac{1\frac{2}{3}}{x}$	A1
			(4)
			Total 7

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4. A sequence of numbers $u_1, u_2, u_3, \ldots$ satisfies

$$u_n = kn - 3^n$$

where k is a constant.

Given that $u_2 = u_4$

(a) find the value of k

(3)

(b) evaluate $\sum_{r=1}^{4} u_r$

(3)

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Question Number	Scheme	Notes	Marks
4(a)	$u_2 = 2k - 3^2$ or $u_4 = 4k - 3^4$	Attempts to use the given formula **correctly** at least once for u_2 or u_4. So e.g. $u_2 = 4k - 3^4$ is M0	M1
	$2k - 9 = 4k - 81 \Rightarrow k = ...$	Puts their u_2 = their u_4 and attempts to solve for k.	M1
	$k = 36$	cao	A1
			(3)
(b)	$u_1 = "36" - 3^1,\ u_2 = 2("36") - 3^2,$ $u_3 = 3("36") - 3^3,\ u_4 = 4("36") - 3^4$	Attempts to find the values of the first 4 terms correctly using their value of k. Allow slips but the method and intention should be clear.	M1
	$\sum_{r=1}^{4} u_r = u_1 + u_2 + u_3 + u_4$ (33 + 63 + 81 + 63)	Adds their first 4 terms. Allow if in terms of k e.g. $k - 3 + 2k - 3^2 + 3k - 3^3 + 4k - 3^4$ ($= 10k - 120$)	M1
	$\left(\sum_{r=1}^{4} u_r =\right) 240$	cao	A1
			(3)
			Total 6

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5. (a) Find the first 4 terms, in ascending powers of x, of the binomial expansion of

$$\left(1 - \frac{1}{2}x\right)^{10}$$

giving each term in its simplest form.

(4)

(b) Hence find the coefficient of x^3 in the expansion of

$$\left(3 + 5x - 2x^2\right)\left(1 - \frac{1}{2}x\right)^{10}$$

(2)

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Question Number	Scheme	Notes	Marks
5(a)	$\left(1-\frac{1}{2}x\right)^{10}$		
	$\left(1-\frac{1}{2}x\right)^{10} = 1+\binom{10}{1}\left(-\frac{1}{2}x\right)+\binom{10}{2}\left(-\frac{1}{2}x\right)^2+\binom{10}{3}\left(-\frac{1}{2}x\right)^3 ...$		M1
	M1: The **method** mark is awarded for an attempt at the Binomial expansion to get the third **and/or** fourth term. The **correct** binomial coefficient needs to be combined with the correct power of *x*. Ignore bracket errors and omission of or incorrect powers of $\pm\frac{1}{2}$. Accept any notation for ${}^{10}C_2$ or ${}^{10}C_3$, e.g. $\binom{10}{2}$ or $\binom{10}{3}$ or 45 or 120 from Pascal's triangle.		
	$=1-5x, +\frac{45}{4}x^2, -15x^3+...$	Allow terms to be "listed". Allow equivalents for $\frac{45}{4}$ e.g. $11\frac{1}{4}, 11.25$ Allow $+\frac{45}{4}x^2$ to come from $\binom{10}{2}\left(\frac{1}{2}x\right)^2$. Do not allow $1+-5x$ for $1-5x$ or $+-15x^3$ for $-15x^3$.	B1, A1, A1
			(4)
(b)	$\left(3+5x-2x^2\right)\left(1-\frac{1}{2}x\right)^{10}$		
	$\left(3+5x-2x^2\right)\left(1-\frac{1}{2}x\right)^{10} = \left(3+5x-2x^2\right)\left(1-5x+\frac{45}{4}x^2-15x^3\right) = ...$ Uses their expansion from part (a) to identify the correct 'pairing' of terms and adds the x^3 terms or the x^3 coefficients together. Look for $3\times("-15")+5\times\left("\frac{45}{4}"\right)+(-2)\times("-5")$ with or without the x^3's		M1
	$\frac{85}{4}$ oe	Cao (Allow $\frac{85}{4}x^3$)	A1
			(2)
			Total 6

Leave blank

6. (a) Sketch the graph of $y = \left(\frac{1}{2}\right)^x$, $x \in \mathbb{R}$, showing the coordinates of the point at which the graph crosses the y-axis.

(2)

The table below gives corresponding values of x and y, for $y = \left(\frac{1}{2}\right)^x$

The values of y are rounded to 3 decimal places.

x	−0.9	−0.8	−0.7	−0.6	−0.5
y	1.866	1.741	1.625	1.516	1.414

(b) Use the trapezium rule with all the values of y from the table to find an approximate value for

$$\int_{-0.9}^{-0.5} \left(\frac{1}{2}\right)^x \, dx$$

(3)

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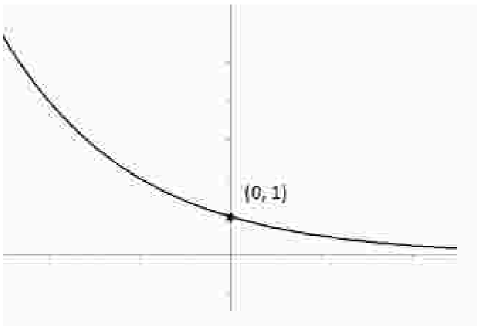
Question Number	Scheme	Notes	Marks
6(a)			
	Either Correct **shape**: Look for a curve in quadrants 1 and 2 that moves smoothly from a negative gradient (< -1) becoming less negative to approximately 0 with no turning points. Allow the curve to tend towards the vertical on the lhs as long as it does not go too far beyond the vertical and allow if it does not appear asymptotic to the x-axis on the rhs. **or** A curve or line with an **intercept** on the positive y-axis marked as 1 or (0, 1) or (1, 0) as long as it is in the correct place. Allow if away from the sketch but must be (0, 1) or e.g. $x = 0, y = 1$ if it is. The sketch has precedence if there is any ambiguity.		B1
	Correct **shape**, **position** and **intercept**: Shape and intercept as above. For position look for an asymptote that is at least below a horizontal line that is half way between the intercept and the x-axis.		B1
			(2)
(b)	$h = 0.1$	Correct h (Allow $h = -0.1$). May be implied by their trapezium rule and may be unsimplified e.g. ((-0.5)-(-0.9))/4	B1
	$A = \frac{1}{2}(0.1)\left[1.866 + 1.414 + 2(1.741 + 1.625 + 1.516)\right]$ A **correct** application of the trapezium rule using their h. **The bracketing must be correct** but may be implied by their final answer. You may need to check if their h is incorrect. Note that $1.866 + 1.414 + 2(1.741 + 1.625 + 1.516) = 13.044$ The 'square' brackets needs to contain first y value plus last y value and the inner bracket to be multiplied by 2 and to be the summation of the remaining y values in the table with no additional values. If the only mistake is a copying error or is to omit one value from inner bracket this may be regarded as a slip and the M mark can be allowed (An extra repeated term forfeits the M mark however). M0 if values used are x values instead of y values. $A = \frac{1}{2}(0.1)1.866 + 1.414 + 2(1.741 + 1.625 + 1.516) = 11.2713$ scores B1M0A0 $A = \frac{1}{2}(0.1)1.866 + 1.414 + 2(1.741 + 1.625 + 1.516) = 0.6522$ scores B1M1A1 Separate trapezia may be used: B1 for $h = 0.1$, M1 for $1/2h(a + b)$ used 3 or 4 times and trapezia added together.		M1
	$A = 0.6522$ or $A = 0.652$	Allow either answer (must be positive) and allow $\frac{3261}{5000}$ if no decimal seen.	A1
			(3)
			Total 5

