Surname	Other	names
Pearson Edexcel GCE	Centre Number	Candidate Number
Coro Mat		
Advanced Subsid	liary	
Advanced Subsid Wednesday 25 May 201 Time: 1 hour 30 minut	6 – Morning es	Paper Reference 6664/01

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 75.
- 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.

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Summe Past Paper	r 2016 www.mystudybro.com This resource was created and owned by Pearson Edexcel	Mathematics C
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1.	A geometric series has first term <i>a</i> and common ratio $r = \frac{3}{4}$	
	The sum of the first 4 terms of this series is 175	
	(a) Show that $a = 64$	
		(2)
	(b) Find the sum to infinity of the series.	
		(2)
	(c) Find the difference between the 9th and 10th terms of the series. Give your answer to 3 decimal places.	
		(3)

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P 4 6 7 1 6 A 0 2 3 2

Question Number	Scheme	Marks
1.	$r = \frac{3}{4}, S_4 = 175$	
(a) Way 1	$\frac{a\left(1-\left(\frac{3}{4}\right)^{4}\right)}{1-\frac{3}{4}} \text{ or } \frac{a\left(1-\frac{3}{4}^{4}\right)}{1-\frac{3}{4}} \text{ or } \frac{a\left(1-0.75^{4}\right)}{1-0.75} \qquad \qquad \text{Substituting } r = \frac{3}{4} \text{ or } 0.75 \text{ and } n = 4$ into the formula for $S_n$	M1
	$175 = \frac{a\left(1-\left(\frac{3}{4}\right)^4\right)}{1-\frac{3}{4}} \Rightarrow a = \frac{175\left(1-\frac{3}{4}\right)}{\left(1-\left(\frac{3}{4}\right)^4\right)} \left\{ \Rightarrow a = \frac{\left(\frac{175}{4}\right)}{\left(\frac{175}{256}\right)} \Rightarrow \right\} \underline{a = 64}^* $ Correct proof	A1*
		[2]
(a) Way 2	$a + a\left(\frac{3}{4}\right) + a\left(\frac{3}{4}\right)^2 + a\left(\frac{3}{4}\right)^3 \qquad \qquad a + a\left(\frac{3}{4}\right) + a\left(\frac{3}{4}\right)^2 + a\left(\frac{3}{4}\right)^3$	M1
	$\frac{175}{64}a = 175 \left( \Rightarrow a = \frac{175}{\left(\frac{175}{64}\right)} \right) \Rightarrow \underline{a = 64}^{*}$ or 2.734375 <i>a</i> =175 $\Rightarrow \underline{a = 64}$ Correct proof	A1*
		[2]
(a) Way 3	$\{S_4 = \} \frac{64\left(1 - \left(\frac{3}{4}\right)^4\right)}{1 - \frac{3}{4}} \text{ or } \frac{64\left(1 - \frac{3}{4}^4\right)}{1 - \frac{3}{4}} \text{ or } \frac{64\left(1 - 0.75^4\right)}{1 - 0.75} $ Applying the formula for $S_n$ with $r = \frac{3}{4}$ , $n = 4$ and $a$ as 64.	M1
	= 175 so $a = 64^*$ Obtains 175 with no errors seen and concludes $a = 64^*$ .	A1*
		[2]
(b)	$\{S_{\infty}\} = \frac{64}{\left(1 - \frac{3}{4}\right)}; = 256 \qquad S_{\infty} = \frac{(\text{their } a)}{1 - \frac{3}{4}} \text{ or } \frac{64}{1 - \frac{3}{4}}$	M1;
,	(4) 256	A1cao [2]
(c)	Writes down either " $64'' \left(\frac{3}{4}\right)^8$ or awrt 6.4 or $\{D = T_9 - T_{10} = \} 64 \left(\frac{3}{4}\right)^8 - 64 \left(\frac{3}{4}\right)^9$ " $64'' \left(\frac{3}{4}\right)^9$ or awrt 4.8, using $a = 64$ or their $a$	M1
	A correct expression for the difference (i.e. $\pm (T_9 - T_{10})$ ) using $a = 64$ or their $a$ .	dM1
	$\left\{ = 64 \left(\frac{3}{4}\right)^8 \left(\frac{1}{4}\right) = 1.6018066 \right\} = \underline{1.602} (3  \text{dp}) $ 1.602 or -1.602	A1 cao
		[3]
-		7

1 ()		Question 1 Notes
<b>I.</b> (a)	M1	Allow invisible brackets around fractions throughout all parts of this question.
		Note that this is a "above that" question with a printed answer
	A1	Note that this is a "show that" question with a printed answer. In <b>Way 1</b> this mark <b>usually</b> requires $a = p/q$ where p and q may be unsimplified brackets from the formula (or could be 11200/175 for example) as an intermediate step before the conclusion $a = 64$ . Exceptions include $a = 175/4 * 256/175$ i.e. multiplication by reciprocal rather than division or 175 = 175a/64 followed by the obvious $a = 64$ These also get A1 In "reverse" methods such as <b>Way 3</b> we need a conclusion "so $a = 64$ " or some implication that their argument is reversible. Also a conclusion can be implied from a <u>preamble</u> , eg: "If I assume $a$ = 64 then find $S = 175$ as given this implies $a = 64$ as required" This is a show that question and there should be no loss of accuracy. In all the methods <b>if</b> decimals are used there should <b>not be rounding</b> . If 0.68359375 appears this is correct. If it is rounded it would not give the exact answer. 64(1-0.31640625) or $43.75$ are each correct – if they are rounded then treat this as incorrect e.g. <b>Way 3:</b> "43.75/0.25 = 175 so $a = 64$ is A1" but "43/0.25 = 175 so $a = 64$ is A0" and "44/0.25 = 175 so $a = 64$ is A0" Yet another <b>variant on Way 3</b> : take $a=64$ then find the next 3 terms as 48, 36, 27 then add $64+48+36+27$ to get 175. Again need conclusion that $a = 64$ or some implication that their
		argument is reversible. Otherwise M1 A0
(b)	M1	$S_{\infty} = \frac{64}{1-\frac{3}{4}}$ or $\frac{(\text{their } a \text{ found in part } (a))}{1-\frac{3}{4}}$
	A1	256 cao
(c)	NB	Using <b>Sum of 10 terms</b> minus <b>Sum of 9 terms</b> is NOT a misread Scores <b>M0M0A0</b>
	M1	Can be <b>implied.</b> Writes down either $64\left(\frac{3}{4}\right)$ or $64\left(\frac{3}{4}\right)$ ,
	Noto	using $a = 64$ (or their <i>a</i> found in part (a)).
	Note	$(2)^8$ $(2)^9$
	Note	$64\left(\frac{5}{4}\right) = 6.407226563 \text{ and } 64\left(\frac{5}{4}\right) = 4.805419922$
	dM1	This is dependent on previous M mark and can be implied. Either
		$64\left(\frac{3}{4}\right)^8 - 64\left(\frac{3}{4}\right)^9$ or $64\left(\frac{3}{4}\right)^9 - 64\left(\frac{3}{4}\right)^8$ or awrt 6.4 – awrt 4.8, using $a = 64$ (or their <i>a</i> from part (a))
	Note	$1^{\text{st}}$ M1 and $2^{\text{nd}}$ M1 can be implied by the value of their
		1:55
		difference = "their <i>a</i> found in part (a)" $\times \frac{4^9}{4^9} \approx \frac{1}{40}$
	Note	Either $64\left(\frac{3}{4}\right)^9 - 64\left(\frac{3}{4}\right)^{10}$ or $64\left(\frac{3}{4}\right)^{10} - 64\left(\frac{3}{4}\right)^9$ is $1^{\text{st}}$ M1, $2^{\text{nd}}$ M0.
	A1	1.602 or -1.602 cao (This answer with no working is M1M1A1) But 1.6 with no working is M0M0A0
	Note	$\left\{ D = \frac{1}{4}T_9 \Longrightarrow \right\} D = \frac{1}{4}(64) \left(\frac{3}{4}\right)^8 \text{ is } 1^{\text{st}} \text{ M1}, 2^{\text{nd}} \text{ M1}$
	Special case	Obtains awrt 6.4, then obtains awrt 4.8 but rounds to 6 – 5 when subtracting – award M1M1A0

(1)

6664 Leave

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2. The curve *C* has equation

 $y=8-2^{x-1}, \qquad 0\leqslant x\leqslant 4$ 

(a) Complete the table below with the value of *y* corresponding to x = 1

x	0	1	2	3	4
у	7.5		6	4	0

(b) Use the trapezium rule, with all the values of y in the completed table, to find an approximate value for  $\int_0^4 (8 - 2^{x-1}) dx$  (3)



Figure 1

Figure 1 shows a sketch of the curve *C* with equation  $y = 8 - 2^{x-1}$ ,  $0 \le x \le 4$ 

The curve C meets the x-axis at the point A and meets the y-axis at the point B.

The region R, shown shaded in Figure 1, is bounded by the curve C and the straight line through A and B.

(c) Use your answer to part (b) to find an approximate value for the area of R.



