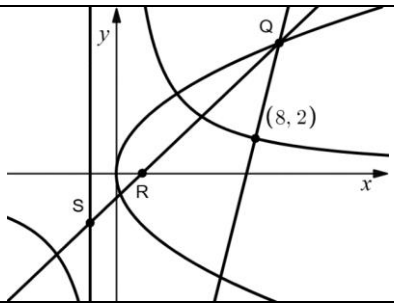
Question Number	Scheme	Notes	Marks
9(a)	$y = c^2x^{-1}$ $\quad xy = c^2$ $\quad x = ct \quad y = \frac{c}{t}$ $\frac{dy}{dx} = -c^2x^{-2} = -\frac{c^2}{x^2}$ $\quad y + x\frac{dy}{dx} = 0$ $\quad \frac{dx}{dt} = c \quad \frac{dy}{dt} = -ct^{-2}$ $\left(ct, \frac{c}{t}\right) \Rightarrow \frac{dy}{dx} = -\frac{c^2}{c^2t^2}$ $\quad \frac{dy}{dx} = -\frac{y}{x} \Rightarrow \frac{-\frac{c}{t}}{ct}$ $\quad \frac{dy}{dx} = -\frac{ct^{-2}}{c}$ Correct expression for $\frac{dy}{dx}$ in terms of c and t (or just t). Award when seen and isw. Allow for a correct $\frac{dx}{dy}$ or $-\frac{dx}{dy}$		**B1**
	$m_T = -\frac{1}{t^2} \Rightarrow m_N = t^2$	Correct perpendicular gradient rule for their $\frac{dy}{dx}$ in terms of t (or c and t)	**M1**
	$y - \frac{c}{t} = "t^2"(x - ct)$ **or** $y = "t^2"x + b \Rightarrow \frac{c}{t} = "t^2"(ct) + b \Rightarrow b = ...$	Correct straight line method with a changed gradient in terms of t (or c and t) with coordinates correctly placed. Condone the use of $y = mx + c$ instead of e.g. $y = mx + b$	**M1**
	$ty - c = t^3x - ct^4$ **or** $y = t^2x + \frac{c}{t} - ct^3$ $\Rightarrow t^3x - ty = c\left(t^4 - 1\right)*$	Fully correct proof with at least one intermediate line before printed answer but allow if equation reversed and/or order altered e.g., $\left(-1 + t^4\right)c = -ty + t^3x$	**A1***
	Score a maximum of 0110 if they start with just $\frac{dy}{dx} = -\frac{1}{t^2}$ and 0010 if just $m_N = t^2$		
			(4)

Question Number	Scheme	Notes	Marks
9(b)	$(8,\ 2) \Rightarrow$ e.g., $c^2 = 16$, $\boldsymbol{c = 4}$; $ct = 8$ or $\frac{c}{t} = 2 \Rightarrow \boldsymbol{t = 2}$	Correct values for c and t seen, used or implied (e.g., by correct normal). If $c = \pm 4,\ t = \pm 2$ then the positive values must be implied by subsequent work	**B1**
	Note that another way of finding t is by using $c = 4$ and (8, 2) in the normal: $\Rightarrow 8t^3 - 2t = 4\left(t^4 - 1\right) \Rightarrow 4t^4 - 8t^3 + 2t - 4 = \left(t - 2\right)\left(4t^3 + 2\right) = 0 \Rightarrow t = 2$		
	normal : $8x - 2y = 60 \Rightarrow$ $y = 4x - 30$ or $x = \frac{15}{2} + \frac{1}{4}y$ $\Rightarrow \left(4x - 30\right)^2 = 6x$ or $y^2 = 45 + \frac{3}{2}y$	Uses their values of c and t in the given normal $t^3x - ty = c\left(t^4 - 1\right)$ [could repeat the work in (a) with $y = 16x^{-1}$] and substitutes into the parabola to obtain a quadratic equation. **Note that appropriate work must be seen for this mark**. $4x - 30 = \sqrt{6x}$ must be followed by a credible attempt to square (i.e., a 3TQ on LHS and ...x on the RHS) but see note below	**M1**
	Note that replacing x with e.g., k^2 in $4x - 30 = \sqrt{6x} \rightarrow$ $4k^2 - 30 = \sqrt{6}\,k \Rightarrow k = \frac{\sqrt{6} \pm \sqrt{6 - 4(4)(-30)}}{2(4)} = \frac{5\sqrt{6}}{4}, -\sqrt{6} \Rightarrow x = \frac{75}{8},\ 6$ Scores the M1 for the quadratic in k and the dM1 for solving via usual rules and also reaching $x = ...$ by squaring.		
	$16x^2 - 246x + 900 = 0 \Rightarrow 8x^2 - 123x + 450 = 0$ $\Rightarrow (8x - 75)(x - 6) = 0 \Rightarrow x = ...$ or $2y^2 - 3y - 90 = 0 \Rightarrow (2y - 15)(y + 6) = 0 \Rightarrow y = ...$	Solves 3TQ (usual rules – one correct root if no working). **Requires previous method mark.**	**dM1**
	$x = \frac{75}{8},\ y = \frac{15}{2}$ or e.g., Q(9.375, 7.5)	Correct values/coordinates. Allow any equivalent fractions. If a second point is given e.g., (6, -6) or (6, 6) score A0 if it is not rejected in (b).	**A1**
			(4)
Alt	$\boldsymbol{c = 4},\ \boldsymbol{t = 2}$	Correct values for c and t seen or used	**B1**
Approaches using parametric coords	Let Q have coordinates $\left(\frac{3}{2}k^2, 3k\right)$: Substituting into the normal with $c = 4$ and $t = 2$: $8\left(\frac{3}{2}k^2\right) - 2\left(3k\right) = 4\left(16 - 1\right)$ **OR** Since gradient of normal to hyperbola $= t^2 = 4$, gradient of AQ where A is $(8,\ 2) = \frac{3k - 2}{\frac{3}{2}k^2 - 8} = 4$ Forms a quadratic equation with their values. The equation in case 2 implies the B1.		**M1**
	$12k^2 - 6k = 60$ or $3k - 2 = 6k^2 - 32 \Rightarrow 6k^2 - 3k - 30 = 0$ $\Rightarrow 2k^2 - k - 10 = 0 \Rightarrow \left(2k - 5\right)\left(k + 2\right) = 0 \Rightarrow k = ...\left[\frac{5}{2}\right]$ $\Rightarrow x = ...$ or $y = ...$	Solves 3TQ (usual rules – one correct root if no working) **and** proceeds to a value of x or y **Requires previous method mark.**	**dM1**
	$x = \frac{75}{8},\ y = \frac{15}{2}$ or e.g., $Q\left(9\frac{3}{8}, 7\frac{1}{2}\right)$	Correct values/coordinates. Allow any equivalent fractions. If a second point is given e.g., (6, -6) or (6, 6) score A0 if it is not rejected in (b).	**A1**
			(4)

