Question Number	Scheme	Marks
	$f'(x) = 4x^2 + \frac{6}{x^2} - 4$	
8 (a)(i)	Substitutes $x = \sqrt{3}$ in $f'(x) = 4\times 3 + \frac{6}{3} - 4$	M1
	$= 10$ which is the same as the gradient of the tangent *	A1*
(a)(ii)	$4x^2 + \frac{6}{x^2} - 4 = 10 \Rightarrow 2x^4 - 7x^2 + 3 = 0$	M1, A1
	$\Rightarrow \left(2x^2 - 1\right)\left(x^2 - 3\right) = 0 \Rightarrow x^2 = \frac{1}{2} \Rightarrow x = \frac{\sqrt{2}}{2}$	dM1, A1
		(6)
(b)	States/implies that gradient of normal at P is $-\frac{1}{10}$ or y coordinate is $4\sqrt{3}$	M1
	Equation is $y - 4\sqrt{3} = -\frac{1}{10}\left(x - \sqrt{3}\right)$	A1
		(2)
(c)	$f'(x) = 4x^2 + \frac{6}{x^2} - 4 \Rightarrow \quad f(x) = \frac{4}{3}x^3 - \frac{6}{x} - 4x + c$	M1, A1
	Uses $\left(\sqrt{3}, 4\sqrt{3}\right) \Rightarrow 4\sqrt{3} = \frac{4}{3}\times 3\sqrt{3} - \frac{6}{\sqrt{3}} - 4\times\sqrt{3} + c \Rightarrow c = ...$	dM1
	$f(x) = \frac{4}{3}x^3 - \frac{6}{x} - 4x + 6\sqrt{3}$	A1
		(4)
		(12 marks)

(a)(i)

M1: Substitutes $x = \sqrt{3}$ in $f'(x)$. There must be evidence of this so award for sight of

$f'(x) = 4\times 3 + \frac{6}{3} - 4$, $f'(x) = 4\times\left(\sqrt{3}\right)^2 + \frac{6}{\left(\sqrt{3}\right)^2} - 4$ or $f'(x) = 12 + 2 - 4$

A1*: Achieves $f'(\sqrt{3}) = 10$ and alludes to the fact that this is equal to the gradient of the tangent. Condone a minimal response here.

……

Note that it is possible to combine both parts of (a) even if it is labelled (i) and find the two possible coordinates of P.

If this is attempted $x = \sqrt{3}$ could be substituted into any of the following equations

$$4x^2 + \frac{6}{x^2} - 4 = 10 \Rightarrow 4x^2 + \frac{6}{x^2} - 14 = 0 \Rightarrow 4x^4 - 14x^2 + 6 = 0 \Rightarrow 2x^4 - 7x^2 + 3 = 0$$

It is also possible to prove that $x = \sqrt{3}$ by solving $2x^4 - 7x^2 + 3 = 0$ via $\left(2x^2 - 1\right)\left(x^2 - 3\right) = 0$

The M1 is scored when they attempt to solve their quartic using a non- calculator method and the A1 when they solve correctly and proceed to $x = \sqrt{3}$

……..

(a)(ii)

M1: Sets $4x^2+\frac{6}{x^2}-4=10$ and attempts to simplify.

Award for

- either collecting constant terms $4x^2+\frac{6}{x^2}-4=10 \Rightarrow 4x^2+\frac{6}{x^2}-14=0$
- or else attempting to multiply through by x^2 seen in at least 3 of the 4 terms

A1: $2x^4-7x^2+3=0$ o.e. such as $4x^4-14x^2+6=0$. The $=0$ may be implied by subsequent work

dM1: Makes suitable progress towards solving their quadratic in x^2 using non calculator methods. Allow

- factorisation $'2x^4-7x^2+3'=0 \Rightarrow \left(ax^2+b\right)\left(cx^2+d\right)=0$ with $|ac|=2$ and $|bd|=3$
- completion of square $'2x^4-7x^2+3'=0 \Rightarrow \left(x^2-\frac{7}{4}\right)^2=k,$
- formula $'2x^4-7x^2+3'=0 \Rightarrow x^2=\frac{7\pm\sqrt{49-24}}{4}$

Condone attempts where a factor of 2 seemingly disappears.

E.g. $4x^4-14x^2+6=0 \Rightarrow \left(2x^2-1\right)\left(x^2-3\right)=0$

Condone attempts in which the roots would not be real, E.g $k<0$, their discriminant < 0

A1: Selects/finds $x=\frac{\sqrt{2}}{2}$ or equivalent $\frac{1}{\sqrt{2}}$ as the other possible *x* coordinate

Any other value found apart from $\sqrt{3}$, e.g $x=-\frac{\sqrt{2}}{2}$, must be either rejected or not selected

(b)

M1: States or implies that gradient at *P* is $-\frac{1}{10}$ **OR** the *y* coordinate of *P* is $4\sqrt{3}$

A1: $y-4\sqrt{3}=-\frac{1}{10}\left(x-\sqrt{3}\right)$ ISW after a correct answer

You may see $y=-\frac{1}{10}x+\frac{41}{10}\sqrt{3}$ if the form $y=mx+c$ is used

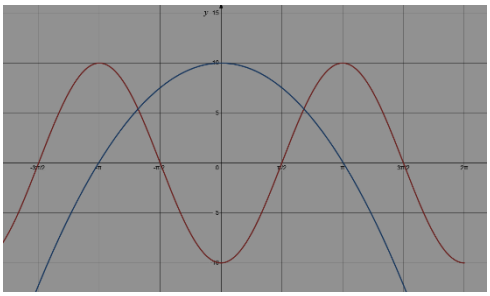
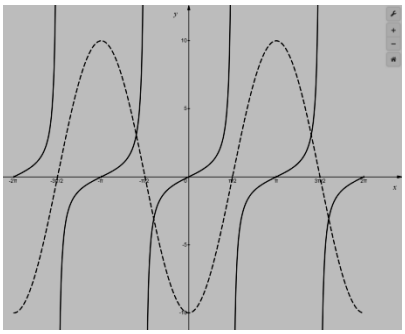
(c) The two marks for the integration may be awarded **anywhere** in Qu 8 as long as they state $\mathrm{f}(x)=...$ or $y=\ldots$ If it is clearly labelled or used in part (c) then the $\mathrm{f}(x)=...$ or $y=\ldots$ are not necessary

M1: Integrates with **TWO** terms having a correct index which must be processed.
Condone the omission of the + *c*

A1: Integrates to $\frac{4}{3}x^3-\frac{6}{x}-4x+c$ with the constant of integration

dM1: Uses $x=\sqrt{3}, y=4\sqrt{3}$ in their integrated function and finds a value for *c*.
It is dependent upon the previous M. Condone the use of decimal values for this mark only.

A1: States $\frac{4}{3}x^3-\frac{6}{x}-4x+6\sqrt{3}$ It is not necessary to have the $\mathrm{f}(x)$ or the y

Question Number	Scheme	Marks
9. (a)	$-10\cos x$ or equivalent such as $10\sin\left(x-\frac{\pi}{2}\right)$	M1, A1 **(2)**
(b) (i)	 ∩ shaped curve symmetrical about y axis passing through $(0,10)$	M1
	x intercepts at approximately $\pm\pi$	A1
(ii)	2 solutions	B1 **(3)**
(c)(i)	 Correct shape with intercepts every π rads	M1
	...and asymptotes at $(2p+1)\frac{\pi}{2}$	A1
(ii)	4 roots in the interval $-2\pi \leqslant x \leqslant 2\pi$ so $50\times 4 = 200$	B1, B1 **(4)**
		(9 marks)