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Question			
Number		Scheme	Marks
	y = 8 - 2	$2^{x-1}, 0, x, 4$	
<b>2.</b> (a)	7	иналикинжилжилжилжилжилжилжилжилжилжилжилжилжилж	B1 cao
			, [1]
		Outside brackets $\frac{1}{2} \times 1$ or $\frac{1}{2}$	B1;
(b)	$\int \int \int d r dr dr$	$2^{x-1}$ dr $2^{x-1}$ dr $2^{x-1}$ dr $2^{x-1}$ dr $2^{x-1}$ dr $2^{x-1}$ For structure of transition	
(0)	$(J_0 (o - $	$\int \frac{1}{2} x_{1}^{2} x_{1}^{2} \frac{1}{2} x_{1}^{2} \frac{1}{2} \frac{1}{2} x_{1}^{2} \frac{1}{2} $	M1
		candidate's v-ordinates	<u>1011</u>
I	$\begin{bmatrix} 1 \end{bmatrix}$		·
	$\begin{cases} = - \times 4 \\ 2 \end{cases}$	$1.5 \} = 20.75$ o.e. 20.75	Al cao
	*********	***************************************	[3]
(c)	Area(R)	$=$ "20.75" $-\frac{1}{-(7.5)(4)}$	M1
		-5.75	A 1
1		– <i>3.75</i>	AI Cao
		***************************************	<u>[4]</u>
		Question 2 Notes	
(2)	R1	For 7 only	
(a)	DI		
(b)	B1	For using $\frac{1}{2} \times 1$ or $\frac{1}{2}$ or equivalent.	
	M1	Requires the correct $\{\dots, \dots\}$ bracket structure. It needs the 7.5 stated but the 0 may be om	itted. The
		inner bracket needs to be multiplied by 2 and to be the summation of the remaining $y$ val	ues in the
		table with no additional values.	
		If the only mistake is a copying error or is to omit one value from 2nd bracket this may be as a slip and the M mark can be allowed (An extra repeated term forfeits the M mark ho	e regarded
		(unless it is 0)). M0 is awarded if values used in brackets are x values instead of y values	,wever
	A1	For 20.75 or fraction equivalent e.g. $20\frac{3}{4}$ or $\frac{83}{4}$	
	Note	<b>NB: Separate trapezia may be used</b> : B1 for 0.5, M1 for $1/2 h(a + b)$ used 3 or 4 times as before	Then A1
	Special	Bracketing mistake $0.5 \times (7.5 + 0) + 2$ (their 7 + 6 + 4) scores B1 M1 A0 unless the fina	l answer
	case:	implies that the calculation has been done correctly (then full marks can be given). An ar	nswer of
		37.75 usually indicates this error.	
	Common	Many candidates use $\frac{1}{2} \times \frac{4}{5}$ and score B0 Then they proceed with $\{7.5+2(\text{"their 7"}+6+6)\}$	$-4)+0\}$
	error:	and score M1 This usually gives 16.6 for B0M1A0	
(c)	M1	their answer to $(b)$ – area of triangle with base 4 and height 7.5 or alternative correct me	thod
		e a their answer to (b) $-\int_{1}^{4} \left(75 - \frac{7.5}{2}r\right) dr$ (Even if this leads to a negative answer) This	may be
		$\int_{0}^{1} \left( 1 - \frac{1}{2} \right)^{-1} dt$	inuy oo
		implied by a correct answer or by an answer where they have subtracted 15 from their an part (b) Must use answer to part (b)	swer to
	A1	5.75 or fraction equivalent e.g. $5\frac{3}{4}$ or $\frac{23}{4}$	



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Question Number	Scheme		
3.	P(7, 8) and $Q(10, 13)$		
(a)	$\{PQ =\} \sqrt{(7-10)^2 + (8-13)^2} \text{ or } \sqrt{(10-7)^2}$	$\frac{1}{13-8^{2}}$ Applies distance formula. Can be implied.	M1
	$\{PQ\} = \sqrt{34}$	$\sqrt{34}$ or $\sqrt{17}.\sqrt{2}$	A1 [2]
(b) Worr 1	$(x-7)^{2} + (y-8)^{2} = 34 \left( \operatorname{or} \left( \sqrt{34} \right)^{2} \right)$	$(x \pm 7)^2 + (y \pm 8)^2 = k,$ where k is a positive value.	M1
way 1		$(x-7)^2 + (y-8)^2 = 34$	A1 oe [2]
(b)	$r^2 + n^2 = 14r = 16n + 70 = 0$	$x^{2} + y^{2} \pm 14x \pm 16y + c = 0$ , where c is any value < 113	M1
Way 2	x + y = 14x = 10y + 79 = 0	$\frac{x^{2} + y^{2} - 14x - 16y + 79 = 0}{x^{2} + y^{2} - 14x - 16y + 79 = 0}$	A1 oe
			[2]
(c) Way 1	{Gradient of radius} = $\frac{13-8}{10-7}$ or $\frac{5}{3}$	This must be seen or implied in part (c).	B1
	Gradient of tangent $= -\frac{1}{m}\left(=-\frac{3}{5}\right)$	Using a perpendicular gradient method on their gradient. So Gradient of tangent = $-\frac{1}{\frac{1}{\text{gradient of radius}}}$	M1
	$y-13 = -\frac{3}{5}(x-10)$	y - 13 = (their changed gradient)(x - 10)	M1
	3x + 5y - 95 = 0	3x + 5y - 95 = 0  o.e.	A1
(c) Way 2	$2(x-7) + 2(y-8)\frac{dy}{dx} = 0$	Correct differentiation (or equivalent). Seen or implied	B1
	$2(10-7) + 2(13-8)\frac{dy}{dx} = 0 \implies \frac{dy}{dx} = -\frac{3}{5}$	Substituting <b>both</b> $x = 10$ and $y = 13$ into a valid differentiation to find a value for $\frac{dy}{dx}$	M1
	$y - 13 = -\frac{3}{5}(x - 10)$	y - 13 = (their gradient)(x - 10)	M1
	3x + 5y - 95 = 0	3x + 5y - 95 = 0 o.e.	A1
(c)	****	10x + 13y - 7(x + 10) - 8(y + 13) + 79 = 0	8 R1
Way 3	10x + 13y - 7(x + 10) - 8(y + 13) + 79 = 0	10x + 13y - 7(x + 10) - 8(y + 13) + c = 0	M2
	3x + 5y - 95 = 0	where <i>c</i> is any value $<113$ 3x + 5y - 95 = 0 o.e.	A1
			[4] 8

		Question 3 Notes					
(a)	M1	Allow for $\{PQ =\}$ $\sqrt{(7-10)^2 + (8-13)^2}$ or for $\{PQ =\}$ $\sqrt{3^2 + 5^2}$ . Can be implied by answer.					
	A1	Need to see $\sqrt{34}$ . You can ignore subsequent work so $\sqrt{34}$ followed by 5.83 earns M1 A1, but					
		$\{PQ =\} \sqrt{3^2 + 5^2} = 5.83$ , with no exact value for the answer given, earns M1A0. Allow					
		$\pm\sqrt{34}$ this time.					
		NB Some use equation of circle to find this distance Achieving $\sqrt{34}$ gets M1A1					
		Others find half of their $\pm\sqrt{34}$ . Do not isw here as it is an error – confusing <i>d</i> with diameter. Give M1A0					
( <b>b</b> )	M1	Either of the correct approaches for equation of circle (as shown on scheme)					
	A1	Correct equation (two are shown and any correct equivalent is acceptable)					
(c)		A correct start to finding the gradient of the tangent (see each scheme)					
	B1	Complete method for finding the gradient of the tangent (see each scheme) Where implicit differentiation has been used the only slips allowed here should be sign slips.					
	1 <sup>st</sup> M1	Correct attempt at line equation for tangent at correct point (10, 13) with <b>their tangent</b> gradient. If the $y = mx + c$ method is used to find the equation, this M1 is earned at the point where the x-					
	2 <sup>nd</sup> M1	and y-values are substituted to find c e.g. $13 = -3/5 \times 10 + c$					
		Accept any correct answer of the required format; so integer multiple of $3x + 5y - 95 = 0$ or					
	A1 3x - 95 + 5y = 0  or  -3x - 5y + 95 = 0  (must include "=0") e.g. 6x + 10y - 190 = 0 Also allow $5y + 3x - 95 = 0$ etc						
	Common error	$\frac{dy}{dx} = 2(x-7) + 2(y-8) = 6 + 10 = 16 \text{ so } (y-13) = 16(x-10) \text{ is marked B0 M0 M1 A0 (Way 2)}$					

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4.		$f(x) = 6x^3 + 13x^2 - 4$	
	(a)	Use the remainder theorem to find the remainder when $f(x)$ is divided by	(2 $x$ + 3). (2)
	(b)	Use the factor theorem to show that $(x + 2)$ is a factor of $f(x)$ .	(2)
	(c)	Factorise $f(x)$ completely.	
			(4)
12			

