Question Number	Scheme	Notes	Marks
9(a)	$xy=c^2 \Rightarrow y=c^2x^{-1} \Rightarrow \frac{dy}{dx}=-c^2x^{-2}$ or $xy=c^2 \Rightarrow x\frac{dy}{dx}+y=0 \Rightarrow \frac{dy}{dx}=-\frac{y}{x}$ or $x=cp, y=\frac{c}{p} \Rightarrow \frac{dy}{dx}=\frac{-cp^{-2}}{c}$ Any correct expression for $\frac{dy}{dx}$		**B1**
	$m_T=-\frac{c^2}{c^2p^2} \Rightarrow m_N=p^2$ or $m_T=-\frac{c/p}{cp} \Rightarrow m_N=p^2$ or $m_T=-p^{-2} \Rightarrow m_N=p^2$ Correct use of the perpendicular gradient rule and the point P to obtain a normal gradient in terms of p (and possibly c)		**M1**
	$y-\frac{c}{p}=p^2(x-cp)$ or $y=p^2x+k, \frac{c}{p}=p^2\times cp+k \Rightarrow k=...\left\{\frac{c}{p}-cp^3\right\}$ Forms the equation of the normal correctly for their changed gradient in terms of p (and possibly c). Only reaching k = ... requires requires sight of y = "p^2"$x+k$		**M1**
	$py-c=p^3x-cp^4$ or $y=p^2x+\frac{c}{p}-cp^3$ $\Rightarrow p^3x-py=c(p^4-1)$*	Obtains the given answer with an intermediate step and no errors. Last line: p^3x and $-py$ on oneside, $c(p^4-1)$ on other	**A1***
			(4)
(b)	Treat the M and dM marks like a B mark and a dB mark - so correct work is required. The first mark is for a significant correct first step and the second is for reaching an equation from which the given result can clearly be easily obtained. **Use this guidance for any potentially creditworthy alternative approaches but use Review if you are in doubt.**		
Way 1 **grad PQ**	gradient $PQ=\frac{\frac{c}{p}-\frac{c}{q}}{cp-cq}$	Correct expression for the gradient of the chord PQ	**M1**
	$\frac{\frac{c}{p}-\frac{c}{q}}{cp-cq}=p^2 \Rightarrow \frac{\frac{q-p}{pq}}{p-q}=p^2$ or $\frac{\frac{c(q-p)}{pq}}{c(p-q)}=p^2$	Equates the 2 gradients (may repeat the work in (a)) and correctly makes the numerator a single fraction or otherwise manipulates correctly to reach an equation from which the given result can clearly be easily obtained - all correct work	**dM1**
	$\Rightarrow p^3q=-1$* Allow e.g., $-1=qp^3$	Fully correct proof. Can proceed directly to the given answer from the expressions shown for the **d**M1	**A1*** **(3)**
Way 2 **Sub. Q into normal**	Substituting Q into the normal: $Q\left(cq, \frac{c}{q}\right)$ in $p^3x-py=c(p^4-1) \Rightarrow cp^3q-\frac{cp}{q}=c(p^4-1)$ (M1: correct equation) e.g., $p^3q+1-\frac{p}{q}-p^4=p^3q+1-\frac{p}{q}(1+p^3q)=(p^3q+1)\left(1-\frac{p}{q}\right)=0$ (**d**M1) $p^3q=-1$(A1*)		
Way 3 **Sub. $xy=c^2$ into normal**	$y=\frac{c}{x}$ in $p^3x-py=c(p^4-1) \Rightarrow p^3x-\frac{pc}{x}=c(p^4-1)$ (M1: correct equation) $p^3x^2-c(p^4-1)x-pc^2=(p^3x+c)(x-pc)=0 \Rightarrow x=-\frac{c}{p^3}=cq$ (dM1) $p^3q=-1$* (A1*) OR $x=\frac{c^2}{y}$ in $p^3x-py=c(p^4-1) \Rightarrow \frac{p^3c^2}{y}-py=c(p^4-1)$ (M1: correct equation) $py^2+cy(p^4-1)-p^3c^2=(py+cp^4)\left(y-\frac{c}{p}\right)=0 \Rightarrow y=-cp^3=\frac{c}{q}$ (dM1) $p^3q=-1$* (A1*)		