Leave blank

7. The point A has coordinates $(-1, 5)$ and the point B has coordinates $(4, 1)$.

The line l passes through the points A and B.

(a) Find the gradient of l.

(2)

(b) Find an equation for l, giving your answer in the form $ax + by + c = 0$ where a, b and c are integers.

(2)

The point M is the midpoint of AB.

The point C has coordinates $(5, k)$ where k is a constant.

Given that the distance from M to C is $\sqrt{13}$

(c) find the exact possible values of the constant k.

(4)

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Question Number	Scheme	Notes	Marks
7(a)	$m=\frac{5-1}{-1-4}$	Attempts $\frac{\text{change in } y}{\text{change in } x}$. Condone one sign slip. Maybe implied by $\pm\frac{4}{5}$	M1
	$=-\frac{4}{5}$	cao	A1
	Correct answer only scores both marks.		
			(2)
(a) Way 2	$5=-m+c$ $1=4m+c$ $\Rightarrow 5-1=-m-4m\Rightarrow m=...$	Correct method for the gradient	M1
	$(m=)-\frac{4}{5}$	cao	A1
			(2)
(b)	$y-5="-\frac{4}{5}"(x+1)$ or $y-1="-\frac{4}{5}"(x-4)$	Uses *A* or *B* and their *m* in a correct straight line method. If using $y = mx + c$ must reach as far as $c = \ldots$ **Attempting the normal is M0.**	M1
	$4x+5y-21=0$	Allow any integer multiple	A1
			(2)
(c)	*M* is $\left(\frac{3}{2}, 3\right)$	Correct midpoint	B1
	$MC^2=\left(5-"\frac{3}{2}"\right)^2+(k-"3")^2$ Correct use of Pythagoras for *MC*. E.g. sight of $\left(5-"\frac{3}{2}"\right)^2+h^2$ or $\sqrt{\left(5-"\frac{3}{2}"\right)^2+h^2}$ where $h = k$ – "3" or $h = k$		M1
	$\left(5-"\frac{3}{2}"\right)^2+(k-"3")^2=13\Rightarrow k=...$	Uses $\sqrt{13}$ correctly to find a value for *k*. Must be a correct method so e.g. $\left(5-"\frac{3}{2}"\right)^2+(k-"3")^2=13^2$ scores M0 **Dependent on the first M mark.**	**d**M1
	$(k=)3\pm\frac{\sqrt{3}}{2}$ oe	Both. Accept e.g. $\frac{24\pm\sqrt{48}}{8},\frac{6\pm\sqrt{3}}{2}$ and ignore how they are referenced, e.g. there is no need for $k = \ldots$	A1
			(4)
			Total 8

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8.

$$f(x) = 2x^3 - 3x^2 + px + q$$

where p and q are constants.

When $f(x)$ is divided by $(x - 1)$, the remainder is -6

(a) Use the remainder theorem to show that $p + q = -5$

(2)

Given also that $(x + 2)$ is a factor of $f(x)$,

(b) find the value of p and the value of q.

(3)

(c) Factorise $f(x)$ completely.

(4)

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Question Number	Scheme	Notes	Marks
8	**(Mark (a) and (b) together)**		
(a)	$2(1)^3-3(1)^2+p(1)+q=-6$	Attempts $f(\pm1)=-6$	M1
	$p+q=-5$ *	Correct equation with no errors.	A1
			(2)
(a) Way 2	Long division of $2x^3-3x^2+px+q$ by $x-1$: quotient $2x^2-x+p-1$; $2x^3-2x^2$; $-x^2+px+q$; $-x^2+x$; $(p-1)x+q$; $(p-1)x-(p-1)$; $p+q-1$ $\Rightarrow p+q-1=-6$	Attempts long division correctly (allow sign slips only) leading to a remainder in p and q which is set $=-6$	M1
	$p+q=-5$ *	Correct equation with no errors.	A1
			(2)
(b)	$2(-2)^3-3(-2)^2+p(-2)+q=0$ A clear attempt at $f(-2)=0$ or $f(2)=0$. May be implied by a correct equation but if the equation is incorrect and no method is shown score M0.		M1
	$p+q=-5,\ q-2p=28$ $\Rightarrow p=-11,\ q=6$	Solves simultaneously. Must be using $p+q=-5$ and their linear equation in p and q and must reach values for both p and q.	M1
		Correct values	A1
			(3)

8(c)	$\dfrac{2x^3-3x^2-11x+6}{x+2}=2x^2+kx+...$	Divides f(x) by $(x+2)$ or compares coefficients or uses inspection and obtains at least the first 2 terms of a quadratic with $2x^2$ as the first term and an x term. Must be seen in (c).	M1
	$2x^2-7x+3$	Correct quadratic	A1
	$2x^2-7x+3=(2x-1)(x-3)$	Attempts to factorise their 3 term quadratic expression. The usual rules apply here so if $2x^2-7x+3$ is factorised as $\left(x-\frac{1}{2}\right)(x-3)$, this scores M0 unless the factor of 2 appears later. **Dependent on the first M mark.**	**d**M1
	$\text{f}(x)=(x+2)(2x-1)(x-3)$ Or e.g. $\text{f}(x)=2(x+2)\left(x-\frac{1}{2}\right)(x-3)$	Fully correct factorisation. Must see all factors together on one line and no commas in between.	A1
			(4)
	Answers with no working in (c) $2x^3-3x^2-11x+6=(x+2)(2x-1)(x-3)$ scores full marks $2x^3-3x^2-11x+6=2(x+2)\left(x-\frac{1}{2}\right)(x-3)$ scores full marks $2x^3-3x^2-11x+6=(x+2)\left(x-\frac{1}{2}\right)(x-3)$ scores a **special case** M1A1M0A0		
	<u>**Just**</u> **writing down roots of the cubic scores no marks.**		
	Ignore any "= 0" and also ignore any subsequent attempts to solve f(x) = 0 once the factorised form is seen.		
			Total 9

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9. A car manufacturer currently makes 1000 cars each week.