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Question	Scheme					
<b>4</b> .	$f(x) = 6x^3 + 13x^2 - 4$					
(a)	$f\left(-\frac{3}{2}\right) =$	$= 6\left(-\frac{3}{2}\right)^{3} + 13\left(-\frac{3}{2}\right)^{2} - 4 = 5$ Attempting $f\left(-\frac{3}{2}\right)$ or $f\left(-\frac{3}{2}\right)$	M1			
(u)	$\left( 2\right) $	$\begin{pmatrix} 2 \\ 2 \end{pmatrix} + \begin{pmatrix} 15 \\ 2 \end{pmatrix} + \begin{pmatrix} 25 \\ 2 \end{pmatrix}$	A1 cao			
1						
	C( 0)	Attempts $f(-2)$ .	M1			
(b)	f(-2) =	$6(-2)^{\circ} + 13(-2)^{\circ} - 4$ f(-2) = 0 with no sign or substitution errors				
	= 0, and so $(x + 2)$ is a factor. and for conclusion.					
			[2]			
(c)	$f(x) = \{($	$(x+2)$ $(6x^2 + x - 2)$	M1 A1			
6	=(x	(+2)(2x-1)(3x+2)	M1 A1			
			[4]			
			8			
		Question 4 Notes				
	Note	Long division scores no marks in part (a). The <u>remainder theorem</u> is required.				
(a)	M1	Attempting $f\left(-\frac{3}{2}\right)$ or $f\left(\frac{3}{2}\right)$ . $6\left(-\frac{3}{2}\right)^2 + 13\left(-\frac{3}{2}\right)^2 - 4$ or $6\left(-\frac{3}{2}\right)^2 + 13\left(-\frac{3}{2}\right)^2 - 4$ is su	ufficient			
(4)						
	A1	5 cao				
(b)	M1	Attempting $f(-2)$ . (This is <b>not</b> given for $f(2)$ )				
	A1	Must correctly show $f(-2) = 0$ and give a conclusion <i>in part (b) only</i> . No simplification	n of terms			
		is required here.				
	Note	Stating "hence factor" or "it is a factor" or a "tick" or "QED" are possible conclusions.				
		Also a conclusion can be implied from a <u>preamble</u> , eg: "If $f(-2) = 0$ , $(x + 2)$ is a factor				
		Long division scores no marks in part (b). The <u>factor theorem</u> is required.				
(c)	1 <sup>st</sup> M1	Attempting to divide by $(x + 2)$ leading to a quotient which is quadratic with at least two	terms			
		beginning with first term of $\pm 6x^2$ + linear or constant term.				
		Or $f(x) = (x + 2)(+6x^2 + \text{linear and/or constant term})$ (This may be seen in part (b) where candid	ates did			
		not use factor theorem and might be referred to here)				
	1st A 1	$(6x^2 + x - 2)$ seen as quotient or as factor. If there is an error in the division resulting in	0			
	IAI	(0x + x - 2) seen as quotient of as factor. If there is an error in the division resulting in	a			
		remainder give A0, but allow recovery to gain next two marks if $(6x + x - 2)$ is used				
	2 <sup>nd</sup> M1	For a <i>valid</i> attempt to factorise <b>their</b> three term quadratic.				
	A1	(x+2)(2x-1)(3x+2) and needs all three factors on the same line.				
		Ignore subsequent work (such as a <b>solution</b> to a quadratic equation).				
	Special	<b>Calculator methods:</b> Award M1A1M1A1 for correct answer $(r + 2)(2r - 1)(3r + 2)$ with no working				
	<b>cases</b> Award M1A1M1A1 for correct answer $(x + 2)(2x - 1)(3x + 2)$ with no working.					
	Award M1AUM1AU for either $(x + 2)(2x + 1)(3x + 2)$ or $(x + 2)(2x + 1)(3x - 2)$ or (x + 2)(2x - 1)(2x - 2) with no working (At last one has last incomed)					
		(x + 2)(2x + 1)(3x + 2) with no working. (At least one bracket incontect)				
		Award M1A1M1A1 for $x = -2, \frac{1}{2}, -\frac{2}{3}$ followed by $(x + 2)(2x - 1)(3x + 2)$ .				
		Award M0A0M0A0 for a candidate who writes down $x = -2, \frac{1}{2}, -\frac{2}{3}$ giving no factors.				
		Award M1A1M1A1 for $6(x + 2)(x - \frac{1}{2})(x + \frac{2}{3})$ or $2(x + 2)(x - \frac{1}{2})(3x + 2)$ or equivalent				
	Award SC: M1A0M1A0 for $x = -2, \frac{1}{2}, -\frac{2}{3}$ followed by $(x + 2)(x - \frac{1}{2})(x + \frac{2}{3})$ .					

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		Leav blanl
5. (a) Find the	first 3 terms, in ascending powers of $x$ , of the binomial ex	pansion of
	$(2-9x)^4$	
giving ea	ich term in its simplest form.	(4)
	$f(x) = (1 + kx)(2 - 9x)^4$ , where k is a constant	
The expansio	on, in ascending powers of $x$ , of $f(x)$ up to and including th	the term in $x^2$ is
	$A - 232x + Bx^2$	
where A and	<i>B</i> are constants.	
(b) Write do	wn the value of A.	(1)
(c) Find the	value of <i>k</i> .	(2)
(d) Hence fin	nd the value of <i>B</i> .	(2)

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Question	Scheme		
Number	Scheme		IVIALKS
5.	$ (a) (2-9x)^{4} = 2^{4} + {}^{4}C_{1}2^{3}(-9x) + {}^{4}C_{2}2^{2}(-9x)^{2}, (b)  f(x) = (1+kx)(2-9x)^{4} = A - 232x + Bx^{2} $		
(a)	First term of 16 in their final series		
Way 1	At least one of $\begin{pmatrix} {}^{4}C_{1} \times \times x \end{pmatrix}$ or $\begin{pmatrix} {}^{4}C_{2} \times \times x^{2} \end{pmatrix}$		
		At least one of $-288x$ or $+1944x^2$	A1
	$=(16) - 288x + 1944x^2$	Both $-288r$ and $+1944r^2$	Δ1
	00000000		[4]
(a)	$(2 \ 9r)^4 - (4 \ 26r + 81r^2)(4 \ 26r + 81r^2)$		
(a)	(2-9x) = (4-30x+81x)(4-30x+81x)		
		First term of 16 in their final series	BI
Wow 2	$-16 - 144x + 324x^2 - 144x + 1206x^2 + 324x^2$	auadratic by the same 3 term	
way 2	= 10 - 144x + 324x - 144x + 1290x + 324x	quadratic to achieve either 2 terms in	M1
		$r$ or at least 2 terms in $r^2$	
		At least one of $-288 r$ or $\pm 1044 r^2$	A 1
	$= (16) - 288x + 1944x^{2}$	At least one of $-288x$ of $+1944x$	AI
		Both $-288x$ and $+1944x^2$	A1
			[4]
(a) <b>Way 3</b>	$\left\{ (2-9x)^4 = \right\} 2^4 \left( 1 - \frac{9}{2}x \right)^4$	First term of 16 in final series	B1
		At least one of	
	$= 2^{4} \left( 1 + 4 \left( -\frac{9}{2}x \right) + \frac{4(3)}{2} \left( -\frac{9}{2}x \right)^{2} + \dots \right)$	$(4 \times \times x) \operatorname{or} \left( \frac{4(3)}{2} \times \times x^2 \right)$	M1
		At least one of $-288x$ or $+1944x^2$	A1
	$= (16) - 288x + 1944x^2$	Doth $289x$ and $\pm 1044x^2$	A 1
		B000 - 200x and $+ 1944x$	AI
	<b>Derta</b> (b) (a) and (d) may be marked together		[4]
(h)	A = "16"	Follow through their value from (a)	D1#
(0)		Fonow through their value from (a)	DIII [1]
		$M_{av}$ be seen in part (b) or (d)	[1]
(c)	$\left\{ (1+kx)(2-9x)^{2} \right\} = (1+kx)(16-288x+\left\{ 1944x^{2}+\ldots \right\})$	and can be implied by work in	M1
		parts (c) or (d).	
	<i>x</i> terms: $-288x + 16kx = -232x$		
		. 7	
	giving, $16k = 56 \implies k = \frac{1}{2}$	$k = \frac{1}{2}$	A1
			[2]
(b)	$r^2$ terms: $1944r^2 - 288kr^2$		
(u)	Δ τομμός, μ. τ. τ. 2008. (7)	See aster	M1
	So, $B = 1944 - 288 \left( \frac{7}{2} \right)$ ; $= 1944 - 1008 = 936$	See notes	IVI I
	(2)	936	Al
			[2]
			9