Question Number	Scheme	Notes	Marks
9(c)	$q^3x-qy=c\left(q^4-1\right)$ and $xy=c^2\Rightarrow$ $q_3x-q\,c^2=c\left(q_4-1\right)$ or $q_3\,c^2-qy=c\left(q_4-1\right)$ $\overline{x}$ $\overline{y}$ $\Rightarrow q^3x^2-c\left(q^4-1\right)x-c^2q=0$ or $qy^2+c\left(q^4-1\right)y-q^3c^2=0$ Or with $q=-\frac{1}{p^3}\Rightarrow-\frac{1}{p^9}x+\frac{1}{p^3}.\frac{c^2}{x}=c\left(\frac{1}{p^{12}}-1\right)\Rightarrow\frac{1}{p^9}x^2+cx\left(\frac{1}{p^{12}}-1\right)-\frac{c^2}{p^3}=0$ or $-\frac{c^2}{p^9y}+\frac{y}{p^3}=c\left(\frac{1}{p^{12}}-1\right)\Rightarrow\frac{y^2}{p^3}-cy\left(\frac{1}{p^{12}}-1\right)-\frac{c^2}{p^9}=0$ Substitutes the equation of the hyperbola into the equation of the normal (which they may obtain from scratch) to obtain a 3 term quadratic equation in x or y Could be uncollected terms in x (or y) and allow slips if the intention is clear		**M1**
	$\Rightarrow(x-cq)\left(q^3x+c\right)=0\Rightarrow x=-\frac{c}{q^3}$ or $\Rightarrow(qy-c)\left(y+cq^3\right)=0\Rightarrow y=-cq^3$ or $p^3x^2+cx\left(1-p^{12}\right)-c^2p^9=\left(p^3x+c\right)\left(x-cp^9\right)=0\Rightarrow x=cp^9$ $p^9y^2-cy\left(1-p^{12}\right)-p^3c^2=\left(p^9y-c\right)\left(y+cp^3\right)=0\Rightarrow y=\frac{c}{p^9}$ Completes a credible attempt to find the x or y coordinate of R (not Q) Note that this may result from work in (b) but this must be restated or used in (c)		**dM1**
	R is $\left(-\frac{c}{q^3},-cq^3\right)$ or $\left(cp^9,\frac{c}{p^9}\right)$	Correct coordinates of R May be seen as $x=...,\ y=...$	**A1**
	Gradient PR is $\frac{\frac{c}{p}+cq^3}{cp+\frac{c}{q^3}}$ or $\frac{\frac{c}{p}-\frac{c}{p^9}}{cp-cp^9}$	Forms a **correct** gradient of PR	**ddM1**
	gradient $PR=\frac{\frac{c}{p}+cq^3}{cp+\frac{c}{q^3}}=\frac{\frac{1+pq^3}{p}}{\frac{pq^3+1}{q^3}}=\frac{q^3}{p}$ and $q=-\frac{1}{p^3}\Rightarrow-\frac{1}{p^9}\times\frac{1}{p}=-\frac{1}{p^{10}}$ or gradient $PR=\frac{\frac{c}{p}-\frac{c}{p^9}}{cp-cp^9}=\frac{\frac{c\left(p^8-1\right)}{p^9}}{cp\left(1-p^8\right)}=-\frac{1}{p^{10}}$ Correct answer. Accept $k=10$ from appropriate work		**A1**
			(5)
			(Total 12 marks)
Alt	Let R have coordinates $\left(cr,\frac{c}{r}\right)$ and $q^3r=-1$	Introduces a 3rd parameter for R e.g. r and states/uses $q^3\,"r"=-1$ somewhere	**M1**
	Gradient PR is $\frac{\frac{c}{p}-\frac{c}{r}}{cp-cr}=-\frac{1}{pr}$	**d**M1: Correctly forms the gradient of PR A1: Correct simplified gradient in terms of p and "r"	**dM1 A1**
	$r=-\frac{1}{q^3}\Rightarrow$ gradient $=\frac{q^3}{p}$	Eliminates "r"	**ddM1**

	and $q = -\frac{1}{p^3} \Rightarrow$ gradient $PR = -\frac{1}{p^9} \times \frac{1}{p} = -\frac{1}{p^{10}}$	Correct answer	**A1**

