Mark Scheme 4752
June 2005

Section A

1	$1+\frac{3}{2}x^{\frac{1}{2}}$	1+3	B2 for $kx^{\frac{1}{2}}$, or M1 for $x^{\frac{3}{2}}$ seen before differentiation or B1 ft their $x^{\frac{3}{2}}$ correctly differentiated	4
2	1170	4	B1 for a = 11 and B1 for d = 5 or 20th term = 106 and M1 for 20/2[their (a) + their(106)] or 20/2[2their (a)+ (20-1)×their(d)] OR M1 for 6×20 and M2 for $5\left(\frac{20}{2}[20+1]\right)$ o.e.	4
3	±√13/4	3	B2 for (-) √13/4 or $\pm\sqrt{\frac{13}{16}}$ or M1 for √13 or $\sin^2\theta+\cos^2\theta=1$ used	3
4	$x + x^{-1}$ soi $y' = 1 - 1/x^2$ subs x = 1 to get y' = 0 $y''=2x^{-3}$ attempted Stating $y'' > 0$ so min cao	B1 B1 B1 M1ft A1	 $1 - x^{-2}$ is acceptable Or solving $1 - x^{-2} = 0$ to obtain x = 1 or checking y' before and after x = 1 Valid conclusion First quadrant sketch scores B2	5
5	(i) 1 (ii) –2 (iii) 6log x	1 2 2	 M1 for $1/9=3^{-2}$ or log(1) – log(3^2) base not requd; M1 for 5 log x or log(x^6)	5
6	Correct curve thro' y axis (0, 1) indicated on sketch or table 5.64	G1 G1 3	y, y' & y'' all positive independent B2 for other versions of 5.64(3....) or B1 for other ans 5.6 to 5.7 or M1 for x log 2 = log 50 and M1 for x = log 50 ÷ log 2	5
7	$y = 7 - 3/x^2$ oe	5	B3 for (y =) $-3/x^2 + c$ [B1 for each of k/x^2, k = – 6/2 and +c] and M1 for substituting (1, 4) in their attempted integration with + c, the constant of integration	5
8	(i) 66° or 66.4 or 66.5…. 293.58 …. to 3 or more sf cao (ii) stretch (one way) parallel to the x-axis sf 0.5	B1 B1 1 1 1	Allow 1.16 or 73.8 Lost for extras in range. Ignore extras outside the range Horizontal, from y axis, in x axis, oe	5
				36

Section B

9	**i**	$3x^2 - 20x + 12$	2	B1 if one error "+c" is an error	2
	ii	$y - 64 = -16(x - 2)$ o.e. eg $y = -16x + 96$	4	M1 for subst $x = 2$ in their y' A1 for $y' = -16$ and B1 for $y = 64$	4
	iii	Factorising $f(x) \equiv (x+2)(x-6)^2$ OR Expanding $(x+2)(x-6)^2$	B3 M2 E1	or B1 for $f(-2) = -8-40-24+72 = 0$ and B1 for $f'(6) = 0$ and B1dep for $f(6)=0$	3
	iv	$\frac{x^4}{4} - \frac{10x^3}{3} + 6x^2 + 72x$ value at ($x = 6$) ~ value at ($x = -2$) 341(.3..) cao	B2 M1 A1	-1 for each error Must have integrated $f(x)$	4
10	**i**	AB = 7.8(0), 7.798 to 7.799 seen	2	M1 for correct use of sine rule For long methods M1A1 for art 7.8	
		area = 52.2 to 52.3	2	M1 for [2×][0.5 ×] their AB × 11.4 × sin 36°	4
	ii	tan 0.91 = ST/12.6 ST = 12.6 × tan 0.91 and completion (16.208...)	M1 E1	Accept 16.2 if ST is explicit but for long methods with pa check that their explicit expression = 16.2	
		area OSTR = [2×][0.5 ×]12.6 × their(16.2) nb 204. …. area of sector = $0.5 \times 12.6^2 \times 1.82$ =144.47… Logo = 59.6 to 60.0	M1 M1 A1 A1	oe using degrees oe using degrees soi by correct ans Accept 144, 144.5	
		arc = 12.6 × 1.82 [=22.9...] perimeter = 55.3 to 55.4	M1 A1	oe using degrees	8
11	**i**	81	1		1
	ii	$(1x)3^{n-1}$	1		1
	iii	(GP with) $a = 1$ and $r = 3$ clear correct use GP sum formula	M1 M1	or M1 for = $1+3+9+ \ldots +3^{n-1}$	2
	iv	(A) 6 www (B) 243	2 1	M1 for $364 = (3^n - 1)/2$	3
	v	their (ii) > 900 $(y - 1)\log 3 > \log 900$ $y - 1 > \log 900 \div \log 3$ $y = 8$ cao	M1ft M1ft M1 B1	-1 once for = or < seen: condone wrong letter / missing brackets / no base	4

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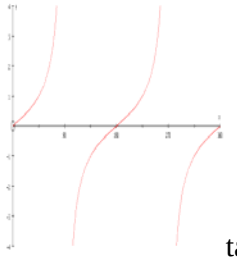
Section A

1	7/9 or 140/180 o.e.	2	B1 for 180° = π rad o.e. or 0.78 or other approximations	2
2	224	2	M1 for $2^3 + 3^3 + 4^3 + 5^3$	2
3	triangle divided into 2 rt angled tris $\sqrt{3}$ and 1 indicated 60 indicated	H1 S1 A1		3
4	16.1  overestimate + expn eg sketch	4 1	M3 for ¼{8.2 + 4.2 + 2 (6.4 + 5.5 + 5 + 4.7 + 4.4)} M2 for one slip/error M1 for two slips/errors	5
5	(i)  tan x = ¾ (ii) 36.8 to 36.9 and 216.8 to 216.9	2 M1 A1A1	no numbers required on axes unless more branches shown. G1 for a correct first sweep Allow 37, 217	5
6	$y'' = 2x - 6$ $y'' = 0$ at $x = 3$ $y' = 0$ at $x = 3$ showing y' does not change sign	B1 B1 B1 E1	 or that y'' changes sign	4
7	(i) 5 (ii) 5.646... to 2 sf or more	2 3	M1 for 6 = 1.2r M2 for 2 x 5x sin 0.6 or $\sqrt{(5^2 + 5^2 - 2.5.5.\cos 1.2)}$ or 5 sin 1.2/sin 0.971 M1 for these methods with 1 error	5
8	$\frac{2}{3}x^{\frac{3}{2}} - 3x^{-2} + c$ o.e.	5	1 for each element	5
9	(i) $\log_{10} y = 0.5x + 3$ (ii) $y = 10^{0.5x+3}$ isw	B3 2	B1 for each term scored in either part o.e. e.g. $y = 1000 \times 10^{\sqrt{x}}$	5

Section B

10	**i**	$y' = 6 - 2x$ $y' = 0$ used $x = 3$ $y = 16$ (0, 7) (–1, 0) and (7,0) found or marked on graph sketch of correct shape	M1 M1 A1 A1 3 1	condone one error 1 each must reach pos. y - axis	 8
	ii	58.6 to 58.7	3 M1	B1 for $7x + 3x^2 - x^3/3$ [their value at 5] – [their value at 1] dependent on integration attempted	3
	iii	using his (ii) and 48	1		1
11	**i**	$3x^2 - 6$	2	1 if one error	2
	ii	$-\sqrt{2} < x < \sqrt{2}$	3	M1 for using their $y' = 0$ B1 f.t. for both roots found	3
	iii	subst $x = -1$ in their y' [=–3] $y = 7$ when $x = -1$ $y + 3x = 4$ $x^3 - 6x + 2 = -3x + 4$ (2, –2) c.a.o.	B1 M1 A1 M1 A1,A1	f.t. f.t. 3 terms f.t.	 6
12	**i**	A 23 B 24 C 480	2 2 2	M1 for 5, 7, 9 etc or AP with $a = 5$, $d = 2$ M1 for $51 = 5 + 2(n - 1)$ o.e. M1 for attempted use of sum of AP formula eg 20/2[10+19×2]	2 2 2
	ii	A 11.78 – 11.80 B $5 \times 1.1^{n-1} > 50$ $1.1^{n-1} > 10$ $(n - 1) \log 1.1 > 1$ $n - 1 > 1/\log 1.1$ n = 26	2 B1 B1 L1 A1 1	 Or other step towards completion (NB answer given) independent	

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Section A

1	1, 3	1,1		2	
2	$r = 0.2$	3	M1 for $10 = 8/(1 - r)$, then M1 dep't for any correct step	3	
3	$1/\sqrt{15}$ i.s.w. not +/–	3	M2 for $\sqrt{15}$ seen M1 for rt angled triangle with side 1 and hyp 4, or $\cos^2\theta = 1 - 1/4^2$.	3	
4	$x^5/5 - 3x^{-1}/-1 + x$ [value at 2 – value at 1] attempted 5.7 c.a.o.	B3 M1 A1	1 each term dep't on B2	5	
5	$[y =] 3x - x^3/3 + c$ subst of (6, 1) in their eqn with c $y = 3x - x^3/3 + 55$ c.a.o	B1 B1 M1 A1	 Dep't on integration attempt Dep't on B0B1 Allow $c = 55$ isw	4	17
6	(i) 3, 8, 13, 18 (ii) use of $n/2[2a + (n - 1)d]$ $(S_{100} =)$ 25 050 or $(S_{50} =)$ 6275 $(S_{49} =)$ 6027 or $(S_{51} =)$ 6528 their$(S_{100} - S_{50})$ dep't on M1 18 775 cao	B1 M1 A1 M1 A1	Ignore extras Use of $a + (n - 1)d$ $u_{51} = 253$ $u_{100} = 498$ $u_{50} = 248$ $u_{52} = 258$ $50/2(\text{their}(u_{51} + u_{100}))$ dep't on M1 or $50/2[2 \times \text{their}(u_{51}) + 49 \times 5]$	5	
7	(i) sketch of correct shape correct period and amplitude period halved for $y = \cos 2x$; amplitude unchanged (ii) 30, 150, 210, 330	G1 G1 G1 B2	Not ruled lines need 1 and –1 indicated; nos. on horiz axis not needed if one period shown B1 for 2 of these, ignore extras outside range.	5	
8	$\sqrt{x} = x^{½}$ soi $18x^2$, $½ x^{-½}$ $36x$ $Ax^{-3/2}$ (from $Bx^{-½}$)	B1 B1B1 B1 B1	 –1 if d/dx(3) not = 0 any A,B	5	
9	$3x \log 5 = \log 100$ $3x = \log 100/\log 5$ $x = 0.954$	M1 M1 A2	allow any or no base or $3x = \log_5 100$ dep't A1 for other rot versions of 0.9537... SC B2/4 for 0.954 with no log wkg SC B1 r.o.t. 0.9537...	4	19

Section B

10	**i** (*A*)	$5.2^2 + 6.3^2 - 2\times5.2 \times 6.3 \times\cos$ "57"	M2	M1 for recognisable attempt at cos rule. or greater accuracy		
		ST = 5.6 or 5.57 cao	A1		3	
	i (*B*)	sin T/5.2 = sin(their 57)/their ST	M1	Or sin S/6.3 = … or cosine rule		
		T=51 to 52 or S = 71 to 72	A1			
		bearing 285 + their T or 408 – their S	B1	If outside 0 to 360, must be adjusted	3	
	ii	5.2θ, $24 \times 26/60$	B1B1			
		θ = 1.98 to 2.02	B1	Lost for all working in degrees		
		θ = their $2 \times 180/\pi$ or 114.6°...	M1	Implied by 57.3		
		Bearing = 293 to 294 cao	A1		5	11
11	**i**	$y' = 3x^2 - 6x$	B1	condone one error		
		use of $y' = 0$	M1			
		(0, 1) or (2, –3)	A2	A1 for one correct or x = 0 , 2 SC B1 for (0,1) from their y'		
		sign of y'' used to test or y' either side	T1	Dep't on M1 or y either side or clear cubic sketch	5	
	ii	$y'(-1) = 3 + 6 = 9$	B1			
		$3x^2 - 6x = 9$	M1	ft for their y'		
		$x = 3$	A1	implies the M1		
		At P $y = 1$	B1			
		grad normal = –1/9 cao	B1			
		$y - 1 = -1/9\ (x - 3)$	M1	ft their (3, 1) and their grad, not 9		
		intercepts 12 and 4/3or use of $\int_0^{12} 4/3 - 1/9\ x\ dx$ (their normal)	B1	ft their normal (linear)		
		½ × 12 × 4/3 cao	A1		8	13
12	**i**	$\log_{10} P = \log_{10} a + \log_{10} 10^{bt}$	B1	condone omission of base		
		$\log_{10} 10^{bt} = bt$	B1			
		intercept indicated as $\log_{10} a$	B1		3	
	ii	3.9(0), 3.94, 4(.00), 4.05, 4.11	T1	to 3 sf or more; condone one error		
		plots ft	P1	1 mm		
		line of best fit ft	L1	ruled and reasonable	3	
	iii	(gradient =) 0.04 to 0.06 seen	M1			
		(intercept =) 3.83 to 3.86 seen	M1			
		(a =) 6760 to 7245 seen	A1			
		$P = 7000 \times 10^{0.05t}$ oe	A1	7000×1.12^t SC $P = 10^{0.05t + 3.85}$ left A2	4	
	iv	17 000 to 18 500	B2	14 000 to 22 000 B1	2	12

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Section A

1	$\frac{5}{2}\times 6x^{\frac{3}{2}}$	1+1	- 1 if extra term	2
2	-0.2	3	M1 for $5=\frac{6}{1-r}$ and M1 dep for correct constructive step	3
3	√8 or 2√2 not ±√8	3	M1 for use of $\sin^2\theta+(1/3)^2=1$ and M1for $\sin\theta=\sqrt{8}/3$ (ignore ±) Diag.: hypot = 3, one side =1 M1 3rd side √8 M1	3
4	(i) C (ii) B (iii) 2^{n-1}	1 1 1		3
5	(i) −0.93, -0.930, -0.9297… (ii) answer strictly between 1.91 and 2 or 2 and 2.1 (iii) $y' = -8/x^3$, gradient = −1	2 B1 M1A1	M1 for grad = (1 – their y_B)/(2 − 2.1) if M0, SC1 for 0.93 don't allow 1.9 recurring	5
6	At least one cycle from (0, 0) amplitude 1 and period 360[°] indicated 222.8 to 223 and 317 to 317.2 [°]	G1 G1dep 2	1 each, ignore extras	4
7	$x < 0$ and $x > 6$	3	B2 for one of these or for 0 and 6 identified or M1 for $x^2 - 6x > 0$ seen (M1 if y found correctly and sketch drawn)	3
8	$a + 6d = 6$ correct $30=\frac{10}{2}(2a+9d)$ correct o.e. elimination using their equations $a = -6$ and $d = 2$ 5th term = 2	M1 M1 M1f.t. A1 A1	Two equations in a and d	5
9	$(y =) 2x^3 + 4x^2 - 1$ accept $2x^3 + 4x^2 + c$ and c = - 1	4	M2 for $(y =) 2x^3 + 4x^2 + c$ (M1 if one error) and M1 for subst of (1, 5) dep on their y =, +c, integration attempt.	4
10	(i) $3\log_a x$ ii) $b=\frac{1000}{c}$	2 2	M1 for $4\log_a x$ or $-\log_a x$; or $\log x^3$ M1 for 1000 or 10^3 seen	4

