

Mark Scheme (FINAL)

Summer 2017

Pearson Edexcel GCE In Core Mathematics 4 (6666/01)



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General Marking Guidance

• All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.

• Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.

• Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.

• There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.

• All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.

• Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.

• When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.

• Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

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PEARSON EDEXCEL GCE MATHEMATICS

General Instructions for Marking

- 1. The total number of marks for the paper is 75
- 2. The Edexcel Mathematics mark schemes use the following types of marks:
- M marks: Method marks are awarded for `knowing a method and attempting to apply it', unless otherwise indicated.
- A marks: Accuracy marks can only be awarded if the relevant method (M) marks have been earned.
- **B** marks are unconditional accuracy marks (independent of M marks)
- Marks should not be subdivided.
- 3. Abbreviations

These are some of the traditional marking abbreviations that will appear in the mark schemes.

- bod benefit of doubt
- ft follow through
- the symbol $\sqrt{}$ will be used for correct ft
- cao correct answer only
- cso correct solution only. There must be no errors in this part of the question to obtain this mark
- isw ignore subsequent working
- awrt answers which round to
- SC: special case
- oe or equivalent (and appropriate)
- d... or dep dependent
- indep independent
- dp decimal places
- sf significant figures
- * The answer is printed on the paper or ag- answer given
- _ or d... The second mark is dependent on gaining the first mark
- 4. All A marks are 'correct answer only' (cao.), unless shown, for example, as A1 ft to indicate that previous wrong working is to be followed through. After a misread however, the subsequent A marks affected are treated as A ft.
- 5. For misreading which does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, in that part of the question affected.

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6. If a candidate makes more than one attempt at any question:

- If all but one attempt is crossed out, mark the attempt which is NOT crossed out.
 - If either all attempts are crossed out or none are crossed out, mark all the attempts and score the highest single attempt.

7. Ignore wrong working or incorrect statements following a correct answer.

Method mark for solving 3 term quadratic:

1. Factorisation

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

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

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. ($x^n \rightarrow x^{n+1}$)

<u>Use of a formula</u>

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:

<u>Method mark</u> 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 <u>not</u> quoted, the method mark can be gained by implication from <u>correct</u> 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.

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Past Paper Number	Mark Scheme) Sche rn fis resource was	s created and owned by PearNoteEdexcel	Mocks			
1.	$x = 3t - 4, y = 5 - \frac{6}{t}, t > 0$					
(a)	$\frac{\mathrm{d}x}{\mathrm{d}t} = 3$, $\frac{\mathrm{d}y}{\mathrm{d}t} = 6t^{-2}$					
	$\frac{dy}{dx} = \frac{6t^{-2}}{3} \left\{ = \frac{6}{3t^2} = 2t^{-2} = \frac{2}{t^2} \right\}$	their $\frac{dy}{dt}$ divided by their $\frac{dx}{dt}$ to give $\frac{dy}{dx}$ in terms of t or their $\frac{dy}{dt}$ multiplied by their $\frac{dt}{dx}$ to give $\frac{dy}{dx}$ in terms of t	M1			
		$\frac{\delta t}{3}$, simplified or un-simplified, in terms of t. See note.	A1 isw			
	Award Special Case 1 st M1 if both $\frac{dx}{dt}$ and $\frac{dy}{dt}$ are stated correctly and explicitly.					
	Note: You can	recover the work for part (a) in part (b).				
(a) Way 2	$y = 5 - \frac{18}{x+4} \Rightarrow \frac{dy}{dx} = \frac{18}{(x+4)^2} = \frac{18}{(3t)^2}$	Writes $\frac{dy}{dx}$ in the form $\frac{\pm \lambda}{(x+4)^2}$, and writes $\frac{dy}{dx}$ as a function of t.	M1			
		in terms of <i>t</i> . See note.	A1 isw			
			[2]			
(b)	$\left\{t = \frac{1}{2} \Longrightarrow\right\} P\left(-\frac{5}{2}, -7\right)$	$x = -\frac{5}{2}, y = -7$ or $P\left(-\frac{5}{2}, -7\right)$ seen or implied.	B1			
	$\frac{dy}{dx} = \frac{2}{\left(\frac{1}{2}\right)^2}$ and either	Some attempt to substitute $t = 0.5$ into their $\frac{dy}{dx}$				
	(2)	which contains t in order to find $m_{\rm T}$ and either				
	• $y r = 8 \left(x\frac{1}{2}\right)$	applies y - (their y_p) = (their m_T)(x - their x_p)	M1			
	• "-7" = ("8")("- $\frac{5}{2}$ ") + C	or finds c from (their y_p) = (their m_T)(their x_p) + c				
	So, $y = (\text{their } m_T)x + "c"$	and uses their numerical c in $y = (\text{their } m_{\text{T}})x + c$				
	T : $y = 8x + 13$	y = 8x + 13 or $y = 13 + 8x$	A1 cso			
	Note: their x_p , their y_p and the	heir m_T must be numerical values in order to award M1	[3]			
(c)	$\left\{ t = \frac{x+4}{2} \Rightarrow \right\} v = 5 - \frac{6}{2}$	An attempt to eliminate <i>t</i> . See notes.	M1			
Way 1	$\begin{pmatrix} 3 \end{pmatrix} \begin{pmatrix} 1 \end{pmatrix} \begin{pmatrix} x+4 \\ 3 \end{pmatrix}$	Achieves a correct equation in x and y only	A1 o.e.			
	$\Rightarrow y = 5 - \frac{18}{x+4} \Rightarrow y = \frac{5(x+4)}{x+4}$	<u>-18</u> 4				
	So, $y = \frac{5x+2}{x+4}$, $\{x > -4\}$	$y = \frac{5x+2}{x+4}$ (or implied equation)	A1 cso			
			[3]			
(c)	$\int_{t} \frac{6}{18} \rightarrow r - \frac{18}{18} = 4$	An attempt to eliminate <i>t</i> . See notes.	M1			
Way 2	$\left \begin{array}{c} 1 & -5 \\ 5 & -y \end{array} \right ^{-1} \int x - \frac{1}{5 - y} = 4$	Achieves a correct equation in <i>x</i> and <i>y</i> only	A1 o.e.			
	$\triangleright (x + 4)(5 - y) = 18 \triangleright 5x - xy +$	20 - 4y = 18				
	$\left\{ \vartriangleright 5x + 2 = y(x + 4) \right\}$ So, $y = \frac{5x + x}{x + x}$	$\frac{x+2}{4}, \{x > -4\}$ $y = \frac{5x+2}{x+4}$ (or implied equation)	A1 cso			
			[3]			
	Note: Some or all of the wo	ork for part (c) can be recovered in part (a) or part (b)	8			

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1. (c)	3at - 4	4a+b $3at$ $4a-b$ $4a-b$	A full method leading to the value of <i>a</i> being found	M1			
Way 3	$y = \frac{3t - 4}{3t - 4}$	$\frac{1}{4+4} = \frac{1}{3t} - \frac{1}{3t} = a - \frac{1}{3t} = b = a = 5$	$y = a - \frac{4a - b}{3t} \text{ and } a = 5$	A1			
	$\frac{4a-b}{3} = 6$	$\Rightarrow b = 4(5) - 6(3) = 2$	Both $a=5$ and $b=2$	A1			
				[3]			
		Question 1 No	tes				
1. (a)	Note	Note Condone $\frac{dy}{dx} = \frac{\left(\frac{6}{t^2}\right)}{3}$ for A1					
	Note	You can ignore subsequent working following or	n from a correct expression for $\frac{dy}{dx}$ in t	terms of <i>t</i> .			
(b)	Note	Using a changed gradient (i.e. applying $\frac{-1}{\text{their } \frac{dy}{dx}}$	Using a changed gradient (i.e. applying $\frac{-1}{\text{their } \frac{dy}{dx}}$ or $\frac{1}{\text{their } \frac{dy}{dx}}$ or $-\left(\text{their } \frac{dy}{dx}\right)$) is M0.				
	Note	Final A1: A correct solution is required from a correct $\frac{dy}{dx}$.					
(-)	Note	Final A1: You can ignore subsequent working f	following on from a correct solution.				
(C)	Note	1 st MII: A full attempt to eliminate <i>t</i> is defined a	is either	ng for t			
		• rearranging one of the parametric equation (only the	e RHS of the equation required for M i	ng 101 <i>i</i> mark)			
		 rearranging both parametric equation (only in 	p make t the subject and putting the result	ults equal			
		to each other.	r				
	Note	Award M1A1 for $\frac{6}{5-y} = \frac{x+4}{3}$ or equivalent.					

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Past Paper (P Question Number	Mark Scher	ne) This re	esource was created and Scheme	l owned by Pearsor	1 Edexcel	Nc	otes	6666 Marks
2.	$\begin{cases} (2+k) \end{bmatrix}$	$(x)^{-3} = 2^{-3} \left(1 + \frac{k}{2} \right)^{-3}$	$\left(\frac{x}{2}\right)^{-3} = \frac{1}{8} \left(1 + (-3)\left(\frac{kx}{2}\right)\right)$	$+\frac{(-3)(-3-1)}{2!}\left(\frac{k}{2!}\right)$	$\left[\frac{x}{2}\right]^2 + \dots \bigg], k$	> 0		
(a)	$\left\{ A = \right\}$	$\frac{1}{8}$	$\frac{1}{8}$ or 2 ⁻³ or 0.125, clear	rly identified as A	or as their answ	wer to p	oart (a)	B1 cao
								[1]
			Uses	s the x^2 term of the	binomial expa	ansion t	to give	
			either $\frac{(-3)}{2}$	$\frac{k}{2!}$ or $\left(\frac{k}{2}\right)^2$ or	$\left(\frac{kx}{2}\right)^2$ or $\frac{(-1)^2}{2}$	$\frac{-3)(-4)}{2}$	or 6	M1
(b)	$\left(\frac{1}{8}\right)\frac{(-3)}{2}$	$\frac{k}{2!}\left(\frac{k}{2}\right)^2$	either (their A	$\left(\frac{(-3)(-4)}{2!}\left(\frac{k}{2}\right)^2\right)$ or	(their A) $\frac{(-3)}{(-3)}$	$\frac{1}{2!}$	$\left(\frac{kx}{2}\right)^2$,	
					where	(their 2	A) ¹ 1,	M1 o.e.
			or $\frac{3}{16}k^2$ or $\frac{3}{16}k^2x^2$ or	or $(2^{-5})\frac{(-3)(-4)}{2!}$	$(x^{2})^{2}$ or $(2^{-5})^{-1}$	$\frac{(-3)(-4)}{2!}$	$\frac{4}{(k)^2}$	l
	$\left\{ \text{So,} \left(\frac{1}{8}\right) \frac{(-3)(-4)}{2!} \left(\frac{k}{2}\right)^2 = \frac{243}{16} \Rightarrow \frac{3}{16}k^2 = \frac{243}{16} \Rightarrow k^2 = 81 \right\}$							
	$\begin{cases} c \\ c $					A1 cso		
	,	Note: $k = \pm 9$ with no reference to $k = 9$ only is A0					[3]	
(c)		Uses the x term of the binomial expansion to give either						
	(their A)(-3) $\left(\frac{k}{2}\right)$ or (their A)(-3) $\left(\frac{kx}{2}\right)$; where (their A)			A) ¹ 1,	M1			
	(0)	(2)	or $(2)^{-4}(-3)(k)$ or $(2)^{-4}(-3)(kx)$ or $-\frac{3k}{16}$					
	$\begin{cases} \text{So, } B \\ \end{cases}$	$= \left(\frac{1}{8}\right)(-3)\left(\frac{9}{2}\right)$	$\Rightarrow \left\{ \underline{B = -\frac{27}{16}} \right.$	_	$\frac{27}{16}$ or $-1\frac{11}{16}$	or -1.	.6875	A1 cso
								[2]
			Oue	stion 2 Notes				6
	NOTE	IN THIS QUE	ESTION IGNORE LAP	BELLING AND M	ARK ALL PA	ARTS T	FOGET	HER.
	Note	$(2+kx)^{-3}=\frac{1}{8}$	$\left(1 - \frac{3}{2}kx + \frac{3}{2}k^2x^2 +\right)$	$= \frac{1}{8} - \frac{3}{16}kx + \frac{3}{16}k$	$x^2x^2 +$			
	Note	Writing down	$\left\{ \left(1 + \frac{kx}{2} \right)^{-3} \right\} = 1 + (-3)$	$\left(\frac{kx}{2}\right) + \frac{(-3)(-3-2)}{2!}$	$\frac{-1}{\left(\frac{kx}{2}\right)^2} + \dots$			
		gets (b) 1 st M1						
	Note	Writing down	$\left\{ (2+kx)^{-3} \right\} = \frac{1}{8} \left(1 + (-3)^{-3} \right)$	$3)\left(\frac{kx}{2}\right) + \frac{(-3)(-3)}{2!}$	$\frac{-1}{2}\left(\frac{kx}{2}\right)^2 + \dots$)		
		gets (b) 1 st M1	1 2 nd M1 and (c) M1			/		
	Note	Writing down	$\left\{ (2+kx)^{-3} \right\} = 2^{-3} + (-3)^{-3} = 2^{-3} = 2^{-3} + (-3)^{-3} = 2^{-3$	$(2^{-4})(kx) + (-3)(-3)(-3)(-3)(-3)(-3)(-3)(-3)(-3)(-3)$	$(2^{-5})(kx)^2$			
		gets (b) 1 st M1	1 2 nd M1 and (c) M1	2				
	Note	Writing down	$\left\{ (2+kx)^{-3} \right\} = (\text{their } A)^{-3}$	$\left(1+(-3)\left(\frac{kx}{2}\right)+\frac{4}{2}\right)$	$\frac{(-3)(-3-1)}{2!}\left(\frac{k}{2}\right)$	$\left(\frac{x}{2}\right)^2 + .$)	
		where (their A	A) ¹ 1, gets (b) 1^{st} M1 2	nd M1 and (c) M1			~	