Question Number	Scheme	Notes	Marks
9(c)	$R\left(\frac{3}{2}, 0\right)$ Correct coordinates for the focus seen or used. Can score anywhere e.g., written across the question. Condone sight of $\left(0, \frac{3}{2}\right)$ if used correctly e.g. in gradient calculation. If on a diagram, accept $\frac{3}{2}$ appropriately placed. Accept 1.5, $\frac{6}{4}$ etc. for $\frac{3}{2}$. Just "a or $x=\frac{3}{2}$" or "$R=\frac{3}{2}$" is insufficient. There must be some recognition of the position of *R*.		**B1**
	Allow work with decimals for the 3 M marks.		
	QR: e.g., $y-0=\left(\frac{"\frac{15}{2}"-0}{"\frac{75}{8}"-"\frac{3}{2}"}\right)(x-"\frac{3}{2}")$ or $y=\left(\frac{"\frac{15}{2}"-0}{"\frac{75}{8}"-"\frac{3}{2}"}\right)x+c \Rightarrow 0=\frac{20}{21}\left(\frac{3}{2}\right)+c \Rightarrow c=...$ Correctly forms equation of *QR* for their *Q* and *R*. *Q* could be "made up" or be an incorrect choice from part (b) but must have real coordinates (A, B), $A>0$, $B\neq 0$ so allow e.g., (6, 6) and (6, -6). *R* must be of form (α, 0), $\alpha > 0$ Allow if a correct gradient is seen but wrongly calculated before line equation is given. If using $y=mx+c$ the equation must be formed correctly and "*c* = ..." reached following correct placement of (α, 0). For $0="\frac{3}{2}"m+c$, $"\frac{15}{2}"="\frac{75}{8}"m+c \Rightarrow m=...$, $c=...$ must find both *m* and *c* with one correct M0 for a vertical line or if a normal gradient is used		**M1**
	$y=\frac{20}{21}x-\frac{10}{7}$, $x=-\frac{3}{2}$ $\Rightarrow y=\frac{20}{21}\left(-\frac{3}{2}\right)-\frac{10}{7}=-\frac{10}{7}-\frac{10}{7}=-\frac{20}{7}$	Substitutes $x = -\alpha$, $\alpha > 0$ into their equation to find a value for the *y* coordinate. Must be using a consistent α **Requires previous M mark.**	**dM1**
	$S\left(-\frac{3}{2}, -\frac{20}{7}\right) \Rightarrow$ $QS=\sqrt{\left(\frac{75}{8}-\left(-\frac{3}{2}\right)\right)^2+\left(\frac{15}{2}-\left(-\frac{20}{7}\right)\right)^2}$	Applies correct distance formula for their $Q(A, B)$, $A>0$, $B\neq 0$ and $S(-\alpha, \pm\beta)$ $\alpha>0$ and consistent, $\beta\neq 0$ Implied by 15.017857... otherwise working must be seen. **Requires both previous M marks.** Note that using $(6, 6)$ or $(6, -6) \rightarrow QS=\frac{25}{2}$	**ddM1**
	$\left[=\sqrt{\left(\frac{87}{8}\right)^2+\left(\frac{145}{14}\right)^2}=\sqrt{\frac{7569}{64}+\frac{21025}{196}}=\sqrt{\frac{707281}{3136}}=\right] \Rightarrow QS=\frac{841}{56}$ Correct exact distance. Any exact equivalent e.g., $15\frac{1}{56}$ and may not be in simplest form		**A1**
Alt **For the last two marks (*QS* = *QR* + *RS*)**	*QS* = *QR* + *RS* but *QR* = shortest distance of *Q* to directrix = $\frac{75}{8}+\frac{3}{2}=\frac{87}{8}$ $QS=\sqrt{\left(0-\left(-\frac{20}{7}\right)\right)^2+\left(\frac{3}{2}-\left(-\frac{3}{2}\right)\right)^2}+\frac{87}{8}=\frac{29}{7}+\frac{87}{8}=\frac{841}{56}$ M1: A full method correct for their *Q* and *S*. Implied only by awrt 15.017857... A1: Correct exact distance (any equivalent)		
			
			(5)
			Total 13
			PAPER TOTAL: 75 marks

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