Section B

11	**i**	Correct attempt at cos rule correct full method for C C = 141.1… bearing = [0]38.8 cao	M1 M1 A1 A1	any vertex, any letter or B4	4
	ii	½ × 118 × 82 × sin their C or supp. 3030 to 3050 [m^2]	M1 A1	or correct use of angle A or angle B	2
	iiiA	sin (θ/2) = (½ × 189)/130 1.6276 → 1.63	M1 A1	or cosθ = (130^2+130^2-189^2)/(2x130x130) In all methods, the more accurate number to be seen.	2
	iiiB	0.5 × 130^2 × sin 1.63 0.5 × 130^2 × 1.63 their sector – their triangle AOB 5315 to 5340	M1 M1 M1 A1	condone their θ (8435) condone their θ in radians (13770) dep on sector > triangle	4
12	**i**	(2x − 3)(x − 4) x = 4 or 1.5	M1 A1A1	or (11 ±√(121 – 96))/4 if M0, then B1 for showing y = 0 when x = 4 and B2 for x = 1.5	3
	ii	y' = 4x − 11 = 5 when x = 4 c.a.o. grad of normal = −1/their y' y[− 0]=<u>their</u> −0.2 (x − 4) y-intercept for <u>their</u> normal area = ½ × 4 × 0.8 c.a.o.	M1 A1 M1f.t. M1 B1f.t. A1	condone one error or 0 = their (-0.2)x4 + c dep on normal attempt s.o.i. normal must be linear or integrating <u>their</u> f(x) from 0 to 4 M1	6
	iii	$\frac{2}{3}x^3 - \frac{11}{2}x^2 + 12x$ attempt difference between value at 4 and value at 1.5 [−]$5\frac{5}{24}$ o.e. or [−]5.2(083..)	M1 M1 A1	condone one error, ignore + c ft their (i), dep on integration attempt. c.a.o.	3
13	**i**	$\log_{10} y = \log_{10} k + \log_{10} 10^{ax}$ $\log_{10} y = ax + \log_{10} k$ compared to y = mx+c	M1 M1		2
	ii	2.9(0), 3.08, 3.28, 3.48, 3.68 plots [tol 1 mm] ruled line of best fit drawn	T1 P1f.t L1f.t.	condone one error	3
	iii	intercept = 2.5 approx gradient = 0.2 approx y = their 300x $10^{x(\text{their } 0.2)}$ or y = $10^{(\text{their } 2.5 + \text{their } 0.2x)}$	M1 M1 M1f.t.	or y – 2.7 = m(x – 1)	3
	iv	subst 75000 in any x/y eqn subst in a correct form of the relationship 11,12 or 13	M1 M1 A1	B3 with evidence of valid working	3
	v	"Profits change" or any reason for this.	R1	too big, too soon	1

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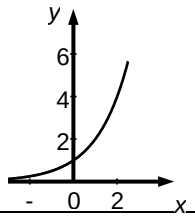
1	(i) $-\sqrt{3}$ (ii) $\frac{5}{3}\pi$	1 2	Accept any exact form accept $\frac{5\pi}{3}$, 1 ⅔π. M1 π rad = 180° used correctly	3
2	$y' = 6\times\frac{3}{2}x^{\frac{1}{2}}$ or $9x^{\frac{1}{2}}$ o.e. $y'' = \frac{9}{2}x^{-\frac{1}{2}}$ o.e. $\sqrt{36} = 6$ used interim step to obtain $\frac{3}{4}$	2 1 M1 A1	1 if one error in coeff or power, or extra term f.t. their y′ only if fractional power f.t. their y″ www answer given	5
3	(i) $y = 2f(x)$ (ii) $y = f(x - 3)$	2 2	1 if 'y=' omitted [penalise only once] M1 for y = kf(x), k > 0 M1 for $y = f(x + 3)$ or y = f(x – k)	4
4	(i) 11 27 or ft from their 11 (ii) 20	1 1 2	 M1 for 1 × 2 + 2× 3 + 3 × 4 soi, or 2,6,12 identified, or for substituting n = 3 in standard formulae	4
5	$\theta = 0.72$ o.e 13.6 [cm]	2 3	M1 for 9 = ½ × 25 × θ No marks for using degrees unless attempt to convert B2 ft for 10 + 5 × their θ or for 3.6 found or M1 for $s = 5\theta$ soi	5
6	(i) $\log_a 1 = 0$, $\log_a a = 1$ (ii) showing both sides equivalent	1+1 3	NB, if not identified, accept only in this order M1 for correct use of 3rd law and M1 for correct use of 1st or 2nd law. Completion www A1. Condone omission of *a*.	5
7	(i) curve with increasing gradient any curve through (0, 1) marked (ii) 2.73	G1 G1 3	correct shape in both quadrants M1 for $x \log 3 = \log 20$ (or $x=\log_3 20$) and M1 for $x = \log 20 \div \log 3$ or B2 for other versions of 2.726833.. or B1 for other answer 2.7 to 2.8	5
8	(i) $2(1 - \sin^2\theta) + 7\sin\theta = 5$ (ii) $(2\sin\theta - 1)(\sin\theta - 3)$ $\sin\theta = ½$ 30° and 150°	1 M1 DM1 A1 A1	for $\cos^2\theta + \sin^2\theta = 1$ o.e. used 1st and 3rd terms in expansion correct f.t. factors B1,B1 for each solution obtained by any valid method, ignore extra solns outside range, 30°, 150° plus extra soln(s) scores 1	5

9	**i**	$y' = 6x^2 - 18x + 12$ $= 12$ $y = 7$ when $x = 3$ tgt is $y - 7 = 12\,(x - 3)$ verifying $(-1, -41)$ on tgt	M1 M1 B1 M1 A1	condone one error subst of $x = 3$ in <u>their</u> y' f.t. their y and y' or B2 for showing line joining (3, 7) and $(-1, -41)$ has gradient 12	5
	ii	$y' = 0$ soi quadratic with 3 terms $x = 1$ or 2 $y = 3$ or 2	M1 M1 A1 A1	Their y' Any valid attempt at solution or A1 for (1, 3) and A1 for (2,2) marking to benefit of candidate	4
	iii	cubic curve correct orientation touching x- axis only at (0.2,0) max and min correct curve crossing y axis only at -2	G1 G1 G1	 f.t.	3
10	**i**	970 [m]	4	M3 for attempt at trap rule ½×10×(28+22+2[19+14+11+12+16]) M2 with 1 error, M1 with 2 errors. Or M3 for 6 correct trapezia, M2 for 4 correct trapezia, M1 for 2 correct trapezia.	4
	ii	concave curve or line of traps is above curve	1	Accept suitable sketch	
		$(19+14+11+11+12+16) \times 10$ 830 to 880 incl.[m]	M1 A1	M1 for 3 or more rectangles with values from curve.	3
	iii	$t = 10$, $v_{\text{model}} = 19.5$ difference = 0.5 compared with 3% of 19 = 0.57	B1 B1f.t.	 or $\frac{0.5}{19} \times 100 \approx 2.6$	2
	iv	$28t - \frac{1}{2}t^2 + 0.005t^3$ o.e. value at 60 [− value at 0] 960	M1 M1 A1	2 terms correct, ignore + c ft from integrated attempt with 3 terms	3
11	**ai**	13	1		1
	aii	120	2	M1 for attempt at AP formula ft their a, d or for $3 + 5 + \ldots + 21$	2
	bi	$\frac{125}{1296}$	2	M1 for $\frac{1}{6} \times \left(\frac{5}{6}\right)^3$	2
	ii	$a = 1/6$, $r = 5/6$ s.o.i. $S_\infty = \frac{\frac{1}{6}}{1-\frac{5}{6}}$ o.e.	1+1 1	If not specified, must be in right order	3
	iii	$\left(\frac{5}{6}\right)^{n-1} < 0.006$ $(n-1)\log_{10}\left(\frac{5}{6}\right) < \log_{10} 0.006$ $n - 1 > \frac{\log_{10} 0.006}{\log_{10}\left(\frac{5}{6}\right)}$ $n_{\min} = 30$ Or $\log(1/6) + \log(5/6)^{n-1} < \log 0.001$ $(n-1)\log(5/6) < \log(0.001/(1/6))$	M1 M1 DM1 B1 M1 M1	 condone omission of base, but not brackets NB change of sign must come at correct place 	4

4752 (C2) Concepts for Advanced Mathematics

Section A

1	$40x^3$	2	-1 if extra term	2
2	(i) 3 (ii) 141	1 2	 M1 for $9 \times (1 + 2 + 3 + 4 + 5) + 1 + 2 + 3$	3
3	right angled triangle with 1 and 2 on correct sides Pythagoras used to obtain hyp = $\sqrt{5}$ $\cos\theta = \frac{a}{h} = \frac{2}{\sqrt{5}}$	M1 M1 A1	or M1 for $\sin\theta = \frac{1}{2}\cos\theta$ and M1 for substituting in $\sin^2\theta + \cos^2\theta = 1$ E1 for sufficient working	3
4	(i)line along $y = 6$ with V (1, 6), (2, 2), (3, 6) (ii) line along $y = 3$ with V (−2,3), (−1,1), (0,3)	2 2	1 for two points correct 1 for two points correct	4
5	$2x^6 + \frac{3}{4}x^{\frac{4}{3}} + 7x + c$	5	1 for $2x^6$; 2 for $\frac{3}{4}x^{\frac{4}{3}}$ or 1 for other $kx^{\frac{4}{3}}$; 1 for $7x$; 1 for $+c$	5
6	(i) correct sine shape through O amplitude of 1 and period 2π shown (ii) $7\pi/6$ and $11\pi/6$	1 1 3	 B2 for one of these; 1 for $-\pi/6$ found	5
7	(i) 60 (ii) −6 (iii)  	2 1 1 1	M1 for $2^2 + 2^3 + 2^4 + 2^5$ o.e. Correct in both quadrants Through (0, 1) shown dep.	5
8	$r = 1/3$ s.o.i. $a = 54$ or ft 18 ÷ their r $S = \frac{a}{1-r}$ used with $-1 < r < 1$ S = 81 c.a.o.	2 M1 M1 A1	1 mark for $ar = 18$ *and* $ar^3 = 2$ s.o.i.	5
9	(i) 0.23 c.a.o. (ii) 0.1 or 1/10 (iii) $4(3x + 2)$ or $12x + 8$ (iv) [y =] 10^{3x+2} o.e.	1 1 1 1	 10^{-1} not sufficient 	4

Section B

10	**i**	$h = 120/x^2$ $A = 2x^2 + 4xh$ o.e. completion to given answer	B1 M1 A1	 at least one interim step shown	 3
	ii	$A' = 4x - 480/x^2$ o.e. $A'' = 4 + 960 / x^3$	2 2	1 for kx^{-2} o.e. included ft their A' only if kx^{-2} seen ; 1 if one error	4
	iii	use of $A' = 0$ $x = \sqrt[3]{120}$ or 4.9(3..) Test using A' or A'' to confirm minimum Substitution of their x in A A = 145.9 to 146	M1 A1 T1 M1 A1	 Dependent on previous M1	 5
11	**iA**	$BC^2 = 348^2 + 302^2 - 2 \times 348 \times 302 \times \cos 72°$ BC = 383.86… 1033.86…[m] or ft 650 + their BC	M2 A1 1	M1 for recognisable attempt at Cosine Rule to 3 sf or more accept to 3 sf or more	4
	iB	$\frac{\sin B}{302} = \frac{\sin 72}{\text{their } BC}$ B = 48.4.. 355 − their B o.e. answer in range 306 to307	M1 A1 M1 A1	Cosine Rule acceptable or Sine Rule to find C or 247 + their C	4
	ii	Arc length PQ = $\frac{224}{360} \times 2\pi \times 120$ o.e. or 469.1... to 3 sf or more QP = 222.5…to 3 sf or more answer in range 690 to 692 [m]	M2 B1 A1	M1 for $\frac{136}{360} \times 2\pi \times 120$	4
12	**iA**	$x^4 = 8x$ (2, 16) c.a.o. PQ = 16 and completion to show ½ × 2 × 16 = 16	M1 A1 A1	 NB answer 16 given	 3
	iB	$x^5/5$ evaluating their integral at their co-ord of P and zero [or 32/5 o.e.] 9.6 o.e.	M1 M1 A1	 ft only if integral attempted, not for x^4 or differentiation c.a.o.	 3
	iiA	$6x^2h^2 + 4xh^3 + h^4$	2	B1 for two terms correct.	2
	iiB	$4x^3 + 6x^2h + 4xh^2 + h^3$	2	B1 for three terms correct	2
	iiC	$4x^3$	1		1
	iiD	gradient of [tangent to] curve	1		1

