



# **Mark Scheme (Results)**

Summer 2018

Pearson Edexcel GCE Mathematics  
Core Mathematics C4 (6666)

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## General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the **candidate's response is not worthy of credit according to the mark scheme.**
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

## EDEXCEL GCE MATHEMATICS

## General Instructions for Marking

1. The total number of marks for the paper is 75.
2. The Edexcel Mathematics mark schemes use the following types of marks:
  - **M marks: method marks are awarded for 'knowing a method and attempting to apply it', unless otherwise indicated.**
  - **A marks:** Accuracy marks can only be awarded if the relevant method (M) marks have been earned.
  - **B marks** are unconditional accuracy marks (independent of M marks)
  - Marks should not be subdivided.
3. Abbreviations

These are some of the traditional marking abbreviations that will appear in the mark schemes.

- bod – benefit of doubt
  - ft – follow through
  - the symbol  $\checkmark$  will be used for correct ft
  - cao – correct answer only
  - cso - correct solution only. There must be no errors in this part of the question to obtain this mark
  - isw – ignore subsequent working
  - awrt – answers which round to
  - SC: special case
  - o.e. – or equivalent (and appropriate)
  - dep – dependent
  - indep – independent
  - dp decimal places
  - sf significant figures
  - \* The answer is printed on the paper
  - $\square$  The second mark is dependent on gaining the first mark
  - dM1 denotes a method mark which is dependent upon the award of the previous method mark.
  - aef “any equivalent form”
4. All **A marks** are ‘correct answer only’ (cao), unless shown, for example, as **A1 ft** to indicate that previous wrong working is to be followed through. After a misread however, the subsequent A marks affected are treated as A ft, but manifestly absurd answers should never be awarded A marks.
  5. For misreading which does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, in that part of the question affected.

6. If a candidate makes more than one attempt at any question:
  - If all but one attempt is crossed out, mark the attempt which is NOT crossed out.
  - If either all attempts are crossed out or none are crossed out, mark all the attempts and score the highest single attempt.
  
7. Ignore wrong working or incorrect statements following a correct answer.

## General Principles for Core Mathematics Marking

*(But note that specific mark schemes may sometimes override these general principles)*

### Method mark for solving 3 term quadratic:

#### 1. Factorisation

$(x^2 + bx + c) = (x + p)(x + q)$ , where  $|pq| = |c|$ , leading to  $x = \dots$

$(ax^2 + bx + c) = (mx + p)(nx + q)$ , where  $|pq| = |c|$  and  $|mn| = |a|$ , leading to  $x = \dots$

#### 2. Formula

Attempt to use the correct formula (with values for  $a$ ,  $b$  and  $c$ ).

#### 3. Completing the square

Solving  $x^2 + bx + c = 0$ :  $\left(x \pm \frac{b}{2}\right)^2 \pm q \pm c = 0$ ,  $q \neq 0$ , leading to  $x = \dots$

### Method marks for differentiation and integration:

#### 1. Differentiation

Power of at least one term decreased by 1. ( $x^n \rightarrow x^{n-1}$ )

#### 2. Integration

Power of at least one term increased by 1. ( $x^n \rightarrow x^{n+1}$ )

### Use of a formula

Where a method involves using a formula that has been learnt, the advice given in recent **examiners' reports is that the formula should be quoted first.**

Normal marking procedure is as follows:

Method mark for quoting a correct formula and attempting to use it, even if there are small errors in the substitution of values.

Where the formula is not quoted, the method mark can be gained by implication from correct working with values, but may be lost if there is any mistake in the working.

### Exact answers

**Examiners' reports have emphasised that where, for example, an exact answer is asked for,** or working with surds is clearly required, marks will normally be lost if the candidate resorts to using rounded decimals.

Question Number	Scheme	Notes	Marks
1. (a)	$\sqrt{4-9x} = (4-9x)^{\frac{1}{2}} = \underline{(4)^{\frac{1}{2}}}\left(1 - \frac{9x}{4}\right)^{\frac{1}{2}} = \underline{2}\left(1 - \frac{9x}{4}\right)^{\frac{1}{2}}$	$\underline{(4)^{\frac{1}{2}}}$ or $\underline{2}$	<b>B1</b>
	$= \{2\} \left[ 1 + \left(\frac{1}{2}\right)(kx) + \frac{(\frac{1}{2})(-\frac{1}{2})}{2!}(kx)^2 + \dots \right]$	see notes	M1 A1ft
	$= \{2\} \left[ 1 + \left(\frac{1}{2}\right)\left(-\frac{9x}{4}\right) + \frac{(\frac{1}{2})(-\frac{1}{2})}{2!}\left(-\frac{9x}{4}\right)^2 + \dots \right]$		
	$= 2 \left[ 1 - \frac{9}{8}x - \frac{81}{128}x^2 + \dots \right]$	see notes	
	$= 2 - \frac{9}{4}x; -\frac{81}{64}x^2 + \dots$	isw	A1; A1
			<b>[5]</b>

(b)	$\sqrt{310} = 10\sqrt{3.1} = 10\sqrt{4-9(0.1)}$ , so $x = 0.1$	E.g. For $10\sqrt{3.1}$ (can be implied by later working) <b>and</b> $x = 0.1$ (or uses $x = 0.1$ ) <b>Note:</b> $\sqrt{(100)(3.1)}$ by itself is B0	B1
	When $x = 0.1$ $\sqrt{4-9x} \approx 2 - \frac{9}{4}(0.1) - \frac{81}{64}(0.1)^2 + \dots$	Substitutes their $x$ , where $ x  < \frac{4}{9}$ into all three terms of their binomial expansion	M1
	$= 2 - 0.225 - 0.01265625 = 1.76234375$		
	So, $\sqrt{310} \approx 17.6234375 = \underline{17.623}$ (3 dp)	17.623 <b>cao</b>	A1 <b>cao</b>
	<b>Note:</b> the calculator value of $\sqrt{310}$ is 17.60681686... which is 17.607 to 3 decimal places		<b>[3]</b>
			<b>8 marks</b>

**Question 1 Notes**

1. (a)	<b>B1</b>	$\underline{(4)^{\frac{1}{2}}}$ or $\underline{2}$ outside brackets or $\underline{2}$ as candidate's constant term in their binomial expansion
	<b>M1</b>	Expands $(\dots + kx)^{\frac{1}{2}}$ to give any 2 terms out of 3 terms simplified or un-simplified, E.g. $1 + \left(\frac{1}{2}\right)(kx)$ or $\left(\frac{1}{2}\right)(kx) + \frac{(\frac{1}{2})(-\frac{1}{2})}{2!}(kx)^2$ or $1 + \dots + \frac{(\frac{1}{2})(-\frac{1}{2})}{2!}(kx)^2$ where $k$ is a numerical value and <b>where</b> $k \neq 1$
	<b>A1ft</b>	A correct simplified or un-simplified $1 + \left(\frac{1}{2}\right)(kx) + \frac{(\frac{1}{2})(-\frac{1}{2})}{2!}(kx)^2$ expansion with <b>consistent</b> $(kx)$
	<b>Note</b>	$(kx)$ , $k \neq 1$ must be consistent (on the RHS, not necessarily on the LHS) in their expansion
	<b>Note</b>	Award B1M1A0 for $2 \left[ 1 + \left(\frac{1}{2}\right)(-9x) + \frac{(\frac{1}{2})(-\frac{1}{2})}{2!}\left(-\frac{9x}{4}\right)^2 + \dots \right]$ because $(kx)$ is not consistent
	<b>Note</b>	<b>Incorrect bracketing:</b> $2 \left[ 1 + \left(\frac{1}{2}\right)\left(-\frac{9x}{4}\right) + \frac{(\frac{1}{2})(-\frac{1}{2})}{2!}\left(-\frac{9x^2}{4}\right) + \dots \right]$ is B1M1A0 unless recovered
	<b>A1</b>	$2 - \frac{9}{4}x$ ( <b>simplified fractions</b> ) or allow $2 - 2.25x$ or $2 - 2\frac{1}{4}x$
	<b>A1</b>	Accept only $-\frac{81}{64}x^2$ or $-1\frac{17}{64}x^2$ or $-1.265625x^2$

**Question 1 Notes Continued**

1. (a) ctd.	<b>SC</b>	If a candidate <i>would otherwise score</i> 2 <sup>nd</sup> A0, 3 <sup>rd</sup> A0 (i.e. scores A0A0 in the final two marks to (a)) then <b>allow Special Case 2<sup>nd</sup> A1 for either</b> <b>SC:</b> $2\left[1 - \frac{9}{8}x; \dots\right]$ or <b>SC:</b> $2\left[1 + \dots - \frac{81}{128}x^2 + \dots\right]$ or <b>SC:</b> $\lambda\left[1 - \frac{9}{8}x - \frac{81}{128}x^2 + \dots\right]$ or <b>SC:</b> $\left[\lambda - \frac{9\lambda}{8}x - \frac{81\lambda}{128}x^2 + \dots\right]$ (where $\lambda$ can be 1 or omitted), where each term in the $[\dots]$ is a simplified fraction or a decimal, <b>OR SC:</b> for $2 - \frac{18}{8}x - \frac{162}{128}x^2 + \dots$ (i.e. for not simplifying their correct coefficients)																																																	
	<b>Note</b>	Candidates who write $2\left[1 + \binom{1}{2k}\left(\frac{9x}{4}\right)^k + \frac{\binom{1}{2}(-\frac{1}{2})}{2!}\left(\frac{9x}{4}\right)^2 + \dots\right]$ , where $k = \frac{9}{4}$ and not $-\frac{9}{4}$ and achieve $2 + \frac{9}{4}x; -\frac{81}{64}x^2 + \dots$ will get B1M1A1A0A1																																																	
	<b>Note</b>	<b>Ignore</b> extra terms beyond the term in $x^2$																																																	
	<b>Note</b>	You can ignore subsequent working following a correct answer																																																	
	<b>Note</b>	Allow B1M1A1 for $2\left[1 + \binom{1}{2}\left(-\frac{9x}{4}\right) + \frac{\binom{1}{2}(-\frac{1}{2})}{2!}\left(\frac{9x}{4}\right)^2 + \dots\right]$																																																	
	<b>Note</b>	Allow B1M1A1A1A1 for $2\left[1 + \binom{1}{2}\left(-\frac{9x}{4}\right) + \frac{\binom{1}{2}(-\frac{1}{2})}{2!}\left(\frac{9x}{4}\right)^2 + \dots\right] = 2 - \frac{9}{4}x - \frac{81}{64}x^2 + \dots$																																																	
(b)	<b>Note</b>	Give B1 M1 for $\sqrt{310} \approx 10\left(2 - \frac{9}{4}(0.1) - \frac{81}{64}(0.1)^2\right)$																																																	
	<b>Note</b>	<b>Other alternative suitable values for <math>x</math> for <math>\sqrt{310} \approx \beta\sqrt{4 - 9(\text{their } x)}</math></b>																																																	
		<table border="1"> <thead> <tr> <th><math>b</math></th> <th><math>x</math></th> <th>Estimate</th> </tr> </thead> <tbody> <tr> <td>7</td> <td><math>-\frac{38}{147}</math></td> <td>17.479</td> </tr> <tr> <td>8</td> <td><math>-\frac{3}{32}</math></td> <td>17.599</td> </tr> <tr> <td>9</td> <td><math>\frac{14}{729}</math></td> <td>17.607</td> </tr> <tr> <td>10</td> <td><math>\frac{1}{10}</math></td> <td>17.623</td> </tr> <tr> <td>11</td> <td><math>\frac{58}{363}</math></td> <td>17.690</td> </tr> <tr> <td>12</td> <td><math>\frac{133}{648}</math></td> <td>17.819</td> </tr> <tr> <td>13</td> <td><math>\frac{122}{507}</math></td> <td>18.009</td> </tr> </tbody> </table>	$b$	$x$	Estimate	7	$-\frac{38}{147}$	17.479	8	$-\frac{3}{32}$	17.599	9	$\frac{14}{729}$	17.607	10	$\frac{1}{10}$	17.623	11	$\frac{58}{363}$	17.690	12	$\frac{133}{648}$	17.819	13	$\frac{122}{507}$	18.009	<table border="1"> <thead> <tr> <th><math>b</math></th> <th><math>x</math></th> <th>Estimate</th> </tr> </thead> <tbody> <tr> <td>14</td> <td><math>\frac{79}{294}</math></td> <td>18.256</td> </tr> <tr> <td>15</td> <td><math>\frac{118}{405}</math></td> <td>18.555</td> </tr> <tr> <td>16</td> <td><math>\frac{119}{384}</math></td> <td>18.899</td> </tr> <tr> <td>17</td> <td><math>\frac{94}{289}</math></td> <td>19.283</td> </tr> <tr> <td>18</td> <td><math>\frac{493}{1458}</math></td> <td>19.701</td> </tr> <tr> <td>19</td> <td><math>\frac{126}{361}</math></td> <td>20.150</td> </tr> <tr> <td>20</td> <td><math>\frac{43}{120}</math></td> <td>20.625</td> </tr> </tbody> </table>	$b$	$x$	Estimate	14	$\frac{79}{294}$	18.256	15	$\frac{118}{405}$	18.555	16	$\frac{119}{384}$	18.899	17	$\frac{94}{289}$	19.283	18	$\frac{493}{1458}$	19.701	19	$\frac{126}{361}$	20.150	20	$\frac{43}{120}$	20.625
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<b>Note</b>	Apply the scheme in the same way for their $\beta$ and their $x$ E.g. Give B1 M1 A1 for $\sqrt{310} \approx 12\left(2 - \frac{9}{4}\left(\frac{133}{648}\right) - \frac{81}{64}\left(\frac{133}{648}\right)^2\right) = 17.819$ (3 dp)																																																		
<b>Note</b>	Allow B1 M1 A1 for $\sqrt{310} \approx 100\left(2 - \frac{9}{4}(0.441) - \frac{81}{64}(0.441)^2\right) = 76.161$ (3 dp)																																																		
<b>Note</b>	Give B1 M1 A0 for $\sqrt{310} \approx 10\left(2 - \frac{9}{4}(0.1) - \frac{81}{64}(0.1)^2 - \frac{729}{512}(0.1)^3\right) = 17.609$ (3 dp)																																																		

