4 (d) Alt 2	Range of $\text{ff}(x)$ is $0 \leq \text{ff}(x) < 3$	M1	1.1b
	As $\frac{7}{2} > 3$, then $\text{ff}(x) = \frac{7}{2}$ has no solutions	A1	2.4
		(2)	

Question 4 Notes:

(a)	
M1:	For one "end" fully correct; e.g. accept $f(x) \geq 0$ (**not** $x \geq 0$) or $f(x) < 4$ (**not** $x < 4$); or for both correct "end" values; e.g. accept $0 < f(x) \leq 4$.
A1:	Correct range using correct notation. Accept $0 \leq f(x) < 4$, $0 \leq y < 4$, $[0, 4)$, $f(x) \geq 0$ and $f(x) < 4$
(b)	
M1:	Attempts to find the inverse by cross-multiplying and an attempt to collect all the *x*-terms (or swapped *y*-terms) onto one side.
M1:	A fully correct method to find the inverse.
A1:	A correct $f^{-1}(x) = \frac{4x}{12 - 3x}$, $0 \leq x < 4$, o.e. expressed fully in function notation, including the domain, which may be correct or followed through from their part (a) answer for their range of f
Note:	Writing $y = \frac{12x}{3x+4}$ as $y = \frac{4(3x+4) - 16}{3x+4} \rightarrow y = 4 - \frac{16}{3x+4}$ leads to a correct $f^{-1}(x) = \frac{1}{3}\left(\frac{16}{4-x} - 4\right)$, $0 \leq x < 4$
(c)	
M1:	Attempts to substitute $f(x) = \frac{12x}{3x+4}$ into $\frac{12f(x)}{3f(x)+4}$
M1:	Applies a method of "rationalising the denominator" for their denominator.
A1*:	Shows $\text{ff}(x) = \frac{9x}{3x+1}$ with no errors seen. **Note:** The domain of $\text{ff}(x)$ is not required in this part.
(d)	
M1:	Sets $\frac{9x}{3x+1}$ to $\frac{7}{2}$ and solves to find $x = \ldots$
A1:	Finds $x = -\frac{7}{3}$, rejects this solution as $\text{ff}(x)$ is valid for $x \geq 0$ only. Concludes that $\text{ff}(x) = \frac{7}{2}$ has no solutions.

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Question	Scheme	Marks	AOs
11 (i)	$\{y = a^x \rightarrow\}\quad \ln y = \ln a^x \rightarrow \ln y = x\ln a \rightarrow \dfrac{1}{y}\dfrac{dy}{dx} = \ln a$	M1	2.1
	$\dfrac{dy}{dx} = y\ln a \rightarrow \dfrac{dy}{dx} = a^x \ln a$ *	A1*	1.1b
		(2)	
(i) Alt 1	$\{y = a^x \rightarrow\}\quad y = e^{x\ln a} \rightarrow \dfrac{dy}{dx} = (\ln a)e^{x\ln a}$	M1	2.1
	$\rightarrow \dfrac{dy}{dx} = a^x \ln a$ *	A1*	1.1b
		(2)	
(ii)	$\dfrac{d}{dy}\left(2\tan y\right) = 2\sec^2 y$	M1	1.1b
	$\{x = 2\tan y \rightarrow\}\quad \dfrac{dx}{dy} = 2\sec^2 y$ or $1 = (2\sec^2 y)\dfrac{dy}{dx}$	A1	1.1b
	$\dfrac{dx}{dy} = 2(1+\tan^2 y)$ or $1 = 2(1+\tan^2 y)\dfrac{dy}{dx}$	M1	1.1b
	E.g. $\dfrac{dx}{dy} = 2\left(1+\left(\dfrac{x}{2}\right)^2\right) \rightarrow \dfrac{dx}{dy} = 2\left(1+\dfrac{x^2}{4}\right) \rightarrow \dfrac{dx}{dy} = 2 + \dfrac{x^2}{2} \rightarrow \dfrac{dx}{dy} = \dfrac{4+x^2}{2} \rightarrow \dfrac{dy}{dx} = \dfrac{2}{4+x^2}$	A1	2.1
		(4)	
(ii) Alt 1	$\{x = 2\tan y \rightarrow\}\quad y = \arctan\left(\dfrac{x}{2}\right) \rightarrow \dfrac{dy}{dx} = \dfrac{1}{1+\left(\dfrac{x}{2}\right)^2} \times \left(\dfrac{1}{2}\right)$	M1 M1 A1	1.1b 1.1b 1.1b
	$\rightarrow \dfrac{dy}{dx} = \dfrac{1}{2\left(1+\dfrac{x^2}{4}\right)} \rightarrow \dfrac{dy}{dx} = \dfrac{1}{\left(2+\dfrac{x^2}{2}\right)} \rightarrow \dfrac{dy}{dx} = \dfrac{1}{\left(\dfrac{4+x^2}{2}\right)}$ $\rightarrow \dfrac{dy}{dx} = \dfrac{2}{4+x^2}$	A1	2.1
		(4)	
			(6 marks)

