1	$x^2 + 9x^2 = 25$ $10x^2 = 25$ $x = \pm(\sqrt{10})/2$ or. $\pm\sqrt{(5/2)}$ or $\pm 5/\sqrt{10}$ oe $y = [\pm]\ 3\sqrt{(5/2)}$ o.e. eg $y = [\pm]\ \sqrt{22.5}$	M1 M1 A2 B1	for subst for x or y attempted or $x^2 = 2.5$ o.e.; condone one error from start [allow $10x^2 - 25 = 0$ + correct substn in correct formula] allow $\pm\sqrt{2.5}$; A1 for one value ft 3 × their x value(s) if irrational; condone not written as coords.	5

2		grad AB = 8/4 or 2 or $y = 2x - 10$ grad BC = 1/–2 or – ½ or $y = -\frac{1}{2}x + 2.5$ product of grads = –1 [so perp] (allow seen or used)	1 1 1		3
	ii	midpt E of AC = (6, 4.5) $AC^2 = (9-3)^2 + (8-1)^2$ or 85 rad = ½ $\sqrt{85}$ o.e. $(x-6)^2 + (y-4.5)^2 = 85/4$ o.e. $(5-6)^2 + (0-4.5)^2 = 1 + 81/4$ [= 85/4]	1 M1 A1 B2 1		6
	iii	$\overrightarrow{BE} = \overrightarrow{ED} = \begin{pmatrix} 1 \\ 4.5 \end{pmatrix}$ D has coords (6 + 1, 4.5 + 4.5) ft or (5 + 2, 0 + 9) = (7, 9)	M1 M1 A1	o.e. ft their centre; or f $\overrightarrow{BC} = \begin{pmatrix} -2 \\ 1 \end{pmatrix}$ or (9 − 2, 8 + 1); condone mixtures of vectors and coords. throughout part iii allow B3 for (7,9)	3

3		(0, 0), $\sqrt{45}$ isw or $3\sqrt{5}$	1+1		2
	ii	$x = 3 - y$ or $y = 3 - x$ seen or used subst in eqn of circle to eliminate variable $9 - 6y + y^2 + y^2 = 45$ $2y^2 - 6y - 36 = 0$ or $y^2 - 3y - 18 = 0$ $(y - 6)(y + 3) = 0$ $y = 6$ or -3 $x = -3$ or 6 $\sqrt{(6 - -3)^2 + (3 - -6)^2}$	M1 M1 M1 M1 M1 A1 A1 M1	for correct expn of $(3 - y)^2$ seen oe condone one error if quadratic or quad. formula attempted [complete sq attempt earns last 2 Ms] or A1 for (6, –3) and A1 for (–3, 6) no ft from wrong points (A.G.)	8

4 (i)	grad AB = $\frac{1-3}{5-(-1)}$ [= −1/3]	**M1**	
	$y - 3$ = their grad ($x - (-1)$) or $y - 1$ = their grad ($x - 5$)	**M1**	or use of y = their gradient $x + c$ with coords of A or B or **M2** for $\frac{y-3}{1-3} = \frac{x-(-1)}{5-(-1)}$ o.e.
	$y = -1/3x + 8/3$ or $3y = -x + 8$ o.e isw	**A1**	o.e. eg $x + 3y - 8 = 0$ or $6y = 16 - 2x$ allow **B3** for correct eqn www
4 (ii)	when $y = 0$, $x = 8$; when $x = 0$, $y = 8/3$ or ft their (i)	**M1**	allow $y = 8/3$ used without explanation if already seen in eqn in (i)
	[Area =] ½ × 8/3 × 8 o.e. cao isw	**M1**	NB answer 32/3 given; allow 4 × 8/3 if first M1 earned; or M1 for $\int_0^8 \left[\frac{1}{3}(8-x)\right] dx = \left[\frac{1}{3}\left(8x - \frac{1}{2}x^2\right)\right]_0^8$ and M1 dep for $\frac{1}{3}(64 - 32[-0])$