4752 (C2) Concepts for Advanced Mathematics

Section A

1	210 c.a.o.	2	1 for π rads = 180° soi	2
2	(i) 5.4×10^{-3}, 0.0054 or $\frac{27}{5000}$ (ii) 6 www	1 2	 M1 for S = 5.4 / (1 − 0.1)	 3
3	stretch, parallel to the *y* axis, sf 3	2	1 for stretch plus one other element correct	2
4	[f′(*x*) =] 12 − 3x^2 their f′(*x*) > 0 or = 0 soi −2 < *x* < 2	B1 M1 A1	 condone −2 ≤ *x* ≤ 2 or "between -2 and 2"	 3
5	(i) grad of chord = $(2^{3.1} - 2^3)/0.1$ o.e. = 5.74 c.a.o. (ii) correct use of A and C where for C, 2.9 < x < 3.1 answer in range (5.36, 5.74)	M1 A1 M1 A1	 or chord with ends x = 3 ± h, where 0 < h ≤ 0.1 s.c.1 for consistent use of reciprocal of gradient formula in parts (i) and (ii)	 4
6	[*y* =] k$x^{3/2}$ [+ *c*] k = 4 subst of (9, 105) in their eqn with *c* or *c* = −3	M1 A1 M1 A1	 may appear at any stage must have *c*; must have attempted integration 	 4
7	sector area = 28.8 or $\frac{144}{5}$ [cm^2] c.a.o. area of triangle = ½ × 6^2 × sin 1.6 o.e. their sector − their triangle s.o.i. 10.8 to 10.81 [cm^2]	2 M1 M1 A1	M1 for ½ × 6^2 × 1.6 must both be areas leading to a positive answer	 5
8	*a* + 10*d* = 1 *or* 121 = 5.5(2a+10d) 5(2*a* + 9*d*) = 120 o.e. *a* = 21 s.o.i. www and *d* = −2 s.o.i. www 4th term is 15	M1 M1 A1 A1 A1	or 121 = 5.5(a + 1) gets M2 eg 2*a* + 9*d* = 24	 5
9	*x* log 5 = log235 or $x = \frac{\log 235}{\log 5}$ 3.39	M1 A2	or *x* = $\log_5 235$ A1 for 3.4 or versions of 3.392…	 3
10	2 (1 − $\cos^2 \theta$) = cos *θ* + 2 − 2 $\cos^2 \theta$ = cos *θ* s.o.i. valid attempt at solving their quadratic in cos *θ* cos *θ* = - ½ www *θ* = 90, 270, 120, 240	M1 A1 DM1 A1 A1	for 1 - $\cos^2 \theta$ = $\sin^2 \theta$ substituted graphic calc method: allow M3 for intersection of *y* = 2 $\sin^2 \theta$ and *y* = cos *θ* + 2 and A2 for all four roots. All four answers correct but unsupported scores B2. 120 and 240 only: B1.	 5

18

18

Section B

11	**i**	$(x + 5)(x - 2)(x + 2)$	2	M1 for $a\ (x + 5)(x - 2)(x + 2)$	2
	ii	$[(x + 2)](x^2 + 3x - 10)$	M1	for correct expansion of one pair of their brackets	
		$x^3 + 3x^2 - 10x + 2x^2 + 6x - 20$ o.e.	M1	for clear expansion of correct factors – accept given answer from $(x + 5)(x^2 - 4)$ as first step	2
	iii	$y' = 3x^2 + 10x - 4$	M2	M1 if one error	
		their $3x^2 + 10x - 4 = 0$ s.o.i.	M1	or M1 for substitution of 0.4 if trying	
		$x = 0.36\ldots$ from formula o.e.	A1	to obtain 0, and A1 for correct demonstration of sign change	
		$(-3.7, 12.6)$	B1+1		6
	iv	(-1.8, 12.6)	B1+1	accept $(-1.9, 12.6)$ or f.t.(½ their max x, their max y)	2
12	**i**	Area = (-)0.136 seen [m^2] www	4	M3 for $0.1/2 \times (0.14 + 0.16 + 2[0.22 + 0.31 + 0.36 + 0.32])$ M2 for one slip; M1 for two slips	
		Volume = 0.34 [m^3] or ft from their area $\times$ 2.5	1	must be positive	5
	ii	$2x^4 - x^3 - 0.25x^2 - 0.15x$ o.e.	M2	M1 for 2 terms correct	
		value at 0.5 [– value at 0]	M1	dep on integral attempted	
		= –0.1375	A1	must have neg sign	
		area of cross section (of trough) or area between curve and x-axis	E1		
		0.34375 r.o.t. to 3 or more sf [m^3]	B1		
		m^3 seen in (i) or (ii)	U1		7
13	**i**	$\log P = \log a + b \log t$ www	1		
		comparison with $y = mx + c$	1	must be with correct equation	
		intercept = $\log_{10} a$	1	condone omission of base	3
	ii	log *t* 0 0.78 1.15 1.18 1.20	1	accept to 2 or more dp	
			1		
		log *P* 1.49 1.64 1.75 1.74 1.76	1		
			1		4
		plots f.t.			
		ruled line of best fit			
	iii	gradient rounding to 0.22 or 0.23	2	M1 for y step / x-step	
			1	accept1.47 – 1.50 for intercept	
		$a = 10^{1.49}$ s.o.i.	1	accept answers that round to 30 – 32 , their positive m	
		$P = 31t^{m}$			4
		allow the form $P = 10^{0.22\log t + 1.49}$			
	iv	answer rounds in range 60 to 63	1		1

4752 (C2) Concepts for Advanced Mathematics

Section A

1	$4x^5$ $-12x^{-\frac{1}{2}}$ $+ c$	1 2 1	 M1 for other $kx^{-\frac{1}{2}}$	4
2	95.25, 95.3 or 95	4	M3 ½×5×(4.3+0+2[4.9+4.6+3.9+2.3+1.2]) M2 with 1 error, M1 with 2 errors. Or M3 for 6 correct trapezia.	4
3	1.45 o.e.	2	M1 for $\frac{1}{2}+\frac{1}{3}+\frac{1}{4}+\frac{1}{5}+\frac{1}{6}$ oe	2
4	105 and 165	3	B1 for one of these or M1 for $2x = 210$ or 330	3
5	(i) graph along $y = 2$ with V at (3,2) (4,1) & (5,2) (ii) graph along $y = 6$ with V at (1,6) (2,3) & (3,6)	2 2	M1 for correct V, or for f(x+2) B1 for (2,k) with all other elements correct	4
6	(i) 54.5 (ii) Correct use of sum of AP formula with n = 50, 20, 19 or 21 with their d and a = 7 eg S_{50} = 3412.5, S_{20} = 615 Their $S_{50} - S_{20}$ dep on use of ap formula 2797.5 c.a.o.	2 M1 M1 A1	B1 for $d = 2.5$ <u>or</u> M2 for correct formula for S_{30} with their d M1 if one slip	5
7	$8x - x^{-2}$ o.e. their $\frac{dy}{dx} = 0$ correct step x = ½ c.a.o.	2 M1 DM1 A1	B1 each term s.o.i. s.o.i.	5
8	(i) 48 geometric, or GP (ii) mention of $\|r\| < 1$ condition o.e. S = 128	1 1 1 2	 M1 for $\frac{192}{1--\frac{1}{2}}$	5
9	(i) 1 (ii) (A) 3.5 $\log_a x$ (ii) (B) $-\log_a x$	1 2 1	 M1 for correct use of 1st or 3rd law	4

Section B

10	**i**	$7 - 2x$ $x = 2$, gradient = 3 $x = 2$, $y = 4$ y – their 4 = their grad $(x - 2)$ subst $y = 0$ in their linear eqn completion to $x = \frac{2}{3}$ (ans given)	M1 A1 B1 M1 M1 A1	differentiation must be used or use of y = their $mx + c$ and subst (2, their 4), dependent on diffn seen	6
	ii	f(1) = 0 or factorising to $(x - 1)(6 - x)$ or $(x - 1)(x - 6)$ 6 www	1 1	or using quadratic formula correctly to obtain $x = 1$	2
	iii	$\frac{7}{2}x^2 - \frac{1}{3}x^3 - 6x$ value at 2 − value at 1 $2\frac{1}{6}$ or 2.16 to 2.17 $\frac{1}{2} \times \frac{4}{3} \times 4$ − their integral 0.5 o.e.	M1 M1 A1 M1 A1	for two terms correct; ignore $+c$ ft attempt at integration only	5
11	**i(**A)	150 (cm) or 1.5 m	2	M1 for 2.5×60 or 2.5×0.6 or for 1.5 with no units	2
	i(B)	½ × 60^2 × 2.5 or 4500 ½ × 140^2 × 2.5 or 24 500 subtraction of these 20 000 (cm^2) isw	M1 M1 DM1 A1	or equivalents in m^2 or 2 m^2	4
	ii(A)	attempt at use of cosine rule $\cos \text{EFP} = \frac{3.5^2 + 2.8^2 - 1.6^2}{2 \times 2.8 \times 3.5}$ o.e. 26.5 to 26.65 or 27	M1 M1 A1	condone 1 error in substitution	3
	ii(B)	2.8 sin (their EFP) o.e. 1.2 to 1.3 [m]	M1 A1		2

12	**i**	$\log a + \log (b^t)$ www clear use of $\log (b^t) = t \log b$ dep	B1 B1	condone omission of base throughout question	2
	ii	(2.398), 2.477, 2.556 , 2.643, 2.724 points plotted correctly f.t. ruled line of best fit f.t.	T1 P1 1	 On correct square 	3
	iii	$\log a = 2.31$ to 2.33 $a = 204$ to 214 $\log b = 0.08$ approx $b = 1.195$ to 1.215	M1 A1 M1 A1	ft their intercept ft their gradient 	4
	iv	eg £210 million dep	1	their £a million	1
	v	$\frac{\log 1000 - \text{their intercept}}{\text{their gradient}} \approx \frac{3 - 2.32}{0.08}$ = 8.15 to 8.85	M1 A1	 or B2 from trials	2

4752 (C2) Concepts for Advanced Mathematics

Section A

1	using Pythagoras to show that hyp. of right angled isos. triangle with sides *a* and *a* is $\sqrt{2}a$ completion using definition of cosine	M1 A1	www *a* any letter or a number NB answer given	2
2	$2x^6 + 5x$ value at 2 − value at 1 131	M2 M1 A1	M1 if one error ft attempt at integration only	4
3	(i) 193 (ii) divergent + difference between terms increasing o.e.	2 1	M1 for 8 + 15 + …+ 63	3
4	(i) 2.4 (ii) 138	2 2	M1 for 43.2 ÷ 18 M1 for their (i) × $\frac{180}{\pi}$ or θ = $\frac{43.2 \times 360}{36\pi}$ o.e. or for other rot versions of 137.50…	4
5	(i)sketch of cos*x* ; one cycle, sketch of cos2*x*; two cycles, Both axes scaled correctly (ii) (1-way) stretch parallel to *y* axis sf 3	1 1 D1 1 D1		5
6	$y' = 3x^2 - 12x - 15$ use of $y' = 0$, s.o.i. ft $x = 5, -1$ c.a.o. $x < -1$ or $x > 5$ f.t.	M1 M1 A1 A1 A1	for two terms correct	5
7	use of $\cos^2\theta = 1 - \sin^2\theta$ at least one correct interim step in obtaining $4\sin^2\theta - \sin\theta = 0$. $\theta = 0$ and 180, 14.(47…) 165 - 166	M1 M1 B1 B1 B1	 NB answer given r.o.t to nearest degree or better -1 for extras in range	5

8	attempt to integrate $3\sqrt{x} - 5$ [*y*=] $2x^{\frac{3}{2}} - 5x + c$ subst of (4, 6) in their integrated eqn *c* = 10 or [*y*=] $2x^{\frac{3}{2}} - 5x + 10$	M1 A2 M1 A1	A1 for two terms correct	5
9	(i) 7 (ii) 5.5 o.e.	1 2	M1 for at least one of $5 \log_{10} a$ or $\frac{1}{2} \log_{10} a$ or $\log_{10} a^{5.5}$ o.e.	3

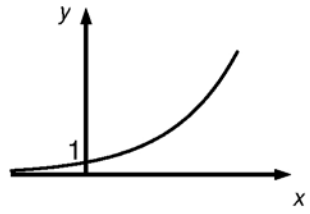
Section B

10	**i**	0.6(0..), 0.8(45..), [1], 1.1(76..) 1.3(0..), 1.6(0..) points plotted correctly f.t. ruled line of best fit	T 1 P1 L1	Correct to 2 d.p. Allow 0.6, 1.3 and 1.6 tol. 1 mm	3
	ii	*b* = their intercept *a* = their gradient -11 ≤ b ≤ -8 *and* 21 ≤ a ≤ 23.5	M1 M1 A1		3
	iii	34 to 35 m	1		1
	iv	29 = "22"logt – "9" t = $10^{\text{"1.727.."}}$ 55 [years] approx	M1 M1 A1	accept 53 to 59	3
	v	For small t the model predicts a negative height (or h = 0 at approx 2.75) Hence model is unsuitable	1 D1		2

11	**iA**	10+20+30+40+50+60	B1	or $\frac{6}{2}(2\times10+5\times10)$ or $\frac{6}{2}(10+60)$	1
	iB	correct use of AP formula with $a = 10$ and $d = 10$	M1		
		n (5 + 5n) or 5n (n + 1) or 5 (n^2 + n) or (5n^2 + 5n)	A1		
		$10n^2 + 10n - 20700 = 0$	M1	Or better	
		45 c.a.o.	A1		4
	iiA	4	1		1
	iiB	£2555	2	M1 for 5(1 + 2 + …2^8) or 5(2^9 − 1) o.e.	2
	iiC	correct use of GP formula with a =5, r = 2	M1		
		5(2^n − 1) o.e.= 2621435	DM1	"S" need not be simplified	
		2^n = 524288 www	M1		
		19 c.a.o.	A1		4
12	**i**	6.1	2	M1 for $\frac{(3.1^2-7)-(3^2-7)}{3.1-3}$ o.e.	2
	ii	$\frac{((3+h)^2-7)-(3^2-7)}{h}$	M1	s.o.i.	
		numerator = $6h + h^2$	M1		
		$6 + h$	A1		3
	iii	as h tends to 0,	M1		
		grad. tends to 6 o.e. f.t.from "6"+h	A1		2
	iv	$y - 2 =$ "6" $(x - 3)$ o.e.	M1		
		$y = 6x - 16$	A1	6 may be obtained from $\frac{dy}{dx}$	2
	v	At P, x = 16/6 o.e. or ft	M1		
		At Q, $x = \sqrt{7}$	M1		
		0.021 cao	A1		3

4752 (C2) Concepts for Advanced Mathematics

1		½ x^2 + 3x^{-1} + c o.e.	3	1 for each term	3
2	**(i)**	5 with valid method	1	eg sequence has period of 4 nos.	
	(ii)	165 www	2	M1 for 13× (1 + 3 + 5 + 3) + 1 + 3 +5 or for 14 × (1 + 3 + 5 + 3) − 3	3
3		rt angled triangle with √2 on one side and 3 on hyp Pythag. used to obtain remaining side = √7 tan θ = $\frac{opp}{adj} = \frac{\sqrt{2}}{\sqrt{7}}$ o.e.	1 1 1	or M1 for $\cos^2\theta = 1 - \sin^2\theta$ used A1 for $\cos\theta = \frac{\sqrt{7}}{\sqrt{9}}$ A1 for $\tan\theta = \frac{\sin\theta}{\cos\theta} = \frac{\sqrt{2}}{\sqrt{7}}$ o.e.	3
4		radius = 6.5 [cm]	3	M1 for ½ × r^2 × 0.4 [= 8.45] o.e. and M1 for $r^2 = \frac{169}{4}$ o.e. [= 42.25]	3
5	**(i)**	sketch of correct shape with P (−0.5,2) Q (0,4) and R (2,2)	2	1 if Q and one other are correct	
	(ii)	sketch of correct shape with P (−1,0.5) Q (0,1) and R (4,0.5)	2	1 if Q and one other are correct	4
6	**(i)**	205	3	M1 for AP identified with d = 4 and M1 for 5 + 50 d used	
	(ii)	$\frac{25}{3}$ o.e.	2	M1 for $r = \frac{2}{5}$ o.e.	5
7	**(i)**	$\frac{\sin A}{5.6} = \frac{\sin 79}{8.4}$ s.o.i. [A =] 40.87 to 41	M1 A1		
	(ii)	[BC^2 =] $5.6^2 + 7.8^2 - 2 \times 5.6 \times 7.8 \times$ cos ("180-79") = 108.8 to 108.9 [BC =] 10.4(…)	M1 A1 A1		5
8		$y' = 3x^{-\frac{1}{2}}$ ¾ when x = 16 y = 24 when x = 16 y − their 24 = their ¾ (x − 16) y − 24 = ¾ (x − 16) o.e.	M1 A1 B1 M1 A1	condone if unsimplified dependent on $\frac{dy}{dx}$ used for m	5