		Question 5 Notes
(a) Ways 1	B1 cao	16
and 3		
	M1	Correct binomial coefficient associated with correct power of x i.e $({}^{*}C_{1} \times \times x)$ or $({}^{*}C_{2} \times \times x^{2})$
		They may have 4 and 6 or 4 and $\frac{4(3)}{2}$ or even $\begin{pmatrix} 4 \\ 1 \end{pmatrix}$ and $\begin{pmatrix} 4 \\ 2 \end{pmatrix}$ as their coefficients. Allow missing
		signs and brackets for the M marks.
	1 <sup>st</sup> A1	At least one of $-288x$ or $+1944x^2$ (allow +- 288x)
	2 <sup>nd</sup> A1	Both $-288x$ and $+1944x^2$ (May list terms separated by commas) Also full marks for correct answer with no working here. Again allow +- $288x$
	Note	If the candidate then divides their final correct answer through by 8 or any other common factor then isw and mark correct series when first seen. So (a) B1M1A1A1 .It is likely that this approach will be followed by (b) B0, (c) M1A0, (d) M1A0 if they continue with their new series e.g. $2-36x + 283x^2 +$ (Do not ft the value 2 as a mark was awarded for 16)
Way 2b	Special Case	Slight Variation on the solution given in the scheme
		$(2-9x)^4 = (2-9x)(2-9x)(4-36x+81x^2)$
		$= (2 - 9x)(8 - 108x + 486x^2 +)$
		$= 16 - 216x + 972x^{2} - 72x + 972x^{2}$ $First term of 16 B1$ $Multiplies out to give either M1$
		$= (16) - 288x + 1944x^{2} + \dots$ $= (16) - 288x + 1944x^{2} + \dots$ $= (16) - 288x + 1944x^{2} + \dots$ $= 100 - 288x + 1944x^{2} + \dots$
(b)	B1ft	<b>Parts (b), (c) and (d) may be marked together.</b> Must <b>identify</b> $A = 16$ or $A = their$ constant term found in part (a). Or may write just 16 if this is clearly their answer to part (b). If they expand their series and have 16 as first term of a series it is not sufficient for this mark.
(c)	M1	Candidate shows intention to multiply $(1+kx)$ by part of their series from (a) e.g. Just $(1 + kx)(16 - 288x +)$ or $(1 + kx)(16 - 288x + 1944x^2 +)$ are fine for M1.
	Note	This mark can also be implied by candidate multiplying out to find <b>two terms</b> (or coefficients) in x. i.e. f.t. their $-288x + 16kx$ N.B. $-288kx = -232x$ with no evidence of brackets is M0 – allow copying slips, or use of factored series, as this is a method mark
	A1	$k = \frac{7}{2}$ o.e. so 3.5 is acceptable
(d)	M1	Multiplies out their $(1 + kx)(16 - 288x + 1944x^2 +)$ to give <b>exactly</b> two terms (or coefficients)
	A1	in $x^2$ and attempts to find <i>B</i> using <b>these two</b> terms and a numerical value of <i>k</i> . 936
	Note	Award A0 for $B = 936x^2$
		But allow A1 for $B = 936x^2$ followed by $B = 936$ and treat this as a correction
		Correct answers in parts (c) and (d) with no method shown may be awarded full credit.

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		Leave
<b>6.</b> (i	) Solve, for $-\pi < \theta \leqslant \pi$ ,	blank
	$1 - 2\cos\left(\theta - \frac{\pi}{2}\right) = 0$	
	$1 - 2\cos\left(0 - \frac{1}{5}\right) = 0$	
	giving your answers in terms of $\pi$ . (3)	
(i	i) Solve, for $0 \leq x < 360^{\circ}$ ,	
	$4\cos^2 x + 7\sin x - 2 = 0$	
	giving your answers to one decimal place.	
	(Solutions based entirely on graphical or numerical methods are not acceptable.) (6)	
1.0		

