OCR Maths C2

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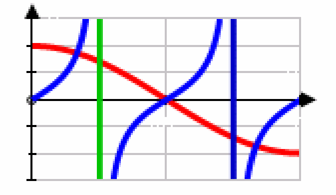
2005-2014

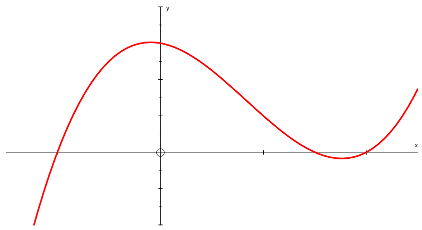
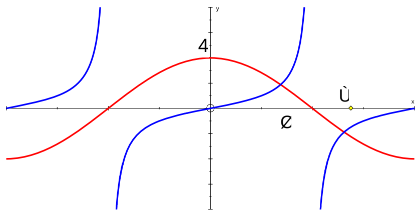
1	(i)	$u_1 = 2$, $u_2 = 5$, $u_3 = 8$ The sequence is an Arithmetic Progression	B1 B1 B1 3	For the correct value of u_1 For both correct values of u_2 and u_3 For a correct statement (any mention of arithmetic)
	(ii)	$\frac{1}{2} \times 100 \times (2 \times 2 + 99 \times 3) = 15050$	M1 M1 A1 3 **6**	For correct interpretation of Sigma notation – ie finding the sum of an AP or GP For use of correct $\frac{1}{2}n(2a + (n-1)d)$, or equiv, with n=100 and a & d not both =1 For correct value 15050
2	(i)	$r\theta = 12$, $\frac{1}{2}r^2\theta = 36$	B1 B1 2	For $r\theta = 12$ stated correctly at any point For $\frac{1}{2}r^2\theta = 36$ stated correctly at any point
	(ii)	$\frac{1}{2}r \times 12 = 36 \Rightarrow r = 6$ Hence $\theta = 2$	B1 B1 2	For showing given value correctly For correct value 2 (or 0.637π)
	(iii)	Segment area is $36 - \frac{1}{2} \times 6^2 \times \sin 2 = 19.6$ cm^2	M1* M1dep* A1 3 **7**	For use of $\Delta = \frac{1}{2}ab\sin C$, or equivalent For attempt at $36 - \Delta$ For correct value (rounding to) 19.6
3	(i)	$\int (2x^2 + 7x + 3)\,dx$ $= \frac{2}{3}x^3 + \frac{7}{2}x^2 + 3x + c$	M1 A1 A1 B1 4	For expanding and integration attempt For at least one term correct For all three terms correct For addition of arbitrary constant, and no $\int$ or dx
	(ii)	$\left[2x^{\frac{1}{2}}\right]_0^9$ = 6	M1 M1 A1 3 **7**	For integral of the form $kx^{\frac{1}{2}}$ For evaluating at least F(9) , following attempt at integration For final answer of 6 only
4	(i)	$\cos BCA = \frac{5^2+6^2-9^2}{2\times5\times6} = -\frac{1}{3}$ So $\sin BCA = \frac{2}{3}\sqrt{2} \approx 0.9428$ ...	M1 M1 A1 B1 M1 M1 A1 B1 4	For relevant use of the correct cosine formula For attempt to rearrange correct formula For obtaining the given value correctly For correct answer for sin BCA in any form OR For substituting cos BCA = $-^1/_3$ For attempt at evaluation For full verification For correct answer for sin BCA in any form
	(ii)	Angles BCA and CAD are equal So $\sin ADC = \frac{5}{15}\sin CAD = \frac{1}{3} \times \frac{1}{3}\sqrt{8} = \frac{2}{9}\sqrt{2}$ $\Rightarrow ADC = 18.3^\circ$	B1 M1 A1√ A1 4 **8**	For stating, using or implying the equal angles For correct use of the sine rule in Δ ADC (sides must be numerical, angles may still be in letters) For a correct equation from their value in (i) For correct answer, from correct working
5	(i)	f(-1) = 0 $\Rightarrow$ $-1 - a + b = 0$ f(3) = 16 $\Rightarrow$ $27 + 3a + b = 16$ Hence a = -3, b = -2	M1 A1 M1 A1 A1 5	For equating their attempt at f(-1) to 0, or equiv For the correct (unsimplified) equation For equating their attempt at f(3) to 16, or equiv For the correct (unsimplified) equation For both correct values – must follow two correct equations
	(ii)	f(2) = 8 – 6 – 2 = 0	B1	For the correct verification (from correct a &

			M1	*b*)
		Hence f(x) = $(x+1)^2(x-2)$	A1 3 **8**	For recognition or use of two linear factors, or full division attempt by either (x + 1) or (x – 2) For correct third factor (repeated) of (x + 1), and full linear factorisation stated
6	(i)	$x^6+3x^3+3+\frac{1}{x^3}$	M1 A1 A1 A1 4	For 4 term binomial attempt or equiv For any one (unsimplified) term correct For any other (unsimplified) term correct For full, simplified, expansion correct
	(ii)	$\frac{1}{7}x^7+\frac{3}{4}x^4+3x-\frac{1}{2}x^{-2}+c$	M1 A1√ M1 A1√ 4 **8**	For any correct use of $\frac{x^{n+1}}{n+1}$ For any two terms integrated correctly For any correct use of x^{n+1} using a negative index For all terms integrated correctly (must have at least 4 terms, including at least 1 negative index) [No penalty for omission of +*c* in this part]
7	(i)	$\log_5\left(\frac{15\times20}{12}\right)=\log_5 25=2$	M1 A1 A1 3	For any relevant combination of log *a* ± log *b* For log 25 – must follow correct working only For correct answer 2
	(ii)	Method A $\frac{1}{3}y=10^{2x}$ Hence $2x=\log_{10}\left(\frac{1}{3}y\right)$ i.e. $x=\frac{1}{2}\log_{10}\left(\frac{1}{3}y\right)$	M1 M1 A1 A1 4	For correct division of both sides by 3 For relevant use of $a=b^c \Leftrightarrow c=\log_b a$ For correct equation involving logs to base 10 For correct answer for *x*
		Method B $\frac{1}{3}y=10^{2x}$ $\log\frac{1}{3}y=\log 10^{2x}$ $\log\frac{1}{3}y=2x\log 10$ i.e. $x=\frac{1}{2}\log_{10}\left(\frac{1}{3}y\right)$	M1 M1 A1 A1 4	For correct division of both sides by 3 For taking logs of both sides For correct linear equation involving logs For correct answer for *x*
		Method C $y=3\times10^{2x}\Rightarrow\log y=\log 3\times10^{2x}$ $\log y=\log 3+\log 10^{2x}$ $\log y=\log 3+2x\log 10$ i.e. $x=\frac{1}{2}\log_{10}\left(\frac{1}{3}y\right)$	M1 A1 M1 A1 4	For introducing logs throughout For correct RHS log 3 + log 10^{2x} For correct use of log a^b = *b* log *a* For correct answer for *x*
		Method D $x=a\log(b\times3\times10^{2x})$ $x=a\log 3b+a\log 10^{2x}$ $x=2ax\log 10\Rightarrow 2a=1\Rightarrow a=\frac{1}{2}$ $a\log 3b=0\Rightarrow 3b=1\Rightarrow b=\frac{1}{3}$	M1 M1 A1 A1 4 **7**	For substituting for *y*, and separating RHS into at least 2 terms For attempting values for *a* and *b* For obtaining $a=\frac{1}{2}$ For obtaining $b=\frac{1}{3}$
8	(i)	100 000 x 0.9^3 = 72900	M1 A1 2	For relevant use of ar^3 or equiv For the correct answer 72900
	(ii)	100 000 x 0.9^x = 5000 Hence $x$log 0.9 = log 0.05 So x = 28.4, 28 or 29; or n = 29.4, 29 or 30 i.e. 30th year / 30 years / year is 2030	B1 M1 A1 A1√ 4	For a correct equation or inequality For complete solution method by logs or trial For correct solution for **their** index – allow integer values either side For correctly linking **their** index to date or

						number of years
	(iii)		Total is $\frac{100000(1-0.9^{30})}{1-0.9} = 957609$	M1 A1√ A1	 3 **9**	For relevant use of $\frac{a(1-r^n)}{1-r}$ For correct (unsimplified) statement for their integer *n* (if no *n* stated then use their year – 2000) For answer 958000 or better, including decimal
9	(a)	(i)	$\cos \frac{1}{6}\pi = \frac{1}{2}\sqrt{3}$ $\tan \frac{1}{3}\pi = \sqrt{3}$ Hence $2\cos \frac{1}{6}\pi = 2 \times \frac{1}{2}\sqrt{3} = \tan \frac{1}{3}\pi$	B1 B1 B1	 3	For any correct exact value For any correct exact value For correct verification (allow via decimals)
		(ii)	 Other roots are $\pi/2$ and $5\pi/6$	B1 B1 B1 B1	 4	For correct sketch of either $y = \tan 2x$ or $y = 2\cos x$ For second correct sketch, with both graphs in proportion (ie 3 points of intersection) For one of $\pi/2$ or $5\pi/6$ (or equiv in degrees) For second correct value, and no others in range $0 \le x \le \pi$
	(b)	(i)	0.05(0.1003 + 2(0.2027 + 0.3093) + 0.4228) = 0.0774	M1 M1 A1 A1	 4	State at least three of tan 0.1, tan 0.2, tan 0.3, tan 0.4 Substitute numerical values (must be attempt at *y*-coords, not *x*-coords) into correct trapezium rule, with *h* consistent with number of strips Obtain 0.05(tan 0.1 + 2(tan 0.2 + tan 0.3)+ tan 0.4) or equiv in decimals (SC – award A1 if values are now decimals from using degrees – gives final answer of 0.00131) Obtain 0.077 or better
		(ii)	Overestimate; tops of trapezia above the curve or equiv	B1	1 **12**	For correct statement and justification

1	(i)	$a+19d=10, \quad a+49d=70$	M1		Attempt to find d from simultaneous equations involving $a+(n-1)d$ or equiv method
		Hence $30d=60 \Rightarrow d=2$	A1		Obtain $d = 2$
		a + (19 x 2) = 10 or a + (49 x 2) = 70	M1		Attempt to find a from $a+(n-1)d$ or equiv
		Hence $a = -28$	A1	**4**	Obtain $a = -28$
	(ii)	$S=\frac{29}{2}\left(2\times -28+(29-1)\times 2\right)=0$	M1		For relevant use of $\frac{1}{2}n\left(2a+(n-1)d\right)$
			A1	**2**	For showing the given result correctly **AG**
				6	
2	(i)	$\Delta=\frac{1}{2}\times 10\times 7\times \sin 80=34.5\text{cm}^2$	M1		For use of $\frac{1}{2}ca\sin B$ or complete equiv.
			A1	**2**	For correct value 34.5
	(ii)	$b^2=10^2+7^2-2\times 10\times 7\times \cos 80$	M1		For attempted use of the correct cosine formula
		Hence length of CA is 11.2 cm	A1	**2**	For correct value 11.2
	(iii)	$\sin C=\frac{10\sin 80}{11.166...}=0.8819...$	M1		For use of the sine rule to find C, or equivalent
		Hence angle C is 61.9°	A1	**2**	For correct value 61.9
				6	
3	(i)	$(1-2x)^{12}=1-24x+264x^2$	B1		Obtain 1 and $-24x$ …
			M1		Attempt x^2 term, including attempt at binomial coeff.
			A1	**3**	Obtain …$264x^2$
	(ii)	$(1\times 264)+(3\times -24)=192$	M1		Attempt coefficient of x^2 from two pairs of terms
			A1√		Obtain correct unsimplified expression
			A1	**3**	Obtain 192
				6	
4	(i)	$\text{perimeter}=(15\times 1.8)+(20\times 1.8)+5+5$	M1		Use $r\theta$ at least once
			A1		Obtain at least one of 27cm or 36cm
		$=73\text{cm}$	A1	**3**	Obtain 73
	(ii)	$\text{area}=\left(\frac{1}{2}\times 20^2\times 1.8\right)-\left(\frac{1}{2}\times 15^2\times 1.8\right)$	M1		Attempt area of sector using $kr^2\theta$
			M1		Find difference between attempts at two sectors
		$=157.5\text{cm}^2$	A1	**3**	Obtain 157.5 / 158
				6	

5	(i)	$r = \frac{4.8}{5} = 0.96 \Rightarrow S_\infty = \frac{5}{0.04} = 125$	B1* B1 dep*	 **2**	For correct value of r used For correct use of $\frac{a}{1-r}$ to show given answer **AG**
	(ii)	$S_n = \frac{5(1-0.96^n)}{1-0.96}$ Hence $1-0.96^n > 0.992 \Rightarrow 0.96^n < 0.008$ $n \log 0.96 < \log 0.008$ Hence $n > \frac{\log 0.008}{\log 0.96} \approx 118.3$ Least value of n is 119	B1 M1 A1 B1 M1 A1	 **6** **8**	For correct, unsimplified, S_n For linking S_n to 124 (> or =) and multiplying through by 0.04, or equiv. For showing the given result correctly, with correct inequality throughout **AG** For correct log statement seen or implied (ignore sign) For dividing both sides by log 0.96 For correct (integer) value 119
6	(a)	$\frac{2}{3}x^{\frac{3}{2}} + 4x + c$	M1 A1 B1 B1	 **4**	For $kx^{\frac{3}{2}}$ For correct first term $\frac{2}{3}x^{\frac{3}{2}}$, or equiv For correct second term $4x$ For $+c$
	(b)(i)	$\int_1^a 4x^{-2}\,dx = \left[-4x^{-1}\right]_1^a$ $= 4 - \frac{4}{a}$	M1 M1 A1	 **3**	Obtain integral of the form kx^{-1} Use limits $x = a$ and $x = 1$ Obtain $= 4 - \frac{4}{a}$, or equivalent
	(ii)	4	B1√	**1** **8**	State 4, or legitimate conclusion from their (b)(i)
7	(i)(a)	$\log_{10}x - \log_{10}y$	B1	**1**	For the correct answer
	(b)	$1 + 2\log_{10}x + \log_{10}y$	M1 A1 A1	 **3**	Sum of three log terms involving 10, x^2, y For correct term $2\log_{10}x$ For both correct terms 1 and $\log_{10}y$
	(ii)	$2\log_{10}x - 2\log_{10}y = 2 + 2\log_{10}x + \log_{10}y$ Hence $3\log_{10}y = -2$ So $y = 10^{-\frac{2}{3}} \approx 0.215$	M1 A1 M1 A1	 **4** **8**	For relevant use of results from (i) For a correct, unsimplified, equation in $\log_{10}y$ only For correct use of $a = \log_{10}c \Leftrightarrow c = 10^a$ For the correct value 0.215

8	(i)	$-2+k+1+6=0 \Rightarrow k=-5$	M1 A1		For attempting f(–1) For equating f(-1) to 0 and deducing the correct value of *k* **AG**
		OR	M1 A1		Match coefficients and attempt *k* Show *k* = -5
		OR	B2		Following division, state remainder is 0, hence (*x* + 1) **is** a factor, hence *k* = -5
		EITHER: $(x+1)(2x^2-7x+6)$	B1 M1		For correct leading term $2x^2$ For attempt at complete division by f(*x*) by (*x* + 1) or equiv.
		$=(x+1)(x-2)(2x-3)$	A1 A1		For completely correct quadratic factor For all three factors correct
		OR: f(2) = 16 – 20 – 2 + 6 = 0 Hence (*x* – 2) is a factor Third factor is (2*x* – 3) Hence f(*x*) $=(x+1)(x-2)(2x-3)$	M1 A1 M1 A1	6	For further relevant use of the factor theorem For correct identification of factor (*x* – 2) For any method for the remaining factor For all three factors correct
	(ii)	$\int_{-1}^{2} f(x)dx = \left[\frac{1}{2}x^4 - \frac{5}{3}x^3 - \frac{1}{2}x^2 + 6x\right]_{-1}^{2}$	B1√ B1√		For any two terms integrated correctly For all four terms integrated correctly
		$=\left(8-\frac{40}{3}-2+12\right)-\left(\frac{1}{2}+\frac{5}{3}-\frac{1}{2}-6\right)$	M1		For evaluation of F(2) – F(–1)
		= 9	A1	4	For correct value 9
	(iii)		B1 B1	2	For sketch of positive cubic, with three distinct, non-zero, roots For correct explanation that some of the area is below the axis
				12	
9	(i)		B1 B1 B1	3	For correct sketch of one curve For correct shape and location of second curve, on same diagram For intercept 4 on *y*-axis
	(ii)	(See diagram above) $\beta = 180 - \alpha$	B1 M1 A1	3	For correct identification of intersections – in correct order For attempt to use symmetry of the graphs For the correct (explicit) answer for β
	(iii)	$\sin x = 4\cos^2 x = 4(1-\sin^2 x)$	M1 M1		For use of $\tan x = \frac{\sin x}{\cos x}$ For use of $\cos^2 x = 1-\sin^2 x$
		Hence $4\sin^2 x + \sin x - 4 = 0$	A1		For showing the given equation correctly
		$\sin x = \frac{-1 \pm \sqrt{65}}{8}$	B1		For correct solution of quadratic
		Hence $\beta - \alpha = 118.02... - 61.97... \approx 56^\circ$	M1 A1	6	Attempt value for *x* from their solutions For the correct value 56
				1	

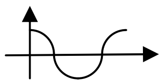
1		$(3x-2)^4 = 81x^4 - 216x^3 + 216x^2 - 96x + 16$	M1 A1 A1 A1	 4 **4**	Attempt binomial expansion, including attempt at coeffs. Obtain one correct, simplified, term Obtain a further two, simplified, terms Obtain a completely correct expansion
2	(i)	$u_2 = -1, u_3 = 2, u_4 = -1$	B1 B1	 2	For correct value –1 for u_2 For correct values for both u_3 and u_4
	(ii)	Sum is $(2+(-1))+(2+(-1))+...+(2+(-1))$ i.e. $50\times(2+(-1))=50$	M1 M1 A1	 3 **5**	For correct interpretation of Σ notation For pairing, or $50\times2-50\times1$ For correct answer 50
3		$y = 4x^{\frac{1}{2}} + c$ Hence $5 = 4\times4^{\frac{1}{2}} + c \Rightarrow c = -3$ So equation of the curve is $y = 4x^{\frac{1}{2}} - 3$	M1 A1 A1 M1 A1√ A1	 6 **6**	For attempt to integrate For integral of the form $kx^{\frac{1}{2}}$ For $4x^{\frac{1}{2}}$, with or without +*c* For relevant use of (4, 5) to evaluate *c* For correct value –3 (or follow through on integral of form $kx^{\frac{1}{2}}$) For correct statement of the equation in full (aef)
4	(i)	Intersect where $x^2 + x - 2 = 0 \Rightarrow x = -2, 1$	M1 A1	 2	For finding *x* at both intersections For both values correct
	(ii)	Area under curve is $\left[4x - \frac{1}{3}x^3\right]_{-2}^{1}$ i.e. $\left(4-\frac{1}{3}\right)-\left(-8+\frac{8}{3}\right)=9$ Area of triangle is 4½ Hence shaded area is 9 – 4½ = 4½ **OR** Area under curve is $\int_{-2}^{1}(2-x-x^2)\mathrm{d}x$ $= \left[-\frac{1}{3}x^3 - \frac{1}{2}x^2 + 2x\right]_{-2}^{1}$ $=\left(-\frac{1}{3}-\frac{1}{2}+2\right)-\left(\frac{8}{3}-2-4\right)$ $= 4\frac{1}{2}$	M1 M1 A1 M1 A1 A1 M1 M1 A1 M1 A1 A1	 6 **8**	For integration attempt with any one term correct For use of limits – subtraction and correct order For correct area of 9 Attempt area of triangle (½*bh* or integration) Obtain area of triangle as 4 ½ Obtain correct final area of 4 ½ Attempt subtraction – either order For integration attempt with any one term correct Obtain $\pm\left[-\frac{1}{3}x^3 - \frac{1}{2}x^2 + 2x\right]$ For use of limits – subtraction and correct order Obtain ± 4 ½ - consistent with their order of subtraction Obtain 4 ½ only, following correct method only

5	(i)	$\sin^2 x = 1 - \cos^2 x \Rightarrow 2\cos^2 x + \cos x - 1 = 0$ Hence $(2\cos x - 1)(\cos x + 1) = 0$ $\cos x = \frac{1}{2} \Rightarrow x = 60^\circ$ $\cos x = -1 \Rightarrow x = 180^\circ$	M1 M1 A1 A1	4	For transforming to a quadratic in cos *x* For solution of a quadratic in cos *x* For correct answer 60° For correct answer 180° [Max 3 out of 4 if any extra answers present in range, or in radians] **SR** answer only is B1, B1 justification – ie graph or substitution is B2, B2
	(ii)	$\tan 2x = -1 \Rightarrow 2x = 135 \text{ or } 315$ Hence $x = 67.5^\circ \text{ or } 157.5^\circ$	M1 M1 A1 A1	4	For transforming to an equation of form tan2*x* = *k* For correct solution method, i.e. inverse tan followed by division by 2 For correct value 67.5 For correct value 157.5
		OR $\sin^2 2x = \cos^2 2x$ $2\sin^2 2x = 1 \quad 2\cos^2 2x = 1$ $\sin 2x = \pm\frac{1}{2}\sqrt{2} \quad \cos 2x = \pm\frac{1}{2}\sqrt{2}$ Hence $x = 67.5^\circ \text{ or } 157.5^\circ$	M1 M1 A1 A1		Obtain linear equation in cos 2*x* or sin 2*x* Use correct solution method For correct value 67.5 For correct value 157.5 [Max 3 out of 4 if any extra answers present in range, or in radians] **SR** answer only is B1, B1 justification – ie graph or substitution is B2, B2
				8	
6	(i)	(a) $100 + 239 \times 5 = £1295$	M1 A1	2	For relevant use of *a* + (*n* – 1)*d* For correct value 1295
		(b) $\frac{1}{2} \times 240 \times (100 + 1295) = £167400$	M1 A1	2	For relevant use of $\frac{1}{2}n(a+l)$ or equivalent For correct value 167400
	(ii)	$100r^{239} = 1500 \Rightarrow r = 1.01139...$ Hence total is $\frac{100(1.01139^{240} - 1)}{1.01139 - 1} = £124359$	B1 M1 A1 M1 A1	5	For correct statement of $100r^{239} = 1500$ Attempt to find *r* For correct value 1.01 For relevant use of GP sum formula For correct value 124359 (3 s.f. or better)
				9	

7	(i)	$AC^2 = 11^2 + 8^2 - 2\times11\times8\times\cos 0.8$ $= 62.3796...$ Hence *AC*=7.90 cm	M1 A1 A1	**3**	Attempt to use the cosine formula Correct unsimplified expression Show the given answer correctly
	(ii)	Area of sector = $\frac{1}{2}\times7.90^2\times1.7 = 53.0$ Area of triangle = $\frac{1}{2}\times7.90^2\times\sin 1.7 = 30.9$ Hence shaded area = 22.1 cm^2	M1 M1 A1	**3**	Attempt area of sector using $\left(\frac{1}{2}\right)r^2\theta$ Attempt area of ΔACD, using $\left(\frac{1}{2}\right)r^2\sin\theta$, or equiv Obtain 22.1
	(iii)	(arc) $DC = 7.90\times1.7 = 13.4$ (line) $DC^2 = 7.90^2 + 7.90^2 - 2\times7.90\times7.90\times\cos 1.7$ $DC = 11.9$ Hence perimeter = 25.3cm	M1 A1 M1 A1	**4** **<u>10</u>**	Use $r\theta$ to attempt arc length Obtain 13.4 Attempt length of line *DC* using cosine rule or equiv. Obtain 25.3
8	(i)	$f(2) = 12 \Rightarrow 4a + 2b = 6$ $f(-1) = 0 \Rightarrow a - b = 12$ Hence *a* = 5, *b* = –7	M1 A1 M1 A1 M1 A1	**6**	For equating f(2) to 12 For correct equation 4*a* + 2*b* = 6 For equating f(–1) to 0 For correct equation *a* – *b* = 12 For attempt to find *a* and *b* For both values correct
	(ii)	Quotient is $2x^2 + x - 9$ Remainder is 8	B1 M1 A1 M1 A1	**5** **<u>11</u>**	For correct lead term of $2x^2$ For complete division attempt or equiv For completely correct quotient For attempt at remainder – either division or f(–2) For correct remainder

9	(i)		M1 A1 B1	3	Attempt sketch of any exponential graph, in at least first quadrant Correct graph – must be in both quadrants For identification of (0, 1)
	(ii)	$A \approx \frac{1}{2} \times 0.5 \times \left\{1 + 2\left(0.5^{\frac{1}{2}} + 0.5 + 0.5^{\frac{3}{2}}\right) + 0.5^2\right\}$ ≈ 1.09	B1 M1 A1 A1	4	State, or imply, at least three correct *y*-values For correct use of trapezium rule, inc correct *h* For correct unsimplified expression For the correct value 1.09, or better
	(iii)	$\left(\frac{1}{2}\right)^x = \frac{1}{6} \Rightarrow x\log_{10}\frac{1}{2} = \log_{10}\frac{1}{6}$ $x = \frac{\log_{10}\frac{1}{6}}{\log_{10}\frac{1}{2}} = \frac{-\log_{10}6}{-\log_{10}2}$ Hence $= \frac{\log_{10}2 + \log_{10}3}{\log_{10}2}$ $= 1 + \frac{\log_{10}3}{\log_{10}2}$	M1 A1 M1 A1	4	For equation $\left(\frac{1}{2}\right)^x = \frac{1}{6}$ and attempt at logs Obtain $x\log\left(\frac{1}{2}\right) = \log\left(\frac{1}{6}\right)$, or equivalent For use of log 6 = log 2 + log 3 For showing the given answer correctly
		OR $\left(\frac{1}{2}\right)^x = \frac{1}{6} \Rightarrow 2^x = 6$ $\Rightarrow x\log_{10}2 = \log_{10}6$ $x = \frac{\log_{10}6}{\log_{10}2}$ $= \frac{\log_{10}2 + \log_{10}3}{\log_{10}2}$ $= 1 + \frac{\log_{10}3}{\log_{10}2}$	M1 A1 M1 A1		For equation $2^x = 6$ and attempt at logs Obtain *x* log 2 = log 6, or equivalent For use of log 6 = log 2 + log 3 For showing the given answer correctly
		OR $\left(\frac{1}{2}\right)^x = \frac{1}{6} \Rightarrow 2^x = 6$ $2^{x-1} = 3$ $(x-1)\log_{10}2 = \log_{10}3$ Hence $x = 1 + \frac{\log_{10}3}{\log_{10}2}$	M1 A1 M1 A1		Attempt to rearrange equation to $2^n = 3$ Obtain $2^{x-1} = 3$ For attempt at logs For showing the given answer correctly
		OR $x = \frac{\log_{10}2 + \log_{10}3}{\log_{10}2}$ $= \frac{\log_{10}6}{\log_{10}2}$ $x\log_{10}2 = \log_{10}6$ $\log_{10}2^x = \log_{10}6$ $2^x = 6$ $\left(\frac{1}{2}\right)^x = \frac{1}{6}$	M1 A1 M1 A1		Use log 2 + log 3 = log 6 Obtain *x*log 2 = log 6 Attempt to remove logarithms Show $\left(\frac{1}{2}\right)^x = \frac{1}{6}$ correctly
				11	

1	$15+19d=72$	M1		Attempt to find d, from $a+(n-1)d$ or $a+nd$
	Hence $d = 3$	A1		Obtain $d = 3$
	$S_n = {}^{100}/_2\ \{(2\times15)+(99\times3)\}$	M1		Use correct formula for sum of n terms
	$= 16350$	A1	**4**	Obtain 16350
			4	
2 **(i)**	$46\times\frac{\pi}{180}=0.802$ / 0.803	M1		Attempt to convert to radians using π and 180 (or 2π & 360)
		A1	**2**	Obtain 0.802 / 0.803, or better
(ii)	8 x 0.803 = 6.4 cm	B1	**1**	State 6.4, or better
(iii)	½ x 8^2 x 0.803 = 25.6 / 25.7 cm^2	M1		Attempt area of sector using $\frac{1}{2}r^2\theta$ or $r^2\theta$, with θ in radians
		A1	**2**	Obtain 25.6 / 25.7, or better
			5	
3 **(i)**	$\int(4x-5)\,dx=2x^2-5x+c$	M1		Obtain at least one correct term
		A1	**2**	Obtain at least $2x^2-5x$
(ii)	$y = 2x^2 - 5x + c$	B1√		State or imply y = their integral from **(i)**
	$7=2\times3^2-5\times3+c\Rightarrow c=4$	M1		Use (3,7) to evaluate c
	So equation is $y=2x^2-5x+4$	A1	**3**	Correct final equation
			5	
4 **(i)**	area = $\frac{1}{2}\times5\sqrt{2}\times8\times\sin60^o$	B1		State or imply that $\sin60^o=\frac{\sqrt{3}}{2}$ or exact equiv
	$=\frac{1}{2}\times5\sqrt{2}\times8\times\frac{\sqrt{3}}{2}$	M1		Use $\frac{1}{2}ac\sin B$
	$=10\sqrt{6}$	A1	**3**	Obtain $10\sqrt{6}$ only, from working in surds
(ii)	$AC^2=(5\sqrt{2})^2+8^2-2\times5\sqrt{2}\times8\times\cos60^o$	M1		Attempt to use the correct cosine formula
		A1		Correct unsimplified expression for AC^2
	AC = 7.58 cm	A1	**3**	Obtain AC = 7.58, or better
			6	
5 **(a)** **(i)**	$\log_3\frac{4x+7}{x}$	B1	**1**	Correct single logarithm, as final answer, from correct working only
(ii)	$\log_3\frac{4x+7}{x}=2$			
	$\frac{4x+7}{x}=9$	B1		State or imply $2=\log_3 9$
	$4x+7=9x$	M1		Attempt to solve equation of form f(x) = 8 or 9
	$x=1.4$	A1	**3**	Obtain x = 1.4, or exact equiv
(b)	$\int_3^9\log_{10}x\,dx\approx\frac{1}{2}\times3\times(\log_{10}3+2\log_{10}6+\log_{10}9)$	B1		State, or imply, the 3 correct y-values only
	≈ 4.48	M1		Attempt to use correct trapezium rule
		A1		Obtain correct unsimplified expression
		A1	**4**	Obtain 4.48, or better
			8	

Q	Part	Answer	Mark	Total	Guidance
6	(i)	$(1+4x)^7 = 1 + 28x + 336x^2 + 2240x^3$	B1		Obtain $1 + 28x$
			M1		Attempt binomial expansion of at least 1 more term, with each term the product of binomial coeff and power of $4x$
			A1		Obtain $336x^2$
			A1	**4**	Obtain $2240x^3$
	(ii)	$28a + 1008 = 1001$	M1		Multiply together two relevant pairs of terms
		Hence $a = -\frac{1}{4}$	A1√		Obtain $28a + 1008 = 1001$
			A1	**3**	Obtain $a = -\frac{1}{4}$
				7	
7	(i)	**(a)** 	B1		Correct shape of $k\cos x$ graph
			B1	**2**	(90, 0), (270, 0) and (0, 2) stated or implied
		(b) $\cos x = 0.4$	M1		Divide by 2, and attempt to solve for x
		$x = 66.4^\circ, 294^\circ$	A1		Correct answer of 66.4° / 1.16 rads
			A1√	**3**	Second correct answer only, in degrees, following their x
	(ii)	$\tan x = 2$	M1		Use of $\tan x = \frac{\sin x}{\cos x}$ (or square and use $\sin^2 x + \cos^2 x \equiv 1$)
		$x = 63.4^\circ, -117^\circ$	A1		Correct answer of 63.4° / 1.56 rads
			A1√	**3**	Second correct answer only, in degrees, following their x
				8	
8	(i)	$-8 - 36 - 14 + 33 = -25$	M1		Substitute $x = -2$, or attempt complete division by $(x + 2)$
			A1	**2**	Obtain -25, as final answer
	(ii)	$27 - 81 + 21 + 33 = 0$ **A.G.**	B1	**1**	Confirm f(3) = 0, or equiv using division
	(iii)	$x = 3$	B1		State $x = 3$ as a root at any point
		$f(x) = (x - 3)(x^2 - 6x - 11)$	M1		Attempt complete division by $(x - 3)$ or equiv
			A1		Obtain $x^2 - 6x + k$
			A1		Obtain completely correct quotient
		$x = \frac{6 \pm \sqrt{36+44}}{2}$	M1		Attempt use of quadratic formula, or equiv, to find roots
		$= 3 \pm 2\sqrt{5}$ or $3 \pm \sqrt{20}$	A1	**6**	Obtain $3 \pm 2\sqrt{5}$ or $3 \pm \sqrt{20}$
				9	
9	(i)	$u_5 = 1.5 \times 1.02^4$	M1		Use $1.5r^4$, or find u_2, u_3, u_4
		$= 1.624$ tonnes **A.G.**	A1	**2**	Obtain 1.624 or better
	(ii)	$\frac{1.5(1.02^N - 1)}{1.02 - 1} \le 39$	M1		Use correct formula for S_N
			A1		Correct unsimplified expressions for S_N
		$(1.02^N - 1) \le (39 \times 0.02 \div 1.5)$	M1		Link S_N to 39 and attempt to rearrange
		$(1.02^N - 1) \le 0.52$			
		Hence $1.02^N \le 1.52$	A1	**4**	Obtain given inequality convincingly, with no sign errors
	(iii)	$\log 1.02^N \le \log 1.52$	M1		Introduce logarithms on both sides and use $\log a^b = b \log$
		$N \log 1.02 \le \log 1.52$	A1		Obtain $N \log 1.02 \le \log 1.52$ (ignore linking sign)
		$N \le 21.144..$	M1		Attempt to solve for N
		$N = 21$ trips	A1	**4**	Obtain $N = 21$ only
				10	

