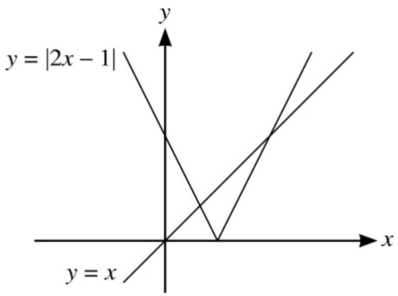
Question			Answer	Marks	AOs	Guidance	
1	(i)		$n = 500$ $\frac{500}{2} \times 1002$ $250\,500$	B1 M1 A1 [3]	3.1a 1.1 1.1	 Use of formula for sum of AP	
1	(ii)	(*A*)	$\frac{n}{2}(2+2n) < 110$ so $n + n^2 < 110$	E1 [1]	2.4	AG	At least one line of working leading to given answer is required
1	(ii)	(*B*)	$n^2 + n - 110 < 0 \Rightarrow (n+11)(n-10) < 0$ $[-11 <]\ x < 10$ $\{1, 2, 3, 4, 5, 6, 7, 8, 9\}$ oe	M1 M1 A1 [3]	1.1a 1.1 1.1	Or roots of quadratic are 10 and −11 Or relevant sketch of quadratic Correct set of numbers clearly stated	
2	(i)		 	B1 B1 [2]	1.1 1.1	$y = x$ straight line with positive gradient through origin $y = \|2x - 1\|$ steeper than $y = x$ and crossing $y = x$ and y-axis as shown	
2	(ii)		**DR** $2x - 1 > x$ $-(2x-1) > x$ Hence $x > 1$, $\frac{1}{3} > x$ $\{x : x < \frac{1}{3}\} \cup \{x : x > 1\}$	 M1 M1 A1 A1	 1.1 1.1a 1.1 2.5	 Allow $2x - 1 = x$ Allow $-(2x-1) = x$ For either of these inequalities Must be in this set notation form or	

Question			Answer	Marks	AOs	Guidance	
				[4]		else stated as ‘ $x < \frac{1}{3}$ or $x > 1$ ’	

Question			Answer	Marks	AOs	Guidance	
3			$\sqrt{1+\ln x}=0 \Rightarrow \ln x=-1$	M1	1.1a		
			$x=\frac{1}{e}$	A1	2.2a	oe but must be exact value	
				[2]			

Question			Answer	Marks	AOs	Guidance	
4	(i)		AD has gradient 3	B1	3.1a		
			$\frac{1-y_2}{2}=3$	M1	1.1		
			(0, –5)	A1	2.2a	Answer given as coordinates	
				[3]			
4	(ii)		AB has gradient $-\frac{1}{3}$	M1	3.1a	Use of $m_1 m_2 = -1$	Or gradient of DC
			Equation of AB is $y=-\frac{1}{3}x-5$	M1	1.1		Or DC is $y=-\frac{1}{3}x+\frac{5}{3}$
			AB meets BC where $-\frac{1}{3}x-5=3x+5$	M1	3.1a		Or DC meets BC where $-\frac{1}{3}x+\frac{5}{3}=3x+5$
			$3\frac{1}{3}x=-10 \Rightarrow x=-3$				$3\frac{1}{3}x=-3\frac{1}{3} \Rightarrow x=-1$
			B is the point (–3, –4)	A1	2.2a		Or C is (–1, 2)
			$AB=\sqrt{10}$	M1	1.1		
			$AD=\sqrt{40}$	M1	1.1		
			Area = 20	A1	2.2a		
				[7]			

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5	(i)		$x=-b$ $y=0$	B1 B1 [2]	2.2a 1.1		
5	(ii)		For negative a, $\frac{a}{(x+b)^2}<0$ So in this case the curve lies below the x-axis and Joe's statement is false	B1 E1 [2]	2.3 2.4		If zero scored, SC1 for $(x+b)^2$ is never negative oe
5	(iii)		$x=-b$ is a line of symmetry $b=-2$ $3=\frac{a}{(1+b)^2}$ $a=3$	M1 A1 M1 A1 [4]	3.1a 2.2a 1.1a 1.1	Or $x=2$ is a line of symmetry Or $3=\frac{a}{(3+b)^2}$	Or $(1+b)^2=(3+b)^2$
6	(i)		$f(x)=x^3-3x^2-10x+25 \Rightarrow f'(x)=3x^2-6x-10$, so the N-R formula gives $x_{n+1}=x_n-\frac{x_n^3-3x_n^2-10x_n+25}{3x_n^2-6x_n-10}$	E1 [1]	2.1	**AG** Must be clear that denominator is derivative of numerator	
	(ii)	(*A*)	Not valid: the sequence may decrease further, far enough to change the first 3 figures	B1 [1]	2.3	Reason for 'not valid' needed	
6	(ii)	(*B*)	$f(3.915)=-0.1255...$ and $f(3.925)=2.03\ldots\times10^{-4}$ Change of sign shows that there is a root in the interval (3.915, 3.925) so the root is 3.92 to 2dp	M1 A1 [2]	2.1 2.2a	Both calculations Complete argument needed	Allow use of any two values closer to 3.92 that give sign change
	(iii)	(*A*)	$x_0=3 \Rightarrow x_1=-2$ $x_2=-3.785\,71\ldots$ and $x_3=-3.168\,34\ldots$	B1 B1 [2]	1.1b 1.1b	Correct first iteration x_2 and x_3 correct to at least 3dp	
	(iii)	(*B*)	The initial value is close to a stationary point, so the tangent meets the x-axis far from the required root, and the sequence converges to the wrong root	B1 B1 [2]	2.3 2.4	'close to stationary point' oe seen 'converges to wrong root' oe seen	

