Question Number	Scheme	Marks
5.(a)	$\frac{dy}{dx} = -10\sin 2x - 24\cos 2x$	M1, A1
	$\left.\frac{dy}{dx}\right\|_{x=\frac{\pi}{3}} = -10\sin\left(\frac{2\pi}{3}\right) - 24\cos\left(\frac{2\pi}{3}\right) = -5\sqrt{3} + 12$	A1
		(3)
(b)	$R = 13$	B1
	$\tan\alpha = \frac{12}{5} \Rightarrow \alpha =$ awrt 1.176	M1A1
		(3)
(c)	Sets $-26\sin(2x + 1.176) = 6$	M1
	$\sin(2x + "1.176") = -\frac{3}{13}$	A1 ft
	$x = \frac{\arcsin\left(-\frac{3}{13}\right) - 1.176}{2} =$ awrt 2.44	dM1, A1
		(4)
		(10 marks)

(a)

M1: Correct attempt at differentiation. Score for $\frac{dy}{dx} = p\sin 2x + q\cos 2x$

There may be attempts in which the double angle formulae have been used.

For example, $y = 5\cos 2x - 12\sin 2x = 5(\pm 2\cos^2 x \pm 1) - 24\sin x\cos x$

In such cases look for applications of the chain rule and product rules condoning slips in sign and loss of coefficients.

A1: $\frac{dy}{dx} = -10\sin 2x - 24\cos 2x$ which may be left un-simplified

If the double angle is used you should see $\frac{dy}{dx} = -20\sin x\cos x + 24\sin^2 x - 24\cos^2 x$

A1: Substitutes $x = \frac{\pi}{3}$ into a correct $\frac{dy}{dx}$ and achieves $-5\sqrt{3} + 12$ o.e.

It must follow the award of M1, A1. ISW after a correct answer

(b)

B1: $R = 13$. Allow for example 13.000 but not 12.99 followed by 13

Note that $\sqrt{169}$ or ± 13 is A0 unless followed by 13

M1: $\tan\alpha = \pm\frac{12}{5}, \tan\alpha = \pm\frac{5}{12} \Rightarrow \alpha = ...$ (Condone $\sin\alpha = 12, \cos\alpha = 5$ in the working)

If R is used to find α accept $\sin\alpha = \pm\frac{12}{R}$ or $\cos\alpha = \pm\frac{5}{R} \Rightarrow \alpha = ...$

A1: $\alpha =$ awrt 1.176 ISW after a correct answer so don't penalise if they then write $\sqrt{13}\cos(2x - 1.176)$

(c) Using their answer to part (b) **Working and method must be shown**. Note: If they had $\alpha = 1.176$ but write the equation of C as $y = 13\cos(2x - 1.176)$ mark (c) as though $\alpha = -1.176$

M1: Differentiates $R\cos(2x+\alpha)$ to $T\sin(2x+\alpha)$ with their α (to at least 2dp) AND sets equal to 6

A1ft: $\sin(2x + \text{'1.176'}) = \pm\frac{3}{13}$ or decimal equivalent. Condone a sign slip on differentiation and follow through on their α (to at least 3 dp) so score for $\sin(2x + \text{their } \alpha) = \pm\frac{3}{13}$

dM1: Complete attempt to find any **positive** value for x using a correct order of operations.

We now must be using correct differentiation including the sign but you can ft on their α ONLY

The following values are acceptable following intermediate working

E.g. $\sin(2x + \text{awrt "1.18"}) = -\frac{3}{13} \Rightarrow 2x + \text{"1.18"} = \text{awrt } 3.37 \Rightarrow x = \text{awrt } \frac{3.37 - \text{"1.18"}}{2} = ...$

E.g. $\sin(2x + \text{awrt } 1.18) = -\frac{3}{13} \Rightarrow 2x + \text{"1.18"} = \text{awrt } 6.05 \Rightarrow x = \frac{6.05 - \text{"1.18"}}{2} = ...$

This dependent method mark may be implied by sight of calculations such as

$\sin(2x + \text{awrt } 1.18) = -\frac{3}{13} \Rightarrow x = \text{awrt } \frac{\arcsin\left(-\frac{3}{13}\right) - 1.18}{2}$ o.e., followed by 1.1 or 2.4

A1: awrt 2.44 following the award of M1, A1, dM1. It must be selected and not part of a list of values

Candidates who state $-26\sin(2x + 1.176) = 6$ o.e and follow this with the correct answer will score 1,0,0,0

Candidates who state $\sin(2x + 1.176) = -\frac{6}{26}$ o.e and follow this with the correct answer will score 1,1,0,0

……

Candidates can use their answer to part (a) but will not score any marks until they put their derivative into a form in which the equation can be easily solved. **There is no follow through marks via this route.**

Use review if you feel unable to award the marks this way

Example I: $6 = -10\sin 2x - 24\cos 2x$

$\Rightarrow 12\cos 2x + 5\sin 2x = -3$

$\Rightarrow \cos\left(2x - 0.395\right) = -\dfrac{3}{13}$ M1, A1

$\Rightarrow x = \dfrac{\arccos\left(-\dfrac{3}{13}\right) + 0.395}{2}, = 2.44$ dM1, A1