10	**(i)** $0 = 1 - \frac{3}{\sqrt{9}}$	B1	**1**	Verification of (9, 0), with at least one step shown
	(ii) $\int_9^a 1 - 3x^{-\frac{1}{2}} \mathrm{d}x = \left[x - 6\sqrt{x}\right]_9^a$	M1		Attempt integration – increase in power for at least 1 term
		A1		For second term of form k$x^{½}$
		A1		For correct integral
	$= \left(a - 6\sqrt{a}\right) - \left(9 - 6\sqrt{9}\right)$	M1		Attempt F(a) – F(9)
	$= a - 6\sqrt{a} + 9$	A1		Obtain $a - 6\sqrt{a} + 9$
	$a - 6\sqrt{a} + 9 = 4$	M1		Equate expression for area to 4
	$a - 6\sqrt{a} + 5 = 0$	M1		Attempt to solve 'disguised' quadratic
	$\left(\sqrt{a} - 1\right)\left(\sqrt{a} - 5\right) = 0$			
	$\sqrt{a} = 1, \sqrt{a} = 5$	A1		Obtain at least $\sqrt{a} = 5$
	$a = 1$, $a = 25$			
	but $a > 9$, so $a = 25$	A1	**9**	Obtain a = 25 only
			10	

1	(i) $u_2 = 12$ $u_3 = 9.6$, $u_4 = 7.68$ (or any exact equivs)	B1 B1√	2	State $u_2 = 12$ Correct u_3 and u_4 from their u_2
	(ii) $S_{20} = \frac{15(1-0.8^{20})}{1-0.8}$ $= 74.1$	M1 A1 A1	3	Attempt use of $S_n = \frac{a(1-r^n)}{1-r}$, with n = 20 or 19 Obtain correct unsimplified expression Obtain 74.1 or better
	OR	M1 A2		List all 20 terms of GP Obtain 74.1
			5	
2	$\left(x+\frac{2}{x}\right)^4 = x^4 + 4x^3\left(\frac{2}{x}\right) + 6x^2\left(\frac{2}{x}\right)^2 + 4x\left(\frac{2}{x}\right)^3 + \left(\frac{2}{x}\right)^4$	M1*		Attempt expansion, using powers of x and $^2/_x$ (or the two terms in their bracket), to get at least 4 terms
		M1* A1dep* A1		Use binomial coefficients of 1, 4, 6, 4, 1 Obtain two correct, simplified, terms Obtain a further one correct, simplified, term
	$= x^4 + 8x^2 + 24 + \frac{32}{x^2} + \frac{16}{x^4}$ (or equiv)	A1	5	Obtain a fully correct, simplified, expansion
	OR	M1* M1*		Attempt expansion using all four brackets Obtain expansion containing the correct 5 powers only (could be unsimplified powers eg x^3. x^{-1})
		A1dep* A1 A1		Obtain two correct, simplified, terms Obtain a further one correct, simplified, term Obtain a fully correct, simplified, expansion
			5	
3	$\log 3^{(2x+1)} = \log 5^{200}$ $(2x+1)\log 3 = 200\log 5$	M1 M1 A1		Introduce logarithms throughout Drop power on at least one side Obtain correct linear equation (now containing no powers)
	$2x+1 = \frac{200\log 5}{\log 3}$ $x = 146$	M1 A1	5	Attempt solution of linear equation Obtain x = 146, or better
	OR $(2x + 1) = \log_3 5^{200}$ $2x + 1 = 200\log_3 5$	M1 M1 A1 M1 A1		Intoduce $\log_3$ on right-hand side Drop power of 200 Obtain correct equation Attempt solution of linear equation Obtain x = 146, or better
			5	
4	(i) area $\approx \frac{1}{2} \times \frac{1}{2} \times \left\{\sqrt{5} + 2\left(\sqrt{7} + \sqrt{9} + \sqrt{11}\right) + \sqrt{13}\right\}$	M1 M1 A1		Attempt y-values for at least 4 of the x = 1, 1.5, 2, 2.5, 3 only Attempt to use correct trapezium rule Obtain $\frac{1}{2} \times \frac{1}{2} \times \left\{\sqrt{5} + 2\left(\sqrt{7} + \sqrt{9} + \sqrt{11}\right) + \sqrt{13}\right\}$, or decimal equiv
	$\approx 0.25 \times 23.766...$ ≈ 5.94	A1	4	Obtain 5.94 or better (answer only is 0/4)
	(ii) This is an underestimate…… …as the tops of the trapezia are below the curve	*B1 B1dep*B1 2		State underestimate Correct statement or sketch
			6	

5	**(i)** $3(1-\sin^2\theta)=\sin\theta+1$ $3-3\sin^2\theta=\sin\theta+1$ $3\sin^2\theta+\sin\theta-2=0$	M1 A1	 2	Use $\cos^2\theta=1-\sin^2\theta$ Show given equation correctly
	(ii) $(3\sin\theta-2)(\sin\theta+1)=0$ $\sin\theta=\frac{2}{3}$ or -1 θ = 42°, 138°, 270°	M1 A1 A1 A1 A1√	 5	Attempt to solve quadratic equation in $\sin\theta$ Both values of $\sin\theta$ correct Correct answer of 270° Correct answer of 42° For correct non-principal value answer, following their first value of θ in the required range (any extra values for θ in required range is max 4/5) (radians is max 4/5) SR: answer only (or no supporting method) is B1 for 42°, B1√ for 138°, B1 for 270°
			7	
6	**(a) (i)** $\int x^3-4x=\frac{1}{4}x^4-2x^2+c$	M1 A1 B1	 3	Expand and attempt integration Obtain ¼ x^4– $2x^2$ (A0 if ∫ or dx still present) + c (mark can be given in (b) if not gained here)
	(ii) $\left[\frac{1}{4}x^4-2x^2\right]_1^6$ =(324 – 72) – (¼ – 2) = 253¾	M1 A1	 2	Use limits correctly in integration attempt (ie F(6) – F(1)) Obtain 253¾ (answer only is M0A0)
	(b) $\int 6x^{-3}\mathrm{d}x=-3x^{-2}+c$	B1 M1 A1	 3	Use of $\frac{1}{x^3}=x^{-3}$ Obtain integral of the form kx^{-2} Obtain correct -3x^{-2} (+ c) (A0 if ∫ or dx still present, but only penalise once in question)
			8	
7	**(a)** $S_{70}=\frac{70}{2}\{(2\times12)+(70-1)d\}$ 35(24 + 69d) = 12915 d = 5	M1 A1 M1 A1	 4	Attempt S_{70} Obtain correct unsimplified expression Equate attempt at S_{70} to 12915, and attempt to find d Obtain d = 5
OR	$\frac{70}{2}\{12+l\}=12915$ l = 357 12 + 69d = 357 d = 5	M1 A1 M1 A1		Attempt to find d by first equating $^n/_2(a+l)$ to 12915 Obtain l = 357 Equate u_{70} to l Obtain d = 5
	(b) ar = -4 $\frac{a}{1-r}=9$ $\frac{-4}{r}=9-9r$ or $a=9-\left(9\times\frac{-4}{a}\right)$ $9r^2-9r-4=0$ $a^2-9a-36=0$ $(3r-4)(3r+1)=0$ $(a+3)(a-12)=0$ $r=\frac{4}{3}$, $r=-\frac{1}{3}$ a = -3, a = 12 Hence $r=-\frac{1}{3}$	B1 B1 M1 A1 M1 A1 A1	 7	Correct statement for second term Correct statement for sum to infinity Attempt to eliminate either a or r Obtain correct equation (no algebraic denominators/brackets) Attempt solution of three term quadratic equation Obtain at least $r=-\frac{1}{3}$ (from correct working only) Obtain $r=-\frac{1}{3}$ only (from correct working only) SR: answer only / T&I is B2 only
			11	

8	**(i)**	$\frac{1}{2}\times AB^2 \times 0.9 = 16.2$ $AB^2 = 36 \Rightarrow AB = 6$	M1 A1 **2**	Use $\left(\frac{1}{2}\right)r^2\theta = 16.2$ Confirm AB = 6 cm (or verify ½ x 6^2 x 0.9 = 16.2)
	(ii)	$\frac{1}{2}\times 6\times AC\times \sin 0.9 = 32.4$ AC = 13.8 cm	M1* M1dep* A1 **3**	Use $\Delta = \frac{1}{2}bc\sin A$, or equiv Equate attempt at area to 32.4 Obtain AC = 13.8 cm, or better
	(iii)	$BC^2 = 6^2 + 13.8^2 - 2\times 6\times 13.8\times \cos 0.9$ Hence BC = 11.1 cm $BD = 6\times 0.9 = 5.4$ cm Hence perimeter = 11.1 + 5.4 + (13.8 – 6) = 24.3 cm	M1 A1√ A1 B1 M1 A1 **6** **11**	Attempt use of correct cosine formula in ΔABC Correct unsimplified equation, from their AC Obtain BC = 11.1 cm, or anything that rounds to this State BD = 5.4 cm (seen anywhere in question) Attempt perimeter of region BCD Obtain 24.3 cm, or anything that rounds to this
9	**(i)** **(a)**	f (-1) = – 1 + 6 – 1 – 4 = 0	B1 **1**	Confirm f(-1) = 0, through any method
	(b)	x = -1 $f(x) = (x+1)(x^2+5x-4)$ $x = \frac{-5\pm\sqrt{25+16}}{2}$ $x = \frac{1}{2}\left(-5\pm\sqrt{41}\right)$	B1 M1 A1 A1 M1 A1 **6**	State x = -1 at any point Attempt complete division by (x + 1), or equiv Obtain $x^2 + 5x + k$ Obtain completely correct quotient Attempt use of quadratic formula, or equiv, find roots Obtain $\frac{1}{2}\left(-5\pm\sqrt{41}\right)$
	(ii) **(a)**	$\log_2(x+3)^2 + \log_2 x - \log_2(4x+2) = 1$ $\log_2\left(\frac{(x+3)^2 x}{4x+2}\right) = 1$ $\frac{(x+3)^2 x}{4x+2} = 2$ $(x^2+6x+9)x = 8x+4$ $x^3 + 6x^2 + x - 4 = 0$	B1 M1 A1 B1 A1 **5**	State or imply that 2log (x + 3) = log $(x+3)^2$ Add or subtract two, or more, of their algebraic logs correctly Obtain correct equation (or any equivalent, with single term on each side) Use $\log_2 a = 1 \Rightarrow a = 2$ at any point Confirm given equation correctly
	(b)	x > 0, otherwise $\log_2 x$ is undefined $x = \frac{1}{2}\left(-5+\sqrt{41}\right)$	B1* B1√dep* **2** **14**	State or imply that log x only defined for x > 0 State $x = \frac{1}{2}\left(-5+\sqrt{41}\right)$ (or x = 0.7) only, following their single positive root in (i)(b)

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		Mark	Total	
1	area of sector = ½ x 11^2 x 0.7	M1		Attempt sector area using (½) $r^2\theta$
	= 42.35	A1		Obtain 42.35, or unsimplified equiv, soi
	area of triangle = ½ x 11^2 x sin0.7 = 38.98	M1		Attempt triangle area using ½*ab*sin*C* or equiv, and
	hence area of segment = 42.35 – 38.98			subtract from attempt at sector
	= 3.37	A1	4	Obtain 3.37, or better
			4	
2	area $\approx \frac{1}{2}\times 2\times\left\{2+2\left(\sqrt{12}+\sqrt{28}\right)+\sqrt{52}\right\}$	M1		Attempt *y*-values at *x* = 1, 3, 5, 7 only
		M1		Correct trapezium rule, any *h*, for their *y* values to find area between *x* = 1 and *x* = 7
		M1		Correct *h* (soi) for their *y* values
	≈ 26.7	A1	4	Obtain 26.7 or better (correct working only)
			4	
3	**(i)** $\log_a 6$	B1	1	State $\log_a 6$ cwo
	(ii) $2\log_{10} x - 3\log_{10} y = \log_{10} x^2 - \log_{10} y^3$	M1*		Use *b* log *a* = log a^b at least once
	$= \log_{10}\frac{x^2}{y^3}$	M1dep*		Use log *a* - log *b* = log $^a/_b$
		A1	3	Obtain $\log_{10}\frac{x^2}{y^3}$ cwo
			4	
4	**(i)** $\frac{BD}{\sin 62} = \frac{16}{\sin 50}$	M1		Attempt to use correct sine rule in Δ*BCD*, or equiv.
	BD = 18.4 cm	A1	2	Obtain 18.4 cm
	(ii) $18.4^2 = 10^2 + 20^2 - 2 \times 10 \times 20 \times \cos\theta$	M1		Attempt to use correct cosine rule in Δ*ABD*
	$\cos\theta = 0.3998$	M1		Attempt to rearrange equation to find cos *BAD* (from $a^2 = b^2 + c^2 \pm (2)bc\cos A$)
	$\theta = 66.4^0$	A1	3	Obtain 66.4^0
			5	
5	$\int 12x^{\frac{1}{2}}\,dx = 8x^{\frac{3}{2}}$	M1		Attempt to integrate
		A1√		Obtain correct, unsimplified, integral following their f(*x*)
		A1		Obtain $8x^{\frac{3}{2}}$, with or without + *c*
	$y = 8x^{\frac{3}{2}} + c \Rightarrow 50 = 8\times 4^{\frac{3}{2}} + c$	M1		Use (4, 50) to find *c*
	$\Rightarrow c = -14$	A1√		Obtain *c* = -14, following $kx^{\frac{3}{2}}$ only
	Hence $y = 8x^{\frac{3}{2}} - 14$	A1	6	State $y = 8x^{\frac{3}{2}} - 14$ aef, as long as single power of *x*
			6	

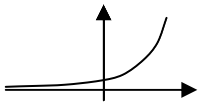
			Mark	Total	
6	(i)	$u_1 = 7$	B1		Correct u_1
		$u_2 = 9$, $u_3 = 11$	B1	2	Correct u_2 and u_3
	(ii)	Arithmetic Progression	B1	1	Any mention of arithmetic
	(iii)	½ N (14 + (N – 1) x 2) = 2200	B1		Correct interpretation of sigma notation
			M1		Attempt sum of AP, and equate to 2200
		$N^2 + 6N - 2200 = 0$	A1		Correct (unsimplified) equation
		$(N - 44)(N + 50) = 0$	M1		Attempt to solve 3 term quadratic in N
		hence $N = 44$	A1	5	Obtain $N = 44$ only ($N = 44$ www is full marks)
				8	
7	(i)	Some of the area is below the x-axis	B1	1	Refer to area / curve below x-axis or 'negative area'…
	(ii)		M1		Attempt integration with any one term correct
			A1		Obtain $^1/_3x^3 - {^3/_2}x^2$
		$\left[\frac{1}{3}x^3 - \frac{3}{2}x^2\right]_0^3 = \left(9 - \frac{27}{2}\right) - (0 - 0)$	M1		Use limits 3 (and 0) – correct order / subtraction
		$= -4\frac{1}{2}$	A1		Obtain (-)4½
		$\left[\frac{1}{3}x^3 - \frac{3}{2}x^2\right]_3^5 = \left(\frac{125}{3} - \frac{75}{2}\right) - \left(9 - \frac{27}{2}\right)$	M1		Use limits 5 and 3 – correct order / subtraction
		$= 8\frac{2}{3}$	A1		Obtain $8^2/_3$ (allow 8.7 or better)
		Hence total area is $13^1/_6$	A1	7	Obtain total area as $13^1/_6$, or exact equiv
					SR: if no longer $\int f(x)dx$, then B1 for using [0, 3] and [3, 5]
				8	
8	(i)	$u_4 = 10 \text{x} 0.8^3$	M1		Attempt u_4 using ar^{n-1}
		$= 5.12$	A1	2	Obtain 5.12 aef
	(ii)	$S_{20} = \dfrac{10\left(1 - 0.8^{20}\right)}{1 - 0.8}$	M1		Attempt use of correct sum formula for a GP
		$= 49.4$	A1	2	Obtain 49.4
	(iii)	$\dfrac{10}{1 - 0.8} - \dfrac{10(1 - 0.8^N)}{(1 - 0.8)} < 0.01$	M1		Attempt S_∞ using $\dfrac{a}{1 - r}$
			A1		Obtain $S_\infty = 50$, or unsimplified equiv
		$50 - 50(1 - 0.8^N) < 0.01$	M1		Link $S_\infty - S_N$ to 0.01 and attempt to rearrange
		$0.8^N < 0.0002$ **A.G.**	A1		Show given inequality convincingly
		$\log 0.8^N < \log 0.0002$	M1		Introduce logarithms on both sides
		$N \log 0.8 < \log 0.0002$	M1		Use $\log a^b = b \log a$, and attempt to find N
		$N > 38.169$, hence $N = 39$	A1	7	Obtain $N = 39$ only
				11	

			Mark	Total	
9	**(i)**	$(90^o, 2), (-90^o, -2)$	B1		State at least 2 correct values
			B1	**2**	State all 4 correct values (radians is B1 B0)
	(ii)	**(a)** $180 - \alpha$	B1	**1**	State $180 - \alpha$
		(b) $-\alpha$ or $\alpha - 180$	B1	**1**	State $-\alpha$ or $\alpha - 180$ (radians or unsimplified is B1B0)
	(iii)	$2\sin x = 2 - 3\cos^2 x$			
		$2\sin x = 2 - 3(1 - \sin^2 x)$	M1		Attempt use of $\cos^2 x = 1 - \sin^2 x$
		$3\sin^2 x - 2\sin x - 1 = 0$	A1		Obtain $3\sin^2 x - 2\sin x - 1 = 0$ aef with no brackets
		$(3\sin x + 1)(\sin x - 1) = 0$	M1		Attempt to solve 3 term quadratic in $\sin x$
		$\sin x = -{}^1/_3$, $\sin x = 1$	A1		Obtain $x = -19.5^o$
		$x = -19.5^o, -161^o, 90^o$	A1√		Obtain second correct answer in range, following their x
			A1	**6**	Obtain 90^o (radians or extra answers is max 5 out of 6) SR: answer only (and no extras) is B1 B1√ B1
				10	
10	**(i)**	$(2x + 5)^4 = (2x)^4 + 4(2x)^3 5 + 6(2x)^2 5^2 + 4(2x)5^3 + 5^4$	M1*		Attempt expansion involving powers of $2x$ and 5 (at least 4 terms)
		$= 16x^4 + 160x^3 + 600x^2 + 1000x + 625$	M1*		Attempt coefficients of 1, 4, 6, 4, 1
			A1dep*		Obtain two correct terms
			A1	**4**	Obtain a fully correct expansion
	(ii)	$(2x + 5)^4 - (2x - 5)^4 = 320x^3 + 2000x$	M1		Identify relevant terms (and no others) by sign change oe
			A1	**2**	Obtain $320x^3 + 2000x$ cwo
	(iii)	$9^4 - (-1)^4 = 6560$ and $7360 - 800 = 6560$ **A.G.**	B1		Confirm root, at any point
		$320x^3 - 1680x + 800 = 0$	M1		Attempt complete division by $(x - 2)$ or equiv
		$4x^3 - 21x + 10 = 0$	A1√		Obtain quotient of $ax^2 + 2ax + k$, where a is their coeff of x^3
		$(x - 2)(4x^2 + 8x - 5) = 0$	A1		Obtain $(4x^2 + 8x - 5)$ (or multiple thereof)
		$(x - 2)(2x - 1)(2x + 5) = 0$	M1		Attempt to solve quadratic
		Hence $x = ½$, $x = -2½$	A1	**6**	Obtain $x = ½$, $x = -2½$ SR: answer only is B1 B1
				12	

4722 Core Mathematics 2

1		$(2 - 3x)^6 = 2^6 + 6.2^5.(-3x) + 15.2^4.(-3x)^2$	**M1**	Attempt (at least) first two terms - product of binomial coefficient and powers of 2 and (-)3x
		$= 64 - 576x + 2160x^2$	**A1**	Obtain $64 - 576x$
			M1	Attempt third term - binomial coefficient and powers of 2 and (-)3x
			A1	Obtain $2160x^2$
	OR			
			M1	Attempt expansion involving all 6 brackets
			A1	Obtain 64
			A1	Obtain $-576x$
			A1	Obtain $2160x^2$
	SR	if the expansion is attempted in descending order, and the required terms are never seen, then **B1 B1 B1** for $4860x^4$, $-2916x^5$, $729x^6$		
			4	
2	**(i)**	$u_2 = {}^2/_3$	**B1**	Obtain correct u_2
		$u_3 = {}^{-1}/_2$	**B1√**	Obtain correct u_3 from their u_2
		$u_4 = 3$	**B1√**	Obtain correct u_4 from their u_3
			3	
	(ii)	sequence is periodic / cyclic / repeating	**B1**	Any equivalent comment
			1	
3	**(i)**	$½ \times 8^2 \times \theta = 48$	**M1**	State or imply (½) $8^2\theta = 48$
		Hence $\theta = 1.5$ radians	**A1**	Obtain $\theta = 1.5$ (or 0.477π), or equiv
			2	
	(ii)	area $= 48 - ½ \times 8^2 \times \sin 1.5$	**M1***	Attempt area of Δ using (½) $8^2 \sin\theta$
		$= 48 - 31.9$	**M1d***	Attempt 48 – area of Δ
		$= 16.1$	**A1**	Obtain 16.1 cm^2
			3	
4	**(i)**	$f(3) = 27a - 36 - 21a + 12 = 0$	**M1***	Attempt f(3)
		$6a = 24$	**M1d***	Equate attempt at f(3) to 0 and attempt to solve
		$a = 4$	**A1**	Obtain $a = 4$
	OR			
			M1*	Attempt complete division / matching coeffs
			M1d*	Equate remainder to 0
			A1	Obtain $a = 4$
			3	
	(ii)	$f(-2) = -32 - 16 + 56 + 12$	**M1**	Attempt f(-2)
		$= 20$	**A1√**	Obtain 20 (or $6a - 4$, following their a)
			2	

5	**(i)**	$\int x\,dy = \int ((y-3)^2 - 2)dy$	**B1**	Show $x = y^2 - 6y + 7$ convincingly
		$= \int (y^2 - 6y + 7)dy$ **A.G.**	**B1**	State or imply that required area = $\int x dy$
		$3+\sqrt{(2+2)} = 5$, $3+\sqrt{(14+2)} = 7$	**B1**	Use x = 2, 14 to show new limits of y = 5, 7
			3	
	(ii)	$\left[\frac{1}{3}y^3 - 3y^2 + 7y\right]_5^7$	**M1**	Integration attempt, with at least one term correct
		$= (^{343}/_3 - 147 + 49) - (^{125}/_3 - 75 + 35)$	**A1**	All three terms correct
		$= 16^1/_3 - 1^2/_3$	**M1**	Attempt F(7) – F(5)
		$= 14\ ^2/_3$	**A1**	Obtain $14\ ^2/_3$, or exact equiv
			4	
6	**(i)**	ABC = 360 – (150 + 110) = 100° **A.G.**	**B1**	Show convincingly that angle ABC is 100°
			1	
	(ii)	$CA^2 = 15^2 + 27^2 - 2\times15\times27\times\cos100^0$	**M1**	Attempt use of correct cosine rule
		= 1094.655…		
		CA = 33.1	**A1**	Obtain 33.1 km
			2	
	(iii)	$\frac{\sin C}{15} = \frac{\sin 100}{33.1}$ or $\frac{\sin A}{27} = \frac{\sin 100}{33.1}$	**M1**	Attempt use of sine rule to find angle C or A (or equiv using cosine rule)
			A1√	Correct unsimplified eqn, following their CA
		C = 26.5° A = 53.5°	**A1**	Obtain C = 26.5° or A = 53.5° (allow 53.4°)
		Hence bearing is 263°	**A1√**	Obtain 263 or 264 (or 290° – their angle C / 210 + their angle A)
			4	
7	**(a)**	$\int (x^5 - x^4 + 5x^3)dx$	**M1**	Expand brackets and attempt integration, or other valid integration attempt
		$= \frac{1}{6}x^6 - \frac{1}{5}x^5 + \frac{5}{4}x^4$ (+ c)	**A1**	Obtain at least one correct term
			A1	Obtain a fully correct expression
			B1	For + c, and no $\int$ or dx (can be given in **(b)(i)** if not given here)
			4	
	(b)	**(i)** $-6x^{-3}$ (+c)	**M1**	Obtain integral of the form kx^{-3}
			A1	Obtain $-6x^{-3}$ (+c)
			2	
		(ii) $\left[-6x^{-3}\right]_2^\infty$	**B1***	State or imply that F(∞) = 0 (for kx^n, n -1)
		= ¾	**B1d***	Obtain ¾ (or equiv)
			2	

8 **(i)**		**M1**	Attempt sketch of exponential graph (1^{st} quad)
			- if seen in 2^{nd} quad must be approx correct
		A1	Correct graph in both quadrants
		B1	State or imply (0, 2) only
		3	
(ii)	$8^x = 2 \times 3^x$		
	$\log_2 8^x = \log_2 (2 \times 3^x)$	**M1**	Form equation in x and take logs (to any consistent base, or no base) – could use $\log_8$
	$x\log_2 8 = \log_2 2 + x\log_2 3$	**M1**	Use $\log a^b = b \log a$
		M1	Use $\log ab = \log a + \log b$,or equiv with $\log {}^a/_b$
	$3x = 1 + x\log_2 3$	**M1**	Use $\log_2 8 = 3$
	$x(3 - \log_2 3) = 1$, hence $x = \dfrac{1}{3-\log_2 3}$ **A.G.**	**A1**	Show given answer correctly
OR	$8^x = 2 \times 3^x$		
	$2^{3x} = 2 \times 3^x$	**M1**	Use $8^x = 2^{3x}$
	$2^{(3x-1)} = 3^x$	**M1**	Attempt to rearrange equation to $2^k = 3^x$
	$\log_2 2^{(3x-1)} = \log_2 3^x$	**M1**	Take logs (to any base)
	$(3x - 1)\log_2 2 = x \log_2 3$	**M1**	Use $\log a^b = b \log a$
	$x(3 - \log_2 3) = 1$, hence $x = \dfrac{1}{3-\log_2 3}$ **A.G.**	**A1**	Show given answer correctly
		5	
9 **(a) (i)**	$2\sin x.\dfrac{\sin x}{\cos x} - 5 = \cos x$	**M1**	Use $\tan x \equiv \dfrac{\sin x}{\cos x}$
	$2\sin^2 x - 5\cos x = \cos^2 x$		
	$2 - 2\cos^2 x - 5\cos x = \cos^2 x$	**M1**	Use $\sin^2 x \equiv 1 - \cos^2 x$
	$3\cos^2 x + 5\cos x - 2 = 0$	**A1**	Show given equation convincingly
		3	
(ii)	$(3\cos x - 1)(\cos x + 2) = 0$	**M1**	Attempt to solve quadratic in $\cos x$
	$\cos x = {}^1/_3$	**M1**	Attempt to find x from root(s) of quadratic
	$x = 1.23$ rad	**A1**	Obtain 1.23 rad or 70.5^o
	$x = 5.05$ rad	**A1**√	Obtain 5.05 rad or 289^o (or 2π / 360^o - their solution)
			SR: B1 B1 for answer(s) only
		4	
(b)	0.5x0.25x{cos0+2(cos0.25+cos0.5+cos0.75)+cos1}	**M1**	Attempt y-coords for at least 4 of the correct 5 x-coords
		M1	Use correct trapezium rule, any h, for their y values to find area between $x = 0$ and $x = 1$
		M1	Correct h (soi) for their y values
	≈ 0.837	**A1**	Obtain 0.837
		4	

10	**(i)**	$u_{15} = 2 + 14 \times 0.5$	**M1**	Attempt use of $a + (n-1)d$
		$= 9$ km	**A1**	Obtain 9 km
			2	
	(ii)	$u_{20} = 2 \times 1.1^{19} = 12.2$	**B1**	State, or imply, $r = 1.1$
			M1	Attempt u_{20} , using ar^{n-1}
		$u_{19} = 2 \times 1.1^{18} = 11.1$	**A1**	Obtain $u_{20} = 12.2$, and obtain $u_{19} = 11.1$
	OR			
			B1	State, or imply, $r = 1.1$
			M1	Attempt to solve $ar^{n-1} = 12$
			A1	Obtain $n = 20$ (allow $n \geq 20$)
			3	
	(iii)	$\frac{2(1.1^n - 1)}{(1.1-1)} > 200$	**B1**	State or imply $S_N = \frac{2(1.1^n - 1)}{(1.1-1)}$
		$1.1^n > 11$	**M1**	Link (any sign) their attempt at S_N (of a GP) to 200 and attempt to solve
		$n > \frac{\log 11}{\log 1.1}$	**A1**	Obtain 26, or 25.2 or better
		$n > 25.2$ ie Day 26	**A1**	Conclude $n = 26$ only, or equiv eg Day 26
			4	
	(iv)	swum = 2 x 30 = 60 km	**B1**	Obtain 60 km, or 2 x 30km
		run = ½ x 30 x (4 + 29 x 0.5) = 277.5 km	**M1**	Attempt sum of AP, $d = 0.5$, $a = 2$, $n = 30$
		cycle = $\frac{2(1.1^{30} - 1)}{(1.1-1)}$ = 329.0 km	**M1**	Attempt sum of GP, $r = 1.1$, $a = 2$, $n = 30$
		total = 666 km	**A1**	Obtain 666 or 667 km
			4	

4722 Core Mathematics 2

1 (i)	$\int (x^3 + 8x - 5)\,dx = \frac{1}{4}x^4 + 4x^2 - 5x + c$	M1		Attempt integration – increase in power for at least 2 terms
		A1		Obtain at least 2 correct terms
		A1	**3**	Obtain $\frac{1}{4}x^4 + 4x^2 - 5x + c$ (and no integral sign or dx)
(ii)	$\int 12x^{\frac{1}{2}}\,dx = 8x^{\frac{3}{2}} + c$	B1		State or imply $\sqrt{x} = x^{\frac{1}{2}}$
		M1		Obtain $kx^{\frac{3}{2}}$
		A1	**3**	Obtain $8x^{\frac{3}{2}} + c$ (and no integral sign or dx) (only penalise lack of + c, or integral sign or dx once)
			6	
2 (i)	$140^\circ = 140 \times \frac{\pi}{180}$	M1		Attempt to convert 140° to radians
	$= \frac{7}{9}\pi$	A1	**2**	Obtain $\frac{7}{9}\pi$, or exact equiv
(ii)	arc $AB = 7 \times \frac{7}{9}\pi$	M1		Attempt arc length using $r\theta$ or equiv method
	= 17.1	A1√		Obtain 17.1, $\frac{49}{9}\pi$ or unsimplified equiv
	chord $AB = 2 \times 7 \sin \frac{7}{18}\pi = 13.2$	M1		Attempt chord using trig. or cosine or sine rules
	hence perimeter = 30.3 cm	A1	**4**	Obtain 30.3, or answer that rounds to this
			6	
3 (i)	$u_1 = 23^1/_3$	B1		State $u_1 = 23^1/_3$
	$u_2 = 22^2/_3$, $u_3 = 22$	B1	**2**	State $u_2 = 22^2/_3$ and $u_3 = 22$
(ii)	$24 - {}^{2k}/_3 = 0$	M1		Equate u_k to 0
	$k = 36$	A1	**2**	Obtain 36
(iii)	$S_{20} = \frac{20}{2}\left(2 \times 23\frac{1}{3} + 19 \times \frac{-2}{3}\right)$	M1		Attempt sum of AP with n = 20
	= 340	A1		Correct unsimplified S_{20}
		A1	**3**	Obtain 340
			7	
4	$\int_{-2}^{2} (x^4 + 3)\,dx = \left[\frac{1}{5}x^5 + 3x\right]_{-2}^{2}$	M1		Attempt integration – increase of power for at least 1 term
		A1		Obtain correct $\frac{1}{5}x^5 + 3x$
	$= (\frac{32}{5} + 6) - (\frac{-32}{5} - 6)$	M1		Use limits (any two of –2, 0, 2), correct order/subtraction
	$= 24\frac{4}{5}$	A1		Obtain $24\frac{4}{5}$
	area of rectangle = 19 x 4	B1		State or imply correct area of rectangle
	hence shaded area = 76 – $24\frac{4}{5}$	M1		Attempt correct method for shaded area
	$= 51\frac{1}{5}$	A1	**7**	Obtain $51\frac{1}{5}$ aef such as 51.2, $\frac{256}{5}$
OR				
	Area = 19 – (x^4 + 3)	M1		Attempt subtraction, either order
	= 16 – x^4	A1		Obtain 16 – x^4 (not from x^4 + 3 = 19)
	$\int_{-2}^{2} (16 - x^4)\,dx = \left[16x - \frac{1}{5}x^5\right]_{-2}^{2}$	M1		Attempt integration
		A1		Obtain $\pm\left(16x - \frac{1}{5}x^5\right)$

	$= (32 - \frac{32}{5}) - (-32 - \frac{-32}{5})$	M1		Use limits – correct order / subtraction
	$= 51\frac{1}{5}$	A1		Obtain $\pm 51\frac{1}{5}$
		A1		Obtain $51\frac{1}{5}$ only, no wrong working
			7	