6. $1 - 2\cos\left(\theta - \frac{\pi}{5}\right) = 0; -\pi < \theta, \pi$ (i) $\cos\left(\theta - \frac{\pi}{5}\right) = \frac{1}{2}$ Rearranges to give $\cos\left(\theta - \frac{\pi}{5}\right) = \frac{1}{2} \text{ or } -\frac{1}{2}$ M1 $\theta = \left\{-\frac{2\pi}{15}, \frac{8\pi}{15}\right\}$ A1 $\theta = \left\{-\frac{2\pi}{15}, \frac{8\pi}{15}, \frac{\pi}{15}\right\}$ A1 $\theta = \left\{-\frac{2\pi}{15}, \frac{8\pi}{15}, \frac{\pi}{15}, $	Question Number	Scheme	Marks
(i) $\frac{\cos\left(\theta - \frac{\pi}{5}\right) = \frac{1}{2}}{15}, \frac{8\pi}{15}}$ At least one of $-\frac{2\pi}{15}$ or $\frac{8\pi}{15}$ or $-24^{\circ}$ or 96° or awrt 1.68 or awrt -0.419 A1 $\theta = \left\{-\frac{2\pi}{15}, \frac{8\pi}{15}\right\}$ At least one of $-\frac{2\pi}{15}$ or $\frac{8\pi}{15}$ or $-24^{\circ}$ or 96° or awrt 1.68 or awrt -0.419 A1 Both $-\frac{2\pi}{15}$ and $\frac{8\pi}{15}$ A1 (3) NB Misread Misreading $\frac{\pi}{5}$ as $\frac{\pi}{6}$ or $\frac{\pi}{3}$ (or anything else) – treat as misread so M1 A0 A0 is maximum mark 4cos <sup>2</sup> x + 7sin x - 2 = 0, 0, x < 360° (ii) $4(1 - \sin^2 x) + 7\sin x - 2 = 0$ Applies $\cos^2 x = 1 - \sin^2 x$ M1 $4 - 4\sin^2 x + 7\sin x - 2 = 0$ Applies $\cos^2 x = 1 - \sin^2 x$ M1 $4 - 4\sin^2 x + 7\sin x - 2 = 0$ Applies $\cos^2 x = 1 - \sin^2 x$ M1 $4 - 4\sin^2 x + 7\sin x - 2 = 0$ Applies $\cos^2 x = 1 - \sin^2 x$ M1 $5 \sin x = -\frac{1}{4}$ , $\{\sin x = 2\}$ Sin $x = -\frac{1}{4}$ (See notes.) A1 co $x = awrt\{194.5, 345.5\}$ At least one of awrt 194.5 or awrt 345.5 or awrt 34.5 or aw	6.	$1 - 2\cos\left(\theta - \frac{\pi}{5}\right) = 0; \ -\pi < \vartheta,, \ \pi$	
$\theta = \left\{-\frac{2\pi}{15}, \frac{8\pi}{15}\right\}$ $\frac{At least one of -\frac{2\pi}{15} or \frac{8\pi}{15} or -24^{\circ} or 96^{\circ} or awrt 1.68 or awrt -0.419}{Both -\frac{2\pi}{15} and \frac{8\pi}{15}} A1$ $\frac{Both -\frac{2\pi}{15} and \frac{8\pi}{15}}{Both -\frac{2\pi}{15} and \frac{8\pi}{15}} A1$ $(3)$ $\frac{NB}{Misread}$ $\frac{Misreading \frac{\pi}{5} as \frac{\pi}{6} or \frac{\pi}{3} (or anything else) - treat as misread so M1 A0 A0 is maximum mark}{4 \cos^2 x + 7\sin x - 2 = 0, 0_{\circ}, x < 360^{\circ}}$ $\frac{4(1 - \sin^2 x) + 7\sin x - 2 = 0}{4\sin^2 x - 7\sin x - 2 = 0}$ $\frac{4\sin^2 x - 7\sin x - 2 = 0}{4\sin^2 x - 7\sin x - 2 = 0}$ $\frac{4\sin^2 x - 7\sin x - 2 = 0}{4\sin^2 x - 7\sin x - 2 = 0}$ $\frac{4\sin^2 x - 7\sin x - 2 = 0}{4\sin^2 x - 7\sin x - 2 = 0}$ $\frac{41}{4 - 4\sin^2 x + 7\sin x - 2 = 0}$ $\frac{41}{4 - 4\sin^2 x + 7\sin x - 2 = 0}$ $\frac{41}{4 - 4\sin^2 x + 7\sin x - 2 = 0}$ $\frac{41}{4 - 4\sin^2 x + 7\sin x - 2 = 0}$ $\frac{41}{4 - 4\sin^2 x + 7\sin x - 2 = 0}$ $\frac{41}{4 - 4\sin^2 x + 7\sin x - 2 = 0}$ $\frac{41}{4 - 4\sin^2 x + 7\sin x - 2 = 0}$ $\frac{41}{4 - 4\sin^2 x - 7\sin^2 x - 2 = 0}$ $\frac{41}{4 - 4\sin^2 x - 7\sin^2 x - 2 = 0}$ $\frac{41}{4 - 4\sin^2 x - 7\sin^2 x - 2 = 0}$ $\frac{41}{4 - 4\sin^2 x - 2}$ $\frac{41}{4$	(i)	$\cos\left(\theta - \frac{\pi}{5}\right) = \frac{1}{2}$ Rearranges to give $\cos\left(\theta - \frac{\pi}{5}\right) = \frac{1}{2}$ or $-\frac{1}{2}$	M1
$\frac{1}{15} \frac{1}{15} \frac$		$\theta = \left\{ -\frac{2\pi}{15}  \frac{8\pi}{15} \right\}$ At least one of $-\frac{2\pi}{15}$ or $\frac{8\pi}{15}$ or $-24^{\circ}$ or 96° or awrt 1.68 or awrt -0.419	A1
NB MisreadMisreading $\frac{\pi}{5}$ as $\frac{\pi}{6}$ or $\frac{\pi}{3}$ (or anything else)- treat as misread so M1 A0 A0 is maximum mark[3](ii) $4(1 - \sin^2 x) + 7\sin x - 2 = 0$ , 0, $x < 360^\circ$ Applies $\cos^2 x = 1 - \sin^2 x$ M1 $4 - 4\sin^2 x + 7\sin x - 2 = 0$ Applies $\cos^2 x = 1 - \sin^2 x$ M1 $4 - 4\sin^2 x + 7\sin x - 2 = 0$ Correct 3 term, $4\sin^2 x - 7\sin x - 2 = 0$ }A1 oe $(4\sin x + 1)(\sin x - 2) \{=0\}$ , $\sin x =$ Valid attempt at solving and $\sin x =$ M1 $\sin^2 x - \frac{1}{4}$ , $\{\sin x = 2\}$ $\sin x = -\frac{1}{4}$ (See notes.)A1 cso $x = awrt \{194.5, 345.5\}$ At least one of awrt 194.5 or awrt 345.5 or awrt 34.0 r awrt 194.5 and awrt 345.5 A1MisreadWriting equation as $4\cos^2 x - 7\sin x - 2 = 0$ with a sign error should be marked by applying the scheme as it simplifies the solution (do not treat as misread) Max mark is $3/6$ M11 $4\sin^2 x + 7\sin x - 2 = 0$ A0A0 $(4\sin x - 1)(\sin x + 2) \{= 0\}$ , $\sin x =$ Valid attempt at solving and $\sin x =$ MI $\sin x = +\frac{1}{4}$ , $\{\sin x = -2\}$ $\sin x = \frac{1}{4}$ (See notes.)		Both $-\frac{2\pi}{15}$ and $\frac{8\pi}{15}$	A1
NB MisreadiMisreading $\frac{\pi}{5}$ as $\frac{\pi}{6}$ or $\frac{\pi}{3}$ (or anything else)- treat as misread so M1 A0 A0 is maximum mark4cos² x + 7sin x - 2 = 0, 0, x < 360°			[3]
4cos <sup>2</sup> x + 7sin x - 2 = 0, 0, x < 360°	NB Misread	<b>Misreading</b> $\frac{\pi}{5}$ as $\frac{\pi}{6}$ or $\frac{\pi}{3}$ (or anything else)– treat as misread so M1 A0 A0 is maximum mark	
(ii) $4(1 - \sin^{2} x) + 7\sin x - 2 = 0$ Applies $\cos^{2} x = 1 - \sin^{2} x$ M1 $4 - 4\sin^{2} x + 7\sin x - 2 = 0$ $4\sin^{2} x - 7\sin x - 2 = 0$ Correct 3 term, $4\sin^{2} x - 7\sin x - 2 \{=0\}$ A1 oe $(4\sin x + 1)(\sin x - 2) \{=0\}$ , $\sin x =$ Valid attempt at solving and $\sin x =$ M1 $\sin x = -\frac{1}{4}$ , $\{\sin x = 2\}$ $\sin x = -\frac{1}{4}$ (See notes.) A1 cso A1 teast one of awrt 194.5 or awrt 345.5 or awrt 3.4 or awrt 6.0 awrt 194.5, 345.5 A1 $(6)$ Misread Writing equation as $4\cos^{2} x - 7\sin x - 2 = 0$ with a sign error should be marked by applying the scheme as it simplifies the solution (do not treat as misread) Max mark is 3/6 $4(1 - \sin^{2} x) - 7\sin x - 2 = 0$ $A0$ $(4\sin x - 1)(\sin x + 2) \{=0\}$ , $\sin x =$ Valid attempt at solving and $\sin x =$ M1 $\sin x = +\frac{1}{4}$ , $\{\sin x = -2\}$ $\sin x = -\frac{1}{4}$ (See notes.) $x = awrt165.5$ $x = awrt165.5$ $A1$ $A0$		$4\cos^2 x + 7\sin x - 2 = 0, 0, x < 360^\circ$	
$\frac{4 - 4\sin^2 x + 7\sin x - 2 = 0}{4\sin^2 x - 7\sin x - 2 \left\{= 0\right\}}$ $\frac{4 - 4\sin^2 x - 7\sin x - 2 \left\{= 0\right\}}{4\sin^2 x - 7\sin x - 2 \left\{= 0\right\}}$ $A1 \text{ oe}$ $(4\sin x + 1)(\sin x - 2) \left\{= 0\right\}, \sin x =$ $Valid attempt at solving and \sin x = M1 \sin x = -\frac{1}{4}, \left\{\sin x = 2\right\} A1 \text{ cso} x = awrt \left\{194.5, 345.5\right\} A1 \text{ fsi} awrt 194.5 \text{ and } awrt 345.5 A1 (61) 9 Writing equation as 4\cos^2 x - 7\sin x - 2 = 0 with a sign error should be marked by applying the scheme as it simplifies the solution (do not treat as misread) Max mark is 3/6 4(1 - \sin^2 x) - 7\sin x - 2 = 0 4\sin^2 x + 7\sin x - 2 = 0 (4\sin x - 1)(\sin x + 2) \left\{= 0\right\}, \sin x = Valid attempt at solving and \sin x = M1 \sin x = \frac{1}{4}, \left\{\sin x = -2\right\} \sin x = \frac{1}{4} (\text{ See notes.}) A1 \text{ cso}$	(ii)	$4(1 - \sin^2 x) + 7\sin x - 2 = 0$ Applies $\cos^2 x = 1 - \sin^2 x$	M1
Al constraint of the second s		$4 - 4\sin^2 x + 7\sin x - 2 = 0$	
NB MisreadWriting equation as $4\cos^2 x - 7\sin x - 2 = 0$ With a sign error should be marked by applying the scheme as it simplifies the solution (do not treat as misread) Max mark is $3/6$ M1NB Misread $\sin x = -\frac{1}{4}$ , $\{\sin x = 2 \}$ $\sin x = -\frac{1}{4}$ (See notes.)A1 csoNB MisreadWriting equation as $4\cos^2 x - 7\sin x - 2 = 0$ with a sign error should be marked by applying the scheme as it simplifies the solution (do not treat as misread) Max mark is $3/6$ M1 $4\sin^2 x + 7\sin x - 2 = 0$ M1 $4\sin^2 x + 7\sin x - 2 = 0$ M1 $\sin x = +\frac{1}{4}$ , $\{\sin x = -2\}$ $\sin x =$ Valid attempt at solving and $\sin x =$ $x = awrt165.5$ A1 ft $x = awrt165.5$ A1 ft $x = awrt165.5$ A1 ft		$4\sin^2 x - 7\sin x - 2 = 0$ Correct 3 term, $4\sin^2 x - 7\sin x - 2 \{= 0\}$	A1 oe
$\frac{\sin x = -\frac{1}{4}, \{\sin x = 2\}}{x = \operatorname{avrt}\{194.5, 345.5\}}$ $\frac{\operatorname{A1 \ cso}}{\operatorname{avrt} \{194.5, 345.5\}}$ $\frac{\operatorname{A1 \ cso}}{\operatorname{avrt} 194.5 \ or \ avrt 345.5 \ or \ a$		$(4\sin x + 1)(\sin x - 2) \{= 0\}$ , $\sin x = \dots$ Valid attempt at solving and $\sin x = \dots$	M1
NB MisreadWriting equation as $4\cos^2 x - 7\sin x - 2 = 0$ with a sign error should be marked by applying the scheme as it simplifies the solution (do not treat as misread) Max mark is $3/6$ A1ft $4(1 - \sin^2 x) - 7\sin x - 2 = 0$ M1 $4\sin^2 x + 7\sin x - 2 = 0$ M1 $4\sin^2 x + 7\sin x - 2 = 0$ M1 $\sin x = +\frac{1}{4}$ , $\{\sin x = -2\}$ $\sin x =$ $\sin x = +\frac{1}{4}$ , $\{\sin x = -2\}$ $\sin x = \frac{1}{4}$ (See notes.) $x = awrt165.5$ A1ftIncorrect answersA0		$\sin x = -\frac{1}{4}$ , $\{\sin x = 2\}$ $\sin x = -\frac{1}{4}$ (See notes.)	A1 cso
awrt 194.5 and awrt 345.5A1(6)9NB MisreadWriting equation as $4\cos^2 x - 7\sin x - 2 = 0$ with a sign error should be marked by applying the scheme as it simplifies the solution (do not treat as misread) Max mark is $3/6$ $4(1 - \sin^2 x) - 7\sin x - 2 = 0$ M1 $4\sin^2 x + 7\sin x - 2 = 0$ M1 $4\sin^2 x + 7\sin x - 2 = 0$ A0 $(4\sin x - 1)(\sin x + 2) \{=0\}$ , $\sin x =$ Valid attempt at solving and $\sin x =$ $\sin x = +\frac{1}{4}$ , $\{\sin x = -2\}$ $\sin x = \frac{1}{4}$ (See notes.) $x = awrt165.5$ A1ftIncorrect answersA0		$x = awrt \{194.5, 345.5\}$ At least one of awrt 194.5 or awrt 345.5 or awrt 3.4 or awrt 6.0	Alft
NB MisreadWriting equation as $4\cos^2 x - 7\sin x - 2 = 0$ with a sign error should be marked by applying the scheme as it simplifies the solution (do not treat as misread) Max mark is $3/6$ M1 $4(1 - \sin^2 x) - 7\sin x - 2 = 0$ M1 $4\sin^2 x + 7\sin x - 2 = 0$ M1 $4\sin^2 x + 7\sin x - 2 = 0$ M1 $(4\sin x - 1)(\sin x + 2) \{=0\}$ , $\sin x =$ Valid attempt at solving and $\sin x =$ $\sin x = +\frac{1}{4}$ , $\{\sin x = -2\}$ $\sin x = \frac{1}{4}$ (See notes.) $x = awrt165.5$ A1ftIncorrect answersA0		awrt 194.5 <b>and</b> awrt 345.5	Al
NB MisreadWriting equation as $4\cos^2 x - 7\sin x - 2 = 0$ with a sign error should be marked by applying the scheme as it simplifies the solution (do not treat as misread) Max mark is 3/69 $4(1 - \sin^2 x) - 7\sin x - 2 = 0$ M1 $4\sin^2 x + 7\sin x - 2 = 0$ M1 $(4\sin x - 1)(\sin x + 2) \{= 0\}$ , $\sin x =$ Valid attempt at solving and $\sin x =$ M1 $\sin x = +\frac{1}{4}$ , $\{\sin x = -2\}$ $\sin x = \frac{1}{4}$ (See notes.)A0 $x = awrt165.5$ A1ftIncorrect answersA0			[6]
NB MisreadWriting equation as $4\cos^2 x - 7\sin x - 2 = 0$ with a sign error should be marked by applying the scheme as it simplifies the solution (do not treat as misread) Max mark is $3/6$ $4(1 - \sin^2 x) - 7\sin x - 2 = 0$ M1 $4\sin^2 x + 7\sin x - 2 = 0$ A0 $(4\sin x - 1)(\sin x + 2) \{= 0\}$ , $\sin x =$ Valid attempt at solving and $\sin x =$ $\sin x = +\frac{1}{4}$ , $\{\sin x = -2\}$ $\sin x = \frac{1}{4}$ (See notes.) $x = awrt165.5$ A1ftIncorrect answersA0			9
Misreadthe scheme as it simplifies the solution (do not treat as misread) Max mark is 3/6 $4(1 - \sin^2 x) - 7\sin x - 2 = 0$ M1 $4\sin^2 x + 7\sin x - 2 = 0$ A0 $(4\sin x - 1)(\sin x + 2) \{= 0\}$ , $\sin x =$ Valid attempt at solving and $\sin x =$ $\sin x = +\frac{1}{4}$ , $\{\sin x = -2\}$ $\sin x = \frac{1}{4}$ (See notes.) $x = awrt165.5$ A1ftIncorrect answersA0	NB	Writing equation as $4\cos^2 x - 7\sin x - 2 = 0$ with a sign error should be marked by applying	
$4(1 - \sin^2 x) - 7\sin x - 2 = 0$ M1 $4\sin^2 x + 7\sin x - 2 = 0$ A0 $(4\sin x - 1)(\sin x + 2) \{= 0\}$ , $\sin x =$ Valid attempt at solving and $\sin x =$ $\sin x = +\frac{1}{4}$ , $\{\sin x = -2\}$ $\sin x = \frac{1}{4}$ (See notes.) $x = awrt165.5$ A1ftIncorrect answersA0	Misread	the scheme as it simplifies the solution (do not treat as misread) Max mark is 3/6	
$4\sin^2 x + 7\sin x - 2 = 0$ A0 $(4\sin x - 1)(\sin x + 2) \{= 0\}$ , $\sin x =$ Valid attempt at solving and $\sin x =$ M1 $\sin x = +\frac{1}{4}$ , $\{\sin x = -2\}$ $\sin x = \frac{1}{4}$ (See notes.)A0 $x = awrt165.5$ A1ftIncorrect answersA0		$4(1 - \sin^2 x) - 7\sin x - 2 = 0$	M1
Alternative 2 = 0 $(4 \sin x - 1)(\sin x + 2) \{= 0\}$ , $\sin x =$ Valid attempt at solving and $\sin x =$ M1 $\sin x = +\frac{1}{4}$ , $\{\sin x = -2\}$ $\sin x = \frac{1}{4}$ (See notes.)A0 $x = awrt165.5$ A1ftIncorrect answersA0		$4\sin^2 r + 7\sin r - 2 = 0$	AO
$\frac{(4\sin x - 1)(\sin x + 2)}{(\sin x - 1)(\sin x + 2)} = 0,  \sin x = \dots$ Valid attempt at solving and $\sin x = \dots$ $\frac{4}{4}$ $\frac{\sin x = -2}{4}$ $\frac{x = awrt165.5}{1 \text{ Incorrect answers}}$ $A0$	1	$U_{\text{abs}} = 1  \text{(abs} = 1)  \text{(b)}  \text{(c)}  (c)$	 M1
	.	$(4\sin x - 1)(\sin x + 2) \{=0\}$ , $\sin x =$ valid attempt at solving and $\sin x =$	1111
x = awrt165.5A1ftIncorrect answersA0		$\sin x = +\frac{1}{4}$ , $\{\sin x = -2\}$ $\sin x = \frac{1}{4}$ (See notes.)	A0
Incorrect answers A0	'	<i>x</i> = awrt165.5	A1ft
	1	Incorrect answers	A0