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Question	Scheme	Marks	AOs
12 (a)	$y = ax^2 + c$ $x = 0,\ y = 4 \longrightarrow c = 4$	M1	3.3
	$x = 50,\ y = 24 \longrightarrow 24 = a(50)^2 + 4 \longrightarrow a = \frac{20}{50^2} = \frac{1}{125}$ or 0.008	M1	3.4
	$y = \frac{1}{125}x^2 + 4 \quad \{-50 \leq x \leq 50\}$	A1	1.1b
		(3)	
(a) **Alt 1**	$y = ax^2 + bx + c$ $x = 0,\ y = 4 \longrightarrow c = 4$ $x = 50,\ y = 24 \longrightarrow 24 = 2500a + 50b + 4$ $x = -50,\ y = 24 \longrightarrow 24 = 2500a - 50b + 4$	M1	3.3
	$0 = 100b \longrightarrow b = 0$ $24 = 2500a + 4 \longrightarrow a = \frac{20}{2500} = \frac{1}{125}$ or 0.008	M1	3.4
	$y = \frac{1}{125}x^2 + 4 \quad \{-50 \leq x \leq 50\}$	A1	1.1b
		(3)	
(b)	$x = 50 - 19 = 31 \longrightarrow y = \frac{1}{125}(31)^2 + 4$	M1	3.4
	$y = 11.688\ \{\in 12\} \longrightarrow$ Lee can safely inspect the defect	A1	2.2b
		(2)	
(b) **Alt 1**	$12 = \frac{1}{125}x^2 + 4 \longrightarrow 8 = \frac{1}{125}x^2 \longrightarrow x = \sqrt{1000}$	M1	3.4
	$x = 31.6227766... \longrightarrow$ Distance from tower $= 50 - 31.6227766...$ $= 18.3772234...\ \{\in 19\} \longrightarrow$ Lee can safely inspect the defect	A1	2.2b
		(2)	
(c)	E.g. • The thickness/diameter of the cable has not been incorporated into the current model • Weather conditions (e.g. strong winds) may affect the shape of the curve • Walkway may not be completely horizontal	B1	3.5b
		(1)	
		(6 marks)	

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Question 12 Notes:	
(a)	
M1:	Attempts to use a model of the form $y = ax^2 + c$ **(containing no *x* term)**
M1:	Uses the constraints $x = 0,\ y = 4$ and $x = 50,\ y = 24$ (or $x = -50,\ y = 24$) to find the values for their c and for their a
A1:	$y = \frac{1}{125}x^2 + 4$ (Ignore $-50 \leqslant x \leqslant 50$)
(a) Alt 1	
M1:	Attempts to use a model of the form $y = ax^2 + bx + c$ **and** finds or deduces that $b = 0$
M1:	Uses the constraints $x = 0, y = 4;\ x = 50,\ y = 24$ and $x = -50,\ y = 24$ to find the values for their c, for their b and for their a
A1:	$y = \frac{1}{125}x^2 + 4$ (Ignore $-50 \leqslant x \leqslant 50$)
(b)	
M1:	Substitutes $x = 50 - 19 \{= 31\}$ or $x = -50 + 19 \{= -31\}$ into their quadratic model
A1:	Obtains $y =$ awrt 11.7 and infers from the model that Lee can safely inspect the defect
(b) Alt 1	
M1:	Substitutes $y = 12$ into their quadratic model and rearranges to find $x = \ldots$
A1:	Obtains distance from tower as awrt 18.4 and infers from the model that Lee can safely inspect the defect
(c)	
B1:	See scheme

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Question	Scheme	Marks	AOs
14	$y = 4xe^{-2x} \rightarrow \left\{ \begin{matrix} u = 4x & v = e^{-2x} \\ \frac{du}{dx} = 4 & \frac{dv}{dx} = -2e^{-2x} \end{matrix} \right\}, \left\{ \begin{matrix} u = 4x & \frac{du}{dx} = 4 \\ \frac{dv}{dx} = e^{-2x} & v = -\frac{1}{2}e^{-2x} \end{matrix} \right\}$		
	$\frac{dy}{dx} = 4e^{-2x} - 8xe^{-2x}$	M1	2.1
		A1	1.1b
	At $P(1, 4e^{-2})$, $m_T = 4e^{-2} - 8e^{-2} = -4e^{-2} \rightarrow m_N = \frac{-1}{-4e^{-2}}$ or $\frac{1}{4}e^2$	M1	1.1b
	l: $y - 4e^{-2} = \frac{e^2}{4}(x - 1)$ and $y = 0 \rightarrow -4e^{-2} = \frac{e^2}{4}(x - 1) \rightarrow x = ...$	M1	3.1a
	$\{ y = 0 \rightarrow x = 1 - 16e^{-4} \}$		
	$\int 4xe^{-2x}\,dx = -2xe^{-2x} - \int -2e^{-2x}\,dx$	M1	2.1
		A1	1.1b
	$= -2xe^{-2x} - e^{-2x}$	A1	1.1b
	Criteria • $\left[-2xe^{-2x} - e^{-2x}\right]_0^1 = \left(-2e^{-2} - e^{-2}\right) - \left(0 - 1\right) \{= 1 - 3e^{-2}\}$ • Area triangle = $\frac{1}{2}\left(16e^{-4}\right)\left(4e^{-2}\right) \{= 32e^{-6}\}$	M1	2.1
	Area(R) = $3e^{-2} - 32e^{-6}$ or $\frac{3e^4 - 32}{e^6}$	M1	3.1a
		A1	1.1b
		(10)	
			(10 marks)