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<table>
<thead>
<tr>
<th>Question</th>
<th>Working</th>
<th>Notes</th>
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<tbody>
<tr>
<td>1</td>
<td>( y = \frac{-5}{4}x - \frac{15}{4} ), gradient = (-\frac{3}{2}) oe ( y = \frac{10}{15}x - \frac{9}{15} ), gradient = (\frac{2}{3}) oe Product of gradients = (-\frac{3}{2} \times \frac{2}{3} = -1 ) ⇒ lines perpendicular</td>
<td>M1 A1 A1 A1 4</td>
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<tr>
<td>2</td>
<td>( x(x + 2) - (x + 1) = 2(x + 1)(x + 2) ) ( x^2 + x - 1 = 2x^2 + 6x + 4 ) ( x^2 + 5x + 5 = 0 ) ( x = \frac{-5 \pm \sqrt{25 - 20}}{2} = -3.62, -1.38 )</td>
<td>M1 A1 M1 A1 4</td>
</tr>
<tr>
<td>3</td>
<td>((3x + 1)(2x - 7) &lt; 0) (-\frac{1}{3} &lt; x &lt; 3 \frac{1}{2})</td>
<td>M1 A1 M1 A1 4</td>
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<td>4</td>
<td>(10! \left(\frac{1}{\sqrt{3}}\right)^3) (= 120 \cdot \frac{1}{27\sqrt{3}}) (= 120 \cdot \frac{\sqrt{3}}{27}) (= \frac{40}{27}\sqrt{3})</td>
<td>Allow all marks if (x^7) included. M1 A1 M1 rationalise A1 4</td>
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| 5 | (a) \( \frac{dy}{dx} = x^2e^x + 2xe^x \) (b) \( \frac{dy}{dx} = 5(x^3 + 2x^2 + 3)^4(3x^2 + 4x) \) | M1 two terms with one correct M1 use chain rule A1 5}
(a) | $x$ | 0 | 0.5 | 1 | 1.5 | 2 | 2.5 | 3 | 3.5 |
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<tbody>
<tr>
<td>$y$</td>
<td>3</td>
<td>2.91</td>
<td>2.63</td>
<td>2.20</td>
<td>1.62</td>
<td>0.95</td>
<td>0.21</td>
<td>-0.53</td>
</tr>
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(b) $y = 3x - 1.5$

(c) $2x - 1 = 2 \cos \left(\frac{x}{2}\right)$
$3x - 1.5 = 3 \cos \left(\frac{x}{2}\right)$
$y = 3x - 1.5$
(a) \( A (1\frac{1}{2} , 0) , B (0 , 1) \)

(b) (i) \( x = 3 \)
(ii) \( y = 2 \)

(c) \[ y = \frac{1}{3} \]

(d) \( \frac{dy}{dx} = \frac{2(x-3) - (2x-3)}{(x-3)^2} = \frac{-3}{(x-3)^2} \)
At \( B, x = 0 \) so \( \frac{dy}{dx} = \frac{-3}{(-3)^2} = \frac{-1}{3} \)
Grad of normal = \(-1/(-1/3) = 3\)
Normal \( y = 3x + 1 \)

(e) At \( D, x = 3 + 1 = \frac{2x-3}{x-3} \)
\( 3x^2 - 8x - 3 = 2x - 3 \)
\( 3x^2 - 10x = 0 \)
\( x(3x - 10) = 0 \)
\( x = 0 \) or \( x = 10/3 \)
At \( D, x = 3\frac{1}{3} \)

B1, B1
B1
B1

two branches in correct quadrants
asymptotes depend on some curve
intercepts

M1 Quotient rule
A1 Result (unsimplified)
A1
B1ft
B1ft
M1
A1
M1
A1
16
**8**

(a) \( k = \frac{\alpha}{\beta} \times \frac{\beta}{\alpha} = 1 \)

(b) \( \alpha \beta = 15 \) and \( \alpha + \beta = -m \)

\[-h = \frac{\alpha}{\beta} + \frac{\beta}{\alpha} = \frac{\alpha^2 + \beta^2}{\alpha \beta} = \frac{(\alpha + \beta)^2 - 2\alpha \beta}{\beta \alpha} \]

\[\Rightarrow h = \frac{30 - m^2}{15} \]

(c) \( \alpha \beta = 15 \Rightarrow \alpha(2\alpha + 1) = 15 \)

\[2\alpha^2 + \alpha - 15 = 0 \]

\[(2\alpha - 5)(\alpha + 3) = 0 \]

\[\alpha = 2.5 \text{ or } \alpha = -3 \]