The manufacturer plans to increase the number of cars it makes each week.

The number of cars made will be increased by 20 each week from 1000 in week 1, to 1020 in week 2, to 1040 in week 3 and so on, until 1500 cars are made in week N.

(a) Find the value of N.

(2)

The car manufacturer then plans to continue to make 1500 cars each week.

(b) Find the total number of cars that will be made in the first 50 weeks starting from and including week 1.

(5)

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Question Number	Scheme	Notes	Marks
9(a)	$1000+(N-1)\times 20=1500 \Rightarrow N=...$	Uses a correct term formula with a = 1000, d = 20 and the 1500 in an attempt to find N. Alternatively calculates $\frac{1500-1000}{20}+1$.	M1
	$(N=)26$	Cao (Allow n or any other letter for N)	A1
	Listing: Uses a correct arithmetic progression, so considers 1000, 1020, 1040 etc. to reach 1500 and so concludes (N =) 26 scores M1A1 together		
	Correct answer only scores both marks		
			(2)
(b)	$S_{26}=\frac{1}{2}("26")[2(1000)+("26"-1)\times 20]$ or $S_{26}=\frac{1}{2}("26")[1000+1500]$	Correct attempt at AP sum with n = their N, a = 1000, d = 20 or n = their N, a = 1000, l = 1500	M1
	=32 500	Correct sum (may be implied)	A1
	constant terms $=(50-N)\times 1500$ Or constant terms $=(50-(N-1))\times 1500$	Attempts $(50-N)\times 1500$ or $(50-(N-1))\times 1500$. So if n = 26 was used for the previous M, allow the use of 24 or 25 here.	M1
	$S_{50}="24"\times 1500+S_{26}$	Adds their AP sum to constant terms where 50 terms are being considered. **Dependent on both previous M's.**	ddM1
	$=68\,500$	cao	A1
			(5)
(b) Way 2	$S_{26}=\frac{1}{2}("26"-1)[2(1000)+("26"-1-1)\times 20]$ or $S_{26}=\frac{1}{2}("26"-1)[1000+1480]$	Correct attempt at AP sum with n = their N – 1, a = 1000, d = 20 or n = their N – 1, a = 1000, l = 1500	M1
	= 31 000	Correct sum (may be implied)	A1
	constant terms $=(50-(N-1))\times 1500$ Or constant terms $=(50-(N-2))\times 1500$	Attempts $(50-(N-1))\times 1500$ or $(50-(N-2))\times 1500$. So if n = 25 was used for the previous M, allow the use of 25 or 26 here.	M1
	$S_{50}="25"\times 1500+S_{26}$	Adds their AP sum to constant terms where 50 terms are being considered. **Dependent on both previous M's.**	ddM1
	$=68\,500$	cao	A1
			(5)
			Total 7

Important Note: Special Case

Candidates who obtain *N* = 25 in part (a) are allowed a full recovery in part (b) for,

$$\frac{1}{2}(25)[2\times1000+24\times20]=31\ 000 \ = \text{M1A1}$$

$$25\times1500(=37\,500) \ = \text{M1}$$

$$31\ 000 + 37\ 500 = 68\ 500 = \text{ddM1A1}$$

Listing in (b):

Week	1	2	3	4	5	6	7	8	9	10	11	12	13
Cars	1000	1020	1040	1060	1080	1100	1120	1140	1160	1180	1200	1220	1240
Total	1000	2020	3060	4120	5200	6300	7420	8560	9720	10900	12100	13320	14560

Week	14	15	16	17	18	19	20	21	22	23	24	25	26
Cars	1260	1280	1300	1320	1340	1360	1380	1400	1420	1440	1460	1480	1500
Total	15820	17100	18400	19720	21060	22420	23800	25200	26620	28060	29520	31000	32500

Week	27	28	29	…	49	50
Cars	1500	1500	1500	…	1500	1500
Total	34000	35500	37000	…	67000	68500

M1: Attempts the sum of either 25 or 26 terms of a series with first term 1000 and $d = 20$
A1: S = 31000 or 32500
Then follow the scheme

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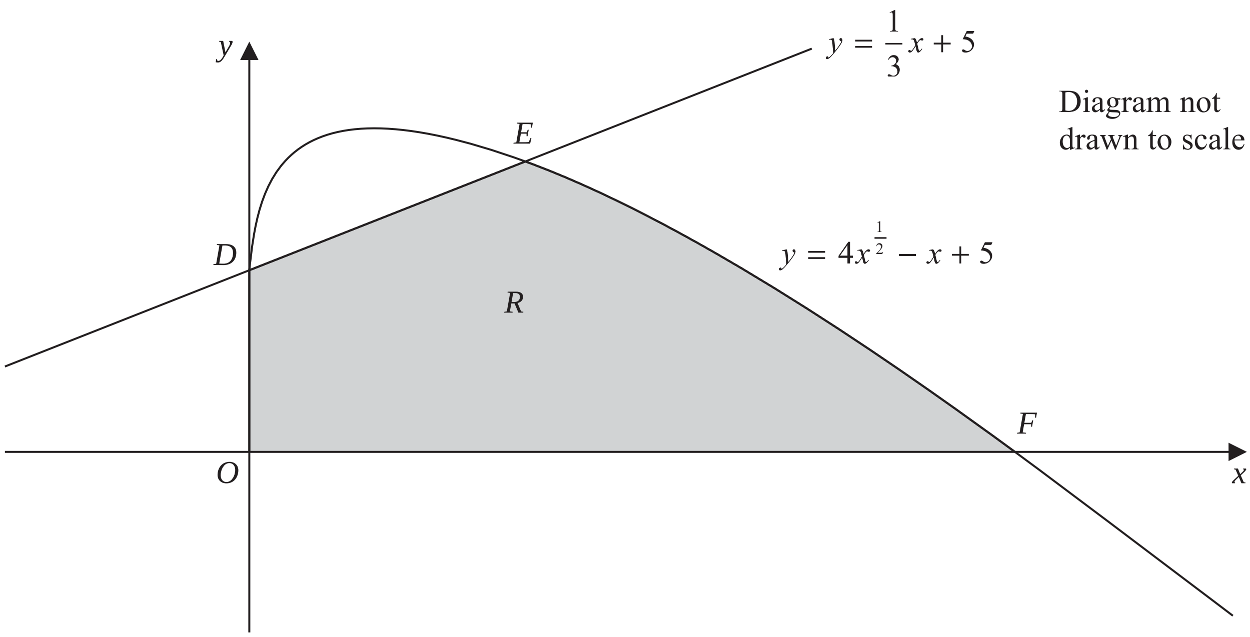

Figure 1

The finite region R, which is shown shaded in Figure 1, is bounded by the coordinate axes, the straight line l with equation $y = \frac{1}{3}x + 5$ and the curve C with equation $y = 4x^{\frac{1}{2}} - x + 5,\ x \geqslant 0$

The line l meets the curve C at the point D on the y-axis and at the point E, as shown in Figure 1.

