1	$\int\left(x^3+\frac{1}{x^3}\right)\mathrm{d}x = \frac{x^4}{4}+\frac{x^{-2}}{-2}+c$	3 × B1 [3]	Allow unsimplified, 1 mark for each term, including "c"
2	$\left(1-\frac{3}{2}x\right)^6$ **(i)** Term in x^2 $\quad {}^6C_2\times\left(\frac{\pm3x}{2}\right)^2=\frac{135x^2}{4}$ Term in x^3 $\quad {}^6C_3\times\left(\frac{\pm3x}{2}\right)^3=\frac{-540x^3}{8}$	M1 A1 A1 [3]	For either unsimplified term co co (omission or error with "–" can still gain 2 out of 3)
	(ii) Term in $x^3 = \frac{270x^3}{4}-\frac{135kx^3}{2}$ $\rightarrow\quad k=1.$	M1 A1 [2]	considers exactly 2 terms in x^3 co
3	**(i)** $x^2+px+q\ =\ (x+3)(x-5)$ $\rightarrow\quad p=-2,\ q=-15.$ (any other method ok)	M1 A1 [2]	Must be $(x+3)$ and $(x-5)$. co
	(ii) $x^2+px+q+r=0$ Use of "b^2-4ac" Uses a, b and c correctly $r=16$ **or** $=(x+k)^2\rightarrow 2k=p$ (M1) $\quad k^2=q+r$ (M1) $\rightarrow\quad k=-1\quad\rightarrow\ r=16$ (A1)	M1 DM1 A1 [3]	Any use of "b^2-4ac" c must include both q and r. co
4	$y=\frac{4}{3x-4}$ **(i)** $\frac{\mathrm{d}y}{\mathrm{d}x}=-4(3x-4)^{-2}\quad\times\quad 3$ If $x=2$, $m=-3$ Eqn of tangent $\quad y-2=-3(x-2)$	B1 B1 M1 A1 [4]	Correct without ×3. For ×3. Correct line eqn. co (for normal M0A0)
	(ii) $\tan\theta=\pm(-3)$ $\rightarrow\quad\theta=\pm108.4°\quad(\text{or }\pm71.6°)$ **or** scalar product, $\tan\theta = y$-step ÷ x-step **or** use of tan $(A-B)$ $\quad$ M1A1 for each	M1 A1√ [2]	Correct link with (± his gradient) co (accept acute or obtuse) or −71.6° or radians

5 **(i)** $\dfrac{\cos\theta}{\tan\theta(1-\sin\theta)} \equiv \dfrac{\cos^2\theta}{\sin\theta(1-\sin\theta)}$	M1	Use of t = s ÷ c
$= \dfrac{1-\sin^2\theta}{\sin\theta(1-\sin\theta)}$	M1	Replaces $\cos^2\theta$ with $1 - \sin^2\theta$ to form f(sinθ).
$= \dfrac{1+\sin\theta}{\sin\theta} = \dfrac{1}{\sin\theta}+1$	A1 [3]	AG. Ensure all ok. Must show difference of 2 squares.
(ii) $\dfrac{\cos\theta}{\tan\theta(1-\sin\theta)} = 4 \rightarrow \dfrac{1}{\sin\theta}+1 = 4$	M1	Linking up to obtain $\sin\theta = k$.
$\rightarrow \sin\theta = ⅓ \rightarrow \theta = 19.5°, 160.5°$	A1 A1√ [3]	co. √ 180° – 1st answer providing there are no other solutions in the range 0° to 360°.
6 **(i)** $f(x) = \dfrac{x+3}{2x-1}$		
$ff(x) = \dfrac{\dfrac{x+3}{2x-1}+3}{\dfrac{2(x+3)}{2x-1}-1} = \dfrac{7x}{7} = x$	B1 M1 A1 [3]	Replacing "x" twice - must be correct Correct algebra – clearing $(2x - 1)$ AG – all correct.
(ii) $y = \dfrac{x+3}{2x-1}$		
$\rightarrow 2xy - y = x + 3$ $\rightarrow x(2y-1) = y + 3$	M1	Attempt to make x the subject and complete method
$\rightarrow f^{-1}(x) = \dfrac{x+3}{2x-1}$	A1 [2]	co
or since $ff(x) = x$, $f^{-1}(x) = f(x) = \dfrac{x+3}{2x-1}$ (M1, A1)		
7 **(i)** (2, 5) to (10, 9) gradient = ½	B1	co
Equation of L_2 $y = \frac{1}{2}x$.	B1√	√ on gradient of L_1
Gradient of perpendicular = – 2	M1	Use of $m_1m_2 = -1$
Eqn of Perp $y - 5 = -2(x-2)$	M1	Correct form of line eqn
Sim Eqns $\rightarrow$ $C(3.6, 1.8)$	A1 [5]	co
(ii) $d^2 = 1.6^2 + 3.2^2 \rightarrow d = 3.58$	M1 A1 [2]	Correct method for AC co (accept with √5 in answer)