Example II: $6 = -10\sin 2x - 24\cos 2x$

Uses a more round-about route

$\Rightarrow 12\cos 2x + 3 = -5\sqrt{1 - \cos^2 2x}$

$\Rightarrow 144\cos^2 2x + 72\cos 2x + 9 = 25\left(1 - \cos^2 2x\right)$

$\Rightarrow 169\cos^2 2x + 72\cos 2x - 16 = 0$ M1, A1

$\Rightarrow \cos 2x = \underline{0.1612}, -0.5873$

$\Rightarrow x =$ awrt 1.1 or 2.4 dM1

$\Rightarrow x =$ awrt 2.44 A1

Using their answer to part (a) which must be of the form $\dfrac{dy}{dx} = \pm 10\sin 2x \pm 24\cos 2x$ the marks would be

M1: Equation in a single trig ratio which should be $26\cos\left(2x \pm 0.3947..\right) = \pm 6$ o.e. following use of $R\cos\left(2x \pm ..\right)$ or $26\sin\left(2x \pm 1.176\right) = \pm 6$ o.e. following use of $R\sin\left(2x \pm ..\right)$

Allow accuracy to 2dp or greater for the angle

A1: Correct equation, which is usually $\cos\left(2x - 0.3947..\right) = -\dfrac{6}{26}$ or $\sin\left(2x + 1.176\right) = -\dfrac{6}{26}$

Accuracy must be 3 dp or greater for the angle

dM1: Correctly solves $\cos\left(2x \pm 0.3947..\right) = -\dfrac{6}{26}$ or $\sin\left(2x \pm 1.176\right) = -\dfrac{6}{26}$ and proceeds to a positive value for x.

As in the main method. It requires intermediate working

A1: awrt 2.44 only

Question Number	Scheme	Marks
6. (a)	$f'(x) = 6(2x-3)^2 e^{4x-2} + 4(2x-3)^3 e^{4x-2}$	M1 A1
	$= 2(2x-3)^2 e^{4x-2}\{3+2(2x-3)\} = 2(4x-3)(2x-3)^2 e^{4x-2}$	dM1 A1
		(4)
(b) (i)	$x = \frac{3}{2}, \frac{3}{4}$	B1 ft
(ii)	Attempts $f\left(\frac{3}{4}\right) = \left(-\frac{3}{2}\right)^3 e^1 = -\frac{27}{8}e, \Rightarrow g\left(\frac{3}{4}\right) = -27e$	M1, A1
	$-27e \leqslant g(x) \leqslant 0$ g g ş	A1
		(4)
		(8 marks)

(a)

M1: Attempts the product rule and achieves $f'(x) = \alpha(2x-3)^2 e^{4x-2} + \beta(2x-3)^3 e^{4x-2}$ where $\alpha > 0, \beta > 0$

A1: $f'(x) = 6(2x-3)^2 e^{4x-2} + 4(2x-3)^3 e^{4x-2}$ which may be left unsimplified

dM1: Correctly takes out a common factor of $(2x-3)^2 e^{4x-2}$ out of $\alpha(2x-3)^2 e^{4x-2} + \beta(2x-3)^3 e^{4x-2}$

Look for $f'(x) = \alpha(2x-3)^2 e^{4x-2} + \beta(2x-3)^3 e^{4x-2} = (2x-3)^2 e^{4x-2}\{\alpha + \beta(2x-3)\}$

A1: $2(4x-3)(2x-3)^2 e^{4x-2}$ following M1, A1, dM1. The order of the terms is not important.

Allow the dM1 to be implied for candidates who go directly from

$6(2x-3)^2 e^{4x-2} + 4(2x-3)^3 e^{4x-2} \rightarrow 2(4x-3)(2x-3)^2 e^{4x-2}$

Marks in part (b) can only be scored following a correct method of differentiation in part (a)

So only allow if $f'(x)$ was of the form $\alpha(2x-3)^2 e^{4x-2} + \beta(2x-3)^3 e^{4x-2}$

They cannot be scored following made up values for *P* and *Q*.

They cannot just appear as this would be relying entirely upon a calculator.

(b)(i)

B1ft: $x = \frac{3}{2}$ and $\frac{3}{4}$ following $f'(x) = 2(4x-3)(2x-3)^2 e^{4x-2}$

Alternatively, candidates can set

$f'(x) = 6(2x-3)^2 e^{4x-2} + 4(2x-3)^3 e^{4x-2} = 0$ and solve to reach $x = \frac{3}{2}$ and $\frac{3}{4}$

If part (a) is not correct follow through on their

- factorised $2(Px+Q)(2x-3)^2 e^{4x-2}$ following M1 and some attempt to combine the terms (not necessarily correctly) in part(a), so award for $x = \frac{3}{2}$ and $-"\frac{Q}{P}"$
- solution of $\alpha(2x-3)^2 e^{4x-2} + \beta(2x-3)^3 e^{4x-2} = 0$ **leading** to the solutions $x = \frac{3}{2}, \frac{3\beta - \alpha}{2\beta}$