**Question 1 Notes Continued**

	<b>Question 1 Notes Continued</b>		
<b>1. (b)</b>	<b>Note</b>	<i>Send to review</i> using $\beta = \sqrt{155}$ and $x = \frac{2}{9}$ (which gives 17.897 (3 dp))	
	<b>Note</b>	<i>Send to review</i> using $\beta = \sqrt{1000}$ and $x = 0.41$ (which gives 27.346 (3 dp))	
<b>1. (a)</b> <b>Alt 1</b>	<b>Alternative method 1:</b> Candidates can apply an alternative form of the binomial expansion $\left\{ (4 - 9x)^{\frac{1}{2}} \right\} = (4)^{\frac{1}{2}} + \binom{\frac{1}{2}}{1} (4)^{-\frac{1}{2}} (-9x) + \frac{\binom{\frac{1}{2}}{2} (-1)^2}{2!} (4)^{-\frac{3}{2}} (-9x)^2$		
	<b>B1</b>	$(4)^{\frac{1}{2}}$ or 2	
	<b>M1</b>	Any two of three (un-simplified) terms correct	
	<b>A1</b>	All three (un-simplified) terms correct	
	<b>A1</b>	$2 - \frac{9}{4}x$ ( <b>simplified fractions</b> ) or allow $2 - 2.25x$ or $2 - 2\frac{1}{4}x$	
	<b>A1</b>	Accept only $-\frac{81}{64}x^2$ or $-1\frac{17}{64}x^2$ or $-1.265625x^2$	
	<b>Note</b>	The terms in C need to be evaluated. So ${}^{\frac{1}{2}}C_0(4)^{\frac{1}{2}} + {}^{\frac{1}{2}}C_1(4)^{-\frac{1}{2}}(-9x) + {}^{\frac{1}{2}}C_2(4)^{-\frac{3}{2}}(-9x)^2$ without further working is B0M0A0	
<b>1. (a)</b>	<b>Alternative Method 2: Maclaurin Expansion</b> $f(x) = (4 - 9x)^{\frac{1}{2}}$		
	$f''(x) = -\frac{81}{4}(4 - 9x)^{-\frac{3}{2}}$	Correct $f'''(x)$	B1
	$f'(x) = \frac{1}{2}(4 - 9x)^{-\frac{1}{2}}(-9)$	$\pm a(4 - 9x)^{-\frac{1}{2}}; a \neq \pm 1$	M1
		$\frac{1}{2}(4 - 9x)^{-\frac{1}{2}}(-9)$	A1 oe
	$\left\{ \therefore f(0) = 2, f'(0) = -\frac{9}{4} \text{ and } f''(0) = -\frac{81}{32} \right\}$		
	So, $f(x) = 2 - \frac{9}{4}x; -\frac{81}{64}x^2 + \dots$		A1; A1



Question Number	Scheme	Notes	Marks
<b>2.</b>	$x^2 + xy + y^2 - 4x - 5y + 1 = 0$		
(a)	<del><math>\frac{dx}{dx}</math></del> $\left\{ \frac{dx}{dx} \right\} 2x + \left( y + x \frac{dy}{dx} \right) + 2y \frac{dy}{dx} - 4 - 5 \frac{dy}{dx} = 0$		M1 <u>A1</u> <u>B1</u>
	$2x + y - 4 + (x + 2y - 5) \frac{dy}{dx} = 0$		dM1
	$\frac{dy}{dx} = \frac{2x + y - 4}{5 - x - 2y}$ or $\frac{4 - 2x - y}{x + 2y - 5}$	<b>o.e.</b>	A1 <b>cso</b>
			[5]
(b)	$\left\{ \frac{dy}{dx} = 0 \Rightarrow \right\} 2x + y - 4 = 0$		M1
	$\{y = 4 - 2x \Rightarrow\} x^2 + x(4 - 2x) + (4 - 2x)^2 - 4x - 5(4 - 2x) + 1 = 0$		dM1
	$x^2 + 4x - 2x^2 + 16 - 16x + 4x^2 - 4x - 20 + 10x + 1 = 0$		
	gives $3x^2 - 6x - 3 = 0$ or $3x^2 - 6x = 3$ or $x^2 - 2x - 1 = 0$	Correct 3TQ in terms of $x$	A1
	$(x - 1)^2 - 1 - 1 = 0$ and $x = \dots$	Method mark for solving a 3TQ in $x$	ddM1
	$x = 1 + \sqrt{2}, 1 - \sqrt{2}$	$x = 1 + \sqrt{2}, 1 - \sqrt{2}$ only	A1
			[5]
(b) <b>Alt 1</b>	$\left\{ \frac{dy}{dx} = 0 \Rightarrow \right\} 2x + y - 4 = 0$		M1
	$\left\{ x = \frac{4 - y}{2} \Rightarrow \right\} \left( \frac{4 - y}{2} \right)^2 + \left( \frac{4 - y}{2} \right) y + y^2 - 4 \left( \frac{4 - y}{2} \right) - 5y + 1 = 0$		dM1
	$\left( \frac{16 - 8y + y^2}{2} \right) + \left( \frac{4y - y^2}{2} \right) + y^2 - 2(4 - y) - 5y + 1 = 0$		
	gives $3y^2 - 12y - 12 = 0$ or $3y^2 - 12y = 12$ or $y^2 - 4y - 4 = 0$	Correct 3TQ in terms of $y$	A1
	$(y - 2)^2 - 4 - 4 = 0$ and $y = \dots$ $x = \frac{4 - (2 + 2\sqrt{2})}{2}, x = \frac{4 - (2 - 2\sqrt{2})}{2}$	Solves a 3TQ in $y$ and finds at least one value for $x$	ddM1
	$x = 1 + \sqrt{2}, 1 - \sqrt{2}$	$x = 1 + \sqrt{2}, 1 - \sqrt{2}$ only	A1
		[5]	
			<b>10</b>
(a) <b>Alt 1</b>	<del><math>\frac{dx}{dx}</math></del> $\left\{ \frac{dx}{dx} \right\} 2x \frac{dx}{dy} + \left( y \frac{dx}{dy} + x \right) + 2y - 4 \frac{dx}{dy} - 5 = 0$		M1 <u>A1</u> <u>B1</u>
	$x + 2y - 5 + (2x + y - 4) \frac{dx}{dy} = 0$		dM1
	$\frac{dy}{dx} = \frac{2x + y - 4}{5 - x - 2y}$ or $\frac{4 - 2x - y}{x + 2y - 5}$	<b>o.e.</b>	A1 <b>cso</b>
			[5]

**Question 2 Notes**

2. (a)	<b>M1</b>	Differentiates implicitly to include either $x \frac{dy}{dx}$ or $y^2 \rightarrow 2y \frac{dy}{dx}$ or $-5y \rightarrow -5 \frac{dy}{dx}$ .  (Ignore $\frac{dy}{dx} = \dots$ )
	<b>A1</b>	$x^2 \rightarrow 2x$ <b>and</b> $y^2 - 4x - 5y + 1 = 0 \rightarrow 2y \frac{dy}{dx} - 4 - 5 \frac{dy}{dx} = 0$
	<b>B1</b>	$xy \rightarrow y + x \frac{dy}{dx}$
	<b>Note</b>	If an extra term appears then award 1 <sup>st</sup> A0
	<b>Note</b>	$2x + y + x \frac{dy}{dx} + 2y \frac{dy}{dx} - 4 - 5 \frac{dy}{dx} \rightarrow 2x + y - 4 = -x \frac{dy}{dx} - 2y \frac{dy}{dx} + 5 \frac{dy}{dx}$ will get 1 <sup>st</sup> A1 (implied) as the "= 0" can be implied the rearrangement of their equation.
	<b>dM1</b>	<b>dependent on the previous M mark</b> An attempt to factorise out <b>all the terms in</b> $\frac{dy}{dx}$ as long as there are <b>at least two terms in</b> $\frac{dy}{dx}$ .
	<b>A1</b> <b>cso</b>	$\frac{2x + y - 4}{5 - x - 2y}$ or $\frac{4 - 2x - y}{x + 2y - 5}$ If the candidate's solution is not completely correct, then do not give the final A mark
(b)	<b>M1</b>	Sets the numerator of their $\frac{dy}{dx}$ equal to zero (or the denominator of their $\frac{dx}{dy}$ equal to zero) o.e.
	<b>Note</b>	This mark can also be gained by setting $\frac{dy}{dx}$ equal to zero in their differentiated equation from (a)
	<b>Note</b>	<b>If the numerator involves one variable only then only the 1<sup>st</sup> M1 mark is possible in part (b).</b>
	<b>dM1</b>	<b>dependent on the previous M mark</b> Substitutes their $x$ or their $y$ (from their numerator = 0) into the printed equation to give an equation in one variable only
	<b>A1</b> <b>Note</b>	For obtaining the correct 3TQ. E.g.: either $3x^2 - 6x - 3 = 0$ or $-3x^2 + 6x + 3 = 0$ This mark can also be awarded for a correct 3 term equation. E.g. either $3x^2 - 6x = 3$ $x^2 - 2x - 1 = 0$ or $x^2 = 2x + 1$ are all fine for A1
	<b>ddM1</b>	<b>dependent on the previous 2 M marks</b> See page 6: Method mark for solving THEIR 3-term quadratic in one variable <b>Quadratic Equation to solve:</b> $3x^2 - 6x - 3 = 0$ <b>Way 1:</b> $x = \frac{6 \pm \sqrt{(-6)^2 - 4(3)(-3)}}{2(3)}$ <b>Way 2:</b> $x^2 - 2x - 1 = 0 \Rightarrow (x-1)^2 - 1 - 1 = 0 \Rightarrow x = \dots$ <b>Way 3:</b> Or writes down at least one <i>exact</i> correct $x$ -root ( <b>or one correct <math>x</math>-root to 2 dp</b> ) from <i>their</i> quadratic equation. This is usually found on their calculator. <b>Way 4: (Only allowed if their 3TQ can be factorised)</b> <ul style="list-style-type: none"> <li><math>(x^2 + bx + c) = (x + p)(x + q)</math>, where <math> pq  =  c </math>, leading to <math>x = \dots</math></li> <li><math>(ax^2 + bx + c) = (mx + p)(nx + q)</math>, where <math> pq  =  c </math> and <math> mn  = a</math>, leading to <math>x = \dots</math></li> </ul>
	<b>Note</b>	If a candidate applies <i>the alternative method</i> then they also need to use their $x = \frac{4 - y}{2}$ to find <b>at least one value</b> for $x$ in order to gain the final M mark.
<b>A1</b>	Exact values of $x = 1 + \sqrt{2}$ , $1 - \sqrt{2}$ (or $1 \pm \sqrt{2}$ ), <b>cao</b> Apply isw if $y$ -values are also found.	
<b>Note</b>	It is possible for a candidate who does not achieve full marks in part (a), (but has a correct numerator for $\frac{dy}{dx}$ ) to gain all 5 marks in part (b)	