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2. (b), (c)	Note	(their A) is defined as either	
		• their answer to part (a)	
		• their stated $A = \dots$	
		• their "2 ⁻³ " in their stated $2^{-3} \left(1 + \frac{kx}{2}\right)^{-3}$	
	Note	Give 2^{nd} M0 in part (b) if (their A) = 1	
	Note	Give M0 in part (c) if (their A) = 1	
2. (c)	Note	Allow M1 for (their A)(-3) $\left(\frac{\text{their } k \text{ from (b)}}{2}\right)$	
	Note	Award A0 for $B = -\frac{27}{16}x$	
	Note	Allow A1 for $B = -\frac{27}{16}x$ followed by $B = -\frac{27}{16}$ or $-1\frac{11}{16}$ or -1.6875	
	Note	$k = -9$ leading to $B = \frac{27}{16}$ or $1\frac{11}{16}$ or 1.6875 is A0	
	Note	Give A0 for finding both $B = -\frac{27}{16}$ and $B = \frac{27}{16}$ (without rejecting $B = \frac{27}{16}$)	as their final answer.
	Note	The A1 mark in part (c) is for a correct solution only.	
	Note	Be careful! It is possible to award M0A0 in part (c) for a solution leading to	$B = -\frac{27}{16}$. E.g.
		$f(x) = (2+kx)^{-3} = 2^{-3}(1+kx)^{-3} = \frac{1}{8} \left(1 + (-3)(kx) + \frac{(-3)(-4)}{2!}(kx)^2 + \dots \right) = \frac{1}{8} \left(1 + (-3)(kx) + \frac{(-3)(-4)}{2!}(kx)^2 + \dots \right)$	$\frac{1}{8} - \frac{3k}{8}x + \frac{3k^2}{4}x^2 + \dots$
		leading to (a) $A = \frac{1}{8}$, (b) $k = \frac{9}{2}$, (c) $B = -\frac{27}{16}$, gets (a) B1, (b) M1M0A0	(c) M0A0
2. (b), (c)	Note	${}^{-3}C_0(2)^{-3} + {}^{-3}C_1(2)^{-4}(kx) + {}^{-3}C_2(2)^{-5}(kx)^2$ with the C terms not evaluated	
		gets (b) 1 st M0 2 nd M0 and (c) M0	

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	x 0	0.2	0.4	0.6	0.8	1	6		
3.	y 2	1.8625426	1.71830	1.56981	1.41994	1.27165	$y = \frac{1}{(2 + 1)^2}$	e^{x})	
(a)	{At $x = 0.2$,} $y = 1$	1.86254 (5 dp)				1	.86254	B1 cao
	No	ote: Look for	this value	on the giver	table or in	their workin	g.		[1]
						Outside	brackets $\frac{1}{2}$	×(0.2)	
	1 -	1			\ ٦		2	1 1	B1 o.e.
(b)	$\frac{1}{2}(0.2)$ 2+1.27165	+ 2(their 1.862	54 + 1.7183	0 + 1.56981 -	+ 1.41994)		or $\frac{1}{10}$ or	$\frac{1}{2} \times \frac{1}{5}$	
						For str	ucture of	·7	M1
	$=\frac{1}{10}(16.41283)$	= 1.641283	= 1.6413 (4	dp)		anything tha	t rounds to	1.6413	A1
									[3]
(c)	$\begin{cases} u = e^x \text{ or } x = \ln i \end{cases}$	ι Þ }							
	$du a^x a^y du$	dx = 1	an du - du	udr etc. on	d à 6	$dr = \dot{0}$	6 du	See	D1 *
	$\frac{1}{dx} = e^{-t} \frac{dt}{dx} = u^{-t}$	$\frac{du}{du} = \frac{1}{u}$	\mathbf{u} \mathbf{u} \mathbf{u} \mathbf{u} \mathbf{u}	<i>i</i> ur etc., an	$10 \frac{1}{(e^x + 2)}$	$\frac{1}{2}ux = 0$	$(+ 2)u^{-1}u^{-1$	notes	BI
	$\{x=0\} \bowtie a=e^0$	Þ <u>a = 1</u>				a=1 as	nd $b = e$ or	$b = e^1$	R1
	$\{x = 1\} \bowtie b = e^1 \bowtie \underline{b} = e$				or evidence of $0 \rightarrow 1$ and $1 \rightarrow e$			$1 1 \rightarrow e$	DI
	NOTE: 1 st B1 mark CANNOT be recovered for work in p				work in part	t (d)		[2]	
(d)	NOTE: 2^{nd} BI mark CAN be recovered for work in part (d)								
Way 1	$\frac{0}{u(u+2)} \circ \frac{n}{u} + \frac{1}{(u+2)}$	$\frac{0}{(u+2)} \circ \frac{A}{u} + \frac{B}{(u+2)} \text{Writing } \frac{0}{u(u+2)} \circ \frac{A}{u} + \frac{B}{(u+2)}, \text{ o.e. or } \frac{1}{u(u+2)} \circ \frac{A}{u} + \frac{Q}{(u+2)}, \text{ o.e. } \frac{1}{u(u+2)} \circ \frac{1}{u} + \frac{Q}{(u+2)}, \text{ o.e. } \frac{1}{u(u+2)} \circ \frac{1}{u(u+2)} \circ \frac{1}{u(u+2)} \circ \frac{1}{u(u+2)} = \frac{1}{u(u+2)} \circ \frac{1}{$					M1		
	\triangleright 6 ° $A(u+2)$ +	$6^{\circ} A(u+2) + Bu$ o.e., and a complete method for finding the value of at least one of					1411		
			Roth their	1 - 3 and	their A or t	their B (or 1	P = 1 or the property of th	heir Q	
	u = 0 P A = 3 u = 2 P B = 3	2		$-\frac{1}{2}$ with	the factor of	f 6 in front o	$I = \frac{1}{2}$ all f the integra	al sign)	A1
	u2 P D	,		$=-\frac{1}{2}$ with			i the integra	ai sigii)	
	$\int \frac{6}{du} = \int$	$\frac{3}{3} - \frac{3}{3}$	du		Integrate	$es \frac{n}{u} \pm \frac{n}{u \pm u}$	$\frac{1}{k}$, M, N ,	<i>k</i> ¹ 0;	
	$\int u(u+2) \qquad \int$	(u + 2))	(i.e. <i>a two term partial fraction</i>) to obtain either				n either	M1
	= 31	nu - 3ln(u + 2)	2)	$\pm / \ln(au)$ or $\pm m \ln(b(u \pm k)); /, m, a, b^{-1} 0$					
	or = 3	$\ln 2u - 3\ln(2u)$	(i+4) In	Integration of both terms is correctly followed through					A1 ft
	$\int \mathbf{S}_{2} \left[2 \mathbf{I}_{2} \mathbf{v} - 2 \mathbf{I}_{2} \mathbf{v} \right]$	$\cdot \cdot $				lonondont o	$\frac{1}{2} \frac{1}{2} \frac{1}$	f mork	
	$\int_{1}^{30} \int_{1}^{311} \sin u = \sin(u)$	$(+2) \rfloor_1 \int$			L L	Applie	es limits of	e and 1	
	$= (3\ln(e) - 3\ln(e +$	$2)) - (3\ln 1 -$	3ln3)	(or their b a	and their <i>a</i> ,	where $b > 0$, <i>b</i> ¹ 1, <i>a</i> >	0) in <i>u</i>	dM1
	[Note: A proper co	onsideration of	of the	or applies limits of 1 and 0 in x and subtracts the					
	$\frac{1111111}{111111} \text{ or } u = 1 \text{ is real}$	quiled for this			(3)		i o unu.	
	$= 3 - 3\ln(e+2) + 1$	3ln3 or 3(1	$-\ln(e+2)$	+ ln3) or 3	$3 + 3\ln\left(\frac{3}{e+1}\right)$	$\overline{\frac{2}{2}}$			
	e (e)	. (1)	e +	2)	(3e)	$(27e^{3})$	se	e notes	A1 cso
	or $3\ln\left(\frac{1}{e+2}\right) - 3$	$\ln\left(\frac{1}{3}\right)$ or 3	$-3\ln\left(\frac{3}{3}\right)$	$-$ or $3 \ln$	$\left(\frac{1}{e+2}\right) = 0$	$r \ln\left(\frac{1}{(e+2)}\right)$	$\overline{)^3}$		
		Note: All	$low e^1 in p$	lace of e fo	or the final A	A1 mark.	I		[6]
	Note: Give final A	A0 for $3-3\ln n$	$e + 2 + \overline{3ln}$	3 (i.e. brack	eting error)	unless recov	vered.		12
	Note: Give final A	0 for 3 - 3ln	(e+2) + 31	n3 - 3ln1, v	where 3ln1	has not been	n simplified	to 0	
	Note: Give final A	0 for 3lne -	$3\ln(e+2)$ -	+ 3ln3, whe	re 31ne has	s not been sin	nplified to	3	