5 (i)	$\frac{TA}{\sin 107} = \frac{50}{\sin 3}$	M1		Attempt use of correct sine rule to find *TA*, or equiv
	$TA = 914$ m	A1	**2**	Obtain 914, or better
(ii)	$TC = \sqrt{914^2 + 150^2 - 2 \times 914 \times 150 \times \cos 70}$	M1		Attempt use of correct cosine rule, or equiv, to find *TC*
		A1√		Correct unsimplified expression for *TC*, following their (i)
	= 874 m	A1	**3**	Obtain 874, or better
(iii)	dist from *A* = 914 x cos 70 = 313 m	M1		Attempt to locate point of closest approach
	beyond *C*, hence 874 m is shortest dist	A1	**2**	Convincing argument that the point is beyond *C*,
OR				or obtain 859, or better
	perp dist = $914 \times \sin 70$ = 859 m			**SR** B1 for 874 stated with no method shown
			7	

6 (i)	$S_\infty = \frac{20}{1-0.9}$	M1		Attempt use of $S_\infty = \frac{a}{1-r}$
	= 200	A1	**2**	Obtain 200
(ii)	$S_{30} = \frac{20(1-0.9^{30})}{1-0.9}$	M1		Attempt use of correct sum formula for a GP, with $n = 30$
	= 192	A1	**2**	Obtain 192, or better
(iii)	$20 \times 0.9^{p-1} < 0.4$	B1		Correct $20 \times 0.9^{p-1}$ seen or implied
	$0.9^{p-1} < 0.02$			
	$(p-1)\log 0.9 < \log 0.02$	M1		Link to 0.4, rearrange to $0.9^k = c$ (or >, <), introduce
	$p - 1 > \frac{\log 0.02}{\log 0.9}$			logarithms, and drop power, or equiv correct method
	$p > 38.1$	M1		Correct method for solving their (in)equation
	hence $p = 39$	A1	**4**	State 39 (not inequality), no wrong working seen
			8	

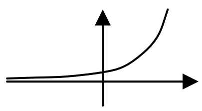
7 (i)	$6k^2a^2 = 24$	M1*		Obtain at least two of 6, k^2, a^2
	$k^2a^2 = 4$	M1dep*		Equate $6k^ma^n$ to 24
	$ak = 2$ **A.G.**	A1	**3**	Show $ak = 2$ convincingly – no errors allowed
(ii)	$4k^3a = 128$	B1		State or imply coeff of *x* is $4k^3a$
	$4k^3\left(\frac{2}{k}\right) = 128$	M1		Equate to 128 and attempt to eliminate *a* or *k*
	$k^2 = 16$	A1		Obtain $k = 4$
	$k = 4$, $a = \frac{1}{2}$	A1	**4**	Obtain $a = ½$
				SR B1 for $k = \pm 4$, $a = \pm\frac{1}{2}$
(iii)	$4 \times 4 \times \left(\frac{1}{2}\right)^3 = 2$	M1		Attempt $4 \times k \times a^3$, following their *a* and *k* (allow if still in terms of *a*, *k*)
		A1	**2**	Obtain 2 (allow $2x^3$)
			9	

8 (a)(i) $\log_a xy = p + q$	B1	**1**	State $p + q$ cwo
(ii) $\log_a \left(\frac{a^2x^3}{y}\right) = 2 + 3p - q$	M1		Use $\log a^b = b \log a$ correctly at least once
	M1		Use $\log \frac{a}{b} = \log a - \log b$ correctly
	A1	**3**	Obtain $2 + 3p - q$
(b)(i) $\log_{10} \frac{x^2-10}{x}$	B1	**1**	State $\log_{10} \frac{x^2-10}{x}$ (with or without base 10)
(ii) $\log_{10} \frac{x^2-10}{x} = \log_{10} 9$	B1		State or imply that $2\log_{10} 3 = \log_{10} 3^2$
$\frac{x^2-10}{x} = 9$	M1		Attempt correct method to remove logs
$x^2 - 9x - 10 = 0$	A1		Obtain correct $x^2 - 9x - 10 = 0$ aef, no fractions
$(x - 10)(x + 1) = 0$	M1		Attempt to solve three term quadratic
$x = 10$	A1	**5**	Obtain $x = 10$ only
		10	
9 (i) $f(1) = 1 - 1 - 3 + 3 = 0$ **A.G.**	B1		Confirm f(1) = 0, or division with no remainder shown, or matching coeffs with $R = 0$
$f(x) = (x - 1)(x^2 - 3)$	M1		Attempt complete division by $(x - 1)$, or equiv
	A1		Obtain $x^2 + k$
	A1		Obtain completely correct quotient (allow $x^2 + 0x - 3$)
$x^2 = 3$	M1		Attempt to solve $x^2 = 3$
$x = \pm\sqrt{3}$	A1	**6**	Obtain $x = \pm\sqrt{3}$ only
(ii) $\tan x = 1, \sqrt{3}, -\sqrt{3}$	B1√		State or imply tan x = 1 or tan x = at least one of their roots from (i)
$\tan x = \sqrt{3} \Rightarrow x = \pi/3, 4\pi/3$	M1		Attempt to solve tan $x = k$ at least once
$\tan x = -\sqrt{3} \Rightarrow x = 2\pi/3, 5\pi/3$	A1		Obtain at least 2 of $\pi/3$, $2\pi/3$, $4\pi/3$, $5\pi/3$(allow degs/decimals)
$\tan x = 1 \Rightarrow x = \pi/4, 5\pi/4$	A1		Obtain all 4 of $\pi/3$, $2\pi/3$, $4\pi/3$, $5\pi/3$ (exact radians only)
	B1		Obtain $\pi/4$ (allow degs / decimals)
	B1	**6**	Obtain $5\pi/4$ (exact radians only) **SR** answer only is B1 per root, max of B4 if degs / decimals
		12	

4722 Core Mathematics 2

1	**(i)** $\cos\theta = \frac{6.4^2+7.0^2-11.3^2}{2\times6.4\times7.0}$	M1		Attempt use of cosine rule (any angle)
	$= -0.4211$	A1		Obtain one of 115°, 34.2°, 30.9°, 2.01, 0.597, 0.539
	$\theta = 115^\circ$ or 2.01 rads	A1	**3**	Obtain 115° or 2.01 rads, or better
	(ii) area $= \frac{1}{2}\times7\times6.4\times\sin115$	M1		Attempt triangle area using (½)$ab\sin C$, or equiv
	$= 20.3\text{ cm}^2$	A1	**2**	Obtain 20.3 (cao)
			[5]	
2	**(i)** $a + 9d = 2(a + 3d)$	M1*		Attempt use of $a + (n-1)d$ or $a + nd$ at least once for u_4, u_{10} or u_{20}
	$a = 3d$	A1		Obtain $a = 3d$ (or unsimplified equiv) and $a + 19d = 44$
	$a + 19d = 44 \Rightarrow 22d = 44$	M1dep*		Attempt to eliminate one variable from two simultaneous equations in a and d, from u_4, u_{10}, u_{20} and no others
	$d = 2$, $a = 6$	A1	**4**	Obtain $d = 2$, $a = 6$
	(ii) $S_{50} = {}^{50}/_2\ (2\text{x}6 + 49\text{x}2)$	M1		Attempt S_{50} of AP, using correct formula, with $n = 50$, allow $25(2a + 24d)$
	$= 2750$	A1	**2**	Obtain 2750
			[6]	
3	$\log 7^x = \log 2^{x+1}$	M1		Introduce logarithms throughout, or equiv with base 7 or 2
	$x\log 7 = (x+1)\log 2$	M1		Drop power on at least one side
		A1		Obtain correct linear equation (allow with no brackets)
	$x(\log 7 - \log 2) = \log 2$	M1		**Either** expand bracket and attempt to gather x terms, **or** deal correctly with algebraic fraction
	$x = 0.553$	A1	**5**	Obtain $x = 0.55$, or rounding to this, with no errors seen
			[5]	
4	**(i)** $(x^2-5)^3 = (x^2)^3 + 3(x^2)^2(-5) + 3(x^2)(-5)^2 + (-5)^3$	M1*		Attempt expansion, with product of powers of x^2 and $\pm$ 5, at least 3 terms
	$= x^6 - 15x^4 + 75x^2 - 125$	M1*		Use at least 3 of binomial coeffs of 1, 3, 3, 1
		A1dep*		Obtain at least two correct terms, coeffs simplified
		A1	**4**	Obtain fully correct expansion, coeffs simplified
	OR			
	$(x^2-5)^3 = (x^2-5)(x^4 - 10x^2 + 25)$	M2		Attempt full expansion of all 3 brackets
	$= x^6 - 15x^4 + 75x^2 - 125$	A1		Obtain at least two correct terms
		A1		Obtain full correct expansion
	(ii) $\int (x^2-5)^3\,dx = \frac{1}{7}x^7 - 3x^5 + 25x^3 - 125x + c$	M1		Attempt integration of terms of form kx^n
		A1√		Obtain at least two correct terms, allow unsimplified coeffs
		A1		Obtain $\frac{1}{7}x^7 - 3x^5 + 25x^3 - 125x$
		B1	**4**	$+ c$, and no dx or ∫ sign
			[8]	

5	**(i)**	$2x = 30^o, 150^o$	M1		Attempt $\sin^{-1} 0.5$, then divide or multiply by 2
		$x = 15^o, 75^o$	A1		Obtain 15^o (allow $^{\pi}/_{12}$ or 0.262)
			A1	**3**	Obtain 75^o (not radians), and no extra solutions in range
	(ii)	$2(1 - \cos^2 x) = 2 - \sqrt{3}\cos x$	M1		Use $\sin^2 x = 1 - \cos^2 x$
		$2\cos^2 x - \sqrt{3}\cos x = 0$	A1		Obtain $2\cos^2 x - \sqrt{3}\cos x = 0$ or equiv (no constant terms)
		$\cos x\,(2\cos x - \sqrt{3}) = 0$	M1		Attempt to solve quadratic in $\cos x$
		$\cos x = 0$, $\cos x = ½\sqrt{3}$	A1		Obtain 30^o (allow $^{\pi}/_{6}$ or 0524), and no extra solns in range
		$x = 90^o$, $x = 30^o$	B1	**5**	Obtain 90^o (allow $^{\pi}/_{2}$ or 1.57), from correct quadratic only
				SR	answer only B1 one correct solution
					B1 second correct solution, and no others
				8	
6		$\int (3x^2 + a)\, dx = x^3 + ax + c$	M1		Attempt to integrate
			A1		Obtain at least one correct term, allow unsimplified
			A1		Obtain $x^3 + ax$
		$(-1, 2) \Rightarrow -1 - a + c = 2$	M1		Substitute at least one of (–1, 2) or (2, 17) into integration attempt involving a and c
		$(2, 17) \Rightarrow 8 + 2a + c = 17$	A1		Obtain two correct equations, allow unsimplified
			M1		Attempt to eliminate one variable from two equations in a and c
		$a = 2$, $c = 5$	A1		Obtain $a = 2$, $c = 5$, from correct equations
		Hence $y = x^3 + 2x + 5$	A1	**8**	State $y = x^3 + 2x + 5$
				8	
7	**(i)**	$f(-2) = -16 + 36 - 22 - 8$	M1		Attempt f(-2), or equiv
		$= -10$	A1	**2**	Obtain -10
	(ii)	$f(½) = ¼ + 2¼ + 5½ - 8 = 0$ AG	M1		Attempt f(½) (no other method allowed)
			A1	**2**	Confirm f(½) = 0, extra line of working required
	(iii)	$f(x) = (2x - 1)(x^2 + 5x + 8)$	M1		Attempt complete division by $(2x - 1)$ or $(x - ½)$ or equiv
			A1		Obtain $x^2 + 5x + c$ or $2x^2 + 10x + c$
			A1	**3**	State $(2x - 1)(x^2 + 5x + 8)$ or $(x - ½)(2x^2 + 10x + 16)$
	(iv)	f(x) has one real root (x = ½)	B1√		State 1 root, following their quotient, ignore reason
		because $b^2 - 4ac = 25 - 32 = -7$			
		hence quadratic has no real roots as $-7 < 0$,	B1√	**2**	Correct calculation, eg discriminant or quadratic formula, following their quotient, or cubic has max at (-2.15, -9.9)
				9	

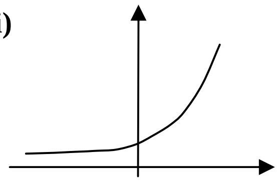
8 **(i)**	$\frac{1}{2} \times r^2 \times 1.2 = 60$	M1		Attempt $(\frac{1}{2})\, r^2\theta = 60$
	$r = 10$	A1		Obtain $r = 10$
	$r\theta = 10 \times 1.2 = 12$	B1√		State or imply arc length is $1.2r$, following their r
	perimeter = 10 + 10 + 12 = 32 cm	A1	**4**	Obtain 32
(ii)(a)	$u_5 = 60 \times 0.6^4$	M1		Attempt u_5 using ar^4, or list terms
	$= 7.78$	A1	**2**	Obtain 7.78, or better
(b)	$S_{10} = \dfrac{60(1-0.6^{10})}{1-0.6}$	M1		Attempt use of correct sum formula for a GP, or sum terms
	$= 149$	A1	**2**	Obtain 149, or better (allow 149.0 – 149.2 inclusive)
(c)	common ratio is less than 1, so series is convergent and hence sum to infinity exists	B1		series is convergent or $-1 < r < 1$ (allow $r < 1$) or reference to areas getting smaller / adding on less each time
	$S_\infty = \dfrac{60}{1-0.6}$	M1		Attempt S_∞ using $\dfrac{a}{1-r}$
	$= 150$	A1	**3**	Obtain $S_\infty = 150$
				SR B1 only for 150 with no method shown
			11	
9 **(i)**		B1		Sketch graph showing exponential growth (both quadrants)
		B1	**2**	State or imply (0, 4)
(ii)	$4k^x = 20k^2$			
	$k^x = 5k^2$	M1		Equate $4k^x$ to $20k^2$ and take logs (any, or no, base)
	$x = \log_k 5k^2$			
	$x = \log_k 5 + \log_k k^2$	M1		Use $\log ab = \log a + \log b$
	$x = 2\log_k k + \log_k 5$	M1		Use $\log a^b = b \log a$
	$x = 2 + \log_k 5$ AG	A1	**4**	Show given answer correctly
OR	$4k^x = 20k^2$			
	$k^x = 5k^2$	M1		Attempt to rewrite as single index
	$k^{x-2} = 5$	A1		Obtain $k^{x-2} = 5$ or equiv eg $4k^{x-2} = 20$
	$x - 2 = \log_k 5$	M1		Take logs (to any base)
	$x = 2 + \log_k 5$ AG	A1		Show given answer correctly
(iii) (a)	area $\approx \frac{1}{2} \times \frac{1}{2} \times \left(4k^0 + 8k^{\frac{1}{2}} + 4k^1\right)$	M1		Attempt y-values at $x = 0$, ½ and 1, and no others
		M1		Attempt to use correct trapezium rule, 3 y-values, $h = \frac{1}{2}$
	$\approx 1 + 2k^{\frac{1}{2}} + k$	A1	**3**	Obtain a correct expression, allow unsimplified
(b)	$1 + 2k^{\frac{1}{2}} + k = 16$	M1		Equate attempt at area to 16
	$\left(k^{\frac{1}{2}} + 1\right)^2 = 16$	M1		Attempt to solve 'disguised' 3 term quadratic
	$k^{\frac{1}{2}} = 3$			
	$k = 9$	A1	**3**	Obtain $k = 9$ only
			12	

4722 Core Mathematics 2

1	**(i)**	$2(1 - \cos^2 x) = 5\cos x - 1$ $2\cos^2 x + 5\cos x - 3 = 0$ **A.G.**	M1 A1	 **2**	Use $\sin^2 x = 1 - \cos^2 x$ Show given equation correctly
	(ii)	$(2\cos x - 1)(\cos x + 3) = 0$ $\cos x = ½$ $x = 60^o$ $x = 300^o$	M1 M1 A1 A1√	 **4**	Recognise equation as quadratic in cos x and attempt recognisable method to solve Attempt to find x from root(s) of quadratic Obtain 60^o or $^{\pi}/_3$ or 1.05 rad Obtain 300^o only (or 360^o – their x) and no extra in range **SR** answer only is B1 B1
				6	
2	**(i)**	$\int (6x - 4)\,dx = 3x^2 - 4x + c$ $y = 3x^2 - 4x + c \Rightarrow 5 = 12 - 8 + c$ $\Rightarrow c = 1$ Hence $y = 3x^2 - 4x + 1$	M1* A1 M1dep* A1	 **4**	Attempt integration (inc. in power for at least one term) Obtain $3x^2 - 4x$ (or unsimplified equiv), with or without + c Use (2, 5) to find c Obtain $y = 3x^2 - 4x + 1$
	(ii)	$3p^2 - 4p + 1 = 5$ $3p^2 - 4p - 4 = 0$ $(p - 2)(3p + 2) = 0$ $p = ^{-2}/_3$	M1* M1dep* A1	 **3**	Equate their y (from integration attempt) to 5 Attempt to solve three term quadratic Obtain $p = ^{-2}/_3$ (allow any variable) from correct working; condone $p = 2$ still present, but A0 if extra incorrect solution
				7	
3	**(i)**	$(2 - x)^7 = 128 - 448x + 672x^2 - 560x^3$	M1 A1 A1 A1	 **4**	Attempt (at least) two relevant terms – product of binomial coeff, 2 and x (or expansion attempt that considers all 7 brackets) Obtain $128 - 448x$ Obtain $672x^2$ Obtain $-560x^3$
	(ii)	$-560 \times (^1/_4)^3 = ^{-35}/_4$	M1 A1	 **2**	Attempt to use coeff of x^3 from **(i)**, with clear intention to cube $^1/_4$ Obtain $^{-35}/_4$ (w^6), (allow $^{35}/_4$ from $+560x^3$ in **(i)**)
				6	

4	**(i)** $\int_3^5 \log_{10}(2+x)\,dx \approx \frac{1}{2}\times\frac{1}{2}\times(\log 5 + 2\log 5.5 +$	M1		Attempt y-coords for at least 4 of the correct 5 x-coords only
	$2\log 6 + 2\log 6.5 + \log 7)$	M1		Use correct trapezium rule, any h, to find area between $x = 3$ and $x = 5$
		M1		Correct h (soi) for their y-values
	≈ 1.55	A1	**4**	Obtain 1.55
	(ii) $\int_3^5 \log_{10}(2+x)^{\frac{1}{2}}\,dx = \frac{1}{2}\int_3^5 \log_{10}(2+x)\,dx$	B1√		Divide by 2, or equiv, at any stage to obtain 0.78 or 0.77,
	$\approx \frac{1}{2} \times 1.55$			following their answer to **(i)**
	≈ 0.78	B1	**2**	Explicitly use $\log\sqrt{a} = \frac{1}{2}\log a$ on a single term
			6	
5	$\int_1^3 \{(11-9x^{-2})-(x^2+1)\}\,dx = \left[9x^{-1} - \frac{1}{3}x^3 + 10x\right]_1^3$	M1		Attempt subtraction (correct order) at any point
	$= (3 - 9 + 30) - (9 - \frac{1}{3} + 10)$	M1		Attempt integration – inc. in power for at least one term
	$= 24 - 18\frac{2}{3}$	A1		Obtain $\pm(-\frac{1}{3}x^3 + 10x)$ or $11x$ and $\frac{1}{3}x^3 + x$
	$= 5\frac{1}{3}$	M1		Obtain remaining term of form kx^{-1}
	OR	A1		Obtain $\pm 9x^{-1}$ or any unsimplified equiv
	$\left[11x + 9x^{-1}\right]_1^3 - \left[\frac{1}{3}x^3 + x\right]_1^3$	M1		Use limits $x = 1, 3$ – correct order & subtraction
	$= [(33 + 3) - (11 + 9)] - [(9 + 3) - (\frac{1}{3} + 1)]$	A1	**7**	Obtain $5\frac{1}{3}$, or exact equiv
	$= 16 - 10\frac{2}{3}$			
	$= 5\frac{1}{3}$			
			7	
6	**(i)** $f(-3) = 0 \Rightarrow -54 + 9a - 3b + 15 = 0$	M1		Attempt $f(-3)$ and equate to 0, or equiv method
	$3a - b = 13$	A1		Obtain $3a - b = 13$, or unsimplified equiv
	$f(2) = 35 \Rightarrow 16 + 4a + 2b + 15 = 35$	M1		Attempt $f(2)$ and equate to 35, or equiv method
	$2a + b = 2$	A1		Obtain $2a + b = 2$, or unsimplified equiv
	Hence $a = 3$, $b = -4$	M1		Attempt to solve simultaneous eqns
		A1	**6**	Obtain $a = 3$, $b = -4$
	(ii) $f(x) = (x + 3)(2x^2 - 3x + 5)$	M1		Attempt complete division by $(x + 3)$, or equiv
		A1		Obtain $2x^2 - 3x + c$ or $2x^2 + bx + 5$, from correct $f(x)$
	ie quotient is $(2x^2 - 3x + 5)$	A1	**3**	Obtain $2x^2 - 3x + 5$ (state or imply as quotient)
			9	

7	(i)	$13^2 = 10^2 + 14^2 - 2 \times 10 \times 14 \times \cos\theta$	M1		Attempt to use correct cosine rule in ΔABC
		$\cos\theta = 0.4536$			
		$\theta = 1.10$ **A.G.**	A1	**2**	Obtain 1.10 radians (allow 1.1 radians) **SR** B1 only for verification of 1.10, unless complete method
	(ii)	arc $EF = 4 \times 1.10 = 4.4$	B1		State or imply EF = 4.4cm (allow 4×1.10)
		perimeter = 4.4 + 10 + 13 + 6	M1		Attempt perimeter of region - sum of arc and three sides with attempt to subtract 4 from at least one relevant side
		= 33.4 cm	A1	**3**	Obtain 33.4 cm
	(iii)	area $AEF = ½ \times 4^2 \times 1.1$	M1		Attempt use of $(½)\, r^2\theta$, with $r = 4$ and $\theta = 1.10$
		= 8.8	A1		Obtain 8.8
		area $ABC = ½ \times 10 \times 14 \times \sin 1.1$	M1		Attempt use of $(½)ab\sin\theta$, sides consistent with angle used
		= 62.4	A1		Obtain 62.4 or better (allow 62.38 or 62.39)
		hence total area = 53.6 cm^2	A1	**5**	Obtain total area as 53.6 cm^2
				10	
8	(i)	$u_5 = 8 + 4 \times 3$	M1		Attempt $a + (n-1)d$ or equiv inc list of terms
		= 20 **A.G.**	A1	**2**	Obtain 20
	(ii)	$u_n = 3n + 5$ ie $p = 3$, $q = 5$	B1		Obtain correct expression, poss unsimplified, eg $8 + 3(n-1)$
			B1	**2**	Obtain correct $3n + 5$, or $p = 3$, $q = 5$ stated
	(iii)	arithmetic progression	B1	**1**	Any mention of arithmetic
	(iv)	$\frac{2N}{2}\left(16+(2N-1)3\right)-\frac{N}{2}\left(16+(N-1)3\right)=1256$	M1		Attempt S_N, using any correct formula (inc $\sum (3n+5)$)
			M1		Attempt S_{2N} , using any correct formula, with $2N$ consistent (inc $\sum (3n+5)$)
		$26N + 12N^2 - 13N - 3N^2 = 2512$			
		$9N^2 + 13N - 2512 = 0$	M1*		Attempt subtraction (correct order) and equate to 1256
		$(9N + 157)(N - 16) = 0$	M1dep*		Attempt to solve quadratic in N
		$N = 16$	A1	**5**	Obtain N = 16 only, from correct working
			OR: alternative method is to use $^n/_2\,(a + l) = 1256$		
			M1		Attempt given difference as single summation with N terms
			M1		Attempt $a = u_{N+1}$
			M1		Attempt $l = u_{2N}$
			M1		Equate to 1256 and attempt to solve quadratic
			A1		Obtain N = 16 only, from correct working
				10	

9	(i)		M1		Reasonable graph in both quadrants
			A1		Correct graph in both quadrants
			B1	**3**	State or imply (0, 6)
	(ii)	$9^x = 150$	M1		Introduce logarithms throughout, or equiv with $\log_9$
		$x \log 9 = \log 150$	M1		Use $\log a^b = b \log a$ and attempt correct method to find x
		$x = 2.28$	A1	**3**	Obtain $x = 2.28$
	(iii)	$6 \times 5^x = 9^x$	M1		Form eqn in x and take logs throughout (any base)
		$\log_3 (6 \times 5^x) = \log_3 9^x$	M1		Use $\log a^b = b \log a$ correctly on $\log 5^x$ or $\log 9^x$ or legitimate combination of these two
		$\log_3 6 + x \log_3 5 = x \log_3 9$	M1		Use $\log ab = \log a + \log b$ correctly on $\log (6 \times 5^x)$ or $\log 6$
		$\log_3 3 + \log_3 2 + x \log_3 5 = 2x$	M1		Use $\log_3 9 = 2$ or equiv (need base 3 throughout that line)
		$x (2 - \log_3 5) = 1 + \log_3 2$			
		$x = \dfrac{1+\log_3 2}{2-\log_3 5}$ **A.G.**	A1	**5**	Obtain $x = \dfrac{1+\log_3 2}{2-\log_3 5}$ convincingly (inc base 3 throughout)
				11	

1 (i)	f(2) = 8 + 4a – 2a –14 2a – 6 = 0 a = 3	**M1***		Attempt f(2) or equiv, including inspection / long division / coefficient matching
		M1d*		Equate attempt at f(2), or attempt at remainder, to 0 and attempt to solve
		A1	**3**	Obtain a = 3
(ii)	f(-1) = -1 + 3 + 3 – 14 = -9	**M1**		Attempt f(-1) or equiv, including inspection / long division / coefficient matching
		A1 ft	**2**	Obtain -9 (or 2a – 15, following their a)
			5	
2 (i)	area $\approx \frac{1}{2}\times 3\times\left(\sqrt[3]{8}+2\left(\sqrt[3]{11}+\sqrt[3]{14}\right)+\sqrt[3]{17}\right)$	**B1**		State or imply at least 3 of the 4 correct y-coords , and no others
		M1		Use correct trapezium rule, any h, to find area between x = 1 and x = 10
	$\approx$ 20.8	**M1**		Correct h (soi) for their y-values – must be at equal intervals
		A1	**4**	Obtain 20.8 (allow 20.7)
(ii)	use more strips / narrower strips	**B1**	**1**	Any mention of increasing n or decreasing h
			5	
3 (i)	$(1 + ½x)^{10} = 1 + 5x + 11.25x^2 + 15x^3$	**B1**		Obtain 1 + 5x
		M1		Attempt at least the third (or fourth) term of the binomial expansion, including coeffs
		A1		Obtain $11.25x^2$
		A1		Obtain $15x^3$
			4	
(ii)	coeff of x^3 = (3 x 15) + (4 x 11.25) + (2 x 5) = 100	**M1**		Attempt at least one relevant term, with or without powers of x
		A1 ft		Obtain correct (unsimplified) terms (not necessarily summed) – either coefficients or still with powers of x involved
		A1	**3**	Obtain 100
			7	

4 (i)	$u_1 = 6$, $u_2 = 11$, $u_3 = 16$	**B1**	**1**	State 6, 11, 16
(ii)	$S_{40} = {}^{40}/_2\,(2 \times 6 + 39 \times 5)$ $= 4140$	**M1**		Show intention to sum the first 40 terms of a sequence
		M1		Attempt sum of their AP from (i), with $n = 40$, a = their u_1 and d = their $u_2 - u_1$
		A1	**3**	Obtain 4140
(iii)	$w_3 = 56$ $5p + 1 = 56$ or $6 + (p - 1) \times 5 = 56$ $p = 11$	**B1**		State or imply $w_3 = 56$
		M1		Attempt to solve $u_p = k$
		A1	**3**	Obtain $p = 11$
			7	
5 (i)	$\dfrac{\sin\theta}{8} = \dfrac{\sin 65}{11}$	**M1**		Attempt use of correct sine rule
	$\theta = 41.2^\circ$	**A1**	**2**	Obtain 41.2°, or better
(ii) a	$180 - (2 \times 65) = 50^\circ$ or $65 \times {}^{\pi}/_{180} = 1.134$ $50 \times {}^{\pi}/_{180} = 0.873$ **A.G.** $\pi - (2 \times 1.134) = 0.873$	**M1**		Use conversion factor of ${}^{\pi}/_{180}$
		A1	**2**	Show 0.873 radians convincingly (**AG)**
(ii) b	area sector = $\frac{1}{2} \times 8^2 \times 0.873 = 27.9$ area triangle = $\frac{1}{2} \times 8^2 \times \sin 0.873 = 24.5$ area segment = $27.9 - 24.5$ $= 3.41$	**M1**		Attempt area of sector, using $(\frac{1}{2})\, r^2\theta$
		M1		Attempt area of triangle using $(\frac{1}{2})\, r^2\sin\theta$
		M1		Subtract area of triangle from area of sector
		A1	**4**	Obtain 3.41or 3.42
			8	

6 a	$\int_3^5 (x^2+4x)\,dx = \left[\frac{1}{3}x^3 + 2x^2\right]_3^5$	**M1**		Attempt integration
	$= (^{125}/_3 + 50) - (9 + 18)$	**A1**		Obtain $^1/_3x^3 + 2x^2$
	$= 64\,^2/_3$	**M1**		Use limits $x = 3, 5$ – correct order & subtraction
		A1	**4**	Obtain $64\,^2/_3$ or any exact equiv
b	$\int (2-6\sqrt{y})\,dy = 2y - 4y^{\frac{3}{2}} + c$	**B1**		State $2y$
		M1		Obtain $ky^{\frac{3}{2}}$
		A1	**3**	Obtain $-4y^{\frac{3}{2}}$ (condone absence of + c)
c	$\int_1^\infty 8x^{-3}\,dx = \left[\frac{-4}{x^2}\right]_1^\infty$	**B1**		State or imply $\frac{1}{x^3} = x^{-3}$
	$= (0) - (-4)$	**M1**		Attempt integration of kx^n
	$= 4$	**A1**		Obtain correct $-4x^{-2}$ $(+c)$
		A1 ft	**4**	Obtain 4 (or $-k$ following their kx^{-2})
			11	
7 (i)	$\frac{\sin^2 x - \cos^2 x}{1-\sin^2 x} = \frac{\sin^2 x - \cos^2 x}{\cos^2 x}$	**M1**		Use either $\sin^2x + \cos^2x = 1$, or $\tan x = {}^{\sin x}/_{\cos x}$
	$= \frac{\sin^2 x}{\cos^2 x} - \frac{\cos^2 x}{\cos^2 x}$			
	$= \tan^2 x - 1$	**A1**	**2**	Use other identity to obtain given answer convincingly.
(ii)	$\tan^2 x - 1 = 5 - \tan x$	**B1**		State correct equation
	$\tan^2 x + \tan x - 6 = 0$ $(\tan x - 2)(\tan x + 3) = 0$	**M1**		Attempt to solve three term quadratic in $\tan x$
	$\tan x = 2$, $\tan x = -3$	**A1**		Obtain 2 and -3 as roots of their quadratic
	$x = 63.4^\circ, 243^\circ$ $x = 108^\circ, 288^\circ$	**M1**		Attempt to solve $\tan x = k$ (at least one root)
		A1ft		Obtain at least 2 correct roots
		A1	**6**	Obtain all 4 correct roots
			8	

8 a	$\log 5^{3w-1} = \log 4^{250}$	**M1***		Introduce logarithms throughout
	$(3w-1)\log 5 = 250 \log 4$	**M1***		Use $\log a^b = b \log a$ at least once
	$3w - 1 = \frac{250\log 4}{\log 5}$	**A1**		Obtain $(3w-1)\log 5 = 250 \log 4$ or equiv
	$w = 72.1$	**M1d***		Attempt solution of linear equation
		A1	**5**	Obtain 72.1, or better
b	$\log_x \frac{5y+1}{3} = 4$	**M1**		Use $\log a - \log b = \log {}^a/_b$ or equiv
	$\frac{5y+1}{3} = x^4$	**M1**		Use $f(y) = x^4$ as inverse of $\log_x f(y) = 4$
	$5y + 1 = 3x^4$	**M1**		Attempt to make y the subject of $f(y) = x^4$
	$y = \frac{3x^4 - 1}{5}$	**A1**	**4**	Obtain $y = \frac{3x^4-1}{5}$, or equiv
			9	
9 (i)	$ar = a + d, \quad ar^3 = a + 2d$ $2ar - ar^3 = a$ $ar^3 - 2ar + a = 0$ $r^3 - 2r + 1 = 0$ **A.G.**	**M1**		Attempt to link terms of AP and GP, implicitly or explicitly.
		M1		Attempt to eliminate d, implicitly or explicitly, to show given equation.
		A1	**3**	Show $r^3 - 2r + 1 = 0$ convincingly
(ii)	$f(r) = (r-1)(r^2 + r - 1)$	**B1**		Identify $(r-1)$ as factor or $r = 1$ as root
		M1*		Attempt to find quadratic factor
	$r = \frac{-1 \pm \sqrt{5}}{2}$	**A1**		Obtain $r^2 + r - 1$
	Hence $r = \frac{-1+\sqrt{5}}{2}$	**M1d***		Attempt to solve quadratic
		A1	**5**	Obtain $r = \frac{-1+\sqrt{5}}{2}$ only
(iii)	$\frac{a}{1-r} = 3 + \sqrt{5}$	**M1**		Equate S_∞ to $3+\sqrt{5}$
	$a = (\frac{3}{2} - \frac{\sqrt{5}}{2})(3+\sqrt{5})$	**A1**		Obtain $\frac{a}{1-\left(\frac{-1+\sqrt{5}}{2}\right)} = 3+\sqrt{5}$
	$a = {}^9/_2 - {}^5/_2$ $a = 2$	**M1**		Attempt to find a
		A1	**4**	Obtain $a = 2$
			12	

1 (i)	$(1 + 2x)^7 = 1 + 14x + 84x^2$	**B1**		Obtain $1 + 14x$	Needs to be simplified, so 1 not 1^7 and $14x$ not 7 x $2x$. B0 if other constant and/or x terms (from terms being sums not products). Must be linked by + sign, so 1, $14x$ is B0, but can still get M1A1 for third term.
		M1		Attempt third term	Needs to be product of 21 and an attempt at squaring $2x$ – allow even if brackets never seen, so $42x^2$ gets M1. No need to see powers of 1 explicitly.
		A1	**3**	Obtain $84x^2$	Coefficient needs to be simplified. Ignore any further terms, right or wrong. Can isw if they subsequently attempt 'simplification' eg dividing by 14, but they won't then get the ft mark in part (ii). If manually expanding brackets they need to consider all 7, but may not necessarily show irrelevant terms. If the expansion is attempted in descending powers, only giving the first three will gain no credit in (i), unless they subsequently attempt the relevant terms in (ii) when we will then give appropriate credit for the marks in (i). This only applies if no attempt at the required terms is made in (i). A full expansion with the required terms at the end is marked as per original scheme.
(ii)	$(2 - 5x)(1 + 14x + 84x^2)$ coeff of $x^2 = -70 + 168$ $= 98$	**M1**		Attempt at least one relevant product	Could be just a single term, or part of a fuller expansion considering terms other than x^2 as well. Allow M1 even if second x^2 term isn't from a relevant product eg -70 + 84 gets M1 A0.
		A1ft		Obtain two correct unsimplified terms (not necessarily summed) – either coefficients or still with powers of x involved	Needs to come from two terms only, and can be awarded for unsimplified terms eg $-5x$ x $14x$… If fuller expansion then A0 if other x^2 terms, but ignore any irrelevant terms. If expansion is incorrect in (i) and candidate only gives a single final answer in (ii) then examiners need to check and award either M1 A1ft or M0.
		A1	**3** **6**	Obtain 98	Allow $98x^2$. Allow if part of a fuller expansion and not explicitly picked out. If clearly finding coefficient of x, allow as misread.

