1	EITHER:	State or imply non-modular inequality $(2(x-3))^2 > (3x+1)^2$, or corresponding quadratic equation, or pair of linear equations $2(x-3) = \pm(3x+1)$	B1	
		Make reasonable solution attempt at a 3-term quadratic, or solve two linear equations	M1	
		Obtain critical values $x = -7$ and $x = 1$	A1	
		State answer $-7 < x < 1$	A1	
	OR:	Obtain critical value $x = -7$ or $x = 1$ from a graphical method, or by inspection, or by solving a linear equation or inequality	B1	
		Obtain critical values $x = -7$ and $x = 1$	B2	
		State answer $-7 < x < 1$	B1	[4]
		[Do not condone: ‹ for <.]		

2	Use law for the logarithm of a power, a quotient, or a product correctly at least once	M1	
	Use ln e = 1 or e = exp(1)	M1	
	Obtain a correct equation free of logarithms, e.g. $1 + x^2 = ex^2$	A1	
	Solve and obtain answer $x = 0.763$ only	A1	[4]
	[For the solution $x = 0.763$ with no relevant working give B1, and a further B1 if 0.763 is shown to be the only root.]		
	[Treat the use of logarithms to base 10 with answer 0.333 only, as a misread.]		
	[SR: Allow iteration, giving B1 for an appropriate formula, e.g. $x_{n+1} = \exp((\ln(1 + x_n^2) - 1)/2)$, M1 for using it correctly once, A1 for 0.763, and A1 for showing the equation has no other root but 0.763.]		

3	Attempt use of $\cos(A + B)$ formula to obtain an equation in $\cos\theta$ and $\sin\theta$	M1	
	Use trig formula to obtain an equation in $\tan\theta$ (or $\cos\theta$, $\sin\theta$ or $\cot\theta$)	M1	
	Obtain $\tan\theta = 1/(4 + \sqrt{3})$ or equivalent (or find $\cos\theta$, $\sin\theta$ or $\cot\theta$)	A1	
	Obtain answer $\theta = 9.9°$	A1	
	Obtain $\theta = 189.9°$, and no others in the given interval	A1	[5]
	[Ignore answers outside the given interval. Treat answers in radians as a misread (0.173, 3.31).]		
	[The other solution methods are *via* $\cos\theta = \pm(4 + \sqrt{3})/\sqrt{\left(1 + \left(4 + \sqrt{3}\right)^2\right)}$ or $\sin\theta = \pm 1/\sqrt{\left(1 + \left(4 + \sqrt{3}\right)^2\right)}$.]		

4	**(i)**	Make recognisable sketch of a relevant graph over the given range	B1	
		Sketch the other relevant graph on the same diagram and justify the given statement	B1	[2]
	(ii)	Consider sign of $4x^2 - 1 - \cot x$ at $x = 0.6$ and $x = 1$, or equivalent	M1	
		Complete the argument correctly with correct calculated values	A1	[2]
	(iii)	Use the iterative formula correctly at least once	M1	
		Obtain final answer 0.73	A1	
		Show sufficient iterations to at least 4 d.p. to justify its accuracy to 2 d.p., or show there is a sign change in the interval (0.725, 0.735)	A1	[3]