9	**(i)**		G1 DG1	for curve of correct shape in both quadrants must go through (0, 1) shown	
	(ii)	$2x + 1 = \frac{\log 10}{\log 3}$ o.e. $[x =]$ 0.55	M1 A2	or M1 for $2x + 1 = \log_3 10$ A1 for other versions of 0.547…or 0.548	5
10	**(i)**	$3x^2 - 6x - 9$ use of their $y' = 0$ $x = -1$ $x = 3$ valid method for determining nature of turning point max at $x = -1$ and min at $x = 3$	M1 M1 A1 A1 M1 A1	 c.a.o.	 6
	(ii)	$x(x^2 - 3x - 9)$ $\frac{3 \pm \sqrt{45}}{2}$ or $(x - \frac{3}{2})^2 = 9 + \frac{9}{4}$ 0, $\frac{3}{2} \pm \frac{\sqrt{45}}{2}$ o.e.	M1 M1 A1	 	 3
	(iii)	sketch of cubic with two turning points correct way up x-intercepts – negative, 0, positive shown	G1 DG1	 	 2
11	**(i)**	47.625 [m^2] to 3 sf or more, with correct method shown	4	M3 for $\frac{1.5}{2} \times (2.3 + 2 + 2[2.7 + 3.3 + 4 + 4.8 + 5.2 + 5.2 + 4.4])$	4
	(ii)	43.05	2	M1 for $1.5 \times (2.3+2.7+3.3+4+4.8+5.2+4.4+2)$	2
	(iii)	$-0.013x^4/4 + 0.16x^3/3 - 0.082x^2/2 + 2.4x$ o.e. their integral evaluated at $x = 12$ (and 0) only 47.6 to 47.7	M2 M1 A1	M1 for three terms correct dep on integration attempted 	 4
	(iv)	5.30.. found compared with 5.2 s.o.i.	1 D1	 	 2
12	**(i)**	$\log P = \log a + bt$ www comparison with $y = mx + c$ s.o.i. intercept = $\log_{10} a$	1 1 1	 must be with correct equation dependent on correct equation	 3
	(ii)	[2.12, 2.21], 2.32, 2.44, 2.57, 2.69 plots ft ruled line of best fit	1 1 1	 Between (10, 2.08) and (10, 2.12)	 3

	(iii)	$0.0100 \leq m < 0.0125$	B2	M1 for $\frac{y - \text{step}}{x - \text{step}}$	
		$a = 10^c$ or $\log a = c$	B1	$1.96 \leq c \leq 2.02$	
		$P = 10^c \times 10^{mt}$ or $10^{mt + c}$	B1	f.t. their m and a	4
	(iv)	use of $t = 105$	B1		
		1.0 – 2.0 billion approx	B1		
		unreliable since extrapolation o.e.	E1		3

RECOGNISING ACHIEVEMENT

GCE

Mathematics (MEI)

Advanced GCE **4752**

Concepts for Advanced Mathematics (C2)

Mark Scheme for June 2010

Oxford Cambridge and RSA Examinations

SECTION A

1	[1], $\frac{1}{2}, \frac{1}{3}, \frac{1}{4}$	**2**	**B1** for [1], $\frac{1}{2}, \frac{1}{3}$
2 (i)	$2\frac{1}{12}$ or $\frac{25}{12}$ or 2.08(3…)	**2**	**M1** for $\frac{1}{1}+\frac{1}{2}+\frac{1}{3}+\frac{1}{4}$
2 (ii)	$\sum_{r=2}^{6} r(r+1)$ o.e.	**2**	**M1** for [f(r) =] $r(r + 1)$ o.e. **M1** for [a =] 6
3 (i)	$3x^2 - 12x - 15$	**2**	**M1** if one term incorrect or an extra term is included.
3 (ii)	Their $\frac{dy}{dx} = 0$ s.o.i. $x = 5$ $x = -1$	**M1** **B1** **B1**	
4	crossing x-axis at 0 and 2.5 min at (1.25, −6.25) crossing x-axis at 0 and 5 min at (2.5, −18.75)	**1** **1** **1** **1**	
5	$x - \frac{6x^{-2}}{-2}$ o.e. their $[5 + \frac{3}{25}] - [2 + \frac{3}{4}]$ = 2.37 o.e. c.a.o.	**2** **M1** **A1**	M1 for 1 term correct Dependent on at least **M1** already earned i.s.w.
6	attempt to integrate $6x^2 + 12x^{\frac{1}{2}}$ [y =] $2x^3 + 8x^{1.5}$ + c Substitution of (4, 10) [y =] $2x^3 + 8a^{1.5}$ –182 or c = –182	**M1** **A2** **M1** **A1**	accept un-simplified; **A1** for 2 terms correct dependent on attempted integral with + c term
7	3.5 $\log_a x$ or k = 3.5	**2**	**B1** for 3 $\log_a x$ or ½ $\log_a x$ or $\log_a x^{3½}$ seen

8	Subst. of $1-\cos^2\theta$ or $1-\sin^2\theta$ $5\cos^2\theta = 1$ or $5\sin^2\theta = 4$ $\cos\theta = \pm\sqrt{\text{their}\,\frac{1}{5}}$ or $\sin\theta = \pm\sqrt{\text{their}\,\frac{4}{5}}$ o.e. 63.4, 116.6, 243.4, 296.6	**M1** **A1** **M1** **B2**	 Accept to nearest degree or better; **B1** for 2 correct (ignore any extra values in range).
9	$\log 18 = \log a + n\log 3$ and $\log 6 = \log a + n\log 2$ $\log 18 - \log 6 = n(\log 3 - \log 2)$ $n = 2.71$ to 2 d.p. c.a.o. $\log 6 = \log a + 2.70951\ldots\log 2$ o.e. $a = 0.92$ to 2 d.p. c.a.o.	 **M1*** **DM1** **A1** **M1** **A1**	or $18 = a\times 3^n$ and $6 = a\times 2^n$ $3 = \left(\frac{3}{2}\right)^n$ $n = \frac{\log 3}{\log 1.5} = 2.71$ c.a.o. $6 = a\times 2^{2.70951}$ o.e. $= 0.92$ c.a.o.

Section A Total: 36

SECTION B

10	**(i)**	$\frac{dy}{dx} = 4x^3$ when $x = 2$, $\frac{dy}{dx} = 32$ s.o.i. when $x = 2$, $y = 16$ s.o.i. $y = 32x - 48$ c.a.o.	**M1** **A1** **B1** **A1**	 i.s.w.
10	**(ii)**	34.481	**2**	**M1** for $\frac{2.1^4 - 2^4}{0.1}$
10	**(iii) (*A*)**	$16 + 32h + 24h^2 + 8h^3 + h^4$ c.a.o.	**3**	**B2** for 4 terms correct **B1** for 3 terms correct
10	**(iii) (*B*)**	$32 + 24h + 8h^2 + h^3$ or ft	**2**	**B1** if one error
10	**(iii) (*C*)**	as $h \to 0$, result $\to$ their 32 from (iii) (B) gradient of tangent is limit of gradient of chord	**1** **1**	

11	**(a)**	$10.6^2 + 9.2^2 - 2\times10.6\times9.2\times\cos68°$ o.e. QR = 11.1(3…) $\frac{\sin 68}{\text{their QR}} = \frac{\sin Q}{9.2}$ or $\frac{\sin R}{10.6}$ o.e. Q = 50.01..° or R = 61.98..° bearing = 174.9 to 175°	**M1** **A1** **M1** **A1** **B1**	 Or correct use of Cosine Rule 2 s.f. or better
11	**(b) (i)**	(*A*) ½ × 80^2 × $\frac{2\pi}{3}$ = $\frac{6400\pi}{3}$	**M1** **A1**	 6702.(…) to 2 s.f. or more
11	**(b) (ii)**	DC = 80 sin($\frac{\pi}{3}$) = 80$\frac{\sqrt{3}}{2}$ Area = ½×their DA×40√3 or ½×40√3×80×sin(their DCA) o.e. area of triangle = 800√3 or 1385.64… to 3s.f. or more	**B1** **M1** **A1**	both steps required s.o.i.
11	**(b) (iii)**	area of ¼ circle = ½ × $\frac{\pi}{2}$ × $(40\sqrt{3})^2$ o.e. "6702" + "1385.6" – "3769.9" = 4300 to 4320	**M1** **M1** **A1**	[=3769.9…] i.e. their(b) (i) + their (b) (ii) – their ¼ circle o.e. 933⅓π + 800√3

12	**(i) (*A*)**	1024	**2**	**M1** for number of buds = 2^{10} s.o.i.
12	**(i) (*B*)**	2047	**2**	**M1** for $1+2+4+\ldots 2^{10}$ or for $2^{11} - 1$ or (their 1024) + 512 + 256 +…+ 1
12	**(ii) (*A*)**	no. of nodes = $1 + 2 + ..+ 2^{n-1}$ s.o.i. $\frac{7\times(2^n-1)}{2-1}$	**1** **1**	no. of leaves = $7 + 14 +\ldots+ 7\times2^{n-1}$
12	**(ii) (*B*)**	$7(2^n - 1) > 200\,000$ $2^n > \frac{200\,000}{7} + 1$ or $\frac{200\,007}{7}$ $n \log 2 > \log(\frac{200\,007}{7})$ and completion to given ans [n =] 15 c.a.o.	**M1** **M1** **M1** **B1**	or $\log7 + \log2^n > \log200\,007$

Section B Total: 36

OCR
RECOGNISING ACHIEVEMENT

GCE

Mathematics (MEI)

Advanced Subsidiary GCE

Unit **4752:** Concepts for Advanced Mathematics

Mark Scheme for January 2011

SECTION A

1	11.4 o.e.	**2**	**M1** for 12/3 + 12/4 + 12/5 + 12/6 o.e.	**M0** unless four terms summed
2	$\frac{1}{2}x^6 + 4x^{\frac{1}{2}} + c$	**4**	**B1** for $\frac{1}{2}x^6$, **M1** for $kx^{\frac{1}{2}}$, **A1** for $k = 4$ or $\frac{4}{1}$, **B1** for + c dependent on at least one power increased	allow $\frac{3}{6}x^6$ isw,
3	½ × 1.5 × (0.6 + 0.7 + 2(2.3+3.1+2.8+1.8)) = 15.975 rounded to 2 s.f. or more	**M2** **A1**	**M1** if one error or **M2** for sum of 5 unsimplified individual trapezia: 2.175, 4.05, 4.425, 3.45, 1.875	basic shape of formula must be correct. Must be 5 strips. **M0** if pair of brackets omitted or h = 7.5 or 1. allow recovery of brackets omitted to obtain correct answer. **M0** for other than 5 trapezia isw only if 15.975 clearly identified as cross-sectional area
4	(i) (3, 15)	**B2**	**B1** for each coordinate	s.c. **B0** for (3, 5)
4	(ii) (1.5, 5)	**B2**	**B1** for each coordinate	s.c. **B0** for (3, 5)
5	$ar = 6$ and $ar^4 = -48$ $r = -2$ tenth term = 1536 $\frac{-3(1-(-2)^n)}{1-(-2)}$ o.e. $(-2)^n - 1$	**M1** **M1** **A1** **M1** **A1**	**B2** for $r = -2$ www **B3** for 1536 www allow **M1** for a = 6÷their r and substitution in GP formula with their a and r c.a.o.	ignore incorrect lettering such as d =-2 condone the omission of the brackets round "-2" in the numerator and / or the denominator

6	$a+2d = 24$ and $a + 9d = 3$ $d = -3$; $a = 30$ $S_{50} - S_{20}$ -2205 cao	**M1** **A1** **A1** **M1** **A1**	 if **M0** , **B2** for either, **B3** for both ft their a and d; **M1** for $S_{30} = \frac{30}{2}(u_{21} + u_{50})$ o.e. **B2** for -2205 www	 do not award **B2** or **B3** if values clearly obtained fortuitously $S_{50} = -2175$; $S_{20} = 30$ $u_{21} = 30 - 20 \times 3 = -30$ $u_{50} = 30 - 49 \times 3 = -117$
7	(i) $17 \log_{10} x$ or $\log_{10} x^{17}$	**B2**	**M1** for $5\log_{10} x$ or $12 \log_{10} x$ or $\log_{10} x^{12}$ as part of the first step	condone omission of base
7	(ii) $-b$	**B2**	**M1** for $\log_a 1 = 0$ or $\log_a a = 1$ soi	allow $0 - b$
8	substitution of $\sin^2\theta = 1 - \cos^2\theta$ $-5\cos^2\theta = \cos\theta$ $\theta = 90$ and 270, 102 258 101 *and* 259	**M1** **A1** **A1** **A1** **A1** **SC 1**	soi or better accept 101.5(…) and 258.(46…) rounded to 3 or more sf; if **M0,** allow **B1** for both of 90 and 270 and **B1** for 102 and **B1** for 258 (to 3 or more sf)	 if the 4 correct values are presented, ignore any extra values which are outside the required range, but apply a penalty of minus 1 for extra values in the range if given in radians deduct 1 mark from total awarded (1.57, 1.77, 4.51, 4.71)

9	area sector = $\frac{1}{2}\times r^2\times\frac{\pi}{6}\left[=\frac{\pi r^2}{12}\right]$	**M1**	soi	
	area triangle = $\frac{1}{2}\times a^2\times\sin\frac{\pi}{6}\left[=\frac{a^2}{4}\right]$	**M1**	soi	allow sin30
	$\frac{1}{2}a^2\times\frac{1}{2}=\frac{1}{2}r^2\times\frac{\pi}{6}\times\frac{1}{2}$	**M1**	soi	no follow through marks available
	$\frac{a^2}{4}=\frac{\pi r^2}{24}$ o.e. and completion to given answer	**A1**		at least one correct intermediate step required, and no wrong working to obtain given answer