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3. (b)	Note	M1: Do not allow an extra y-value <i>or</i> a repeated y value in their [] Do not allow an omission of a y-ordinate in their [] for M1 unless they give	ve the correct answer of
	Note	A1 : Working must be seen to demonstrate the use of the trapezium rule	
	note	(Actual area is 1.64150274)	
	Note	Full marks can be gained in part (b) for awrt 1.6413 even if B0 is given in part	art (a)
	Note	Award B1M1A1 for	
		$\frac{1}{10}(2+1.27165) + \frac{1}{5}(\text{their } 1.86254 + 1.71830 + 1.56981 + 1.41994) = \text{awrt } 1$.6413
	Bracke	ting mistakes: Unless the final answer implies that the calculation has b	een done correctly
	Award	B1M0A0 for $\frac{1}{2}(0.2) + 2 + 2$ (their 1.86254 + 1.71830 + 1.56981 + 1.41994) +	+ 1.27165 (=16.51283)
	Award	B1M0A0 for $\frac{1}{2}(0.2)(2 + 1.27165) + 2$ (their 1.86254 + 1.71830 + 1.56981 + 1	.41994) (=13.468345)
	Award	B1M0A0 for $\frac{1}{2}(0.2)(2) + 2$ (their 1.86254 + 1.71830 + 1.56981 + 1.41994) +	1.27165 (=14.61283)
	<u>Alterna</u>	ative method: Adding individual trapezia	_
	Area ≈0	$0.2 \times \left[\frac{2 + "1.86254"}{2} + \frac{"1.86254" + 1.71830}{2} + \frac{1.71830 + 1.56981}{2} + \frac{1.56981 + 1.41994}{2}\right]$	$+\frac{1.41994+1.27165}{2}$
	=	1.641283	
	B1	0.2 and a divisor of 2 on all terms inside brackets	
	M1	First and last ordinates once and two of the middle ordinates inside bracket	s ignoring the 2
2 ()	Al	anything that rounds to 1.6413	
3. (c)	1ª B1	Must start from either	
		• $\hat{0} y dx$, with integral sign and dx	
		• $\dot{0} \frac{6}{(e^x + 2)} dx$, with integral sign and dx	
		• $\dot{0} \frac{6}{(e^x + 2)} \frac{dx}{du} du$, with integral sign and $\frac{dx}{du} du$	
		and state either $\frac{du}{dx} = e^x$ or $\frac{du}{dx} = u$ or $\frac{dx}{du} = \frac{1}{u}$ or $du = u dx$	
		and end at $\hat{0}\frac{6}{u(u+2)}$ du, with integral sign and du, with no incorrect v	working.
	Note	So, just writing $\frac{du}{dx} = e^x$ and $\hat{0}\frac{6}{(e^x + 2)}dx = \hat{0}\frac{6}{u(u + 2)}du$ is sufficient f	or 1 st B1
	Note	Give 2^{nd} B0 for $b = 2.718$, without reference to $a = 1$ and $b = e$ or $b = e$	1
	Note	You can also give the 1 st B1 mark for using a reverse process. i.e.	
		Proceeding from $0 \frac{1}{u(u+2)} du$ to $0 \frac{1}{(e^x+2)} dx$, with no incorrect work	king,
		and stating either $\frac{du}{dt} = e^x$ or $\frac{du}{dt} = u$ or $\frac{dx}{dt} = \frac{1}{2}$ or $du = u dx$	
		$\frac{dx}{dx} = \frac{dx}{dx} + \frac{dx}{du} = \frac{du}{u}$	
3. (d)	Note	Give final A0 for $3 - 3\ln(e+2) + 3\ln 3$ simplifying to $1 - \ln(e+2) + \ln 3$	
		(i.e. dividing their correct final answer by 3)	
		Otherwise, you can ignore incorrect working (isw) following on from a con	rect exact value.
	Note	A decimal answer of 1.641502724 (without a correct exact answer) is fir	hal A0
	Note	$\left[-3\ln(u+2)+3\ln u\right]_{1}^{e}$ followed by awrt 1.64 (without a correct exact answer	ver) is final M1A0

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		Question 3 Notes Continued
3. (d)	Note	BE CAREFUL! Candidates will assign their own "A" and "B" for this question.
	Note	Writing down $\frac{6}{(u+2)u}$ in the form $\frac{A}{(u+2)} + \frac{B}{u}$ with at least one of A or B correct is 1 st M1
	Note	Writing down $\frac{6}{(u+2)u}$ as $\frac{-3}{(u+2)} + \frac{3}{u}$ is 1 st M1 1 st A1.
	Note	Condone $\int \left(\frac{3}{u} - \frac{3}{(u+2)}\right) du$ to give $3\ln u - 3\ln u + 2$ (poor bracketing) for 2^{nd} A1.
	Note	Award M0A0M1A1ft for a candidate who writes down
		e.g. $\int \frac{6}{u(u+2)} du = \int \left(\frac{6}{u} + \frac{6}{(u+2)}\right) du = 6\ln u + 6\ln(u+2)$
		AS EVIDENCE OF WRITING $\frac{6}{u(u+2)}$ AS PARTIAL FRACTIONS.
	Note	Award M0A0M0A0 for a candidate who writes down
		$\hat{0} \frac{6}{u(u+2)} du = 6 \ln u + 6 \ln(u+2)$ or $\hat{0} \frac{6}{u(u+2)} du = \ln u + 6 \ln(u+2)$
		WITHOUT ANY EVIDENCE OF WRITING $\frac{6}{u(u+2)}$ as partial fractions.
	Note	Award M1A1M1A1 for a candidate who writes down
		$\hat{0}\frac{6}{u(u+2)}du = 3\ln u - 3\ln(u+2)$
		WITHOUT ANY EVIDENCE OF WRITING $\frac{6}{u(u+2)}$ as partial fractions.
	Note	If they lose the "6" and find $\hat{D}_1 = \frac{1}{u(u+2)} du$ we can allow a maximum of M1A0M1A1ftM1A0

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		Question	3 Notes Contir	nued		
3. (d) Way 2	$\left\{\int \frac{6}{u^2 + 2u} du = \int \frac{3(2u+2)}{u^2 + 2u} du - \int \frac{6u}{u^2 + 2u} du\right\}$					
	$=\int \frac{3(2u+2)}{2} du - \int \frac{6}{1+2} du$	$i \qquad \dot{0}^{\pm 2}$	$\frac{\partial(2u+2)}{u^2+2u}\left\{\mathrm{d}u\right\}\ \pm$	$= \mathbf{\hat{0}} \frac{d}{u+2} \{ \mathrm{d}u \},$	$\alpha, \beta, \delta \neq 0$	M1
	$\mathbf{J} \ \mathbf{u} + 2\mathbf{u} \qquad \mathbf{J} \ \mathbf{u} + 2$			Correct	t expression	A1
		Integrates $\frac{\pm \Lambda}{\Lambda}$	$\frac{M(2u+2)}{u^2+2u} \pm \frac{N}{u\pm u}$	$\frac{N}{k}, M, N, k^{-1}$	0, to obtain	M
×	$= 3\ln(u^2 + 2u) - 6\ln(u + 2)$	any one	any one of $\pm / \ln(u^2 + 2u)$ or $\pm m \ln(b(u \pm k));$			MI
		Integration of both terms is correctly followed through from their M and from their N			A1 ft	
	$\left\{\operatorname{So}, \left[\operatorname{3ln}(u^2 + 2u) - \operatorname{6ln}(u + 2)\right]_1^{\mathrm{e}}\right\}$		dep (Applies limit or their b and the $b > 0, b^{-1} 1$,	2nd M mark as of e and 1 eir a , where a > 0) in u	dM1
	$= (3\ln(e^2 + 2e) - 6\ln(e + 2))$	$-(3\ln 3 - 6\ln 3)$	or applies limits of 1 and 0 in x and subtracts the correct way round.			
	$= 3\ln(e^2 + 2e) - 6\ln(e + 2) +$	3ln3	$3\ln(e^2+2e)-6\ln(e+2)+3\ln 3$			A1 o.e.
	A 1 ' ~ 1					[6]
3. (d)	Applying $u = Q - 1$					
Way 3	$\left\{\int_{1}^{e} \frac{6}{u(u+2)} \mathrm{d}u = \right\} \int_{2}^{1+e} \frac{6}{(\theta-1)(\theta+1)} \mathrm{d}\theta = \int_{2}^{1+e} \frac{6}{(\theta-1)(\theta+1)} \mathrm{d}\theta$		$\frac{6}{\theta^2 - 1} \mathrm{d}u = \left[3\ln\right]$	$\left(\frac{\theta-1}{\theta+1}\right)\Big]_2^{1+e}$		M1A1M1A1
	$= 3\ln\left(\frac{1+e-1}{e+1+1}\right) - 3\ln\left(\frac{2-2}{2+1}\right)$	$\frac{1}{1} = 3\ln\left(\frac{e}{e+2}\right) -$	$3\ln\left(\frac{1}{3}\right)$	3 rd M mark is on	s dependent 2 nd M mark	dM1A1
						[6]

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Question	,	Scheme			Notes	Marks	
4.		$4x^2 - y^3 - 4xy + 2^y = 0$					
(a) Way 1	$\left\{\frac{\partial f_{X}}{\partial \mathbf{x}}\times\right\}\underline{8x-3}$	$\left\{ \frac{8x - 3y^2 \frac{\mathrm{d}y}{\mathrm{d}x}}{2} - \frac{4y - 4x \frac{\mathrm{d}y}{\mathrm{d}x}}{4} + \frac{2^y \ln 2 \frac{\mathrm{d}y}{\mathrm{d}x}}{2} = 0 \right\}$				M1 <u>A1 M1</u> B	=
	$8(-2) - 3(4)^2 \frac{d}{d}$	$3(4)^2 \frac{dy}{dx} - 4(4) - 4(-2)\frac{dy}{dx} + 2^4 \ln 2\frac{dy}{dx} = 0$			dent on the first M mark	dM1	
	-16	$-16 - 48\frac{dy}{dx} - 16 + 8\frac{dy}{dx} + 16\ln 2\frac{dy}{dx} = 0$					
	$\frac{\mathrm{d}y}{\mathrm{d}x} = \frac{32}{-40+16}$	$\frac{-32}{5\ln 2}$ or $\frac{-32}{40-16\ln 2}$ or	$\frac{4}{-5+2\ln 2}$	or $\frac{1}{-5}$	$\frac{4}{+\ln 4}$ or exact equivalent	A1 cso	
		NOTE: You can recover	work for p	art (a) i	n part (b)		[6]
(b)	e.g. $m_{\rm N} = \frac{-40}{-100}$	$\frac{0+16\ln 2}{-32}$ or $\frac{40-16\ln 2}{32}$	Applying	$m_{\rm N} = \frac{-}{n}$ Can be	$\frac{1}{m_{\rm T}}$ to find a numerical $m_{\rm N}$ implied by later working	M1	
	• y - 4 =	$=\left(\frac{40-16\ln 2}{32}\right)(x-2)$	I		Using a numerical $m_{\rm N}$ (¹ $m_{\rm T}$), either		
	Cuts y-	Cuts y-axis $\Rightarrow x = 0 \Rightarrow y - 4 = \left(\frac{40 - 16\ln 32}{32}\right)$			$y-4 = m_N(x-2)$ and sets $x=0$ in their normal equation	M1	
	• $4 = \left(\frac{4}{4}\right)$	$4 = \left(\frac{40 - 16\ln 2}{32}\right) \left(-2\right) + c$			$4 = (\text{their } m_{N})(-2) + c$		
	$\left\{ \Rightarrow c = 4 + \frac{40}{2} \right\}$	$= 4 + \frac{40 - 16\ln 2}{16}, \text{ so } y = \frac{104 - 16\ln 2}{16} \Rightarrow $					
	$y(\text{or } c) = \frac{13}{2}$ -	$\frac{104}{2} - \ln 2$ $\frac{104}{16} - \ln 2$ or $\frac{13}{2} - \ln 2$ or $-\ln 2 + \frac{13}{2}$					
	Note:	Allow exact equivalents in the	ne form p	- ln2 fo	r the final A mark		[3]
							9
(a) Way 2	$\left\{\frac{\partial \mathbf{x}}{\partial \mathbf{x}}\times\right\}\underline{8x\frac{\mathrm{d}x}{\mathrm{d}y}}$	$-3y^2 - 4y\frac{\mathrm{d}x}{\mathrm{d}y} - 4x + \overline{2^y \ln x}$	$\frac{1}{2} = 0$			M1 <u>A1</u> <u>M1</u> B	= \$1
	$8(-2)\frac{\mathrm{d}x}{\mathrm{d}y} - 3(4)$	$\int (x^2 - 4(4)) \frac{dx}{dy} - 4(-2) + 2^4 \ln 2$. = 0	depen	dent on the first M mark	dM1	
	$\frac{dy}{dx} = \frac{32}{-40 + 16\ln 2} \text{ or } \frac{-32}{40 - 16\ln 2} \text{ or } \frac{4}{-5 + 2\ln 2} \text{ or } \frac{4}{-5 + \ln 4} \text{ or exact equivalent}$					A1 cso	
	Note: You must be clear that Way 2 is being applied before you use this scheme						[6]
4 (2)	Note Fort	he first four morks	Question	4 Notes	j		
+. (a)	Writin	ng down from no working					
	•	$\frac{dy}{dx} = \frac{4y - 8x}{-3y^2 - 4x + 2^y \ln 2}$	or $\frac{8}{3y^2}$ +	$\frac{4x-4y}{4x-2^y}$	ln2 scores M1A1M1B1		
	•	$\frac{dy}{dx} = \frac{8x - 4y}{-3y^2 - 4x + 2^y \ln 2}$	$\frac{4}{3y^2}$ or $\frac{4}{3y^2}$ +	$\frac{y - 8x}{4x - 2^y}$	ln2 scores M1A0M1B1		
	Writi	ng $8x dx - 3y^2 dy - 4y dx -$	$4x dy + 2^y$	$\ln 2 dy =$	0 scores M1A1M1B1		