2 (i)	$u_1 = 5$, $u_2 = 8$, $u_3 = 11$	**B1**		Obtain at least one correct term	Just a list of numbers is fine, no need for labels.
		B1	**2**	Obtain all three correct terms	Ignore extra terms beyond u_3.
(ii)	arithmetic progression	**B1**	**1**	Any mention of arithmetic	Allow AP, but not description eg constant difference. Ignore extra description eg diverging as long as not wrong or contradictory.
(iii)	$S = {}^{100}/_2\,(305 + 602)$ or ${}^{100}/_2(2\text{x}305 + 99\text{x}3)$ $= 45{,}350$ (or $S_{200} - S_{100} = 60{,}700 - 15{,}350$)	**M1**		Attempt relevant S_n using correct formula	Must use correct formula to sum an AP – only exception is using $(\frac{1}{2}\,n - 1)d$ rather than $(n - 1)d$. Must use $d = 3$ (or their d from (i) as long as constant difference). If (i) is incorrect they can still get full marks in (iii) as independent. They need to be finding the sum of 99, 100, 101 or 200 terms and make a reasonable attempt at a value of a consistent with their n – if $n = 99$ then $a = 305$ / if $n = 100$ then $a = 5$ or $a = 305$ / if $n = 101$ then $a = 5$ / if $n = 200$ then $a = 5$. Allow slips on $a = 305$ as long as clearly intending to find u_{101}. If using $\frac{1}{2}\,n\,(a + l)$ then there also needs to be a reasonable attempt at l. Attempting to sum from $n = 101$ to $n = 200$ gets both method marks together (assuming that the attempt satisfies above conditions).
		M1		Attempt correct method to find required sum	$S_{200} - S_{101}$ is M0. M0 M1 is possible for correct method but with incorrect formula for S_N (but must be recognisable as attempt at sum of AP). Need to show subtraction to gain M1, just calculating two relevant sums is not yet enough. Still need $a = 5$ and $d = 3$.
		A1	**3**	Obtain 45,350	Answer only gets full marks.
			6		**SR:** if candidates attempt to manually add terms… **M1** Attempt to sum all terms from u_{101} to u_{200} **A2** Obtain 45,350

3 (i)	$0.5\times 0.5\times\left\{\sqrt{0}+2\left(\sqrt{0.5}+\sqrt{1}+\sqrt{1.5}\right)+\sqrt{2}\right\}$ =1.82	**M1**		Attempt at least 4 correct *y*-coords, and no others	If first term of 0 not explicit then other 4 terms need to be seen. Could be implied by eg √(4 – 3), or implied by a table with correct *x*-coords in one column and attempts at *y*-coords in second column. Allow rounded or truncated decimals. Allow an error in rearrangement eg √*x* - √3.
		M1		Attempt correct trapezium rule, any *h*, to find area between $x = 3$ and $x = 5$.	Correct structure ie 0.5 x (any *h*) x (first + last + 2 x middles) – no omissions allowed. The first *y*-coord should correspond to attempt when $x = 3$ (though may not be shown explicitly), and last to $x = 5$. It could be implied by using y_0 etc in rule, when these have already been attempted elsewhere and clearly labelled. It could use other than 4 strips, but these must be at equal widths. Using just one strip is M0. The 'big brackets' must be seen, or implied by later working (omission of these can lead to 3.41 or 1.91 or 6.21…). If ½ x *k* seen at start of rule then assume that ½ is part of a correct rule and the *k* is an incorrect strip width.
		M1		Use correct *h* (soi) for their *y*-values – must be at equal intervals	Must be in attempt at the trapezium rule, not Simpson's rule. Allow if muddle over placing *y*-values. Allow if one *y*-value missing (including first or last) or extra. Allow if ½ missing. Using $h = 2$ with only one strip is M0.
		A1	**4**	Obtain 1.82, or better	More accurate solution is 1.819479… Answer only is 0/4. Using integration is 0/4. Using trapezium rule on the result of an integration attempt is 0/4. Using 4 separate trapezia can get full marks. If other than 4 trapezia, mark as above.
(ii)	Underestimate as tops of trapezia are below curve	**B1***		State underestimate	Ignore any reasons given.
		B1d*	**2** **6**	Convincing reason referring to trapezia being below curve	Referring to gaps between curve and trapezia can get B1. Could use sketch with brief explanation (but sketch alone is B0) – must show more than one trapezium (but not nec 4) or imply this in the text. Trapezia must show clear intention to have top vertices on the curve. Sketching rectangles is B0. Triangle is B0. Explanation that refers to calculated area from integration is B0. Only referring to concave / convex is B0. Can get B1 for 'rate of change of gradient (or second derivative) is negative', but not for 'gradient is decreasing'.

4 (a)	$\log 5^{x-1} = \log 120$ $(x-1)\log 5 = \log 120$ $x - 1 = 2.97$ $x = 3.97$	**M1***		Introduce logarithms throughout (or $\log_5 120$ / $\log_{120} 5$) & drop power	Don't need to see base if taking logs on both sides, though if shown it must be the same base. If taking logs on one side only base must be explicit.
		A1		Obtain $(x-1)\log 5 = \log 120$, or equiv (eg $x - 1 = \log_5 120$)	Condone lack of brackets ie $x - 1 \log 5 = \log 120$, as long as clearly implied by later working.
		M1d*		Attempt to solve	Attempt at correct process ie ${}^{\log 120}/_{\log 5} \pm 1$ or equiv ${}^{(\log 120 + \log 5)}/_{\log 5}$. Allow M1 if ${}^{\log 120}/_{\log 5} \pm 1$ subsequently becomes $\log 24 \pm 1$, but M0 if log 24 appears before -1 is dealt with. Allow M1 if processing slips when evaluating ${}^{\log 120}/_{\log 5}$ eg 2.23 from incorrect brackets.
		A1	**4**	Obtain 3.97, or better	Allow more accurate solution, such as 3.975 and then isw if rounded to 3.98. However, 3.98 without more accurate answer seen is A0. Answer only is 0/3. Trial and improvement is 0/3.
(b)	$\log_2 x + \log_2 9 = \log_2(x+5)$ $\log_2(9x) = \log_2(x+5)$ $9x = x + 5$ $x = {}^5/_8$	**B1**		State or imply $2\log 3 = \log 9$ or $\log 3^2$	Could be done at any stage. Must be correct statement when done, so LHS becoming $\log_2(x+9)$ in one step is B0. Condone lack of base throughout question.
		M1		Use $\log a + \log b = \log ab$, or equiv	Must be used to combine 2 (or more) terms of $\log x + \log k = \log(x+5)$, with k most typically (but not exclusively) 6, 8 or 9. Could move $\log_2 x$ and/or $\log_2 9$ across to RHS and then use $\log a - \log b$, but must still be $\log_2(x+5)$ as single term.
		A1		Obtain correct equation with single log term on each side (or single log = 0)	$\log_2(9x) = \log_2(x+5)$, $\log_2 x = \log_2 {}^{(x+5)}/_9$, $\log_2 9 = \log_2 {}^{(x+5)}/_x$, $\log_2 {}^{(x+5)}/_{9x} = 0$. Allow A1 for correct equation with logs removed if several steps run together.
		A1	**4**	Obtain $x = {}^5/_8$	Allow 0.625
			8		

5 (i)	$4a = \dfrac{a}{1-r}$	M1		Equate $\dfrac{a}{1-r}$ to $4a$, or substitute $r = \frac{3}{4}$ into S_∞	S_∞ must be quoted correctly. Allow $4ar^0$ for $4a$. Initially using a numerical value for a is M0. Once equation in a is seen ie $4a = \dfrac{a}{1-r}$ assume that a has been cancelled if this subsequently becomes $4 = \dfrac{1}{1-r}$. If initial equation in a is never seen then assume that a =1 is being used and mark accordingly.
	$1 - r = \frac{1}{4}$	M1		Attempt to find value for r or evaluate S_∞	Need to get as far as attempting r. Need to see at least one extra line of working between initial statement and given answer. Substituting numerical value for a is M0 (so M1 M0 possible depending at what stage the substitution happens).
	$r = \frac{3}{4}$	A1	3	Obtain $r = \frac{3}{4}$ (or show $S_\infty = 4a$)	Allow $r = 0.75$.
(ii)	$\left(\frac{3}{4}\right)^2 a = 9$	M1*		Attempt use of ar^2	Must use $r = ¾$ not their incorrect value from (i). Must be clearly intended as ar^2, so $(^{3a}/_4)^2 = 9$ is M0, unless correct expression previously seen. Can use equivalent method with ratio of $^4/_3$ ie $9 \times (^4/_3)^2$.
	$a = 16$	M1d*		Equate to 9 and attempt to find a	Must get as far as attempting value for a.
		A1	3	Obtain $a = 16$	Answer only gets full credit.
(iii)	$S_{20} = \dfrac{16\left(1-\frac{3}{4}^{20}\right)}{1-\frac{3}{4}}$	M1		Attempt use of correct sum formula for a GP	Must be correct formula, with a = their (ii), $r = ¾$ and $n = 20$.
	$= 63.8$	A1	2 **8**	Obtain 63.8, or better	More accurate answer is 63.79704… **NB** using $n - 1$ rather than n in the formula gives 63.729 (M0), and using $n + 1$ gives 63.848 (M0). Must be decimal, rather than exact answer with power of ¾ .

6(a)	$\int \frac{x^3+3x^{\frac{1}{2}}}{x}\,dx = \int \left(x^2 + 3x^{-\frac{1}{2}}\right)dx$	**M1**		Simplify and attempt integration	Need to attempt to divide both terms by x, or multiply entire numerator by x^{-1} – allow if intention is clear even if errors when simplifying, or one term doesn't actually change. Need to simplify each of the two terms as far as x^n before integrating. For integration attempt, need to increase power by 1 for at least one term.
	$= \frac{1}{3}x^3 + 6x^{\frac{1}{2}} + c$	**A1**		Obtain at least one correct term	Allow unsimplified terms.
		A1		Obtain $\frac{1}{3}x^3 + 6x^{\frac{1}{2}}$	Coefficients must now be simplified. Could be $6\sqrt{x}$ for second term.
		B1	**4**	Obtain $+ c$	Not dependent on previous marks as long as no longer original function. B0 if integral sign or dx still present in answer. Ignore anything that appears on LHS of an equation eg $y = \ldots$, d$x = \ldots$ or even $\int = \ldots$
(b)(i)	$\int_2^a 6x^{-4}dx = \left[-2x^{-3}\right]_2^a$	**M1**		Obtain integral of the form kx^{-3}	Any k, as long as numerical, including unsimplified. Allow $+ c$. Condone integral sign or dx still present.
	$= \frac{1}{4} - 2a^{-3}$	**M1**		Attempt F(a) – F(2)	Must be correct order and subtraction. $-2a^{-3} - {}^2/_8$ is M0 unless clear evidence suggesting that there was an intention to subtract and that this is a sign error. Not dependent on first M mark, so substituting into their integration attempt (eg kx^{-5}) can still get M1, but using kx^{-4} is M0.
		A1	**3**	Obtain $\frac{1}{4} - 2a^{-3}$	Allow ${}^2/_8$ for ¼ , but not – ($-{}^2/_8$), but want 2 not ${}^6/_3$. A0 if $+ c$, integral sign or dx still present. isw any subsequent work, usually equating to 0 or writing as inequality.
(b)(ii)	$\frac{1}{4}$	**B1ft**	**1** **8**	State $\frac{1}{4}$, following their **(i)**	Allow ${}^2/_8$. Do not allow 0 + ¼ . Must appreciate that limit is required not inequality so <, ≈ , tends to ¼ , → ¼ etc are all B0. Picking large number for a and then concluding correctly is B1. Condone denominator changing from ∞ to 0 (or even 0 being used as top limit) if final answer correct. For the ft mark their (i) must be of form $a \pm bx^{-n}$, with $n \neq 4$. If solution in (i) is incorrect but candidate restarts in (ii) and produces ¼ oe with no wrong working then allow B1.

7(i)	$\tan 2x = \frac{1}{3}$ $2x = 18.4^o, 198.4^o$ $x = 9.22^o, 99.2^o$	**M1**		Attempt correct solution method	Attempt $\tan^{-1}(^1/_3)$ and then halve answer.
		A1		Obtain one of 9.22^o or 99.2^o, or better	Allow radian equiv (0.161 or 1.73).
		A1ft	**3**	Obtain second correct angle	Maximum of 2 marks if angles not in degrees. A0 if extra solutions in given range, but ignore extra outside range If M1 A0 given, award A1ft for adding 90^o or $^{\pi}/_2$ to their angle. **SR:** if no working shown then allow B1 for each correct solution. Maximum of B1 if in radians, or extra solutions in given range. **SR:** if using tan 2*x* identity then… **M1** Attempt to find *x* from solving quadratic equation in tan 2*x*, derived from correct tan 2*x* identity. **A1** Obtain at least one of 9.22^o or 99.2^o, or better (or radian equiv) **A1** Obtain second correct angle
(ii)	$3(1 - \sin^2 x) + 2\sin x - 3 = 0$ $3\sin^2 x - 2\sin x = 0$ $\sin x\,(3\sin x - 2) = 0$ $\sin x = 0$, $\sin x = {}^2/_3$ $x = 0^o, 180^o$ $x = 41.8^o, 138^o$	**M1**		Use $\cos^2 x = 1 - \sin^2 x$, aef	Must be used not just stated. Must be used correctly, so $1 - 3\sin^2 x$ is M0.
		A1		Obtain $3\sin^2 x - 2\sin x = 0$	Allow aef, but must be simplified (ie no constant term; allow 0).
		M1		Attempt to solve equation to find solutions for *x*	Not dependent on first M1 so could get M0 M1 if $\cos^2 x = \sin^2 x - 1$ previously used. Must be quadratic in sin*x* (must have sin*x* term), but can still get M1 if constant term in their quadratic as well. Candidates need to be solving for *x*, so need to $\sin^{-1}$ at least one of the solutions to their quadratic. Must be acceptable method – if factorising then it must give correct lead term and one other on expansion (inc $c = 0$), if using formula then allow sign slips but no other errors. **SR** If solving the quadratic involves cancelling by sin *x* rather than factorising then M0, but give B1 if both 41.8^o and 138^o found (or radian equivs)
		A1		Obtain two of $0^o, 180^o, 41.8^o, 138^o$	Must come from correct factorisation of correct quadratic equation ie $\sin x\,(3\sin x + 2) = 0$ leading to $\sin x = 0$ and hence $x = 0^o, 180^o$ is A0. Allow radian equivs – 0, π (or 3.14), 0.73, 2.41.
		A1	**5** **8**	Obtain all four angles	Must now all be in degrees, with no extra in given range (ignore any outside range). **SR** If no working out seen, then allow B1 for each of 41.8^o and 138^o, and B1 for both 0^o and 180^o. Maximum of B2 if in radians or extra solutions in given range.

8(i)	½ x 5^2 x sin θ = 8 sin θ = 0.64 θ = π – 0.694 = 2.45	**M1***		Attempt to solve (½)r^2sin θ = 8 to find a value for θ	Allow M1 if using r^2sin θ = 8. Need to get as far as attempting θ (acute or obtuse).
		M1d*		Attempt to find obtuse angle from their principal value.	ie π – θ in radians, or 180° – θ in degrees (eg 140.2°).
		A1	**3**	Obtain θ = 2.45, or better	Allow answer rounding to 2.45 with no errors seen. Must be in radians, and clearly intended as only final solution (eg underlined if acute angle still present). A0 if angle then becomes 2.45π ie this is not isw.
(ii)	½ x 5^2 x 2.447 = 30.6 hence area = 30.6 – 8 = 22.6 cm^2	**M1***		Attempt area of sector using (½)$r^2\theta$	Allow M1 if using $r^2\theta$. θ must be numerical and in radians, but allow if incorrect from their attempt at (i) eg 2.45π . Allow equivalent method using fraction of circle – must be $^{\theta}/_{2\pi}$ if using radians or $^{\theta}/_{360}$ if using degrees . Can get M1 if using an acute angle from (i) (gives 8.68 from 0.694 or 8.625 from 0.69). Using an angle of 0.64 is M0 – this is sin θ not θ. However, could still get M1 if using other angle clearly associated with θ in (i).
		M1d*		Attempt area of segment	Subtract 8 from their sector area. Allow M1 if new attempt made at area of triangle, even if their area isn't 8, eg could attempt ½ r^2 (θ – sin θ), with incorrect θ.
		A1	**3**	Obtain area of segment as 22.6	Allow more sig fig as long as it rounds to 22.6 with no errors seen. Units not needed, and ignore if incorrect.
(iii)	arc = 5 x 2.447 = 12.2	**B1ft**		State or imply arc length is 5θ	θ must be numerical and in radians, or equiv method in degrees. ft on their angle in (i), including acute angle – calculation may not be shown explicitly so examiners will need to check.
	chord = 2 x 5sin1.22 = 9.40 or $AB^2 = 5^2 + 5^2 - 2\times5\times5\times\cos 2.447$ or $^{AB}/_{\sin 2.45} = {}^{5}/_{\sin 0.347}$ or ½ x 5 x AB x sin 1.22 = 8	**M1**		Attempt length of chord AB	Any reasonable method, and allow radian / degree muddle when evaluating. If using cosine rule, then must be correct formula even if slip when evaluating. Need to get as far as a^2 = … but not nec √ . If using right-angled trig then must use ½ θ to find relevant side, and double it. Could use sine rule or area of a triangle with angle of ½ (π – θ).
		A1		Obtain 9.40 (allow 9.41)	Allow any answer in range 9.40 ≤ AB ≤ 9.41 (before rounding), including more sig fig, with no errors seen.
	perimeter = 12.2 + 9.40 = 21.6 cm	**A1**	**4**	Obtain perimeter as 21.6 (allow 21.7)	Allow any answer in range 21.6 ≤ perimeter ≤ 21.7 (before rounding), inc more sig fig, with no errors seen.
			10		

9(i)	f(3) = –108 + 81 + 30 – 3 = 0 hence $(x – 3)$ is a factor	**B1**		Show that f(3) = 0, detail required	Substitute $x = 3$ and confirm f(3) = 0 – must show detail of substitution rather than just state f(3) = 0. Allow $f(3) = -4 \times 3^3 + 9 \times 3^2 + 10 \times 3 – 3 = 0$ for B1.
		B1	**2**	State $(x – 3)$ as factor (allow $(3 – x)$ as the factor)	Not dependent on first B1. Must be seen in (i) so no back credit from (ii). Allow if not explicitly stated as factor (and allow $f(x) = x – 3$). Ignore other factors if also given at this stage.
(ii)	$f(x) = (x – 3)(–4x^2 – 3x + 1)$ or $f(x) = (3 – x)(4x^2 + 3x – 1)$ or $f(x) = (x + 1)(– 4x^2 + 13x – 3)$ or $f(x) = (– x – 1)(4x^2 – 13x + 3)$ or $f(x) = (1 – 4x)(x^2 – 2x – 3)$ or $f(x) = (4x – 1)(– x^2 + 2x + 3)$	**M1**		Attempt complete division by $(x – 3)$, or equiv (allow division by $(3 – x)$)	Must be a full attempt to find three term quadratic. Can use inspection, but must be a reasonable attempt at middle term, with first and last correct. Can use coefficient matching, but must be full method with reasonable attempts at all 3 coefficients. Allow M1 if actually factorising –f(x).
		A1		Obtain $–4x^2 – 3x + c$ or $–4x^2 + bx + 1$ (or the negative of these if dividing by $(3 – x)$)	c, b non-zero constants. First option is likely to come from division, second option from inspection. Coefficient matching could lead to either. Allow A1 for negative of either of these from factorising –f(x).
		A1	**3**	Obtain $(x – 3)(–4x^2 – 3x + 1)$ (or $(3 – x)(4x^2 + 3x – 1)$)	Needs to be written as a product as per request in question paper. Allow $– (x – 3)(4x^2 + 3x – 1)$, but $(x – 3)(4x^2 + 3x – 1)$ is A0. A0 if now 3 linear factors and product of linear and quadratic never seen. If using one of the other two correct factors then all three marks are available, and apply mark scheme as above ie M1 for full attempt at division or equiv, A1 for lead term plus one other correct and A1 for product of linear and quadratic. **SR:** If candidates initially state three linear factors and then expand to get the product of a linear and quadratic as requested award **B3** if fully correct and simplified otherwise **B0**.
(iii)	$–4x^2 – 3x + 1 = 0$ $(1 – 4x) (x + 1) = 0$ $x = ¼$, $x = –1$	**M1**		Attempt to solve quadratic	If factorising, needs to give two correct terms when brackets expanded. If using formula allow sign slips only – need to substitute and attempt one further step. If completing the square must get to $(x + p) = \pm\sqrt{q}$, with reasonable attempts at p and q.
		A1	**2**	Obtain (¼ , 0), (–1, 0)	Condone only x values given rather than coordinates. Allow if $x = 3$ is still present as well.

(iv)	$\int f(x)dx = -x^4 + 3x^3 + 5x^2 - 3x$	**B1**		Obtain $-x^4 + 3x^3 + 5x^2 - 3x$	Allow unsimplified coefficients. Condone + c.
	$F(3) - F(\frac{1}{4}) = (36) - (^{-101}/_{256}) = 36^{101}/_{256}$ $F(\frac{1}{4}) - F(-1) = (^{-101}/_{256}) - (4) = -4^{101}/_{256}$	**M1***		Attempt F(3) – F(¼) or F(¼) – F(-1)	Allow use of incorrect limits from their (iii). Limits need to be in correct order, and subtraction. Allow slips when evaluating but clear subtraction attempt must be seen or implied at least once. If minimal method shown then it must appear to be a plausible attempt eg F(3) = 198 or even F(3) – F(¼) = 198.4.
		A1		Obtain at least one correct area, including decimal equivs	Obtain $36^{101}/_{256}$ or $^{9317}/_{256}$ or 36.4 or $-4^{101}/_{256}$ or $-^{1125}/_{256}$ or – 4.4 Can get A1 if both areas attempted and one is correct but the other isn't.
		M1d*		Attempt full method to find total area including dealing correctly with negative area	Need to see modulus of negative integral from attempt at F(¼) – F(-1) (just changing sign from –ve to +ve is sufficient). If values incorrect in (iii) then can only get this mark if their integral gives negative value. Need to have positive integral from F(3) – F(¼).
	Hence area = $36^{101}/_{256} + 4^{101}/_{256} = 40^{101}/_{128}$	**A1**	**5** **12**	Obtain $40^{101}/_{128}$ or $^{5221}/_{128}$ or 40.8	Allow exact fraction (including unsimplified ie $^{10442}/_{256}$), or decimal answer to 3dp or better (rounding to 40.8 with no errors seen) **SR:** If candidate attempts F(3) – F(¼) **and** F(-1) – F(¼) as an alternative method for dealing with negative area then mark as **B1** correct integral **M2** complete method **A1** obtain one correct area **A1** obtain correct total area Any attempts using this method must be fully supported by evidence of intention, especially -1 as top limit and ¼ as bottom limit used consistently throughout integration attempt. It should not be awarded if candidate appears to have simply confused their order of subtraction.

1 (i)	$BC^2 = 9^2 + 17^2 - 2 \times 9 \times 17 \times \cos 40^o$ BC = 11.6 cm	**M1**		Attempt use of correct cosine rule	Must be correct formula seen or implied, but allow a slip when evaluating eg omission of 2, or incorrect use of an additional big bracket. Allow M1 even if subsequently evaluated in radian mode (23.96). Allow M1 if expression is not square rooted, as long as it is clear that correct formula was used ie either BC^2 = … or even just a^2 = … if the power disappears from *BC*.
		A1	**2**	Obtain 11.6, or better	Actual answer is 11.644329… so allow more accurate answer as long as it rounds to 11.64
(ii)	area = $\frac{1}{2} \times 9 \times 17 \times \sin 40$ = 49.2 cm^2	**M1**		Attempt triangle area using (½)*ab*sin*C*, or equiv	Condone omission of ½ from this formula, but no other errors allowed. If using right-angled triangle, must use ½*bh* with reasonable attempt at perpendicular sides. Allow M1 if subsequently evaluated in radian mode (57.00). If using 40^o, must be using sides of 9 and 17, not 11.6 from (i). If using another angle, can still get M1 as long as sides used are consistent with this angle.
		A1	**2**	Obtain 49.2, or better	Actual answer is 49.17325… so allow more accurate answer as long as it rounds to 49.17 Must come from correct working only.
(iii)	$\frac{BD}{\sin 40} = \frac{9}{\sin 63}$ BD = 6.49 cm	**M1**		Attempt use of correct sine rule, or equiv, to find length *BD*	No further rearrangement required. Could have both fractions the other way up. Must be angles of 40^o and 63^o if finding *BD* directly. Must be attempting *BD*, so using 77^o to find *AD* is M0 unless attempt is then made to find *BD* by any valid method. Placing *D* on *BC* is M0.
		A1		Obtain correct unsimplified expression involving *BD* as the only unknown	Can still get A1 even if evaluated in radians (40.07). If using a multi-step method (eg use 77^0 to find *AD* and then use cosine rule to find *BD*) then this A mark is only given when a correct (unsimplified) expression involving *BD* as the only unknown is obtained.
		A1	**3**	Obtain 6.49, or better	Actual answer is 6.492756… so allow more accurate answer as long as it rounds to 6.493 Must come from correct working only not eg sin 117.
			7		

2 (i)	$\int\left(6x^{\frac{1}{2}}-1\right)dx = 4x^{\frac{3}{2}} - x + c$	M1		Obtain $kx^{\frac{3}{2}}$	Any k, as long as numerical. Allow both M1 and A1 for equiv eg $x\sqrt{x}$
		A1		Obtain $4x^{\frac{3}{2}}$	Allow for unsimplified coefficient as well (ie $^{6}/_{1.5}$).
		B1	3	Obtain $-x$ (don't penalise lack of + c)	Allow -1x. Maximum of 2 marks if $\int$ or dx still present in final answer. Maximum of 2 marks if not given as one expression – eg the two terms are integrated separately and never combined.
(ii)	$y = 4x^{\frac{3}{2}} - x + c$ $17 = 32 - 4 + c \Rightarrow c = -11$ hence $y = 4x^{\frac{3}{2}} - x - 11$	M1*		State or imply y = their integral from (i)	Must have come from integration attempt ie increase in power by 1 for at least one term, but allow if -1 disappeared in part (i) ie at least one of the M1 and the B1 must have been awarded in part (i). Can still get this M1 if no + c. The y does not have to be explicit – it could be implied by eg 17 = F(4). M0 if they start with y = their integral from (i), but then attempt to use $y - 17 = m(x - 4)$. This is a re-start and gains no credit.
		M1d*		Attempt to find c using (4, 17)	M0 if no + c. M0 if using x = 17, y = 4.
		A1	3	Obtain $y = 4x^{\frac{3}{2}} - x - 11$	Coefficients now need to be simplified, so -1x is A0. Allow A1 for equiv eg $x\sqrt{x}$ Must be an equation ie y = …, so A0 for 'equation = …' or 'f(x) = …'
			6		

3 (i)	perimeter = $2r + r\theta$ $16 + 8\theta = 23.2$ $8\theta = 7.2$ $\theta = 0.9$ rads	**B1***		State or imply that arc length 8θ, or equiv in degrees ie $\frac{\theta}{360} \times 16\pi$	Allow B1 by implication for $\frac{23.2}{8}$ or equivalent in degrees.
		M1d*		Equate attempt at perimeter to 23.2 and attempt to solve for θ	Need to get as far as attempting θ. Must include 2 radii and correct expression for arc length, either in radians or degrees. M0 if using chord length.
		A1	**3**	Obtain $\theta = 0.9$ rads	Obtaining 0.9 and then giving final answer as 0.9π is A0 – do not isw as this shows lack of understanding. Finding θ in degrees (51.6°) and then converting to radians can get A1 as long as final answer is 0.9 (and not eg 0.9006 from premature approximation).
(ii)	$\frac{1}{2} \times 8^2 \times 0.9 = 28.8$	**M1**		Attempt area of sector using $(\frac{1}{2})\, r^2\theta$	Condone omission of ½, but no other error. Allow if incorrect angle from part (i), as long as clearly intended to be in radians. Allow equivalent method using fractions of the area. Allow working in degrees as long as it is a valid method. Allow M1 if using 0.9π (even if 0.9 was answer to (i)), as long as clearly attempting $(\frac{1}{2})\, r^2\theta$ with error on angle rather then $(\frac{1}{2})\, \pi r^2\theta$.
		A1	**2** **5**	Obtain 28.8	Or any exact equiv. If 0.9 obtained incorrectly in part (i), full credit can still be gained in part (ii). Condone minor inaccuracies from working in degrees, as long as final answer is given as 28.8 exactly.

4 (i) $x + 4 = (y + 1)^2$ $x + 4 = y^2 + 2y + 1$ $x = y^2 + 2y - 3$ **A.G.**	**M1**	Attempt to make x the subject	Allow M1 for $x = (y \pm 1)^2 \pm 4$ only. Allow M1 if $(y + 1)^2$ becomes $y^2 + 1$, but only if clearly attempting to square the entire bracket – squaring term by term is M0. Must be from correct algebra, so M0 if eg $\sqrt{(x + 4)} = \sqrt{x} + \sqrt{4}$ is used.
	A1 **2**	Verify $x = y^2 + 2y - 3$	Need to see an extra step from $(y + 1)^2 - 4$ to given answer ie explicit expansion of bracket. No errors seen. **SR B1** for verification, using $y = -1 + \sqrt{(y^2 + 2y - 3 + 4)}$, and confirming relationship convincingly, or for rearranging $x = f(y)$ to obtain given $y = f(x)$.
(ii) $\int_1^3 (y^2 + 2y - 3)\,dy = \left[\tfrac{1}{3}y^3 + y^2 - 3y\right]_1^3$ $= (9 + 9 - 9) - (\tfrac{1}{3} + 1 - 3)$ $= (9) - (-1\tfrac{2}{3})$ $= 10\tfrac{2}{3}$	**B1**	State or imply that the required area is given by $\int_1^3 (y^2 + 2y - 3)\,dy$	No further work required beyond stating this. Allow if $3x$ appears in integral. Any further consideration of other areas is B0.
	M1	Attempt integration	Increase in power of y by 1 for at least two of the three terms. Can still get M1 if the -3 disappears, or becomes $3x$. Allow M1 for integrating a function of y that is no longer the given one, eg subtracted from 3, or using their incorrect rearrangement from part (i).
	A1ft	Obtain at least two correct terms	Allow for unsimplified coefficients. Allow follow-through on any function of y as long as at least 2 terms and related to the area required. Condone $\int$, dy or + c present.
	M1	Attempt F(3) – F(1) for their integral	Must be correct order and subtraction. This is independent of first M1 so can be given for substituting into any expression other than $y^2 + 2y - 3$, including $2y + 2$. If last term is $3x$ allow M1 for using 3 and 1 throughout integral, but M0 if x value is used instead.
	A1 **5** **7**	Obtain $10\tfrac{2}{3}$ aef	Must be an exact equiv so $10.\dot{6}$ is fine (but $9^5/_3$ is A0). 10.7, 10.66… or $10^2/_3 + c$ are A0. Must come from correct integral, so A0 if from $3x$. Must be given as final answer, so further work eg subtracting another area is A0 rather than ISW. Answer only is 0/5, as no evidence is provided of integration. **SR** Finding the shaded area by direct integration with respect to x (ie a C3 technique) can have **5** if done correctly, **4** if non-exact decimal given as final answer but no other partial credit.

