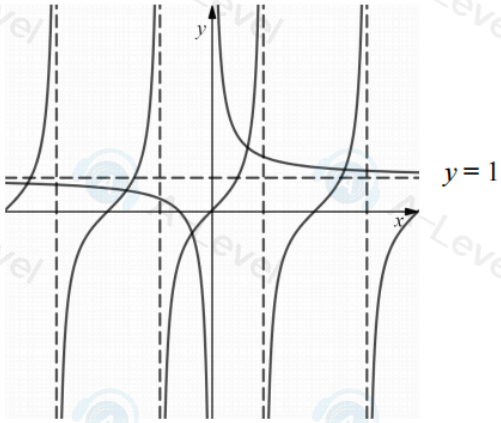
| Question Number | Scheme | Marks |
|---|---|---|
| | $y=\frac{1}{2}x^4-3+\frac{10}{x^2}$ | |
| **5(a)** | $\left(\int \frac{1}{2}x^4-3+\frac{10}{x^2}\,\mathrm{d}x=\right)\frac{1}{10}x^5-3x-\frac{10}{x}+c$ | M1A1A1 |
| | | **(3)** |
| **(b)(i)** | $\left(\frac{\mathrm{d}y}{\mathrm{d}x}=\right)2x^3-\frac{20}{x^3}$ | M1A1A1 |
| | | **(3)** |
| **(b)(ii)** | $2x^3-\frac{20}{x^3}=3\Rightarrow 2x^6-20=3x^3$ | M1 |
| | $2x^6-3x^3-20=0\Rightarrow\left(2x^3+5\right)\left(x^3-4\right)=0\Rightarrow x^3=...\Rightarrow x=...$<br>or e.g.<br>$x^3=a\Rightarrow(2a+5)(a-4)=0\Rightarrow a=...\Rightarrow x^3=...\Rightarrow x=...$ | dM1 |
| | $\Rightarrow x=-\sqrt[3]{\frac{5}{2}},\quad \sqrt[3]{4}$ | A1A1 |
| | | **(4)** |
| | | **(10 marks)** |


| Question Number | Scheme | Marks |
|---|---|---|
| | $y=\frac{1}{2}x^4-3+\frac{10}{x^2}$ | |
| **5(a)** | $\left(\int \frac{1}{2}x^4-3+\frac{10}{x^2}\,\mathrm{d}x=\right)\frac{1}{10}x^5-3x-\frac{10}{x}+c$ | M1A1A1 |
| | | **(3)** |
| **(b)(i)** | $\left(\frac{\mathrm{d}y}{\mathrm{d}x}=\right)2x^3-\frac{20}{x^3}$ | M1A1A1 |
| | | **(3)** |
| **(b)(ii)** | $2x^3-\frac{20}{x^3}=3\Rightarrow 2x^6-20=3x^3$ | M1 |
| | $2x^6-3x^3-20=0\Rightarrow\left(2x^3+5\right)\left(x^3-4\right)=0\Rightarrow x^3=...\Rightarrow x=...$<br>or e.g.<br>$x^3=a\Rightarrow(2a+5)(a-4)=0\Rightarrow a=...\Rightarrow x^3=...\Rightarrow x=...$ | dM1 |
| | $\Rightarrow x=-\sqrt[3]{\frac{5}{2}},\quad \sqrt[3]{4}$ | A1A1 |
| | | **(4)** |
| | | **(10 marks)** |

| Question Number | Scheme | Marks |
|---|---|---|
| **1.** | $\int\left(\frac{8x^3}{5}-\frac{2}{3x^4}-1\right)\mathrm{d}x=\frac{1}{4}\times\frac{8x^4}{5}-\frac{2}{3}\times\frac{1}{-3}x^{-3}-x$ | M1 A1 |
| | $\frac{2}{5}x^4+\frac{2}{9}x^{-3}-x+c$ | A1 A1 |
| | | **(4)** |
| | | **Total 4** |