5	**(i)**	State or imply d$x = 2\cos\theta\,\mathrm{d}\theta$, or $\dfrac{\mathrm{d}x}{\mathrm{d}\theta} = 2\cos\theta$, or equivalent	B1	
		Substitute for x and dx throughout the integral	M1	
		Obtain the given answer correctly, having changed limits and shown sufficient working	A1	[3]
	(ii)	Replace integrand by $2 - 2\cos 2\theta$, or equivalent	B1	
		Obtain integral $2\theta - \sin 2\theta$, or equivalent	B1√	
		Substitute limits correctly in an integral of the form $a\theta \pm b\sin 2\theta$, where ab Þ 0	M1	
		Obtain answer $\dfrac{1}{3}\pi - \dfrac{\sqrt{3}}{2}$ or exact equivalent	A1	[4]
		[The f.t. is on integrands of the form $a + c\cos 2\theta$, where ac Þ 0.]		
6	**(i)**	State modulus is 2	B1	
		State argument is $\frac{1}{6}\pi$, or 30°, or 0.524 radians	B1	[2]
	(ii)	**(a)** State answer $3\sqrt{3} + \mathrm{i}$	B1	
		(b) *EITHER*: Multiply numerator and denominator by $\sqrt{3} - \mathrm{i}$, or equivalent	M1	
		Simplify denominator to 4 or numerator to $2\sqrt{3} + 2\mathrm{i}$	A1	
		Obtain final answer $\frac{1}{2}\sqrt{3} + \frac{1}{2}\mathrm{i}$, or equivalent	A1	
		OR 1: Obtain two equations in x and y and solve for x or for y	M1	
		Obtain $x = \frac{1}{2}\sqrt{3}$ or $y = \frac{1}{2}$	A1	
		Obtain final answer $\frac{1}{2}\sqrt{3} + \frac{1}{2}\mathrm{i}$, or equivalent	A1	
		OR 2: Using the correct processes express iz*/z in polar form	M1	
		Obtain $x = \frac{1}{2}\sqrt{3}$ or $y = \frac{1}{2}$	A1	
		Obtain final answer $\frac{1}{2}\sqrt{3} + \frac{1}{2}\mathrm{i}$, or equivalent	A1	[4]
	(iii)	Plot A and B in relatively correct positions	B1	
		EITHER: Use fact that angle AOB = arg(iz*) – arg z	M1	
		Obtain the given answer	A1	
		OR 1: Obtain tan $A\hat{O}B$ from gradients of OA and OB and the correct tan($A - B$) formula	M1	
		Obtain the given answer	A1	
		OR 2: Obtain cos $A\hat{O}B$ by using correct cosine formula or scalar product	M1	
		Obtain the given answer	A1	[3]

7	**(i)**	State correct equation in any form, e.g. $\mathbf{r} = \mathbf{i} + 2\mathbf{j} + 2\mathbf{k} + \lambda(2\mathbf{i} + 2\mathbf{j} - 2\mathbf{k})$	B1	[1]
	(ii)	*EITHER*: Equate a relevant scalar product to zero and form an equation in λ	M1	
		OR 1: Equate derivative of OP^2 (or OP) to zero and form an equation in λ	M1	
		OR 2: Use Pythagoras in *OAP* or *OBP* and form an equation in λ	M1	
		State a correct equation in any form	A1	
		Solve and obtain $\lambda = -\frac{1}{6}$ or equivalent	A1	
		Obtain final answer $\overrightarrow{OP} = \frac{2}{3}\mathbf{i} + \frac{5}{3}\mathbf{j} + \frac{7}{3}\mathbf{k}$, or equivalent	A1	[4]
	(iii)	*EITHER*: State or imply $\overrightarrow{OP}$ is a normal to the required plane	M1	
		State normal vector $2\mathbf{i} + 5\mathbf{j} + 7\mathbf{k}$, or equivalent	A1√	
		Substitute coordinates of a relevant point in $2x + 5y + 7z = d$ and evaluate d	M1	
		Obtain answer $2x + 5y + 7z = 26$, or equivalent	A1	
		OR 1: Find a vector normal to plane *AOB* and calculate its vector product with a direction vector for the line *AB*	M1*	
		Obtain answer $2\mathbf{i} + 5\mathbf{j} + 7\mathbf{k}$, or equivalent	A1	
		Substitute coordinates of a relevant point in $2x + 5y + 7z = d$ and evaluate d	M1(dep*)	
		Obtain answer $2x + 5y + 7z = 26$, or equivalent	A1	
		OR 2: Set up and solve simultaneous equations in a, b, c derived from zero scalar products of $a\mathbf{i} + b\mathbf{j} + c\mathbf{k}$ with **(i)** a direction vector for line *AB*, **(ii)** a normal to plane *OAB*	M1*	
		Obtain $a : b : c = 2 : 5 : 7$, or equivalent	A1	
		Substitute coordinates of a relevant point in $2x + 5y + 7z = d$ and evaluate d	M1(dep*)	
		Obtain answer $2x + 5y + 7z = 26$, or equivalent	A1	
		OR 3: With $Q(x, y, z)$ on plane, use Pythagoras in *OPQ* to form an equation in x, y and z	M1*	
		Form a correct equation	A1√	
		Reduce to linear form	M1(dep*)	
		Obtain answer $2x + 5y + 7z = 26$, or equivalent	A1	
		OR 4: Find a vector normal to plane *AOB* and form a 2-parameter equation with relevant vectors, e.g., $\mathbf{r} = \mathbf{i} + 2\mathbf{j} + 2\mathbf{k} + \lambda(2\mathbf{i} - 2\mathbf{j} + 2\mathbf{k}) + \mu(8\mathbf{i} - 6\mathbf{j} + 2\mathbf{k})$	M1*	
		State three correct equations in x, y, z, λ and μ	A1	
		Eliminate λ and μ	M1(dep*)	
		Obtain answer $2x + 5y + 7z = 26$, or equivalent	A1	[4]

