Question			Answer	Marks	Guidance	Question
1	**(i)**		[radius =] $\sqrt{125}$ isw or $5\sqrt{5}$ [C =] (10, 2)	B1 B1 **[2]**	 condone $x = 10$, $y = 2$	
1	**(ii)**		verifying / deriving that (21, 0) is one of the intersections with the axes (−1, 0) (0, –3) and (0, 7)	B1 B1 B2 **[4]**	using circle equation or Pythagoras; or putting $y = 0$ in circle equation and solving to get 21 and −1; condone omission of brackets **B1** each; if B0 for D and E, then **M1** for substitution of $x = 0$ into circle equation or use of Pythagoras showing $125 - 10^2$ or $h^2 + 10^2 = 125$ ft their centre and/or radius	equation may be expanded first condone not written as coordinates condone not written as coordinates; condone not identified as D and E; condone D = (0, 7), E = (0, –3) – will penalise themselves in (iii)

1	**(iii)**		midpt BE = (21/2 , 7/2 ft) oe	B1	ft their E or stating that the perp bisector of a chord always passes through the centre of the circle	NB examiners must use annotation in this part; a tick where each mark is earned is sufficient must be explicit generalised statement; need more than just that C is on this perp bisector
			grad BE = $\frac{7-0}{0-21}$ oe isw	M1	ft their E; M0 for using grad BC (= –2/11)	condone $-1/3x$ oe
			grad perp bisector = 3 oe	M1	for use of $m_1m_2 = -1$ oe soi; ft their grad BE; no ft from grad BC used	condone $3x$ oe; allow M1 for eg $-1/3 \times 3 = -1$
			$y - 7/2 = 3(x - 21/2)$ oe	M1	ft; M0 for using grad BE or perp to BC allow this M1 for C used instead of midpoint	or use of $y = 3x + c$ and subst of (21/2 , 7/2) oe ft
			$y = 3x - 28$ oe	A1	must be a simplified equation	no ft; those who assume that C is on the line and use it to find $y = 3x - 28$ can earn B0M1M1M1A1A0 those who argue that the perp bisector of a chord always passes through the centre of the circle and then uses C rather than midpt of BE are eligible for all 6 marks
			verifying that (10, 2) is on this line	A1 **[6]**	no ft; A0 if C used to find equation of line, unless B1 earned for correct argument	

Question			Answer	Marks	Guidance	
2	**(i)**		(7, 0)	1 **[1]**	accept $x = 7$, $y = 0$	condone 7, 0
2	**(ii)**		$\sqrt{13}$	2	M1 for Pythagoras used correctly eg $[r^2 =]\ 3^2 + 2^2$ or for subst A or their B in $(x-4)^2+(y-2)^2\left[=r^2\right]$ or B1 for $[r =]\ \pm\sqrt{13}$	annotate this question if partially correct allow recovery if some confusion between squares and roots but correct answer found
			$(x-4)^2 + (y-2)^2 = 13$ or ft their evaluated r^2, isw	2 **[4]**	M1 for one side correct, as part of an equation with x and y terms	do not accept $(\sqrt{13})^2$ instead of 13; allow M1 for LHS for $(x-4)^2+(y-2)^2=r^2$ (or worse, $(x-4)^2+(y-2)^2=r$) (may be seen in attempt to find radius)
2	**(iii)**		(7, 4)	2 **[2]**	B1 each coord accept $x = 7$, $y = 4$ if B0, then M1 for a vector or coordinates approach such as '3 along and 2 up' to get from A to C oe or M1 for $\frac{x_D+1}{2}=4$ and $\frac{y_D+0}{2}=2$	condone 7, 4 or M1 for longer method, finding the equation of the line CD as $y = 2/3\ (x - 1)$ oe <u>and</u> then attempting to find intn with their circle