| Question Number | Scheme | Marks |
|---|---|---|
| **10(a)** | $\mathrm{f}'(x)=ax-12x^{\frac{1}{3}}\Rightarrow\mathrm{f}''(x)=a-4x^{-\frac{2}{3}}$ | B1 |
| | Sets $\mathrm{f}''(27)=0\Rightarrow 0=a-4\times\frac{1}{9}\qquad\Rightarrow a=\frac{4}{9}$ | M1 A1 |
| | | **(3)** |
| **(b)** | $\mathrm{f}'(x)=ax-12x^{\frac{1}{3}}\Rightarrow\left(\mathrm{f}(x)=\right)\frac{1}{2}ax^2-9x^{\frac{4}{3}}+c$ | M1 A1ft |
| | Substitutes $x=1,\mathrm{f}(x)=-8\Rightarrow c=\ldots$ | dM1 |
| | $\left(\mathrm{f}(x)=\right)\frac{2}{9}x^2-9x^{\frac{4}{3}}+\frac{7}{9}$ | A1 |
| | | **(4)** |
| | | **(7 marks)** |

| Question Number | Scheme | Marks |
|---|---|---|
| **10** | $y=\frac{2}{3}x^3-25x-\frac{56}{x}+\frac{194}{3}$ | |
| **(a)** | $\frac{\mathrm{d}y}{\mathrm{d}x}=2x^2-25+\frac{56}{x^2}$ | M1, A1 |
| | Finds $\left.\frac{\mathrm{d}y}{\mathrm{d}x}\right\|_{x=2}=2\times4-25+\frac{56}{4}=-3$ | dM1 |
| | Equation of tangent $y+8=\text{"}-3\text{"}(x-2)\Rightarrow y=-3x-2$ * | ddM1, A1* |
| | | **(5)** |
| **(b)** | Sets $2x^2-25+\frac{56}{x^2}=-3$ | M1 |
| | $x^4-11x^2+28=0$ | dM1, A1 |
| | $\left(x^2-4\right)\left(x^2-7\right)=0\Rightarrow x^2=..$ | ddM1 |
| | $x=\sqrt{7}$ only | A1 |
| | | **(5)** |
| | | **(10 marks)** |

| Question Number | Scheme | Marks |
|---|---|---|
| **9(a)** | $x = \frac{3\pi}{2}$ oe | B1 |
| | | **(1)** |
| **(b)(i)** |  | B1B1 |
| **(ii)** | 5 (solutions)<br>Number of solutions are the number of points of intersections between the graphs | B1<br>B1 |
| | | **(4)** |
| **(c)**<br>**(i)** | (Number of solutions) = 40 | B1ft |
| **(ii)** | (Number of solutions) = 14 | B1 |
| | | **(2)** |
| | | **(7 marks)** |

| Question Number | Scheme | Marks |
|---|---|---|
| | $f'(x) = 4\sqrt{x^3} + \frac{k}{x^2} = 4x^{\frac{3}{2}} + kx^{-2}$ | |
| **10 (a)** | $f''(x) = 6x^{\frac{1}{2}} - 2kx^{-3}$ | M1, A1 |
| | $f''(2) = 6\sqrt{2} - 2k \times \frac{1}{8} = 0 \Rightarrow k = 24\sqrt{2}$ | dM1, A1 |
| | | **(4)** |
| **(b)** | $f'(x) = 4x^{\frac{3}{2}} + kx^{-2} \Rightarrow \quad f(x) = 4 \times \frac{2}{5}x^{\frac{5}{2}} - kx^{-1}(+c)$ | M1, A1 ft |
| | Uses $P\left(2, 8\sqrt{2}\right) \Rightarrow 8\sqrt{2} = 4 \times \frac{2}{5} \times 2^{\frac{5}{2}} - \frac{k}{2} + c \Rightarrow c = p\sqrt{2}$ | dM1 |
| | $f(x) = \frac{8}{5}x^{\frac{5}{2}} - \frac{24\sqrt{2}}{x} + \frac{68}{5}\sqrt{2}$ | A1 |
| | | **(4)**<br>**(8 marks)** |

| Question Number | Scheme | Marks |
|---|---|---|
| **3.(a)** | Attempts $\left(\frac{dy}{dx}=\right) 2x+3$ at $x=3$ | M1 |
| | At $x=3$ gradient of tangent $=9$ | A1 **(2)** |
| **(b)** | $\left(y_Q=\right)\ (3+h)^2+3(3+h)-2$ | B1 |
| | Gradient $PQ=\dfrac{(3+h)^2+3(3+h)-2-16}{3+h-3}=\dfrac{9h+h^2}{h}=9+h$ | M1 A1 **(3)** |
| **(c)** | States as $h\to 0$ Gradient $PQ\to 9$ = Gradient of tangent | B1 **(1)** |
| | | **(6 marks)** |