(d) \( \beta = 2 \times 2.5 + 1 = 6 \) or \( \beta = 2 \times -3 + 1 = -5 \)

\[m = -(\alpha + \beta) = -(2.5 + 6) \text{ or } -(-3 - 5) \]

\[m = -8.5 \text{ or } 8 \]

**9**

(a) \( BD^2 = 5^2 + 6^2 = 61, BC^2 = 8^2 + 6^2 = 100, CD^2 = 8^2 + 5^2 = 89 \)

\[100 = 61 + 89 - 2 \sqrt{61 \cdot 89} \cos \angle BDC \]

\[\cos \angle BDC = \frac{25}{\sqrt{61 \cdot 89}} \approx 0.3393 \]

\[\angle BDC = 70.2^\circ \]

(b) Area \( BDC = \frac{1}{2} \sqrt{61 \cdot 89} \sin 70.2^\circ \approx 34.7 \text{ cm}^2 \) (3sf)

(c) Area \( DAC = \frac{1}{2} \times 5 \times 8 = 20 \)

(d) \( 20 = \frac{1}{2} \times \sqrt{89} \times AE \Rightarrow AE = \frac{40}{\sqrt{89}} \)

(e) Angle is \( \angle BEA \)

\[\tan \angle BEA = \frac{6}{AE} = \frac{6 \sqrt{89}}{40} \]

\[= 1.415 \]

\[\Rightarrow \angle BEA = 54.8^\circ \]
10

(a)  
(i) \[ \overrightarrow{BC} = -\frac{1}{2} \mathbf{c} - \mathbf{a} + \frac{1}{2} \mathbf{c} - \mathbf{a} \]

(ii) \[ \overrightarrow{PQ} = \frac{1}{2} \mathbf{a} + \frac{1}{2} \mathbf{c} + \frac{1}{2}(\frac{1}{2} \mathbf{c} - \mathbf{a}) = \frac{5}{12} \mathbf{a} + \frac{7}{6} \mathbf{c} \]

(b)  
(i) \[ \overrightarrow{AT} = -\frac{3}{4} \mathbf{a} + \lambda \left( \frac{5}{12} \mathbf{a} + \frac{7}{6} \mathbf{c} \right) \]

(ii) \[ \overrightarrow{AT} = \mu (\mathbf{c} - \mathbf{a}) \]

(c) \[ -\frac{3}{4} \mathbf{a} + \lambda \left( \frac{5}{12} \mathbf{a} + \frac{7}{6} \mathbf{c} \right) = \mu (\mathbf{c} - \mathbf{a}) \]
\[ \Rightarrow -\frac{3}{4} + \frac{5}{12} \lambda = -\mu \text{ and } \frac{7}{6} \lambda = \mu \]
\[ \Rightarrow \frac{5}{12} \lambda = 9 - 8 \lambda \]
\[ \Rightarrow \lambda = \frac{9}{13} \]
\[ \Rightarrow PT: TQ = 9 : 4 \]

11

(a) \[ V = \pi \int_0^h x^2 \, dy = \pi \int_0^h (10y - y^2) \, dy \]
\[ = \pi \left[ 5y^2 - \frac{1}{3} y^3 \right]_0^h \]
\[ = \pi \left[ 5h^2 - \frac{1}{3} h^3 \right] \]
\[ = \frac{1}{3} \pi h^2 (15 - h) \]

(b) \[ V = \pi (5h^2 - \frac{1}{3}h^3) \Rightarrow \frac{dV}{dh} = \pi (10h - h^2) \]

(c) \[ \frac{dV}{dt} = \pi (10h - h^2) \frac{dh}{dt} \]
When \( h = 1.5 \), \( 6 = \pi (15 - 2.25) \frac{dh}{dt} \)
\[ \Rightarrow \frac{dh}{dt} = 6/(12.75 \pi) = 0.150 \text{ cm/s} (3sf) \]

(d) \[ W = \pi y^2 = \pi (10y - y^2) \]
When depth is \( h \), \( W = \pi (10h - h^2) \)
\[ \frac{dW}{dt} = \pi (10h - h^2) \frac{dh}{dt} = W \frac{dh}{dt} \]
Since \( \frac{dW}{dt} = 6 \), \( \frac{dh}{dt} = 6/W \) so \( k = 6 \)