Question			Answer	Marks	Guidance	
2	**(iv)**		grad tgt = –3/2 oe	M2	correctly obtained or ft their D if used M1 for grad AD = $\frac{4-0}{7-1}$ oe isw or 2/3 oe seen or used in this part or for their grad tgt = –1/ their grad AD	annotate this question if partially correct may use AD, CD or AC NB grad AD etc may have been found in part (iii); allow marks if used in this part – mark the copy of part (iii) that appears below the image for part (iv)
			y – their 4 = their (–3/2) (x – their 7)	M1	or subst (7, 4) into y = their (–3/2) $x + b$ M0 if grad AD oe used or if a wrong gradient appears with no previous working	
			$y = -1.5x + 14.5$ oe isw	A1	must be in form $y = ax + b$	condone $y = \frac{-3x+29}{2}$ condone $y = -1.5x + b$ and $b = 14.5$ oe
				[4]		

3	**(i**		[radius =] $\sqrt{20}$ or $2\sqrt{5}$ isw	B1	B0 for $\pm\sqrt{20}$ oe	
			[centre =] (3, 2)	B1		condone lack of brackets with coordinates, here and in other questions
				[2]		

3	**(ii**		substitution of $x = 0$ or $y = 0$ into circle equation	M1	or use of Pythagoras with radius and a coordinate of the centre eg $20 - 2^2$ or $h^2 + 3^2 = 20$ ft their centre and/or radius	equation may be expanded first, and may include an error bod intent allow M1 for $(x-3)^2 = 20$ and/or $(y-2)^2 = 20$
			$(x-7)(x+1)$ [=0]	M1	no ft from wrong quadratic; for factors giving two terms correct, or formula or completing square used with at most one error	completing square attempt must reach at least $(x-a)^2 = b$ following use of Pythagoras allow M1 for attempt to add 3 to [±]4
			(7, 0) and (–1, 0) isw	A1	accept $x = 7$ or -1 (both required)	
			$[y=]\dfrac{4\pm\sqrt{(-4)^2-4\times1\times(-7)}}{2}$ oe	M1	no ft from wrong quadratic; for formula or completing square used with at most one error	completing square attempt must reach at least $(y-a)^2 = b$ following use of Pythagoras allow M1 for attempt to add 2 to [±] $\sqrt{11}$
			$\left(0, 2\pm\sqrt{11}\right)$ or $\left(0, \dfrac{4\pm\sqrt{44}}{2}\right)$ isw	A1	accept $y = \dfrac{4\pm\sqrt{44}}{2}$ oe isw	annotation is required if part marks are earned in this part: putting a tick for each mark earned is sufficient
				[5]		

3	**(iii**		show both A and B are on circle (4, 5) $\sqrt{10}$	B1 B2 B2 **[5]**	explici substitution in circle equation and at least one stage of interim working required oe B each or M1 for $\left(\frac{7+1}{2}, \frac{6+4}{2}\right)$ from correct midpoint and centre used; B1 for $\pm\sqrt{10}$ M1 for $(4-3)^2 + (5-2)^2$ or $1^2 + 3^2$ or ft their centre and/or midpoint, or for the square root of this	or clear use of Pythagoras to show AC and BC each = $\sqrt{20}$ may be a longer method finding length of ½ AB and using Pythag. with radius; no ft if one coord of midpoint is same as that of centre so that distance formula/Pythag is not required eg centre correct and midpt (3, −1) annotation is required if part marks are earned in this part: putting a tick for each mark earned is sufficient

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4			obtaining a correct relationship in any 3 of C, d, r and A	M2	may substitute into given relationship;	eg M2 for $Cd = 4\pi r^2$ or $\pi d^2 = k\pi r^2$ seen/obtained
			or obtaining a correct relationship in k and no more than 2 other variables		or M1 for at least two of $A = \pi r^2$, $C = \pi d$, $C = 2\pi r$, $d = 2r$ or $r = \frac{d}{2}$ seen or used	condone eg Area $= \pi r^2$; allow $A = \pi\left(\frac{d}{2}\right)^2$ to imply $A = \pi r^2$ and $r = \frac{d}{2}$ and so earn M1, if M2 not earned
			convincing argument leading to $k = 4$	A1 **[3]**	must be from general argument, not just substituting values for r or d; may start from given relationship and derive $k = 4$	eg M1only for eg $A = \pi r^2$ and $C = \pi d$ and so $k = 4$ with no further evidence

