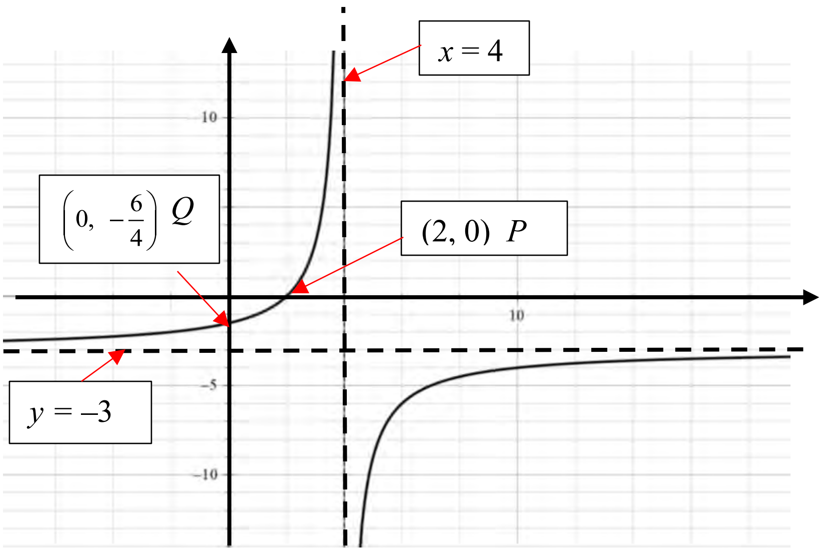
Question	Scheme	Marks
10(a) **(i)** **(ii)**	When $y=0,\quad x=2$ or $(2, 0)$ When $x=0, y=-\frac{6}{4}$ oe or $\left(0,-\frac{6}{4}\right)$ oe **If not labelled part (i) and (ii), do not award marks unless the candidate has presented in the correct order or has made it clear which coordinate or pair of values is *P* and which is *Q***	B1 B1 [2]
(b)	(i) $x=4$ (ii) $y=-3$ **If not labelled part (i) and (ii), do not award marks unless the candidate has presented in the correct order or has identification of horizontal (or parallel to *x*-axis) and vertical (or parallel to *y*-axis) is clear.**	B1 B1 [2]
(c)		B1 B1 ft B1 ft [3]
(d)	$\left(\frac{dy}{dx}=\right)\frac{-3(x-4)-(6-3x)\times 1}{(x-4)^2}=\left[\frac{6}{(x-4)^2}\right]$ oe where $x=2$ $\frac{dy}{dx}=\frac{6}{(2-4)^2}=\frac{6}{4}\Rightarrow$ Gradient of normal $=-\frac{4}{6}$ oe Equation of normal: $y-0=\text{"}-\frac{4}{6}\text{"}(x-2)\Rightarrow[3y=-2x+4]$ oe	M1A1A1 M1 dM1A1 [6]
(e)	$\frac{6-3x}{x-4}=\frac{-2x+4}{3}\Rightarrow 2x^2-21x+34=0$ $\Rightarrow(2x-17)(x-2)=0$ At R $\Rightarrow x=\frac{17}{2}$, (2)	M1 M1 A1 [3]
		Total 16 marks

Part	Mark	Notes
(a) (i)	**B1**	Must state $y=0,\ x=2$ or $(2, 0)$ or clearly stating $x = 2$
(ii)	**B1**	Must state $x=0, y=-\frac{6}{4}$ oe or $\left(0,-\frac{6}{4}\right)$ oe or clearly stating $y=-\frac{6}{4}$
(b)(i)	**B1**	For $x = 4$
(ii)	**B1**	For $y = -3$
(c)	**B1**	For a negative reciprocal curve drawn anywhere in the grid – there **must** be two branches present, they **must not** cross any asymptotes drawn and **must not** obviously 'bend back' on themselves. Mark intention.
	B1ft	For the asymptotes drawn, follow through their (b)(i) and (ii). There **must** be at least one branch of a negative reciprocal curve present in the correct place for their work in (a) and (b), which **must** not cross or obviously bend back from the asymptotes. The asymptotes **must** be labelled with their equation or shown as passing through 4 on the x-axis and – 3 on the y-axis, both clearly labelled.