**Question 2 Notes**

<b>2. (a) Alt 1</b>	<b>M1</b>	Differentiates implicitly to include either $y \frac{dx}{dy}$ or $x^2 \rightarrow 2x \frac{dx}{dy}$ or $-4x \rightarrow -4 \frac{dx}{dy}$ . (Ignore $\frac{dx}{dy} = \dots$ )
	<b>A1</b>	$x^2 \rightarrow 2x \frac{dx}{dy}$ <b>and</b> $y^2 - 4x - 5y + 1 = 0 \rightarrow 2y - 4 \frac{dx}{dy} - 5 = 0$
	<b>B1</b>	$xy \rightarrow y \frac{dx}{dy} + x$
	<b>Note</b>	If an extra term appears then award 1 <sup>st</sup> A0
	<b>Note</b>	$2x \frac{dx}{dy} + y \frac{dx}{dy} + x + 2y - 4 \frac{dx}{dy} - 5 \rightarrow x + 2y - 5 = -2x \frac{dx}{dy} - y \frac{dx}{dy} + 4 \frac{dx}{dy}$ will get 1 <sup>st</sup> A1 (implied) as the " $= 0$ " can be implied the rearrangement of their equation.
	<b>dM1</b>	<b>dependent on the previous M mark</b> An attempt to factorise out <b>all the terms in</b> $\frac{dx}{dy}$ as long as there are <b>at least two terms</b> in $\frac{dx}{dy}$
	<b>A1</b>	$\frac{dy}{dx} = \frac{2x + y - 4}{5 - x - 2y}$ or $\frac{dy}{dx} = \frac{4 - 2x - y}{x + 2y - 5}$
<b>cso</b>	If the candidate's solution is not completely correct, then do not give the final A mark	
<b>(a)</b>	<b>Note</b>	Writing down <b>from no working</b> <ul style="list-style-type: none"> <li>• <math>\frac{dy}{dx} = \frac{2x + y - 4}{5 - x - 2y}</math> or <math>\frac{dy}{dx} = \frac{4 - 2x - y}{x + 2y - 5}</math> scores M1 A1 B1 M1 A1</li> <li>• <math>\frac{dy}{dx} = \frac{4 - 2x - y}{5 - x - 2y}</math> or <math>\frac{dy}{dx} = \frac{2x + y - 4}{x + 2y - 5}</math> scores M1 A0 B1 M1 A0</li> </ul>
	<b>Note</b>	Writing $2x dx + y dx + x dy + 2y dy - 4 dx - 5 dy = 0$ scores M1 A1 B1



Question Number	Scheme	Notes	Marks
3. (i)	$\frac{13-4x}{(2x+1)^2(x+3)} \equiv \frac{A}{2x+1} + \frac{B}{(2x+1)^2} + \frac{C}{x+3}$		
(a)	$B=6, C=1$	At least one of $B=6$ or $C=1$	B1
		Both $B=6$ and $C=1$	B1
	$13-4x \equiv A(2x+1)(x+3) + B(x+3) + C(2x+1)^2$ $x=-3 \Rightarrow 25 = 25C \Rightarrow C=1$ $x=-\frac{1}{2} \Rightarrow 13--2 = \frac{5}{2}B \Rightarrow 15 = 2.5B \Rightarrow B=6$	Writes down a correct identity and attempts to find the value of either one of $A$ or $B$ or $C$	M1
	Either $x^2: 0 = 2A + 4C$ , constant: $13 = 3A + 3B + C$ , $x: -4 = 7A + B + 4C$ or $x=0 \Rightarrow 13 = 3A + 3B + C$ leading to $A = -2$	Using a correct identity to find $A = -2$	A1
			[4]
(b)	$\int \frac{13-4x}{(2x+1)^2(x+3)} dx = \int \frac{-2}{(2x+1)} + \frac{6}{(2x+1)^2} + \frac{1}{x+3} dx$		
	$= \frac{(-2)}{2} \ln(2x+1) + \frac{6(2x+1)^{-1}}{(-1)(2)} + \ln(x+3) \{+c\}$ o.e. $\{-\ln(2x+1) - 3(2x+1)^{-1} + \ln(x+3) \{+c\}\}$	See notes	M1
		<b>At least two</b> terms correctly integrated	A1ft
		Correct answer, o.e. Simplified or un-simplified. The correct answer must be stated on one line Ignore the absence of '+c'	A1
			[3]
(ii)	$\{(e^x + 1)^3 =\} e^{3x} + 3e^{2x} + 3e^x + 1$	$e^{3x} + 3e^{2x} + 3e^x + 1$ , simplified or un-simplified	B1
		At least 3 examples (see notes) of correct ft integration	M1
	$\left\{ \int (e^x + 1)^3 dx \right\} = \frac{1}{3}e^{3x} + \frac{3}{2}e^{2x} + 3e^x + x \{+c\}$	$\frac{1}{3}e^{3x} + \frac{3}{2}e^{2x} + 3e^x + x$ , simplified or un-simplified with or without +c	A1
			[3]
(iii)	$\int \frac{1}{4x+5x^{\frac{1}{3}}} dx, x > 0; u^3 = x$		
	$3u^2 \frac{du}{dx} = 1$	$3u^2 \frac{du}{dx} = 1$ or $\frac{dx}{du} = 3u^2$ or $\frac{du}{dx} = \frac{1}{3}x^{-\frac{2}{3}}$ or $3u^2 du = dx$ o.e.	B1
	$= \int \frac{1}{4u^3 + 5u} \cdot 3u^2 du \left\{ = \int \frac{3u}{4u^2 + 5} du \right\}$	Expression of the form $\int \frac{\pm ku^2}{4u^3 \pm 5u} \{du\}$ , $k \neq 0$ Does not have to include integral sign or $du$ Can be implied by later working	M1
	$= \frac{3}{8} \ln(4u^2 + 5) \{+c\}$	<b>dependent on the previous M mark</b> $\pm \lambda \ln(4u^2 + 5)$ ; $\lambda$ is a constant; $\lambda \neq 0$	dM1
	$= \frac{3}{8} \ln\left(4x^{\frac{2}{3}} + 5\right) \{+c\}$	Correct answer in $x$ with or without +c	A1
			[4]
			<b>14</b>

**Question 3 Notes**

3. (iii) Alt 1	<b>Alternative method 1 for part (iii)</b>	
		Attempts to multiply numerator and denominator by $x^{-\frac{1}{3}}$ M1
	$\left\{ \int \frac{1}{4x+5x^{\frac{2}{3}}} dx \right\} = \int \frac{x^{-\frac{1}{3}}}{4x^{\frac{2}{3}}+5} dx$	Expression of the form $\int \frac{\pm kx^{-\frac{1}{3}}}{4x^{\frac{2}{3}}+5} dx, k \neq 0$ Does not have to include integral sign or $du$ Can be implied by later working M1
	$= \frac{3}{8} \ln \left( 4x^{\frac{2}{3}} + 5 \right) \{+ c\}$	$\pm \lambda \ln(4x^{\frac{2}{3}} + 5); \lambda$ is a constant; $\lambda \neq 0$ dM1
		Correct answer in $x$ with or without $+ c$ A1
<b>[4]</b>		
3. (i) (a)	<b>M1</b>	Writes down <b>a correct identity</b> (although this can be implied) and attempts <b>to find the value of at least one</b> of either $A$ or $B$ or $C$ . This can be achieved by <b>either</b> substituting values into their identity <b>or</b> comparing coefficients.
	<b>Note</b>	The correct partial fraction from no working scores B1B1M1A1
(i) (b)	<b>M1</b>	At least 2 of either $\pm \frac{P}{(2x+1)} \rightarrow \pm D \ln(2x+1)$ or $\pm D \ln(x+\frac{1}{2})$ or $\pm \frac{Q}{(2x+1)^2} \rightarrow \pm E(2x+1)^{-1}$ or $\pm \frac{R}{(x+3)} \rightarrow \pm F \ln(x+3)$ for their constants $P, Q, R$ .
	<b>A1ft</b>	At least two terms from any of $\pm \frac{P}{(2x+1)}$ or $\pm \frac{Q}{(2x+1)^2}$ or $\pm \frac{R}{(x+3)}$ correctly integrated.
	<b>Note</b>	Can be un-simplified for the A1ft mark.
	<b>A1</b>	Correct answer of $\frac{(-2)}{2} \ln(2x+1) + \frac{6(2x+1)^{-1}}{(-1)(2)} + \ln(x+3) \{+ c\}$ simplified or un-simplified. with or without $+ c$ .
	<b>Note</b>	Allow final A1 for equivalent answers, e.g. $\ln\left(\frac{x+3}{2x+1}\right) - \frac{3}{2x+1} \{+ c\}$ or $\ln\left(\frac{2x+6}{2x+1}\right) - \frac{3}{2x+1} \{+ c\}$
	<b>Note</b>	<b>Beware that</b> $\int \frac{-2}{(2x+1)} dx = \int \frac{-1}{(x+\frac{1}{2})} dx = -\ln(x+\frac{1}{2}) \{+ c\}$ is correct integration
	<b>Note</b>	E.g. Allow M1 A1ft A1 for a correct un-simplified $\ln(x+3) - \ln(x+\frac{1}{2}) - \frac{3}{2}(x+\frac{1}{2})^{-1} \{+ c\}$
	<b>Note</b>	Condone 1 <sup>st</sup> A1ft for poor bracketing, but do not allow poor bracketing for the final A1 E.g. Give final A0 for $-\ln 2x+1 - 3(2x+1)^{-1} + \ln x+3 \{+ c\}$ unless recovered
(ii)	<b>Note</b>	Give B1 for an un-simplified $e^{3x} + 2e^{2x} + e^{2x} + 2e^x + e^x + 1$
	<b>M1</b>	At least 3 of either $ae^{3x} \rightarrow \frac{a}{3}e^{3x}$ or $be^{2x} \rightarrow \frac{b}{2}e^{2x}$ or $de^x \rightarrow de^x$ or $\mu \rightarrow \mu x; \alpha, \beta, \delta, \mu \neq 0$
	<b>Note</b>	Give A1 for an un-simplified $\frac{1}{3}e^{3x} + e^{2x} + \frac{1}{2}e^{2x} + 2e^x + e^x + x$ , with or without $+ c$
(iii)	<b>Note</b>	1 <sup>st</sup> M1 can be implied by $\int \frac{\pm ku}{4u^2 \pm 5} \{du\}, k \neq 0$ . Does not have to include integral sign or $du$
	<b>Note</b>	Condone 1 <sup>st</sup> M1 for expressions of the form $\int \left( \frac{\pm 1}{4u^3 \pm 5u} \cdot \frac{\pm k}{u^{-2}} \right) \{du\}, k \neq 0$
	<b>Note</b>	Give 2 <sup>nd</sup> M0 for $\frac{3u}{8u} \ln(4u^2 + 5) \{+ c\}$ ( $u$ 's not cancelled) unless recovered in later working
	<b>Note</b>	E.g. Give 2 <sup>nd</sup> M0 for integration leading to $\frac{3}{4}u \ln(4u^2 + 5)$ as this is not in the form $\pm \lambda \ln(4u^2 + 5)$