	Question 6 Notes			
(i)	M1	Rearranges to give $\cos\left(\theta - \frac{\pi}{5}\right) = \pm \frac{1}{2}$		
	Note	M1 can be implied by seeing either $\frac{\pi}{3}$ or 60° as a result of taking cos <sup>-1</sup> ().		
	A1	Answers <b>may be in degrees or radians</b> for this mark and may have just one correct answer Ignore mixed units in working if correct answers follow (recovery)		
	A1	Both answers correct and in radians as multiples of $\pi = -\frac{2\pi}{15}$ and $\frac{8\pi}{15}$		
		Ignore EXTRA solutions outside the range $-\pi < \theta \le \pi$ but lose this mark for extra solutions in this range.		
(ii)	1 <sup>st</sup> M1	Using $\cos^2 x = 1 - \sin^2 x$ on the given equation. [Applying $\cos^2 x = \sin^2 x - 1$ , scores M0.]		
	1 <sup>st</sup> A1	Obtaining a correct three term equation eg. either $4\sin^2 x - 7\sin x - 2 = 0$		
		or $-4\sin^2 x + 7\sin x + 2 = 0$ or $4\sin^2 x - 7\sin x = 2$ or $4\sin^2 x = 7\sin x + 2$ , etc.		
	2 <sup>nd</sup> M1	For a valid attempt at solving a 3TQ quadratic in sine. Methods include factorization, quadratic formula, completion of the square (unlikely here) and calculator. (See notes on page 6 for general principles on awarding this mark) Can use any variable here, $s$ , $y$ , $x$ or $\sin x$ , and an attempt to find at least one of the solutions for sinx. This solution may be outside the range for sinx		
	2 <sup>nd</sup> A1	$\sin x = -\frac{1}{4}$ BY A CORRECT SOLUTION ONLY UP TO THIS POINT. Ignore extra answer		
		of sin $x = 2$ , but penalise if candidate states an incorrect result. e.g. sin $x = -2$ .		
	Note	$\sin x = -\frac{1}{4}$ can be implied by later correct working if no errors are seen.		
	3rd A1ft	At least one of awrt 194.5 or awrt 345.5 or awrt 3.4 or awrt 6.0. This is a limited follow through.		
		Only follow through on the error $\sin x = \frac{1}{4}$ and allow for 165.5 special case (as this is equivalent		
		work) This error is likely to earn M1A1M1A0A1A0 so 4/6 or M1A0M1A0A1A0 if the quadratic had a sign slip.		
	4 <sup>th</sup> A1	awrt 194.5 and awrt 345.5		
	Note	If there are any EXTRA solutions inside the range 0 , $x < 360^{\circ}$ and the candidate would		
		otherwise score FULL MARKS then withhold the final A1 mark.		
	Special	Ignore EXTRA solutions outside the range 0, $x < 360$ . Rounding error Allow M1A1M1A1A1A0 for those who give two correct answers but		
	Cases	wrong accuracy e.g. awrt 194, 346 (Remove final A1 for this error)		
		Answers in radians:- lose final mark so either or both of 3.4, 6.0 gets A1ftA0		
		It is possible to earn M1A0A1A1 on the final 4 marks if an error results fortuitously in		
		$\sin x = -1/4$ then correct work follows.		

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Figure 3

Figure 3 shows a sketch of part of the curve with equation

$$y = 3x - x^{\frac{3}{2}}, \qquad x \ge 0$$

The finite region S, bounded by the x-axis and the curve, is shown shaded in Figure 3.

(a) Find

$$\int \left(3x - x^{\frac{3}{2}}\right) \mathrm{d}x \tag{3}$$

(b) Hence find the area of S.

(3)



