Question Number	Scheme	Marks
6(a)(i)	Centre is (–4, 2)	B1
(ii)	$x^2+y^2+8x-4y=0$ $\Rightarrow (x+4)^2+(y-2)^2-16-4=0 \Rightarrow r=...$	M1
	$r=2\sqrt{5}$ oe	A1
		(3)
(b)	$x^2+y^2+8x-4y=0,\ x+2y+10=0$ $\Rightarrow (-2y-10)^2+y^2+8(-2y-10)-4y=0$ or $x^2+\left(\frac{-x-10}{2}\right)^2+8x-4\left(\frac{-x-10}{2}\right)=0$	M1
	$y^2+4y+4=0$ or e.g. $x^2+12x+36=0$	A1
	$(y+2)^2=0 \Rightarrow y=...$ or e.g. $(x+6)^2=0 \Rightarrow x=...$	dM1
	(–6, –2)	A1
		(4)
(c)	$x+2y+10=0 \Rightarrow m_T=-\frac{1}{2} \Rightarrow m_N=2$ or $m_N=\frac{"2"-("-2")}{"-4"-("-6")}$	M1
	Usually either $y-2=2(x+4)$ or $y+2=2(x+6)$	dM1
	$y=2x+10$	A1
		(3)
		Total 10

(a)(i) Mark (i) and (ii) together.

B1 Correct centre. Allow written as $x=-4,\ y=2$

(ii)

M1 Correct method for the radius. Award for $(x\pm a)^2+(y\pm b)^2....\Rightarrow r=\sqrt{"a^2"+"b^2"}=...$ or maybe seen using the general equation of a circle e.g. $x^2+2gx+y^2+2fy+c=0 \Rightarrow r=\sqrt{f^2+g^2-c}$
May be implied by a correct radius for their centre if no method is shown.

A1ft $r=2\sqrt{5}$ or exact equivalent eg $\sqrt{20}$. Do not accept $\pm$.
Only follow through their centre with coordinates $(\pm 4, \pm 2)$

(b) Note that answer only scores 0 marks.

M1 Uses both equations to eliminate one variable. Condone slips in substituting in. Also allow use of the equation of the circle in the form $(x-a)^2+(y-b)^2=r^2$ oe allowing for slips in manipulation

A1 Correct 3TQ or any multiple of this (allow any equivalent 3 term equations) which do not need all the terms on one side of an equation. Condone lack of = 0

dM1 Solves their 3TQ to obtain the x or y coordinate of P. Usual rules apply. (May need to check if via a calculator). It is dependent on the first method mark.

A1 Correct coordinates. Allow written as $x=-6,\ y=-2$.

Alt (b) Geometric approach example

M1 Forms a right angled triangle using the radius as the hypotenuse and letting the two shorter sides be $2a$ and a (gradient of the radius from the centre to tangent is 2) such that $(2a)^2+a^2=\left("2\sqrt{5}"\right)^2\Rightarrow a=...$

A1 $a=2$

dM1 A correct method to find x or y: $x="-4"-"2"=...$ and $y="2"-2("2")=...$

A1 (–6, –2)

Alt (b) Finding the point of intersection between the tangent and the normal

M1 Attempts to find the equation of the normal using their centre and a gradient of 2

A1 $y=2x+10$

dM1 Attempts to solve simultaneously to find x or y

A1 (–6, –2)

Alt (b) Implicit differentiation

M1 Attempts to differentiate implicitly, substituting in $\frac{\mathrm{d}y}{\mathrm{d}x}=-\frac{1}{2}$ and using the equation of the tangent to C at P to eliminate one variable. $x^2+y^2+8x-4y=0\Rightarrow 2x+2y\frac{\mathrm{d}y}{\mathrm{d}x}+8-4\frac{\mathrm{d}y}{\mathrm{d}x}=0$

$\Rightarrow 2x+2y\left(-\frac{1}{2}\right)+8-4\left(-\frac{1}{2}\right)=0\Rightarrow 2x-y+10=0$

$\Rightarrow 2(-2y-10)-y+10=0$ or $x+2(2x+10)+10=0$ (using the equation of the tangent to C at P)

A1 A correct simplified linear equation in x or y
e.g. $5y=-10$ or $5x=-30$ which may be implied by the correct x or y coordinate.

dM1 Attempts to solve their linear equation to find x or y

A1 (–6, –2)

There may be other credit worthy methods so look carefully at their solution and send to review if unsure

(c) Credit worthy work may be seen in (b) but must be used in (c)

M1 Attempts to find the gradient of the line between their centre and their P by either using

- the given tangent equation which may be implied by sight or use of gradient = 2
- their centre and their P. Score for a correct expression to find the gradient using their centre and their P eg $\frac{"2"-("-2")}{"-4"-("-6")}$. Also allow with other valid coordinates which would lie on the normal e.g. (–2, 6) which may have come from solving simultaneously the equation of the normal with the equation of the circle.

Allow this mark if they then subsequently find the negative reciprocal of this.

dM1 Correct straight line method using their normal gradient (via a correct method) and their centre or their P (or any other valid pair of coordinates which would lie on the normal
e.g. using their gradient using a geometric approach 1 to the right, 2 up

If they use $(y - y_1) = m(x - x_1)$ then both brackets including signs must be correct for their coordinates.

If they use $y = mx + c$ they must proceed as far as $c = ...$

It is dependent on the previous method mark.

A1 $y = 2x + 10$ cao

Question Number	Scheme	Marks
7(a)	$r = \sqrt{\frac{12.8}{20}} = 0.8*$ or e.g. $20 \times 0.8 \times 0.8 = 12.8$ so $r = 0.8*$	B1*
		(1)
(b)	$a = 20 \div 0.8^2$	M1
	$= 31.25$	A1
		(2)
(c)	$\frac{31.25\left(1-0.8^n\right)}{1-0.8} > 156$	M1
	Eg $1-0.8^n > 0.9984$ $\Rightarrow 0.8^n < 0.0016$	dM1
	$0.8^n < 0.0016 \Rightarrow n > \frac{\log\left(0.0016\right)}{\log(0.8)}$ or $0.8^n < 0.0016 \Rightarrow n > \log_{0.8} 0.0016$	M1
	$n = 29$	A1
		(4)
		Total 7

(a)

B1* Correctly demonstrates $r = 0.8$ oe with no incorrect working seen. If they use 0.8 within their solution there must be either some preamble or concludes $r = 0.8$

Minimum acceptable is an expression for r which is not 0.8 or an equation involving r with all values substituted in. At some point we must see r being linked with 0.8 either as part of an equation or e.g. with a conclusion $r = 0.8$

May all be in fractions instead eg $20 \times \frac{4}{5} \times \frac{4}{5} = \frac{64}{5} \Rightarrow r = \frac{4}{5}$ is B1

Note that $ar^5 = 12.8,\ ar^3 = 20 \Rightarrow r = \sqrt{\frac{12.8}{20}} = 0.8$ is B0

(b) Work seen in (a) must be used or stated in (b) to score.

M1 Correct method for the first term. Score for the expression $12.8 \div 0.8^4$ or $20 \div 0.8^2$ oe

May be seen as $\frac{64}{5} \div \left(\frac{4}{5}\right)^4$ (Do not penalise invisible brackets for this mark).

If a candidate has stated incorrectly $ar^5 = 12.8$ or $ar^3 = 20$ in (a) then allow M1 if they use this correctly to find a for their equation.

A1 31.25 or $\frac{125}{4}$ or $31\frac{1}{4}$ with no incorrect working seen