<b>Note</b>	Condone 2 <sup>nd</sup> M1 for poor bracketing, but do not allow poor bracketing for the final A1 E.g. Give final A0 for $\frac{3}{8} \ln 4x^{\frac{2}{3}} + 5 \{+c\}$ unless recovered
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Question Number	Scheme	Notes	Marks
<b>3. (ii) Alt 1</b>	$\int (e^x + 1)^3 dx; u = e^x + 1 \Rightarrow \frac{du}{dx} = e^x$		
	$\left\{ = \int \frac{u^3}{(u-1)} du = \int \left( u^2 + u + 1 + \frac{1}{u-1} \right) du \right.$	$\int \left( u^2 + u + 1 + \frac{1}{u-1} \right) \{du\}$ where $u = e^x + 1$	B1
	$= \frac{1}{3}u^3 + \frac{1}{2}u^2 + u + \ln(u-1) \{+c\}$	At least 3 of either $\alpha u^2 \rightarrow \frac{\alpha}{3}u^3$ or $\beta u \rightarrow \frac{\beta}{2}u^2$ or $\delta \rightarrow \delta u$ or $\frac{\lambda}{u-1} \rightarrow \lambda \ln(u-1); \alpha, \beta, \delta, \lambda \neq 0$	M1
	$= \frac{1}{3}(e^x + 1)^3 + \frac{1}{2}(e^x + 1)^2 + (e^x + 1) + \ln(e^x + 1 - 1) \{+c\}$		
	$= \frac{1}{3}(e^x + 1)^3 + \frac{1}{2}(e^x + 1)^2 + (e^x + 1) + x \{+c\}$	$\frac{1}{3}(e^x + 1)^3 + \frac{1}{2}(e^x + 1)^2 + (e^x + 1) + x$ or $\frac{1}{3}(e^x + 1)^3 + \frac{1}{2}(e^x + 1)^2 + e^x + x$ simplified or un-simplified with or without $+c$ <b>Note:</b> $\ln(e^x + 1 - 1)$ needs to be simplified to $x$ for this mark	A1
			<b>[3]</b>
<b>3. (ii) Alt 2</b>	$\int (e^x + 1)^3 dx; u = e^x \Rightarrow \frac{du}{dx} = e^x$		
	$\left\{ = \int \frac{(u+1)^3}{u} du = \int \left( u^2 + 3u + 3 + \frac{1}{u} \right) du \right.$	$\int \left( u^2 + 3u + 3 + \frac{1}{u} \right) \{du\}$ where $u = e^x$	B1
	$= \frac{1}{3}u^3 + \frac{3}{2}u^2 + 3u + \ln u \{+c\}$	At least 3 of either $\alpha u^2 \rightarrow \frac{\alpha}{3}u^3$ or $\beta u \rightarrow \frac{\beta}{2}u^2$ or $\delta \rightarrow \delta u$ or $\frac{\lambda}{u} \rightarrow \lambda \ln u; \alpha, \beta, \delta, \lambda \neq 0$	M1
	$= \frac{1}{3}e^{3x} + \frac{3}{2}e^{2x} + 3e^x + x \{+c\}$	$\frac{1}{3}e^{3x} + \frac{3}{2}e^{2x} + 3e^x + x,$ simplified or un-simplified with or without $+c$ <b>Note:</b> $\ln(e^x)$ needs to be simplified to $x$ for this mark	A1



Question Number	Scheme	Notes	Marks
4. (a)	$\frac{r}{h} = \tan 30 \Rightarrow r = h \tan 30 \left\{ \Rightarrow r = \frac{h}{\sqrt{3}} \text{ or } r = \frac{\sqrt{3}}{3} h \right\}$ <p>or</p> $\frac{h}{r} = \tan 60 \Rightarrow r = \frac{h}{\tan 60} \left\{ \Rightarrow r = \frac{h}{\sqrt{3}} \text{ or } r = \frac{\sqrt{3}}{3} h \right\}$ <p>or</p> $\frac{r}{\sin 30} = \frac{h}{\sin 60} \Rightarrow r = \frac{h \sin 30}{\sin 60} \left\{ \Rightarrow r = \frac{h}{\sqrt{3}} \text{ or } r = \frac{\sqrt{3}}{3} h \right\}$ <p>or</p> $h^2 + r^2 = (2r)^2 \Rightarrow r^2 = \frac{1}{3} h^2$	<p>Correct use of trigonometry to find <math>r</math> in terms of <math>h</math>                      or correct use of Pythagoras to find <math>r^2</math> in terms of <math>h^2</math></p>	M1
	$\left\{ V = \frac{1}{3} \pi r^2 h \Rightarrow \right\} V = \frac{1}{3} \pi \left( \frac{h}{\sqrt{3}} \right)^2 h \Rightarrow V = \frac{1}{9} \pi h^3 *$	<p>Correct proof of <math>V = \frac{1}{9} \pi h^3</math> or <math>V = \frac{1}{9} h^3 \pi</math>                      Or shows <math>\frac{1}{9} \pi h^3</math> or <math>\frac{1}{9} h^3 \pi</math> with some reference to <math>V =</math> in their solution</p>	A1 *
			[2]
(b) Way 1	$\frac{dV}{dt} = 200$		
	$\frac{dV}{dh} = \frac{1}{3} \pi h^2$		$\frac{1}{3} \pi h^2$ o.e. B1
	Either <ul style="list-style-type: none"> <li><math>\left\{ \frac{dV}{dh} \times \frac{dh}{dt} = \frac{dV}{dt} \Rightarrow \right\} \left( \frac{1}{3} \pi h^2 \right) \frac{dh}{dt} = 200</math></li> <li><math>\left\{ \frac{dh}{dt} = \frac{dV}{dt} \div \frac{dV}{dh} \Rightarrow \right\} \frac{dh}{dt} = 200 \times \frac{1}{\frac{1}{3} \pi h^2}</math></li> </ul>	either $\left( \text{their } \frac{dV}{dh} \right) \times \frac{dh}{dt} = 200$ or $200 \div \left( \text{their } \frac{dV}{dh} \right)$	M1
	When $h = 15, \frac{dh}{dt} = 200 \times \frac{1}{\frac{1}{3} \pi (15)^2} \left\{ = \frac{200}{75\pi} = \frac{600}{225\pi} \right\}$	dependent on the previous M mark	dM1
	$\frac{dh}{dt} = \frac{8}{3\rho} \text{ (cm s}^{-1}\text{)}$		$\frac{8}{3\rho}$ A1 cao
			[4]
			6
(b) Way 2	$\frac{dV}{dt} = 200 \Rightarrow V = 200t + c \Rightarrow \frac{1}{9} \pi h^3 = 200t + c$		
	$\left( \frac{1}{3} \pi h^2 \right) \frac{dh}{dt} = 200$		$\frac{1}{3} \pi h^2$ o.e. B1
		as in Way 1	M1
	When $h = 15, \frac{dh}{dt} = 200 \times \frac{1}{\frac{1}{3} \pi (15)^2} \left\{ = \frac{200}{75\pi} = \frac{600}{225\pi} \right\}$	dependent on the previous M mark	dM1
	$\frac{dh}{dt} = \frac{8}{3\rho} \text{ (cm s}^{-1}\text{)}$		$\frac{8}{3\rho}$ A1 cao
			[4]

		<b>Question 4 Notes</b>
<b>4. (a)</b>	<b>Note</b>	Allow M1 for writing down $r = h \tan 30$
	<b>Note</b>	Give M0 A0 for writing down $r = \frac{h\sqrt{3}}{3}$ or $r = \frac{h}{\sqrt{3}}$ with no evidence of using trigonometry on $r$ and $h$ or Pythagoras on $r$ and $h$
	<b>Note</b>	Give M0 (unless recovered) for evidence of $\frac{1}{3}\pi r^2 h = \frac{1}{9}\pi h^3$ leading to either $r^2 = \frac{1}{3}h^2$ or $r = \frac{h\sqrt{3}}{3}$ or $r = \frac{h}{\sqrt{3}}$
<b>(b)</b>	<b>B1</b>	Correct simplified or un-simplified differentiation of $V$ . E.g. $\frac{1}{3}\pi h^2$ or $\frac{3}{9}\pi h^2$
	<b>Note</b>	$\frac{dV}{dh}$ does not have to be explicitly stated, but it should be clear that they are differentiating their $V$
	<b>M1</b>	$\left(\text{their } \frac{dV}{dh}\right) \times \frac{dh}{dt} = 200$ or $200 \div \left(\text{their } \frac{dV}{dh}\right)$
	<b>dM1</b>	<b>dependent on the previous M mark</b> Substitutes $h = 15$ into an expression <i>which is a result</i> of either $200 \div \left(\text{their } \frac{dV}{dh}\right)$ or $200 \times \frac{1}{\left(\text{their } \frac{dV}{dh}\right)}$
	<b>A1</b>	$\frac{8}{3\pi}$ (units are not required)
	<b>Note</b>	Give final A0 for using $\frac{dV}{dt} = -200$ to give $\frac{dh}{dt} = -\frac{8}{3\pi}$ , unless recovered to $\frac{dh}{dt} = \frac{8}{3\pi}$