5	Throughout this question, candidates may do valid work in the incorrect answer space. This can be marked and given credit wherever it occurs, as long as it does not contradict the working and final answer given in the designated space.				
(i)	243	**B1**	**1**	State 243, or 3^5	B0 if other terms still present eg ${}^5C_0$ or 3^0. Could be part of a longer expansion, in which case ignore all other terms unless also solely numerical.
(ii)	2^{nd} term = 5 x 3^4 x (kx) = $405kx$ 3^{rd} term = 10 x 3^3 x $(kx)^2$ = $270k^2x^2$ $405k = 270k^2 \Rightarrow k = 1.5$	**B1**		Obtain $405k$ as coeff of x	Either stated, or written as $405kx$. Allow unsimplified expression ie 5 x 3^4 x k or 5 x 3^4 x (kx), even if subsequently incorrectly evaluated. B0 if still ${}^5C_1$ unless later clearly used as 5.
		M1		Attempt coeff of x^2	Needs to be an attempt at a product involving the relevant binomial coefficient (not just ${}^5C_2$ unless later seen as 10), 3^3 and an intention to square the final term (but allow for kx^2). $67.5k^2$ is M0 (from ${}^5/_2$ x 3^3).
		A1		Obtain $270k^2$	Allow unsimplified ie 10 x 3^3 x k^2 or 10 x 3^3 x $(kx)^2$ even if subsequently incorrectly evaluated. Allow $270k^2$ following 10 x 3^3 x kx^2 ie an invisible bracket was used.
		M1		Equate coefficients and attempt to solve for k	Must be one linear and one quadratic term in k, and must be appropriate method to solve this two term quadratic eg factorise or cancel common factor of k. Condone powers of x still present when equated, as long as not actually used in solution method. Could still gain M1 if incorrect, or no, binomial coefficients used – each term must be product of powers of 3 (poss incorrect), correct powers of k and any binomial coefficient used.
		A1	**5**	Obtain k = 1.5 (ignore any mention of k = 0)	Any exact equivalent, including unsimplified fraction. Could be implied by writing $(3 + 1.5x)^5$. **NB** If expansion is given as $405kx + 270kx^2$, and candidate then concludes that $k = {}^{405}/_{270}$ this is B1 M1 only as k^2 never seen.

(iii)	$10 \times 3^2 \times 1.5^3 = 303.75$	**M1**		Attempt $10 \times 3^2 \times k^3$	Need to see 10 so just $^5C_3$ is not good enough for M1. Need to see correct powers intended, even if incorrectly evaluated. This includes a clear intention to cube 1.5 (or their k), so $10 \times 9 \times 1.5x^3 = 135x^3$ is M0. Can get M1 if using their incorrect k, including 0, but M0 if the value of k used is different to that obtained in (ii). For incorrect numerical answer (following incorrect k), we need to see evidence of method – it cannot be implied by answer only. If k = -1, 0 or 1 we still need to see evidence of cubing. If $90k^3$ is seen in part (ii) (or even (i)) then this is sufficient for M1 unless contradicted by their work in part (iii). Allow if still k rather than numerical.
		A1	**2**	Obtain 303.75 (allow $303.75x^3$)	Or any exact equivalent. Ignore if subsequently rounded eg to 304 as long as exact value seen. If 1.5 obtained incorrectly in part (ii), full credit can still be gained in part (iii).
			8		

6(i)	f(1) = 1 f(–1) = 21 f(2) = 0, hence (x – 2) is a factor	**M1**		Attempt use of factor theorem at least once	Just substituting at least one value for x is enough for M1, showing either the working or the result, or both. Just stating f(a) = k is enough – don't need to see term by term evaluation. If result is inconsistent with the f(a) being attempted, then we do need to see evidence of method used. No conclusion required. M0 A0 for division attempts, even if considering remainder.
		A1	**2**	Obtain factor of (x – 2)	Allow A1 for sight of (x – 2), even if x = 2 also present. No words required, but penalise if used incorrectly ie A0 if explicitly labelled as 'root'. A0 if (x – 2) not seen in this part, even if subsequently used in (ii). **SR B1** for (x – 2) stated with no justification, and no incorrect terminology.
(ii)	f(x) = (x – 2)(x^2 + 3x – 5) $x = \frac{-3 \pm \sqrt{29}}{2}$ or x = 2	**M1**		Attempt complete division by a linear factor, or equivalent ie inspection or coefficient matching	Need linear factor of form ($x \pm a$), $a \neq 0$. Allow if factor different to their answer to (i), inc no answer to (i). Must be complete attempt at all three terms. If long division then need to be subtracting lower line; if coefficient matching then need to be considering all possible terms from their expansion to equate to relevant coefficient from cubic; if inspection then expansion must give at least one correct coefficient for the two middle terms in the cubic.
		A1		Obtain $x^2 + 3x + c$ or $x^2 + bx - 5$	Obtain x^2 and one other correct term. Just having two correct terms does not imply M1 – need to look at method used for third term. If coefficient matching allow for stating values eg a = 1 etc. If quadratic factor given with minimal working in (ii), there may be more evidence of method shown in (i).
		A1		Obtain $x^2 + 3x - 5$	Could appear as quotient in long division, or as part of product if inspection. If coefficient matching, must now be explicitly stated rather than just a = 1, b = 3, c = -5.
		M1		Attempt to solve quadratic equation	Using quadratic formula or completing the square – see extra guidance sheet. Quadratic must come from division attempt, even if this was not good enough for first M1.
		A1		Obtain ½ (–3 ± √29)	Or $^{-3}/_2 \pm {}^{\sqrt{29}}/_4$ from completing the square. Ignore terminology and ignore if subsequently given as factors, as long as seen fully simplified as roots.
		B1	**6**	State 2 as root, at any point	Must be stated in this part, not just in part (i). Ignore terminology.
			8		

7(a) (i)	$u_9 = 7 \times (-2)^8$ $= 1792$	**M1**		Attempt u_9 using ar^8	Allow for 7×-2^8. Using $r = 2$ will be marked as a misread.
		A1	**2**	Obtain 1792	Condone brackets not being shown explicitly in working. **SR B2** for listing terms, as long as signs change. Need to stop at u_9 or draw attention to it in a longer list.
(ii)	$S_{15} = \frac{7\left(1-(-2)^{15}\right)}{1-(-2)}$ $= 76{,}461$	**M1**		Attempt sum of GP using correct formula	Must be using correct formula, so denominator of 1–2 is M0 unless $1 - r$ clearly seen previously. If $n = 14$ used, then only mark as misread if no contradictory evidence seen – starting with $S_{15} = \ldots$ implies error in using in formula so M0.
		A1	**2**	Obtain 76,461	Condone brackets not being shown explicitly in working. **SR B2** for listing terms and then manually adding them.
(b)	$^N/_2\,(2 \times 7 + (N-1) \times -2) = -2900$ $N(16 - 2N) = -5800$ $N^2 - 8N - 2900 = 0$ $(N - 58)(N + 50) = 0$ $N = 58$	**B1**		State correct unsimplified S_N	If $(n-1)d$ is written as $(N-1) - 2$, then give benefit of doubt and allow B1, even if misused in subsequent work (eg becomes $N - 3$), unless there is clearly an error in the formula used.
		M1		Equate attempt at S_N to –2900 and rearrange to $f(N) = 0$	Must be attempt at S_N for an AP, so using u_N or GP formulae will be M0. M0 if $(N-1) - 2$ becomes $N - 3$. To give M1 at least one of the two terms in the bracket must have been multiplied by -2. Can still get M1 if incorrect formula as long as recognisable, and is quadratic in N. Expand brackets and collect all terms on one side of equation. Allow slips eg not dividing all terms in bracket by 2.
		A1		Obtain $N^2 - 8N - 2900 = 0$	Any equivalent form as long as $f(N) = 0$ (but condone 0 not being explicit).
		M1		Attempt to solve 3 term quadratic	Any valid method – as long as it has come from equating an attempt at S_N of an AP to -2900..
		A1	**5**	Obtain 58 only	58 must clearly be intended as only final answer – could be through underlining, circling or deleting other value for N. No need to see other value for N – if seen, allow slips as long as factorisation / substitution into formula is correct.
			9		58 from answer only or trial and improvement can get 5/5. 58 and -50 with no working is 4/5.

8(i)	translation of 3 units in negative y-direction	**B1**		State translation	Not shift, move etc.
		B1	**2**	State or imply 3 units in negative y-direction	Independent of first B1. Statement needs to clearly intend a vertical downwards move of 3, without ambiguity or contradiction, such as '3 down', '-3 in the y direction' etc or vector notation. B0 if direction unclear, such as 'in the y-axis' (could be along or towards) or 'along the y-axis' (unless direction made clear). Allow '3' or '3 units' but not '3 places', '3 spaces', '3 squares', '3 coordinates' or mention of (scale) factor of 3. If both a valid statement and an ambiguous statement are made eg '3 units down on the y-axis' then still award B1. Ignore irrelevant statements, such as where the y-intercept is, whether correct or incorrect. Give BOD on double negatives eg 'down the y-axis by – 3 units' unless clearly wrong or contradictory eg 'negative y-direction by $\begin{pmatrix}-3\\0\end{pmatrix}$'.
(ii)	$y = -2$	**B1**	**1**	State or imply $y = -2$	Just stating -2 is enough. B0 for final answer of $2^0 - 3$ or $1 - 3$. (-2, 0) is B0 unless -2 already seen or implied as y-coordinate.
(iii)	$2^x = 3$ $x = \log_2 3$	**M1**		Attempt to solve $2^x - 3 = 0$	Rearrange to $2^x = 3$, introduce logarithms (could be no base or any base as long as consistent) and then attempt expression for x. M0 for $x = \log_3 2$. M1 A0 for alternative, correct, log expressions such as $^{\log 3}/_{\log 2}$ or $1/\log_3 2$. Decimal equivalent of 1.58 can get M1 A0. $x = \log_2 (y + 3)$ is M0 (unless y then becomes 0).
		A1	**2**	State $\log_2 3$	Doesn't need to be $x = \ldots$ Change of base is not on the specification, but is a valid method and can gain both marks. Allow if base not initially specified, but then both logs become base 2. **NB** $x - \log_2 3 = 0$ leading to correct answer, can get full marks as there is no incorrect statement seen.

(iv)	$2^p = 65$ $\log 2^p = \log 65$ $p\log 2 = \log 65$ $p = 6.02$	**M1***		Rearrange equation and introduce logs (or $\log_2$)	Must first rearrange to $2^p = k$, with k from attempt at 62 ± 3, before introducing logs. Can use logs to any base, as long as consistent, or equiv with $\log_2$.
		M1d*		Drop power and attempt to solve	Dependent on first M1. $p = \log_2 k$ will gain both M marks in one step. If taking logs to any other base, or no base, or $\log_2$ on both sides then need to drop power of p and attempt to solve using a sound algebraic method ie $p = {}^{\log k}/_{\log 2}$.
		A1	**3**	Obtain 6.02, or better	Decimal answer reqd, if more than 3sf it must be in range [6.022, 6.023]. Answer only, or trial and improvement, is 0/3 as no evidence of using logs as requested.
(v)	$0.5\times0.5\times\{2^3-3+2(2^{3.5}-3)+2^4-3\}$ $= 8.66$	**M1**		Attempt y-values at $x =$ 3, 3.5, 4	M0 if other y-values also found (unless not used in trap rule). Allow M1 for using incorrect function as long as still clearly y-values that are intended to be the original function eg $2x - 3$ or $2^{(x-3)}$.
		M1		Attempt correct trapezium rule	Must be correct structure ie 0.5 x 0.5 x ($y_0 + 2y_1 + y_2$). Must be finding area from 3 to 4, so using eg x = 0, 0.5, 1 is M0. Allow if still in terms of y_0 etc as long as these have been clearly defined elsewhere. Using x-values in trapezium rule is M0, even if labelled y-values. Allow a different number of strips (except 1) as long as their h is consistent with this, and the limits are still 3 and 4.
		A1	**3**	Obtain 8.66, or better	If final answer given to more than 3sf, allow answers in range [8.655, 8.657].
			11		Exact answer from integrating $e^{x\ln 2} - 3$ is 0/3. Answer only is 0/3. Attempting integration before using trapezium rule is 0/3. Using two separate trapezia is fine.

9(a) (i)	π radians	**B1**	**1**	State π	Allow 3.14 radians or 180^0. B0 for $0 \le x \le \pi$.
(ii)	$(^{\pi}/_2\ , -1)$	**B1**		State $x = {}^{\pi}/_2$	Allow 1.57 radians, or better. Allow $A = {}^{\pi}/_2$. B0 for 90^0.
		B1	**2**	State $y = -1$	Allow cos $2A = -1$. **SR** Award **B1** for $(-1, {}^{\pi}/_2)$
(iii)	$\cos 2x = 0.5$ $2x = {}^{\pi}/_3, {}^{5\pi}/_3$ $x = {}^{\pi}/_6, {}^{5\pi}/_6$ hence ${}^{\pi}/_6 \le x \le {}^{5\pi}/_6$	**M1**		Attempt correct solution method	Inverse cos and then divide by 2, to find at least one angle.
		A1		Obtain ${}^{\pi}/_6$ (allow 0.524 or 30^o)	Just mark angle, ignore any (in)equality signs.
		A1		Obtain ${}^{5\pi}/_6$ (allow 2.62 or 150^o)	Needs to be single term so $\pi - {}^{\pi}/_6$ is A0. Just mark angle, ignore any (in)equality signs. A0 if any other angles in range $0 \le x \le \pi$.
		A1	**4**	Obtain ${}^{\pi}/_6 \le x \le {}^{5\pi}/_6$ (exact radians only)	Allow two separate inequalities as long as both correct and linked by **'and'** (not 'or', a comma or no link). Mark final answer and condone incorrect inequality signs elsewhere in solution. **SR** If alternative methods (eg double angle formulae) or inspection are used (or no method shown at all) then mark as **B2** Obtain one correct angle (degrees or radians) **A1** Obtain second correct angle – and no others **A1** Obtain correct inequality (exact radians only)

(b)	$\tan 2x = {}^{1}/_{\sqrt{3}}$ $2x = {}^{\pi}/_{6}, {}^{7\pi}/_{6}$ $x = {}^{\pi}/_{12}, {}^{7\pi}/_{12}$	**B1**		Obtain $\tan 2x = {}^{1}/_{\sqrt{3}}$	Allow for decimal equiv ie $\tan 2x = 0.577$ Allow for $\sqrt{3} \tan 2x = 1$.
		M1		Attempt correct solution method of $\tan 2x = k$	Inverse tan and then divide by 2, to find at least one angle. Could follow error eg $\tan 2x = \sqrt{3}$, even if $\tan 2x = {}^{\cos 2x}/_{\sin 2x}$ clearly used.
		A1		Obtain one correct angle	Could be exact (${}^{\pi}/_{12}$ or ${}^{7\pi}/_{12}$), decimals (0.262 or 1.83) or degrees (15^{o} or 105^{o}). Must come from correct working only.
		A1	**4**	Obtain both correct angles	Must now both be in exact radians. A0 if any other angles in range $0 \le x \le \pi$.
			11		
	OR $\cos^2 2x = 3\sin^2 2x$ $4\sin^2 2x = 1$ $4\cos^2 2x = 3$ $\sin 2x = \pm {}^{1}/_{2}$ $\cos 2x = \pm {}^{\sqrt{3}}/_{2}$ $2x = {}^{\pi}/_{6}, {}^{5\pi}/_{6}, {}^{7\pi}/_{6}, {}^{11\pi}/_{6}$ $x = {}^{\pi}/_{12}, {}^{5\pi}/_{12}, {}^{7\pi}/_{12}, {}^{11\pi}/_{12}$	**B1**		Obtain correct equation in either $\sin^2 2x$ or $\cos^2 2x$	Square both sides and use $\sin^2 2x + \cos^2 2x = 1$ to obtain $4\sin^2 2x = 1$ or $4\cos^2 2x = 3$, or any equiv, including unsimplified eg $1 - \sin^2 2x = 3\sin^2 2x$.
		M1		Attempt correct solution of $\sin 2x = k$ or $\cos 2x = k$	Inverse sin or cos and then divide by 2, to find at least one angle.
	$x = {}^{\pi}/_{12}, {}^{7\pi}/_{12}$	**A1**		Obtain one correct angle	Could be exact (${}^{\pi}/_{12}$ or ${}^{7\pi}/_{12}$), decimals (0.262 or 1.83) or degrees (15^{o} or 105^{o}). Must come from correct working only.
		A1		Obtain both correct angles	Must now both be in exact radians. A0 if any other angles in range $0 \le x \le \pi$. **SR** If using alternative methods, such as more advanced trig identities, or no method at all shown, then mark as **B3** Obtain one correct angle, (degrees or radians)with no errors seen **B1** Obtain second correct angle, now both in radians

Question			Answer	Marks	Guidance	
1	(i)		perimeter = (4.2 × 12) + (2 × 12) = 74.4 cm	M1*	Use $s = 12\theta$	Allow equiv method using fractions of a circle If working in degrees, must use 180 and π (or 360 and 2π) to find angle M0 if 12θ used with θ in degrees M0 if 4.2π used instead of 4.2 M1 if attempting arc of minor sector (12 × 2.1 (or better))
				M1d*	Attempt perimeter of sector	Add 24 to their attempt at 12θ M0 if using minor sector
				A1	Obtain 74.4	Units not required Allow a more accurate answer that rounds to 74.4, with no errors seen (poss resulting from working in degrees)
				[3]		
1	(ii)		area = $\frac{1}{2} \times 12^2 \times 4.2$ = 302.45 cm^2	M1	Use $A = (\frac{1}{2})12^2\theta$	Condone omission of $\frac{1}{2}$, but no other error Allow equiv method using fractions of a circle M0 if $(\frac{1}{2})12^2\theta$ used with θ in degrees M0 if 4.2π used instead of 4.2 M1 if attempting area of minor sector
				A1	Obtain 302, or better	Units not required Allow 302 or a more accurate answer that rounds to 302.4, with no errors seen (could be slight inaccuracy if using fractions of a circle)
				[2]		

Question			Answer	Marks	Guidance	
2	(i)		0.5 × 1.5 × {lg9 + 2(lg12 + lg15 + lg18) + lg21} = 6.97	**B1**	State, or use, *y*-values of lg9, lg12, lg15, lg18 and lg21	B0 if other *y*-values also found (unless not used in trap rule) Allow decimal equivs (0.95, 1.08, 1.18, 1.26, 1.32 or better)
				M1	Attempt correct trapezium rule, any *h*, to find area between $x = 4$ and $x = 10$	Correct structure required, including correct placing of *y*-values The 'big brackets' must be seen, or implied by later working Could be implied by stating general rule in terms of y_0 etc, as long as these have been attempted elsewhere and clearly labelled Could use other than 4 strips as long as of equal width Using *x*-values is M0 Can give M1, even if error in *y*-values eg using 9, 12, 15, 18, 21 or using now incorrect function eg log(2*x*) + 1 Allow BoD if first or last *y*-value incorrect, unless clearly from an incorrect *x*-value (eg $y_0 = \lg 7$, but $x = 4$ not seen)
				M1	Use correct *h* in recognisable attempt at trap rule	Must be in attempt at trap rule, not Simpson's rule Allow if muddle over placing *y*-values (but M0 for *x*-values) Allow if $\frac{1}{2}$ missing Allow other than 4 strips, as long as *h* is consistent Allow slips which result in *x*-values not equally spaced
				A1	Obtain 6.97, or better	Allow answers in the range [6.970, 6.975] if >3sf Answer only is 0/4 Using the trap rule on result of an integration attempt is 0/4 Using 4 separate trapezia can get full marks – if other than 4 trapezia then mark as above However, using only one trapezium is 0/4
				[4]		

Question			Answer	Marks	Guidance	
2	(ii)		tops of trapezia are below curve	**B1** **[1]**	Convincing reason referring to the top of a trapezium being below the curve, or the gap between a trapezium and the curve – explanation must be sufficient and fully correct	B0 for 'the trapezium is below the curve' (ie 'top' not used) Sketch with explanation is fine, even if just arrow and 'gap' Sketching rectangles / triangles is B0, as is a trapezium that doesn't have both top vertices intended to be on curve Concave / convex is B0, as is comparing to exact area B1 for reference to decreasing gradient
3	(i)		$20 \times 4^3 \times a^3 = 160$ $1280a^3 = 160$ $a^3 = \frac{1}{8}$ $a = \frac{1}{2}$	**M1**	Attempt relevant term	Must be an attempt at a product involving a binomial coeff of 20 (not just ${}^6C_3$ unless later seen as 20), 4^3 and an intention to cube ax (but allow for ax^3) Could come from $4^6(1 + {}^{ax}/_4)^6$ as long as done correctly Ignore any other terms if fuller expansion attempted
				A1	Obtain correct $1280a^3$, or unsimplified equiv	Allow $1280a^3x^3$, or $1280(ax)^3$, but not $1280ax^3$ unless a^3 subsequently seen, or implied by working
				M1	Equate to 160 and attempt to solve for a	Must be equating coeffs – allow if x^3 present on both sides (but not just one) as long as they both go at same point Allow for their coeff of x^3, as long as two, or more, parts of product are attempted eg $20ax^3$ / $64ax^3$ Allow M1 for $1280a = 160$ (giving $a = 0.125$) M0 for incorrect division (eg giving $a^3 = 8$)
				A1 **[4]**	Obtain $a = \frac{1}{2}$	Allow 0.5, but not an unsimplified fraction Answer only gets full credit, as does T&I **SR: max of 3 marks** for $a = 0.5$ from incorrect algebra, eg $1280ax^3 = 160$, so $a = 0.5$ would get M1A1(implied)B1

Question			Answer	Marks	Guidance	
3	(ii)		$4^6 + 6 \times 4^5 \times \frac{1}{2} = 4096 + 3072x$	B1	State 4096	Allow 4^6 if given as final answer Mark final answer – so do not isw if a constant term is subsequently added to 4096 from an incorrect attempt at second term eg using sum rather than product
				B1FT	State $3072x$, or $(6144 \times \text{their } a)x$	Must follow a numerical value of *a*, from attempt in part **(i)** Must be of form kx so just stating coeff of x is B0 Mark final answer B2 can still be awarded if two terms are not linked by a '+' sign – could be a comma, 'and', or just two separate terms **SR: B1** can be awarded if both terms seen as correct, but then 'cancelled' by a common factor
				[2]		
4	(i)		$b^2 = 2.4^2 + 2^2 - 2 \times 2.4 \times 2 \times \cos 40°$ $b = 1.55$ km	M1	Attempt use of correct cosine rule	Must be correct formula seen or implied, but allow slip when evaluating eg omission of 2, incorrect extra 'big bracket' Allow M1 even if subsequently evaluated in rad mode (4.02) Allow M1 if expression is not square rooted, as long as LHS was intended to be correct ie $b^2 = \dots$ or $AC^2 = \dots$
				A1	Obtain 1.55, or better	Actual answer is 1.55112003… so allow more accurate answer as long as it rounds to 1.551 Units not required
				[2]		

Question			Answer	Marks	Guidance	
4	(ii)		$\frac{\sin A}{2} = \frac{\sin 40}{1.55}$ $\frac{\sin C}{2.4} = \frac{\sin 40}{1.55}$ $A = 56^o$ $C = 84^o$ hence bearing is 124^o	**M1** **A1** **A1ft** **[3]**	Attempt to find one of the other two angles in triangle Obtain $A = 56^o$, or $C = 84^o$ Obtain 124^o, following their angle *A* or *C*	Could use sine rule or cosine rule, but must be correct rule attempted Need to substitute in and rearrange as far as sin *A* = … / cos *A* = … etc, but may not actually attempt angle Any angle rounding to 56^o or 84^o, and no errors seen Allow any answer rounding to 124 Finding bearing of *A* from *C* is A0 – ie not a MR
4	(iii)		$d = 2 \times \sin\ 40^o$ $= 1.29$ km	**M1** **A1** **[2]**	Attempt perpendicular distance Obtain 1.29, or better	Any valid method, but must attempt required distance Can still get M1 if using incorrect or inaccurate sides / angles found earlier in question Allow M1 if evaluated in rad mode (1.49) Allow more accurate final answers in range [1.285, 1.286] A0 for inaccurate answers due to PA elsewhere in question (typically *C* = 84.4, so *A* = 55.6, so *d* = 1.28) Units not required
5	(i)		f(3) = 54 + 27 – 51 + 6 = 36	**M1** **A1** **[2]**	Attempt f(3) Obtain 36	Allow equiv methods as long as remainder is attempted A0 if answer subsequently stated as –36 ie do not isw

Question			Answer	Marks	Guidance	
5	(ii)		$f(x) = (x - 2)(2x^2 + 7x - 3)$	**B1**	State or imply that $(x - 2)$ is a factor	Just stating this is enough for B1, even if not used Could be implied by attempting division, or equiv, by $(x - 2)$
				M1	Attempt full division, or equiv, by $(x \pm 2)$	Must be complete method – ie all three terms attempted If long division then must subtract lower line (allow one slip); if inspection then expansion must give correct first and last terms and also one of the two middle terms of the cubic; if coefficient matching then must be valid attempt at all 3 quadratic coeffs, considering all relevant terms each time Allow M1 for valid division attempt by $(x + 2)$
				A1	Obtain $2x^2$ and at least one other correct term	If coeff matching then allow for stating values eg $A = 2$ etc
				A1 **[4]**	Obtain $(x - 2)(2x^2 + 7x - 3)$	Must be stated as a product
5	(iii)		$b^2 - 4ac = 73$ > 0 hence 3 roots	**M1**	Attempt explicit numerical calculation to find number of roots of quadratic	Could attempt discriminant (allow $b^2 \pm 4ac$) , or could use full quadratic formula to attempt to find the roots themselves (implied by stating decimal roots); M0 for factorising unless their incorrect quotient could be factorised M0 for '3 roots as positive discriminant' but no evidence
				A1ft **[2]**	State 3 roots (√ their quotient) Condone no explicit check for repeated roots	Sufficient working must be shown, and all values shown must be correct Discriminant needs to be 73 (allow $7^2 - 4(2)(-3)$) Quadratic formula must be correct, though may not necessarily be simplified as far as $\frac{1}{4}(-7 \pm \sqrt{73})$ Need to state no. of roots – just listing them is not enough **SR:** if a conclusion is given in part **(iii)** then allow evidence from part **(ii)** eg finding actual roots

Question			Answer	Marks	Guidance	
6	(i)		$u_1 = 80$ $u_2 = 75$, $u_3 = 70$	**B1** **B1** **[2]**	State 80 State 75 and 70	Just a list of numbers is fine, no need for labels Ignore extra terms beyond u_3
6	(ii)		$S_{20} = \frac{20}{2}(2 \times 80 + 19 \times -5)$ $= 650$	**M1** **M1** **A1** **[3]**	Show intention to sum 1st 20 terms of an arithmetic sequence Attempt use of correct sum formula for an AP, with $n = 20$, $a = 80$, $d = \pm 5$ Obtain 650	Any recognisable attempt at the sum of an AP, including manual addition of terms – no need to list all of the terms, but intention (inc no of terms) must be clear Must use correct formula – only exception is $10(2a + 9d)$ If using $\frac{1}{2}n(a + l)$, must be a valid attempt at l, either from $a + 19d$ or from u_{20} Answer only gets full marks, as does manual addition

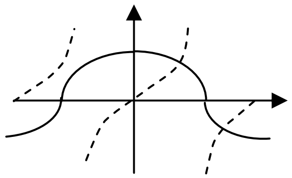
Question			Answer	Marks	Guidance	
6	(iii)		$r = \frac{60}{80} = 0.75$ $u_p = 80 \times 0.75^2 = 45$ $85 - 5p = 45$ $p = 8$	**M1***	Attempt to find u_p	Allow any valid method, inc informal Allow if first and/or second terms of their GP are incorrect Allow ratio of $\frac{4}{3}$ if used correctly to find 3rd term ($60 \div \frac{4}{3}$)
				A1	Obtain 45	Seen or implied **SR: M1* A0** if 45 results from using $u_n = ar^n$. The following M1A1 are still available.
				M1d*	Attempt to solve $85 - 5p = k$	k must be from attempt at third term of GP LHS could be $80 + (p - 1)(-5)$, from p^{th} term of the AP, but M0 if incorrect eg $80 + (p - 1)(5)$
				A1 **[4]**	Obtain $p = 8$	Allow full credit for answer only Any variable, including n
6	(iv)		$S_\infty = \frac{80}{1 - 0.75}$ $= 320$	**M1**	Use correct formula for sum to infinity	Must be from attempt at r for their GP
				A1 **[2]**	Obtain 320	A0 for 'tends to 320', 'approximately 320' etc

Question			Answer	Marks	Guidance	
7	(a)		$\int(x^3 - 6x^2 + 4x - 24)\,dx$	M1	Expand and attempt in	Must attempt to expand brackets first Increase in power by 1 for the majority of their terms Allow if the constant term disappears
			$= \frac{1}{4}x^4 - 2x^3 + 2x^2 - 24x + c$	A1ft	Obtain at least two correct (algebraic) terms	At least two correct from their expansion Allow for unsimplified coefficients
				A1	Obtain fully correct expression, inc + c	All coefficients now simplified A0 if integral sign or dx still present in their answer (but allow $\int$ = …)
				[3]		
7	(b)		$\int 6x^{\frac{3}{2}}\,dx = \frac{12}{5}x^{\frac{5}{2}}$	M1	Obtain $kx^{\frac{5}{2}}$	Any exact equiv for the index
				A1	Obtain $\frac{12}{5}x^{\frac{5}{2}}$, or any exact equiv	Including unsimplified coefficient
			$\int(8x^{-2} - 2)\,dx = -8x^{-1} - 2x$	M1	Obtain at least one of $-8x^{-1}$ and $-2x$	Allow M1 even if –2 disappears Could be part of a sum or difference; with consistent signs
			$\left[\frac{12}{5}x^{\frac{5}{2}}\right]_0^1 = \frac{12}{5}$	A1	Obtain $-8x^{-1} - 2x$	Allow unsimplified expressions If subtraction from other curve attempted before integration then allow for $8x^{-1} + 2x$
			$\left[-8x^{-1} - 2x\right]_1^2 = (-8) - (-10) = 2$			
			hence total area = $\frac{22}{5}$	B1	State or imply that pt of intersection is (2, 0)	Could imply by using it as a limit
				M1	Use limits correctly at least once	Must be using correct x limits, and subtracting, with the appropriate function (allow implicit use of $x = 0$); the only error allowed is an incorrect (2, 0) Allow use in any function other than the original, inc from differentiation

7	**(b) con**			**M1**	Attempt fully correct process to find required area	Use both pairs of limits correctly (allow an incorrect (2, 0)), in appropriate functions and sum the two areas
				A1	Obtain $\frac{22}{5}$, or any exact equiv	Answer only is 0/8, as no evidence is provided of integration
				[8]		
			Alternative scheme for those who integrate between the curves and the *y*-axis Some solutions may involve both integration onto *x*-axis and *y*-axis, so you may need to combine aspects of both schemes	**M1**	Obtain $ky^{\frac{5}{3}}$	
				A1	Obtain $6^{\frac{-2}{3}} \times \frac{3}{5} \times y^{\frac{5}{3}}$	
				M1	Obtain $k\sqrt{2+y}$	
				A1	Obtain $2\sqrt{8}\sqrt{2+y}$	
				M1	Use limits of 6 (and 0) correctly at least once	
				M1	Attempt correct method to find required area – correct use of limits required	
				A2	Obtain 4.4	

Question			Answer	Marks	Guidance	
8	(a)		$\log 7^{w-3} = \log 184$ $(w-3)\log 7 = \log 184$ $w - 3 = 2.68$ $w = 5.68$	**M1***	Rearrange, introduce logs and use $\log a^b = b \log a$	Must first rearrange to $7^{w-3} = k$, with k from attempt at 180±4, before introducing logs Can use logs to any base, as long as consistent on both sides If taking $\log_7$ then base must be explicit
				A1	Obtain $(w-3)\log 7 = \log 184$, or equiv eg $w - 3 = \log_7 184$	Condone lack of brackets ie $w - 3 \log 7 = \log 184$, as long clearly implied by later working
				M1d*	Attempt to solve linear equation	Attempt at correct process ie $w = {}^{\log k}/_{\log 7} \pm 3$, or equiv following expanding bracket first
				A1	Obtain 5.68, or better	More accurate final answer must round to 5.680
				[4]		Answer only, or T&I, is 0/4

Question			Answer	Marks	Guidance	
8	(b)		log xy = log 3 hence $xy = 3$ $3x + y = 10$	M1	Attempt correct use of log law to combine 2 (or more) logs	Must be used on at least two of log$x$ / log$y$ / log3 Allow log ($^{xy}/_3$) (condone no = 0)
			$x(10 – 3x) = 3$ $3x^2 – 10x + 3 = 0$	A1	Obtain $xy = 3$	aef as long as no logs present, or equiv in one variable
			$(3x – 1)(x – 3) = 0$ **or**	B1	Obtain $3x + y = 10$	aef as long as no logs present, or equiv in one variable
			$^1/_3(10 – y)y = 3$ $y^2 – 10y + 9 = 0$ $(y – 1)(y – 9) = 0$			**SR:** if A0 B0 given above, then allow **B1** for a correct combination of the 2 eqns eg $9x + 3y = 10xy$ (others poss)
			$x = {}^1/_3$, $y = 9$ $x = 3$, $y = 1$	M1	Attempt to eliminate one variable, and solve the resulting three term quadratic	Elimination of one variable could happen prior to removal of logs from one equation – as long as logs are then removed completely to obtain three term quadratic
				A1	Obtain two correct values	Could be for two values for one variable, or for one pair of correct (x, y) values
				A1 **[6]**	Obtain $x = {}^1/_3$, $y = 9$ and $x = 3$, $y = 1$	Pairings must be clear, but not necessarily as coordinates **SR: B1** for each pair of correct (x, y) values but no method **M1A1B1B1 -** 1 pair of (x, y) values, from 2 correct eqns but no other method shown (but 6/6 if both pairs found)