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		Question 4 Notes Continued
4. (a)	1 st M1	Differentiates implicitly to include <i>either</i> $\pm 4x \frac{dy}{dx}$ or $-y^3 \rightarrow \pm \lambda y^2 \frac{dy}{dx}$ or $2^y \rightarrow \pm m 2^y \frac{dy}{dx}$
		(Ignore $\left(\frac{dy}{dx}\right)$). /, <i>m</i> are constants which can be 1
	1 st <u>A1</u>	Both $4x^2 - y^3 \rightarrow 8x - 3y^2 \frac{dy}{dx}$ and $= 0 \rightarrow = 0$
	Note	e.g. $8x - 3y^2 \frac{dy}{dx} - 4y - 4x \frac{dy}{dx} + 2^y \ln 2 \frac{dy}{dx} \rightarrow -3y^2 \frac{dy}{dx} - 4x \frac{dy}{dx} + 2^y \ln 2 \frac{dy}{dx} = 4y - 8x$
		or e.g. $-16 - 48\frac{dy}{dx} - 16 + 8\frac{dy}{dx} + 16\ln 2\frac{dy}{dx} \rightarrow -48\frac{dy}{dx} + 8\frac{dy}{dx} + 16\ln 2\frac{dy}{dx} = 32$
		will get I^{st} A1 (implied) as the " = 0" can be implied by the rearrangement of their equation.
	2 nd <u>M1</u>	$-4xy \rightarrow -4y - 4x \frac{dy}{dx}$ or $4y - 4x \frac{dy}{dx}$ or $-4y + 4x \frac{dy}{dx}$ or $4y + 4x \frac{dy}{dx}$
	B 1	$2^{y} \rightarrow 2^{y} \ln 2 \frac{dy}{dx}$ or $2^{y} \rightarrow e^{y \ln 2} \ln 2 \frac{dy}{dx}$
	Note	If an extra term appears then award 1 st A0
	3 rd dM1	dependent on the first M mark
		For substituting $x = -2$ and $y = 4$ into an equation involving $\frac{dy}{dx}$
	Note	M1 can be gained by seeing at least one example of substituting $x = -2$ and at least one
		example of substituting $y = 4$ unless it is clear that they are instead applying $x = 4$ and $y = -2$
		Otherwise, you will NEED to check (with your calculator) that $x = -2$, $y = 4$ that has been
		substituted into their equation involving $\frac{dy}{dx}$
	Note	AI cso: If the candidate's solution is not completely correct, then do not give this mark.
(1)	Note	Isw: You can, however, ignore subsequent working following on from correct solution.
(b)	Note	The 2 nd M1 mark can be implied by later working.
		Eq. Award 1 st M1 and 2 nd M1 for $\frac{y-4}{z} = \frac{-1}{z}$
		2 their $m_{\rm T}$ evaluated at $x = -2$ and $y = 4$
	Note	A1: Allow the alternative answer $\left\{y = \right\} \ln\left(\frac{1}{2}\right) + \frac{13}{2\ln 2}(\ln 2)$ which is in the form $p + q \ln 2$
4. (a) Way 2	1 st M1	Differentiates implicitly to include <i>either</i> $\pm 4y \frac{dx}{dy}$ or $4x^2 \rightarrow \pm /x \frac{dx}{dy}$
		(Ignore $\left(\frac{dx}{dy}\right)$ =). / is a constant which can be 1
	1 st <u>A1</u>	Both $4x^2 - y^3 \rightarrow 8x \frac{dx}{dy} - 3y^2$ and $= 0 \rightarrow = 0$
	2 nd <u>M1</u>	$-4xy \rightarrow -4y \frac{dx}{dy} - 4x \text{ or } 4y \frac{dx}{dy} - 4x \text{ or } -4y \frac{dx}{dy} + 4x \text{ or } 4y \frac{dx}{dy} + 4x$
	 R1	$2^{\nu} \rightarrow 2^{\nu} \ln 2$
	3 rd dM1	dependent on the first M mark
		For substituting $x = -2$ and $y = 4$ into an equation involving $\frac{dx}{dy}$

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Question Number		Scheme		Notes			
5.	$y = e^{x}$	$x^{4} + 2e^{-x}, x^{3} 0$					
Way 1	$\left\{V=\right\}\mathcal{P}$	$D \dot{0}_{0}^{\ln 4} \left(e^{x} + 2e^{-x} \right)^{2} dx$	Ig	For $\pi \int (e^x + 2e^{-x})^2$ nore limits and dx. Can be implied.	B1		
		• ln 4	Expands $(e^x +$	$2e^{-x}$ $\xrightarrow{2}$ \rightarrow $+ 2e^{2x} + be^{-2x} + d$ where			
	$=\{\pi$	$\Big\} \Big(e^{2x} + 4e^{-2x} + 4 \Big) dx$	$\alpha, \beta, \delta \neq 0$. Igr	nore π , integral sign, limits and dx.	M1		
		JO		This can be implied by later work.			
			Integrates at least	one of either $\pm a e^{2x}$ to give $\pm \frac{a}{2} e^{2x}$	M1	\square	
		Γ_1 $\Box_{\rm ln4}$		or $\pm b e^{-2x}$ to give $\pm \frac{2}{2} e^{-2x} a, b^{-1} 0$			
	= {p	$\left \frac{1}{2}e^{2x} - 2e^{-2x} + 4x\right $		dependent on the 2 nd M mark			
				$e^{2x} + 4e^{-2x} \rightarrow \frac{1}{2}e^{2x} - 2e^{-2x}$,	A1 _		
			whic	ch can be simplified or un-simplified			
	$4 \rightarrow 4x \text{ or } 4e^{0}x$,	
	dependent on the previous method mark. Some evidence of						
	[][$\begin{pmatrix} 1 \\ 2^{2(\ln 4)} \end{pmatrix} = 2^{-2(\ln 4)} + 4(\ln 4) \begin{pmatrix} 1 \\ 1 \end{pmatrix}$	-9 $2-9$ (0)	-1N/1	\mathcal{I}		
	= {p}	$\frac{-1}{2}e^{-1} - 2e^{-1} + 4(114) - (\frac{-1}{2}e^{-1})$	e - 2e + 4(0)	alvi i			
	$= \{\pi\} \left(\left(8 - \frac{1}{4} + 4 \ln 4 \right) - \left(\frac{1}{4} - 2 \right) \right)$						
		8) (2))	(75				
		$=\frac{75}{8}\rho + 4\rho\ln 4$ or $\frac{75}{8}\rho + 8\rho$	$p \ln 2 \text{ or } \pi \left(\frac{75}{8} + 4 \right)$	$\ln 4$) or $\pi \left(\frac{75}{8} + 8 \ln 2 \right)$	A1 isw	1	
	(or $\frac{75}{8}\rho + \ln 2^{8\rho}$ or $\frac{75}{8}\rho + \rho \ln 2^{8\rho}$	256 or $\ln\left(2^{8\rho}e^{\frac{75}{8}}\right)$	$\left(\frac{1}{8} \right) $ or $\frac{1}{8} \rho (75 + 32 \ln 4)$, etc			
						[7]	
			Question 5 N	otes	I		
5.	Note	π is only required for the 1 st B	1 mark and the fina	al A1 mark.			
	Note	Give 1^{st} B0 for writing $\rho \hat{0} y^2 d$	1x followed by $2p$	$\dot{0}\left(\mathbf{e}^{x}+2\mathbf{e}^{-x}\right)^{2}\mathbf{d}x$			
	Note	Give $1^{\text{st}} \text{ M1 for } \left(e^x + 2e^{-x} \right)^2 \rightarrow 2^{-x}$	$\Rightarrow e^{2x} + 4e^{-2x} + 2e^{0}$	+ $2e^{0}$ because $d = 2e^{0} + 2e^{0}$			
	Note	A decimal answer of 46.8731	. or <i>p</i> (14.9201)	(without a correct exact answer) is A	.0		
	Note	$\rho \left[\frac{1}{2} e^{2x} - 2e^{-2x} + 4x \right]_0^{\ln 4} $ followe	ed by awrt 46.9 (wit	hout a correct exact answer) is final o	dM1A0		
	Note	Allow exact equivalents which	should be in the fo	rm $a\rho + b\rho \ln c$ or $\rho(a + b\ln c)$,			
		where $a = \frac{75}{8}$ or $9\frac{3}{8}$ or 9.375	5. Do not allow $a =$	$=\frac{150}{16}$ or $9\frac{6}{16}$			
	Note	Give BIM0M1A1B0M1A0 for $\mathbf{c}^{\ln 4}$	r the common respo	1 $\int^{\ln 4} 75$			
		$\left[\mathcal{P} \right]_{0} \left(e^{x} + 2e^{-x} \right)^{2} dx \to \mathcal{P} \int_{0} \left(e^{x} + 2e$	$e^{2x} + 4e^{-2x} dx = \rho \left[\frac{1}{2} \right]$	$\frac{1}{2}e^{2x} - 2e^{-2x} \bigg _{0} = \frac{15}{8}p$			