Question Number	Scheme		Notes	Marks
5.	$x = 1 + t - 5\sin t, y = 2 - 4\cos t, -\pi \leq t \leq \pi; A(k, 2), k > 0, \text{ lies on } C$			
(a)	$\{\text{When } y=2,\} 2 = 2 - 4\cos t \Rightarrow t = -\frac{\pi}{2}, \frac{\pi}{2}$ $k(\text{ or } x) = 1 + \frac{\pi}{2} - 5\sin\left(\frac{\pi}{2}\right) \text{ or } k(\text{ or } x) = 1 - \frac{\pi}{2} - 5\sin\left(-\frac{\pi}{2}\right)$		Sets $y = 2$ to find $t$ and some evidence of using their $t$ to find $x = \dots$	M1
	$\{\text{When } t = -\frac{\pi}{2}, k > 0,\} \text{ so } k = 6 - \frac{\pi}{2} \text{ or } \frac{12 - \pi}{2}$		$k(\text{ or } x) = 6 - \frac{\pi}{2} \text{ or } \frac{12 - \pi}{2}$	A1
				[2]
(b)	$\frac{dx}{dt} = 1 - 5\cos t, \frac{dy}{dt} = 4\sin t$		At least one of $\frac{dx}{dt}$ or $\frac{dy}{dt}$ correct (Can be implied)	B1
			Both $\frac{dx}{dt}$ and $\frac{dy}{dt}$ are correct (Can be implied)	B1
	$\frac{dy}{dx} = \frac{4\sin t}{1 - 5\cos t}$ at $t = -\frac{\pi}{2}, \frac{dy}{dx} = \frac{4\sin\left(-\frac{\pi}{2}\right)}{1 - 5\cos\left(-\frac{\pi}{2}\right)} \{ = -4 \}$		Applies their $\frac{dy}{dt}$ divided by their $\frac{dx}{dt}$ and substitutes their $t$ into their $\frac{dy}{dx}$ <b>Note:</b> their $t$ can lie outside $-\pi \leq t \leq \pi$ for this mark	M1
	<ul style="list-style-type: none"> <li><math>y - 2 = -4\left(x - \left(6 - \frac{\pi}{2}\right)\right)</math></li> <li><math>2 = (-4)\left(6 - \frac{\pi}{2}\right) + c \Rightarrow y = -4x + 2 + 4\left(6 - \frac{\pi}{2}\right)</math></li> </ul>		Correct straight line method for an equation of a tangent where $m_T (\neq m_N)$ is found using calculus <b>Note:</b> their $k$ (or $x$ ) must be in terms of $\pi$ and correct bracketing must be used or implied	M1
	$\{y - 2 = -4x + 24 - 2\pi \Rightarrow\} y = -4x + 26 - 2\pi$		<b>dependent on all previous marks in part (b)</b> $y = -4x + 26 - 2\pi$	A1 cso
			$(p = -4, q = 26 - 2\pi)$	[5]
				7
<b>Question 5 Notes</b>				
5. (a)	<b>Note</b>	M1 can be implied by either $x$ or $k = 6 - \frac{\pi}{2}$ or awrt 4.43 or $x$ or $k = \frac{\pi}{2} - 4$ or awrt $-2.43$		
	<b>Note</b>	An answer of 4.429... without reference to a correct <b>exact</b> answer is A0		
	<b>Note</b>	M1 can be earned in part (a) by working in degrees		
	<b>Note</b>	Give M0 for not substituting their $t$ back into $x$ . E.g. $2 = 2 - 4\cos t \Rightarrow t = -\frac{\pi}{2} \Rightarrow k = -\frac{\pi}{2}$		
	<b>Note</b>	If two values for $k$ are found, they must identify the correct answer for A1		
	<b>Note</b>	Condone M1 for $2 = 2 - 4\cos t \Rightarrow t = -\frac{\pi}{2}, \frac{\pi}{2} \Rightarrow x = 1 - \frac{\pi}{2} - 5\sin\left(\frac{\pi}{2}\right)$		
(b)	<b>Note</b>	The 1 <sup>st</sup> M mark may be implied by their value for $\frac{dy}{dx}$ e.g. $\frac{dy}{dx} = \frac{4\sin t}{1 - 5\cos t}$ , followed by an answer of $-4$ (from $t = -\frac{\pi}{2}$ ) or $4$ (from $t = \frac{\pi}{2}$ )		
	<b>Note</b>	Give 1 <sup>st</sup> M0 for <b>applying</b> their $\frac{dx}{dt}$ divided by their $\frac{dy}{dt}$ even if they state $\frac{dy}{dx} = \frac{dy}{dt} \div \frac{dx}{dt}$		
	<b>2<sup>nd</sup> M1</b>	<ul style="list-style-type: none"> <li><b>applies</b> <math>y - 2 = (\text{their } m_T)(x - (\text{their } k))</math>,</li> <li><b>applies</b> <math>2 = (\text{their } m_T)(\text{their } k) + c</math> <b>leading to</b> <math>y = (\text{their } m_T)x + (\text{their } c)</math></li> </ul> where $k$ must be in terms of $\pi$ and $m_T (\neq m_N)$ is a numerical value found using calculus		
	<b>Note</b>	Correct bracketing must be used for 2 <sup>nd</sup> M1, but this mark can be implied by later working		

**Question 5 Notes Continued**

<b>5. (b)</b>	<b>Note</b>	The final A mark is dependent on all previous marks in part (b) being scored. This is because the correct answer can follow from an incorrect $\frac{dy}{dx}$
	<b>Note</b>	The first 3 marks can be gained by using degrees in part (b)
	<b>Note</b>	Condone mixing a correct $t$ with an incorrect $x$ or an incorrect $t$ with a correct $x$ for the M marks
	<b>Note</b>	Allow final A1 for any answer in the form $y = px + q$ E.g. Allow final A1 for $y = -4x + 26 - 2\pi$ , $y = -4x + 2 + 4\left(6 - \frac{\pi}{2}\right)$ or $y = -4x + \left(\frac{52 - 4\pi}{2}\right)$
	<b>Note</b>	Do not apply isw in part (b). So, an incorrect answer following from a correct answer is A0
	<b>Note</b>	Do not allow $y = 2(-2x + 13 - \pi)$ for A1
	<b>Note</b>	$y = -4x + 26 - 2\pi$ followed by $y = 2(-2x + 13 - \pi)$ is condoned for final A1

Question Number	Scheme	Notes	Marks
6.	$\frac{dy}{dx} = \frac{y^2}{3\cos^2 2x}; -\frac{1}{2} < x < \frac{1}{2}; y = 2 \text{ at } x = -\frac{\pi}{8}$		
	$\int \frac{1}{y^2} dy = \int \frac{1}{3\cos^2 2x} dx$	Separates variables as shown Can be implied by a correct attempt at integration Ignore the integral signs	B1
	$\int \frac{1}{y^2} dy = \int \frac{1}{3} \sec^2 2x dx$		
	$-\frac{1}{y} = \frac{1}{3} \left( \frac{\tan 2x}{2} \right) \{+c\}$	$\pm \frac{A}{y^2} \rightarrow \pm \frac{B}{y}; A, B \neq 0$	M1
		$\pm \lambda \tan 2x$	M1
		$-\frac{1}{y} = \frac{1}{3} \left( \frac{\tan 2x}{2} \right)$	A1
	$-\frac{1}{2} = \frac{1}{6} \tan \left( 2 \left( -\frac{\pi}{8} \right) \right) + c$	Use of $x = -\frac{\pi}{8}$ and $y = 2$ in an integrated equation <b>containing a constant of integration</b> , e.g. $c$	M1
	$-\frac{1}{2} = -\frac{1}{6} + c \Rightarrow c = -\frac{1}{3}$		
$-\frac{1}{y} = \frac{1}{6} \tan 2x - \frac{1}{3} = \frac{\tan(2x) - 2}{6}$			
$y = \frac{-1}{\frac{1}{6} \tan 2x - \frac{1}{3}}$ or $y = \frac{6}{2 - \tan 2x}$ or $y = \frac{6 \cot 2x}{-1 + 2 \cot 2x} \left\{ -\frac{1}{2} < x < \frac{1}{2} \right\}$		A1 o.e.	
			[6]
			6

**Question 6 Notes**

6.	<b>B1</b>	Separates variables as shown. $dy$ and $dx$ should be in the correct positions, though this mark can be implied by later working. Ignore the integral signs. The number “3” may appear on either side. E.g. $\int \frac{1}{y^2} dy = \int \frac{1}{3} \sec^2 2x dx$ or $\int \frac{3}{y^2} dy = \int \frac{1}{\cos^2 2x} dx$ are fine for B1
	<b>Note</b>	Allow e.g. $\int \frac{1}{y^2} dy = \int \frac{1}{3} \sec^2 2x dx$ for B1 or condone $\int \frac{1}{y^2} = \int \frac{1}{3} \sec^2 2x$ for B1
	<b>Note</b>	B1 can be implied by correct integration of both sides
	<b>M1</b>	$\pm \frac{A}{y^2} \rightarrow \pm \frac{B}{y}; A, B \neq 0$
	<b>M1</b>	$\frac{1}{\cos^2 2x}$ or $\sec^2 2x \rightarrow \pm \lambda \tan 2x; \lambda \neq 0$
	<b>A1</b>	$-\frac{1}{y} = \frac{1}{3} \left( \frac{\tan 2x}{2} \right)$ with or without '+c'. E.g. $-\frac{6}{y} = \tan 2x$
	<b>M1</b>	Evidence of using both $x = -\frac{\pi}{8}$ and $y = 2$ in an integrated or changed equation containing $c$
	<b>Note</b>	This mark can be implied by the correct value of $c$
	<b>Note</b>	You may need to use your calculator to check that they have satisfied the final M mark
	<b>Note</b>	Condone using $x = \frac{\pi}{8}$ instead of $x = -\frac{\pi}{8}$
<b>A1</b>	$y = \frac{-1}{\frac{1}{6} \tan 2x - \frac{1}{3}}$ or $y = \frac{6}{2 - \tan 2x}$ <b>or any equivalent correct answer in the form <math>y = f(x)</math></b>	
<b>Note</b>	You can ignore subsequent working, which follows from a correct answer	

**Question 6 Notes Continued**

	<b>Question 6 Notes Continued</b>	
<b>6.</b>	<b>Note</b>	Writing $\frac{dy}{dx} = \frac{y^2}{3\cos^2 2x} \Rightarrow \frac{dy}{dx} = \frac{1}{3}y^2 \sec^2 2x$ leading to e.g. <ul style="list-style-type: none"><li>• <math>y = \frac{1}{9}y^3 \left(\frac{1}{2}\tan 2x\right)</math> gets 2<sup>nd</sup> M0 for <math>\pm\lambda \tan 2x</math></li><li>• <math>u = \frac{1}{3}y^2, \frac{dv}{dx} = \sec^2 2x \Rightarrow \frac{du}{dx} = \frac{2}{3}y, v = \frac{1}{2}\tan 2x</math> gets 2<sup>nd</sup> M0 for <math>\pm\lambda \tan 2x</math></li></ul> because the variables have not been separated