(a) Use algebra to find the coordinates of the points D and E.

(4)

The curve C crosses the x-axis at the point F.

(b) Verify that the x coordinate of F is 25

(1)

(c) Use algebraic integration to find the exact area of the shaded region R.

(6)

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P 5 4 9 4 1 A 0 2 8 5 2

Question Number	Scheme	Notes	Marks
10(a)	$\frac{1}{3}x+5=4x^{\frac{1}{2}}-x+5 \Rightarrow x=3x^{\frac{1}{2}}$	Sets line = curve and obtains an equation of the form $\alpha x=\beta x^{\frac{1}{2}}$ or equivalent e.g. $\alpha x-\beta x^{\frac{1}{2}}=0$	M1
	$x=9$	Obtains x = 9 from a correct equation	A1
	Note that $x-3x^{\frac{1}{2}}=0 \Rightarrow x^2-9x=0 \Rightarrow x=9$ is acceptable		
	$(0,\ 5)$	Correct point. Coordinates not necessary and may be seen on the diagram.	B1
	$(9,\ 8)$	Correct point. Coordinates not necessary and may be seen as values and/or on the diagram.	A1
			(4)
(b)	$x=25 \Rightarrow 4(25)^{\frac{1}{2}}-25+5=20-25+5=0$ So x-coordinate of F is 25	Shows F's x coordinate is 25. Need to see $4(25)^{\frac{1}{2}}$ evaluated as 4×5 or 20	B1
	Note: This may be shown by solving $4x^{\frac{1}{2}}-x+5=0$ **Example 1** $4x^{\frac{1}{2}}-x+5=0 \Rightarrow x-4x^{\frac{1}{2}}-5=0 \Rightarrow \left(x^{\frac{1}{2}}+1\right)\left(x^{\frac{1}{2}}-5\right)=0$ $x^{\frac{1}{2}}-5=0 \Rightarrow x^{\frac{1}{2}}=5 \Rightarrow x=25$ **Example 2** $4x^{\frac{1}{2}}-x+5=0 \Rightarrow 4x^{\frac{1}{2}}=x-5 \Rightarrow 16x=(x-5)^2$ $x^2-26x+25=0 \Rightarrow (x-25)(x-1)=0 \Rightarrow x=25$ (In this case, ignore any reference to the other root provided x = 25 is obtained)		
			(1)
(c)	**The first 2 marks (M1A1) in (c) are to be scored as follows irrespective of the method used to find the shaded area:**		
	$\int\left(4x^{\frac{1}{2}}-x+5\right)\mathrm{d}x=\frac{8}{3}x^{\frac{3}{2}}-\frac{x^2}{2}+5x$ or $\int\left(4x^{\frac{1}{2}}-x+5-\left(\frac{1}{3}x+5\right)\right)\mathrm{d}x=\int\left(4x^{\frac{1}{2}}-\frac{4}{3}x\right)\mathrm{d}x=\frac{8}{3}x^{\frac{3}{2}}-\frac{2}{3}x^2$ M1: $x^n \to x^{n+1}$ seen at least once A1: Correct integration, simplified or unsimplified. Score as soon as the correct integration is seen. Can be awarded for the curve or their $\pm(\text{curve}-\text{line})$. Award this mark even if mistakes have been made in 'simplifying' their $\pm(\text{curve}-\text{line})$ as long as the subsequent integration is correct.		M1A1

WAY 1:

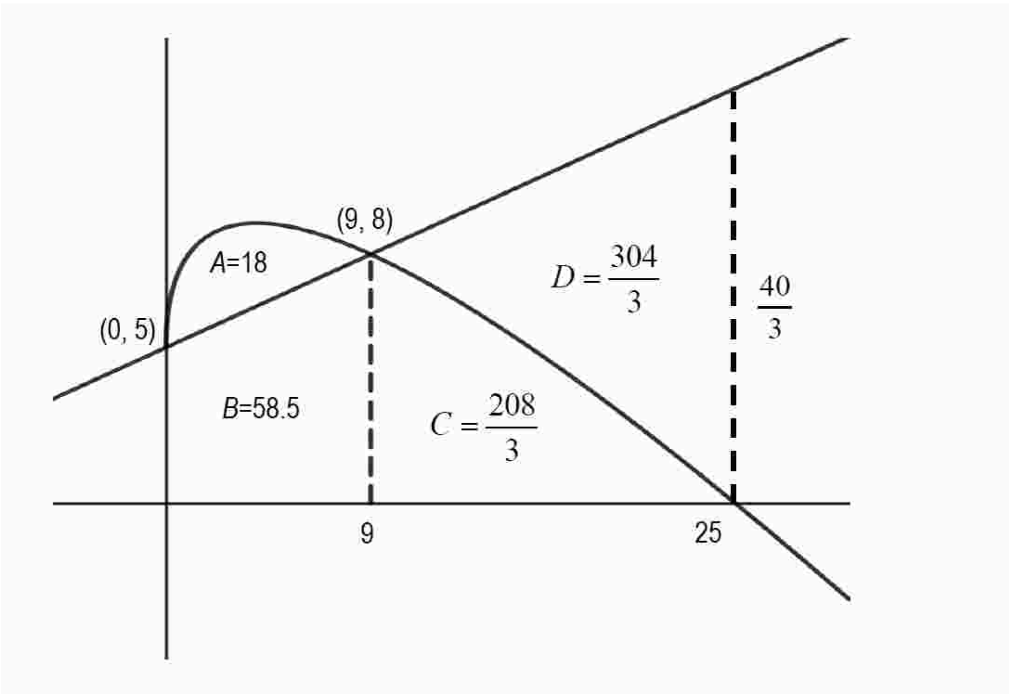
Area *B* + Area *C*

Requires:

1	$\left[\frac{8}{3}x^{\frac{3}{2}}-\frac{x^2}{2}+5x\right]_{"9"}^{25}=\frac{875}{6}-\frac{153}{2}$	Uses the limits 25 and "9" in their integrated (changed) curve and subtracts either way round.