Section A Total: 36

SECTION B

10	(i) eqn of AB is $y = 3x + 1$ o.e. their "$3x + 1$" = $4x^2$ $(4x + 1)(x - 1) = 0$ o.e. so $x = -1/4$ at C, $x = -1/4$, $y = 4 \times (-1/4)^2$ or $3 \times (-1/4) + 1$[=1/4 as required]	**M1** **M1** **M1** **A1**	or equiv in y: $y = 4\left(\frac{y-1}{3}\right)^2$ or rearranging and deriving roots $y = 4$ or ¼ condone verification by showing lhs = rhs o.e. or y = ¼ implies $x = \pm$ ¼ so at C $x = -$ ¼	**SC3** for verifying that A, B and C are collinear and that C also lies on the curve **SC2** for verifying that A, B and C are collinear by showing that gradient of AB = AC (for example) or showing C lies on AB solely verifying that C lies on the curve scores 0
10	(ii) $y' = 8x$ at A $y' = 8$ eqn of tgt at A $y - 4$ = their"8"$(x - 1)$ $y = 8x - 4$ at C $y' = 8 \times -1/4$ [$=-2$] $y - ¼ = -2(x - (- ¼))$ or other unsimplified equivalent to obtain given result. allow correct verification that (-¼,¼) lies on given line	**M1** **A1** **M1** **A1** **M1** **A1**	ft their gradient NB if m = -2 obtained from given answer or only showing that (− ¼, ¼) lies on given line $y = -2x - ¼$ then 0 marks.	gradient must follow from evaluation of $\frac{dy}{dx}$ condone unsimplified versions of $y = 8x - 4$ dependent on award of first **M1** **SC2** if equation of tangent and curve solved simultaneously to correctly show repeated root
10	(iii) their "$8x - 4$" = $-2x - ¼$ $y = -1$ www	**M1** **A1**	or $\frac{y+4}{8} = \frac{y+\frac{1}{4}}{-2}$	o.e. [$x = 3/8$]

11	(i) $\frac{x^4}{4} - x^3 - \frac{x^2}{2} + 3x$ their integral at 3 − their integral at 1 [= –2.25 − 1.75] = −4 isw represents area between curve and x axis between x = 1 and 3 negative since below x-axis	**M2** **M1** **A1** **B1** **B1**	**M1** if at least two terms correct dependent on integration attempted	ignore $+ c$ M0 for evaluation of $x^3 - 3x^2 - x + 3$ or of differentiated version **B0** for area *under* or above curve between x = 1 and 3
11	(ii) $y' = 3x^2 - 6x - 1$ their $y' = 0$ soi $x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$ with a = 3, b = -6 and c = -1 isw $x = \frac{6 \pm \sqrt{48}}{6}$ or better as final answer $\frac{6-\sqrt{48}}{6} < x < \frac{6+\sqrt{48}}{6}$ or ft their final answer	**M1** **M1** **M1** **A1** **B1**	dependent on differentiation attempted or $3(x-1)^2 - 4$ [= 0] or better eg **A1** for $1 \pm \frac{2}{3}\sqrt{3}$ allow ≤ instead of <	no follow through; NB $\frac{6 \pm \sqrt{48}}{6}$ or better stated without working implies use of correct method **A0** for incorrect simplification, eg 1 ± √48 allow **B1** if *both* inequalities are stated separately and it's clear that both apply allow **B1** if the terms and the signs are in reverse order
12	(i) 50% of 25 000 is 12 500 and the population [in 2005] is 12 000 [so consistent]	**B1**	or 12 000 is 48% of 25 000 so less than 50%[so consistent]	
12	(ii) $\log_{10} P = \log_{10} a - kt$ or $\log_{10} \frac{P}{a} = -kt$ o.e. www	**B2**	condone omission of base; **M1** for $\log_{10} P = \log_{10} a + \log_{10} 10^{-kt}$ or better www	

12	(iii) 4.27, 4.21, 4.13, 4.08 plots ruled line of best fit drawn	**B1** **B1** **B1**	accept 4.273…, 4.2108…, 4.130…, 4.079… rounded to 2 or more dp 1 mm tolerance ft their values if at least 4 correct values are correctly plotted	 f.t. if at least two calculated values correct must have at least one point on or above and at least one point on or below the line and must cover $0 \leq t \leq 25$
12	(iv) a = 25000 to 25400 $0.01 \leq k \leq 0.014$ $P = a \times 10^{-kt}$ or $P = 10^{\log a - kt}$ with values in acceptable ranges	**B1** **B2** **B1**	allow $10^{4.4..}$ **M1** for $-k = \frac{\Delta y}{\Delta x}$ using values from table or graph; condone $+k$ **B0** if left in logarithmic form	**M1** for a correct first step in solving a pair of valid equations in either form **A1** for k **A1** for a **A1** for $P = a \times 10^{-kt}$
12	(v) $P = a \times 10^{-35k}$ 8600 to 9000 comparing their value with 9375 o.e. and reaching the correct conclusion for their value	**M1** **A1** **A1**	T heir a and k f.t.	allow $\log P = \log a - 35k$

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OCR
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Unit **4752:** Concepts for Advanced Mathematics

Mark Scheme for June 2011

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SECTION A

1	$\frac{1}{2}x^4 + 3x$ F[5] – F[2] [=327.5 − 14] =313.5 o.e.	**M1** **M1** **A1**	accept unsimplified at least one term correctly integrated, may be implied by A1	ignore + c condone omission of brackets 313.5 unsupported scores 0
2	0.05, 2000, 1.25×10^{-6} or $\frac{1}{20}$, 2000, $\frac{1}{800\,000}$ o.e. divergent	**B2** **B1**	**B1** for two correct allow "alternate terms tend to zero and to infinity" o.e.	 do *not* allow "oscillating", "getting bigger and smaller", "getting further apart"
3	(i) $m = \frac{\sqrt{1+2\times4.1}-\sqrt{1+2\times4}}{4.1-4}$ s.o.i grad = $\frac{\sqrt{9.2}-\sqrt{9}}{4.1-4}$ s.o.i 0.3315 cao	**M1** **M1** **A1**		no marks for use of Chain Rule or any other attempt to differentiate **SC2** for 0.33…. appearing only embedded in equation of chord
3	(ii) selection of value in (4, 4.1) and 4 or of two values in [3.9, 4.1] centred on 4 answer closer to 1/3 than 0.3315(...)	**M1** **A1**		allow selection of 4 and value in (3.9, 4)
4	$6 = ab$ and $3.6 = ab^2$ $a = 10$, $b = 0.6$ c.a.o.	**M1** **A2**	$\log 6 = \log a + \log b$ *and* $\log 3.6 = \log a + \log b^2$ **A1** each; if **M0** then **B3** for both, **B1** for one	

5	$[\frac{dy}{dx} =]\ 32x^3$ c.a.o. substitution of $x = ½$ in their $\frac{dy}{dx}$ grad normal = $\frac{-1}{their 4}$ when $x = ½$, $y = 4\ ½$ o.e. $y - 4\frac{1}{2} = -\frac{1}{4}(x - \frac{1}{2})$ i.s.w	**M1** **M1** **M1** **B1** **A1**	 [= 4] $y = -\frac{1}{4}x + 4\frac{5}{8}$ o.e.	 must see kx^3 their 4 must be obtained by calculus
6	$\frac{dy}{dx} = 6x^{\frac{1}{2}} - 2$ $y = kx^{\frac{3}{2}} - 2x + c$ o.e. $y = 4x^{\frac{3}{2}} - 2x + c$ o.e. correct substitution of $x = 9$ and $y = 4$ in their equation of curve $y = 4x^{\frac{3}{2}} - 2x - 86$	 **M2** **A1** **M1 dep** **A1**	 **M1** for $k\,x^{\frac{3}{2}}$ and **M1** for -2*x* + c dependent on at least **M1** already awarded allow **A1** for $c = -86$ i.s.w. if simplified equation for *y* seen earlier	$x^{\frac{1}{6}}$ is a mistake, not a misread "*y* =" need not be stated at this point, but must be seen at some point for full marks must see "+ *c*"

7	$\frac{\sin\theta}{\cos\theta} = 2\sin\theta$ $2\cos\theta - 1 = 0$ *and* $\sin\theta = 0$ $[\theta =]$ 0, 180, 360, $[\theta =]$ 60, 300 if 4 marks awarded, lose 1 mark for extra values in the range, ignore extra values outside the range	**M1** **A1** **B1** **B1**	*may* be implied by $2\cos\theta - 1 = 0$ or better	or, if to advantage of candidate **B4** for all 5 correct **B3** for 4 correct **B2** for 3 correct **B1** for 2 correct if extra value(s) in range, deduct one mark from total do not award if values embedded in trial and improvement approach
8	$\log p = \log s + \log t^n$ $\log p = \log s + n\log t$ $[n =]\frac{\log p - \log s}{\log t}$ or $\frac{\log\left(\frac{p}{s}\right)}{\log t}$ [base not required]	**M1** **M1** **A1**	or $\frac{p}{s} = t^n$ $n\log t = \log\left(\frac{p}{s}\right)$ as final answer (i.e. penalise further incorrect simplification)	or **A2** for $[n =]\log_t\left(\frac{p}{s}\right)$ [base t needed] following first M1
9	$\log 16^{½}$ or $[-]\log 5^2$ s.o.i. $\log(4\times75)$ or $\log\frac{75}{25}$ s.o.i. $x = 12$ www	**M1** **M1** **A1**	$x = \frac{4\times75}{25}$ implies **M1M1**	if $a = 10$ assumed, $x = 12$ c.a.o. scores **B3** www no follow through
10	$t_1 = -\sin\theta$ $t_2 = \sin\theta$	**B1** **B1**	www www	e.g. $\sin(\theta + 360) = \sin\theta + \sin360 = \sin\theta$ **B0**

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SECTION B

11	(i) $200 - 2\pi r^2 = 2\pi rh$ $h = \frac{200 - 2\pi r^2}{2\pi r}$ o.e. substitution of correct h into $V = \pi r^2 h$ $V = 100r - \pi r^3$ convincingly obtained	**M1** **M1** **M1** **A1**	$100 = \pi r^2 + \pi rh$ $100r = \pi r^3 + \pi r^2 h$ $100r = \pi r^3 + V$ $V = 100r - \pi r^3$ or **M1 f**or $h = \frac{V}{\pi r^2}$ **M1** for $200 = 2\pi r^2 + 2\pi r \times \frac{V}{\pi r^2}$ **M1** for $200 = 2\pi r^2 + 2\frac{V}{r}$ **A1** for $V = 100r - \pi r^3$ convincingly obtained	**sc3** for complete argument working backwards: $V = 100r - \pi r^3$ $\pi r^2 h = 100r - \pi r^3$ $\pi rh = 100 - \pi r^2$ $100 = \pi rh + \pi r^2$ $200 = A = 2\pi rh + 2\pi r^2$ **sc0** if argument is incomplete
11	(ii) $\frac{dV}{dr} = 100 - 3\pi r^2$ $\frac{d^2V}{dr^2} = -6\pi r$	**B2** **B1**	**B1** for each term	allow 9.42(….) r^2 or better if decimalised -18.8(…) r or better if decimalised

11	(iii) their $\frac{dV}{dr} = 0$ s.o.i. $r = 3.26$ c.a.o. $V = 217$ c.a.o.	**M1** **A2** **A1**	must contain r as the only variable **A1** for $r = (\pm)\sqrt{\frac{100}{3\pi}}$; may be implied by 3.25… deduct 1 mark only in this part if answers not given to 3 sf,	there must be evidence of use of calculus

12	(i)(A) 390	**B2**	**M1** for $500 - 11 \times 10$	
12	(i)(B) $S_{24} = \frac{24}{2}(2\times500+(24-1)\times-10)$ o.e. i.s.w. *or* $S_{24} = \frac{24}{2}(500+270)$ o.e. i.s.w. [=9240] (answer given)	**B2**	nothing simpler than $12(1000 + 23\times\text{-}10)$ or $\frac{24}{2}(1000-230)$ or $12(2\times500-230)$ if **B2** not awarded, then **M1** for use of a.p. formula for S_{24} with $n = 24$, $a = 500$ and $d = -10$ or **M1** for $l = 270$ s.o.i.	condone omission of final bracket or "(23)-10" if recovered in later work if they write the sum out, all the terms must be listed for 2 marks $12 \times (1000 - 230)$ or 12×770 on its own do not score
12	(ii)(A) 368.33(...) or 368.34	**B2**	**M1** for 460×0.98^{11}	
12	(ii)(B) $J_{20} = 310$ M_{20} = 313.36(...), 313.4, 313.3, 313.37 or 313 $J_{19} = 320$ M_{19} = 319.76(...), 319.8 or 319.7	**B3**	**B3** for all 4 values correct or **B2** for 3 values correct or **B1** for 2 values correct	values which are clearly wrongly attributed do not score
12	(ii)(C) 8837 to 8837.06	**B2**	**M1** for $S_{24} = \frac{460(1-0.98^{24})}{1-0.98}$ o.e.	
12	(ii)(D) $\frac{a(1-0.98^{24})}{(1-0.98)} = 9240$ o.e. 480.97 to 480.98	**M1** **A1**	f.t. their power of 24 from (ii)C	

13	(i) arc AC = 2.1×1.8 = 3.78 c.a.o. area = their 3.78×5.5 = 20.79 or 20.8 i.s.w.	**M1** **A1** **M1 dep*** **A1**	$\frac{103}{360} \times 2\pi \times 2.1$ dependent on first M1	103° or better 3.78 must be seen but may be embedded in area formula
13	(ii) BD = 2.1 cos (π − 1.8) or 2.1cos1.3(4159…..) or 2.1sin0.2(292…) r.o.t to 1 d.p. or more = 0.48	**M2** **A1**	**M1** for $\cos(\pi - 1.8) = \frac{BD}{2.1}$ o.e. allow any answer which rounds to 0.48	**M2** for BD = 2.1 cos 76.8675…° or 2.1sin13.1324…rounded to 2 or more sf or **M2** for CD = 2.045... r.o.t. to 3 s.f. or better and BD = $\sqrt{(2.1^2 - 2.045^2)}$
13	(iii) sector area = 3.969 triangle area = 0.487 to 0.491 24.5	**M2** **M2** **A1**	**M1** for ½ × 2.1^2 × 1.8 **M1** for ½ × 2.1 × their 0.48 × sin (π − 1.8) *or* ½ × their 0.48 × 2.045.. r.o.t. to 3 s.f. or better allow any answer which rounds to 24.5	or equivalent with degrees for first two Ms N.B. 5.5 × 3.969 = 21.8295 so allow M2 for 21.8295 may be sin 1.8 instead of sin (π − 1.8) N.B. 5.5 × area = 2.6785 to 2.7005 so allow M2 for a value in this range