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5.	$y = e^x + 2e^{-x}, x^3 0$					
Way 2	$\left\{V=\right\}\mathcal{P} \stackrel{\text{in4}}{\bigcup}_{0} \left(e^{x}+2e^{-x}\right)^{2} dx$		Ignore limits	For $\pi \int (e^x + 2e^{-x})^2$ is and dx . Can be implied.	B1	
	$u = e^x \triangleright \frac{\mathrm{d}u}{\mathrm{d}x} = e^x = u \text{ and } x = \ln 4$	\triangleright <i>u</i> = 4, <i>x</i> = 0 \triangleright	$u = e^0 = 1$			
	$V = \{ \rho \} \int_{1}^{4} \left(u + \frac{2}{u} \right)^{2} \frac{1}{u} du = \{ \rho \} \int_{1}^{4} du$	$\left(u^2 + \frac{4}{u^2} + 4\right)\frac{1}{u}\mathrm{d}u$				
	$= \{\rho\} \int_{1}^{4} \left(u + \frac{4}{u^{3}} + \frac{4}{u}\right) du$ $= \{\rho\} \int_{1}^{4} \left(u + \frac{4}{u^{3}} + \frac{4}{u}\right) du$ $= \{\rho\} \int_{1}^{4} \left(u + \frac{4}{u^{3}} + \frac{4}{u}\right) du$ $= \{\rho\} \int_{1}^{4} \left(u + \frac{4}{u^{3}} + \frac{4}{u}\right) du$ $= \{\rho\} \int_{1}^{4} \left(u + \frac{4}{u^{3}} + \frac{4}{u}\right) du$ $= \{\rho\} \int_{1}^{4} \left(u + \frac{4}{u^{3}} + \frac{4}{u}\right) du$ $= \{\rho\} \int_{1}^{4} \left(u + \frac{4}{u^{3}} + \frac{4}{u}\right) du$ $= \{\rho\} \int_{1}^{4} \left(u + \frac{4}{u^{3}} + \frac{4}{u}\right) du$ $= \{\rho\} \int_{1}^{4} \left(u + \frac{4}{u^{3}} + \frac{4}{u}\right) du$ $= \{\rho\} \int_{1}^{4} \left(u + \frac{4}{u^{3}} + \frac{4}{u}\right) du$ $= \{\rho\} \int_{1}^{4} \left(u + \frac{4}{u^{3}} + \frac{4}{u}\right) du$ $= \{\rho\} \int_{1}^{4} \left(u + \frac{4}{u^{3}} + \frac{4}{u}\right) du$ $= \{\rho\} \int_{1}^{4} \left(u + \frac{4}{u^{3}} + \frac{4}{u}\right) du$ $= \{\rho\} \int_{1}^{4} \left(u + \frac{4}{u^{3}} + \frac{4}{u}\right) du$ $= \{\rho\} \int_{1}^{4} \left(u + \frac{4}{u^{3}} + \frac{4}{u}\right) du$ $= \{\rho\} \int_{1}^{4} \left(u + \frac{4}{u^{3}} + \frac{4}{u}\right) du$ $= \{\rho\} \int_{1}^{4} \left(u + \frac{4}{u^{3}} + \frac{4}{u}\right) du$ $= \{\rho\} \int_{1}^{4} \left(u + \frac{4}{u^{3}} + \frac{4}{u}\right) du$ $= \{\rho\} \int_{1}^{4} \left(u + \frac{4}{u^{3}} + \frac{4}{u}\right) du$ $= \{\rho\} \int_{1}^{4} \left(u + \frac{4}{u^{3}} + \frac{4}{u}\right) du$ $= \{\rho\} \int_{1}^{4} \left(u + \frac{4}{u^{3}} + \frac{4}{u}\right) du$ $= \{\rho\} \int_{1}^{4} \left(u + \frac{4}{u^{3}} + \frac{4}{u}\right) du$ $= \{0\} \int_{1}^{4} \left(u + \frac{4}{u^{3}} + \frac{4}{u}\right) du$ $= \{0\} \int_{1}^{4} \left(u + \frac{4}{u^{3}} + \frac{4}{u^{3}}\right) du$ $= \{0\} \int_{1}^{4} \left(u + \frac{4}{u^{3}} + \frac{4}{u^{3}}\right) du$ $= \{0\} \int_{1}^{4} \left(u + \frac{4}{u^{3}} + \frac{4}{u^{3}}\right) du$ $= \{0\} \int_{1}^{4} \left(u + \frac{4}{u^{3}} + \frac{4}{u^{3}}\right) du$ $= \{0\} \int_{1}^{4} \left(u + \frac{4}{u^{3}} + \frac{4}{u^{3}}\right) du$ $= \{0\} \int_{1}^{4} \left(u + \frac{4}{u^{3}} + \frac{4}{u^{3}}\right) du$ $= \{0\} \int_{1}^{4} \left(u + \frac{4}{u^{3}} + \frac{4}{u^{3}}\right) du$ $= \{0\} \int_{1}^{4} \left(u + \frac{4}{u^{3}} + \frac{4}{u^{3}}\right) du$ $= \{0\} \int_{1}^{4} \left(u + \frac{4}{u^{3}} + \frac{4}{u^{3}}\right) du$ $= \{0\} \int_{1}^{4} \left(u + \frac{4}{u^{3}} + \frac{4}{u^{3}}\right) du$ $= \{0\} \int_{1}^{4} \left(u + \frac{4}{u^{3}} + \frac{4}{u^{3}}\right) du$ $= \{0\} \int_{1}^{4} \left(u + \frac{4}{u^{3}} + \frac{4}{u^{3}}\right) du$ $= \{0\} \int_{1}^{4} \left(u + \frac{4}{u^{3}} + \frac{4}{u^{3}}\right) du$ $= \{0\} \int_{1}^{4} \left(u + \frac{4}{u^{3}} + \frac{4}{u^{3}}\right) du$ $= \{0\} \int_{1}^{4} \left(u + \frac{4}{u^{3}} + \frac{4}{u^{3}}\right) du$ $= \{0\} \int_{1}^{4} \left(u + \frac{4}{u^{3}} + \frac{4}{u^{3}$				<u>M1</u>	
	г ¬4	Integrates at or $\pm bu^{-3}$ t	least one of e to give $\pm \frac{b}{2}u$	where $\pm \partial u$ to give $\pm \frac{\partial}{2}u^2$ $a, b^{-2} \partial, b^{-1} 0$, where $u = e^x$	M1	
	$= \{ p \} \left \frac{1}{2} u^2 - \frac{2}{2} + 4 \ln u \right ^2$	dependent on the 2 nd M mark				
	$\begin{bmatrix} 1 & 1 \\ 2 & 1 \end{bmatrix}_{1}$		$u + 4u^{-3} \rightarrow \frac{1}{2}u^2 - 2u^{-2},$	A1		
		sir				
			41	$u^{-1} \rightarrow 4 \ln u$, where $u = e^x$	B1 cao	
	$= \left\{ \rho \right\} \left\{ \left(\frac{1}{2} (4)^2 - \frac{2}{(4)^2} + 4 \ln 4 \right) - \left(\frac{1}{2} (1)^2 + 4 \ln 4 \right) \right\}$	$(1)^2 - \frac{2}{(1)^2} + 4\ln 1$	dependent mark. S limit function ir integrated f	t on the previous method some evidence of applying ts of 4 and 1 to a changed in u [or ln 4 o.e. and 0 to an unction in x] and subtracts the correct way round.	dM1	
	$= \{\pi\} \left(\left(8 - \frac{1}{8} + 4\ln 4 \right) - \left(\frac{1}{2} - 2 \right) \right)$					
	$= \frac{75}{8}\rho + 4\rho \ln 4 \text{ or } \frac{75}{8}\rho$ or $\frac{75}{8}\rho + \ln 2^{8\rho}$ or $\frac{75}{8}\rho + \rho$	+ $8\rho \ln 2$ or $\pi \left(\frac{75}{8}\right)$	$+ 4\ln 4 \int \mathbf{or}$ $e^{\frac{75}{8}\rho} \int \mathbf{or} \ \frac{1}{8}\rho$	$\pi\left(\frac{75}{8} + 8\ln 2\right)$ $p(75 + 32\ln 4), \text{ etc}$	A1 isw	7
						[7]

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6.	$l_1: \mathbf{r} = \begin{pmatrix} 4\\28\\4 \end{pmatrix} + \lambda \begin{pmatrix} \\ \end{pmatrix}$	$ \begin{pmatrix} -1 \\ -5 \\ 1 \end{pmatrix}, l_2: \mathbf{r} = \begin{pmatrix} 5 \\ 3 \\ 1 \end{pmatrix} $	$\begin{pmatrix} 3\\ 0\\ -4 \end{pmatrix}$; $\overrightarrow{OA} = \begin{pmatrix} 2\\ 18\\ 6 \end{pmatrix}$ li	es on l_1 Let q_{Ac} acute au between	be the ngle l_1 and l_2	
(a)	$\{l_1 = l_2 \Rightarrow\} 28 - 1$ or $4 - \lambda = 5 + 3\mu$	$5\lambda = 3 \{ \Rightarrow \lambda = 5 \}$ and $4 + \lambda = 1 - 4\mu$	$\{ \Rightarrow \mu = -2 \}$	$4 - $ or $\lambda = 5$	$28 - 1 = 5 + 3m$ and $4 + 3m$ or $\mu = -2$ (Can be	$5\lambda = 3$ or $\lambda = 1 - 4m$ be implied).	B1
	$\left\{\overrightarrow{OX} = \right\} \begin{pmatrix} 4\\28\\4 \end{pmatrix} +$	$5\begin{pmatrix} -1\\ -5\\ 1 \end{pmatrix} \text{ or } \begin{pmatrix} 5\\ 3\\ 1 \end{pmatrix} -$	$-2\begin{pmatrix}3\\0\\-4\end{pmatrix}$	Puts $l_1 = l_2$ a and substitution	nd solves to find / itutes their value fo or their value for	and/or <i>m</i> or λ into l_1 or μ into l_2	M1
	So, X(-1, 3, 9)		(-1, 3, 9)	or $\begin{pmatrix} -1\\ 3\\ 9 \end{pmatrix}$ or -	$\mathbf{i} + 3\mathbf{j} + 9\mathbf{k}$ or con	-1 done 3 9	A1 cao
	(1)		(2)		11 .1 .11	1. 1.	[3]
(b) Way 1	$\mathbf{d}_1 = \begin{pmatrix} -1 \\ -5 \\ 1 \end{pmatrix}, \ \mathbf{d}_2 =$	$ \begin{pmatrix} 3 \\ 0 \\ -4 \end{pmatrix} \Rightarrow \begin{pmatrix} -1 \\ -5 \\ 1 \end{pmatrix} \bullet $	$\begin{pmatrix} 3\\0\\-4 \end{pmatrix}$	R i:	ealisation that the of s required between or a multiple of	dot product \mathbf{d}_1 and \mathbf{d}_2 \mathbf{d}_1 and \mathbf{d}_2	M1
	$\cos\theta = \frac{1}{\sqrt{(-1)^2 + 1}}$	$ \pm \begin{pmatrix} -1 \\ -5 \\ 1 \end{pmatrix} \bullet \begin{pmatrix} 3 \\ 0 \\ -4 \\ \hline (-5)^2 + (1)^2 \cdot \sqrt{(3)^2} \\ \hline \end{array} $	$\left(+ (0)^{2} + (-4)^{2} \right)^{2}$	$\overline{2} \left\{ = \frac{-7}{\sqrt{27} \cdot \sqrt{25}} \right\}$	depend 1 st M mar dot produ between d ₁ a multiple of	lent on the k. Applies act formula and \mathbf{d}_2 or a \mathbf{d}_1 and \mathbf{d}_2	dM1
	${q = 105.6303588}$	$\beta \dots \triangleright \} \theta_{Acute} = 74$.36964117	= 74.37 (2 dp)	awrt 74.37 seen	in (b) only	A1
							[3]
(c)	$\overrightarrow{AX} = "\overrightarrow{OX}" - \overrightarrow{OA}$	$ = \left(\begin{array}{c} -1\\ 3\\ 9\end{array}\right) - \left(\begin{array}{c} 1\\ 1\\ 0 \end{array}\right) $	$ \begin{pmatrix} 2\\8\\6 \end{pmatrix} = \begin{pmatrix} -3\\-15\\3 \end{pmatrix} $) or $A_{/=2}, X_{/=1}$	$_{5} \bowtie AX = 3 \mathbf{d}_{1} , \{ \mathbf{d}_{1} \}$	$\left \mathbf{d}_{1}\right = \sqrt{27}$	
	$AX = \sqrt{(-3)^2 + (-3)^2}$	$(15)^2 + (3)^2$ or $3\sqrt{7}$	$\frac{1}{27} \left\{ = \sqrt{243} \right\}$	$=9\sqrt{3}$ Full 1	nethod for finding	AX or XA	M1
					9√3 seen	in (c) only	A1 cao
	Note:	You cannot recov	$\frac{\text{ver work for }}{V^{A}}$	part (c) in either p	$\frac{\operatorname{art}(d) \operatorname{or} \operatorname{part}(e)}{ \longrightarrow }$		[2]
(d) Way 1	$\frac{YA}{"9\sqrt{3}"} = \tan("74.$	36964")	$\frac{1}{\text{their}} \frac{1}{AX}$	$\int = \tan \theta \text{ or } YA =$	$(\text{their } AX) \tan \theta$,	where θ is	M1
	<i>YA</i> = 55.71758	= 55.7 (1 dp)			anything that rou	nds to 55.7	A1
							[2]
(e)	$\left\{A_{\lambda=2}, X_{\lambda=5} \Rightarrow S\right\}$	So $AX = 2AB \Longrightarrow S$	So at B , $\lambda = 3$	$3.5 \text{ or } \lambda = 0.5) \Big\}$			
Way 1		$\begin{pmatrix} -1 \end{pmatrix} \begin{pmatrix} 0 \end{pmatrix}$	5)		(their / v found i	in(a)) + 2	
	$\overrightarrow{OB} = \begin{bmatrix} 28\\4 \end{bmatrix} + 3.$	$5\left(\begin{array}{c} -5\\ 1 \end{array}\right); = \left(\begin{array}{c} 10.3\\ 10.3\\ 7.5 \end{array}\right)$	5 5	or $l_b = 3 - \frac{1}{2}$	$=\frac{2}{\frac{2}{\frac{1}{x}}}$	$(a))$ into l_1	M1;
	$\left \begin{array}{c} 4 \\ \hline \end{array} \right $	$\begin{bmatrix} -1 \\ -1 \end{bmatrix} \begin{bmatrix} 3.5 \\ -1 \end{bmatrix}$	5	At least	one position vector	r is correct.	A1
	$OB = \begin{bmatrix} 28 \\ 4 \end{bmatrix} + 0.$	$\begin{bmatrix} -5 \\ 1 \end{bmatrix}; = \begin{bmatrix} 25 \\ 4 \end{bmatrix}$	5	Bot	(Also allow co h position vectors a (Also allow co	are correct.	A1
					([3]
							13