2	Area of trapezium = $\frac{("8"+5)}{2}\times"9"=58.5$ or Triangle + Rectangle $="5"\times"9"+\frac{"5"\times"9"}{2}=58.5$	Correct trapezium area method or may be done as triangle + rectangle or as $\int_0^{"9"}\left(\frac{1}{3}x+5\right)\mathrm{d}x=\left[\frac{1}{6}x^2+5x\right]_0^{"9"}=58.5$ Must be correct integration and correct use of limits in this case.

	Uses process 1 **or** process 2		M1
	Uses process 1 **and** process 2 (Even if other areas have been calculated) **Dependent on the previous M**		dM1
	$R=\frac{208}{3}+58.5=...$	Adds their areas. **Dependent on all the previous M marks.**	**d**M1
	$=\frac{767}{6}$	cao	A1
			(6)



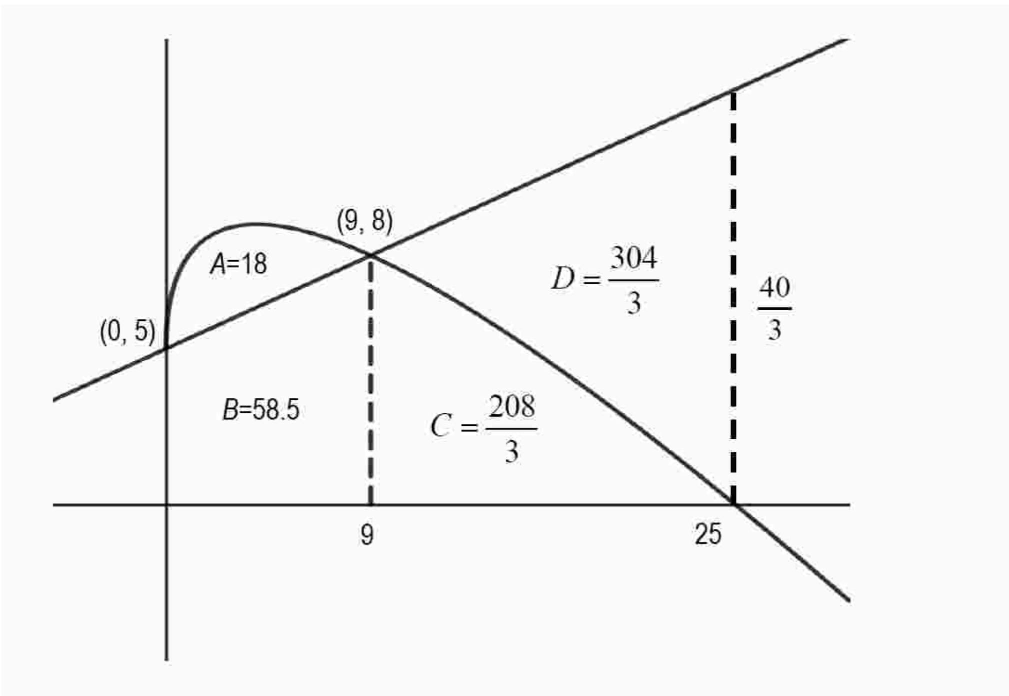
WAY 2:

Area (*A*+*B*+*C*) - Area *A*

Requires:

1	$\left[\frac{8}{3}x^{\frac{3}{2}} - \frac{x^2}{2} + 5x\right]_0^{25} = \frac{1000}{3} - \frac{625}{2} + 125$	Uses the limits 25 and 0 in their integrated (changed) curve and subtracts either way round.
2	Area between line and curve $= \int_0^{"9"} \left(4x^{\frac{1}{2}} - \frac{4}{3}x\right) dx = \left[\frac{8}{3}x^{\frac{3}{2}} - \frac{2}{3}x^2\right]_0^{"9"} = 18$	Uses the limits "9" and 0 on their integrated (changed) $\pm(\text{curve} - \text{line})$ and subtracts either way round.

	Uses process 1 **or** process 2		M1
	Uses process 1 **and** process 2 (Even if other areas have been calculated) **Dependent on the previous M**		dM1
	$R = \frac{875}{6} - 18 = ...$	Subtracts their areas. **Dependent on all the previous M marks.**	**d**M1
	$= \frac{767}{6}$	cao	A1
			(6)



WAY 3:

Area (*B*+*C*+*D*) - Area *D*

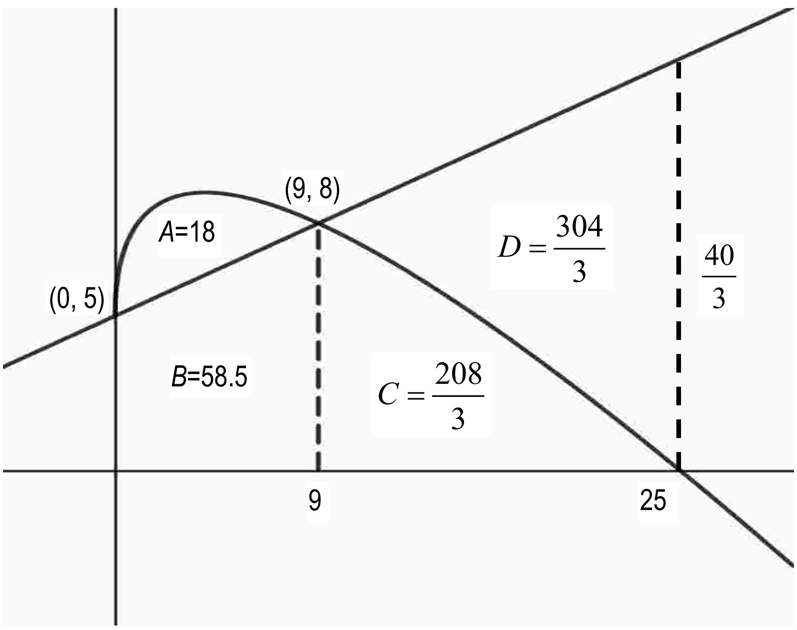
Requires:

1	$\left[\frac{2}{3}x^2 - \frac{8}{3}x^{\frac{3}{2}}\right]_{"9"}^{25} = \frac{250}{3} + 18 = \frac{304}{3}$	Uses the limits 25 and "9" in their integrated (changed) $\pm(\text{curve} - \text{line})$ and subtracts either way round.
2	Area of trapezium = $\frac{("5" + \frac{1}{3}\times 25 + 5)}{2}\times 25 = \frac{1375}{6}$ or Triangle + Rectangle $= "5"\times 25 + \frac{25\times\frac{1}{3}\times 25}{2} = \frac{1375}{6}$	Correct trapezium area method or may be done as triangle + rectangle or as $\int_0^{25}\left(\frac{1}{3}x+5\right)dx = \left[\frac{1}{6}x^2 + 5x\right]_0^{25} = \frac{1375}{6}$ Must be correct integration and correct use of limits in this case.