Question Number		Scheme	Marks
<b>7.</b> (a)	$\left\{ \int \left( 3x - x^{\frac{3}{2}} \right)^2 \right\}$	$\left. \int dx \right\} = \frac{3x^2}{2} - \frac{x^{\frac{5}{2}}}{\left(\frac{5}{2}\right)} \left\{ + c \right\} $ Either $3x \to \pm \lambda x^2 \text{ or } x^{\frac{3}{2}} \to \pm \mu x^{\frac{5}{2}}, \lambda, \mu \neq 0$ At least one term correctly integrated Both terms correctly integrated	M1 ~ A1
(b)	$0 = 3x - x^{\frac{3}{2}} \Rightarrow 0 = 3 - x^{\frac{1}{2}} \text{ or } 0 = x\left(3 - x^{\frac{1}{2}}\right) \Rightarrow x = \dots$ Sets $y = 0$ , in order to find the correct $\frac{1}{2}$ , $2$ , or $u = 0$		
	$\left\{ \operatorname{Area}(S) = \right[$	$\left[\frac{3x^2}{2} - \frac{2}{5}x^{\frac{5}{2}}\right]_0^9$	
	$=\left(\frac{3(9)^2}{2}-\right)$	$\left(\frac{2}{5}\right)(9)^{\frac{5}{2}} - \{0\}$ Applies the limit 9 on an integrated function with <b>no wrong lower limit</b> .	ddM1
	$\left\{=\left(\frac{243}{2}-\frac{4}{2}\right)\right\}$	$\frac{86}{5} - \{0\} = \frac{243}{10} \text{ or } 24.3 \qquad \qquad \frac{243}{10} \text{ or } 24.3$	A1 oe
			6
		Question 7 Notes	
(a)	M1	Either $3x \to \pm \lambda x^2$ or $x^{\frac{3}{2}} \to \pm \mu x^{\frac{3}{2}}$ , $\lambda, \mu \neq 0$	
	1 <sup>st</sup> A1	At least one term correctly integrated. Can be simplified or un-simplified but power must b simplified. Then isw.	e
	2 <sup>nd</sup> A1	Both terms correctly integrated. Can be un-simplified (as in the scheme) but the $n+1$ in each denominator and power should be a single number. (e.g. $2 - \text{not } 1+1$ ) Ignore subsequent we there are errors simplifying. Ignore the omission of " $+c$ ". Ignore integral signs in their ans	h ork if swer.
(b)	1 <sup>st</sup> M1	Sets $y = 0$ , and reaches the <b>correct</b> $x^{\frac{1}{2}} = 3$ or $x = 9$ (isw if $x^{\frac{1}{2}} = 3$ is followed by $x = \sqrt{3}$	3)
		Just seeing $x = \sqrt{3}$ without the correct $x^2 = 3$ gains M0. May just see $x = 9$ .	
		Use of trapezium rule to find area is M0A0 as hence implies integration needed.	
	ddM1	This mark is dependent on the two previous method marks and needs both to have been awa Sees the limit <b>9</b> substituted in an integrated function. (Do not follow through their value of x not need to see MINUS 0 but if another value is used as lower limit – this is M0. This mark may be implied by 9 in the limit and a correct answer.	trded. c) Do
	A1	$\frac{243}{10}$ or 24.3	
	Common Error	<b>Common Error</b> $0 = 3x - x^{\frac{3}{2}} \implies x^{\frac{1}{2}} = 3 \text{ so } x = \sqrt{3}$ <b>Then</b> uses limit $\sqrt{3}$ etc gains M1 M0 A0 so 1/3	

8.

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(3)

(4)

blank

(i) Given that  $\log_3(3b+1) - \log_3(a-2) = -1, \qquad a > 2$ express b in terms of a. (ii) Solve the equation  $2^{2x+5} - 7(2^x) = 0$ giving your answer to 2 decimal places. (Solutions based entirely on graphical or numerical methods are not acceptable.) 

Question	Scheme	Marks
Number 8(i)	Two Ways of answering the question are given in part (i)	
0(1)	$\begin{pmatrix} 2h+1 \end{pmatrix}$ $\begin{pmatrix} a & 2 \end{pmatrix}$	
Way 1	$\log_3\left(\frac{3b+1}{a-2}\right) = -1$ or $\log_3\left(\frac{a-2}{3b+1}\right) = 1$ Applying the subtraction law of logarithms	M1
	$\frac{3b+1}{a-2} = 3^{-1} \left\{ = \frac{1}{3} \right\} \text{ or } \left( \frac{a-2}{3b+1} \right) = 3$ Making a correct connection between log base 3 and 3 to a power.	M1
	$\{9b+3=a-2 \Rightarrow\} \ b=\frac{1}{9}a-\frac{5}{9}$ $b=\frac{1}{9}a-\frac{5}{9}$ or $b=\frac{a-5}{9}$	A1 oe
		[3]
	In <b>Way 2</b> a correct connection between log base 3 and "3 to a power" is used before applying the subtraction or addition law of logs	
(i)	Either $\log_3(3b+1) - \log_3(a-2) = -\log_3 3$ or $\log_3(3b+1) + \log_3 3 = \log_3(a-2)$	2 <sup>nd</sup> M1
Way 2	$\log_3(3b+1) = \log_3(a-2) - \log_3 3 = \log_3\left(\frac{a-2}{3}\right) \text{ or } \log_3 3(3b+1) = \log_3(a-2)$	1 <sup>st</sup> M1
	$\{3b+1=\frac{a-2}{2}\}$ $b=\frac{1}{9}a-\frac{5}{9}$	A1
		[3]
	Five Ways of answering the question are given in part (ii)	
(ii)	$32(2^{2x}) - 7(2^x) = 0$ Deals with power 5 correctly giving ×32	M1
Way 1		
See also common approach below in notes	So, $2^x = \frac{7}{32}$ or $y = \frac{7}{32}$ or $y = \frac{7}{32}$ or awrt 0.219	A1 oe dM1
notes	$x \log 2 = \log\left(\frac{7}{32}\right)$ or $x = \frac{\log\left(\frac{7}{32}\right)}{\log 2}$ or $x = \log_2\left(\frac{7}{32}\right)$ A valid method for solving $2^x = \frac{7}{32}$ Or $2^x = k$ to achieve $x = \dots$	
	x = -2.192645 awrt $-2.19$	Al
		[4]
	Begins with $2^{2x+5} = 7(2^x)$ (for Way 2 and Way 3) (see notes below)	
(ii)	Correct application of	M1
Way 2	$(2x+5)\log 2 = \log 7 + x\log 2$ either the power law or addition law of logarithms	
	the power <b>and</b> addition laws of logarithms.	A1
	$2x \log 2 + 5 \log 2 = \log 7 + x \log 2$	
	$\Rightarrow$ $x = \frac{\log 7 - 5\log 2}{\log 2}$ Multiplies out collects x terms to achieve $x =$	dM1
	log 2	GIVII
	x = -2.192645 awrt $-2.19$	A1
		[4]
(ii)	Evidence of $\log_2$ and either $2^{2x+5} \rightarrow 2x+5$	M1
Way 3	$2x + 5 = \log_2 7 + x$ or $7(2^x) \to \log_2 7 + \log_2(2^x)$	
	$2x + 5 = \log_2 7 + x \text{ oe.}$	A1
	$2x - x = \log_2 7 - 5$ $\Rightarrow x = \log_2 7 - 5$ Collects x terms to achieve $x =$	dM1
	x = -2.192645 awrt $-2.19$	A1
		[4]

(ii) Wey 4	$2^{2x+5} = 7(2^x) \Longrightarrow 2^{x+5} = 7$	
way 4		+
	Evidence of $\log_2$ $x + 5 = \log_2 7$ or $\frac{\log 7}{\log 2}$ and either $2^{x+5} \rightarrow x + 5$ or $7 \rightarrow \log_2 7$	M1
	$x + 5 = \log_2 7 \text{ oe.}$	A1
	$x = \log_2 7 - 5$ Rearranges to achieve $x =$	dM1
	x = -2.192645 awrt $-2.19$	Al
		[4]
Way 5 (similar to	$2^{2x+5} = 2^{\log_2 7} (2^x)$ 7 is replaced by $2^{\log_2 7}$	M1
Way 3)	$2x + 5 = \log_2 7 + x$ $2x + 5 = \log_2 7 + x$ oe.	A1
	$2x - x = \log_2 7 - 5$ $\Rightarrow x = \log_2 7 - 5$ Collects x terms to achieve $x =$	dM1
	x = -2.192645 awrt $-2.19$	Al
		[4]
	n of the second s	7

		Question 8 Notes
(i)	1 <sup>st</sup> M1	Applying either the addition or subtraction law of logarithms correctly to combine
		any two log terms into one log term.
	2 <sup>nd</sup> M1	For making a correct connection between log base 3 and 3 to a power.
	A1	$b = \frac{1}{9}a - \frac{5}{9}$ or $b = \frac{a-5}{9}$ o.e. e.g. Accept $b = \frac{1}{3}\left(\frac{a}{3} - \frac{5}{3}\right)$ but not $b = \frac{a-2}{9} - \frac{3}{9}$ nor $b = \frac{\left(\frac{a}{3} - \frac{5}{3}\right)}{3}$
(ii)	1 <sup>st</sup> M1	First step towards solution – an equation with one side or other correct or one term dealt with
		correctly (see five* possible methods above)
	1 <sup>st</sup> A1	Completely correct first step – giving a correct equation as shown above
	dM1	Correct complete method (all log work correct) and working to reach $x = in$ terms of logs
		reaching a correct expression or one where the only errors are slips solving linear equations
	2 <sup>na</sup> A1	Accept answers which round to -2.19 If a second answer is also given this becomes A0
	Special Case in	Writes $\frac{\log_3(3b+1)}{\log_3(a-2)} = -1$ and proceeds to $\frac{3b+1}{a-2} = 3^{-1} \left\{ = \frac{1}{3} \right\}$ and to correct answer-Give
	(i)	M0M1A1 (special case)
	Common	Let $2^x = y$ Treat this as <b>Way 1</b> They get $32y^2 - 7y = 0$ for M1 and need to reach $y = \frac{7}{32}$ for A1
	approach to part	Then back to <b>Way 1</b> as before. Any letter may be used for the new variable which I have called <i>y</i> .
	(ii)	If they use x and obtain $x = \frac{7}{32}$ , this may be awarded M1A0M0A0
		Those who get $y^2 - 7y + 32 = 0$ or $y^7 - 7y = 0$ will be awarded M0,A0,M0,A0
	Common	<b>Many begin with</b> $\log(2^{2x+5}) - \log(7(2^x)) = 0$ . It is possible to reach this in two stages
	Present- ation of Work in	correctly so do not penalise this and award the full marks if they continue correctly as in <b>Way 2</b> . If however the solution continues with $(2x+5)\log 2 - x\log 14 = 0$ or with
	ii	$(2x+5)\log 2 - 7x\log 2 = 0$ (both incorrect) then they are awarded M1A0M0A0 just getting
		credit for the $(2x + 5) \log 2$ term.
	Note	N.B. The answer (+)2.19 results from "algebraic errors solving linear equations" leading to $2^x = \frac{32}{7}$ and gets M1A0M1A0

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(2)



Figure 4 shows a plan view of a sheep enclosure.