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Question			Answer	Marks	Guidance	
1			$\frac{1}{2}x^{-\frac{1}{2}} - 3x^{-2}$ oe; isw	B3 **[3]**	need not be simplified B2 for one term correct ignore + *c*	if B0 allow M1 for either $x^{1/2}$ or x^{-1} seen before differentiation deduct one mark for extra term in *x*
2			(5), 8, 11, (14),…isw *a* = 5 and *d* = 3 soi $S_{50} = \frac{50}{2}(2\times5 + (50-1)\times3)$ oe 3925	B1 B1 M1 A1 **[4]**	 if M0, SC1 for use of *a* = 8 and obtaining 4075	 if M0, award B2 if 3925 is obtained from summing individual terms or if unsupported
3	(i)		$9.8^2 + 6.4^2 - 2 \times 9.8 \times 6.4 \times \cos 53.4$ $9.8^2 + 6.4^2 - 74.79...$ [= 62.2...] 7.887… or 7.89 or 7.9	M1 M1 A1 **[3]**	 for evidence of correct order of operations used; may be implied by correct answer if M0, B3 for 7.89 or more precise www	 6.89 implies M0 262.4368 implies M1 (calc in radian mode), (NB √262.436..=16.199…) NB 9.8sin53.4 = 7.87
3	(ii)		½ × 9.8 × 7.3 × sin (180 – 53.4) oe seen 28.716…or 28.72 or 28.7 or 29 isw	M1 A1 **[2]**	or sin 53.4 used; may be embedded if M0, B2 for 28.7 or more precise www	may be split into height = 9.8 × sin 53.4 then Area = ½ × 7.3 × height
4	(i)		(6, 9)	2 **[2]**	1 for each co-ordinate	SC0 for (6, 3)
4	(ii)		(1.5, 3)	2 **[2]**	1 for each co-ordinate	SC0 for (6, 3)
5			45 = ½ r^2 × 1.6 oe r^2 = 90/1.6 oe *r* = 7.5 or exact equivalent cao (their 7.5) × 1.6 27	M1 M1 A1 M1 A1 **[5]**	$45 = \pi r^2 \times \frac{91.673...}{360}$ or B3 www $2\pi \times (\text{their } r) \times \frac{91.673...}{360}$ or B2 www	 allow recovery to 7.5 if working in degrees, but A0 for (eg) 7.49 12 implies M1

Question			Answer	Marks	Guidance	
6			gradient = 3 seen	B1	may be embedded	
			$\log_{10} y - 5 =$ (their 3)($\log_{10} x -$ 1) or using (5, 17)	M1	or $\log_{10} y = 3 \log_{10} x + c$ and substitution of (1, 5) or (5, 17) for $\log_{10} x$ and $\log_{10} y$	condone omission of base throughout NB may recover from eg $Y = 3X + 2$
			$\log_{10} y = 3 \log_{10} x + 2$ oe	A1		
			$y = 10^{3\log_{10} x+2}$ oe	M1	or $\log_{10} y = \log_{10} x^3 + \log_{10} 100$	or $\log_{10} \frac{y}{x^3} = 2$ or $\log_{10} y = \log_{10} 100x^3$
			$y = 100x^3$	A1 **[5]**		
7			$\frac{6x^{\frac{3}{2}}}{\frac{3}{2}}$	M1*		
			$4x^{\frac{3}{2}}$	A1	may appear later	
			$-5x + c$	B1	B0 if from $y = (6x^{\frac{1}{2}} - 5)x + c$	condone "+ c" not appearing until substitution
			substitution of (4, 20)	M1dep*		
			[$y =$] $4x^{1.5} - 5x + 8$ or $c = 8$ isw	A1 **[5]**		
8			0.775397.. soi	M1	or 44.427..°	
			0.388, 1.18, 3.53, 4.32	A4	A1 each value	if any of final answers not given to three sf deduct 1 mark from total A marks
			in degrees: 22.2, 67.8, 202, 248*		if A0 then B1 for at least two of 2.366…, 7.058…, 8.649…for 2θ or all of 135.57…, 404.427…, 495.57…	*if final answers in degrees deduct 1 from total A marks ignore extra values outside range if four correct answers in degrees or radians, deduct 1 for extra values in range
				[5]		

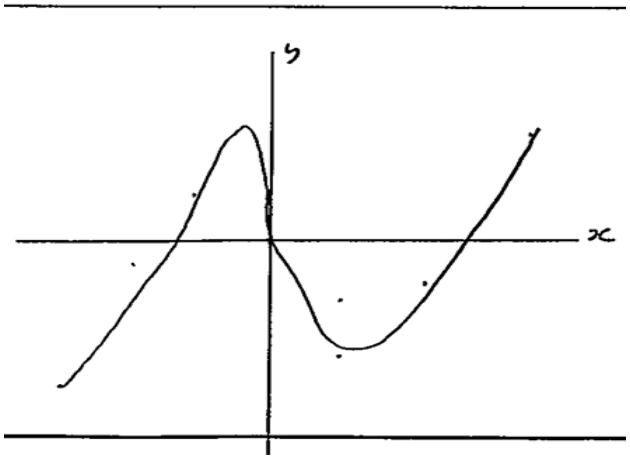
Question			Answer	Marks	Guidance	
9	(i)		½ × 0.2 (0 + 0 + 2(0.5 + 0.7 + 0.75 + 0.7 + 0.5)) [=0.63]	M3	M2 if one error, M1 if two errors condone omission of zeros or M3 for 0.05 + 0.12 + 0.145 + 0.145 + 0.12 + 0.05 may be unsimplified, must be summed	basic shape of formula must be correct must be 6 strips M0 if brackets omitted, but allow recovery M0 if h = 1 or 1.2 Area = 6.3 and 0.53 imply M0
			(their 0.63) × 50 31.5	M1 A1 **[5]**		
9	(ii)	(*A*)	$3.8\times0.2^4 - 6.8\times0.2^3 + 7.7\times0.2^2 - 4.2\times0.2$ 0.01968 cao isw	M1 A1 **[2]**	±0.58032 implies M1 or B2 if unsupported	condone one sign error allow – 0.01968
9	(ii)	(*B*)	$\frac{3.8x^5}{5} - \frac{6.8x^4}{4} + \frac{7.7x^3}{3} - \frac{4.2x^2}{2} + c$ F(0.9) [– F(0)] 50 × their ±F(0.9) 24.8 to 24.9 cao	M2 M1* M1dep* A1 **[5]**	M1 for two terms correct excluding c condone omission of c as long as at least M1 awarded	accept 2.56 to 2.57 for coefficient of x^3 allow M1 if all signs reversed NB F(0.9) = – 0.496...

Question			Answer	Marks	Guidance	
10	(i)		$y' = 3x^2 - 5$	M1		
			their $y' = 0$	M1		
			(1.3, – 4.3) cao	A1	or A1 for $x = \pm\sqrt{\frac{5}{3}}$ oe soi	
			(– 1.3, 4.3) cao	A1	allow if not written as co-ordinates if pairing is clear	ignore any work relating to second derivative
				[4]		
10	(ii)		crosses axes at (0, 0)	B1	condone x and y intercepts not written as co-ordinates; may be on graph	See examples in Appendix
			and ($\pm\sqrt{5}$, 0)	B1	±(2.23 to 2.24) implies $\pm\sqrt{5}$	
			sketch of cubic with turning points in correct quadrants and of correct orientation and passing through origin	B1		must meet the x-axis three times B0 eg if more than 1 point of inflection
			x-intercepts $\pm\sqrt{5}$ marked	B1	may be in decimal form (±2.2…)	
				[4]		
10	(iii)		substitution of $x = 1$ in $f'(x) = 3x^2 - 5$	M1		sight of – 2 does not necessarily imply M1: check $f'(x) = 3x^2 - 5$ is correct in part (i)
			– 2	A1		
			$y - -4 =$ (their $f'(1)$) × $(x - 1)$ oe	M1*	or $-4 = -2\times(1) + c$	
			$-2x - 2 = x^3 - 5x$ and completion to given result www	M1dep*		
			use of Factor theorem in $x^3 - 3x + 2$ with – 1 or ± 2	M1	or any other valid method; must be shown	eg long division or comparing coefficients to find $(x - 1)(x^2 + x - 2)$ or $(x + 2)(x^2 - 2x + 1)$ is enough for M1 with both factors correct
			$x = -2$ obtained correctly	A1		NB M0A0 for $x(x^2 - 3) = -2$ so $x = -2$ or $x^2 - 3 = -2$ oe
				[6]		

Question			Answer	Marks	Guidance	
11	(i)		$ar = 6$ oe	B1	must be in a and r	
			$\frac{a}{1-r} = 25$ oe	B1	must be in a and r	
			$25 = \frac{a}{1-6/a}$	M1	or $\frac{6}{r} = 25(1-r)$	NB assuming $a = 10$ earns M0
			$a^2 - 25a + 150$ [= 0]	A1	or $25r^2 - 25r + 6$ [= 0]	All signs may be reversed
			$a = 10$ obtained from formula, factorising, Factor theorem or completing the square	A1	$r = 0.4$ and $r = 0.6$	
			$a = 15$	A1	$a = 15$	if M0, B1 for $r = 0.4$ **and** 0.6 and B1 for $a = 15$ by trial and improvement mark to benefit of candidate
			$r = 0.4$ and 0.6	A1	$a = \frac{6}{0.6} = 10$ oe	
				[7]		
11	(ii)		$10 \times (3/5)^{n-1}$ and $15 \times (2/5)^{n-1}$ seen	M1		
			$15 \times 2^{n-1} : 10 \times 3^{n-1}$ or $3 \times \frac{2^{n-1}}{5^{n-1}} : 2 \times \frac{3^{n-1}}{5^{n-1}}$	M1	may be implied by $3 \times 2^{n-1} : 2 \times 3^{n-1}$	condone ratio reversed
			$3 \times 2^{n-1} : 2 \times 3^{n-1}$	A1	and completion to given answer www	condone ratio reversed
				[3]		

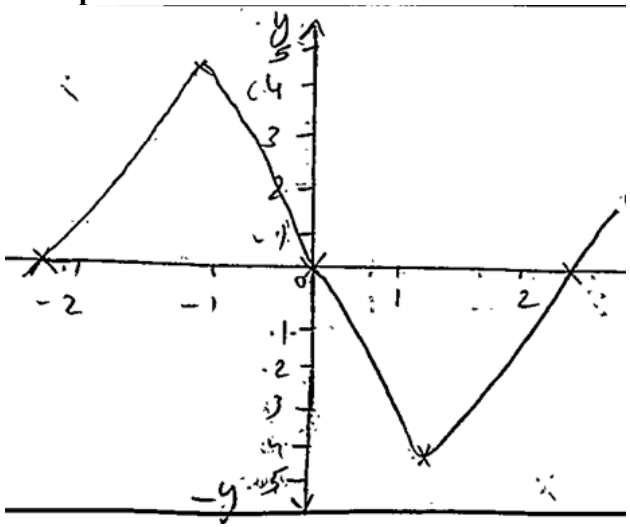
Appendix: examples for Question 10(ii)

Example 1



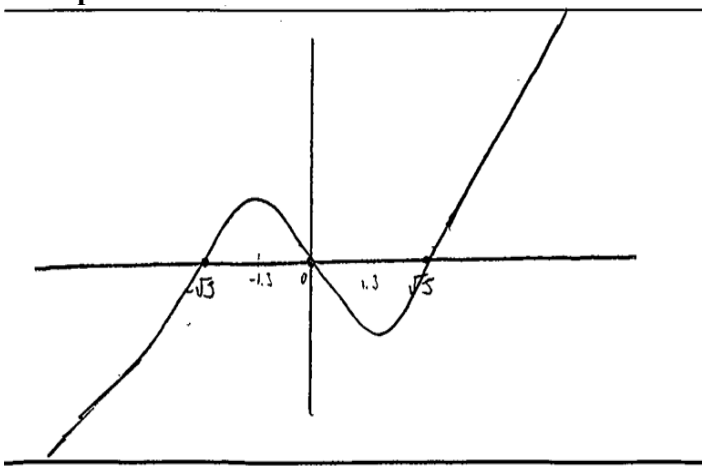
3rd B1 BOD inflection

Example 2



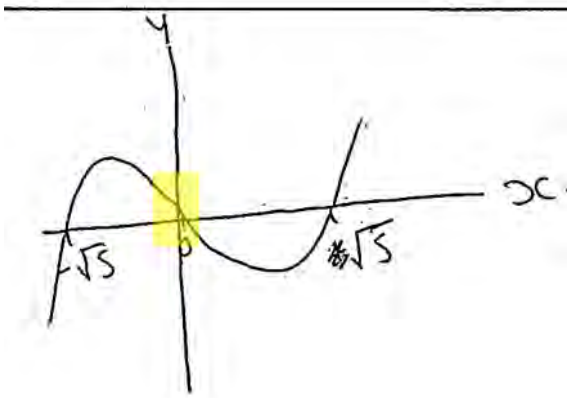
3rd B1 BOD Shape

Example 3



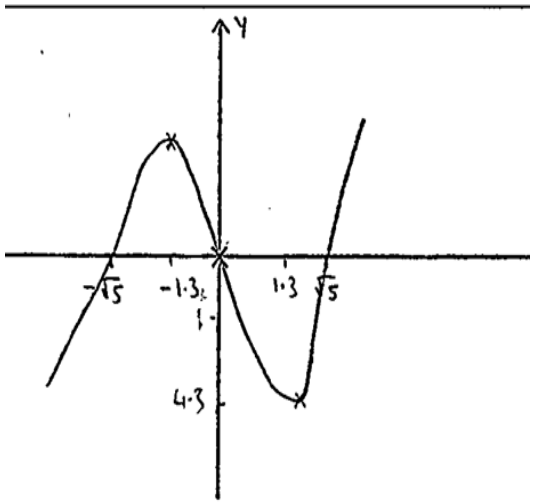
3rd B1 BOD Point of inflection on left

Example 4



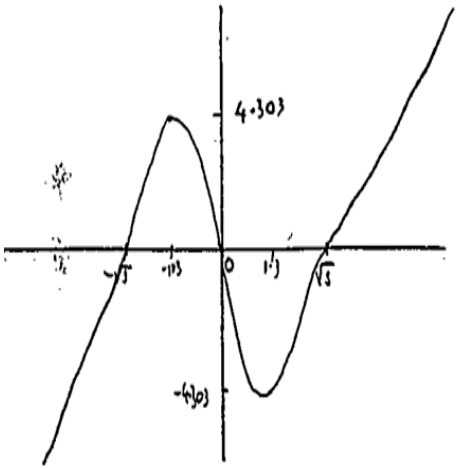
Clearly does not pass through origin
3rd B0