| Question Number | Scheme | Marks |
|---|---|---|
| | $f'(x)=4\sqrt{x^3}+\dfrac{k}{x^2}=4x^{\frac{3}{2}}+kx^{-2}$ | |
| **10 (a)** | $f''(x)=6x^{\frac{1}{2}}-2kx^{-3}$ | M1, A1 |
| | $f''(2)=6\sqrt{2}-2k\times\dfrac{1}{8}=0\Rightarrow k=24\sqrt{2}$ | dM1, A1 **(4)** |
| **(b)** | $f'(x)=4x^{\frac{3}{2}}+kx^{-2}\Rightarrow\ f(x)=4\times\dfrac{2}{5}x^{\frac{5}{2}}-kx^{-1}\left(+c\right)$ | M1, A1 ft |
| | Uses $P\left(2,8\sqrt{2}\right)\Rightarrow 8\sqrt{2}=4\times\dfrac{2}{5}\times 2^{\frac{5}{2}}-\dfrac{k}{2}+c\Rightarrow c=p\sqrt{2}$ | dM1 |
| | $f(x)=\dfrac{8}{5}x^{\frac{5}{2}}-\dfrac{24\sqrt{2}}{x}+\dfrac{68}{5}\sqrt{2}$ | A1 **(4)** |
| | | **(8 marks)** |

| Question | Scheme | Marks |
|---|---|---|
| **1** | $\int\left(10x^4-\dfrac{3}{2x^3}-7\right)dx=2x^5+\dfrac{3}{4}x^{-2}-7x+c$ | M1A1A1 |
| | | **(3)** |
| | | **Total 3** |

| Question | Scheme | Marks |
|---|---|---|
| **8(a)** | $y=(x-2)(x^2-8x+16) \Rightarrow y=x^3-8x^2+16x-2x^2+16x-32 \Rightarrow$<br>$y=x^3 \pm ...x^2 \pm ...x \pm 32$ | M1 |
| | $=x^3-10x^2+32x-32$ | A1 |
| | $\frac{dy}{dx}=3x^2-20x+32*$ | M1A1* |
| | | **(4)** |
| **(b)** | $x=6 \Rightarrow y=(6-2)(6-4)^2=16$ | B1 |
| | $\frac{dy}{dx}=3(6)^2-20(6)+32=20$ | B1 |
| | $y-"16"="20"(x-6)$ | M1 |
| | $y=20x-104$ | A1 |
| | | **(4)** |
| **(c)** | $3x^2-20x+32="20" \Rightarrow 3x^2-20x+12=0$ | M1 |
| | $3x^2-20x+12=0 \Rightarrow (3x-2)(x-6)=0 \Rightarrow x=...$ | dM1 |
| | $\alpha=\frac{2}{3}$ | A1 |
| | | **(3)** |
| | | **(11 marks)** |

| Question Number | Scheme | Marks |
|---|---|---|
| **1.** | $\int 12x^3+\frac{1}{6\sqrt{x}}-\frac{3}{2x^4}dx=12\times\frac{x^4}{4}+\frac{1}{6}\times 2x^{\frac{1}{2}}-\frac{3}{2}\times\frac{x^{-3}}{-3}$ | M1 |
| | $=3x^4+\frac{1}{3}x^{\frac{1}{2}}+\frac{1}{2}x^{-3}+c$ | A1A1A1A1 |
| | | **(5)** |
| | | **(5 marks)** |

| Question Number | Scheme | Marks |
|---|---|---|
| **9.** | $\frac{4x^2+9}{2\sqrt{x}}=\frac{4x^2}{2\sqrt{x}}+\frac{9}{2\sqrt{x}}=2x^{\frac{3}{2}}+\frac{9}{2}x^{-\frac{1}{2}}$ | M1 A1 |
| | $\left(\frac{dy}{dx}=\right)\ 3x^{\frac{1}{2}}-\frac{9}{4}x^{-\frac{3}{2}}$ | M1 A1 |
| | $\left(\frac{dy}{dx}=\right)\ 3x^{\frac{1}{2}}-\frac{9}{4}x^{-\frac{3}{2}}=0 \Rightarrow x^2=\frac{3}{4} \Rightarrow x=\frac{\sqrt{3}}{2}$ | M1 A1 |
| | | **(6)** |
| | | **(6 marks)** |