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Question Number	Scheme	Notes	Marks				
6. (e)	$\left\{AX = 2AB \Rightarrow AB = \frac{1}{2}AX. \text{ So, } \overrightarrow{OB} = \overrightarrow{OA} \pm \overrightarrow{AB} \Rightarrow \overrightarrow{OB} = \overrightarrow{OA} \pm \frac{1}{2}\overrightarrow{AX}\right\}$						
Way 2	$\overrightarrow{OB} = \begin{pmatrix} 2 \\ 18 \\ 6 \end{pmatrix} + 0.5 \begin{pmatrix} -3 \\ -15 \\ 3 \end{pmatrix}; = \begin{pmatrix} 0.5 \\ 10.5 \\ 7.5 \end{pmatrix}$	Applies either $\overrightarrow{OA} + 0.5\overrightarrow{AX}$ or $\overrightarrow{OA} - 0.5\overrightarrow{AX}$ where (their \overrightarrow{AX}) = ±[(their \overrightarrow{OX}) – \overrightarrow{OA}]	M1;				
	\overline{OP} $\begin{pmatrix} 2\\ 18 \end{pmatrix}$ $O = \begin{pmatrix} -3\\ 15 \end{pmatrix}$ $\begin{pmatrix} 3.5\\ 25 = 5 \end{pmatrix}$	At least one position vector is correct (Also allow coordinates)	A1				
	$OB = \left(\begin{array}{c} 18\\6\end{array}\right)^{-0.5} \left(\begin{array}{c} -15\\3\end{array}\right)^{+0.5} \left(\begin{array}{c} 25.5\\4.5\end{array}\right)$	Both position vectors are correct (Also allow coordinates)	A1				
			[3]				
6. (e) Way 3	$\overrightarrow{AB} = \begin{pmatrix} 4-\lambda\\28-5\lambda\\4+\lambda \end{pmatrix} - \begin{pmatrix} 2\\18\\6 \end{pmatrix} = \begin{pmatrix} 2-\lambda\\10-5\lambda\\-2+\lambda \end{pmatrix} = \begin{pmatrix} 1\\3\\-2\\-2+\lambda \end{pmatrix}$	$ \begin{array}{l} 1(2-\lambda) \\ 5(2-\lambda) \\ 1(2-\lambda) \end{array} \end{array} ; \overrightarrow{AX} = \left(\begin{array}{c} -3 \\ -15 \\ 3 \end{array} \right) \qquad AX^2 = 243 \vartriangleright \\ AB^2 = 27(2-1)^2 \end{array} $					
	$AX = 2AB \vartriangleright AX^2 = 4AB^2 \vartriangleright 243 = 4(27)(2)$	$(-/)^2 \vdash (2-/)^2 = \frac{9}{4}$ or $(27/)^2 - 108/ + \frac{189}{4} = 0$					
	or $108/^2 - 432/ + 189 = 0$ or $4/^2 - 16/ + 7$	$7 = 0 \Rightarrow / = 3.5 \text{ or } / = 0.5$					
	$\overrightarrow{OB} = \begin{pmatrix} 4\\28\\4 \end{pmatrix} + 3.5 \begin{pmatrix} -1\\-5\\1 \end{pmatrix}; = \begin{pmatrix} 0.5\\10.5\\7.5 \end{pmatrix}$	Full method of solving for / the equation $AX^2 = 4AB^2$ using (their \overrightarrow{AX}) and \overrightarrow{AB} and substitutes at least one of their values for / into l_1	M1;				
	$\overrightarrow{OB} = \begin{pmatrix} 4 \\ 28 \end{pmatrix} + 0.5 \begin{pmatrix} -1 \\ -5 \end{pmatrix}; = \begin{pmatrix} 3.5 \\ 25.5 \end{pmatrix}$	At least one position vector is correct (Also allow coordinates)	A1				
	$\left(\begin{array}{c} 4 \end{array}\right) \left(\begin{array}{c} 1 \end{array}\right) \left(\begin{array}{c} 4.5 \end{array}\right)$	Both position vectors are correct (Also allow coordinates)	A1				
	Note: $AX = 2AB \Rightarrow \overrightarrow{AX} = \pm 2\overrightarrow{AB}$. Hence, / $x: -3 = \pm 2(2 - 1)$ or $y: -15 = \frac{1}{2}$	= 3.5 or / = 0.5 can be found from solving either $\pm 2(10 - 5/)$ or z: -3 = $\pm 2(-2 + /)$	[3]				
6. (e) Way 4	$\overrightarrow{OB} = \begin{pmatrix} -1 \\ 3 \\ 9 \end{pmatrix} + 0.5 \begin{pmatrix} 3 \\ 15 \\ -3 \end{pmatrix}; = \begin{pmatrix} 0.5 \\ 10.5 \\ 7.5 \end{pmatrix}$	Applies either (their \overrightarrow{OX}) + 0.5 \overrightarrow{XA} or (their \overrightarrow{OX}) + 1.5 \overrightarrow{XA} where (their \overrightarrow{XA}) = \overrightarrow{OA} – (their \overrightarrow{OX})	M1;				
	$\overrightarrow{OB} = \begin{pmatrix} -1 \\ 3 \\ -1 \end{pmatrix}_{\pm 1.5} \begin{pmatrix} 3 \\ 15 \\ -15 \end{pmatrix}_{\pm 1.5} \begin{pmatrix} 3.5 \\ 25.5 \end{pmatrix}$	At least one position vector is correct (Also allow coordinates)	A1				
	$OB = \begin{bmatrix} 3 \\ 9 \end{bmatrix} + 1.5 \begin{bmatrix} 15 \\ -3 \end{bmatrix}; = \begin{bmatrix} 25.5 \\ 4.5 \end{bmatrix}$	Both position vectors are correct (Also allow coordinates)	A1				
			[3]				
6. (e) Way 5	$\overrightarrow{OB} = 0.5 \left(\left(\begin{array}{c} -1 \\ 3 \\ 9 \end{array} \right) + \left(\begin{array}{c} 2 \\ 18 \\ 6 \end{array} \right) \right); = \left(\begin{array}{c} 0.5 \\ 10.5 \\ 7.5 \end{array} \right)$	Applies $\frac{1}{2} \left[(\text{their } \overrightarrow{OX}) + \overrightarrow{OA} \right]$	M1;				
	$\overrightarrow{OR} = \begin{pmatrix} 2 \\ 18 \end{pmatrix} \begin{pmatrix} -3 \\ 15 \end{pmatrix} \begin{pmatrix} 3.5 \\ 25 \end{pmatrix}$	At least one position vector is correct (Also allow coordinates)	A1				
	$\begin{array}{c} \mathbf{C}\mathbf{D} = \left(\begin{array}{c} 16\\6\end{array}\right)^{-10.5} \left(\begin{array}{c} -15\\3\end{array}\right)^{+10.5} \left(\begin{array}{c} 25.5\\4.5\end{array}\right)$	Both position vectors are correct (Also allow coordinates)	A1				
			[3]				

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Question Number	Scheme Notes							
6. (e) Way 6	$\left\{ \left \overrightarrow{AX} \right = \right.$	$=9\sqrt{3}$, $ d_1 = 3\sqrt{3} \implies K = \frac{9\sqrt{3}}{3\sqrt{3}} = 3 \implies \overline{AX} = 3\mathbf{d}_1$; S	o, $\overrightarrow{OB} = \overrightarrow{OA} \pm \frac{1}{2}\overrightarrow{AX} = \overrightarrow{OA} \pm \frac{1}{2}(3\mathbf{d}_1)$					
	$\overrightarrow{OB} = \left(\begin{array}{c} \\ \\ \end{array} \right)$	$\begin{pmatrix} 2\\18\\6 \end{pmatrix} + 0.5 \begin{pmatrix} -1\\-5\\1 \end{pmatrix} ; = \begin{pmatrix} 0.5\\10.5\\7.5 \end{pmatrix}$	Applies either $\overrightarrow{OA} + 0.5(K\mathbf{d}_1)$ or $\overrightarrow{OA} - 0.5(K\mathbf{d}_1)$, where $K = \frac{\text{their} \overrightarrow{AX} }{3\sqrt{3}}$	M1;				
	$\overrightarrow{OB} =$	At least one position vector is correct (Also allow coordinates)	A1					
		$\begin{pmatrix} 6 \end{pmatrix} \left(\begin{pmatrix} 1 \end{pmatrix} \right) \left(4.5 \right)$	Both position vectors are correct (Also allow coordinates)	A1				
				[3]				
		Question 6 N	otes					
6. (a)	Note	M1 can be implied by at least two correct follow	through coordinates from their / or fr	om their <i>m</i>				
(b)	Note	Evaluating the dot product (i.e. $(-1)(3) + (-5)(0)$ for the M1, dM1 marks.	+(1)(-4)) is not required					
	Note	For M1 dM1: Allow one slip in writing down th	eir direction vectors, \mathbf{d}_1 and \mathbf{d}_2					
	Note	Allow M1 dM1 for						
	$\left(\sqrt{(-1)^{2} + (-5)^{2} + (1)^{2}} \cdot \sqrt{(3)^{2} + (0)^{2} + (-4)^{2}}\right) \cos q = \pm \begin{pmatrix} -1 \\ -5 \\ 1 \end{pmatrix} \cdot \begin{pmatrix} 3 \\ 0 \\ -4 \end{pmatrix}$							
	Note	$q = 1.297995^{\circ}$, (without evidence of awrt 74.37	') is A0					
6. (b)	Altern	ative Method: Vector Cross Product						
Way 2	Only a	pply this scheme if it is clear that a vector cross p	roduct method is being applied.					
	$\mathbf{d}_1 \times \mathbf{d}_2$	$= \underbrace{\begin{pmatrix} -1 \\ -5 \\ 1 \end{pmatrix}} \times \begin{pmatrix} 3 \\ 0 \\ -4 \end{pmatrix} = \begin{cases} \mathbf{i} \mathbf{j} \mathbf{k} \\ -1 -5 1 \\ 3 0 -4 \end{cases} = 20\mathbf{i} - \mathbf{j}$	+ 15k $\left\{ \begin{array}{c} \text{Realisation that the vector} \\ \text{cross product is required} \\ \text{between } \mathbf{d}_1 \text{ and } \mathbf{d}_2 \\ \text{or a multiple of } \mathbf{d}_1 \text{ and } \mathbf{d}_2 \end{array} \right.$	M1				
	sin q =	$= \frac{\sqrt{(20)^2 + (-1)^2 + (15)^2}}{\sqrt{(-1)^2 + (-5)^2 + (1)^2} \cdot \sqrt{(3)^2 + (0)^2 + (-4)^2}}$	Applies the vector product formula between \mathbf{d}_1 and \mathbf{d}_2 or a multiple of \mathbf{d}_1 and \mathbf{d}_2	dM1				
	$\sin q =$	$= \frac{\sqrt{626}}{\sqrt{27} \cdot \sqrt{25}} \triangleright q = 74.36964117 = 74.37 \ (2 \text{ dp})$	awrt 74.37 seen in (b) only	A1				
				[3]				
6. (c)	M1	Finds the difference between their \overline{OX} and \overline{OA} and	applies Pythagoras to the result to fin	d AX or XA				
		OR applies $\left \left(\text{their } /_X \text{ found in } (a) \right) - 2 \right \sqrt{(-1)^2 + (-1)^2}$	$(-5)^2 + (1)^2$					
	Note	For M1: Allow one slip in writing down their \overrightarrow{OX}	and \overline{OA}					
	1,000	$\left(\begin{array}{c} 2 \end{array}\right)$						
	Note	Allow M1A1 for $\begin{pmatrix} 3\\15\\3 \end{pmatrix}$ leading to $AX = \sqrt{(3)^2 + (3)^2}$	$(15)^2 + (3)^2 = \sqrt{243} = 9\sqrt{3}$					
(e)	Note	Imply M1 for no working leading to any two comp	onents of one of the \overrightarrow{OB} which are co	orrect.				
L		0 · · · · · · · · · · · · · · · ·						