Question			Answer	Marks	Guidance	
5	(i)		$\sqrt{20}$ isw or $2\sqrt{5}$ (2, 0)	B1 B1 **[2]**	0 for $\pm\sqrt{20}$	
5	(ii)		subst of $x = 0$ into circle eqn soi	M1	or Pythag used on sketch of circle: $2^2 + y^2 = 20$ oe	M0 for just $y^2 = 20$; M1 for $y^2 = 16$ or for $y = 4$ ignore intns with x-axis also found
			$y = \pm 4$ oe	A1	or B2 for just $y = \pm 4$ seen oe; accept both 4 and –4 shown on y axis on sketch if both values not stated	
			sketch of circle with centre (2, 0) or ft their centre from (i)	B1 **[3]**	if the centre is not marked, it should look roughly correct by eye – coords need not be given on sketch; condone intersections with axes not marked	circle should intersect both +ve and neg x- and y-axes; must be clear attempt at circle; ignore any tangents drawn
5	(iii)		$(x-2)^2 + (2x+k)^2 = 20$	M1	for attempt to subst $2x + k$ for y	allow for attempt to subst $k = y - 2x$ into given eqn
			$x^2 - 4x + 4 + 4x^2 + 4kx + k^2 = 20$	M1 dep	for correct expansion of at least one set of brackets, dependent on first M1	similarly for those working backwards
			$5x^2 + (4k-4)x + k^2 - 16 = 0$	A1 **[3]**	correct completion to given answer; dependent on both Ms	condone omission of further interim step if both sets of brackets expanded correctly, but for cands working backwards, at least one interim step is needed; if cands have made an error and tried to correct it, corrections must be complete to award this A mark

Question			er	Marks	Guidance	
5	(iv)		$b^2 - 4ac = 0$ seen or used	M1	need not be substituted into; may be stated after formula used or argument towards expressing eqn as a perfect square	eg M1 for $(4k - 4)^2 - 4 \times 5 \times (k^2 - 16) = 0$
			$4k^2 + 32k - 336$ [= 0] or $k^2 + 8k - 84$ [= 0]	M1	expansion and collection of terms, condoning one error ft their $b^2 - 4ac$	dep on an attempt at $b^2 - 4ac$ with at least two of a, b and c correct; may be earned with < 0 etc; may be in formula
			use of factorising or quadratic formula or completing square	M1	condone one error ft	dep on attempt at obtaining required quadratic equation in k, not for use with any eqn/inequality they have tried
			$k = 6$ or -14 <u>or</u> Grad of tgt is 2, and normal passes through centre, hence finding equation of normal as $y = -\frac{1}{2}x + 1$ oe	A1 <u>or</u> M1		
			finding x values where diameter $y = -x/2 + 1$ intersects circle as $x = 6$ or -2 (condone one error in method)	M1	oe for y values; condone one error in method	or finding intn of tgt and normal as $\left(\frac{2-2k}{5}, \frac{k+4}{5}\right)$
			finding corresponding y values on circle and subst into $y = 2x + k$ or subst their x values into $5x^2 + (4k - 4)x + k^2 - 16 = 0$	M1	intns are (6, –2) and (–2, 2), M0 for just (6, 2) and (–2, –2) used but condone used as well as correct intns this last method gives extra values for k, for the non-tangent lines $y =$ through (6, 2) and (–2, –2), but allow for the M mark	or subst their intn of tgt and normal into eqn of circle: $\left(\frac{2-2k}{5} - 2\right)^2 + \left(\frac{k+4}{5}\right)^2 = 20$ or ft
			$k = 6$ or -14	A1 **[4]**	and no other values	