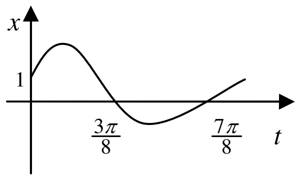
Question number	Scheme	Marks
1.	$\sum_{r=1}^{n}(r-1)(r+2)=\sum_{r=1}^{n}r^2+\sum_{r=1}^{n}r-\left(\sum_{r=1}^{n}\right)2$	M1
	$=\frac{1}{6}n(n+1)(2n+1)+\frac{1}{2}n(n+1),-2n$	A1, A1
	$=\frac{1}{6}n(2n^2+6n-8)$ M: Use factor n and use common denom. (e.g.3, 6, 12)	M1
	$=\frac{1}{3}n(n^2+3n-4)=\frac{1}{3}(n-1)n(n+4)$ M: Attempt complete factorisation (*)	M1 A1 cso (6)
		Total 6 marks

2.	2 is a 'critical value', e.g. used in solution, or $x = 2$ seen as an asymptote	B1
	$x^2 = 2x^2 - 4x \Rightarrow x^2 - 4x = 0$	
	$x = 0, \quad x = 4$ M1: two other critical values	M1 A1
	$x < 0$	B1
	$2 < x < 4$ M1: An inequality using the critical value 2	M1 A1 (6)
		Total 6 marks

3.	(a) $z+2\mathrm{i}=\mathrm{i}z+\lambda$ $\quad (1-\mathrm{i})z=\lambda-2\mathrm{i}$, $\quad z=\frac{\lambda-2\mathrm{i}}{1-\mathrm{i}}$	M1, A1
	$z=\frac{\lambda-2\mathrm{i}}{1-\mathrm{i}}\times\frac{1+\mathrm{i}}{1+\mathrm{i}}, \quad =\frac{1}{2}(.........)$	M1, A1
	$=\left(\frac{\lambda}{2}+1\right)+\left(\frac{\lambda}{2}-1\right)\mathrm{i}$ (*)	A1 cso (5)
	(b) $\frac{\frac{\lambda}{2}-1}{\frac{\lambda}{2}+1}=\frac{1}{2}, \quad \lambda=6$ $\quad$ 2nd M: Solving $\frac{\frac{\lambda}{2}-1}{\frac{\lambda}{2}+1}=k$ (constant k)	M1, M1 A1 (3)
	(c) $z=4+2\mathrm{i}, \quad \lvert z\rvert^2=4^2+2^2=20$ M: Subs. λ value and attempt $\lvert z\rvert$ or $\lvert z\rvert^2$	M1 A1 (2)
		Total 10 marks

Question number	Scheme	Marks
4.	(a) $m^2+2m+5=0 \quad \Rightarrow \quad m=-1\pm 2\text{i}$	M1 A1
	$x=\text{e}^{-t}\left(A\cos 2t+B\sin 2t\right)$ M: Correct form (needs the two different constants)	M1 A1 (4)
	(b) (1, 0) $\Rightarrow$ $A = 1$	dB1
	$\dot{x}=-\text{e}^{-t}\left(A\cos 2t+B\sin 2t\right)+\text{e}^{-t}\left(-2A\sin 2t+2B\cos 2t\right)$ M: Product diff. attempt	dM1
	With $A = 1$, $\text{e}^{-t}\{\cos 2t(-1+2B)+\sin 2t(-B-2)\}$	
	$\dot{x}=1, t=0 \quad \Rightarrow \quad 1=-A+2B$	M1
	$B = 1$ $\left(x=\text{e}^{-t}\left(\cos 2t+\sin 2t\right)\right)$ M: Use value of A to find B.	dM1 A1cso (5)
	(c) 	
	'Single oscillation' between 0 and π	B1
	Decreasing amplitude (dep. on a turning point)	B1ft
	Initially increasing to maximum	B1ft
	Any <u>one</u> correct intercept, whether in terms of π or not: 1 or $\frac{3\pi}{8}$ or $\frac{7\pi}{8}$	B1 (4)
	(Allow degrees: 67.5° or 157.5°) (Allow awrt 0.32π or 1.18 or 2.75)	**Total 13 marks**