Example 5



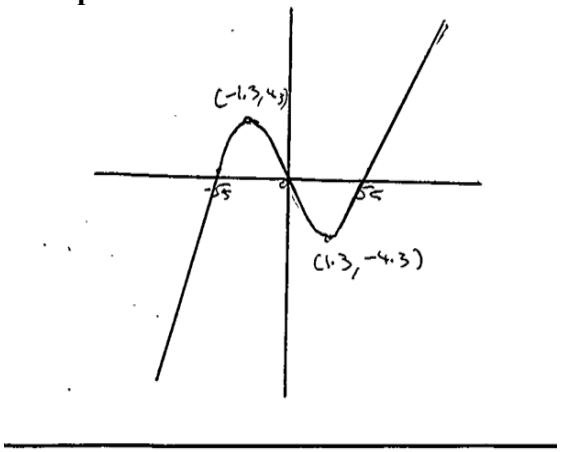
3rd B1

Example 6



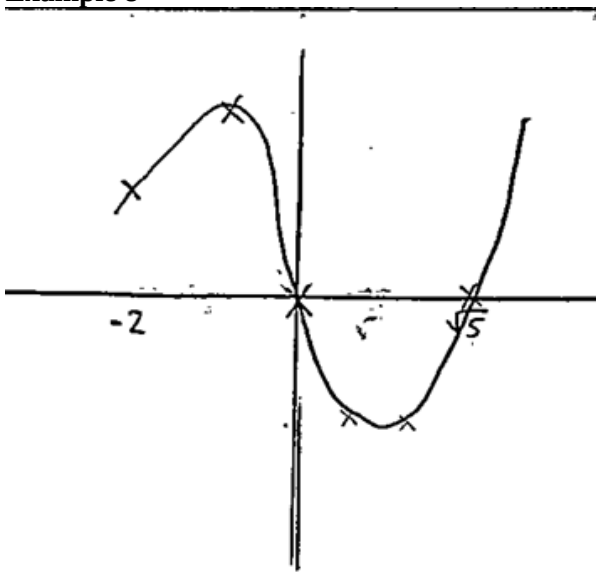
3rd B1 condone RHS

Example 7



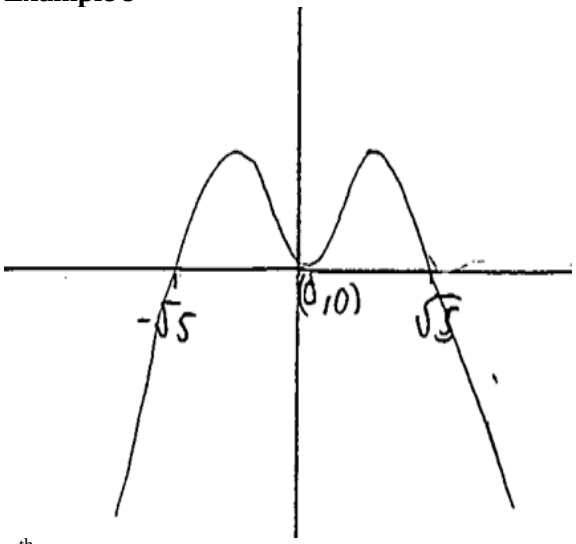
3rd B1 condone extreme ends ruled

Example 8



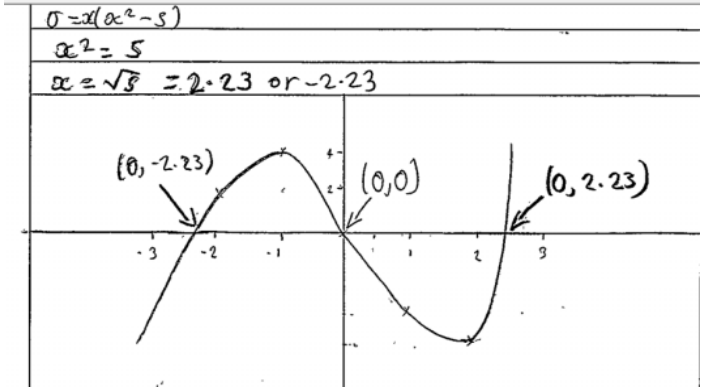
3rd B0 doesn't meet *x*- axis 3 times

Example 9



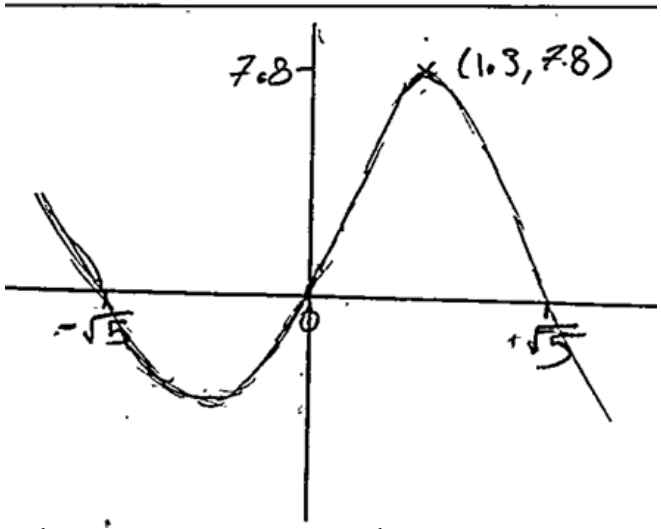
4th B1is earned in spite of the curve not being a cubic

Example 10



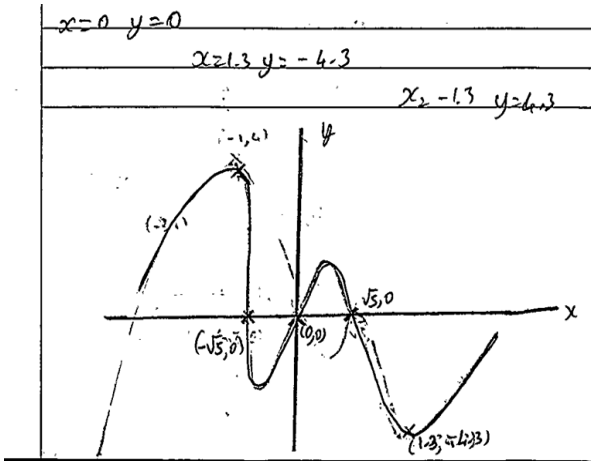
x-intercepts: co-ordinates reversed but condone this as candidates who write –2.23 , 2.23 only would not be penalised
4th B1

Example 11



(3rd B0: incorrect orientation) 4th B1

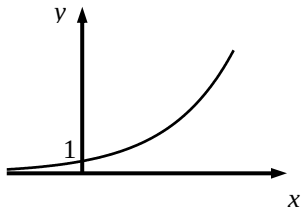
Example 12



4th B1 earned.

Question			Answer	Marks	Guidance	
1			$kx^{\frac{5}{2}}$ $k = 12$ $+ c$	M1 A1 A1 **[3]**		
2	**(i)**		converging + valid reason	1 **[1]**		eg converges to 0, $r = ½$, difference between terms decreasing, sum of terms converges to 6, G.P. with $\|r\| < 1$
2	**(ii)**		neither + valid reason	1 **[1]**		eg divergent oe, A.P., $d = 4$ oe, convergent and periodic ruled out with correct reasons
2	**(iii)**		periodic + valid reason	1 **[1]**		eg repeating cycle of terms
3	**(i)**		(0.8, −2) oe	2 **[2]**	**B1** each coordinate	**SC0** for (4, −2)
3	**(ii)**		Translation $\begin{pmatrix} 90 \\ 0 \end{pmatrix}$ oe	B1 B1 **[2]**	or eg 270 to left	allow **B2** for rotation through 180° about (45, 0) oe

Question			Answer	Marks	Guidance	
4	(i)		$1.2r = 4.2$ 3.5 cao	M1 A1 **[2]**	or $\frac{68.7549...}{360} \times 2\pi r = 4.2$ with θ to 3 sf or better	**B2** if correct answer unsupported
4	(ii)		$\cos 0.6 = \frac{d}{\text{their}3.5}$ 2.888.. to 2.9	M1 A1 **[2]**	or $\cos 34.377.. = \frac{d}{\text{their}3.5}$ with θ to 3 sf or better	or correct use of Sine Rule with 0.9708 (55.623°) or area = 5.709 = 0.5 × h × 3.952, or $3.5^2 - 1.976^2 = d^2$
5			gradient = $\frac{4\sqrt{9.5} - 12}{9.5 - 9}$ 0.6577 to 0.66 $9 < x_C < 9.5$	M1 A1 B1 **[3]**	or 0.657656...isw	$4\sqrt{38} - 24$ $4\sqrt{38} - 24$ allow $8.53 \leq x_C < 9$
6			$6x^2 + 18x - 24$ their $6x^2 + 18x - 24 = 0$ or > 0 or ≥ 0 −4 and + 1 identified oe $x < -4$ and $x > 1$ cao	B1 M1 A1 A1 **[4]**	or $x \leq -4$ and $x \geq 1$	or sketch of $y = 6x^2 + 18x - 24$ with attempt to find x-intercepts if **B0M0** then **SC2** for fully correct answer

Question			Answer	Marks	Guidance	
7			$\cos A = \frac{105^2 + 92^2 - 75^2}{2 \times 105 \times 92}$ oe	M1	or $\cos B = \frac{75^2 + 92^2 - 105^2}{2 \times 75 \times 92}$ oe	or $\cos C = \frac{105^2 + 75^2 - 92^2}{2 \times 105 \times 75}$ oe
			0.717598…soi	A1	0.2220289…soi	0.519746…soi
			A = 44.14345…° soi [0.770448553…]	A1	B = 77.1717719……° soi [1.346901422]	C = 58.6847827…° soi [1.024242678…]
						ignore minor errors due to premature rounding for second **A1** condone *A*, *B* or *C* wrongly attributed
			½ × 92 × 105 × sin (*their* A)	M1	or ½ × 75 × 92 × sin (*their* B)	or ½ × 75 × 105 × sin (*their* C)
			3360 or 3361 to 3365	A1		**or** **M3** for $\sqrt{136(136-75)(136-105)(136-92)}$ **A2** for correct answer 3360 or 3363 - 3364
				[5]		
8	(i)			M1	for curve of correct shape in both quadrants	**SC1** for curve correct in 1st quadrant and touching (0,1) or identified in commentary
				A1	through (0, 1) shown on graph or in commentary	
				[2]		

Question			Answer	Marks	Guidance	
8	(ii)		$5x - 1 = \dfrac{\log_{10} 500\,000}{\log_{10} 3}$	M1	or $5x - 1 = \log_3 500\,000$	condone omission of base 10 use of logs in other bases may earn full marks
			$x = (\dfrac{\log_{10} 500\,000}{\log_{10} 3} + 1) \div 5$	M1	$x = (\log_3 500000 + 1) \div 5$	
			[x =] 2.588 to 2.59	A1 **[3]**	oe; or **B3** www	if unsupported, **B3** for correct answer to 3 sf or more www
9	(i)		$(\dfrac{\sin\theta}{\cos\theta}) = 1$ oe	M1		
			$\sin\theta = \cos^2\theta$ and completion to given result	A1 **[2]**	www	
9	(ii)		$\sin^2\theta + \sin\theta - 1$[= 0]	M1	allow 1 on RHS if attempt to complete square	condone $y^2 + y - 1 = 0$ mark to benefit of candidate
			[$\sin\theta$ =] $\dfrac{-1 \pm \sqrt{5}}{2}$ oe may be implied by correct answers	A1	may be implied by correct answers	ignore any work with negative root & condone omission of negative root with no comment eg **M1** for 0.618…
			[θ =] 38.17... ,or 38.2 and 141.83..., 141.8 or 142	A1 **[3]**	ignore extra values outside range, **A0** if extra values in range or in radians **NB** 0.6662 and 2.4754 if working in radian mode earns **M1A1A0**	if unsupported, **B1** for one of these, **B2** for both. If both values correct with extra values in range, then **B1**. **NB** 0.6662 and 2.4754 to 3sf or more

Question			Answer	Marks	Guidance	
10	(i)		at A $y = 3$	B1		
			$\frac{dy}{dx} = 2x - 4$	B1		
			their $\frac{dy}{dx} = 2 \times 4 - 4$	M1*	must follow from attempt at differentiation	
			grad of normal = $^{-1}/_{\text{their 4}}$	M1dep*		
			$y - 3 = (^{-1}/_{4}) \times (x - 4)$ oe isw	A1		
			substitution of $y = 0$ and completion to given result with at least 1 correct interim step www	A1	or substitution of $x = 16$ to obtain $y = 0$	correct interim step may occur before substitution
				[6]		
10	(ii)		at B, $x = 3$	B1	may be embedded	
			$F[x] = \frac{x^3}{3} - \frac{4x^2}{2} + 3x$	M1*	condone one error, must be three terms, ignore + c	
			F[4] – F[their 3]	M1* dep	dependent on integration attempted	
			area of triangle = 18 soi	B1		may be embedded in final answer
			area of region = $19\frac{1}{3}$ oe isw	A1	19.3 or better	
				[5]		

Question			Answer	Marks	Guidance	
11	(i)	(*A*)	$2A + D = 25$ oe $4A + 6D = 250$ oe $D = 50$, $A = -12.5$ oe	B1 B1 B1 B1 **[4]**		condone lower-case *a* and *d*
11	(i)	(*B*)	$\frac{50}{2}(2 \times their A + 49 \times their D)$ [= 60 625] or $\frac{20}{2}(2 \times their A + 19 \times their D)$ [= 9250] their "$S_{50} - S_{20}$" 51 375 cao	M1 M1 A1 **[3]**	or a = their $A + 20D$ $S_{30} = \frac{30}{2}(a + l)$ oe with l = their $A + 49D$	 $S_{30} = \frac{30}{2}(2 \times their 987.5 + 29 \times their 50)$