Question			Answer	Marks	Guidance	
9	(i)			B1	Correct shape for $y = k\cos(\frac{1}{2}x)$	Must show intention to pass through $(-\pi, 0)$ and $(\pi, 0)$ Should be roughly symmetrical in the y-axis, but condone slightly different y-values at -2π and 2π Ignore graph outside of given range
				B1	Correct shape for $y = \tan(\frac{1}{2}x)$	Must show intention to pass through $(-2\pi, 0)$, $(0, 0)$, $(2\pi, 0)$ Asymptotes need not be marked, but there should be no clear overlap of the limbs, nor significant gaps between them Ignore graph outside of given range
				B1	$(0, 3)$ stated or clearly indicated	Can still be given if $y = 3\cos(\frac{1}{2}x)$ graph is incorrect or not attempted If more than one point marked on the y-axis then mark the label on the graph intercept
				[3]		

Question			Answer	Marks	Guidance	
9	(ii)		$\frac{\sin(\frac{1}{2}x)}{\cos(\frac{1}{2}x)} = 3\cos(\frac{1}{2}x)$ $\sin(\frac{1}{2}x) = 3\cos^2(\frac{1}{2}x)$ $\sin(\frac{1}{2}x) = 3(1 - \sin^2(\frac{1}{2}x))$ $3\sin^2(\frac{1}{2}x) + \sin(\frac{1}{2}x) - 3 = 0$ **AG**	M1	Attempt use of relevant identities to show given equation	Must attempt use of both identities; these must be correct but allow poor notation eg using $\frac{\sin}{\cos}(\frac{1}{2}x)$ and/or $3(1 - \sin^2)(\frac{1}{2}x)$ could get M1A0
				A1	Obtain given equation, with no errors seen	Use both identities correctly, to obtain given equation Brackets around the $\frac{1}{2}x$ not required
			$\sin(\frac{1}{2}x) = 0.847, -1.18$ $\frac{1}{2}x = 1.01, 2.13$ $x = 2.02, 4.26$	M1	Attempt to solve given quadratic to find solution(s) for $\sin(\frac{1}{2}x)$	Must use quadratic formula (or completing the square) – M0 if attempting to factorise Allow variables other than $\sin(\frac{1}{2}x)$, eg y =, or even x = Allow –1.18 to be discarded at any stage
				M1	Attempt to solve $\sin(\frac{1}{2}x) = k$	Attempt $\sin^{-1}$ (their root) and then double the answer
				A1	Obtain one correct angle	Allow in degrees (116^{o} and 244^{o})
				A1	Obtain both correct angles, and no others in given range	Must both be in radians (allow equivs as multiples of π) A0 if extra, incorrect, angles in given range of $[-2\pi, 2\pi]$ but ignore any outside of given range **SR:** if no working shown then allow B1 for each correct solution (max of B1if in degrees, or extra solns in range)
				[6]		

Question			Answer	Marks	Guidance	
1	(i)		$(3 + 2x)^5 = 243 + 810x + 1080x^2 + 720x^3 + 240x^4 + 32x^5$	M1*	Attempt expansion – products of powers of 3 and $2x$	Must attempt at least 5 terms. Each term must be an attempt at a product, including binomial coeffs if used. Allow M1 for no, or incorrect, binomial coeffs. Powers of 3 and $2x$ must be intended to sum to 5 within each term (allow slips if intention correct). Allow M1 even if powers used incorrectly with the $2x$ ie $2x^3$ not $(2x)^3$ can get M1. Allow M1 for powers of ${}^2/_3x$ from expanding $k(1 + {}^2/_3x)^5$, any k (allow if powers only applied to x and not ${}^2/_3$) .
				M1d*	Attempt to use correct binomial coefficients	At least 5 correct from 1, 5, 10, 10, 5, 1 - allow missing or incorrect (but not if raised to a power). May be implied rather than explicit. Must be numerical eg ${}^5C_1$ is not enough. They must be part of a product within each term. The coefficient must be used in an attempt at the relevant term ie 5 x 3^3 x $(2x)^2$ is M0. Allow M1 for correct coefficients from expanding $k(1 + {}^2/_3x)^5$, any k.
				A1	Obtain at least four correct simplified terms	Either linked by '+' or as part of a list.
				A1	Obtain fully correct expansion	With all coefficients simplified. Terms must be linked by '+' and not just commas.
				[4]		**SR for reasonable expansion attempt:** M2 for attempt involving all 5 brackets resulting in a quintic with at most one term missing A1 for four correct, simplified, terms A1 for fully correct, simplified, expansion

Question			Answer	Marks	Guidance	
1	(ii)		$(3 + 2x)^5 + (3 - 2x)^5$ $= 486 + 2160x^2 + 480x^4$	M1	Attempt to change signs of relevant terms	Must change the sign on all of the relevant terms from their expansion, and no others. Expansion in part (i) must have at least 5 terms. Allow M1 even if no attempt to then combine expansions, or if difference rather than sum found. If expanding $(3 - 2x)^5$, then it must be a reasonable attempt, involving the product of correct binomial coeffs, powers of 2 and powers of $-3x$, and each term must be of the correct sign.
				A1 FT **[2]**	Obtain $486 + 2160x^2 + 480x^4$, from their **(i)**	Must have been a 6 term quintic in (i) to get FT mark. A0 if subsequent division by a common factor, so not isw.

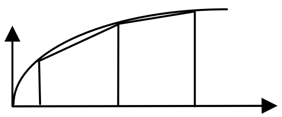
Question			Answer	Marks	Guidance	
2	(i)		$\int (x^2 - 2x + 5)\,dx = \frac{1}{3}x^3 - x^2 + 5x + c$	M1	Attempt integration	An increase in power by 1for at least 2 terms. Allow if the +5 disappears.
				A1	Obtain two correct (algebraic) terms	Allow if the coefficient if x^2 isn't yet simplified.
				A1	Obtain fully correct expression (allow no + *c*)	Allow if the coefficient if x^2 isn't yet simplified. A0 if integral sign or d*x* still present in their answer (but allow $\int$ = ...). A0 if a list of terms rather than an expression.
				[3]		
2	(ii)		$y = \frac{1}{3}x^3 - x^2 + 5x + c$	M1*	State or imply *y* = their integral from (i)	Must have come from integration attempt ie the M1 must have been gained in part (i). Allow slips when transferring expression from (i). Can still get this M1 if no + *c*. The *y* does not have to be explicit - it could be implied by eg 11 = F(3) (but not by 3 = F(11)). Using definite integration with limits of 3 & 11 is M0. M0 if they start with *y* = their integral from (i), but then attempt to use *y* - 11 = *m* (*x* - 3). This is a re-start and gains no credit.
			$11 = 9 - 9 + 15 + c \Rightarrow c = -4$	M1d*	Attempt to find *c* using (3, 11)	Need to get as far as attempting *c*. M1 could be implied by eg 11 = 9 – 9 + 15 and then an attempt to include a constant to balance the eqn, even though + *c* never actually seen. M0 if no + *c* seen or implied. M0 if using *x* = 11, *y* = 3.
			hence $y = \frac{1}{3}x^3 - x^2 + 5x - 4$	A1	Obtain $y = \frac{1}{3}x^3 - x^2 + 5x - 4$	Coeff of x^2 now needs to be simplified (A0 for $-1x^2$). Must be an equation ie *y* = ..., so A0 for 'f(*x*) = ...' or 'equation = ...' Allow aef, such as $3y = x^3 - 3x^2 + 15x - 12$.
				[3]		

Question			Answer	Marks	Guidance	
3	(i)		$72^o = 72 \times {}^{\pi}/_{180} = {}^{2\pi}/_5$ radians	B1 **[1]**	State $\frac{2\pi}{5}$, $\frac{2}{5}\pi$ or 0.4π	Must be simplified. B0 for decimal equiv (1.26), but isw if exact simplified value seen but then given in decimals.
3	(ii)		$\frac{1}{2} \times r^2 \times {}^{2\pi}/_5 = 45\pi$	M1	Equate attempt at area using $(\frac{1}{2})r^2\theta$ to 45π and attempt to solve for r	Condone omission of ½, but no other error. Must be equated to 45π (so M0 for = 45) except for $(\frac{1}{2})r^2 \text{ x } {}^2/_5 = 45$ (assuming π has been cancelled). Allow M1 for using 0.4 or 1.26π. Allow if using incorrect angle from part (i), as long as clearly intended to be in radians. Allow equivalent method using fractions of the circle. Valid method using degrees can get M1 (and A1 if exact). Must get as far as attempt at r. Allow M1 for T&I, as long as comparing to 45π.
			$r = 15$ cm	A1 **[2]**	Obtain $r = 15$	Must be exact working only – any use of decimals is A0 (but allow 15.0 if giving previously exact answer to 3sf). Any evidence of 15 having come from rounding an inaccurate answer is A0.
3	(iii)		area triangle = $\frac{1}{2} \times 15^2 \times \sin({}^{2\pi}/_5) = 106.99$	M1*	Attempt area of triangle using $(\frac{1}{2})r^2\sin\theta$	Condone omission of ½, but no other error. Must be using their r and angle linked to their θ. Could be using degrees or radians. Allow even if evaluated in incorrect mode (deg mode gives 2.47, rad mode gives 28.66). If using a right-angled triangle, it must be ½bh, any valid use of trig to find b and h.
			area segment = $45\pi - 106.99$	M1d*	Attempt 45π – area of triangle	Must be using 45π (not 45), decimal equiv of 141.4 or $\frac{1}{2} \text{ x } 15^2 \text{ x } 1.26$ (or better), so M0 for any other value. M0 if area of triangle is greater than 45π. Using $\frac{1}{2} \text{ x } 15^2 \text{ x } (\theta - \sin\theta)$ with incorrect θ is M1M0.
			$= 34.4 \text{ cm}^2$	A1 **[3]**	Obtain 34.4 cm^2	If >3sf then allow any values rounding to 34.4.

Question			Answer	Marks	Guidance	
4			$4(1 - \sin^2 x) + 7\sin x - 7 = 0$	M1	Use $\cos^2 x = 1 - \sin^2 x$	Must be used and not just stated Must be used correctly, so M0 for $1 - 4\sin^2 x$.
			$4\sin^2 x - 7\sin x + 3 = 0$	A1	Obtain correct quadratic	aef, as long as three term quadratic with all the terms on one side of the equation. Condone $4\sin^2 x - 7\sin x + 3$ ie no = 0.
			$(\sin x - 1)(4\sin x - 3) = 0$	M1	Attempt to solve quadratic in sin x	Not dependent on previous M1, so could get M0M1 if $\cos^2 x = \sin^2 x - 1$ used. This M mark is just for solving a 3 term quadratic (see guidance sheet for acceptable methods). Condone any substitution used, inc $x = \sin x$.
			$\sin x = 1$, $\sin x = {}^3/_4$	M1	Attempt to find x from roots of quadratic	Attempt $\sin^{-1}$ of at least one of their roots. Allow for just stating $\sin^{-1}$ (their root) inc if $\lvert\sin x\rvert > 1$. Not dependent on previous marks so M0M0M1 poss. If going straight from $\sin x = k$ to $x = \ldots$, then award M1 only if their angle is consistent with their k.
			$x = 90°$ $x = 48.6°, 131°$	A1	Obtain two correct solutions	Allow 3sf or better. Must come from a correct solution of the correct quadratic – if the second bracket was correct but the first was $(\sin x + 1)$ then A0 even though 2 solutions will be as required. Allow radian equivs – ${}^\pi/_2$ or 1.57 / 0.848 / 2.29.
				A1	Obtain all 3 correct solutions, and no others	Must now all be in degrees. Allow 3sf or better. A0 if other incorrect solutions in range $0^o - 360^o$ (but ignore any outside this range).
				[6]		**SR** If no working shown then allow **B1** for each correct solution (max of **B2** if in radians, or if extra solns in range).

Question			Answer	Marks	Guidance	
5	(a)	(i)	$u_2 = ½$ $u_3 = 4$	B1 B1 FT **[2]**	State ½ State 4, following their u_2	Allow 0.5 or $^2/_4$. Follow through on their u_2 (simplifying if possible). B0 for $^2/_{0.5}$, $^2/_{½}$ etc.
5	(a)	(ii)	periodic / alternating / repeating / oscillating / cyclic	B1 **[1]**	Any correct description	Allow associated words eg 'repetitive'. Must be a mathematical term rather than a description such as 'it changes between 4 and ½' or 'odd terms are 4, even terms are ½. Mark independently of any values given in part (i). Ignore irrelevant terms (eg 'recursive'), but B0 if additional incorrect terms (eg 'geometric').
5	(b)		$a + 8d = 18$ $^9/_2\ (2a + 8d) = 72$ $a + 8d = 18$ and $2a + 8d = 16$ $a = –2$, $d = {}^5/_2$	B1 B1 M1 A1 A1 **[5]**	State $a + 8d = 18$ State $^9/_2\ (2a + 8d) = 72$ Attempt to solve simultaneously Obtain either $a = –2$ or $d = {}^5/_2$ Obtain both $a = –2$, $d = {}^5/_2$	Allow any equivalent, including unsimplified. Must be correct when seen – can't be implied by eg being stated but with incorrect a substituted. Allow any equivalent, including unsimplified. Must be correct when seen – as above. M1 is awarded for eliminating a variable from two linear equations in a and d, from attempt at $u_9 = 18$ and attempt at $S_9 = 72$ (formulas must be recognisable, and for APs, but not necessarily correct). Don't need to actually solve. If balancing equations, then there must be intention to subtract (but allow $a = 2$). If substituting then allow sign errors (eg $a = 8d – 18$), but not operational errors (eg $a = {}^{18}/_{8d}$). A1 is given for the first correct value, from 2 correct eqns. Allow $d = 2½$ or 2.5, but not unsimplified fractions. A1 is given for obtaining second correct value. Allow $d = 2½$ or 2.5, but not unsimplified fractions.

Question			Answer	Marks	Guidance	
			OR		**Alternative method using $^n/_2(a + l)$**	**NB If using $a + (n - 1)d = 18$ and $^9/_2\ (2a + (n - 1)d) = 72$ and solving simultaneously to get a and d, then mark as per scheme below.**
			$^9/_2\ (a + 18) = 72$	B1*	State $^9/_2\ (a + 18) = 72$	Allow any equivalent. Award B1 as soon as seen correct, even if subsequent error.
			$a = -2$	B1d*	Obtain $a = -2$	Must come from correct equation.
			$-2 + 8d = 18$ or $^9/_2\ (-4 + 8d) = 72$	M1	Attempt use of either u_9 or S_9	Must be attempting either $u_9 = 18$ or $S_9 = 72$. Must be using correct formula.
				A1FT	Obtain correct equation, following their a	Allow any equivalent, including unsimplified.
			$d = {^5/_2}$	A1	Obtain $d = {^5/_2}$	Allow $d = 2½$ or 2.5, but not unsimplified fractions.

Question			Answer	Marks	Guidance	
6	(i)		$0.5 \times 4 \times (4\sqrt{1} + 8\sqrt{5} + 4\sqrt{9})$	M1*	Attempt y-values at $x = 1, 5, 9$ only	Must be using y, not an attempt at integration. Allow slips eg $\sqrt{(4x)}$ as long as clearly intended as y. Allow decimal equiv for y_1 (8.94). Allow M1 for 4, 20, 72 (ie omitting the $\sqrt{}$). M0 if other y-values found (unless not used in trap rule).
			$= 2(16 + 8\sqrt{5})$	M1d*	Attempt correct trapezium rule, inc $h = 4$	Correct structure, including 'big brackets' seen or implied. Allow 2 used for ½ h – no need for ½ x 4 to be explicit. Allow slips when calculating y values, but all other aspects must be correct. Could use two separate trapezia.
			$= 32 + 16\sqrt{5}$ **AG**	A1 **[3]**	Obtain $32 + 16\sqrt{5}$	Must come from exact working, so A0 if answer first found in decimals (67.777…) which is then stated to be the same as $32 + 16\sqrt{5}$. However, isw if exact answer found first, and then decimal equiv stated.
6	(ii)		 Curve is above tops of trapezia	B1*	Sketch showing correct graph of $y = 4\sqrt{x}$ and two trapezia (allow if only tops of trapezia seen as chords)	Correct graph shown, existing for at least $1 \le x \le 9$. Exactly two trapezia must be shown, of roughly equal widths, with top vertices on the curve.
				B1d* **[2]**	Reason comparing the tops of trapezia to the curve, or referring to the gap between the trapezia and the curve	Must refer to the tops of the trapezia so B0 for 'trapezia are below curve' (ie 'top' not used). Allow 'trapezium' rather than 'trapezia'. Could shade gaps on their diagram but some text also reqd. B0 for 'some area not calculated' unless clear which area. Concave / convex is B0, as is comparing to exact area. B1 for decreasing gradient (but B0 for decreasing curve). B0 (rather than isw) if explanation is partially incorrect. No sketch is B0, irrespective of explanation given. **SR B1** for correct explanation, and trapezia, and correct graph of $y = 4\sqrt{x}$ for $1 \le x \le 9$ but incorrect outside range (eg curvature / y-intercept / not just in first quadrant).

Question			Answer	Marks	Guidance	
6	(iii)		$\int_1^9 4x^{\frac{1}{2}}\,dx = \left[\frac{8}{3}x^{\frac{3}{2}}\right]_1^9$	M1	Obtain $k\,x^{\frac{3}{2}}$	Any numerical k, including 4. Any exact equiv for the index.
			$= \ 72 - \frac{8}{3}$	A1	Obtain $\frac{8}{3}x^{\frac{3}{2}}$	Allow unsimplified coefficient, inc $\frac{4}{1.5}$ or $\frac{2}{3}\times 4$. Allow non exact decimal ie 2.7, 2.67 etc. Allow + c.
			$= 69^1/_3$	M1	Attempt correct use of limits	Must be F(9) – F(1) ie subtraction with limits in the correct order. Allow use in any function other than the original, including from differentiation. Allow processing errors eg $\left(\frac{8}{3}\times 9\right)^{1.5}$.
				A1	Obtain $69^1/_3$, or any exact equiv	Allow improper fraction, or recurring decimal. A0 for 69.333…. A0 for $69^1/_3 + c$.
				[4]		Answer only is 0/4.

Question			Answer	Marks	Guidance	
7	(a)	(i)	$\cos\alpha = {}^{5}/_{\sqrt{29}}$	M1	Attempt cos α	Could draw triangle and use Pythagoras to find the hypotenuse, or use trig identities. Must get as far as attempting cos α. Must be working in exact values for M1. Must be using correct ratios for tan α and cos α.
				A1	Obtain ${}^{5}/_{\sqrt{29}}$	Allow any exact equiv, including rationalised surd or $\sqrt{({}^{25}/_{29})}$ isw if decimal equiv subsequently given. Answer only gets full credit.
				[2]		**SR B1** for exact answer following decimal working.
7	(a)	(ii)	$\cos\beta = {}^{-\sqrt{40}}/_{7}$	M1	Attempt cos *β*	Could draw triangle and use Pythagoras to find the adjacent, or use trig identities. Must get as far as attempting cos *β*. Must be working in exact values for M1. Must be using correct ratios for sin α and cos α.
				A1	Obtain ${}^{\sqrt{40}}/_{7}$	Allow any exact equiv, including $\sqrt{({}^{40}/_{49})}$. Allow $\pm\, {}^{\sqrt{40}}/_{7}$ (from using $\cos^2 x = 1 - \sin^2 x$). isw if decimal equiv subsequently given. Answer only gets M1A1.
				A1 FT	Obtain ${}^{-\sqrt{40}}/_{7}$, or –ve of their exact numerical value for cos *β*	A1 FT can only be awarded following M1. isw if decimal equiv subsequently given. Answer only gets full credit.
				[3]		**SR B1** for ${}^{\sqrt{40}}/_{7}$, or equiv, following decimal working **SR B2** for ${}^{-\sqrt{40}}/_{7}$, or equiv, following decimal working **SR B1** for decimal answer in range [-0.904, -0.903]

Question			Answer	Marks	Guidance	
7	(b)		$\frac{\sin\gamma}{6} = \frac{\sin 60}{8}$	M1*	Attempt use of correct sine rule	Must be correct sine rule, either way up (just need to substitute values in – no rearrangement needed).
				M1d*	Use $\sin 60° = \sqrt{3}/2$	Could be implied eg $\frac{6}{\sin\gamma} = \frac{16}{3}\sqrt{3}$
			$\sin\gamma = \frac{3\sqrt{3}}{8}$	A1	Obtain $\sin\gamma$ as $\frac{3\sqrt{3}}{8}$	Must be seen simplified to this, or $0.375\sqrt{3}$ or $\frac{9}{8\sqrt{3}}$, but isw if decimal equiv subsequently given. isw any attempt to find the angle. A0 if only ever seen as $\sin^{-1}\frac{3\sqrt{3}}{8}$
				[3]		

Question			Answer	Marks	Guidance	
8	(i)		f(2) = 8 + 2a – 6 + 2b = 0 g(2) = 24 + 4 + 10a + 4b = 0	M1	Attempt at least one of f(2), g(2)	Allow for substituting x =2 into either equation – no need to simplify at this stage. Division – complete attempt to divide by (x – 2). Coeff matching - attempt all 3 coeffs of quadratic factor.
				M1	Equate at least one of f(2) and g(2) to 0	Just need to equate their substitution attempt to 0 (but just writing eg f(2) = 0 is not enough). It could be implied by later working, even after attempt to solve equations. Division - equating their remainder to 0. Coeff matching – equate constant terms.
			2a + 2b = –2, 5a + 2b = –14	A1	Obtain two correct equations in a and b	Could be unsimplified equations. Could be 8a + 2b = –26 (from f(2) = g(2)).
			hence 3a = –12	M1	Attempt to find a (or b) from two simultaneous eqns	Equations must come from attempts at two of f(2) = 0, g(2) = 0, f(2) = g(2). M1 is awarded for eliminating a or b from 2 sim eqns – allow sign slips only. Most will attempt a first, but they can also gain M1 for finding b from their simultaneous equations.
			so a = –4 **AG**	A1	Obtain a = –4, with necessary working shown	If finding b first, then must show at least one line of working to find a (unless earlier shown explicitly eg a = – 1 – b).
			b = 3	A1	Obtain b = 3	Correct working only
				[6]		**SR Assuming *a* = -4** **Either use this scheme, or the original, but don't mix elements from both** M1 Attempt either f(2) or g(2) M1 Equate f(2) or g(2) to 0 (also allow f(2) = g(2)) A1 Obtain b = 3 A1 Use second equation to confirm a = -4, b = 3

Question			Answer	Marks	Guidance	
8	(ii)		$f(x) = (x-2)(x^2+2x-3)$ $= (x-2)(x+3)(x-1)$	M1	Attempt full division of their $f(x)$ by $(x-2)$ Could also be for full division attempt by $(x-1)$ or $(x+3)$ if identified as factors	Must be using $f(x) = x^3 - 7x + k$. Must be complete method – ie all 3 terms attempted. Long division – must subtract lower line (allow one slip). Inspection – expansion must give at least three correct terms of their cubic. Coefficient matching – must be valid attempt at all 3 quadratic coeffs, considering all relevant terms each time. Factor theorem – must be finding 2 more factors / roots.
				A1	Obtain x^2 and at least one other correct term, from correct $f(x)$	Could be middle or final term depending on method. Coeff matching – allow for stating values eg $A = 1$ etc. Factor theorem – state factors of $(x+3)$ and $(x-1)$.
				A1	Obtain $(x-2)(x+3)(x-1)$	Must be seen as a product of three linear factors. Answer only gains all 3 marks.
			$g(x) = (x-2)(3x^2+7x-6)$ $= (x-2)(x+3)(3x-2)$ **OR** $g(1) = -4$, $g(-3) = 0$	M1	Attempt to verify two common factors	Possible methods are: Factorise $g(x)$ completely – $f(x)$ must have been factorised. Find quadratic factor of $g(x)$ and identify $x = -3$ as root. Test their roots of $f(x)$ in $g(x)$. Just stating eg $g(-3) = 0$ is not enough – working required. If $f(x)$ hasn't been factorised, allow M1 for using factor thm on both functions to find common factor, or for factorising $g(x)$ and testing roots in $f(x)$.
			Hence common factor of $(x+3)$	A1 **[5]**	Identify $(x+3)$ as a common factor	Just need to identify $(x+3)$ - no need to see $(x-2)$ or to explicitly state 'two common factors'. Need to see $(x+3)$ as factor of $g(x)$ – just showing $g(-3) = 0$ and then stating 'common factor' is not enough. CWO (inc A0 for $g(x) = (x-2)(x+3)(x - {}^2/_3)$). If using factor thm, no need to find $g(1)$ if $g(-3)$ done first. Just stating $(x+3)$ with no supporting evidence is M0A0. A0 if referring to -3 (and 2) as 'factors'. A0 if additional incorrect factor given.

Question			Answer	Marks	Guidance	
9	(a)	(i)	$u_4 = \log_2 27 + 3\log_2 x$	**M1**	Use $u_4 = a + 3d$	Allow missing / incorrect / inconsistent log bases. Starting with $\log_2 27 + \log_2 x^3$ is M0M0. Starting with $\log_2 27 \text{ x } 3\log_2 x$ is M0 (but can get M1 below). Starting with $\log_2 27 + \log_2 x + \log_2 x + \log_2 x$ can get full credit.
			$= \log_2 27 + \log_2 x^3$	**M1**	Use $b \log a = \log a^b$ on $3\log_2 x$	u_4 must still be shown as two terms. Could get M1 if using $a + 4d$. Could get M1 for $\log_2 27 \text{ x } 3\log_2 x = \log_2 27 \text{ x } \log_2 x^3$ or for $\log_2 27 \text{ x } 3\log_2 x = \log_2 27 + \log_2 x^3$. Allow missing / incorrect / inconsistent log bases.
			$= \log_2(27x^3)$ **AG**	**A1** **[3]**	Show $\log_2(27x^3)$ convincingly	Can go straight from $\log_2 27 + \log_2 x^3$ to final answer. CWO, including using base 2 throughout. **SR – finding consecutive terms (each step must be explicit)** **B1** for $u_2 = \log_2 27 + \log_2 x = \log_2 27x$ **B1** for $u_3 = \log_2 27x + \log_2 x = \log_2 27x^2$ **B1** for $u_4 = \log_2 27x^2 + \log_2 x = \log_2 27x^3$
9	(a)	(ii)	$27x^3 = 2^6$	B1*	State correct equation no longer involving $\log_2 x$	Equation could still involve constant terms such as $\log_2 27$ or $\log_2 3$. Allow truncated or rounded decimals.
			$x = {}^4/_3$	B1d* **[2]**	Obtain ${}^4/_3$	Must be ${}^4/_3$, $1{}^1/_3$ or an exact recurring decimal only (not 1.333….). A0 if cube root still present. Working must be exact, so sight of decimals in method used is B0, even if final answer is exact. Answer only gets full credit.

Question			Answer	Marks	Guidance	
9	(b)	(i)	½ < y < 2	**M1**	Identify at least one of ½ and 2 as end-points	Only one end-point required. Ignore if additional incorrect end-point also given. Ignore any signs used.
				A1	Obtain ½ < y < 2	Not two separate inequalities, unless linked by 'and'. A0 for ½ ≤ y ≤ 2.
				[2]		
9	(b)	(ii)	$\frac{\log_2 27}{1-\log_2 y} = 3$	B1	State $\frac{\log_2 27}{1-\log_2 y} = 3$	Allow B1 if no base stated, but B0 if incorrect base. Must be equated to 3 for B1.
			$\log_2 27 = 3 - 3\log_2 y$ $\log_2 27 = 3 - \log_2 y^3$ $\log_2(27y^3) = 3$	M1*	Attempt to rearrange equation to $\log_2 f(y) = k$	Must be using $\frac{\log_2 27}{\pm 1 \pm \log_2 y}$ (but allow for no bases). Allow at most 2 manipulation errors (eg +/– or x/÷ muddles, or slips when expanding brackets) but M0 if other errors (eg incorrect use of logs).
			$27y^3 = 8$	M1d*	Use $f(y) = 2^k$ as inverse of $\log_2 f(y) = k$	Must have first been arranged to $\log_2 f(y) = k$. No need to go any further than stating their $f(y) = 2^k$.
				A1*	Obtain correct exact equation no longer involving $\log_2 y$	Equation could still involve constant terms such as $\log_2 27$ or $\log_2 3$. Sight of decimals used is A0, even if answer is exact.
			$y^3 = {}^8/_{27}$ $y = {}^2/_3$	A1d*	Obtain ${}^2/_3$	Allow equiv recurring decimal, but not 0.666… A0 if still cube root present.
				[5]		**SR** answer only is **B3** Correct $S_\infty = 3$, then answer with no further working is **B3.**

Question			Answer	Marks	Guidance	
1	(i)		$\frac{\sin A}{10} = \frac{\sin 63}{14}$ $A = 39.5^o$	M1	Attempt use of correct sine rule	Must be correct sine rule, either way up Need to rearrange at least as far as sin *A* = ..., using a valid method Allow M1 even if subsequently evaluated in rads (0.120)
				A1 **[2]**	Obtain 39.5^o, or better	Actual answer is 39.52636581... so allow more accurate answer as long as it rounds to 39.53
1	(ii)		$c^2 = 10^2 + 14^2 - 2\text{x}10\text{x}14\text{x}\cos 77.5^o$ c = 15.3	M1	Attempt use of correct cosine rule, or equiv, inc attempt at 77.5^o	Angle used must be 77.5^o or must come from a clear attempt at 180 - (63 + their *A*). **NB** Using 102.5^o in sine rule will give 15.3, but this is M0. Must be correct formula seen or implied, but allow slip when evaluating eg omission of 2, incorrect extra 'big bracket' Allow M1 if expression is not square rooted, as long as LHS was intended to be correct ie $c^2 = \ldots$ or $AB^2 = \ldots$ Allow M1 even if subsequently evaluated in rad mode Allow any equiv method, including sine rule (as far as sin *C* = ...) or right-angled triangle trig (must be full and valid method)
				A1 **[2]**	Obtain 15.3, or better	Allow more accurate answer as long as it rounds to 15.34

Question			Answer	Marks	Guidance	
2	**(i)**		7 + 16 x 4 = 71 **AG**	M1	Attempt to find 17th term in the given AP	Attempt to use $u_n = a + (n - 1)d$ with $a = 7$ and $d = 4$ Allow a more informal method, including writing out the sequence with $a = 7$ and $d = 4$ Could also attempt u_{17} from attempt at $u_n = 4n + 3$ – must be seen explicitly
				A1	Show clear detail to obtain $u_{17} = 71$	If listing terms, 71 must either be last number in list or clearly identified eg underlined
				[2]		
2	**(ii)**		$S_{35} = {}^{35}/_2\,(2 \text{ x } 7 + 34 \text{ x } 4)$ $= 2625$	M1	Attempt sum of first 35 terms of given AP	Must use correct formula, with $a = 7$ and $d = 4$ If using $\frac{1}{2}n\,(a + l)$ then must be valid attempt at l Could use $4\sum n + \sum 3$, but M0 for $4\sum n + 3$
				A1	Obtain 2625	Must be evaluated Allow M1A1 for 2625 from no working
			either $S_{50} = {}^{50}/_2\,(2 \text{ x } 7 + 49 \text{ x } 4)$ $= 5250$ $5250 - 2625 = 2625$ **AG** or $S_{36-50} = {}^{15}/_2\,(2 \text{ x } 147 + 14 \text{ x } 4)$ $= 2625$ **AG**	M1	Attempt a correct method to show given relationship	Must show explicit calculation so M0 for just stating eg $S_{50} = 5250$ Could sum first 50 terms of AP **and** find the difference between this and the sum of the first 35 terms, or equiv Could attempt to sum terms from u_{36} to u_{50} but M0 if summing from u_{35} (= 143)
				A1	Show given equality convincingly	No need for explicit conclusion once both sums shown to be 2625
				[4]		

Question			Answer	Marks	Guidance	
3	(i)		$2k \times 3 = 9$ $k = 1.5$	M1	Attempt to find k	Substitute $x = 2$ and $^{dy}/_{dx} = 9$ into given differential equation and attempt to find k
				A1	Obtain $k = 1.5$	Allow any exact equiv. including $^9/_6$
				[2]		
3	(ii)		$y = x^3 - 0.75x^2 + c$ $7 = 8 - 3 + c$ hence $c = 2$ $y = x^3 - 0.75x^2 + 2$	M1	Expand bracket and attempt integration	M0 if bracket not expanded first M1 can still be gained for integrating an incorrect expansion as long as there are two terms For an 'integration attempt' there must be an increase in power by 1 for both terms
				A1ft	Obtain at least one correct term (allow still in terms of k)	Follow through on their value of k (but not on an incorrect expansion at start of part (ii)) Can also get A1 if still in terms of k Allow unsimplified coefficients
				A1	Obtain $x^3 - 0.75x^2$ (condone no + c)	Must now be numerical, and no f-t Allow unsimplified coefficients A0 if integral sign or dx still present, unless it later disappears
				M1	Attempt to find c using (2, 7)	There must have been an attempt at integration, but can follow M0 eg if the bracket was not expanded first Need to get as far as actually attempting c M1 could be implied by eg 7 = 8 - 3 followed by an attempt to include a constant to balance the equation M0 if no + c seen or implied M0 if using $x = 7$, $y = 2$
				A1	Obtain $y = x^3 - 0.75x^2 + 2$	Coefficients now need to be simplified (0.75 or $^3/_4$) Must be an equation ie $y = ...$, so A0 for 'f(x) = ...' or 'equation = ...' Allow aef, such as $4y = 4x^3 - 3x^2 + 8$
				[5]		