Question Number	Scheme			Notes	Mar	rks
6. (d) Way 2	$\frac{"9\sqrt{3}"}{YA} = \tan(90 - "74.36964")$	$\frac{\text{their } \overline{A}}{YA}$ where θ is the	$\frac{\text{their} \overrightarrow{AX} }{YA} = \tan(90 - \theta) \text{ or } AY = \frac{\text{their} \overrightarrow{AX} }{\tan(90 - \theta)},$ where θ is the acute or obtuse angle between L and L			
	<i>YA</i> = 55.71758 = 55.7 (1 dp)			anything that rounds to 55.7	A1	
						[2]
6. (d) Way 3	$\frac{YA}{\sin("74.36964")} = \frac{"9\sqrt{3}"}{\sin(90 - "74.36964")}$	")	$\frac{YA}{\sin\theta} =$ acute o	$= \frac{\text{their } \overline{AX}}{\sin(90-\theta)} \text{ o.e., where } \theta \text{ is the}$ or obtuse angle between l_1 and l_2	M1	
	$YA = \frac{9\sqrt{3}\sin(74.36964)}{\sin(15.63036)} = 55.71758$. = 55.7 (1 dp)		anything that rounds to 55.7	A1	
						[2]
6. (d) Way 4	$\mathbf{d}_{1} = \begin{pmatrix} -1 \\ -5 \\ 1 \end{pmatrix}, \overrightarrow{OY} = \begin{pmatrix} 5 \\ 3 \\ 1 \end{pmatrix} + \mu \begin{pmatrix} 3 \\ 0 \\ -4 \end{pmatrix}$	$ = \left(\begin{array}{c} 5+3\mu \\ 3 \\ 1-4\mu \end{array} \right) $				
	$\overrightarrow{YA} = \begin{pmatrix} 2\\18\\6 \end{pmatrix} - \begin{pmatrix} 5+3\mu\\3\\1-4\mu \end{pmatrix} = \begin{pmatrix} -3-3\mu\\15\\5+4\mu \end{pmatrix}$					
	$\overrightarrow{YA} \bullet \mathbf{d}_1 = 0 \implies \begin{pmatrix} -3 - 3\mu \\ 15 \\ 5 + 4\mu \end{pmatrix} \bullet \begin{pmatrix} -1 \\ -5 \\ 1 \end{pmatrix} =$	= 0	App	(Allow a sign slip in copying \mathbf{d}_1) blies $\overrightarrow{YA} \bullet \mathbf{d}_1 = 0$ or $\overrightarrow{AY} \bullet \mathbf{d}_1 = 0$	M1	
	$\Rightarrow 3 + 3m - 75 + 5 + 4m = 0 \Rightarrow m = \frac{67}{7}$	to	or \overline{YA}	• $(K\mathbf{d}_1) = 0$ or $\overrightarrow{AY} \bullet (K\mathbf{d}_1) = 0$ and applies Pythagoras to find a		
	$YA^{2} = \left(-3 - 3\left(\frac{67}{7}\right)\right)^{2} + \left(15\right)^{2} + \left(5 + 4\left(-\frac{1}{7}\right)^{2}\right)^{2} + \left(-3 - 3\left(\frac{67}{7}\right)^{2}\right)^{2} + \left(-3 - 3\left(67$	$\left(\frac{67}{7}\right)^2$	numeric	cal expression for AY^2 or for the distance AY		
	So, $YA = \sqrt{\left(-\frac{222}{7}\right)^2 + \left(15\right)^2 + \left(\frac{303}{7}\right)^2}$					
	= 55.71758 = 55.7 (1 dp)			anything that rounds to 55.7	A1	
	Note: $\overrightarrow{OY} = \frac{236}{7}\mathbf{i} + 3\mathbf{j} - \frac{261}{7}\mathbf{k}$, $\overrightarrow{AY} = -$	$\frac{222}{7}$ i + 15 j + $\frac{30}{7}$	$\frac{33}{7}$ k			[2]

Mathematics C4

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Question Number	Scheme		Notes	Marks	
7.	$\frac{\mathrm{d}h}{\mathrm{d}t} = k \sqrt{(h-9)}, 9 < h \neq 200;$	$h = 130, \ \frac{\mathrm{d}h}{\mathrm{d}t} = -1.1$			
(a)	$-1.1 = k \sqrt{(130 - 9)} \bowtie k =$	Substitutes $h = 13$ into the printed	30 and either $\frac{dh}{dt} = -1.1$ or $\frac{dh}{dt} = 1.1$ I equation and rearranges to give $k =$	M1	
	so, $k = -\frac{1}{10}$ or -0.1		$k = -\frac{1}{10}$ or -0.1	A1	
(b) Way 1	$\int \frac{\mathrm{d}h}{\sqrt{(h-9)}} = \int k \mathrm{d}t$	Separates the variables the wrong position	s correctly. dh and dt should not be in us, although this mark can be implied by later working. Ignore the integral signs.	B1	
	$\int (h-9)^{-\frac{1}{2}} \mathrm{d}h = \int k \mathrm{d}t$				
	1	Integrates $-$	$\frac{\pm\lambda}{(h-9)}$ to give $\pm m\sqrt{(h-9)}$; /, m^{-1} 0	M1	
	$\frac{(h-9)^2}{\left(\frac{1}{2}\right)} = kt(+c)$	$\frac{(h-9)^{\frac{1}{2}}}{\left(\frac{1}{2}\right)} = kt \text{or} -$	$\frac{(h-9)^{\frac{1}{2}}}{\left(\frac{1}{2}\right)} = (\text{their } k)t, \text{with/without } + c,$	A1	
	or equivalent, which can be un-simplified or simplified. $\{t = 0, h = 200 \vartriangleright\}$ $2\sqrt{(200 - 9)} = k(0) + c$ $t = 0$ and $h = 200$ to changed equation				
	$ \begin{array}{c} \hline c = 2\sqrt{191} & \overrightarrow{c} & 2(h-9)^{\frac{1}{2}} = -0.1t + 2\sqrt{191} \\ \hline h = 50 \Rightarrow \end{array} \begin{array}{c} c \\ 2\sqrt{(50-9)} = -0.1t + 2\sqrt{191} \\ t = \dots \end{array} \begin{array}{c} \hline c \\ dependent on the previous M m \\ Applies h = 50 and their value of their changed equation and rearrant to find the value of their changed equation and rearrant to find the value of their changed equation and rearrant to find the value of their changed equation and rearrant to find the value of their changed equation and rearrant to find the value of the valu$				
	$t = 20\sqrt{191} - 20\sqrt{41}$ or $t = 148.3430145 = 148$ (minut	tes) (nearest minute)	$t = 20\sqrt{191} - 20\sqrt{41}$ isw or awrt 148	A1 cso	
				[6]	
(b) Way 2	$\int_{200}^{50} \frac{\mathrm{d}h}{\sqrt{(h-9)}} = \int_{0}^{T} k \mathrm{d}t$	in the wrong posit by later working.	les correctly. dh and dt should not be ions, although this mark can be implied Integral signs and limits not necessary.	B1	
	$\int_{200}^{50} (h-9)^{-\frac{1}{2}} dh = \int_{0}^{T} k dt$				
	$\begin{bmatrix} 1 & 1 \\ 1 & 0 \end{bmatrix}^{\frac{1}{2}}$	Integrates $\frac{1}{\sqrt{2}}$	$\frac{\pm \lambda}{(h-9)} \text{ to give } \pm m\sqrt{(h-9)}; \ /, \ m^{-1} 0$	M1	
	$\left\lfloor \frac{(n-9)^2}{\left(\frac{1}{2}\right)} \right\rfloor_{200} = \left\lfloor kt \right\rfloor_0^T$	$\frac{(h-9)^{\frac{1}{2}}}{\left(\frac{1}{2}\right)} = kt \text{ or } \frac{(h-1)^{\frac{1}{2}}}{(h-1)^{\frac{1}{2}}}$	$(\frac{k-9}{2})^{\frac{1}{2}} = (\text{their } k)t, \text{ with/without limits,}$	A1	
		$\begin{array}{c} \hline \\ \hline $			
	$2\sqrt{41} - 2\sqrt{191} = kt$ or kT	and (can be implied) $t = 0$ to their changed equation		M1 7	
	$t = \frac{2\sqrt{41} - 2\sqrt{191}}{-0.1}$	The	dependent on the previous M mark en rearranges to find the value of $t =$	dM1	
	$t = 20\sqrt{191} - 20\sqrt{41}$ or $t = 148.3430145 = 148$ (minut	tes) (nearest minute)	$t = 20\sqrt{191} - 20\sqrt{41}$ or awrt 148 or 2 hours and awrt 28 minutes	A1 cso	
				[6]	
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		Question 7 Notes
7. (b)	Note	Allow first B1 for writing $\frac{dt}{dh} = \frac{1}{k\sqrt{(h-9)}}$ or $\frac{dt}{dh} = \frac{1}{(\text{their } k)\sqrt{(h-9)}}$ or equivalent
	Note	$\frac{\mathrm{d}t}{\mathrm{d}h} = \frac{1}{k\sqrt{(h-9)}} \text{ leading to } t = \frac{2}{k}\sqrt{(h-9)} \ (+c) \text{ with/without } +c \text{ is B1M1A1}$
	Note	After finding $k = 0.1$ in part (a), it is only possible to gain full marks in part (b) by initially writing
		$\frac{\mathrm{d}h}{\mathrm{d}t} = -k\sqrt{(h-9)} \text{ or } \grave{0}\frac{\mathrm{d}h}{\sqrt{(h-9)}} = \grave{0}-k\mathrm{d}t \text{ or } \frac{\mathrm{d}h}{\mathrm{d}t} = -0.1\sqrt{(h-9)} \text{ or } \grave{0}\frac{\mathrm{d}h}{\sqrt{(h-9)}} = \grave{0}-0.1\mathrm{d}t$
		Otherwise, those candidates who find $k = 0.1$ in part (a), should lose at least the final A1 mark in
		part (b).