Question			Answer	Marks	Guidance	
11	(ii)		$\frac{a\left(r^2-1\right)}{r-1}=25$ or $\frac{a\left(r^4-1\right)}{r-1}=250$	B1		
			$\frac{a\frac{(r^4-1)}{r-1}}{a\frac{(r^2-1)}{(r-1)}}=\frac{250}{25}$ oe	M1		allow $a(1 + r)$ as the denominator in the quadruple- decker fraction
			and completion to given result www		at least one correct interim step required	
			use of $r^4 - 1 = (r^2 - 1)(r^2 + 1)$ to obtain $r^2 + 1 = 10$ www	M1	or multiplication and rearrangement of quadratic to obtain $r^4 - 10r^2 + 9 = 0$ oe with all three terms on one side	$r^2 = x$ oe may be used or **M1** for valid alternative algebraic approaches eg using $a(1 + r) = 25$ <u>and</u> $ar^2 + ar^3 = ar^2 (1 + r) = 225$
			$r = \pm 3$	A1		or **B2** for all four values correct, **B1** for both r values or both a values or one pair of correct values if second **M** mark not earned
			$a = 6.25$ or -12.5 oe	A1	or **A1** for one correct pair of values of r and a	
				[5]		
12	(i)		$\log_{10}p = \log_{10}a + \log_{10}10^{kt}$	M1	condone omission of base;	if unsupported, **B2** for correct equation
			$\log_{10}p = \log_{10}a + kt$ www	A1		
				[2]		
12	(ii)		2.02, 2.13, 2.23	B1	allow given to more sig figs	2.022304623…, 2.129657673, 2.229707433
			plots correct	B1f.t.	to nearest half square	
			ruled line of best fit	B1	y-intercept between 1.65 and 1.7 and at least one point on or above the line and at least one point on or below the line	ft their plots must cover range from $x = 9$ to 49
				[3]		

Question			Answer	Marks	Guidance	
12	(iii)		0.0105 to 0.0125 for k 1.66 to 1.69 for $\log_{10}a$ or 45.7 to 49.0 for a	B1 B1		must be connected to k must be connected to a
			$\log_{10}p$ = their kt + their $\log_{10}a$ p = their "$47.9 \times 10^{0.0115t}$" or "$10^{1.6785+0.0115t}$"	B1 B1 **[4]**	must be a correct form for equation of line and with their y-intercept and their gradient (may be found from graph or from table, must be correct method) as above, "47.9" and "0.0115" must follow from correct method	
12	(iv)		45.7 to 49.0 million	1 **[1]**	'million' needed, not just the value of p	
12	(v)		reading from graph at 2.301.. their 54 2014 cao	M1* M1dep* A1 **[3]**	or $\log_{10}200$ = "$\log_{10}a + kt$" eg for their $t = \dfrac{\log 200 - 1.68}{0.0115}$ if unsupported, allow **B3** only if consistent with graph	or 200 = "$10^{\log a + kt}$" oe or **M1** for their $t = \dfrac{\log \dfrac{200}{47.9}}{0.0115}$

Question			Answer	Marks	Guidance	
1	(i)		$-10x^{-6}$ isw	**B1** **B1** **[2]**	for -10 for x^{-6} ignore + *c* and *y* =	if **B0B0** then **SC1** for $-5\times2x^{-5-1}$ or better soi
1	(ii)		$y = x^{1/3}$ soi kx^{n-1} $\frac{1}{3}x^{-\frac{2}{3}}$ isw	**B1** **M1** **A1** **[3]**	condone $y' = x^{1/3}$ if differentiation follows ft their fractional *n* ignore + *c* and *y* =	 allow 0.333 or better
2	(i)		11.5, 11 and 10.5 oe arithmetic and/or divergent	**B1** **B1** **[2]**	 allow AP ignore references to *a*, *d* or *n*	ignore labelling incorrect embellishments such as converging arithmetic…, diverging geometric… do not score. **B0** if a choice is given eg AP/GP.
2	(ii)		*n* = 30 identified as number of terms in relevant AP $S_{30} = \frac{30}{2}(2\times11.5+(30-1)\times-0.5)$ 127.5 oe	**B1** **M1** **A1** **[3]**	 or $S_{30} = \frac{30}{2}(11.5+-3)$ allow recovery from slip in working (eg omission of minus sign)	eg 1 + 2 + 3 + …+ 30 is not a relevant AP condone one error in *a*, *d* or *n* but do not condone *l* = –½ **SC3** if each term calculated and summed to correct answer or for 127.5 unsupported
3			kx^{-2} $-9x^{-2}$ $+ 2x + c$ substitution of *x* = 3 and *y* = 6 in their expression following integration *c* = 1	**M1*** **A1** **M1*** **M1dep** **A1** **[5]**	 may be awarded later *c* may appear at substitution stage on award of *either* of previous **M1**s **A0** if spoiled by further working	$k \neq 0$ no marks at all for responses based on "$mx + c$" eg $6 = k3^{-2} + 2\times3 + c$ for full marks, **must** see "*y* =" at some stage

Question			Answer	Marks	Guidance	
4	(i)		clear diagram or explanation starting with equilateral triangle correctly showing 30 as half angle and sides 1 and 2 or multiples of these lengths	B1		units for sides and angle not required
			correct use of Pythagoras *and* adjacent and hypotenuse correctly identified to obtain given result $\cos 30° = \frac{\sqrt{3}}{2}$	B1 [2]	adjacent and hypotenuse may be identified on diagram	condone abbreviations
4	(ii)		$\pm\frac{\pi}{6}$ or $-\frac{5\pi}{6}$ soi	M1	may be implied by correct answer or ±0.523598775…, or may appear on quadrant diagram or graph	condone ±30° or − 150°
			$\frac{11\pi}{6}$	A1	if **A0A0**, **SC1** for 1.8333333π and 1.16666666π to 3 or more sf or **SC1** for 330° and 210° www	ignore extra values outside the range if full marks or **SC1** awarded, subtract 1 for extra values *in* the range
			$\frac{7\pi}{6}$	A1 [3]		
5	(i)		ruled line touching curve at $x = 2$	M1		intent to touch, but must not clearly cut curve
			their $\frac{y_2 - y_1}{x_2 - x_1}$ from their *tangent*	M1	may be on graph or in working; must use correct points from their line their tangent may be at another point	**M0** for reciprocal,
			answer in range 2.5 to 3.0 inclusive	A1 [3]	both **M1**s must be awarded	(value is approx 2.773)
5	(ii)		3.482202253... and 4.59479342... rot to 3 or more sf	B1		
			2.78 to 2.7815 or 2.8	B1 [2]	mark the final answer	2.781477917..

Question			Answer	Marks	Guidance	
6	(i)		$2S$ cao	**B1** **[1]**		
6	(ii)		$\frac{a}{1-r^2}$ $\frac{S}{1+r}$ or $\frac{1}{1+r}S$	**M1** **A1** **[2]**	if **M0, SC1** for $\frac{1-r}{1-r^2}\times S$ oe	
7			h = 1.5 $\frac{1.5}{2}\times(2.3+2(2.9+4+4.6+4.2+3)+0)$ all y-values correct and correctly placed in formula 29.775 to 3 sf or better; isw	**B1** **M1** **B1** **A1** **[4]**	h = 1.5 basic shape of formula correct, omission of brackets may be recovered later condone omission of outer brackets and/or omission of 0 answer only does not score	allow if used with 6 separate trapezia at least 4 y-values in middle bracket, eg $\frac{1.5}{2}\times(2.3+2(2.9+4+4.6+4.2)+3)$ **M0** if any x values used or **B1** + **B3** if 6 separate trapezia calculated to give correct answer
8	(i)		graph from (–1, 1) to (1, 1) to (2, 2) to (3, 0)	**2** **[2]**	**B1** for three points correct or for all four points correct but clearly not joined	points must be joined, but not always easy to see, so BOD if in doubt. Accept freehand drawing.
8	(ii)		graph from (–2, 3) to (2, 3) to (4, 6) to (6, 0)	**2** **[2]**	**B1** for three points correct or for all four points correct but clearly not joined	points must be joined, but not always easy to see, so BOD if in doubt. Accept freehand drawing.

Question			Answer	Marks	Guidance	
9	(i)		$3x^2 - 6x - 22$	M1	condone one incorrect term, but must be three terms	condone "$y =$"
			their $y' = 0$ soi	M1	at least one term correct in their y'	may be implied by use of eg quadratic formula, completing square, attempt to factorise
			3.89 −1.89	A1 A1	if **A0A0**, **SC1** for $\frac{3 \pm 5\sqrt{3}}{3}$ or $1 \pm {}^{5}/_{\sqrt{3}}$ or better, or both decimal answers given to a different accuracy or from truncation	3.886751346 and −1.886751346
				[4]		
9	(ii)		$x^3 - 3x^2 - 22x + 24 = 6x + 24$ $x^3 - 3x^2 - 28x$ [= 0]	M1 M1	may be implied by $x^3 - 3x^2 - 28x$ [= 0] may be implied by $x^2 - 3x - 28$[= 0]	
			other point when $x = 7$ isw	A1	dependent on award of both **M** marks	ignore other values of x
				[3]		
9	(iii)		F[x] = $\frac{x^4}{4} - \frac{3x^3}{3} - \frac{22x^2}{2} + 24x$	M1*	allow for three terms correct; condone $+ c$	**alternative method** **M1** for $\int ((x^3 - 3x^2 - 22x + 24) - (6x + 24))dx$ may be implied by 2nd **M1**
			F[0] – F[−4]	M1dep	allow 0 – F[−4], condone – F[−4], but do not allow F[−4] only	**M1*** for F[x] = $\frac{x^4}{4} - \frac{3x^3}{3} - \frac{28x^2}{2}$ condone one error in integration **M1dep** for F[0] – F[−4]
			area of triangle = 48	B1		
			area required = 96 from fully correct working	A1	**A0** for – 96, ignore units,	no marks for 96 unsupported
				[4]		

Question			Answer	Marks	Guidance	
10	(i)	(*A*)	$AC^2 = 12.8^2 + 7.5^2$ oe	**M1**	allow correct application of cosine rule or from finding relevant angle and using trig	
			$AC = 14.83543056..$	**A1**	rot to 3 or more sf , or 15	**B2** for 14.8 or better unsupported
			$\tan C = {}^{12.8}/_{7.5}$	**M1**	or $\sin C = {}^{12.8}/_{\text{their}14.8}$	or $\frac{\sin C}{12.8} = \frac{\sin 90}{\textit{their}14.8}$
			or $C = 90 - \tan^{-1}({}^{7.5}/_{12.8})$ oe		or $\cos C = {}^{7.5}/_{\text{their}14.8}$	or $\cos C = \frac{\textit{their}14.8^2 + 7.5^2 - 12.8^2}{2 \times 7.5 \times \textit{their}14.8}$
			59.6 to 59.64	**A1**		
			$\frac{AD}{\sin(155 - \textit{their}59.6)} = \frac{\textit{their}14.8}{\sin 35}$ oe	**M1**		
			25.69 to 25.8	**A1**	allow **B2** for $25.69 \leq AD < 25.8$ unsupported…..but **B0** for 25.8 unsupported	**M0A0** for ${}^{14.8}/_{\cos 55} = 25.803...$
				[6]		

Question			Answer	Marks	Guidance	
10	(i)	(*B*)	area of *ABC* = 48 soi	**B1**	may be implied by correct final answer in range or by sight of ½ × 12.8 × 7.5 oe	condone 48.0…
			½×their 14.8…×their 25.7…×sin(their 59.6 – 10)	**M1**	may be implied by 144.8 to 146	
			192.8 to 194[m^2]	**A1**		**B3** for correct answer in range if unsupported
				[3]		
10	(ii)		angle *HMG* = $\frac{\pi - 1.1}{2}$ or *MHG* = 0.55 (31.5126°)	**B1**	or angle *EMF* or angle *MEF*	allow 1.02 to 1.021 *or* 58.487° to 58.5°
			HM = 1.7176 to 1.7225	**B1**		may be implied by final answer
			½ × 1.1 × *their HM*^{2} or $\frac{\theta}{360} \times \pi \times theirHM^2$	**M1**	1.63(0661924…) θ =63(.025357…)	check arithmetic if necessary their *HM* ≠ 0.9 or 1.8
			area of triangle *EMF* = 0.652 to 0.662	**B1**	or *MGH*	may be implied by final answer or in double this (1.304 to 1.324)
			2.95 to 2.952 [m^2] cao	**A1**		full marks may be awarded for final answer in correct range ie allow recovery of accuracy
				[5]		
11	(i)		65 ×$(1 - 0.017)^3$ oe	**M1**	may be longer method finding decrease year by year etc	NB use of 3×0.017 leads to 61.685, which doesn't score
			61.7410... showing more than 3 sf	**A1**	answer 61.7 given	
				[2]		
11	(ii)		[*d* =] 65 × 0.983^n oe	**B1**	eg 63.895 × 0.983^{n-1} or 61.7 × 0.983^{n-3}	
				[1]		

Question			Answer	Marks	Guidance	
11	(iii)		$65 \times 0.983^n < 3$ or $\log_{10}(65 \times 0.983^n) < \log_{10}3$ oe	**M1***		condone omission of base 10 throughout
			$\log_{10}65 + \log_{10}0.983^n < \log_{10}3$ www	**M1dep**	may be implied by eg $\log_{10}65 + n\log_{10}0.983 < \log_{10}3$	if **M0M0**, **SC1** for $\log_{10}65 + n\log_{10}0.983 < \log_{10}3$ even if < is replaced by eg = or > with no prior incorrect log moves
			$[\log_{10}65 + n\log_{10}0.983 < \log_{10}3]$ $n\log_{10}0.983 < \log_{10}3 - \log_{10}65$ and		or $[\log_{10}0.983^n < \log_{10}3 - \log_{10}65]$	NB watch for correct inequality sign at each step
			completion to $n > \dfrac{\log_{10}3 - \log_{10}65}{\log_{10}0.983}$ **AG** www	**A1**	inequality signs must be correct throughout	reason for change of inequality sign not required
			$n = 180$ cao	**B1** **[4]**	**B0** for $n > 180$	$n > 179.38...$
11	(iv)		$63.895 = 65 \times 10^{-k}$ soi	**B1**	or $65 \times 0.983 = 65 \times 10^{-k}$	accept 63.895 rot to 3 or 4 sf; **B1** may be awarded for substitution of $t = 1$ after manipulation
			$\log_{10}$(their 63.895) = $\log_{10}65 - k$ or $-k = \log_{10}$(their 0.983)	**M1**	their 63.895 must be from attempt to reduce 65 by 1.7% at least once	**M1A1A1** may be awarded if other value of t with correct d is used
			$[k =] 7.4 \times 10^{-3}$ to 7.45×10^{-3}	**A1**	$[k =] -\log_{10}0.983$ isw	
			$[d =]$ 42.1... to 42.123 [°C] isw	**A1** **[4]**		NB **B1M1A0A1** is possible; unsupported answers for k and/or d do not score