4 **(iii)**	grad perp = −1/grad AB stated, or used after their grad AB stated in this part midpoint [of AB] = (2, 2) $y - 2$ = their grad perp $(x - 2)$ or ft their midpoint <u>alt method working back from ans</u>: grad perp = −1/grad AB and showing/stating same as given line finding intn of their $y = -1/3x - 8/3$and $y = 3x - 4$ is (2, 2) showing midpt of AB is (2, 2)	**M1** **M1** **M1** **or** **M1** **M1** **M1**	or showing $3 \times -1/3 = -1$ if (i) is wrong, allow the first M1 here ft, provided the answer is correct ft must state 'midpoint' or show working for **M3** this must be correct, starting from grad AB = –1/3, and also needs correct completion to given ans $y = 3x - 4$ mark one method or the other, to benefit of candidate, not a mixture eg stating $-1/3 \times 3 = -1$ or showing that (2, 2) is on $y = 3x - 4$, having found (2, 2) first [for both methods: for **M3** must be fully correct]

5	**(i)**		midpt of AB = $\left(\frac{1}{2}, \frac{5}{2}\right)$ oe www	B2	allow unsimplified B1 for one coordinate correct	if working shown, should come from $\left(\frac{3+-2}{2}, \frac{4+1}{2}\right)$ oe NB B0 for x coord. = $\frac{5}{2}$, (obtained from subtraction instead of addition)
			grad AB = $\frac{4-1}{3-(-2)}$ oe	M1	must be obtained independently of given line; accept 3 and 5 correctly shown eg in a sketch, followed by 3/5 M1 for rise/run = 3/5 etc M0 for just 3/5 with no evidence	for those who find eqn of AB first, M0 for just $\frac{y-4}{1-4} = \frac{x-3}{-2-3}$ oe, but M1 for $y-4 = \frac{1-4}{-2-3}(x-3)$ oe ignore their going on to find the eqn of AB after finding grad AB
			using gradient of AB to obtain grad perp bisector	M1	for use of $m_1m_2 = -1$ soi or ft their gradient AB M0 for just $\frac{-5}{3}$ without AB grad found	this second M1 available for starting with given line = $\frac{-5}{3}$ and obtaining grad. of AB from it
			$y - 2.5 = \frac{-5}{3}(x - 0.5)$ oe	M1	eg M1 for $y = \frac{-5}{3}x + c$ and subst of midpt; ft their gradient of perp bisector and midpt; M0 for just rearranging given equation	no ft for gradient of AB used

			completion to given answer $3y + 5x = 10$, showing at least one interim step	M1 **[6]**	condone a slight slip if they recover quickly and general steps are correct (eg sometimes a slip in working with the c in $y = \frac{-5}{3}x + c$ - condone $3y = -5x + c$ followed by substitution and consistent working) M0 if clearly 'fudging'	NB answer given; mark process not answer; annotate if full marks not earned eg with a tick for each mark earned scores such as B2M0M0M1M1 are possible after B2, allow full marks for complete method of showing given line has gradient perp to AB (grad AB must be found independently at some stage) and passes through midpt of AB
5	**(ii)**		$3y + 5(4y - 21) = 10$	M1	or other valid strategy for eliminating one variable attempted eg $\frac{-5}{3}x + \frac{10}{3} = \frac{x}{4} + \frac{21}{4}$; condone one error	or eg $20y = 5x + 105$ and subtraction of two eqns attempted no ft from wrong perp bisector eqn, since given allow M1 for candidates who reach $y = 115/23$ and then make a worse attempt, thinking they have gone wrong
			$(-1, 5)$ or $y = 5$, $x = -1$ isw	A2 **[3]**	A1 for each value; if AO allow SC1 for both values correct but unsimplified fractions, eg $\left(\frac{-23}{23}, \frac{115}{23}\right)$	NB M0A0 in this part for finding E using info from (iii) that implies E is midpt of CD