8 **(i)** $\overrightarrow{BA}.\overrightarrow{BC}$ or $\overrightarrow{AB}.\overrightarrow{CB}$	B1	Correct two vectors for angle ABC.
$\overrightarrow{BA} = \begin{pmatrix} -2 \\ 1 \\ 2 \end{pmatrix}$, $\overrightarrow{BC} = \begin{pmatrix} 6 \\ -2 \\ 3 \end{pmatrix}$	M1	Correct method for one of the sides.
$\overrightarrow{BA}.\overrightarrow{BC} = -8$	M1	Correct use for **any** pair of vectors.
$= 3 \times 7 \times \cos\theta$	M1	Correct method for moduli.
$\rightarrow \theta = 112.4°$ or 1.96 radians	M1 A1	All linked correctly. co
	[6]	(67.6° usually gets 4/6)
(ii) $\overrightarrow{OD} = \overrightarrow{OA} + \overrightarrow{AD} = \overrightarrow{OA} + \overrightarrow{BC}$	M1	Correct method. (allow for **d** = **a** + **b** – **c** or for **d** = **a** + **c** – **b** or for **d** = **b** + **c** – **a**)
$= \begin{pmatrix} 8 \\ 1 \\ 8 \end{pmatrix}$	A1√	A1√ for his $\overrightarrow{BC}$.
	[2]	
9 **(i)** **(a)** $f(x) = 3 - 4\cos^2 x$.		
One limit is -1	B1	co irrespective of inequalities
Other limit is 3	B1	co irrespective of inequalities
	[2]	
(b) $3 - 4\cos^2 x = 1 \rightarrow \cos^2 x = ½$		
$\rightarrow \cos x = \pm\dfrac{1}{\sqrt{2}}$	M1	Makes cos x the subject.
$\rightarrow x = ¼\pi$ or $¾\pi$	A1 A1√	co (radians). √ for "π – (1st answer)" ("exact" means that decimal answers only earn A0 A1√)
	[3]	
(ii) **(a)**	B1	Joins (0, –1) to (π, 7), providing increasing function
	B1	Not a line, flattens at extremities-needs inflexion.
	[2]	
(b) f has an inverse since it is 1:1 or increasing or no turning points.	B1	co independent of part (**i**)
	[1]	

10 **(a)** $a+5d=4a$ or $\frac{(a+4a)}{2}\times 6$	B1	co
$\frac{6}{2}(2a+5d)$ or $\frac{(a+4a)}{2}\times 6=360$	M1 A1	Correct left-hand side. All correct.
Sim Eqns $a=24°$ or $\frac{2\pi}{15}$ rads	A1	Either answer.
Arc length = 5θ	M1	Correct use of arc length with θ in rads.
Perimeter = 12.1.	A1 [6]	co
(b) **(i)** $\frac{k+6}{2k+3}=\frac{k}{k+6}$	M1 A1	Correct eqn for k.
$\rightarrow k^2-9k-36=0 \rightarrow k=12$ (NB stating a, ar, ar^2 as f(k) gets M1)	A1 [3]	Co condone inclusion of $k=-3$.
(ii) $r=⅔$, $a=27$ $\rightarrow S_\infty = 27\div⅓ = 81$.	M1 A1 [2]	Correct formula for S_∞ must have $-1 \le r \le 1$. co.
11 $y=4\sqrt{x}-x$.		
(i) At A, $4\sqrt{x}-x=0 \rightarrow A(16, 0)$	B1	co – independent of working.
$\frac{dy}{dx}=2x^{-\frac{1}{2}}-1$	B1 B1	B1 for each part.
$=0$ when $x=4 \rightarrow (4, 4)$	M1 A1 [5]	Sets to 0 and solves his eqn. co
(ii) Vol = $\pi\int y^2\,dx=$		
$\pi\int(16x+x^2-8x^{\frac{3}{2}})\,dx$	M1	Use of correct formula + attempt at integration
$\pi[8x^2+\frac{x^3}{3}-8\frac{x^{\frac{5}{2}}}{\frac{5}{2}}]$	A3,2,1	One mark for each term – unsimplified
	DM1	Correct use of his limits.
Limits 0 to 16 $\rightarrow$ 136.5π. (or 137π)	A1 [6]	co – (429 ok)