Question			Answer	Marks	AOs	Guidance	
7	(i)		Tangent perpendicular to radius	B1 [1]	2.4		
7	(ii)		Draw horizontal line from B to AD : $\cos A = \frac{6-2}{6+2}$ $\cos A = \frac{1}{2} \Rightarrow A = \frac{1}{3}\pi$	M1 A1 [2]	3.1a 2.1	 AG Successful completion	
7	(iii)		$DC = (6+2)\sin\frac{1}{3}\pi$ $= 4\sqrt{3}$ Trapezium ABCD has area $\frac{1}{2}(6+2)\times 4\sqrt{3}$ $= 16\sqrt{3}\text{ cm}^2$	M1 A1 M1 A1 [4]	3.1a 1.1 1.1 2.1	 AG	
7	(iv)		Angle $ABC = \frac{2}{3}\pi$ $16\sqrt{3} - \frac{1}{2}\times 6^2 \times \frac{1}{3}\pi - \frac{1}{2}\times 2^2 \times \frac{2}{3}\pi$ 4.674 cm^2	M1 M1 A1 [3]	3.1a 1.1 1.1	 Either sector correct	

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8	(i)		**DR**				
			$\frac{dy}{dx}=0$ when $\frac{dy}{d\theta}=\cos\theta=0$	M1	3.1a		
			$\theta=\frac{1}{2}\pi,\ \frac{3}{2}\pi$	M1	1.1		
			$x=-2$	A1	1.1		
			$y=3$	A1	3.2a		
			Alternative solution				
			Maximum y occurs when $\sin\theta=1$	M1			
			$y=3$	A1			
			$\theta=\frac{1}{2}\pi$	M1			
			$x=-2$	A1			
				[4]			
8	(ii)		**DR**				
			$7\cos\theta+2\cos 2\theta=0 \Rightarrow 4\cos^2\theta+7\cos\theta-2=0$	M1	3.1a	Use of double angle formula	
			$(4\cos\theta-1)(\cos\theta+2)=0$	M1	1.1	Method for solving quadratic	
			$\cos\theta=\frac{1}{4}$ or -2	A1	1.1		
			Reject $\cos\theta=-2$	B1	3.2a	May be seen later	
			$\sin^2\theta=1-\cos^2\theta=1-\left(\frac{1}{4}\right)^2=\frac{15}{16}$	M1	3.1a		
			$y=2\pm\frac{\sqrt{15}}{4}$	A1	2.2a	oe exact form	
				[6]			

9	(i)		Translation	B1	1.1a		
			$\frac{b}{3a}$ parallel to x-axis	B1	1.1	oe	
				[2]			
9	(ii)		$\alpha-\frac{b}{3a}$	B1	2.2a		
				[1]			

Question			Answer	Marks	AOs	Guidance	
10	(i)		$x^3 = \left(y - \frac{m}{3y}\right)^3$ $= y^3 - 3y^2\left(\frac{m}{3y}\right) + 3y\left(\frac{m}{3y}\right)^2 - \left(\frac{m}{3y}\right)^3$ $= y^3 - my + \frac{m^2}{3y} - \frac{m^3}{27y^3}$ $x^3 + mx = y^3 - \frac{m^3}{27y^3}$ $y^3 - \frac{m^3}{27y^3} = n \Rightarrow \left(y^3\right)^2 - \frac{m^3}{27} = ny^3$ This is a quadratic in y^3	M1 A1 E1 **[3]**	1.1a 1.1 2.1	Successful completion	
10	(ii)		$\left(y^3\right)^2 - ny^3 - \frac{m^3}{27} = 0$ has distinct real roots when $(-n)^2 - 4\left(-\frac{m^3}{27}\right) > 0$ $n^2 + \frac{4m^3}{27} > 0$ certainly true when $m > 0$	M1 E1 **[2]**	3.1a 2.4	Use of their $b^2 - 4ac$	

Question			Answer	Marks	AOs	Guidance	
11	(i)		$-\frac{1}{a_1^3}=-\frac{2}{5+\sqrt{29}}=-\frac{2\left(5-\sqrt{29}\right)}{25-29}=\frac{5-\sqrt{29}}{2}=a_2^3$	B1	2.1	AG Convincingly shown	
			Alternative solution $a_1^3a_2^3=\frac{5+\sqrt{29}}{2}\times\frac{5-\sqrt{29}}{2}=\frac{25-29}{4}=-1\Rightarrow a_2^3=-\frac{1}{a_1^3}$	B1		AG Convincingly shown	
				[1]			
11	(ii)		$a_2^3=-\frac{1}{a_1^3}\Rightarrow a_2=-\frac{1}{a_1}$	B1	2.2a		
			$a_2-\frac{1}{a_2}=-\frac{1}{a_1}+a_1=a_1-\frac{1}{a_1}$	B1	2.1	AG Convincing completion	
				[2]			

Question			Answer	Marks	AOs	Guidance	
12	(i)		$\frac{\mathrm{d}y}{\mathrm{d}x}=3x^2+2bx+c$	B1	1.1a		
			At stationary points $3x^2+2bx+c=0$	B1	3.1a		
			No real roots if $(2b)^2<4\times3c$ hence if $3c>b^2$	B1	2.1	AG	
				[3]			
12	(ii)		The gradient is never zero, hence is always positive or always negative so the graph must cross the x-axis in one place.	E1 [1]	2.4	Convincing explanation	