Question Number	Scheme	Notes	Marks
7.	$\vec{OA} = \begin{pmatrix} -3 \\ 7 \\ 2 \end{pmatrix}, \vec{AB} = \begin{pmatrix} 4 \\ -6 \\ 2 \end{pmatrix}, \vec{OP} = \begin{pmatrix} 9 \\ 1 \\ 8 \end{pmatrix}; \vec{OQ} = \begin{pmatrix} 9+4\mu \\ 1-6\mu \\ 8+2\mu \end{pmatrix}$ or $\vec{OQ} = \begin{pmatrix} 9+2\mu \\ 1-3\mu \\ 8+\mu \end{pmatrix}$	Let $\theta =$ size of angle $PAB$ . $A, B$ lie on $l_1$ and $P$ lies on $l_2$	
(a)	$\{\vec{OB} = \vec{OA} + \vec{AB} \Rightarrow\}$ $\vec{OB} = \begin{pmatrix} -3 \\ 7 \\ 2 \end{pmatrix} + \begin{pmatrix} 4 \\ -6 \\ 2 \end{pmatrix} = \begin{pmatrix} 1 \\ 1 \\ 4 \end{pmatrix} \Rightarrow B(1, 1, 4)$	Attempts to add $\vec{OA}$ to $\vec{AB}$ $(1, 1, 4)$ or $\begin{pmatrix} 1 \\ 1 \\ 4 \end{pmatrix}$ or $\mathbf{i} + \mathbf{j} + 4\mathbf{k}$	M1 A1
<b>Note:</b> M1 can be implied by at least 2 correct components for $B$			<b>[2]</b>
(b)	$\vec{AP} = \vec{OP} - \vec{OA} = \begin{pmatrix} 9 \\ 1 \\ 8 \end{pmatrix} - \begin{pmatrix} -3 \\ 7 \\ 2 \end{pmatrix} = \begin{pmatrix} 12 \\ -6 \\ 6 \end{pmatrix}$ or $\vec{PA} = \begin{pmatrix} -12 \\ 6 \\ -6 \end{pmatrix}$	An attempt to find $\vec{AP}$ or $\vec{PA}$	M1
	$\left\{ \cos \theta = \frac{\vec{AP} \cdot \vec{AB}}{ \vec{AP}   \vec{AB} } \right\} = \frac{\begin{pmatrix} 12 \\ -6 \\ 6 \end{pmatrix} \cdot \begin{pmatrix} 4 \\ -6 \\ 2 \end{pmatrix}}{\sqrt{(12)^2 + (-6)^2 + (6)^2} \cdot \sqrt{(4)^2 + (-6)^2 + (2)^2}}$	Applies dot product formula between their $(\vec{AP}$ or $\vec{PA})$ and $(\vec{AB}$ or $\vec{BA})$ or a multiple of these vectors	dM1
	$\left\{ \cos \theta = \frac{96}{\sqrt{216} \cdot \sqrt{56}} \Rightarrow \cos \theta \right\} = \frac{4}{\sqrt{21}}$ or $\frac{4}{21} \sqrt{21}$	$\frac{4}{\sqrt{21}}$ or $\frac{4}{21} \sqrt{21}$	A1
			<b>[3]</b>
(c)	$\left\{ \cos \theta = \frac{4}{\sqrt{21}} \right\} \Rightarrow \sin \theta = \frac{\sqrt{21-16}}{\sqrt{21}} = \frac{\sqrt{5}}{\sqrt{21}} = \frac{\sqrt{105}}{21}$	A correct method for converting an exact value for $\cos \theta$ to an exact value for $\sin \theta$	M1
	Area $PAB = \frac{1}{2} (\sqrt{216})(\sqrt{56}) \left( \frac{\sqrt{5}}{\sqrt{21}} \right) \left\{ = 12\sqrt{21} \left( \frac{\sqrt{5}}{\sqrt{21}} \right) \right\} = 12\sqrt{5}$	see notes $12\sqrt{5}$	M1 A1 <b>cao</b>
			<b>[3]</b>
(d)	$\{l_2 : \} \mathbf{r} = \begin{pmatrix} 9 \\ 1 \\ 8 \end{pmatrix} + \mu \begin{pmatrix} 4 \\ -6 \\ 2 \end{pmatrix}$ or $\mathbf{r} = \begin{pmatrix} 9 \\ 1 \\ 8 \end{pmatrix} + \mu \begin{pmatrix} 2 \\ -3 \\ 1 \end{pmatrix}$	$\mathbf{p} + \lambda \mathbf{d}$ or $\mathbf{p} + \mu \mathbf{d}, \mathbf{p} \neq 0, \mathbf{d} \neq 0$ with either $\mathbf{p} = 9\mathbf{i} + \mathbf{j} + 8\mathbf{k}$ or $\mathbf{d} = 4\mathbf{i} - 6\mathbf{j} + 2\mathbf{k}$ or $\mathbf{d} =$ multiple of $2\mathbf{i} - 3\mathbf{j} + \mathbf{k}$	M1
		Correct vector equation	A1
			<b>[2]</b>
(e)	$\vec{BQ} = \begin{pmatrix} 9+4\mu \\ 1-6\mu \\ 8+2\mu \end{pmatrix} - \begin{pmatrix} 1 \\ 1 \\ 4 \end{pmatrix} = \begin{pmatrix} 8+4\mu \\ -6\mu \\ 4+2\mu \end{pmatrix}$ $\left\{ \vec{QB} = \begin{pmatrix} -8-4\mu \\ 6\mu \\ -4-2\mu \end{pmatrix} \right\}$	Applies their $\vec{OQ}$ - their $\vec{OB}$ or their $\vec{OB}$ - their $\vec{OQ}$	M1
	$\vec{BQ} \cdot \vec{AP} = 0 \Rightarrow \begin{pmatrix} 8+4\mu \\ -6\mu \\ 4+2\mu \end{pmatrix} \cdot \begin{pmatrix} 12 \\ -6 \\ 6 \end{pmatrix} = 0 \Rightarrow \mu = \dots$	Applies $\vec{BQ} \cdot \vec{AP} = 0$ , o.e. and <i>solves</i> the resulting equation to find a value for $\mu$	dM1
	$\Rightarrow 96 + 48\mu + 36\mu + 24 + 12\mu = 0 \Rightarrow 96\mu + 120 = 0 \Rightarrow \mu = -\frac{5}{4}$	$\mu = -\frac{120}{96}$ or $\mu = -\frac{5}{4}$	A1 o.e.
	$\vec{OQ} = \begin{pmatrix} 9+4(-1.25) \\ 1-6(-1.25) \\ 8+2(-1.25) \end{pmatrix} = \begin{pmatrix} 4 \\ 8.5 \\ 5.5 \end{pmatrix} \Rightarrow Q(4, 8.5, 5.5)$	Substitutes their value of $\mu$ into $\vec{OQ}$ $(4, 8.5, 5.5)$ or $\begin{pmatrix} 4 \\ 8.5 \\ 5.5 \end{pmatrix}$ or $4\mathbf{i} + 8.5\mathbf{j} + 5.5\mathbf{k}$	ddM1 A1 o.e.
			<b>[5]</b>
			<b>15</b>

Question Number	Scheme	Notes	Marks
7.	$\vec{OA} = \begin{pmatrix} -3 \\ 7 \\ 2 \end{pmatrix}, \vec{AB} = \begin{pmatrix} 4 \\ -6 \\ 2 \end{pmatrix}, \vec{OP} = \begin{pmatrix} 9 \\ 1 \\ 8 \end{pmatrix}; \vec{OQ} = \begin{pmatrix} 9+4\mu \\ 1-6\mu \\ 8+2\mu \end{pmatrix}$ or $\vec{OQ} = \begin{pmatrix} 9+2\mu \\ 1-3\mu \\ 8+\mu \end{pmatrix}$	Let $\theta =$ size of angle $PAB$ . $A, B$ lie on $l_1$ and $P$ lies on $l_2$	
(e) Alt 1	$\vec{BQ} = \begin{pmatrix} 9+2\mu \\ 1-3\mu \\ 8+\mu \end{pmatrix} - \begin{pmatrix} 1 \\ 1 \\ 4 \end{pmatrix} = \begin{pmatrix} 8+2\mu \\ -3\mu \\ 4+\mu \end{pmatrix}$ or $\vec{QB} = \begin{pmatrix} -8-2\mu \\ 3\mu \\ -4-\mu \end{pmatrix}$	Applies their $\vec{OQ} -$ their $\vec{OB}$ or their $\vec{OB} -$ their $\vec{OQ}$	M1
	$\vec{BQ} \cdot \vec{AP} = 0 \Rightarrow \begin{pmatrix} 8+2\mu \\ -3\mu \\ 4+\mu \end{pmatrix} \cdot \begin{pmatrix} 12 \\ -6 \\ 6 \end{pmatrix} = 0 \Rightarrow \mu = \dots$	Applies $\vec{BQ} \cdot \vec{AP} = 0$ , o.e. and <i>solves</i> the resulting equation to find a value for $\mu$	dM1
	$\Rightarrow 96 + 24\mu + 18\mu + 24 + 6\mu = 0 \Rightarrow 48\mu + 120 = 0 \Rightarrow \mu = -\frac{5}{2}$	$\mu = -\frac{5}{2}$	A1 o.e.
	$\vec{OQ} = \begin{pmatrix} 9+2(-2.5) \\ 1-3(-2.5) \\ 8+1(-2.5) \end{pmatrix} = \begin{pmatrix} 4 \\ 8.5 \\ 5.5 \end{pmatrix} \Rightarrow Q(4, 8.5, 5.5)$	Substitutes their value of $\mu$ into $\vec{OQ}$	ddM1
		$(4, 8.5, 5.5)$ or $\begin{pmatrix} 4 \\ 8.5 \\ 5.5 \end{pmatrix}$ or $4\mathbf{i} + 8.5\mathbf{j} + 5.5\mathbf{k}$	A1 o.e.
			[5]
(b) Alt 1	<b>Vector Cross Product:</b> Use this scheme if a vector cross product method is being applied		
	$\vec{AP} = \vec{OP} - \vec{OA} = \begin{pmatrix} 9 \\ 1 \\ 8 \end{pmatrix} - \begin{pmatrix} -3 \\ 7 \\ 2 \end{pmatrix} = \begin{pmatrix} 12 \\ -6 \\ 6 \end{pmatrix}$ or $\vec{PA} = \begin{pmatrix} -12 \\ 6 \\ -6 \end{pmatrix}$	An attempt to find $\vec{AP}$ or $\vec{PA}$	M1
	$\mathbf{d}_1 \times \mathbf{d}_2 = \begin{pmatrix} 12 \\ -6 \\ 6 \end{pmatrix} \times \begin{pmatrix} 4 \\ -6 \\ 2 \end{pmatrix} = \left\{ \begin{vmatrix} \mathbf{i} & \mathbf{j} & \mathbf{k} \\ 12 & -6 & 6 \\ 4 & -6 & 2 \end{vmatrix} = 24\mathbf{i} + 0\mathbf{j} - 48\mathbf{k} \right\}$		
	$\sin \theta = \frac{\sqrt{(24)^2 + (0)^2 + (-48)^2}}{\sqrt{(12)^2 + (-6)^2 + (6)^2} \cdot \sqrt{(4)^2 + (-6)^2 + (2)^2}}$	Applies vector cross product formula between their $(\vec{AP}$ or $\vec{PA})$ and $(\vec{AB}$ or $\vec{BA})$ or a multiple of these vectors	dM1
	$\left\{ \sin \theta = \frac{\sqrt{2880}}{\sqrt{216} \cdot \sqrt{56}} = \sqrt{\frac{5}{21}} \right\} \Rightarrow \cos \theta = \sqrt{\frac{16}{21}} = \frac{4}{\sqrt{21}}$ or $\frac{4}{21}\sqrt{21}$	$\frac{4}{\sqrt{21}}$ or $\frac{4}{21}\sqrt{21}$	A1
			[3]
(b) Alt 2	<b>Cosine Rule</b>		
	$\vec{AP} = \vec{OP} - \vec{OA} = \begin{pmatrix} 9 \\ 1 \\ 8 \end{pmatrix} - \begin{pmatrix} -3 \\ 7 \\ 2 \end{pmatrix} = \begin{pmatrix} 12 \\ -6 \\ 6 \end{pmatrix}$ or $\vec{PA} = \begin{pmatrix} -12 \\ 6 \\ -6 \end{pmatrix}$	An attempt to find $\vec{AP}$ or $\vec{PA}$	M1
	Note: $ \vec{PA}  = \sqrt{216},  \vec{AB}  = \sqrt{56}$ and $ \vec{PB}  = \sqrt{80}$		
	$(\sqrt{80})^2 = (\sqrt{216})^2 + (\sqrt{56})^2 - 2(\sqrt{216})(\sqrt{56})\cos \theta$	Applies the cosine rule the correct way round	dM1
	$\cos \theta = \frac{216 + 56 - 80}{2\sqrt{216}\sqrt{56}} = \frac{192}{2\sqrt{216}\sqrt{56}}$		
	$\Rightarrow \cos \theta = \frac{4}{\sqrt{21}}$ or $\frac{4}{21}\sqrt{21}$	$\frac{4}{\sqrt{21}}$ or $\frac{4}{21}\sqrt{21}$	A1
			[3]

