1	(i)	State $\sin 2\alpha = 2\sin\alpha\cos\alpha$ and $\sec\alpha = 1/\cos\alpha$	B1	
		Obtain $2\sin\alpha$	B1	[2]
	(ii)	Use $\cos 2\beta = 2\cos^2\beta - 1$ or equivalent to produce correct equation in $\cos\beta$	B1	
		Solve three-term quadratic equation for $\cos\beta$	M1	
		Obtain $\cos\beta = \frac{1}{3}$ only	A1	[3]
2		State $\frac{du}{dx} = 3\sec^2 x$ or equivalent	B1	
		Express integral in terms of u and du (accept unsimplified and without limits)	M1	
		Obtain $\int \frac{1}{3}u^{\frac{1}{2}}\,du$	A1	
		Integrate $Cu^{\frac{1}{2}}$ to obtain $\frac{2C}{3}u^{\frac{3}{2}}$	M1	
		Obtain $\frac{14}{9}$	A1	[5]
3		Obtain $\frac{2}{2t+3}$ for derivative of x	B1	
		Use quotient of product rule, or equivalent, for derivative of y	M1	
		Obtain $\frac{5}{(2t+3)^2}$ or unsimplified equivalent	A1	
		Obtain $t = -1$	B1	
		Use $\frac{dy}{dx} = \frac{dy}{dt} / \frac{dx}{dt}$ in algebraic or numerical form	M1	
		Obtain gradient $\frac{5}{2}$	A1	[6]
4		Separate variables correctly and recognisable attempt at integration of at least one side	M1	
		Obtain $\ln y$, or equivalent	B1	
		Obtain $k\ln(2+e^{3x})$	B1	
		Use $y(0) = 36$ to find constant in $y = A(2+e^{3x})^k$ or $\ln y = k\ln(2+e^{3x}) + c$ or equivalent	M1*	
		Obtain equation correctly without logarithms from $\ln y = \ln\left(A(2+e^{3x})^k\right)$	*M1	
		Obtain $y = 4(2+e^{3x})^2$	A1	[6]

5	(i)	Either	Multiply numerator and denominator by $\sqrt{3}+\mathrm{i}$ and use $\mathrm{i}^2=-1$	M1	
			Obtain correct numerator $18+18\sqrt{3}\mathrm{i}$ or correct denominator 4	B1	
			Obtain $\frac{9}{2}+\frac{9}{2}\sqrt{3}\mathrm{i}$ or $\left(18+18\sqrt{3}\mathrm{i}\right)/4$	A1	
			Obtain modulus or argument	M1	
			Obtain $9\mathrm{e}^{\frac{1}{3}\pi\mathrm{i}}$	A1	[5]
		OR	Obtain modulus and argument of numerator or denominator, or both moduli or both arguments	M1	
			Obtain moduli and argument 18 and $\frac{1}{6}\pi$ or 2 and $-\frac{1}{6}\pi$		
			or moduli 18 and 2 or arguments $\frac{1}{6}\pi$ and $-\frac{1}{6}\pi$ (allow degrees)	B1	
			Obtain $18\mathrm{e}^{\frac{1}{6}\pi\mathrm{i}}\div 2\mathrm{e}^{-\frac{1}{6}\pi\mathrm{i}}$ or equivalent	A1	
			Divide moduli and subtract arguments	M1	
			Obtain $9\mathrm{e}^{\frac{1}{3}\pi\mathrm{i}}$	A1	[5]
	(ii)	State $3\mathrm{e}^{\frac{1}{6}\pi\mathrm{i}}$, following through their answer to part (i)		B1√	
		State $3\mathrm{e}^{\frac{1}{6}\pi\mathrm{i}\pm\frac{1}{2}\pi\mathrm{i}}$, following through their answer to part (i)		B1√	
		Obtain $3\mathrm{e}^{-\frac{5}{6}\pi\mathrm{i}}$		B1	[3]
6	(i)	Use law for the logarithm for a product or quotient or exponentiation AND for a power		M1	
		Obtain $(4x-5)^2(x+1)=27$		B1	
		Obtain given equation correctly $16x^3-24x^2-15x-2=0$		A1	[3]
	(ii)	Obtain $x=2$ is root or $(x-2)$ is a factor, or likewise with $x=-\frac{1}{4}$		B1	
		Divide by $(x-2)$ to reach a quotient of the form $16x^2+kx$		M1	
		Obtain quotient $16x^2+8x+1$		A1	
		Obtain $(x-2)(4x+1)^2$ or $(x-2)$, $(4x+1)$, $(4x+1)$		A1	[4]
	(iii)	State $x=2$ only		A1	[1]
7	(i)	Obtain $2x-3y+6z$ for LHS of equation		B1	
		Obtain $2x-3y+6z=23$		B1	[2]
	(ii)	Either	Use correct formula to find perpendicular distance	M1	
			Obtain unsimplified value $\frac{\pm 23}{\sqrt{2^2+(-3)^2+6^2}}$, following answer to (i)	A1√	
			Obtain $\frac{23}{7}$ or equivalent	A1	[3]