8 **(i)** State or imply the form $\dfrac{A}{1+x} + \dfrac{Bx+C}{1+2x^2}$ B1
Use any relevant method to evaluate a constant M1
Obtain one of $A = -1$, $B = 2$, $C = 1$ A1
Obtain a second value A1
Obtain the third value A1 [5]

(ii) Use correct method to obtain the first two terms of the expansion of $(1+x)^{-1}$ or $(1+2x^2)^{-1}$ M1
Obtain correct expansion of each partial fraction as far as necessary A1√ + A1√
Multiply out fully by $Bx + C$, where BC þ 0 M1
Obtain answer $3x - 3x^2 - 3x^3$ A1 [5]

[Symbolic binomial coefficients, e.g., $\begin{pmatrix} -1 \\ 1 \end{pmatrix}$ are not sufficient for the first M1. The f.t. is on A, B, C.]
[If B or C omitted from the form of fractions, give B0M1A0A0A0 in **(i)**; M1A1√A1√ in **(ii)**, max 4/10.]
[If a constant D is added to the correct form, give M1A1A1A1 and B1 if and only if $D = 0$ is stated.]
[If an extra term $D/(1 + 2x^2)$ is added, give B1M1A1A1, and A1 if $C + D = 1$ is resolved to $1/(1 + 2x^2)$.]
[In the case of an attempt to expand $3x(1 + x)^{-1}(1 + 2x^2)^{-1}$, give M1A1A1 for the expansions up to the term in x^2, M1 for multiplying out fully, and A1 for the final answer.]
[For the identity $3x \equiv (1 + x + 2x^2 + 2x^3)(a + bx + cx^2 + dx^3)$ give M1A1; then M1A1 for using a relevant method to find two of $a = 0$, $b = 3$, $c = -3$ and $d = -3$; and then A1 for the final answer in series form.]

9 **(i)** Use correct product rule M1
Obtain correct derivative in any form A1
Equate derivative to zero and find non-zero x M1
Obtain $x = \exp\left(-\frac{1}{3}\right)$, or equivalent A1
Obtain $y = -1/(3e)$, or any ln-free equivalent A1 [5]

(ii) Integrate and reach $kx^4 \ln x + l\int x^4 . \dfrac{1}{x}\,dx$ M1
Obtain $\frac{1}{4}x^4 \ln x - \frac{1}{4}\int x^3\,dx$ A1
Obtain integral $\frac{1}{4}x^4 \ln x - \frac{1}{16}x^4$, or equivalent A1
Use limits $x = 1$ and $x = 2$ correctly, having integrated twice M1
Obtain answer $4\ln 2 - \dfrac{15}{16}$, or exact equivalent A1 [5]

10	**(i)**	State or imply $\frac{dx}{dt} = k(20 - x)$	B1	
		Show that $k = 0.05$	B1	[2]
	(ii)	Separate variables correctly and integrate both sides	B1	
		Obtain term $-\ln(20 - x)$, or equivalent	B1	
		Obtain term $\frac{1}{20}t$, or equivalent	B1	
		Evaluate a constant or use limits $t = 0$, $x = 0$ in a solution containing terms $a \ln(20 - x)$ and bt	M1*	
		Obtain correct answer in any form, e.g. $\ln 20 - \ln(20 - x) = \frac{1}{20}t$	A1	[5]
	(iii)	Substitute $t = 10$ and calculate x	M1(dep*)	
		Obtain answer $x = 7.9$	A1	[2]
	(iv)	State that x approaches 20	B1	[1]