Write your name here

Surname	Other names

Pearson Edexcel GCE

Centre Number | Candidate Number

Core Mathematics C3

Advanced

Tuesday 21 June 2016 – Morning
Time: 1 hour 30 minutes

Paper Reference
6665/01

You must have:
Mathematical Formulae and Statistical Tables (Pink)

Total Marks

Candidates may use any calculator allowed by the regulations of the Joint Council for Qualifications. Calculators must not have the facility for symbolic algebra manipulation, differentiation and integration, or have retrievable mathematical formulae stored in them.

Instructions

- Use **black** ink or ball-point pen.
- If pencil is used for diagrams/sketches/graphs it must be dark (HB or B). Coloured pencils and highlighter pens must not be used.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions and ensure that your answers to parts of questions are clearly labelled.
- Answer the questions in the spaces provided – *there may be more space than you need.*
- You should show sufficient working to make your methods clear. Answers without working may not gain full credit.
- When a calculator is used, the answer should be given to an appropriate degree of accuracy.

Information

- The total mark for this paper is 75.
- The marks for each question are shown in brackets – *use this as a guide as to how much time to spend on each question.*

Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.

1. The functions f and g are defined by

$$f : x \to 7x - 1, \qquad x \in \mathbb{R},$$

$$g : x \to \frac{4}{x-2}, \qquad x \neq 2, x \in \mathbb{R},$$

(*a*) Solve the equation $fg(x) = x$.

(4)

(*b*) Hence, or otherwise, find the largest value of a such that $g(a) = f^{-1}(a)$.

(1)

(Total 5 marks)

---

2. $$y = \frac{4x}{x^2 + 5}.$$

(*a*) Find $\frac{dy}{dx}$, writing your answer as a single fraction in its simplest form.

(4)

(*b*) Hence find the set of values of x for which $\frac{dy}{dx} < 0$.

(3)

(Total 7 marks)

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3. (*a*) Express $2 \cos \theta - \sin \theta$ in the form $R \cos (\theta + \alpha)$, where R and α are constants, $R > 0$ and $0 < \alpha < 90°$ Give the exact value of R and give the value of α to 2 decimal places.

(3)

(*b*) Hence solve, for $0 \leq \theta < 360°$,

$$\frac{2}{2\cos\theta - \sin\theta - 1} = 15.$$

Give your answers to one decimal place.

(5)

(*c*) Use your solutions to parts (*a*) and (*b*) to deduce the smallest positive value of θ for which

$$\frac{2}{2\cos\theta + \sin\theta - 1} = 15.$$

Give your answer to one decimal place.

(2)

(Total 10 marks)

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4.

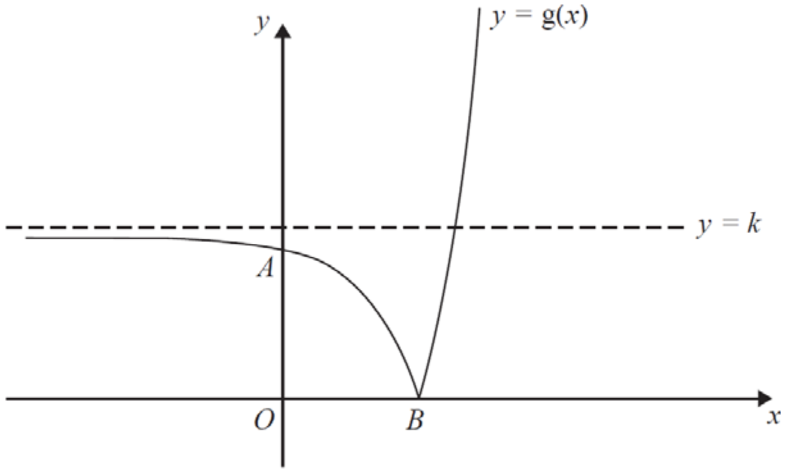

Figure 1

Figure 1 shows a sketch of part of the curve with equation $y = \mathrm{g}(x)$, where

$$\mathrm{g}(x) = |4e^{2x} - 25|, \qquad x \in \mathbb{R}.$$

The curve cuts the y-axis at the point A and meets the x-axis at the point B. The curve has an asymptote $y = k$, where k is a constant, as shown in Figure 1.