	Uses process 1 **or** process 2		M1
	Uses process 1 **and** process 2 (Even if other areas have been calculated) **Dependent on the previous M**		dM1
	$R = \frac{1375}{6} - \frac{304}{3} = ...$	Subtracts their areas. **Dependent on all the previous M marks.**	**d**M1
	$= \frac{767}{6}$	cao	A1
			(6)

No algebraic integration seen:

Candidates may perform the integration on their calculators. In such cases a maximum of 2 marks is available: **M0A0M1dM1dM0A0** if the values for the areas for the M2 and M3 follow from their values found in part (a) (you may need to check)



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11. The equation $7x^2 + 2kx + k^2 = k + 7$, where k is a constant, has two distinct real roots.

(a) Show that k satisfies the inequality

$$6k^2 - 7k - 49 < 0$$

(4)

(b) Find the range of possible values for k.

(4)

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Question Number	Scheme	Notes	Marks
11(a)	$7x^2+2kx+k^2-k-7(=0)$ or $a=7, b=2k, c=k^2-k-7$ Attempts to collect terms to one side so look for $7x^2+2kx+k^2\pm k\pm 7(=0)$ (the " = 0" may be implied) or writes down values for "a", "b" and "c" where "a" = 7, "b" = $2k$ and "c" = $k^2\pm k\pm 7$ which may also be implied by their work.		
	E.g. $(2k)^2-4\times7\times(k^2-k-7)$ $(2k)^2-4\times7\times(k^2-k-7)>0$ $(2k)^2-4\times7\times(k^2-k-7)<0$ $(2k)^2=4\times7\times(k^2-k-7)$	Use of b^2-4ac with $a=\pm7$, $b=\pm2k$ and $c=\pm k^2\pm k\pm 7$. May be seen as part of e.g. $b^2=4ac$ but not as part of the quadratic formula – the b^2-4ac must be 'extracted'. Condone missing brackets for this mark provided the intention is clear. There must be no x's.	M1
	$(2k)^2-4\times7\times(k^2-k-7)>0$ Obtains a correct quadratic inequality that is not the printed answer. This mark can be recovered from missing brackets around the "$2k$" or the "k^2-k-7" but do not allow this mark if there was an incorrect rearrangement of $7x^2+2kx+k^2=k+7$ earlier and/or incorrect values of any of "a", "b" or "c" stated e.g. identifying "c" as k^2-k+7 initially and then using "c" as k^2-k-7		A1
	$6k^2-7k-49<0$ * **Fully correct proof with no errors**. This includes bracketing errors, sign errors and e.g. identifying "c" as k^2-k+7 initially and then using "c" as k^2-k-7 Starting with e.g. $7x^2+2kx+k^2-k-7>0$ or $7x^2+2kx+k^2-k-7<0$ would also be an error.		A1*
			(4)
(b)	$6k^2-7k-49=0\Rightarrow k=...$	Attempt to solve the 3TQ from part (a) to obtain 2 values for k. (see general guidance for solving a 3TQ). May be implied by their values but if no working is shown and the roots are incorrect, score M0 here.	M1
	$k=-\frac{7}{3}, \frac{7}{2}$	Correct values. May be seen as part of their inequalities. Allow $k=\frac{7\pm35}{12}$	A1
	$-\frac{7}{3}<k<\frac{7}{2}$ or $\left(-\frac{7}{3},\frac{7}{2}\right)$ or $k>-\frac{7}{3}$ **and** $k<\frac{7}{2}$	Attempt inside region for their critical values. Do not award simply for diagram or table.	M1
		Cao. ($k>-\frac{7}{3}$, $k<\frac{7}{2}$ is A0 i.e. must see "**and**" if regions given separately)	A1
	Note that $-\frac{7}{3}<k<\frac{7}{2}$ with no working scores full marks in part (b)		
	Note: Allow x to be used in (b) rather than k but the final mark requires k only		
			(4)
			Total 8

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12. (a) Show that the equation

$$6\cos x - 5\tan x = 0$$

may be expressed in the form

$$6\sin^2 x + 5\sin x - 6 = 0$$

(3)

(b) Hence solve for $0 \leqslant \theta < 360°$

$$6\cos(2\theta - 10°) - 5\tan(2\theta - 10°) = 0$$

giving your answers to one decimal place.

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

(5)

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Question Number	Scheme	Notes	Marks
12(a)	$6\cos x - 5\tan x = 6\cos x - 5\dfrac{\sin x}{\cos x}$	Uses $\tan x = \dfrac{\sin x}{\cos x}$. This may be implied by e.g. $6\cos x - 5\tan x = 0 \Rightarrow 6\cos^2 x - 5\sin x = 0$	M1
	$6\cos^2 x - 5\sin x = 6\left(1-\sin^2 x\right) - 5\sin x$	Uses $\cos^2 x = 1 - \sin^2 x$	M1
	$6\sin^2 x + 5\sin x - 6 = 0$ *	Correct proof with no notational errors, missing brackets, missing variables, $\sin x^2$ instead of $\sin^2 x$ etc. Allow the proof to be in terms of a different variable but the final equation must be in terms of x. If everything is moved to one side, allow the "= 0" to appear at the end.	A1*
	Allow to work backwards: $6\sin^2 x + 5\sin x - 6 = 0 \Rightarrow 6\left(\sin^2 x - 1\right) + 5\sin x = 0$ $-6\cos^2 x + 5\sin x = 0$ M1: Uses $\cos^2 x = 1 - \sin^2 x$ $-6\cos x + \dfrac{5\sin x}{\cos x} = 0 \Rightarrow -6\cos x + 5\tan x = 0$ M1: Uses $\tan x = \dfrac{\sin x}{\cos x}$ A1: $6\cos x - 5\tan x = 0$ Achieves this result with no errors as described above		
			(3)