The enclosure *ABCDEA*, as shown in Figure 4, consists of a rectangle *BCDE* joined to an equilateral triangle *BFA* and a sector *FEA* of a circle with radius *x* metres and centre *F*.

The points *B*, *F* and *E* lie on a straight line with FE = x metres and  $10 \le x \le 25$ 

(a) Find, in  $m^2$ , the exact area of the sector *FEA*, giving your answer in terms of x, in its simplest form.

Given that BC = y metres, where y > 0, and the area of the enclosure is 1000 m<sup>2</sup>,

(b) show that

$$y = \frac{500}{x} - \frac{x}{24} \left( 4\pi + 3\sqrt{3} \right)$$
(3)

(c) Hence show that the perimeter P metres of the enclosure is given by

$$P = \frac{1000}{x} + \frac{x}{12} \left( 4\pi + 36 - 3\sqrt{3} \right)$$
(3)

(d) Use calculus to find the minimum value of P, giving your answer to the nearest metre. (5)

(e) Justify, by further differentiation, that the value of P you have found is a minimum. (2)





Question Number	Scheme	Marks
<b>9.</b> (a)	Area( <i>FEA</i> ) = $\frac{1}{2}x^2\left(\frac{2\pi}{3}\right)$ ; = $\frac{\pi x^2}{3}$ $\frac{1}{2}x^2 \times \left(\frac{2\pi}{3}\right)$ or $\frac{120}{360} \times \pi x^2$ simplified or unsimplified.	M1
	$\frac{\pi x^2}{3}$	A1
		[2]
	Parts (b) and (c) may be marked together	
(b)	${A = }\frac{1}{2}x^2\sin 60^\circ + \frac{1}{3}\pi x^2 + 2xy$ Correct expression for at least two terms of A	A1
1	$\sqrt{3}x^2 \pi x^2 = 500 \sqrt{3}x \pi x$	
	$1000 = \frac{\sqrt{2}x}{4} + \frac{\pi}{3} + 2xy \implies y = \frac{2\pi}{x} - \frac{\sqrt{2}x}{8} - \frac{\pi}{6}$	
	$\Rightarrow v = \frac{500}{x} - \frac{x}{x} \left(4\pi + 3\sqrt{3}\right) * $ Correct proof.	A1 *
	$\frac{x}{x} = 24(\frac{x}{x} + 24)$	
1		[2]
	$(\gamma_{\pi_{x}})$	[3]
(c)	$\{P = \} x + x\theta + y + 2x + y \ \left\{ = 3x + \frac{2\pi x}{3} + 2y \right\}$ Correct expression in x and y for their $\theta$ measured in rads	B1ft
1	$2y = +2\left(\frac{500}{x} - \frac{x}{24}\left(4\pi + 3\sqrt{3}\right)\right)$ Substitutes expression from (b) into y term.	M1
	$P = 3x + \frac{2\pi x}{3} + \frac{1000}{x} - \frac{\pi x}{3} - \frac{\sqrt{3}}{4}x \implies P = \frac{1000}{x} + 3x + \frac{\pi x}{3} - \frac{\sqrt{3}}{4}x$	
	$\Rightarrow \underline{P} = \frac{1000}{x} + \frac{x}{12} \left( 4\pi + 36 - 3\sqrt{3} \right) $ Correct proof.	A1 *
	Parts (d) and (e) should be marked together	[3]
	$\frac{1000}{x} \rightarrow \frac{\pm \lambda}{x^2}$	M1
(d)	$\frac{dx}{dx} = -1000x + \frac{12}{12}, = 0$ Correct differentiation (need not be simplified).	A1;
1	Their $P' = 0$	Ml
	$\Rightarrow x = \sqrt{\frac{1000(12)}{4\pi + 36 - 3\sqrt{3}}} \ (= 16.63392808) \qquad \sqrt{\frac{1000(12)}{4\pi + 36 - 3\sqrt{3}}} \ \text{or awrt 17 (may be}$	A1
1	implied)	
	$\left\{P = \frac{1000}{(16.63)} + \frac{(16.63)}{12} \left(4\pi + 36 - 3\sqrt{3}\right)\right\} \Longrightarrow P = 120.236 \text{ (m)}$ awrt 120	A1
		[5]
	Finds $P''$ and considers sign.	MI
(e)	$\frac{d^2 r}{dx^2} = \frac{2000}{x^3} > 0 \Rightarrow$ Minimum $\frac{2000}{x^3}$ (need not be simplified) and > 0 and conclusion.	A1ft
1	Only follow through on a correct $P''$ and x in range $10 \le x \le 25$ .	[2]
	***************************************	15

		Question 9 Notes
<b>(a)</b>	M1	Attempts to use Area( <i>FEA</i> ) = $\frac{1}{2}x^2 \times \frac{2\pi}{2}$ (using radian angle) or $\frac{120}{2} \times \pi x^2$ (using angle in
		degrees) $2  3  360$
	A1	$\frac{\pi x^2}{2}$ cao (Must be simplified and be their answer in part (a)) Answer only implies M1A1.
		N.B. Area( <i>FEA</i> ) = $\frac{1}{2}x^2 \times 120$ is awarded M0A0
( <b>b</b> )		
(0)	M1	An attempt to sum 3 " areas" consisting of rectangle, triangle and sector (allow slips even in dimensions) but <b>one area</b> should be correct
	1 <sup>st</sup> A1	Correct expression for <b>two</b> of the <b>three</b> areas listed above.
		Accept any correct equivalents e.g. two correct from $\frac{1}{2}x^2 \sin\left(\frac{\pi}{3}\right)$ or $\frac{1}{4}x^2\sqrt{3}$ , $\frac{1}{2} \times \frac{2}{3}\pi x^2$ , $2xy$
	2 <sup>nd</sup> A1*	This is a given answer which should be stated and should be achieved without error so all three areas must have been correct and their sum put equal to 1000 and an intermediate step of rearrangement should be present.
( <b>c</b> )	B1ft	Correct expression for P from arc length, length AB and three sides of rectangle in terms of both x and y with $2y$ (or $y + y$ ), $3x$ (or $x + 2x$ ) (or $x + x + x$ ), and $x\theta$ clearly listed. Allow addition
		after substitution of y. $\pi = 2\pi$
		NB $\theta = \frac{\alpha}{3}$ but allow use of their consistent $\theta$ in radians (usually $\theta = \frac{\alpha}{3}$ ) from parts (a) and
		(b) for this mark. 120x or 60x do not get this mark. 500 - r
	M1	Substitutes $y = \frac{300}{x} - \frac{x}{24}(4\pi + 3\sqrt{3})$ or their unsimplified attempt at y from earlier (allow
	A1*	slips e.g. sign slips) into 2 <i>y</i> term.
	1st М1	Need to see at least $1000 \pm \lambda$
( <b>d</b> )		Need to see at least $\xrightarrow{x} \xrightarrow{x^2} x^2$
	I AI	correct differentiation of both terms (need not be simplified) Not follow through. Allow any correct equivalent.
		e.g. $\frac{dP}{dx} = -1000x^{-2} + \frac{\pi}{3} + 3 - \frac{\sqrt{3}}{4}$ Also allow $\frac{dP}{dx} = -1000x^{-2} + awrt 3.61$
		Check carefully as there are many correct equivalents and some have two terms in $x\pi$ to $2\pi$ , $8\pi$ , $\pi$
		differentiate obtaining for example $\frac{2\pi}{3} - \frac{6\pi}{24}$ instead of $\frac{\pi}{3}$
	2 <sup>nd</sup> M1	Setting their $\frac{dP}{dx} = 0$ . Do not need to find x, but if inequalities are used this mark cannot be
		gained until candidate states or uses a value of $x$ without inequalities. May not be explicit but
		may be implied by correct working and value or expression for x. May result in $x^2 < 0$ so M1A0
	2 <sup>nd</sup> A1	There is no requirement to write down a value for $x$ , so this mark may be implied by a correct
	3 <sup>rd</sup> A1	value for <i>P</i> . It may be given for a correct expression or value for <i>x</i> of 16.6, 16.7 or 17 Allow answers wrt 120 but not 121
(e)	M1	Finds $P''$ and considers sign. Follow through correct differentiation of their $P'$ (not just reduction of power)
	A1ft	Need $\frac{2000}{2}$ and > 0 (or positive value) and conclusion. Only follow through on a correct P"
		$x^{3}$ and a value for x in the range $10 < x < 25$ (need not see x substituted but an x should have been
		found) If <i>P</i> is substituted then this is awarded M1 A0

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Special	(d) Some candidates multiply P by 12 to "simplify" If they write
case	$\frac{dP}{dx} = -12000x^{-2} + 4\pi + 36 - 3\sqrt{3}; = 0 \text{ then solve they will get the correct } x \text{ and } P \text{ They}$
	should be awarded M1A0M1A1A1 in part (d). If they then do part (e) writing
	$\frac{d^2 P}{dx^2} = \frac{24000}{x^3} > 0 \Rightarrow \text{Minimum They should be awarded M1A0 (so lose 2 marks in all)}$
	If they wrote $\frac{d(12P)}{dx} = -12000x^{-2} + 4\pi + 36 - 3\sqrt{3}$ ; = 0 etc they could get full marks.