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	OR 1	Use scalar product of (4, –1, 2) and a vector normal to the plane	M1	
		Use unit normal to plane to obtain $\pm\frac{(8+3+12)}{\sqrt{49}}$	A1	
		Obtain $\frac{23}{7}$ or equivalent	A1	[3]
	OR 2	Find parameter intersection of p and $\mathbf{r} = \mu(2\mathbf{i} - 3\mathbf{j} + 6\mathbf{k})$	M1	
		Obtain $\mu = \frac{23}{49}$ [and $\left(\frac{46}{49}, -\frac{69}{49}, \frac{138}{49}\right)$ as foot of perpendicular]	A1	
		Obtain distance $\frac{23}{7}$ or equivalent	A1	[3]
(iii)	Either	Recognise that plane is $2x - 3y + 6z = k$ and attempt use of formula for perpendicular distance to plane at least once	M1	
		Obtain $\frac{\lvert 23-k \rvert}{7} = 14$ or equivalent	A1	
		Obtain $2x - 3y + 6z = 121$ and $2x - 3y + 6z = -75$	A1	[3]
	OR	Recognise that plane is $2x - 3y + 6z = k$ and attempt to find at least one point on q using l with $\lambda = \pm 2$	M1	
		Obtain $2x - 3y + 6z = 121$	A1	
		Obtain $2x - 3y + 6z = -75$	A1	[3]

8	(i)	Sketch $y = \operatorname{cosec} x$ for at least $0 , x , \pi$	B1	
		Sketch $y = x(\pi - x)$ for at least $0 , x , \pi$	B1	
		Justify statement concerning two roots, with evidence of 1 and $\frac{1}{4}\pi^2$ for y-values on graph via scales	B1	[3]
	(ii)	Use $\operatorname{cosec} x = \frac{1}{\sin x}$ and commence rearrangement	M1	
		Obtain given equation correctly, showing sufficient detail	A1	[2]
	(iii)	**(a)** Use the iterative formula correctly at least once	M1	
		Obtain final answer 0.66	A1	
		Show sufficient iterations to 4 decimal places to justify answer or show a sign change in the interval (0.655, 0.665)	A1	[3]
		(b) Obtain 2.48	B1	[1]

9 **(i)** Either State or imply partial fractions are of form $\frac{A}{3-x}+\frac{B}{1+2x}+\frac{C}{(1+2x)^2}$ B1

Use any relevant method to obtain a constant M1

Obtain $A = 1$ A1

Obtain $B = \frac{3}{2}$ A1

Obtain $C = -\frac{1}{2}$ A1 [5]

Or State or imply partial fractions are of form $\frac{A}{3-x}+\frac{Dx+E}{(1+2x)^2}$ B1

Use any relevant method to obtain a constant M1
Obtain $A = 1$ A1
Obtain $D = 3$ A1
Obtain $E = 1$ A1 [5]

(ii) Obtain the first two terms of one of the expansion of $(3-x)^{-1}$, $\left(1-\frac{1}{3}x\right)^{-1}$

$(1+2x)^{-1}$ and $(1+2x)^{-2}$ M1

Obtain correct unsimplified expansion up to the term in x^2 of each partial fraction, following in each case the value of A, B, C A1√
A1√
A1√

Obtain answer $\frac{4}{3}-\frac{8}{9}x+\frac{1}{27}x^2$ A1 [5]

[If A, D, E approach used in part (i), give M1A1√A1√ for the expansions, M1 for multiplying out fully and A1 for final answer]

10 **(i)** Use of product or quotient rule M1

Obtain $-5e^{-\frac{1}{2}x}\sin 4x + 40e^{-\frac{1}{2}x}\cos 4x$ A1

Equate $\frac{dy}{dx}$ to zero and obtain $\tan 4z = k$ or $R\cos(4x \pm \alpha)$ M1

Obtain $\tan 4x = 8$ or $\sqrt{65}\cos\left(4x \pm \tan^{-1}\frac{1}{8}\right)$ A1

Obtain 0.362 or 20.7° A1
Obtain 1.147 or 65.7° A1 [6]

(ii) State or imply that x-coordinates of T_n are increasing by $\frac{1}{4}\pi$ or 45° B1

Attempt solution of inequality (or equation) of form $x_1 + (n-1)k\pi$. 25 M1

Obtain $n > \frac{4}{\pi}(25-0.362)+1$, following through on their value of x_1 A1√

$n = 33$ A1 [4]

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