5	**(iii)**		$(x-a)^2 + (y-b)^2 = r^2$ seen or used	M1	or for $(x + 1)^2 + (y - 5)^2 = k$, or ft their E, where $k > 0$	
			$1^2 + 4^2$ oe (may be unsimplified), from clear use of A or B	M1	for calculating AE or BE or their squares, or for subst coords of A or B into circle eqn to find r or r^2, ft their E;	this M not earned for use of CE or DE or ½ CD NB some cands finding $AB^2 = 34$ then obtaining 17 erroneously so M0
			$(x + 1)^2 + (y - 5)^2 = 17$	A1	for eqn of circle centre E, through A and B; allow A1 for $r^2 = 17$ found after $(x + 1)^2 + (y - 5)^2 = r^2$ stated and second M1 clearly earned if $(x + 1)^2 + (y - 5)^2 = 17$ appears without clear evidence of using A or B, allow the first M1 then M0 SC1	SC also earned if circle comes from C or D and E, but may recover and earn the second M1 later by using A or B
			showing midpt of CD = (–1, 5)	M1		
			showing CE or DE = $\sqrt{17}$ oe or showing one of C and D on circle	M1	alt M1 for showing $CD^2 = 68$ oe allow to be earned earlier as an invalid attempt to find r	

				[5]	showing that both C and D are on circle and commenting that E is on CD is enough for last M1M1; similarly showing $CD^2 = 68$ and both C and D are on circle oe earns last M1M1	other methods exist, eg: may find eqn of circle with centre E and through C or D and then show that A and B and other of C/D are on this circle – the marks are then earned in a different order; award M1 for first fact shown and then final M1 for completing the argument; if part-marks earned, annotate with a tick for each mark earned beside where earned

6	(i) rad AB = $\frac{0-6}{1-(-1)}$ oe [= −3] isw grad BC = $\frac{0-4}{1-13}$ oe [= 1/3] isw product of grads = −1 [so lines perp] stated or shown numerically	**M1** **M1** **M1**	for full marks, it should be clear that grads are independently obtained or 'one grad is neg. reciprocal of other' **or** **M1** for length of one side (or square of it) **M1** for length of other two sides (or their squares) found independently **M1** for showing or stating that Pythag holds [so triangle rt angled]	eg grads of –3 and 1/3 without earlier working earn **M1M0** for **M3**, must be fully correct, with gradients evaluated at least to –6/2 and –4/–12 stage $AB^2 = 6^2 + 2^2 = 40$, $BC^2 = 4^2 + 12^2 = 160$, $AC^2 = 14^2$ + $\ ^2 = 200$
6	(ii) A √40 or BC = √160 ½ × √40 × √160 oe or ft their AB, BC 40	**M1** **M1** **A1**	**or M1** for one of area under AC (=70), under AB (=6) under BC (=24) (accept unsimplified) and **M1** for their trap. – two triangles	allow **M1** for $\sqrt{(1-(-1))^2+(6-0)^2}$ or for $\sqrt{(13-1)^2+(4-0)^2}$ **or** for rectangle – 3 triangles method, $[\,6\times14-\frac{1}{2}(2)(6)-\frac{1}{2}(4)(12)-\frac{1}{2}(2)(14)$ =84 – 6 – 24 – 14] **M1** for two of the 4 areas correct and **M1** for the subtraction

6	(iii) le subtended by diameter = 90° soi mid point M of AC = (6, 5) rad of circle = $\frac{1}{2}\sqrt{14^2+2^2}$ $[=]\frac{1}{2}\sqrt{200}$ oe or equiv using r^2 $(x-a)^2 + (y-b)^2 = r^2$ seen or $(x - \text{their } 6)^2 + (y - \text{their } 5)^2 = k$ used, with $k > 0$ $(x-6)^2 + (y-5)^2 = 50$ cao	**B1** **B2** **M1** **M1** **A1**	or angle at centre = twice angle at circumf = 2 × 90 = 180 soi or showing BM = AM or CM, where M is midpt of AC; or showing that BM = ½ AC allow if seen in circle equation ; **M1** for correct working seen for **both** coords accept unsimplified; or eg $r^2 = 7^2 + 1^2$ or $5^2 + 5^2$; may be implied by correct equation for circle or by correct method for AM, BM or CM ft their M or $x^2 + y^2 - 12x - 10y + 11 = 0$	condone 'AB and BC are perpendicular' or 'ABC is right angled triangle' provided no spurious extra reasoning allow **M1** bod intent for AC = $\sqrt{200}$ followed by $r = \sqrt{100}$ must be simplified (no surds)
6	(iv) (11, 10)	**1**		