5.	(a) f(1.8) = 19.6686… − 20 = − 0.3313… Allow awrt ± 0.33	B1
	f(2) = 20.6424… − 20 = 0.6424… Allow awrt ± 0.64	B1
	$\frac{\alpha-1.8}{\text{"}0.33\text{"}}=\frac{2-\alpha}{\text{"}0.64\text{"}}$, $\left(\alpha=1.8+\frac{0.33}{0.33+0.64}\times 0.2\right)$ 1.87	M1, A1 (4)
	(b) $\text{f}(1.9)\approx 0.1651795...$, or just $1.9+6-20\text{e}^{-0.5\times 1.9}$ Allow awrt 0.165	B1
	$\text{f}'(t)=1+10\text{e}^{-0.5t}$	M1 A1
	$\text{f}'(1.9)=4.8674...$, or just $1+10\text{e}^{-0.5\times 1.9}$ Allow awrt 4.87	A1
	$\alpha_2=1.9-\frac{0.16518}{4.867410}\approx 1.866$	M1 A1 (6)
	(c) 112 (min) (1 h 52 m)	B1 (1)
		Total 11 marks

Question number	Scheme	Marks
6.	(a) $\frac{dy}{dx} = v + x\frac{dv}{dx}$	B1
	$v + x\frac{dv}{dx} = \frac{3x-4vx}{4x+3vx}$ (All in terms of v and x)	M1
	$x\frac{dv}{dx} = \frac{3-4v-v(4+3v)}{4+3v}$ (Requires $x\frac{dv}{dx} = f(v)$, 2 terms over common denom.)	M1
	$x\frac{dv}{dx} = -\frac{3v^2+8v-3}{3v+4}$ (*)	A1 cso (4)
	(b) $\frac{3v+4}{3v^2+8v-3}dv = -\frac{1}{x}dx$ Separating variables	M1
	$\pm \ln x$	B1
	$\frac{1}{2}\ln(3v^2+8v-3)$ M: $k\ln(3v^2+8v-3)$	M1 A1
	$\frac{1}{2}\ln\left(\frac{3y^2}{x^2}+\frac{8y}{x}-3\right) = -\ln x + C$ Or any equivalent form	A1 (5)
	(c) $\frac{3y^2}{x^2}+\frac{8y}{x}-3 = \frac{A}{x^2}$ Removing ln's correctly at any stage, dep. on having C.	M1
	Using (1, 7) to form an equation in A (need not be $A = \ldots$)	M1
	$(1, 7) \Rightarrow 3\times 49 + 56 - 3 = A \Rightarrow A = 200$ (or equiv., can still be ln)	A1
	$3y^2 + 8yx - 3x^2 = 200$ $(3y-x)(y+3x) = 200$ (M dependent on the 2 previous M's) (*)	M1 A1 cso (5)
		Total 14 marks

Question number	Scheme	Marks
7.	(a)(i) $r^2\sin^2\theta = a^2\cos 2\theta\sin^2\theta = a^2\left(1-2\sin^2\theta\right)\sin^2\theta$	B1 (1)
	$\left(=a^2\left(\sin^2\theta-2\sin^4\theta\right)\right)$	
	(ii) $\frac{\mathrm{d}}{\mathrm{d}\theta}\left(a^2\left(\sin^2\theta-2\sin^4\theta\right)\right)=a^2\left(2\sin\theta\cos\theta-8\sin^3\theta\cos\theta\right)$, $=0$	M1 A1, M1
	$2=8\sin^2\theta$ (Proceed to $a\sin^2\theta=b$)	M1
	$\sin\theta=\frac{1}{2} \Rightarrow \theta=\frac{\pi}{6}$, $r=\frac{a}{\sqrt{2}}$ (*)	A1, A1 cso (6)
	(b) $\frac{a^2}{2}\int\cos 2\theta\,\mathrm{d}\theta=\frac{a^2}{4}\sin 2\theta$ M: Attempt $\frac{1}{2}\int r^2\,\mathrm{d}\theta$, to get $k\sin 2\theta$	M1 A1
	$\left[\dots\right]_{\pi/6}^{\pi/4}=\frac{a^2}{4}\left[1-\frac{\sqrt{3}}{2}\right]$ M: Using correct limits	M1 A1
	$\Delta=\frac{1}{2}\left(\frac{a}{\sqrt{2}}.\frac{1}{2}\right)\times\left(\frac{a}{\sqrt{2}}.\frac{\sqrt{3}}{2}\right)=\frac{\sqrt{3}a^2}{16}$ M: Full method for rectangle or triangle	M1 A1
	$R=\frac{\sqrt{3}a^2}{16}-\frac{a^2}{4}\left[1-\frac{\sqrt{3}}{2}\right]=\frac{a^2}{16}\left(3\sqrt{3}-4\right)$ M: Subtracting, either way round (*)	dM1 A1 cso (8)
		Total 15 marks