**Question 7 Notes**

7. (b)	<b>Note</b>	If no “subtraction” seen, you can award 1 <sup>st</sup> M1 for 2 out of 3 correct components of the difference
	<b>Note</b>	For dM1 the dot product formula can be applied as $\sqrt{(12)^2 + (-6)^2 + (6)^2} \cdot \sqrt{(4)^2 + (-6)^2 + (2)^2} \cos \theta = \begin{pmatrix} 12 \\ -6 \\ 6 \end{pmatrix} \cdot \begin{pmatrix} 4 \\ -6 \\ 2 \end{pmatrix}$
	<b>Note</b>	<i>Evaluation</i> of the dot product for $12\mathbf{i} - 6\mathbf{j} + 6\mathbf{k}$ & $2\mathbf{i} - 3\mathbf{j} + \mathbf{k}$ is not required for the dM1 mark
	<b>A1</b>	For either $\frac{4}{\sqrt{21}}$ or $\frac{4}{21}\sqrt{21}$ or $\cos \theta = \frac{4}{\sqrt{21}}$ or $\frac{4}{21}\sqrt{21}$
	<b>Note</b>	Using $12\mathbf{i} - 6\mathbf{j} + 6\mathbf{k}$ & $2\mathbf{i} - 3\mathbf{j} + \mathbf{k}$ gives $\cos \theta = \frac{24+18+6}{\sqrt{216} \cdot \sqrt{14}} = \frac{48}{12\sqrt{21}} = \frac{4}{\sqrt{21}}$ or $\frac{4}{21}\sqrt{21}$
	<b>Note</b>	Using $2\mathbf{i} - \mathbf{j} + \mathbf{k}$ & $2\mathbf{i} - 3\mathbf{j} + \mathbf{k}$ gives $\cos \theta = \frac{4+3+1}{\sqrt{6} \cdot \sqrt{14}} = \frac{8}{2\sqrt{21}} = \frac{4}{\sqrt{21}}$ or $\frac{4}{21}\sqrt{21}$
	<b>Note</b>	Give M1M1A0 for finding $\theta = \text{awrt } 29.2$ without reference to $\cos \theta = \frac{4}{\sqrt{21}}$ or $\frac{4}{21}\sqrt{21}$
	<b>Note</b>	Condone taking the dot product between vectors the wrong way round for the M1 dM1 marks
	<b>Note</b>	<b>Vectors the wrong way round</b>
		<ul style="list-style-type: none"> <li>E.g. taking the dot product between <math>\overrightarrow{PA}</math> and <math>\overrightarrow{AB}</math> to give <math>\cos \theta = -\frac{4}{\sqrt{21}}</math> or <math>-\frac{4}{21}\sqrt{21}</math>  <i>with no other working</i> is final A0</li> <li>E.g. taking the dot product between <math>\overrightarrow{PA}</math> and <math>\overrightarrow{AB}</math> to give <math>\cos \theta = -\frac{4}{\sqrt{21}}</math> or <math>-\frac{4}{21}\sqrt{21}</math>  <b>followed by</b> <math>\cos \theta = \frac{4}{\sqrt{21}}</math> or <math>\frac{4}{21}\sqrt{21}</math> or just simply writing <math>\frac{4}{\sqrt{21}}</math> or <math>\frac{4}{21}\sqrt{21}</math> is final A1</li> </ul>
	<b>Note</b>	In part (b), give M0dM0 for finding and using $\overrightarrow{AP} = \overrightarrow{OP} - \overrightarrow{OA} = (5\mathbf{i} + 7\mathbf{j} + 6\mathbf{k})$
(c)	<b>Note</b>	Give 1 <sup>st</sup> M0 for $\sin \theta = \sin \left( \cos^{-1} \left( \frac{4\sqrt{21}}{21} \right) \right)$ or $\sin \theta = 1 - \left( \frac{4}{21}\sqrt{21} \right)^2$ <b>unless recovered</b>
	<b>M1</b>	Give 2 <sup>nd</sup> M1 for either <ul style="list-style-type: none"> <li><math>\frac{1}{2}</math>(their length AP)(their length AB)(their attempt at <math>\sin \theta</math>)</li> <li><math>\frac{1}{2}</math>(their length AP)(their length AB)sin(their 29.2° from part (b))</li> <li><math>\frac{1}{2}</math>(their length AP)(their length AB)sin <math>\theta</math>; where <math>\cos \theta = \dots</math> in part (b)</li> </ul>
	<b>Note</b>	$\frac{1}{2}(\sqrt{216})(\sqrt{56})\sin(\text{awrt } 29.2^\circ \text{ or awrt } 150.8^\circ) \{ = \text{awrt } 26.8 \}$ without reference to finding $\sin \theta$ as an exact value if M0 M1 A0
	<b>Note</b>	Anything that rounds to 26.8 without reference to finding $\sin \theta$ as an exact value is M0 M1 A0
	<b>Note</b>	Anything that rounds to 26.8 without reference to $12\sqrt{5}$ is A0
	<b>Note</b>	If they use $\overrightarrow{AP} = \overrightarrow{OP} - \overrightarrow{OA} = (5\mathbf{i} + 7\mathbf{j} + 6\mathbf{k})$ in part (b), then this can be followed through in part (c) for the 2 <sup>nd</sup> M mark as e.g. $\frac{1}{2}(\sqrt{110})(\sqrt{56})\sin \theta$
	<b>Note</b>	Finding $12\sqrt{5}$ in part (c) is M1 dM1 A1, even if there is little or no evidence of finding an exact value for $\sin \theta$ . So $\frac{1}{2}(\sqrt{216})(\sqrt{56})\sin(29.2^\circ) = 12\sqrt{5}$ is M1 dM1 A1

**Question 7 Notes Continued**

7. (d)	<b>Note</b>	Writing $\mathbf{r} = \dots$ or $l_2 = \dots$ or $l = \dots$ or Line 2 = ... is not required for the M mark		
	<b>A1</b>	Writing $\mathbf{r} = \begin{pmatrix} 9 \\ 1 \\ 8 \end{pmatrix} + \mu \begin{pmatrix} 4 \\ -6 \\ 2 \end{pmatrix}$ or $\mathbf{r} = \begin{pmatrix} 9 \\ 1 \\ 8 \end{pmatrix} + \mu \begin{pmatrix} 2 \\ -3 \\ 1 \end{pmatrix}$ or $\mathbf{r} = \begin{pmatrix} 9 \\ 1 \\ 8 \end{pmatrix} + \mu \mathbf{d}$ , where $\mathbf{d}$ = a multiple of $2\mathbf{i} - 3\mathbf{j} + \mathbf{k}$		
	<b>Note</b>	Writing $\mathbf{r} = \dots$ or $l_2 = \dots$ or $l = \dots$ or Line 2 = ... is required for the A mark		
	<b>Note</b>	Other valid $\mathbf{p} = \begin{pmatrix} 9 \\ 1 \\ 8 \end{pmatrix}$ are e.g. $\mathbf{p} = \begin{pmatrix} 13 \\ -5 \\ 10 \end{pmatrix}$ or $\mathbf{p} = \begin{pmatrix} 5 \\ 7 \\ 6 \end{pmatrix}$ . So $\mathbf{r} = \begin{pmatrix} 13 \\ -5 \\ 10 \end{pmatrix} + \mu \begin{pmatrix} 4 \\ -6 \\ 2 \end{pmatrix}$ is M1 A1		
	<b>Note</b>	Give A0 for writing $l_2 : \begin{pmatrix} 9 \\ 1 \\ 8 \end{pmatrix} + \mu \begin{pmatrix} 4 \\ -6 \\ 2 \end{pmatrix}$ or ans = $\begin{pmatrix} 9 \\ 1 \\ 8 \end{pmatrix} + \mu \begin{pmatrix} 4 \\ -6 \\ 2 \end{pmatrix}$ unless recovered		
	<b>Note</b>	Using scalar parameter $\lambda$ or other scalar parameters (e.g. $\mu$ or $s$ or $t$ ) is fine for M1 and/or A1		
(e)	<b>ddM1</b>	Substitutes their value of $\mu$ into $\overline{OQ}$ , where $\overline{OQ}$ = their equation for $l_2$		
	<b>Note</b>	If they use $\overline{AP} = \overline{OP} - \overline{AB} = (5\mathbf{i} + 7\mathbf{j} + 6\mathbf{k})$ in part (b), then this can be followed through in part (e) for the 2 <sup>nd</sup> M mark and the 3 <sup>rd</sup> M mark		
	<b>Note</b>	You imply the final M mark in part (e) for at least 2 correctly followed through components for $Q$ from their $\mu$		
Question Number	Scheme	Notes	Marks	
7. (c) Alt 1	<b>Vector Cross Product:</b> Use this scheme if a vector cross product method is being applied			
	$\overline{AP} \times \overline{AB} = \begin{pmatrix} 12 \\ -6 \\ 6 \end{pmatrix} \times \begin{pmatrix} 4 \\ -6 \\ 2 \end{pmatrix} = \left\{ \begin{vmatrix} \mathbf{i} & \mathbf{j} & \mathbf{k} \\ 12 & -6 & 6 \\ 4 & -6 & 2 \end{vmatrix} = 24\mathbf{i} + 0\mathbf{j} - 48\mathbf{k} \right\}$			
	Area $PAB = \frac{1}{2} \sqrt{(24)^2 + (-48)^2}$	Uses a vector product and $\sqrt{("24")^2 + ("0")^2 + ("48")^2}$		M1
		Uses a vector product and $\frac{1}{2} \sqrt{("24")^2 + ("0")^2 + ("48")^2}$		M1
	$= 12\sqrt{5}$	$12\sqrt{5}$		A1 <b>cao</b>
			<b>[3]</b>	
7. (c) Alt 2	<b>Note:</b> $\cos APB = \frac{5}{\sqrt{30}}$ or $\frac{1}{6}\sqrt{30}$ <b>Note:</b> $ \overline{PA}  = \sqrt{216}$ and $ \overline{PB}  = \sqrt{80}$			
	$\sin \theta = \frac{\sqrt{30-25}}{\sqrt{30}} = \frac{\sqrt{5}}{\sqrt{30}} = \frac{\sqrt{6}}{6}$	A correct method for converting an exact value for $\cos \theta$ to an exact value for $\sin \theta$		M1
	Area $PAB = \frac{1}{2}(\sqrt{216})(\sqrt{80})\left(\frac{\sqrt{5}}{\sqrt{30}}\right) = 12\sqrt{30}\left(\frac{\sqrt{5}}{\sqrt{30}}\right) = 12\sqrt{5}$	$\frac{1}{2}(\text{their } PA)(\text{their } PB)\sin \theta$		M1
		$12\sqrt{5}$		A1 <b>cao</b>
				<b>[3]</b>

Question Number	Scheme	Notes	Marks
8. (a)	$\left\{ \int x \cos 4x \, dx \right\}$	$\pm \alpha x \sin 4x \pm \beta \int \sin 4x \, dx$ , with or without $dx$ ; $\alpha, \beta \neq 0$	M1
	$= \frac{1}{4} x \sin 4x - \int \frac{1}{4} \sin 4x \, dx$	$\frac{1}{4} x \sin 4x - \int \frac{1}{4} \sin 4x \, dx$ , with or without $dx$ <b>Can be simplified or un-simplified</b>	A1
	$= \frac{1}{4} x \sin 4x + \frac{1}{16} \cos 4x \, \{+c\}$	$\frac{1}{4} x \sin 4x + \frac{1}{16} \cos 4x$ o.e. with or without $+c$ <b>Can be simplified or un-simplified</b>	A1
	<b>Note:</b> You can ignore subsequent working following on from a correct solution		
(b) Way 1	$\{V =\} \pi \int_0^{\frac{\pi}{4}} (\sqrt{x} \sin 2x)^2 \, dx$	$\pi \int (\sqrt{x} \sin 2x)^2 \, dx$ Ignore limits and $dx$ . Can be implied	B1
	$\left\{ \int x \sin^2 2x \, dx = \right\}$ $\int x \left( \frac{1 - \cos 4x}{2} \right) \, dx$	For writing down a correct equation linking $\sin^2 2x$ and $\cos 4x$ (e.g. $\cos 4x = 1 - 2\sin^2 2x$ ) <b>and</b> some attempt at applying this equation (or a manipulation of this equation which can be incorrect) to their integral Can be implied.	M1
		Simplifies $\int x \sin^2 2x \, dx$ to $\int x \left( \frac{1 - \cos 4x}{2} \right) \, dx$	A1
	$\left\{ \int \left( \frac{1}{2} x - \frac{1}{2} x \cos 4x \right) \, dx \right\}$ $= \frac{1}{4} x^2 - \frac{1}{2} \left( \frac{1}{4} x \sin 4x + \frac{1}{16} \cos 4x \right) \, \{+c\}$	Integrates to give $\pm Ax^2 \pm Bx \sin 4x \pm C \cos 4x$ ; $A, B, C \neq 0$ which can be simplified or un-simplified. <b>Note:</b> Allow one transcription error (on $\sin 4x$ or $\cos 4x$ ) in the copying of their answer from part (a) to part (b)	M1
	$\left\{ \int_0^{\frac{\pi}{4}} (\sqrt{x} \sin 2x)^2 \, dx = \left[ \frac{1}{4} x^2 - \frac{1}{8} x \sin 4x - \frac{1}{32} \cos 4x \right]_0^{\frac{\pi}{4}} \right\}$		
	$= \left( \frac{1}{4} \left( \frac{\pi}{4} \right)^2 - \frac{1}{8} \left( \frac{\pi}{4} \right) \sin \left( 4 \left( \frac{\pi}{4} \right) \right) - \frac{1}{32} \cos \left( 4 \left( \frac{\pi}{4} \right) \right) \right) - \left( 0 - 0 - \frac{1}{32} \cos 0 \right)$	<b>dependent on the previous M mark</b> see notes	dM1
	$= \left( \frac{\pi^2}{64} + \frac{1}{32} \right) - \left( -\frac{1}{32} \right) = \frac{\pi^2}{64} + \frac{1}{16}$		
	So, $V = \pi \left( \frac{\pi^2}{64} + \frac{1}{16} \right)$ or $\frac{1}{64} \pi^3 + \frac{1}{16} \pi$ or $\frac{\pi}{2} \left( \frac{\pi^2}{32} + \frac{1}{8} \right)$ o.e.	two term exact answer	A1 o.e.
			[6]
			9