12(b)	$6\sin^2 x + 5\sin x - 6 = 0 \Rightarrow \sin x = ...$	Attempt to solve the given quadratic for $\sin x$ or for $\sin\left(2\theta - 10^{\circ}\right)$ or e.g. y or even x. Allow this mark if their quadratic is a clear mis-copy e.g. if they attempt to solve $6\sin^2 x - 5\sin x - 6 = 0$ having previously obtained $6\sin^2 x + 5\sin x - 6 = 0$	M1
	$\sin x = \frac{2}{3}$ or $\sin\left(2\theta - 10^{\circ}\right) = \frac{2}{3}$	Correct value (Ignore how they reference it so just look for $\frac{2}{3}$). The other root can be ignored whether it is correct or incorrect.	A1
	$2\theta - 10^{\circ} = \sin^{-1}\left(\frac{2}{3}\right) = ... \Rightarrow \theta = ...$	Finds arcsin of their 2/3. May be implied 41.81… or by their value of $\sin^{-1}\left(\frac{2}{3}\right)$ **and attempts** $\frac{\sin^{-1}\left(\frac{2}{3}\right) \pm 10}{2}$. Their $\sin^{-1}\left(\frac{2}{3}\right)$ must be a value and not just $\sin^{-1}\left("\frac{2}{3}"\right)$. May be implied by sight of 25.9°	M1
	$(\theta =)\, 25.9^{\circ},\ 74.1^{\circ},\ 205.9^{\circ},\ 254.1^{\circ}$	Awrt two correct angles	A1
		All four angles and allow awrt the answers shown. Ignore answers outside the range (0, 360°) but withhold this mark for extra answers in range. (Degree symbols not required)	A1
			(5)
			Total 8

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13. (i) Find the value of x for which

$$4^{3x+2} = 3^{600}$$

giving your answer to 4 significant figures.

(3)

(ii) Given that

$$\log_a (3b - 2) - 2\log_a 5 = 4, \qquad a > 0, a \neq 1, b > \frac{2}{3}$$

find an expression for b in terms of a.

(4)

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Question Number	Scheme	Notes	Marks
13(i)	$\log 4^{3x+2} = (3x+2)\log 4\left(\text{allow } 3x+2\log 4\right)$ $\log 3^{600} = 600\log 3$ $\log_4 4^{3x+2} = 3x+2$ $\log_3 3^{600} = 600$ $3x+2 = \log_4 3^{600}$	Evidence of the application of the power law of logarithms or the definition of a logarithm. This is independent of any other working – see examples. Generally this is for e.g. $\log_x y^k = k\log_x y$ or $\log_x x^k = k$ or $\log y^k = k\log y$ etc. where x, y and k are any variables/numbers.	M1
	Examples: $x = \frac{1}{3}\left(\frac{600\log 3}{\log 4} - 2\right)$ **or** $x = \frac{600\log_4 3 - 2}{3}$ **or** $x = \frac{\frac{600}{\log_3 4} - 2}{3}$	This mark is for a correct expression or a correct value for x. Note that it must be an expression that can be evaluated e.g. $x = \frac{\log_4 3^{600} - 2}{3}$ is A0. May be implied by awrt 158 following correct work.	A1
	$x = 157.8$	Cao (Must be this value **not** awrt)	A1
			(3)
(ii)	$2\log_a 5 = \log_a 25$ or $\log_a 5^2$		B1
	$\log_a(3b-2) - \log_a 25 = \log_a \frac{(3b-2)}{25}$ or $\log_a 25 + \log_a a^4 = \log_a 25a^4$	Correct use of subtraction or addition rule	M1
	$a^4 = \frac{3b-2}{25}$	Removes logs correctly. **Dependent on the previous M.**	dM1
	$b = \frac{25a^4+2}{3}$	Cao oe e.g. $b = \frac{25a^4}{3} + \frac{2}{3}$	A1
			(4)
	Special Case: $\log_a(3b-2) - \log_a 25 = \log_a \frac{25}{3b-2} \Rightarrow a^4 = \frac{25}{3b-2}$ Scores B1M0dM1A0		
			Total 7

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14. The circle C has equation

$$x^2 + y^2 + 16y + k = 0$$

where k is a constant.

(a) Find the coordinates of the centre of C.

(2)

Given that the radius of C is 10

(b) find the value of k.

(2)

The point $A(a, -16)$, where $a > 0$, lies on the circle C. The tangent to C at the point A crosses the x-axis at the point D and crosses the y-axis at the point E.

(c) Find the exact area of triangle ODE.

(7)

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Question Number	Scheme	Notes	Marks
14	**Mark (a) and (b) together**		
(a)	$(0, -8)$	$x = 0$ **or** $y = -8$ (May be seen on a sketch)	B1
		$x = 0$ **and** $y = -8$ (May be seen on a sketch)	B1
			(2)
(b)	Uses 64, 100 and k (not k^2) to obtain a value for k		M1
	$k = -36$	cao	A1
	***k* = –36 scores both marks**		
			(2)

14(c)	$y=-16 \Rightarrow a=6$	Correct x-coordinate. Allow $x = 6$ or just sight of 6. May be seen on a sketch.	B1
	$m_N=\frac{-16+8}{6-0}\left(=-\frac{4}{3}\right)$ or $m_N=\frac{-16+8}{a-0}\left(=-\frac{8}{a}\right)$	Correct attempt at gradient using the centre and their A. Allow one sign slip. If they use O for the centre, this is M0. Allow if in terms of a i.e. if they haven't found or can't find a.	M1
	$m_T=-1\div"-\frac{4}{3}"=...$ or $m_T=-1\div"-\frac{8}{a}"=...$	Correct use of perpendicular gradient rule. Allow if in terms of a.	M1
	Alternative by implicit differentiation: **Note that there is no penalty for an incorrect value of k here.** $x^2+y^2+16y+k=0\Rightarrow 2x+2y\frac{dy}{dx}+16\frac{dy}{dx}=0$ M1 for $\alpha x+\beta y\frac{dy}{dx}+c\frac{dy}{dx}=0$ $2(6)+2(-16)\frac{dy}{dx}+16\frac{dy}{dx}=0\Rightarrow\frac{dy}{dx}=\frac{12}{16}$ M1 for substituting x = "6" or $x = a$ and $y = -16$ to find the gradient from differentiation that yielded 2 terms in $\frac{dy}{dx}$		
	$y+16=\frac{3}{4}(x-"6")$ or $y+16=\frac{a}{8}(x-"6")$	Correct straight line method using a gradient which is **not** the radius gradient and their A or (a, -16). Allow a gradient in terms of a.	M1
	$x=0\Rightarrow y=-\frac{41}{2},\ y=0\Rightarrow x=\frac{82}{3}$	Correct values	A1
	Area = $\frac{1}{2}\times\frac{41}{2}\times\frac{82}{3}$	Correct method for area using vertices of the form (0, 0), (X, 0) and (0, Y) where X and Y are numeric and have come from the intersections of their tangent with the axes. Allow negative lengths here. **Dependent on the previous M mark.**	**d**M1
	$=\frac{1681}{6}$ or $280\frac{1}{6}$ or $280.1\dot{6}$ (clear dot over 6)	Cao. Must be **positive** and may be recovered from sign errors on $-\frac{41}{2}$ and/or $\frac{82}{3}$ **but must be from a correct tangent equation**.	A1
			(7)
			Total 11

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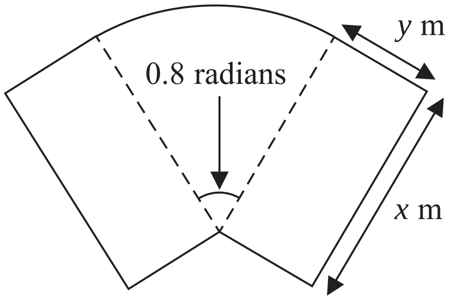

Figure 2

Figure 2 shows a plan for a garden.
The garden consists of two identical rectangles of width y m and length x m, joined to a sector of a circle with radius x m and angle 0.8 radians, as shown in Figure 2.