	B1ft	For at least one branch of a negative reciprocal curve in the correct place for their work in (a) and (b), passing through their intercepts on the axes. The intercepts should be correctly labelled with the coordinates or the axes labelled correctly with $-\frac{6}{4}$ (oe) and 2 (or their ft values) but condone labelling to be P and Q.
(d)	**M1**	For an expression of the form. $\frac{-a(x-4)-(6-3x)\times b}{(x-4)^2}$ oe
	A1	For an expression of the form. $\frac{-3(x-4)-(6-3x)\times b}{(x-4)^2}$ or $\frac{-a(x-4)-(6-3x)\times 1}{(x-4)^2}$ .oe
	A1	Fully correct – need not be simplified.
	M1	For substituting $x = 2$ into their $\frac{\mathrm{d}y}{\mathrm{d}x}$ and finding the gradient of the normal. This is not a dependent method mark, but the substitution must be into a **changed** function. If their expression does not allow substitution of $x = 2$, this mark cannot be awarded.
	dM1	For a complete and correct method to find the equation of the normal using their (changed gradient), $y = 0$ and $x = 2$. Dependent on the previous mark. If $y = mx + c$ is used they must find a value for c.
	A1	For any correct equation. **This can be in any form and may be left unsimplified.**
(e)	**M1**	For equating their equation of the normal to C and attempting to form a 3TQ. The attempt must involve correctly removing both denominators of the equation as a minimum and any attempt to collect terms.
	M1	For a minimally acceptable (see general guidance) and complete attempt to solve their quadratic equation, leading to a value of x..
	A1	For the x coordinate of point R $x=\frac{17}{2}$

Question	Scheme	Marks
11 (a)(i)	$\left(\alpha-\beta=2\sqrt{6}\Rightarrow(\alpha-\beta)^2=24\right)\Rightarrow(\alpha+\beta)^2-4\alpha\beta=24$ oe **(1)**	M1
	$\alpha^2+\beta^2=30\Rightarrow(\alpha+\beta)^2-2\alpha\beta=30$ oe **(2)**	M1
	(2) – (1) $6=2\alpha\beta\Rightarrow\alpha\beta=3$ cso	dM1A1* [4]
ALT1	$\left((\alpha-\beta)^2=\alpha^2+\beta^2-2\alpha\beta\Rightarrow\right)2\alpha\beta=\alpha^2+\beta^2-(\alpha-\beta)^2$ oe	M1
	$30-\left(2\sqrt{6}\right)^2=6$	M1
	$2\alpha\beta=6\Rightarrow\alpha\beta=3$	dM1A1 [4]
(ii)	$30=(\alpha+\beta)^2-2\times3\Rightarrow(\alpha+\beta)^2=36\Rightarrow\alpha+\beta=6$ $[\alpha>\beta>0]$ cso	M1A1* [2]
ALT2 (i)	$\alpha-\beta=2\sqrt{6}\rightarrow\alpha=2\sqrt{6}+\beta$	
	$\alpha^2+\beta^2=30\rightarrow\left(2\sqrt{6}+\beta\right)^2+\beta^2=30$	M1
	$2\beta^2+4\sqrt{6}\beta-6=0$ oe eg $\beta^2+2\sqrt{6}\beta-3=0$	M1
	$(\beta=)\dfrac{-2\sqrt{6}\pm\sqrt{\left(2\sqrt{6}\right)^2-4(1)(-3)}}{2}$ oe $\rightarrow\beta\left(=3-\sqrt{6}\right)$	dM1
	$\alpha=3+\sqrt{6}$	
	$\alpha\beta=\left(3+\sqrt{6}\right)\left(3-\sqrt{6}\right)=9+6\sqrt{3}-6\sqrt{3}-6=3$	A1* [4]
(ii)	$\alpha+\beta=3+\sqrt{6}+3-\sqrt{6}=6$	M1A1 [2]
(b)(i)	$\alpha^4+\beta^4=\left(\alpha^2+\beta^2\right)^2-2(\alpha\beta)^2=30^2-2\times3^2=882$	M1A1 [2]
(b) ii)	$\alpha^4-\beta^4=\left(\alpha^2+\beta^2\right)\left(\alpha^2-\beta^2\right)=\left(\alpha^2+\beta^2\right)(\alpha-\beta)(\alpha+\beta)$	M1
	$\alpha^4-\beta^4=30\times6\times2\sqrt{6}=360\sqrt{6}$	A1 [2]
(c)	$\left(\alpha^4+\beta^4\right)+\left(\alpha^4-\beta^4\right)=2\alpha^4=882+360\sqrt{6}\Rightarrow\alpha^4=441+180\sqrt{6}$	M1A1 [2]