**Question 8 Notes**

<b>SC</b>	<p><b>Special Case for the 2<sup>nd</sup> M and 3<sup>rd</sup> M mark for those who use their answer from part (a)</b>                  You can apply the 2<sup>nd</sup> M and 3<sup>rd</sup> M marks for integration of the form <math>\pm Ax^2 \pm</math> (their answer to part (a)) where their answer to part (a) is in the form</p> <ul style="list-style-type: none"> <li>• <math>\pm Bx \sin kx \pm C \cos px</math> to give <math>\pm Ax^2 \pm Bx \sin kx \pm C \cos px</math></li> <li>• <math>\pm Bx \sin kx \pm C \sin px</math> to give <math>\pm Ax^2 \pm Bx \sin kx \pm C \sin px</math></li> <li>• <math>\pm Bx \cos kx \pm C \sin px</math> to give <math>\pm Ax^2 \pm Bx \cos kx \pm C \sin px</math></li> <li>• <math>\pm Bx \cos kx \pm C \cos px</math> to give <math>\pm Ax^2 \pm Bx \cos kx \pm C \cos px</math></li> </ul> <p><math>k, p \neq 0</math>, <math>k, p</math> can be 1</p>
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Question Number	Scheme	Notes	Marks
8. (b) Way 2	$\{V = \} \pi \int_0^{\frac{\pi}{4}} (\sqrt{x} \sin 2x)^2 \{dx\}$	$\pi \int (\sqrt{x} \sin 2x)^2 \{dx\}$ Ignore limits and dx. Can be implied	B1
	$\left\{ \int x \sin^2 2x dx = \right\}$ $\int x \left( \frac{1 - \cos 4x}{2} \right) \{dx\}$	For writing down a correct equation linking $\sin^2 2x$ and $\cos 4x$ (e.g. $\cos 4x = 1 - 2\sin^2 2x$ ) <b>and</b> some attempt at applying this equation (or a manipulation of this equation which can be incorrect) to their integral. Can be implied	M1
		Simplifies $\int x \sin^2 2x \{dx\}$ to $\int x \left( \frac{1 - \cos 4x}{2} \right) \{dx\}$ <b>Note:</b> This mark can be implied for stating $u = x$ <b>and</b> $\frac{dv}{dx} = \frac{1 - \cos 4x}{2}$ <b>or</b> $u = \frac{1}{2}x$ <b>and</b> $\frac{dv}{dx} = 1 - \cos 4x$	A1
	$= x \left( \frac{1}{2}x - \frac{1}{8} \sin 4x \right) - \int \left( \frac{1}{2}x - \frac{1}{8} \sin 4x \right) dx$		
	$= x \left( \frac{1}{2}x - \frac{1}{8} \sin 4x \right) - \left( \frac{1}{4}x^2 + \frac{1}{32} \cos 4x \right) \{+c\}$	Integrates to give $\pm Ax^2 \pm Bx \sin 4x \pm C \cos 4x$ ; $A, B, C \neq 0$ or an expression that can be simplified to this form	M1 (B1 on ePEN)
	$\left\{ \int_0^{\frac{\pi}{4}} (\sqrt{x} \sin 2x)^2 dx = \left[ \frac{1}{4}x^2 - \frac{1}{8}x \sin 4x - \frac{1}{32} \cos 4x \right]_0^{\frac{\pi}{4}} \right\}$		
	$= \left( \frac{1}{4} \left( \frac{\pi}{4} \right)^2 - \frac{1}{8} \left( \frac{\pi}{4} \right) \sin \left( 4 \left( \frac{\pi}{4} \right) \right) - \frac{1}{32} \cos \left( 4 \left( \frac{\pi}{4} \right) \right) \right) - \left( 0 - 0 - \frac{1}{32} \cos 0 \right)$	<b>dependent on the previous M mark</b> see notes	dM1
	$= \left( \frac{\pi^2}{64} + \frac{1}{32} \right) - \left( -\frac{1}{32} \right) = \frac{\pi^2}{64} + \frac{1}{16}$		
So, $V = \pi \left( \frac{\pi^2}{64} + \frac{1}{16} \right)$ or $\frac{1}{64} \pi^3 + \frac{1}{16} \pi$ or $\frac{\pi}{2} \left( \frac{\pi^2}{32} + \frac{1}{8} \right)$ o.e.		A1 o.e.	
<b>[6]</b>			

**Question 8 Notes Continued**

8. (a)	SC	Give <i>Special Case</i> M1A0A0 for writing down the correct “by parts” formula and using $u = x, \frac{dv}{dx} = \cos 4x$ , but making only one error in the application of the correct formula
(b)	Note	You can imply B1 for seeing $\pi \int y^2 \{dx\}$ , followed by $y^2 = (\sqrt{x} \sin 2x)^2$ or $y^2 = x \sin^2 2x$
	Note	If the form $\cos 4x = \cos^2 2x - \sin^2 2x$ or $\cos 4x = 2\cos^2 2x - 1$ is used, the 1 <sup>st</sup> M cannot be gained until $\cos^2 2x$ has been replaced by $\cos^2 2x = 1 - \sin^2 2x$ and the result is applied to their integral
	Note	Mixing $x$ 's and e.g. $\theta$ 's : Condone $\cos 4\theta = 1 - 2\sin^2 2\theta, \sin^2 2\theta = \frac{1 - \cos 4\theta}{2}$ or $\lambda \sin^2 2\theta = \lambda \left( \frac{1 - \cos 4\theta}{2} \right)$ if recovered in their integration
	Final M1	<b>Complete</b> method of applying limits of $\frac{\pi}{4}$ and 0 to all terms of an expression of the form $\pm Ax^2 \pm Bx \sin 4x \pm C \cos 4x$ ; $A, B, C \neq 0$ and subtracting the correct way round.
	Note	For the final M1 mark in Way 1, allow one transcription error (on $\sin 4x$ or $\cos 4x$ ) in the copying of their answer from part (a) to part (b)

**Question 8 Notes Continued**

<p><b>8. (b)</b></p>	<p><b>Note</b></p>	<p>Evidence of a proper consideration of the limit of 0 on <math>\cos 4x</math> <b>where applicable</b> is needed for the final M mark</p> <p>E.g. <math>\left[ \frac{1}{4}x^2 - \frac{1}{8}x \sin 4x - \frac{1}{32} \cos 4x \right]_0^{\frac{\pi}{4}} =</math></p> <ul style="list-style-type: none"> <li>• <math>= \left( \frac{1}{4} \left( \frac{\pi}{4} \right)^2 - \frac{1}{8} \left( \frac{\pi}{4} \right) \sin \left( 4 \left( \frac{\pi}{4} \right) \right) - \frac{1}{32} \cos \left( 4 \left( \frac{\pi}{4} \right) \right) \right) + \frac{1}{32}</math> is final M1</li> <li>• <math>\left( \frac{1}{4} \left( \frac{\pi}{4} \right)^2 - \frac{1}{8} \left( \frac{\pi}{4} \right) \sin \left( 4 \left( \frac{\pi}{4} \right) \right) - \frac{1}{32} \cos \left( 4 \left( \frac{\pi}{4} \right) \right) \right) - 0</math> is final M0</li> <li>• <math>\left( \frac{1}{4} \left( \frac{\pi}{4} \right)^2 - \frac{1}{8} \left( \frac{\pi}{4} \right) \sin \left( 4 \left( \frac{\pi}{4} \right) \right) - \frac{1}{32} \cos \left( 4 \left( \frac{\pi}{4} \right) \right) \right) - \frac{1}{32}</math> is final M0 (adding)</li> <li>• <math>\left( \frac{1}{4} \left( \frac{\pi}{4} \right)^2 - \frac{1}{8} \left( \frac{\pi}{4} \right) \sin \left( 4 \left( \frac{\pi}{4} \right) \right) - \frac{1}{32} \cos \left( 4 \left( \frac{\pi}{4} \right) \right) \right) - \left( \frac{1}{32} \right)</math> is final M1 (condone)</li> <li>• <math>\left( \frac{1}{4} \left( \frac{\pi}{4} \right)^2 - \frac{1}{8} \left( \frac{\pi}{4} \right) \sin \left( 4 \left( \frac{\pi}{4} \right) \right) - \frac{1}{32} \cos \left( 4 \left( \frac{\pi}{4} \right) \right) \right) - (0+0+0)</math> is final M0</li> </ul>
<p><b>8. (b)</b></p>	<p><b>Note</b></p>	<p><b>Alternative Method:</b></p> $\left\{ \begin{array}{l} u = \sin^2 2x \\ \frac{du}{dx} = 2 \sin 4x \end{array} \right. \left\{ \begin{array}{l} \frac{dv}{dx} = x \\ v = \frac{1}{2} x^2 \end{array} \right. , \left\{ \begin{array}{l} u = x^2 \\ \frac{du}{dx} = 2x \end{array} \right. \left\{ \begin{array}{l} \frac{dv}{dx} = \sin 4x \\ v = -\frac{1}{4} \cos 4x \end{array} \right.$ <p><math>\int x \sin^2 2x dx</math></p> $= \frac{1}{2} x^2 \sin^2 2x - \int \frac{1}{2} x^2 (2 \sin 4x) dx$ $= \frac{1}{2} x^2 \sin^2 2x - \int x^2 \sin 4x dx$ $= \frac{1}{2} x^2 \sin^2 2x - \left( -\frac{1}{4} x^2 \cos 4x - \int 2x \left( -\frac{1}{4} \cos 4x \right) dx \right)$ $= \frac{1}{2} x^2 \sin^2 2x - \left( -\frac{1}{4} x^2 \cos 4x + \frac{1}{2} \int x \cos 4x dx \right)$ $= \frac{1}{2} x^2 \sin^2 2x + \frac{1}{4} x^2 \cos 4x - \frac{1}{2} \int x \cos 4x dx$ $= \frac{1}{2} x^2 \sin^2 2x + \frac{1}{4} x^2 \cos 4x - \frac{1}{2} \left( \frac{1}{4} x \sin 4x + \frac{1}{16} \cos 4x \right) \{+ c\}$ $= \frac{1}{2} x^2 \sin^2 2x + \frac{1}{4} x^2 \cos 4x - \frac{1}{8} x \sin 4x - \frac{1}{32} \cos 4x \{+ c\}$ $V = \pi \int_0^{\frac{\pi}{4}} (\sqrt{x} \sin 2x)^2 dx = \pi \left( \frac{\pi^2}{64} + \frac{1}{16} \right) \text{ or } \frac{1}{64} \pi^3 + \frac{1}{16} \pi \text{ or } \frac{\pi}{2} \left( \frac{\pi^2}{32} + \frac{1}{8} \right) \text{ o.e.}$