Question			Answer	Marks	Guidance	
4	**(i)**		$(2 + x)^5 = 32 + 80x + 80x^2 + 40x^3 + 10x^4 + x^5$	M1*	Attempt expansion resulting in at least 5 terms – products of powers of 2 and x	Each term must be an attempt at a product, including binomial coeffs if used Allow M1 for no, or incorrect, binomial coeffs Powers of 2 and x must be intended to sum to 5 within each term (allow slips if intention correct) Allow M1 for powers of $\frac{1}{2}x$ from expanding $k(1 + \frac{1}{2}x)^5$, any k (allow if powers only applied to x and not $\frac{1}{2}$)
				M1d*	Attempt to use correct binomial coefficients	At least 5 correct from 1, 5, 10, 10 , 5, 1 - allow missing or incorrect (but not if raised to a power) May be implied rather than explicit Must be numerical eg $^5C_1$ is not enough They must be part of a product within each term The coefficient must be used in an attempt at the relevant term ie 5 x 2^3 x x^3 is M0 Allow M1 for correct coeffs from $k(1 + \frac{1}{2}x)^5$, any k
				A1	Obtain at least 4 correct simplified terms	Either linked by '+' or as part of a list
				A1	Obtain a fully correct expansion	Terms must be linked by '+' and not just commas A0 if a correct expansion is subsequently spoiled by attempt to simplify, including division **SR for expanding brackets:** M2 - for attempt using all 5 brackets giving a quintic A1 - obtain at least 4 correct simplified terms A1 - obtain a fully correct expansion
				[4]		

Question			Answer	Marks	Guidance	
4	(ii)		$80\,(3y + y^2)^2 + 40\,(3y + y^2)^3$ coeff of $y^3 = (80 \times 6) + (40 \times 27)$ $= 1560$	M1	Attempt to use $x = 3y + y^2$	Replace x with $3y + y^2$ in at least one relevant term and attempt expansion, including relevant numerical coeff from (i) or from restart
				A1	Obtain $480(y^3)$ or $1080(y^3)$	Could be with other terms, inc y^3
				A1	Obtain 1560 (or $1560y^3$)	Ignore terms involving powers other than y^3
			OR $(1 + y)^5(2 + y)^5$ $= (1 + 5y + 10y^2 + 10y^3 ...)\ \times$ $(32 + 80y + 80y^2 + 40y^3 ...)$ coeff of $y^3 = 320 + 800 + 400 + 40$			**OR** M1- attempt expansion of both $(1 + y)^5$ and $(2 + y)^5$ (allow powers higher than 3 to be discarded) and make some attempt at the product A1 - obtain at least 2 correct coeffs of y^3 A1 - obtain 1560 (or $1560y^3$)
			OR $((2 + 3y) + y^2)^5$ $= (2 + 3y)^5 + 5(2 + 3y)^4y^2$ $= \dots 10 \times 4 \times 27y^3 \dots$ $+ 5 \times 4 \times 8 \times 3y \times y^2$ coeff of $y^3 = 1080 + 480 = 1560$			**OR** M1 – attempt expansion of at least one relevant term A1 - obtain $480(y^3)$ or $1080(y^3)$ A1 - obtain 1560 (or $1560y^3$) **OR** M1 – attempt expansion of all 5 brackets (allow powers higher than 3 to be discarded throughout method) A2 – obtain 1560 (or $1560y^3$)
				[3]		

Question			Answer	Marks	Guidance	
5	(i)		$2\sin x\ {}^{\sin x}/_{\cos x} = 4\cos x - 1$ $2\sin^2 x = 4\cos^2 x - \cos x$ $2 - 2\cos^2 x = 4\cos^2 x - \cos x$ $6\cos^2 x - \cos x - 2 = 0$ **AG**	M1	Use $\tan x = {}^{\sin x}/_{\cos x}$ and rearrange to a form not involving fractions	Must be used and not just stated Must multiply all terms by $\cos x$ so $4\cos^2 x - 1$ is M0, but allow M1 for $\cos x(4\cos x - 1)$ even if subsequent errors
				M1	Use $\sin^2 x = 1 - \cos^2 x$	Must be used and not just stated Must be used correctly, so M0 for $1 - 2\cos^2 x$ Not dependent on previous M mark, so M0 M1 possible Must be attempting quadratic in $\cos x$ so M0 for $\cos^2 x = 1 - \sin^2 x$
				A1	Obtain $6\cos^2 x - \cos x - 2 = 0$ with no errors seen	Must be equation ie = 0 Allow poor notation (eg cos not cos*x*, or $\tan x = {}^{\sin}/_{\cos}\,(x)$) as long as final answer is correct
				[3]		
5	(ii)		$(3\cos x - 2)(2\cos x + 1) = 0$ $\cos x = {}^{2}/_{3}$, $\cos x = {}^{-1}/_{2}$ $x = 48.2^o, 312^o, 120^o, 240^o$	M1	Attempt to solve quadratic in $\cos x$	This M mark is just for solving a 3 term quadratic (see guidance sheet for acceptable methods) Condone any substitution used, including $x = \cos x$
				M1	Attempt to find x from root(s) of quadratic	Attempt $\cos^{-1}$ of at least one of their roots Allow for just stating $\cos^{-1}$(their root) inc if $\lvert \cos x \rvert > 1$ Not dependent so M0 M1 possible If going straight from $\cos x = k$ to $x = ...$ then award M1 only if their angle is consistent with their k
				A1	Obtain at least 2 correct angles	Allow 3sf or better Must come from correct solution of quadratic - ie correct factorisation or correct substitution into formula so A0 if two correct roots from eg $(3\cos x + 2)(2\cos x + 1) = 0$ Allow radian equivs - 0.841, 5.44, ${}^{2\pi}/_{3}$ or 2.09, ${}^{4\pi}/_{3}$ or 4.19
				A1	Obtain all 4 correct angles, with no extra in given range	Must now be in degrees **SR** If no working shown then allow **B1** for 2 correct angles (poss in rads) or **B2** for 4 correct angles, no extras
				[4]		

Question			Answer	Marks	Guidance	
6	(i)		$(x + 4) – 2x = (2x – 7) – (x + 4)$ **OR** $2x + d = x + 4 \quad 2x + 2d = 2x – 7$	M1	Attempt to eliminate d to obtain equation in x only	Equate two expressions for d, both in terms of x Could use $a + (n – 1)d$ twice, and then eliminate d Could use $u_1 + u_2 + u_3 = S_3$ or $u_2 = ½ (u_1 + u_3)$
				A1	Obtain correct equation in just x	Allow unsimplified equation A0 if brackets missing unless implied by subsequent working or final answer
			$2x = 15$ $x = 7.5$	A1	Obtain $x = 7.5$	Any equivalent form Allow from no working or T&I **Alt method:** B1 - state, or imply, $2x + 2d = 2x – 7$, to obtain $d = -3.5$ M1 - attempt to find x from second equation in x and d A1- obtain $x = 7.5$
				[3]		
6	(ii)	(a)	terms are 16, 12, 9	B1	List 3 terms	Ignore any additional terms given
			$^{12}/_{16} = 0.75$, $^{9}/_{12} = 0.75$ common ratio of 0.75 so GP	B1	Convincing explanation of why it is a GP	Must show two values of 0.75, or unsimplified fractions Must state, or imply, that ratio has been checked twice, using both pairs of consecutive terms No need to show actual division of terms to justify 0.75, so allow eg arrows from one term to the next with 'x0.75' **SR B2** if 16, 12, 9 never stated explicitly in a list but are soi in a convincing method for $r = 0.75$ twice
			$S_\infty = {}^{16}/_{1 – 0.75}$ $= 64$	M1	Attempt use of $^{a}/_{1 – r}$	Must be correct formula Could be implied by method Allow if used with their incorrect a and/or r Allow if using $a = 8$, even if 16 given correctly in list
				A1	Obtain 64	A0 if given as 'approximately 64'
				[4]		

Question			Answer	Marks	Guidance	
6	**(ii)**	**(b)**	$^{(2x-7)}/_{(x+4)} = {}^{(x+4)}/_{2x}$ $4x^2 - 14x = x^2 + 8x + 16$ **OR** $2xr = x + 4 \quad 2xr^2 = 2x - 7$ $3x^2 - 22x - 16 = 0$ $(3x + 2)(x - 8) = 0$ $x = {}^{-2}/_3,\ x = 8$	M1* A1 M1d* A1 **[4]**	Attempt to eliminate r to obtain equation in x only Obtain $3x^2 - 22x - 16 = 0$ Attempt to solve quadratic Obtain $x = {}^{-2}/_3$	Equate two expressions for r, both in terms of x Could use ar^{n-1} twice, and then eliminate r from simultaneous eqns Allow $6x^2 - 44x - 32 = 0$ Allow $3x^3 - 22x^2 - 16x = 0$, or a multiple of this Allow any equivalent form, as long as no brackets and like terms have been combined Condone no = 0, as long as implied by subsequent work Dependent on first M1 for valid method to eliminate r See guidance sheet for acceptable methods Allow recurring decimal, but not rounded or truncated Condone $x = 8$ also given Allow from no working or T&I
7	**(i)**		$\cos^{-1} {}^6/_7 = 0.5411$ **AG**	M1 A1 **[2]**	Attempt correct method to find angle *CAB* Obtain 0.5411	Either use cosine rule or right-angled trigonometry Allow M1 for $\cos A = {}^6/_7$ or equiv from cosine rule If first finding another angle, they must get as far as attempting angle *CAB* for the M1 Allow in degrees or radians Must be given to exactly 4sf, as per question If angle found as 31° then conversion to radians must be shown explicitly

Question			Answer	Marks	Guidance	
7	(ii)		arc length = 7 x (2 x 0.5411) = 7.575 perimeter = 15.2	M1	Attempt arc length using 7θ	Must be using $r = 7$ Allow if using $\theta = 0.5411$ not 1.0822 If no method shown then award M1 for value seen in the range [7.56, 7.58] M0 if using angle other than 0.5411 or 1.0822 (inc M0 for 1.0822π) but allow M1 if required angle is intended eg 0.54 or a slip when doubling 0.5411 Allow valid method with degrees, but M0 for 7θ with θ in degrees Allow equivalent method using fractions of the circle
				A1 **[2]**	Obtain perimeter as 15.2, or better	Allow 15.15, or anything that rounds to this with no errors seen

Question			Answer	Marks	Guidance	
7	(iii)		sector area = ½ x 7^2 x (2 x 0.5411) = 26.51 triangle area = ½ x 7^2 x sin 1.082 = 21.63 area of segment = 4.88 shaded area = 9.76 cm^2	M1*	Attempt area of one sector using (½) x 7^2 x θ, or equiv	Allow if using θ = 0.5411 not 1.0822 Allow M1 if 13.3 or 26.5 seen with no method M0 if using angle other than 0.5411 or 1.0822 (inc M0 for 1.0822π) unless clearly intended as correct angle Allow equivalent method using fractions of the circle Allow valid method with degrees, but M0 for (½)$r^2\theta$ with θ in degrees Condone omission of ½, but no other error May be seen explicitly or implied in method eg as part of ½$r^2(\theta$ - sin $\theta)$
				M1*	Attempt area of relevant triangle or area of rhombus	Condone omission of ½ from ½absinθ Allow if using θ = 0.5411 not 1.0822 in (½) x 7^2 x sinθ Allow if attempting area of triangle ABC Could be using radians or degrees Allow even if evaluated in incorrect mode If using a right-angled triangle, it must be ½bh, and valid use of trig to find b or h
				A1	Obtain 4.88, or better, either as final answer or soi in method	Could come from finding area of segment but omitting to double it Allow inaccuracy - values in range [4.85, 4.9] Allow even if value not seen explicitly – could be implied by part of a calculation or even by final answer
				M1d*	Attempt correct method to find required area	Must be full and valid method – including attempted use of correct angle and subtraction in correct order Could find area of one segment and double it Other methods are possible eg 2 x sector minus rhombus
				A1	Obtain 9.76, or better	Allow answer rounding to 9.76, no errors seen
				[5]		

Question			Answer	Marks	Guidance	
8	**(i)**		Translation of 3 units in positive x-direction	B1	State translation	Must be 'translation' and not 'move', slide', 'shift' etc
				B1	State or imply 3 units in positive x-direction	Independent of first B1 Allow vector notation, but not a coordinate ie (3, 0) Worded descriptions must give clear intention of direction, so B0 for just 'x-direction' or 'parallel to x-axis' unless +3 also stated (as '+' implies the direction) For the direction, allow 'in the positive x-direction', 'parallel to the positive x-axis' or 'to the right' Do not allow 'in the positive x-axis' or 'along the positive x-axis' even if combined with correct statement eg 'right' Allow '3' or '3 units' but not '3 places', '3 squares', 'sf 3'... Ignore irrelevant statements (eg intercepts on axes), but penalise contradictions **B0 B0** if second transformation also given
				[2]		

Question			Answer	Marks	Guidance	
8	**(ii)**		$a = 8$	B1 **[1]**	State 8	Allow x not a Allow implied value eg (8, 3) or $\log_2 8 = 3$
8	**(iii)**		$b - 3 = 2^{1.8}$ $b = 6.48$	B1 B1 **[2]**	State or imply $b - 3 = 2^{1.8}$ Obtain 6.48, or better	Allow x not b More accurate answer is 6.482202253... Answer only can gain B2 as long as accurate
8	**(iv)**		$\log_2 c - \log_2(c-3) = 4$ $\log_2 \frac{c}{c-3} = 4$ $\frac{c}{c-3} = 2^4$ $c = 16c - 48$ $c = \frac{48}{15} = \frac{16}{5}$	M1	Equate difference in y-coordinates to ± 4	Allow in terms of x not c Allow any equiv eg $\log_2 c = \log_2(c-3) + 4$ Brackets must be seen, or implied by later working Allow if subtraction is the other way around, but M0 if two log terms are summed Allow as part of an attempt at Pythagoras' theorem eg $\sqrt{\{(c-c)^2 + (\log_2 c - \log_2(c-3))^2\}} = 4$
				M1	Use $\log a - \log b = \log \frac{a}{b}$	Could be implied if $\log_2$ dealt with at the same time Must be used on difference not sum if using the two algebraic terms ie $\pm(\log_2 c - \log_2(c-3))$ Starting with $\log_2 c = \log_2(c-3)$, rearranging to equal 0 and then using a log law could get M1 Allow if 4 is attempted as $\log_2 k$ ($k \neq 4$) and then combined with at least one of the other two terms (possibly using $\log a + \log b$) Allow if attempted with their now incorrect 4 Allow if they started with a constant other than ± 4 ie attempting to rewrite k as $\log_2 2^k$ and then combining with at least one of the algebraic logs gets M1
				A1	Obtain $\frac{c}{c-3} = 2^4$	Any correct equation, in a form not involving logs
				A1 **[4]**	Obtain $\frac{16}{5}$ oe	Allow 3.2, or unsimplified fraction **SR B2** for answer only or T&I

Question			Answer	Marks	Guidance	
9	**(i)**		$\int(2x - 5 + 4x^{-2})\,dx = x^2 - 5x - 4x^{-1}$ $(4a^2 - 10a - {}^2/_a) - (a^2 - 5a - {}^4/_a)$ $= 0$ $3a^2 - 5a + {}^2/_a = 0$ $3a^3 - 5a^2 + 2 = 0$ **AG**	M1	Attempt to rewrite integrand in a suitable form	Attempt to divide all 3 terms by x^2, or attempt to multiply all 3 terms by x^{-2} soi
				A1	Obtain $2x - 5 + 4x^{-2}$	Allow if third term is written in fractional form
				M1	Attempt integration of their integrand	Their integrand must be written as a polynomial ie with all terms of the form kx^n, and no brackets At least two terms must increase in power by 1 Allow if the – 5 disappears
				A1	Obtain $x^2 - 5x - 4x^{-1}$	Allow unsimplified (eg ${}^4/_{-1}\, x^{-1}$)
				M1	Attempt use of limits	Must be F(2a) - F(a) ie subtraction with limits in the correct order Allow if no brackets ie $4a^2 - 10a - {}^2/_a - a^2 - 5a - {}^4/_a$ Must be in integration attempt, but allow M1 for limits following M0 for integration eg if fraction not dealt with before integrating
				A1	Equate to 0 and rearrange to obtain $3a^3 - 5a^2 + 2 = 0$	Must be equated to 0 before multiplying through by a At least one extra line of working required between $(4a^2 - 10a - {}^2/_a) - (a^2 - 5a - {}^4/_a) = 0$ and the final answer **AG** so look carefully at working
				[6]		

Question			Answer	Marks	Guidance	
9	(ii)		$f(1) = 3 - 5 + 2 = 0$ **AG**			**Allow working in *x* not *a* throughout**
			$f(a) = (a - 1)(3a^2 - 2a - 2)$	B1	Confirm f(1) = 0 – detail required	$3(1)^3 - 5(1)^2 + 2 = 0$ is enough B0 for just f(1) = 0 If using division must show '0' on last line If using coefficient matching must show 'R = 0' If using inspection then there must be some indication of no remainder eg expand to show correct cubic
			$a = \frac{2\pm\sqrt{4+24}}{6} = \frac{2\pm 2\sqrt{7}}{6} = \frac{1\pm\sqrt{7}}{3}$			
			hence $a = {}^1/_3(1 + \sqrt{7})$			
				M1	Attempt full division by $(a - 1)$, or equiv method	Must be complete method - ie all 3 terms attempted Long division - must subtract lower line (allow one slip) Inspection - expansion must give at least three correct terms of the cubic Coefficient matching - must be valid attempt at all coeffs of quadratic, considering all relevant terms each time
				A1	Obtain $3a^2$ and one other correct term	Could be middle or final term depending on method Must be correctly obtained Coeff matching - allow for $A = 3$ etc
				A1	Obtain fully correct quotient	Could appear as quotient in long division, or as part of a product if using inspection. For coeff matching it must now be explicit not just $A = 3$, $B = -2$, $C = -2$
				M1	Attempt to solve quadratic	Using the quadratic formula, or completing the square (see guidance sheet) though negative root may be lost at any point M0 if factorising attempt as expected root is a surd Quadratic must come from division attempt, even if this was not good enough for first M1
				A1 **[6]**	Obtain ${}^1/_3(1 + \sqrt{7})$ only	Must give the positive root only, so A0 if negative root still present (but condone $a = 1$ also given) Allow aef but must be a simplified surd as per request on question paper (ie simplify $\sqrt{28}$)

Question			Answer	Marks	Guidance	
1			$\frac{1}{2} \times 2 \times ({}^{8}/_{5} + 2({}^{8}/_{7} + {}^{8}/_{9}) + {}^{8}/_{11})$	M1	Attempt the 4 correct *y*-coordinates, and no others	M0 if other *y*-values also found (unless not used) Allow decimal equivs
				M1	Attempt correct trapezium rule, any *h*, to find area between $x = 5$ and $x = 11$	Correct structure required, including placing of *y*-values The 'big brackets' must be seen, or implied by later working - this may not be clear if using $h = 2$ so allow BOD for eg $\frac{1}{2} \times 2 \times ({}^{8}/_{5} + {}^{8}/_{11}) + 2({}^{8}/_{7} + {}^{8}/_{9})$ Could be implied by stating general rule in terms of y_0 etc, as long as these have been attempted elsewhere and clearly labelled Could use other than 3 strips as long as of equal width Using *x*-values is M0 Can give M1, even if error in evaluating *y*-values as long correct intention is clear Allow BoD if first or last *y*-value incorrect, unless clearly from an incorrect *x*-value
				M1	Use correct *h* (soi) for their *y*-values (must have equally spaced *x*-values), to find area between $x = 5$ and $x = 11$	Must be in attempt at trap rule, not Simpson's rule As $h = 2$, allow BOD if ${}^{1}/_{2} \times 2$ not seen explicitly Allow if muddle over placing *y*-values, including duplication, (but M0 for *x*-values) Allow if ½ missing Allow other than 3 strips, as long as *h* is consistent
			= 6.39	A1	Obtain 6.39, or better	Allow answers in the range [6.390, 6.391] if >3sf Answer only is 0/4 Using 2 strips of width 3 is M0M1M1 and not a misread Using the trap rule on result of an integration attempt is 0/4 – this includes functions such as 8*x* even if integration is not explicit Using 3 separate trapezia can get full marks – if other than 3 trapezia then mark as above However, using only one trapezium is 0/4
				[4]		

Question			Answer	Marks	Guidance	
2	**(i)**		$\frac{1}{2}x = 53.1°, 126.9°$	B1	Obtain 106°, or better	Allow answers in the range [106.2, 106.3] Ignore any other solutions for this mark Must be in degrees, so 1.85 rad is B0
			$x = 106°, 254°$	M1	Attempt correct solution method to find second angle	Could be 2(180° – their 53.1°) or (360° – their 106°) Allow valid method in radians, but M0 for eg (360 – 1.85)
				A1	Obtain 254°, or better	Allow answers in the range [253.7°, 254°] A0 if in radians (4.43) A0 if extra incorrect solutions in range **SR** If no working shown then allow B1 for 106° and B2 for 254° (max B2 if additional incorrect angles)
				[3]		
2	**(ii)**		$\tan x = 3$	B1	State $\tan x = 3$	Allow B1 for correct equation even if no, or an incorrect, attempt to solve Give BOD on notation eg $^{\sin}/_{\cos}(x)$ as long as correct equation is seen or implied at some stage
			$x = 71.6°, 252°$	M1	Attempt to solve $\tan x = k$	Not dep on B1, so could gain M1 for solving eg $\tan x = {}^{1}/_{3}$ Could be implied by a correct solution
				A1	Obtain 71.6° and 252°, or better	A0 if extra incorrect solutions in range **Alt method:** **B1** Obtain $10\sin^2 x = 9$ or $10\cos^2 x = 1$ **M1** Attempt to solve $\sin^2 x = k$ or $\cos^2 x = k$ (allow M1 if just the positive square root used) **A1** Obtain 71.6° and 252°, with no extra incorrect solutions in range **SR** If no working shown at all then allow B1 for each correct angle (max B1 if additional incorrect angles), but allow full credit if $\tan x = 3$ seen first
				[3]		

Question			Answer	Marks	Guidance	
3	**(i)**		$(2 + 5x)^6 = 64 + 960x + 6000x^2$	M1	Attempt at least first 2 terms– products of binomial coeff and correct powers of 2 and $5x$	Must be clear intention to use correct powers of 2 and $5x$ Binomial coeff must be 6 soi; ${}^6C_1$ is not yet enough Allow BOD if 6 results from ${}^6/_1$ Allow M1 if expanding $k(1 + {}^5/_2\,x)^6$, any k
				A1	Obtain $64 + 960x$	Allow 2^6 for 64 Allow if terms given as list rather than linked by '+'
				M1	Attempt 3rd term – product of binomial coeff and correct powers of 2 and $5x$	Allow M1 for $5x^2$ rather than $(5x)^2$ Binomial coeff must be 15 soi; ${}^6C_2$ is not yet enough Allow M1 if expanding $k(1 + {}^5/_2\,x)^6$, any k $1200x^2$ implies M1, as long as no errors seen (including no working shown)
				A1 **[4]**	Obtain $6000x^2$	A0 if an otherwise correct expansion is subsequently spoiled by attempt to simplify eg $4 + 60x + 375x^2$ **If expanding brackets:** Mark as above, but must consider all 6 brackets for the M marks (allow irrelevant terms to be discarded)
3	**(ii)**		$(9 + 6cx \ldots)(64 + 960x + \ldots)$	M1*	Expand first bracket and attempt at least one relevant product	Expansion of first bracket does not have to be correct, but must be attempted so M0 if using $(3 + cx)(64 + 960x\ldots)$ No need to see third term in expansion of first bracket Must then consider a product and not just use $6c + 960$ Expansion could include irrelevant / incorrect terms Using an incorrect expansion associated with part **(i)** can get M1 M1
			$(9 \times 960) + (6c \times 64) = 4416$ $8640 + 384c = 4416$ $384c = -4224$	M1d*	Equate sum of the two relevant terms to 4416 and attempt to solve for c	Must now consider just the two relevant terms M0 if additional terms, even if error has resulted in kx BOD if presence of x is inconsistent within equation
			$c = -11$	A1 **[3]**	Obtain $c = -11$	A0 for $c = -11x$

Question			Answer	Marks	Guidance	
4	**(a)**		${}^{5}/_{4}x^4 - 3x^2 + x + c$	M1	Attempt integration	Increase in power by 1 for at least two of the three terms Allow M1 if the +1 disappears
				A1	Obtain at least 2 correct (algebraic) terms	Integral must be of form $ax^4 + bx^2 + cx$ Allow for unsimplified ${}^{6}/_{2}\ x^2$ and/or $1x$
				A1	Obtain a fully correct integral, including $+ c$	Coeff of x^2 must now be simplified, as well as x not $1x$ A0 if integral sign or dx still present in final answer Ignore notation on LHS such as $\int = ...$, $y = ...$, ${}^{dy}/_{dx} = ...$
				[3]		
4	**(b)**	**(i)**	$-12x^{-2} + c$	M1	Obtain integral of form kx^{-2}	Any k, including unsimplified
				A1	Obtain fully correct integral, including $+ c$	Coeff must now be simplified A0 if integral sign or dx still present in final answer Do not penalise again if already penalised in part **(a)**, even if different error including omission of $+ c$ Ignore notation on LHS such as $\int = ...$, $y = ...$, ${}^{dy}/_{dx} = ...$
				[2]		
4	**(b)**	**(ii)**	$(0) - (-12a^{-2}) = 3$	M1*	Attempt F(∞) – F(a) and use or imply that F(∞) = 0	Must be subtraction and correct order Could use a symbol for the upper limit, eg s, and then consider $s \to \infty$ $0 - 12a^{-2}$, with no other supporting method, is M0 as this implies addition Allow BOD for $-12 \times (0)^{-2}$ as long as it then becomes 0 Allow M1 for using incorrect integral from **(b)(i)** as long as it is of the form kx^{-n} with $n \neq 3$
			$a^2 = 4$	M1d*	Equate to 3 and attempt to find a	Dependent on first M1 soi Allow muddle with fractions eg $a^2 = {}^{1}/_{4}$
			$a = 2$	A1	Obtain $a = 2$ only	A0 if –2 still present as well
				[3]		Answer only is 0/3 **NB** watch for $a = 2$ as a result of solving $24a^{-3} = 3$, which gets no credit

Question			Answer	Marks	Guidance	
5	(i)		sector area = ½ × 16^2 × 0.8 = 102.4	M1*	Attempt area of sector using (½) $r^2\theta$, or equiv	Condone omission of ½, but no other errors Must have r = 16, not 7 M0 if 0.8π used not 0.8 M0 if (½) $r^2\theta$ used with θ in degrees Allow equiv method using fractions of a circle
			triangle area = ½ × 16 × 7 × sin 0.8 = 40.2	M1*	Attempt area of triangle using (½) $ab\sin C$ or equiv	Condone omission of ½, but no other errors Angle could be in radians (0.8 not 0.8π) or degrees (45.8°) Must have sides of 16 and 7 Allow even if evaluated in incorrect mode (gives 0.78) If using ½ × b × h, then must be valid use of trig to find b and h
				M1d*	Attempt area of sector – area of triangle	Using ½ × 16^2 × (0.8 – sin 0.8) will get M1 M0 M0
			area BDC = 62.2 cm^2	A1 **[4]**	Obtain 62.2, or better	Allow answers in range [62.20, 62.25] if > 3sf
5	(ii)		$BD^2 = (16^2 + 7^2 - 2\times16\times7\times\cos 0.8)$ BD = 12.2	M1	Attempt length of BD using correct cosine rule	Must be correct cosine rule Allow M1 if not square rooted, as long as BD^2 seen M0 if 0.8π used not 0.8 Allow if evaluated in degree mode (gives 9.00) Allow if incorrectly evaluated - using $(16^2 + 7^2 - 2 \times 16 \times 7) \times \cos 0.8$ gives 7.51 Allow any equiv method, as long as valid use of trig Attempting the cosine rule in part **(i)** will only get credit if result appears in part **(ii)**
				A1	Obtain 12.2, or better	Allow any answer rounding to 12.2, with no errors seen Could be implied in method rather than explicit
			arc BC = 16 × 0.8 = 12.8	B1	State or imply that arc BC is 12.8	Allow if 16 × 0.8 seen, even if incorrectly evaluated
			per = 12.2 + 12.8 + 9 = 34.0 cm	A1 **[4]**	Obtain 34, or better	Accept 34 or 34.0, or any answer rounding to 34.0 if >3sf

Question			Answer	Marks	Guidance	
6	**(i)**		$S_{30} = {}^{30}/_2\ (2 \times 6 + 29 \times 1.8)$	M1	Use $d = 1.8$ in AP formula	Could be attempting S_{30} or u_{30} Formula must be recognisable, though not necessarily fully correct, so allow M1 for eg 15(6 + 29 × 1.8), 15(12 + 14 × 1.8) or even 15(12 + 19 × 1.8) Must have $d = 1.8$ (not 1.3), $n = 30$ and $a = 6$
				A1	Correct unsimplified S_{30}	Formula must now be fully correct Allow for any unsimplified correct expression If using ${}^1/_2 n(a + l)$ then l must be correct when substituted
			= 963	A1 **[3]**	Obtain 963	Units not required
6	**(ii)**		$r = {}^{7.8}/_6 = 1.3$	M1	Use $r = 1.3$ in GP formula	Could be attempting S_N , u_N or even S_∞ Formula must be recognisable, though not necessarily fully correct Must have $r = 1.3$ (not 1.8) and $a = 6$
			$\frac{6(1-1.3^N)}{1-1.3} \leq 1800$	A1	Correct unsimplified S_N	Formula must now be fully correct Allow for any unsimplified correct expression
			$1 - 1.3^N \geq -90$	M1	Link sum of GP to 1800 and attempt to rearrange to $1.3^N \leq k$	Must have used correct formula for S_N of GP Allow =, ≥ or ≤ Allow slips when rearranging, including with indices, so rearranging to $7.8^N \leq k$ could get M1
			$1.3^N \leq 91$ **AG**	A1	Obtain given inequality	Must have correct inequality signs throughout Correct working only, so A0 if 6×1.3^N becomes 7.8^N, even if subsequently corrected

Question			Answer	Marks	Guidance	
			$N \log 1.3 \le \log 91$	M1	Introduce logs throughout and attempt to solve equation / inequality	Must be using $1.3^N \le 91$, $1.3^N = 91$ or $1.3^N \ge 91$ This M1 (and then A1) is independent of previous marks Must get as far as attempting N M0 if no evidence of use of logarithms M0 if invalid use of logarithms in attempt to solve
			$N \le 17.19$ hence $N = 17$	A1	Conclude $N = 17$	Must come from solving $1.3^N \le 91$or $1.3^N = 91$ (ie not incorrect inequality sign) Answer must be integer value Answer must be equality, so A0 for $N \le 17$ **SR** Candidates who use numerical value(s) for N can get M1 Use $r = 1.3$ in a recognisable GP formula (M0 if N is not an integer value) A1 Obtain a correct unsimplified S_N Candidates who solve $1.3^N \le 91$ and then use a value associated with their N (usually 17 and/or 18) in a GP formula will be eligible for the M1A1 for solving the inequality and also the M1A1 in the **SR** above
				[6]		

Question			Answer	Marks	Guidance	
7	(i)		$\int_1^4 \left(x^{\frac{3}{2}} - 1\right) dx = \left[\frac{2}{5}x^{\frac{5}{2}} - x\right]_1^4$	M1	Attempt integration	Increase in power by 1 for at least one term - allow the –1 to disappear
				A1	Obtain fully correct integral	Coeff could be unsimplified eg $^{1}/_{2.5}$ Could have + c present
			= (12.8 – 4) – (0.4 – 1)	M1	Attempt correct use of limits	Must be explicitly attempting F(4) – F(1), either by clear substitution of 4 and 1 or by showing at least (8.8) – (–0.6) Allow M1 if + c still present in both F(4) and F(1), but M0 if their c is now numerical Allow use in any function other than the original
			= $9^{2}/_{5}$ **AG**	A1 **[4]**	Obtain $9^{2}/_{5}$	**AG**, so check method carefully Allow $^{47}/_{5}$ or 9.4
7	(ii)		$m = {}^{3}/_{2} \times \sqrt{4} = 3$	M1*	Attempt to find gradient at (4, 7) using differentiation	Must be reasonable attempt at differentiation ie decrease the power by 1 Need to actually evaluate derivative at $x = 4$
			$y = 3x - 5$	M1d*	Attempt to find point of intersection of tangent with x-axis or attempt to find base of triangle	Could attempt equation of tangent and use $y = 0$ Could use equiv method with gradient eg $3 = {}^{7}/_{4-x}$ Could just find base of triangle using gradient eg $3 = {}^{7}/_{b}$
			tangent crosses x-axis at $({}^{5}/_{3}, 0)$	A1	Obtain $x = {}^{5}/_{3}$ as pt of intersection or obtain ${}^{7}/_{3}$ as base of triangle	Allow decimal equiv, such as 1.7, 1.67 or even 1.6 www Allow M1M1A1 for $x = {}^{5}/_{3}$ with no method shown
			area of triangle = ${}^{1}/_{2} \times (4 - {}^{5}/_{3}) \times 7$ $= 8^{1}/_{6}$	M1d**	Attempt complete method to find shaded area	Dependent on both previous M marks Find area of triangle and subtract from $9^{2}/_{5}$ Must have 1 < their x < 4, and area of triangle < $9^{2}/_{5}$ If using $\int(3x - 5)dx$ then limits must be 4 and their x M1 for area of trapezium – area between curve and y-axis
			shaded area = $9^{2}/_{5} - 8^{1}/_{6} = 1^{7}/_{30}$	A1 **[5]**	Obtain $1^{7}/_{30}$, or exact equiv	A0 for decimal answer (1.23), unless clearly a recurring decimal (but not eg 1.2333...)