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8.	$x = 3q\sin q, \ y = \sec^3 q$	$q, 0 \neq q < \frac{1}{2}$	$\frac{p}{2}$				
(a)	{When $y = 8$,} $8 = set$	$ec^3 \theta \Rightarrow cos$	$s^3 \theta = \frac{1}{8} \Rightarrow$	$\cos\theta = \frac{1}{2}$	$\Rightarrow \theta = \frac{\pi}{3}$	Sets $y = 8$ to find θ and attempts to substitute their θ	M1
	$k \text{ (or } x) = 3\left(\frac{1}{3}\right)$	$\left(\frac{1}{3}\right)$				$\frac{\sqrt{3p}}{\sqrt{3p}} \text{ or } \frac{3p}{\sqrt{3p}}$	Δ1
	$\frac{30 \times (01 \times) - \frac{1}{2}}{2}$, • • <i>,</i>	1 0	7 .1 .		$2 2\sqrt{3}$	
	Note: Ob	taining two	o value for	k without a	ccepting the c	correct value is final A0	[2]
(b)	$\frac{\mathrm{d}x}{\mathrm{d}\theta} = 3\sin\theta + 3\theta\cos\theta$	θ				$3\theta \sin \theta \rightarrow 3\sin \theta + 3\theta \cos \theta$ Can be implied by later working	B1
	$\left\{\int y \frac{\mathrm{d}x}{\mathrm{d}q} \left\{\mathrm{d}q\right\}\right\} = \int (s)^2 ds$	$\sec^3 q$)(3sin	n <i>q</i> + 3qcos	q) $\left\{ dq \right\}$		Applies $(\pm K \sec^3 q) (\tanh \frac{dx}{dq})$ Ignore integral sign and dq : K^{-1} 0	M1
				Achieves	the correct r	esult no errors in their working a g	
	$= 3 \hat{0} q \sec^2 q + \tan q \sec^2 q$	$ec^2 q dq$		Must	have integra	bracketing or manipulation errors. al sign and $d\theta$ in their final answer.	A1 *
	$x=0$ and $x=k \Rightarrow$	$\underline{\alpha} = 0$ and	$\frac{\beta = \frac{\pi}{3}}{3}$	$\alpha = 0$	and $\beta = \frac{\pi}{3}$	or evidence of $0 \rightarrow 0$ and $k \rightarrow \frac{\pi}{3}$	B1
	Not	e: The wo	rk for the fi	inal B1 mar	k must be see	en in part (b) only.	[4]
					$q \sec^2 q$ -	$\rightarrow Aqg(q) - B \int g(q), A > 0, B > 0,$	
		where $g(q)$ is a trigonometric function in q and					
(c)	$\int \partial g_{\alpha\alpha} \partial^2 g d\alpha$ $\int g_{\alpha} \partial g \partial \alpha$ $\partial f_{\alpha} \partial f_{\alpha} \partial f_{\alpha}$				g(q) = thei	$r i sec^2 q dq$. [Note: $g(q)^1 sec^2 q$]	
Way 1	$\left\{ \left\{ 0^{q \sec q d q} \right\} = q \right\}$	tan <i>q</i> – 0 tai	$nq\{aq\}$		de	ependent on the previous M mark	
				Either $/q \sec^2 q \rightarrow Aq \tan q - B \int \tan q, A > 0, B > 0$			
				or $q \sec^2 q \to q \tan q - \int \tan q$			
	$= q \tan q - \ln(\sec q)$			$q \sec q$	$c^2 q \rightarrow q \tan q$	$q - \ln(\sec q)$ or $q \tan q + \ln(\cos q)$ or	
	or =	$= q \tan q + \frac{1}{2}$	$\ln(\cos q)$	$1 q \sec^2 q$	$r \to /q \tan q$	$- / \ln(\sec q)$ or $/ q \tan q + / \ln(\cos q)$	A1
	Note: (Condone q	$\gamma \sec^2 q \rightarrow$	$q \tan q - \ln(q)$	$\sec x$) or qt	$an q + \ln(\cos x)$ for A1	
	$\left\{ \grave{\mathbf{h}} \tan q \sec^2 q \mathrm{d} q \right\}$			$\tan\theta \sec^2$	$^{2}\theta$ or $/\tan\theta$	$q \sec^2 q \rightarrow \pm C \tan^2 q$ or $\pm C \sec^2 q$	M1
						or $\pm Cu$, where $u = \cos q$	
	$= \frac{1}{2}\tan^2 q \text{ or } \frac{1}{2}\sec^2 q$	^{2}q	tan q se	$c^2 q \rightarrow \frac{1}{2} tar$	$n^2 q$ or $\frac{1}{2}$ sec	$r^2 q$ or $\frac{1}{2\cos^2 q}$ or $\tan^2 q - \frac{1}{2}\sec^2 q$	
	or $\frac{1}{2u^2}$ where $u =$	$\cos q$		or 0.5	u^{-2} , where u	$u = \cos q$ or $0.5u^2$, where $u = \tan q$	A1
	or $\frac{1}{2}u^2$ where $u = 1$	tan q		or λ	$\tan\theta \sec^2\theta$ –	$\rightarrow \frac{\pi}{2} \tan^2 \theta \text{ or } \frac{\pi}{2} \sec^2 \theta \text{ or } \frac{\pi}{2 \cos^2 \theta}$	
	Δ			or $0.5/u^{-1}$	2 , where u =	$= \cos q$ or $0.5/u^2$, where $u = \tan q$	
	$\left\{\operatorname{Area}(R)\right\} = \left[3q \tan q - \right]$	$3\ln(\sec q) +$	$\frac{3}{2}\tan^2 q \bigg]_0^{\frac{\rho}{3}}$	or $\left[3q \tan q \right]$	$-3\ln(\sec q) +$	$\frac{3}{2}\sec^2 q \bigg]_0^{\frac{\rho}{3}}$	
	$= \left(3\left(\frac{\pi}{3}\right)\sqrt{3}\right)$	$3 - 3\ln 2 + \frac{2}{2}$	$\left(\frac{3}{2}(3)\right) - (0)$	or $\left(3\left(\frac{\pi}{3}\right)\right)$	$\sqrt{3} - 3\ln 2 + \frac{3}{2}(1 + \frac{3}{2})$	$(4) \left(-\left(\frac{3}{2}\right) \right) \right)$	
	$= \frac{9}{2} + \sqrt{3}$	p - 3ln2	or $\frac{9}{2} + \sqrt{3}$	$p + 3\ln\left(\frac{1}{2}\right)$	or $\frac{9}{2} + \sqrt{3}$	$\pi - \ln 8$ or $\ln \left(\frac{1}{8}e^{\frac{9}{2} + \sqrt{3}\rho}\right)$	A1 o.e.
							[6]
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Question Number		Scheme		Notes				
8. (c)	Way 2 fo	or the first 5 marks: Applying integ	gration b	by parts on $\partial (q + \tan q) \sec^2 q dq$				
Way 2	$ \hat{0}^{(q \sec^2 q + \tan q \sec^2 q) dq} = \hat{0}^{(q + \tan q) \sec^2 q dq}, \begin{cases} u = q + \tan q \Rightarrow \frac{du}{dq} = 1 + \sec^2 q \\ \frac{dv}{dq} = \sec^2 q \Rightarrow v = \tan q = g(q) \end{cases} $							
	h(q) and	g(q) are trigonometric functions in	q and g	$g(q) = \text{their } \hat{g} \sec^2 q \mathrm{d} q.$ [Note: $g(q)^{-1} \sec^2 q$]				
			A(q	+ $\tan q$)g(q) - $B\dot{0}(1 + h(q))g(q), A > 0, B > 0$	M1			
	$= (q + \tan q) \tan q - \dot{0} (1 + \sec^2 q) \tan q \{ dq \}$			dependent on the previous M mark Either $/\left[(q + \tan q)\sec^2 q\right] \rightarrow A(q + \tan q)\tan q - B\dot{0}(1 + h(q))\tan q, A^{-1} 0, B > 0$ or $(q + \tan q)\tan q - \dot{0}(1 + h(q))\tan q$				
	$= (q + \tan q) \tan q - \dot{0} (\tan q + \tan q \sec^2 q) \{ \mathrm{d}q \}$							
	$= (q + \tan q) \tan q - \ln(\sec q) - \dot{0} \tan q \sec^2 q \{ \mathrm{d}q \}$			$(q + \tan q)\tan q - \ln(\sec q) \text{ o.e.}$ or $\left \left[(q + \tan q)\tan q - \ln(\sec q) \right] \text{ o.e.} \right $				
		1 2		$\tan q \sec^2 q \to \pm C \tan^2 q \text{ or } \pm C \sec^2 q$				
	$= (q + \tan q)\tan q - \ln(\sec q) - \frac{1}{2}\tan^2 q$ or $= (q + \tan q)\tan q - \ln(\sec q) - \frac{1}{2}\sec^2 q$ etc.			$(q + \tan q)\tan q - \frac{1}{2}\tan^2 q$ or $(q + \tan q)\tan q - \frac{1}{2}\sec^2 q$				
	Note	Allow the first two marks in part (c) for $q \tan q - \partial \tan q$ embedded in their working						
	Note	Allow the first three marks in part	(c) for	$q \tan q - \ln(\sec q)$ embedded in their working				
	Note	Allow 3 rd M1 2 nd A1 marks for either $\tan^2 q - \frac{1}{2}\tan^2 q$ or $\tan^2 q - \frac{1}{2}\sec^2 q$ embedded in their working						
			Questi	on 8 Notes				
8. (a)	Note	Allow M1 for an answer of $k = a_k$	wrt 2.72	without reference to $\frac{\sqrt{3}p}{2}$ or $\frac{3p}{2\sqrt{3}}$				
	Note	Allow M1 for an answer of $k = 3$	(arccos($\left(\frac{1}{2}\right)\sin\left(\arccos\left(\frac{1}{2}\right)\right)$ without reference to $\frac{\sqrt{3}\rho}{2}$ or	$\frac{3p}{2\sqrt{3}}$			
	Note	E.g. allow M1 for $q = 60^{\circ}$, leading to $k = 3(60)\sin(60)$ or $k = 90\sqrt{3}$						

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8. (b)	Note	To gain A1, dq does not need to appear until the	ey obtain $3\hat{0}(q\sec^2 q + \tan q \sec^2 q) dq$		
	Note	For M1, their $\frac{dx}{dq}$, where their $\frac{dx}{dq}$ ¹ $3q\sin q$, needs to be a trigonometric function in q			
	Note	Writing $\hat{0}(\sec^3 q)(3\sin q + 3q\cos q) = 3\hat{0}(q\sec^2 q + \tan q\sec^2 q)dq$ is sufficient for B1M1A1			
	Note	Writing $\frac{dx}{d\theta} = 3\sin\theta + 3\theta\cos\theta$ followed by writing $\partial y \frac{dx}{dq} dq = 3 \partial (q \sec^2 q + \tan q \sec^2 q) dq$ is sufficient for B1M1A1			
	Note	The final A mark would be lost for $\hat{0} \frac{1}{\cos^3 q} 3\sin q + 3q\cos q = 3 \hat{0} (q \sec^2 q + \tan q \sec^2 q) dq$ [lack of brackets in this particular case].			
	Note	Give 2 nd B0 for $a = 0$ and $b = 60^{\circ}$, without reference to $b = \frac{p}{3}$			
(c)	Note	A decimal answer of 7.861956551 (without a correct exact answer) is A0.			
(-)	Note	First three marks are for integrating $\theta \sec^2 \theta$ with respect to θ			
	Note	Fourth and fifth marks are for integrating $\tan \theta \sec^2 \theta$ with respect to θ			
	Note	Candidates are not penalised for writing $\ln \sec q$ as either $\ln(\sec q)$ or $\ln \sec q$			
	Note	$q \sec^2 q \rightarrow q \tan q + \ln(\sec q)$ WITH NO INTERMEDIATE WORKING is M0M0A0			
	Note	$q \sec^2 q \rightarrow q \tan q - \ln(\cos q)$ WITH NO INTERMEDIATE WORKING is M0M0A0			
	Note	$q \sec^2 q \rightarrow q \tan q - \ln(\sec q)$ WITH NO INTERMEDIATE WORKING is M1M1A1			
	Note	$q \sec^2 q \rightarrow q \tan q + \ln(\cos q)$ WITH NO INTERMEDIATE WORKING is M1M1A1			
	Note	Writing a correct $uv - \partial v \frac{du}{dx}$ with $u = q$, $\frac{dv}{dq} = \tan q$, $\frac{du}{dq} = 1$ and $v = \text{their } g(q)$ and making one error in the direct application of this formula is 1 st M1 only.			
8. (c)	Alternativ	ve method for finding $\hat{0}$ tan $q \sec^2 q dq$			
	$\begin{cases} u = \tan \\ \frac{\mathrm{d}v}{\mathrm{d}q} = \sec \theta \end{cases}$	$q \implies \frac{\mathrm{d}u}{\mathrm{d}q} = \sec^2 q$ $c^2 q \implies v = \tan q$			
	à tan	$a q \sec^2 q dq = \tan^2 q - h \tan q \sec^2 q dq$			
	⊳ 2òtan	$q \sec^2 q dq = \tan^2 q$			
			$\tan\theta \sec^2\theta$ or $\rightarrow \pm C\tan^2q$	M1	
) tanqsec	$e^2 q \mathrm{d}q = \frac{1}{2} \tan^2 q$	$\tan q \sec^2 q \to \frac{1}{2} \tan^2 q$	A1	
	or $\begin{cases} u = \\ \frac{dv}{dq} \end{cases}$	$\sec q \qquad \Rightarrow \frac{\mathrm{d}u}{\mathrm{d}q} = \sec q \tan q$ $= \sec q \tan q \Rightarrow v = \sec q$			
	⊳òtanG	$q \sec^2 q dq = \sec^2 q - \dot{q} \sec^2 q \tan q dq$			
	Þ 2òtan	$q \sec^2 q dq = \sec^2 q$			
	à tan Gas	$r^{2} q d q = \frac{1}{1} c q q^{2} q$	$\tan \theta \sec^2 \theta \text{ or } \to \pm C \sec^2 q$	M1	
	$\int \frac{1}{2} $		$\tan q \sec^2 q \to \frac{1}{2} \sec^2 q$	A1	

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