The area of the garden is 60 m^2.

(a) Show that the perimeter, P m, of the garden is given by

$$P = 2x + \frac{120}{x}$$

(5)

(b) Use calculus to find the exact minimum value for P, giving your answer in the form $a\sqrt{b}$, where a and b are integers.

(4)

(c) Justify that the value of P found in part (b) is the minimum.

(2)

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Question Number	Scheme	Notes	Marks
15(a)	$(\text{Arc length} =)\,0.8x$	Correct expression	B1
	$P = 2x + 4y + 0.8x$	$P = \alpha x + \beta y + "0.8x", \quad \alpha, \beta \neq 0$	M1
	This may be implied by e.g. $P = 2x + 4(\text{their } y) + 0.8x$		
	$2xy + \frac{1}{2}(0.8)x^2 = 60$	Correct equation for the area	B1
	$y = \frac{60 - 0.4x^2}{2x} \Rightarrow P = 4\left(\frac{60 - 0.4x^2}{2x}\right) + 2.8x$	Makes y the subject and substitutes	M1
	$P = \frac{120}{x} + 2x$ *	Obtains printed answer with no errors with $P = \ldots$ or Perimeter $= \ldots$ appearing at some point.	A1*
	Note that it is sufficient to go from $P = 4\left(\frac{60 - 0.4x^2}{2x}\right) + 2.8x$ to $P = \frac{120}{x} + 2x$ *		
			(5)

15(b)	**Mark (b) and (c) together** **Allow e.g.** $\frac{dy}{dx}$ **for** $\frac{dP}{dx}$ **and/or** $\frac{d^2y}{dx^2}$ **for** $\frac{d^2P}{dx^2}$		
	$\frac{dP}{dx} = 2 - \frac{120}{x^2}$	Correct derivative	B1
	$2 - \frac{120}{x^2} = 0 \Rightarrow x = \sqrt{60}$	$\frac{dP}{dx} = 0$ and solves for x. Must be fully correct algebra for their $\frac{dP}{dx} = 0$ which is solvable.	M1
	$P = \frac{120}{\sqrt{60}} + 2\sqrt{60}$	Substitutes into P, a **positive** x which has come from an attempt to solve their $\frac{dP}{dx} = 0$	M1
	$P = 4\sqrt{60}$ or $8\sqrt{15}$ or $\sqrt{960}$	Correct exact answer. Cso.	A1
	Note that if $\frac{dP}{dx} = 2 + \frac{120}{x^2}$ **is obtained, this could score a maximum of B0M0M1A0 if a positive value of** x **is substituted into** P**.**		
			(4)
(c)			
	$\left(\frac{d^2P}{dx^2} =\right)\frac{240}{x^3} = \frac{240}{\left(\sqrt{60}\right)^3}$	Attempts the second derivative $x^n \to x^{n-1}$ seen at least once (allow $k \to 0$ as evidence) and then substitutes at least one **positive** value of x from their $\frac{dP}{dx} = 0$ **or** makes reference to the sign of the second derivative provided they have a positive x.	M1
	$\left(\frac{d^2P}{dx^2} =\right)\frac{240}{\left(\sqrt{60}\right)^3} \Rightarrow \frac{d^2P}{dx^2} > 0 \therefore$ minimum Requires a **correct second derivative** and the **correct value of** x. There must be a reference to the sign of the second derivative. If x is substituted and then $\frac{d^2P}{dx^2}$ is evaluated incorrectly allow this mark if the other conditions are met. If x is not substituted then the reference to $\frac{d^2P}{dx^2}$ being positive must also include a reference to the fact that x is positive.		A1
	Allow alternatives e.g. considers **values** of P either side of $\sqrt{60}$ or **values** of $\frac{dP}{dx}$ either side of $\sqrt{60}$ can score M1 and then A1 if a full **reason and conclusion** is given.		
			(2)
			Total 11

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16. The first three terms of a geometric series are $(k + 5)$, k and $(2k - 24)$ respectively, where k is a constant.

(a) Show that $k^2 - 14k - 120 = 0$

(3)

(b) Hence find the possible values of k.

(2)

(c) Given that the series is convergent, find

(i) the common ratio,

(ii) the sum to infinity.

(4)

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Question Number	Scheme	Notes	Marks
16(a)	**Examples:** $\frac{2k-24}{k}=\frac{k}{k+5}$ or $\frac{k+5}{k}=\frac{k}{2k-24}$ or $(2k-24)(k+5)=k^2$	Correct method. I.e. a method that uses the fact that the 3 terms are in geometric progression to establish an equation in *k*.	M1
	$(2k-24)(k+5)=2k^2-14k-120$	Expands $(2k-24)(k+5)$. Must be an attempt at the full expansion but allow the *k* terms to be combined. **Dependent on the first M**.	**d**M1
	$2k^2-14k-120=k^2 \Rightarrow k^2-14k-120=0$ *	Correct solution with no errors including bracketing errors e.g. $2k-24(k+5)=...$	A1*
			(3)
(b)	$(k+6)(k-20)=0 \Rightarrow k=...$	Attempts to solve the given quadratic. See General Guidance.	M1
	$k=-6,\ 20$	Correct values	A1
			(2)
(c)(i)	$r=\frac{\text{"20"}}{\text{"20"}+5}$ or $r=\frac{2\times\text{"20"}-24}{\text{"20"}}$	Correct attempt at *r*. Allow this to score for any of their *k* values.	M1
	$r=\frac{4}{5}$ oe	Correct *r* from using *k* = 20. Allow this mark even if the 'other' value of *r* is also calculated. Allow unsimplified e.g. $\frac{20}{20+5}$	A1
(ii)	$a=\text{"20"}+5 \Rightarrow S_\infty=\frac{\text{"25"}}{1-\text{"}\frac{4}{5}\text{"}}$	Attempts to find *a* and S_∞ with $\lvert r\rvert<1$	M1
	$S_\infty=125$	Cao with no other values – if other values are found they must be clearly rejected and 125 "chosen".	A1
			(4)
			Total 9