ALT1	$\alpha-\beta=2\sqrt{6},\alpha+\beta=6\Rightarrow\alpha=3+\sqrt{6}$	
	$\alpha^4=\left(3+\sqrt{6}\right)^4$	M1
	$\alpha^4=441+180\sqrt{6}$	A1 [2]
ALT2	$\alpha-\beta=2\sqrt{6},\alpha+\beta=6\Rightarrow\beta=3-\sqrt{6}$	
	$\alpha^4=\beta^4+360\sqrt{6}=\left(3-\sqrt{6}\right)^4+360\sqrt{6}$	M1
	$\alpha^4=441+180\sqrt{6}$	A1 [2]
		Total 12 marks

Part	Mark	Notes
(a) (i)	M1	For forming an equation of the form $(\alpha+\beta)^2 \pm p\alpha\beta = 24$ oe or $(\alpha+\beta)^2 \pm t\alpha\beta = 30$ oe
	M1	For this equation being fully correct. Both marks may be implied by early substitution of values.
	dM1	For correctly solving their simultaneous equations in $\alpha+\beta$ and $\alpha\beta$ to find a value for $\alpha\beta$, dependent on 1st method mark.
	A1*cso	For the correct value of $\alpha\beta$
ALT1	M1	For forming an equation of the form $q\alpha\beta = \alpha^2+\beta^2-(\alpha-\beta)^2$ oe
	M1	For this equation being fully correct. Both marks may be implied by early substitution of values.
	dM1	For correct substitution into their equation, dependent on 1st method mark.
	A1*cso	For the correct value of $\alpha\beta$
(a) (ii)	M1	Correctly uses either of their equations (must be of the required form) to substitute the given value of $\alpha\beta$ and obtains a value for $\alpha+\beta$
	A1*cso	For the correct value of $\alpha+\beta$
ALT2 (i)	M1	For an attempt to eliminate α or β and arrive at an unsimplified quadratic equation in one variable. Allow one error
	M1	For the correct quadratic equation
	dM1	For a **fully correct method** to solve their quadratic equation in α or β, dependent on the 1st method mark
	A1*cso	For correctly finding α and β and showing the minimum steps shown to find $\alpha\beta$
	M1	For finding $\alpha+\beta$ with their values
	A1*cso	For finding $\alpha+\beta$ with the correct values, minimum steps as shown.
(b) (i)	M1	For the correct algebra $\alpha^4+\beta^4 = (\alpha^2+\beta^2)^2 - 2(\alpha\beta)^2$, if they use more complex algebra, it must be correct and fully ready for substitution of given values. Do not allow $\alpha^4+\beta^4 = (\alpha^2+\beta^2)^2 - 2\alpha^2\beta^2$ unless recovered
	A1	For substituting the given values to find the correct value for $\alpha^4+\beta^4$
(b) (ii)	M1	For the correct algebra to write $\alpha^4-\beta^4$ in terms of $(\alpha^2+\beta^2), (\alpha-\beta)$ and $(\alpha+\beta)$
	A1	For the correct value of $\alpha^4-\beta^4$
(c)	M1	For adding together $\alpha^4+\beta^4$ and $\alpha^4-\beta^4$ to eliminate β^4 and reach α^4 either as an expression or implied by adding their values together and dividing by 2. If students subtract $\alpha^4+\beta^4$ and $\alpha^4-\beta^4$ to eliminate α^4 and reach β^4, they must then reach α^4 as an expression or implied by subtracting their values, using one of the expressions from part b and dividing by 2.
	A1	For the correct value of $\alpha^4 = 441+180\sqrt{6}$
ALT1	M1	For $\alpha^4 = (3+\sqrt{6})^4$
	A1	For the correct value of $\alpha^4 = 441+180\sqrt{6}$
ALT2	M1	For $\alpha^4 = \beta^4 + 360\sqrt{6} = (3-\sqrt{6})^4 + 360\sqrt{6}$
	A1	For the correct value of $\alpha^4 = 441+180\sqrt{6}$

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