Question			Answer	Marks	Guidance	
8	**(i)**	**(a)**	(0, 1)	B1 **[1]**	State (0, 1)	Allow no brackets B1 for $x = 0$, $y = 1$ – must have $x = 0$ stated explicitly B0 for $y = a^0 = 1$ (as $x = 0$ is implicit)
		(b)	(0, 4)	B1 **[1]**	State (0, 4)	Allow no brackets B1 for $x = 0$, $y = 4$ – must have $x = 0$ stated explicitly B0 for $y = 4b^0 = 4$ (as $x = 0$ is implicit)
		(c)	State a possible value for *a* State a possible value for *b*	B1 B1 **[2]**	Must satisfy $a > 1$ Must satisfy $0 < b < 1$	Must be a single value Could be irrational eg *e* Must be fully correct so B0 for eg 'any positive number such as 3' Must be a single value Could be irrational eg e^{-1} Must be fully correct **SR** allow B1 if both *a* and *b* given correctly as a range of values

Question			Answer	Marks	Guidance	
8	(ii)		$\log_2 a^x = \log_2(4b^x)$	M1	Equate a^x and $4b^x$ and introduce logarithms at some stage	Could either use the two given equations, or b could have already been eliminated so using two eqns in a only Must take logs of each side soi so M0 for $4\log_2(b^x)$ Allow just log, with no base specified, or $\log_2$ Allow logs to any base, or no base, as long as consistent
			$\log_2 a^x = \log_2 4 + \log_2 b^x$	M1	Use $\log ab = \log a + \log b$ correctly	Or correct use of $\log {}^a/_b = \log a - \log b$ Used on a correct expression eg $\log_2(4b^x)$ or $\log_2 4({}^2/_a)^x$ Equation could either have both a and b or just a Must be used on an expression associated with $a^x = 4b^x$, either before or after substitution, so M0 for $\log_2(ab) = 1$ hence $\log_2 a + \log_2 b = 1$ Could be an equiv method with indices before using logs eg $a^{2x} = 4 \times 2^x$ hence $a^{2x} = 2^{2+x}$
			$x\log_2 a = \log_2 4 + x\log_2 b$	M1	Use $\log a^b = b \log a$ correctly at least once	Allow if used on an expression that is possibly incorrect Allow M1 for $x\log_2 a = x\log_2 4b$ as one use is correct Equation could either have both a and b or just a
			$x\log_2 a = \log_2 4 + x\log_2({}^2/_a)$	B1	Use $b = {}^2/_a$ to produce a correct equation in a and x only	Can be gained at any stage, including before use of logs If logs involved then allow for no, or incorrect, base as long as equation is fully correct – ie if $\log 2^k = k$ used then base must be 2 throughout equation Could be an equiv method eg $(a \times a)^x = 4(a \times b)^x$ hence $a^{2x} = 4 \times 2^x$ Must be eliminating b, so $({}^2/_b)^x = 4b^x$ is B0 unless the equation is later changed to being in terms of a
			$x\log_2 a = 2 + x\log_2 2 - x\log_2 a$ $x(2\log_2 a - 1) = 2$ $x = \dfrac{2}{2\log_2 a - 1}$ **AG**	A1	Obtain given relationship with no wrong working	Proof must be fully correct with enough detail to be convincing Must use $\log_2$ throughout proof for A1 – allow 1 slip Using numerical values for a and b will gain no credit Working with equation(s) involving y is M0 unless y is subsequently eliminated
				[5]		

Question			Answer	Marks	Guidance	
9	**(i)**		f(2) = 32 – 14 –3 = 15	M1	Attempt f(2) or equiv	M0 for using x = –2 (even if stated to be f(2)) At least one of the first two terms must be of the correct sign Must be evaluated and not just substituted Allow any other valid method as long as remainder is attempted (see guidance in part **(ii)** for acceptable methods)
				A1	Obtain 15	Do not ISW if subsequently given as –15 If using division, just seeing 15 on bottom line is fine unless subsequently contradicted by eg –15 or $^{15}/_{x-2}$
				[2]		
9	**(ii)**		$f(^{-1}/_2) = {}^{-1}/_2 + {}^{7}/_2 - 3 = 0$ **AG**	B1	Confirm $f(^{-1}/_2) = 0$, with at least one line of working	$4(^{-1}/_2)^3 - 7(^{-1}/_2) - 3 = 0$ is enough B0 for just $f(^{-1}/_2) = 0$ If, and only if, $f(^{-1}/_2)$ is **not** attempted then allow B1 for other evidence such as division / coeff matching etc If using division must show '0' on last line or make equiv comment such as 'no remainder' If using coefficient matching must show 'R = 0' Just writing f(x) as the product of the three correct factors is not enough evidence on its own for B1
			$f(x) = (2x + 1)(2x^2 - x - 3)$	M1	Attempt complete division by $(2x + 1)$, or another correct factor	Could divide by $(x + 1)$, $(x + {}^1/_2)$, $(2x - 3)$, $(x - {}^3/_2)$ Must be complete method - ie all 3 terms attempted Long division - must subtract lower line (allow one slip) Inspection - expansion must give at least three correct terms of the cubic Coefficient matching - must be valid attempt at all coeffs of quadratic, considering all relevant terms each time

Question			Answer	Marks	Guidance	
			$= (2x + 1)(2x - 3)(x + 1)$	A1	Obtain $2x^2$ and one other correct term	Could be middle or final term depending on method Must be correctly obtained Coeff matching - allow for $A = 2$ etc Or lead term and one another correct for their factor
				A1	Obtain fully correct quotient of $2x^2 - x - 3$	Could appear as quotient in long division, or as part of a product if using inspection. For coeff matching it must now be explicit not just $A = 2$, $B = -1$, $C = -3$ Or fully correct quotient for their factor
				M1	Attempt to factorise their quadratic quotient from division attempt by correct factor	Allow M1 if brackets would give two correct terms on expansion **SR** allow even if their quadratic does not have rational roots If solving quadratic (eg using the formula) then must attempt factors for M1, but allow eg $(x - {}^3/_2)(x + 1)$
				A1	Obtain $(2x + 1)(2x - 3)(x + 1)$	Final answer must be seen as a product of all three factors Allow factorised equiv such as $2(2x + 1)(x - {}^3/_2)(x + 1)$ but A0 for $(2x + 1)(x - {}^3/_2)(2x + 2)$ as not fully factorised isw if subsequent confusion over 'roots' and 'factors' **SR** If repeated use of factor theorem, or answer given with no working, then allow a possible B1for $f({}^{-1}/_2) = 0$ with an additional **B5** for $(2x + 1)(2x - 3)(x + 1)$, or **B3** for a multiple such as $(2x + 1)(x - {}^3/_2)(x + 1)$
				[6]		

Question			Answer	Marks	Guidance	
9	(iii)		$2\cos\theta + 1 = 0$ $\cos\theta + 1 = 0$ $2\cos\theta - 3 = 0$	M1*	Identify relationship between factors of f(cos θ) and factors of f(x)	Replace x with cos θ in at least one of their factors (could be implied by later working, inc their solutions)
			$\cos\theta = {}^{-1}/_{2}$ $\cos\theta = -1$ $\cos\theta = {}^{3}/_{2}$	M1d*	Attempt to solve cos $\theta = k$ at least once	Must actually attempt θ, with $-1 \le k \le 1$
			$\theta = {}^{2\pi}/_{3}$, ${}^{4\pi}/_{3}$ $\theta = \pi$	A1	Obtain at least 2 correct angles	Allow angles in degrees (120°, 240°, 180°) Allow decimal equivs (2.09, 4.19, 3.14) Allow if $2\cos\theta + 1 = 0$ is the only factor used, or if other incorrect factors are also used Allow M1M1A1 for 2 correct angles with no working shown
				A1	Obtain all 3 correct angles	Must be exact and in radians A0 if additional incorrect angles in range Allow full credit if no working shown Angles must come from 3 correct roots of f(x), but allow if a factor was eg ($x - {}^{3}/_{2}$) not ($2x - 3$) A0 if incorrect root, even if it doesn't affect the three solutions eg one of their factors was ($2x + 3$) not ($2x - 3$)
				[4]		

Question			Answer	Marks	Guidance	
1	**(i)**		area = $^1/_2 \times 8 \times 10 \times \sin 65°$	M1	Attempt area of triangle using $\frac{1}{2}ab\sin\theta$	Must be correct formula, including $\frac{1}{2}$ Allow if evaluated in radian mode (gives 33.1) If using $\frac{1}{2} \times b \times h$, then must be valid use of trig to find h
			= 36.3	A1	Obtain 36.3, or better	If > 3sf, allow answer rounding to 36.25 with no errors seen
				[2]		
	(ii)		$BD^2 = 8^2 + 10^2 - 2 \times 8 \times 10 \times \cos 65°$	M1	Attempt use of correct cosine rule	Must be correct cosine rule Allow M1 if not square rooted, as long as BD^2 seen Allow if evaluated in radian mode (gives 15.9) Allow if correct formula is seen but is then evaluated incorrectly - using $(8^2 + 10^2 - 2 \times 8 \times 10) \times \cos 65°$ gives 1.30 Allow any equiv method, as long as valid use of trig
			$BD = 9.82$	A1	Obtain 9.82, or better	If > 3sf, allow answer rounding to 9.817 with no errors seen
				[2]		
	(iii)		$\frac{BC}{\sin 65} = \frac{8}{\sin 30}$	M1	Attempt use of correct sine rule (or equiv)	Must get as far as attempting BC, not just quoting correct sine rule Allow any equiv method, as long as valid use of trig including attempt at any angles used If using their BD from part **(ii)** it must have been a valid attempt (eg M0 for $BD = 8\sin 65$, $BC = {}^{BD}/_{\sin 30} = 14.5$)
			$BC = 14.5$	A1	Obtain 14.5, or better	If >3sf, allow answer rounding to 14.5 with no errors in method seen In multi-step solutions (eg using 9.82) interim values may be slightly inaccurate – allow A1 if answer rounds to 14.5
				[2]		

Question			Answer	Marks	Guidance	
2	(i)		2, 5, 8	B1	Obtain at least one correct value	Either stated explicitly or as part of a longer list, but must be in correct position eg -1, 2, 5 is B0
				B1	Obtain all three correct values	Ignore any subsequent values, if given
				[2]		
	(ii)		$S_{40} = \frac{40}{2}(2 \times 2 + 39 \times 3)$	B1*	Identify AP with $a = 2$, $d = 3$	Could be stated, listing of further terms linked by '+' sign or by recognisable attempt at any formula for AP including attempt at u_{40}
			$= 2420$	M1d*	Attempt to sum first 40 terms of the AP	Must use correct formula, with $a = 2$ and $d = 3$ If using $\frac{1}{2}n(a + l)$ then must be valid attempt at l Could use $3\sum n - \sum 1$, but M0 for $3\sum n - 1$ If summing manually then no need to see all middle terms explicitly as long as intention is clear
				A1	Obtain 2420	Either from formula or from manual summing of 40 terms
				[3]		

Question			Answer	Marks	Guidance	
3	(i)		arc = $12 \times \frac{2\pi}{3}$	M1	Attempt use of $r\theta$	Allow M1 if using θ as $^2/_3$ M1 implied by sight of 25.1, or better M0 if $r\theta$ used with θ in degrees M1 for equiv method using fractions of a circle, with θ as 120^o
			$= 8\pi$	A1 **[2]**	Obtain 8π only	Given as final answer - A0 if followed by 25.1
	(ii)		sector = $\frac{1}{2} \times 12^2 \times \frac{2\pi}{3} = 48\pi$	M1*	Obtain area of sector using $\frac{1}{2}r^2\theta$	Must be correct formula, including $\frac{1}{2}$ Must have $r = 12$ Allow M1 if using θ as $^2/_3$ M0 if $\frac{1}{2}r^2\theta$ used with θ in degrees M1 for equiv method using fractions of a circle, with θ as 120^o M1 implied by sight of 151 or better
			triangle = $\frac{1}{2} \times 12^2 \times \sin\frac{2\pi}{3} = 36\sqrt{3}$	M1*	Attempt area of triangle using $\frac{1}{2}r^2\sin\theta$	Must be correct formula, including $\frac{1}{2}$ Must have $r = 12$ Allow M1 if using θ as $^2/_3$ Allow even if evaluated in incorrect mode (2.63 or 41.8) If using ½ × b × h, then must be valid use of trig to find b and h M1 implied by sight of 62.4, or better
			segment = $48\pi - 36\sqrt{3}$	M1d*	Correct method to find segment area	Area of sector – area of triangle M0 if using θ as $^2/_3$ Could be exact or decimal values
				A1	Obtain either $48\pi - 36\sqrt{3}$ or 88.4	Allow decimal answer in range [88.44, 88.45] if >3sf
				A1 **[5]**	Obtain $48\pi - 36\sqrt{3}$ only	Given as final answer - A0 if followed by 88.4

Question			Answer	Marks	Guidance	
4	**(i)**		$\tan x(\sin x - \cos x) = 6\cos x$ $\tan x(\sin x / \cos x - 1) = 6$ $\tan x(\tan x - 1) = 6$	M1	Use $\tan x = \frac{\sin x}{\cos x}$ correctly once	Must be used clearly at least once - either explicitly or by writing eg 'divide by cos *x*' at side of solution Allow M1 for any equiv eg $\sin x = \cos x \tan x$ Allow poor notation eg writing just tan rather than tan *x*
			$\tan^2 x - \tan x = 6$ $\tan^2 x - \tan x - 6 = 0$ **AG**	A1	Obtain $\tan^2 x - \tan x - 6 = 0$	Correct equation in given form, including = 0 Correct notation throughout so A0 if eg tan rather than tan*x* seen in solution
				[2]		
	(ii)		$(\tan x - 3)(\tan x + 2) = 0$ $\tan x = 3$, $\tan x = -2$	M1	Attempt to solve quadratic in tan *x*	This M mark is just for solving a 3 term quadratic (see guidance sheet for acceptable methods) Condone any substitution used, inc $x = \tan x$
			$x = \tan^{-1}(3)$, $x = \tan^{-1}(-2)$	M1	Attempt to solve $\tan x = k$ at least once	Attempt $\tan^{-1}k$ at least once Not dependent on previous mark so M0M1 possible If going straight from $\tan x = k$ to $x = \ldots$, then award M1 only if their angle is consistent with their *k*
			$x = 71.6°, 252°, 117°, 297°$	A1	Obtain two correct solutions	Allow 3sf or better Must come from a correct method to solve the quadratic (as far as correct factorisation or substitution into formula) Allow radian equivs ie 1.25 / 4.39 / 2.03 / 5.18
				A1	Obtain all 4 correct solutions, and no others in range	Must now all be in degrees Allow 3sf or better A0 if other incorrect solutions in range $0^o - 360^o$ (but ignore any outside this range) **SR** If no working shown then allow **B1** for each correct solution (max of **B3** if in radians, or if extra solns in range).
				[4]		

Question			Answer	Marks	Guidance	
5			$(4x - 1)\log_{10}2 = (5 - 2x)\log_{10}3$	M1*	Introduce logs throughout and drop power(s)	Allow no base or base other than 10 as long as consistent, including $\log_3$ on LHS or $\log_2$ on RHS Drop single power if $\log_3$ or $\log_2$ or both powers if any other base
				A1	Obtain $(4x - 1)\log_{10}2 = (5 - 2x)\log_{10}3$	Brackets must be seen, or implied by later working Allow no base, or base other than 10 if consistent Any correct linear equation ie $4x - 1 = (5 - 2x)\log_2 3$ or $(4x - 1)\log_3 2 = 5 - 2x$
			$x(4\log_{10}2 + 2\log_{10}3) = \log_{10}2 + 5\log_{10}3$	M1*	Attempt to make x the subject	Expand bracket(s) and collect like terms - as far as their $4x\log_{10}2 + 2x\log_{10}3 = \log_{10}2 + 5\log_{10}3$ Expressions could include $\log_2 3$ or $\log_3 2$ Must be working exactly, so M0 if log(s) now decimal equivs
				A1	Obtain a correct equation in which x only appears once	LHS could be $x(4\log_{10}2 + 2\log_{10}3)$, $x\log_{10}144$ or even $\log_{10}144^x$ Expressions could include $\log_2 3$ or $\log_3 2$ RHS may be two terms or single term
			$x\log_{10}144 = \log_{10}486$	M1d*	Attempt correct processes to combine logs	Use $b\log a = \log a^b$, then $\log a + \log b = \log ab$ correctly on at least one side of equation (or $\log a - \log b$) Dependent on previous M1 but not the A1 so $\log_{10}486$ will get this M1 irrespective of the LHS
			$x = \frac{\log_{10}486}{\log_{10}144}$	A1	Obtain correct final expression	Base 10 required in final answer - allow A1 if no base earlier, or if base 10 omitted at times, but A0 if different base seen previously (unless legitimate working to change base seen) Do not isw subsequent incorrect log work eg $x = {}^{\log 27}/_{\log 8}$
				[6]		

Question			Answer	Marks	Guidance	
			Alternative solution $2^{4x} \div 2 = 3^5 \div 3^{2x}$ $2^{4x} \times 3^{2x} = 3^5 \times 2$	M1	Use index laws to split both terms	Either into fractions, or into products involving negative indices ie $2^{4x} \times 2^{-1}$
			$16^x \times 9^x = 243 \times 2$	A1	Obtain $2^{4x} \times 3^{2x} = 3^5 \times 2$ oe	Combine like terms on each side
			$144^x = 486$	M1	Use $a^{bx} = (a^b)^x$	Use at least once correctly
			$\log_{10} 144^x = \log_{10} 486$	A1	Obtain $144^x = 486$	Any correct equation in which x appears only once – logs may have been introduced prior to this
			$x \log_{10} 144 = \log_{10} 486$	M1	Introduce logs on both sides and drop power	Allow no base, or base other than 10 if consistent
			$x = \frac{\log_{10} 486}{\log_{10} 144}$	A1	Obtain correct final answer	Do not isw subsequent incorrect log work

Question			Answer	Marks	Guidance	
6	**(i)**		$(x^3)^4 + 4(x^3)^3(2x^{-2}) + 6(x^3)^2(2x^{-2})^2 + 4(x^3)(2x^{-2})^3 + (2x^{-2})^4$ $= x^{12} + 8x^7 + 24x^2 + 32x^{-3} + 16x^{-8}$	M1*	Attempt expansion – products of powers of x^3 and $2x^{-2}$	Must attempt at least 4 terms Each term must be an attempt at a product, including binomial coeffs if used Allow M1 if no longer $2x^{-2}$ due to index errors Allow M1 for no, or incorrect, binomial coeffs Powers of x^3 and $2x^{-2}$ must be intended to sum to 4 within each term (allow slips if intention correct) Allow M1 even if powers used incorrectly with $2x^{-2}$ ie only applied to x^{-2} and not to 2 as well Allow M1 for expansion of bracket in $x^k(1 + 2x^{-5})^4$ with $k = 3$ or 12 only, or $x^k(x^5 + 2)^4$ with $k = -2$ or -8 only, oe
				M1d*	Attempt to use correct binomial coeffs	At least 4 correct from 1, 4, 6, 4, 1 - allow missing or incorrect (but not if raised to a power) May be implied rather than explicit Must be numerical eg ${}^4C_1$ is not enough They must be part of a product within each term The coefficient must be used in an attempt at the relevant term ie $6(x^3)^3(2x^{-2})$ is M0 Allow M1 for correct coefficients when expanding the bracket in $x^k(1 + 2x^{-5})^4$ or $x^k(x^5 + 2)^4$ $x^{12} + 8x^7 + 12x^2 + 8x^{-3} + 2x^{-8}$ gets M1 M1 implied (even if no method seen) – will also get the first A1 as well
				A1	Obtain two correct simplified terms	Either linked by '+' or as part of a list Powers and coefficients must be simplified
				A1	Obtain a further two correct terms	Either linked by '+' or as part of a list Powers and coefficients must be simplified
				A1 **[5]**	Obtain a fully correct expansion	Terms must be linked by '+' and not just commas Powers and coefficients must be simplified A0 if subsequent attempt to simplify indices (eg x by x^8)

Question			Answer	Marks	Guidance	
						SR for reasonable expansion attempt: M2 for attempt involving all 4 brackets resulting in a quartic with at most one term missing A1 for two correct, simplified, terms A1 for a further two correct, simplified, terms A1 for fully correct, simplified, expansion
	(ii)		$\frac{1}{13}x^{13} + x^8 + 8x^3 - 16x^{-2} - \frac{16}{7}x^{-7} + c$	M1*	Attempt integration	Increase in power by 1 for at least three terms (other terms could be incorrect) Can still gain M1 if their expansion does not have 5 terms Allow if the three terms include x^{-1} becoming $k \ln x$ (but not x^0)
				A1FT	Obtain at least 3 correct terms, following their **(i)**	Allow unsimplified coefficients
				A1	Obtain fully correct expression	Coefficients must be fully simplified, inc x^8 not $1x^8$ isw subsequent errors eg $16x^{-2}$ then being written with 16 as well as x^2 in the denominator of a fraction
				B1d* **[4]**	+ c, and no dx or integral sign in answer	Ignore notation on LHS such as $\int = \ldots$, $y = \ldots$, $\frac{dy}{dx} = \ldots$

Question			Answer	Marks	Guidance	
7	(i)		$f(-2) = 12 - 22(-2) + 9(-2)^2 - (-2)^3$ $= 12 + 44 + 36 + 8$	M1	Attempt f(–2) or equiv	M0 for using $x = 2$ (even if stated to be f(-2)) Allow slips in evaluation as long as intention is clear At least one of the second or fourth terms must be of the correct sign Allow any other valid method to divide by $(x + 2)$ as long as remainder is attempted (see guidance in part **(iii)** for acceptable methods)
			$= 100$	A1	Obtain 100	Do not ISW if subsequently given as -100 If using division, just seeing 100 on bottom line is fine unless subsequently contradicted by eg -100 or $^{100}/_{x+2}$
				[2]		
	(ii)		$f(3) = 12 - 66 + 81 - 27 = 0$	B1	Attempt f(3), and show = 0	$12 - 22(3) + 9(3)^2 - (3)^3 = 0$ is enough B0 for just stating f(3) = 0 If using division must show '0' on last line or make equiv comment such as 'no remainder' If using coefficient matching must show 'R = 0' Just writing f(x) as the product of the linear factor and the correct quadratic factor is not enough evidence - need to show that the expansion would give f(x) Ignore incorrect terminology eg '$x = 3$ is a factor' or '$(3 - x)$ is a root'
				[1]		

Question			Answer	Marks	Guidance	
	(iii)		f(x) = $(3 - x)(x^2 - 6x + 4)$	M1	Attempt complete division by $(3 - x)$ or $(x - 3)$, or equiv	Must be complete method - ie all 3 terms attempted Allow M1 if dividing $x^3 - 9x^2 + 22x - 12$ by $(3 - x)$ oe Long division - must subtract lower line (allow one slip) Inspection - expansion must give at least three correct terms of the cubic Coefficient matching - must be valid attempt at all coeffs of quadratic, considering all relevant terms each time Synthetic division - must be using 3 (not -3) and adding within each column (allow one slip); expect to see 3 | 1 | -9 | 22 | -12 | | 3 | -18 | 1 | -6 | 4
				A1	Obtain $x^2 - 6x + 4$ or $-x^2 + 6x - 4$	Allow A1 even if division is inconsistent eg dividing f(x) by $(x - 3)$ or -f(x) by $(3 - x)$ Must be explicit and not implied ie A = 1 etc in coeff matching method or just the bottom line in the synthetic division method is not enough
				A1 **[3]**	Obtain $(3 - x)(x^2 - 6x + 4)$ or $(x - 3)(-x^2 + 6x - 4)$	Must be written as a product, just stating the quadratic quotient by itself is not enough Must come from a method with consistent signs in the divisor and dividend
	(iv)		$x = 3$	B1	State $x = 3$	At any point
			$x = 3 \pm \sqrt{5}$	M1	Attempt to find roots of quadratic quotient	Can gain M1 if using an incorrect quotient from **(iii)**, as long as it is a three term quadratic and comes from a division attempt by $(3 - x)$ or $(x - 3)$ See Appendix 1 for acceptable methods
				A1 **[3]**	Obtain $x = 3 \pm \sqrt{5}$	Must be in simplified surd form Allow A1 if from $-$f(x) = 0 eg $(x - 3)(x^2 - 6x + 4) = 0$

Question			Answer	Marks	Guidance	
8	(a)		$u_k = 50 \times 0.8^{k-1}$	B1	State correct $50 \times 0.8^{k-1}$	Allow B1 even if it subsequently becomes 40^{k-1} Could be implied by a later (in)equation eg $0.8^{k-1} < 0.003$ Must be seen correct numerically so stating $a = 50$, $r = 0.8$, $u_k = ar^{k-1}$ is not enough
			$50 \times 0.8P^{k-1} < 0.15$ $0.8^{k-1} < 0.003$ $\log 0.8^{k-1} < \log 0.003$	M1	Link to 0.15, rearrange and introduce logs or equiv	Allow any sign, equality or inequality Allow no, or consistent, log base on both sides or $\log_{0.8}$ on RHS If starting with $\log(50 \times 0.8^{k-1}) < \log 0.15$ then the LHS must be correctly split to $\log 50 + \log 0.8^{k-1}$ for M1 M0 if solving $40^{k-1} < 0.15$ Allow M1 if using 50×0.8^k M0 if using S_k
			$(k-1)\log 0.8 < \log 0.003$	A1	Obtain correct linear (in)equation	Could be $(k-1)\log 0.8 < \log 0.003$, $(k-1) < \log_{0.8} 0.003$ or $\log 50 + (k-1)\log 0.8 < \log 0.15$ Allow no brackets if implied by later work Allow any linking sign, including >
			$k > 27.03$ $k = 28$	A1 **[4]**	Obtain $k = 28$ (equality only)	Must be equality in words or symbols ie $k = 28$ or k is 28, but A0 for $k \geq 28$ or k is at least 28 Allow BOD if inequality sign not correct throughout as long correct final conclusion Answer only, or trial and improvement, is eligible for the first B1 only Allow n not k throughout

Question			Answer	Marks	Guidance	
	(b)		$ar = -3$, $\frac{a}{1-r} = 4$	B1	State $ar = -3$	Any correct statement, including $a \times r^{(2-1)} = -3$ etc soi
				B1	State $\frac{a}{1-r} = 4$	Any correct statement, not involving r^{∞} (unless it becomes 0) soi
			$-\frac{3}{r} = 4(1-r)$	M1*	Attempt to eliminate either a or r	Using valid algebra so M0 for eg $a = -3 - r$ Must be using ar^k and $^{\pm a}/_{(\pm 1 \pm r)}$ Award as soon as equation in one variable is seen
			$4r^2 - 4r - 3$ (= 0) / $a^2 - 4a - 12$ (= 0)	A1	Obtain correct simplified quadratic	Any correct quadratic not involving fractions or brackets ie $4r^2 = 4r + 3$ gets A1
			$(2r-3)(2r+1)=0$ / $(a-6)(a+2)=0$	M1d*	Attempt to solve 3 term quadratic	See Appendix 1 for acceptable methods
			$r = -\frac{1}{2}$	M1**	Identify $r = -\frac{1}{2}$ as only ratio with a minimally acceptable reason	M0 if no, or incorrect, reason given Must have correct quadratic, correct factorisation and correct roots (if stated) If $r = -\frac{1}{2}$ is not explicitly identified then allow M1 when they use only this value to find a (or later eliminate the other value) Could accept $r = -\frac{1}{2}$ as $\lvert r \rvert < 1$or reject $r = \frac{3}{2}$ as > 1 Could reject $a = -2$ as S_∞ is positive Could refer to convergent / divergent series
			$a = 6$	A1	Obtain $a = 6$ only	If solving quadratic in a, then both values of a may be seen initially - A1 can only be awarded when $a = 6$ is given as only solution
			for sum to infinity $-1 < r < 1$	A1d**	Convincing reason for $r = -\frac{1}{2}$ as the only possible ratio	Must refer to $\lvert r \rvert < 1$ or $-1 < r < 1$ oe in words A0 if additional incorrect statement
				[8]		No credit for answer only unless both r first found

Question			Answer	Marks	Guidance	
9	**(i)**		$0.5 \times 2.5 \times (1 + 2(-3 + 2\sqrt{6.5}) + 3)$	M1*	Attempt y-values at $x = 0, 2.5, 5$ only	M0 if additional y-values found, unless not used y_1 can be exact or decimal (2.1 or better) Allow M1 for using incorrect function as long as still clearly y-values that are intended to be the original function eg $-3 + 2\sqrt{x} + 4$ (from $\sqrt{(x + 4)} = \sqrt{x} + \sqrt{4}$)
			$= 10.2$	M1d*	Attempt correct trapezium rule, inc $h = 2.5$	Fully correct structure reqd, including placing of y-values The 'big brackets' must be seen, or implied by later working Could be implied by stating general rule in terms of y_0 etc, as long as these have been attempted elsewhere and clearly labelled Using x-values is M0 Can give M1, even if error in evaluating y-values as long correct intention is clear
				A1	Obtain 10.2, or better	Allow answers in the range [10.24, 10.25] if >3sf A0 if exact surd value given as final answer Answer only is 0/3 Using 2 separate trapezia can get full marks Using anything other than 2 strips of width 2.5 is M0 Using the trapezium rule on result of an integration attempt is 0/3
				[3]		
	(ii)		$(5 \times 3) - 10.2 = 4.8$	M1	Attempt area of rectangle – their **(i)**	As long as $0 <$ their **(i)** < 15
				A1FT	Obtain 4.8, or better	Allow for exact surd value as well Allow answers in range [4.75, 4.80] if > 2sf
				[2]		

Question			Answer	Marks	Guidance	
	(iii)		$x = \frac{1}{4}(y^2 + 6y - 7)$	M1	Attempt to write as $x = f(y)$	Must be correct order of operations, but allow slip with inverse operations eg + / – , and omitting to square the $\frac{1}{2}$ Allow $y^2 + 9$ from an attempt to square $y + 3$, even if $(y + 3)^2$ is not seen explicitly first Allow maximum of 1 error
				A1	Obtain $x = \frac{1}{4}(y^2 + 6y - 7)$ aef	Allow A1 as soon as any correct equation seen in format $x = f(y)$, eg $x = \frac{1}{4}(y + 3)^2 - 4$ or $x = \frac{1}{4}(y^2 + 6y + 9) - 4$, and isw subsequent error
			area = $\left[\frac{1}{12}y^3 + \frac{3}{4}y^2 - \frac{7}{4}y\right]_1^3$	M1*	Attempt integration of $f(y)$	Expand bracket and increase in power by 1 for at least two terms (allow if constant term disappears) Independent of rearrangement attempt so M0M1 is possible Can gain M1 if their $f(y)$ has only two terms, as long as both increase in power by 1 Allow M1 for $k(y + 3)^3$, any numerical k, as the integral of $(y + 3)^2$ or M1 for $k(\frac{1}{2}(y + 3))^3$ from $(\frac{1}{2}(y + 3))^2$ oe if their power is other than 2
				A1	Obtain $\frac{1}{12}y^3 + \frac{3}{4}y^2 - \frac{7}{4}y$ aef	Or $\frac{1}{12}(y + 3)^3 - 4y$ A0 if constant term becomes $-\frac{7}{4}x$ not $-\frac{7}{4}y$
				B1	State or imply limits are $y = 1, 3$	Stated, or just used as limits in definite integral Allow B1 even if limits used incorrectly (eg wrong order, or addition) Allow B1 even if constant term is $-\frac{7}{4}x$ (or their cx)

Question			Answer	Marks	Guidance	
			$= \frac{15}{4} - (-\frac{11}{12})$	M1d*	Attempt correct use of limits	Correct order and subtraction Allow M1 (BOD) if y limits used in $-\frac{7}{4}x$ (or their cx), but M0 if $x = 0, 5$ used Minimum of two terms in y Only term allowed in x is their c becoming cx Allow processing errors eg $(\frac{1}{12} \text{ x } 3)^3$ for $\frac{1}{12} \text{ x } 3^3$ Answer is given so M0 if $\frac{14}{3}$ appears with no evidence of use of limits Minimum working required is $\frac{15}{4} + \frac{11}{12}$ Allow M1 if using decimals (0.92 or better for $\frac{11}{12}$) M0 if using lower limit as $y = 0$, even if $y = 3$ is also used Limits must be from attempt at y-values, so M0 if using 0 and 5
			$= \frac{14}{3}$ **AG**	A1	Obtain $\frac{14}{3}$	Must come from exact working ie fractions or recurring decimals **-** correct notation required so A0 for 0.9166... A0 if $-\frac{7}{4}x$ seen in solution **SR** for candidates who find the exact area by first integrating onto the x-axis: **B4** obtain area between curve and x-axis as $10\ ^1/_3$ **B1** subtract from 15 to obtain $^{14}/_3$ And, if seen in the solution, **M1A1** for $x = f(y)$ as above
				[7]		