(*a*) Find, giving each answer in its simplest form,

(i) the y coordinate of the point A,

(ii) the exact x coordinate of the point B,

(iii) the value of the constant k.

(5)

The equation $\mathrm{g}(x) = 2x + 43$ has a positive root at $x = \alpha$.

(*b*) Show that α is a solution of $x = \frac{1}{2}\ln\left(\frac{1}{2}x + 17\right)$.

(2)

The iteration formula

$$x_{n+1} = \frac{1}{2}\ln\left(\frac{1}{2}x_n + 17\right)$$

can be used to find an approximation for α.

(*c*) Taking $x_0 = 1.4$, find the values of x_1 and x_2. Give each answer to 4 decimal places.

(2)

(d) By choosing a suitable interval, show that $\alpha = 1.437$ to 3 decimal places.

(2)

(Total 11 marks)

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5. (i) Find, using calculus, the x coordinate of the turning point of the curve with equation

$$y = e^{3x} \cos 4x, \quad \frac{\pi}{4} \le x < \frac{\pi}{2}.$$

Give your answer to 4 decimal places.

(5)

(ii) Given $x = \sin^2 2y$, $0 < y < \frac{\pi}{4}$, find $\frac{dy}{dx}$ as a function of y.

Write your answer in the form

$$\frac{dy}{dx} = p \operatorname{cosec}(qy), \quad 0 < y < \frac{\pi}{4},$$

where p and q are constants to be determined.

(5)

(Total 10 marks)

---

6. $$f(x) = \frac{x^4 + x^3 - 3x^2 + 7x - 6}{x^2 + x - 6}, \qquad x > 2, \qquad x \in \mathbb{R}.$$

(*a*) Given that

$$\frac{x^4 + x^3 - 3x^2 + 7x - 6}{x^2 + x - 6} \equiv x^2 + A + \frac{B}{x-2},$$

find the values of the constants A and B.

(4)

(*b*) Hence or otherwise, using calculus, find an equation of the normal to the curve with equation $y = f(x)$ at the point where $x = 3$.

(5)

(Total 9 marks)

---

7. (*a*) For $-\frac{\pi}{2} \le y \le \frac{\pi}{2}$, sketch the graph of $y = g(x)$ where

$$g(x) = \arcsin x, \qquad -1 \le x \le 1.$$

(2)

(*b*) Find the exact value of x for which

$$3g(x + 1) + \pi = 0.$$

(3)

(Total 5 marks)

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8. (*a*) Prove that

$$2 \cot 2x + \tan x \equiv \cot x, \qquad x \neq \frac{n\pi}{2}, \qquad n \in \mathbb{Z}.$$

(4)

(*b*) Hence, or otherwise, solve, for $-\pi \leq x < \pi$,

$$6 \cot 2x + 3 \tan x = \operatorname{cosec}^2 x - 2.$$

Give your answers to 3 decimal places.

(*Solutions based entirely on graphical or numerical methods are not acceptable.*)

(6)

(Total 8 marks)

---

9. The amount of an antibiotic in the bloodstream, from a given dose, is modelled by the formula

$$x = D\mathrm{e}^{-0.2t},$$

where x is the amount of the antibiotic in the bloodstream in milligrams, D is the dose given in milligrams and t is the time in hours after the antibiotic has been given.

A first dose of 15 mg of the antibiotic is given.

(*a*) Use the model to find the amount of the antibiotic in the bloodstream 4 hours after the dose is given. Give your answer in mg to 3 decimal places.

(2)

A second dose of 15 mg is given 5 hours after the first dose has been given. Using the same model for the second dose,

(*b*) show that the **total** amount of the antibiotic in the bloodstream 2 hours after the second dose is given is 13.754 mg to 3 decimal places.

(2)

No more doses of the antibiotic are given. At time T hours after the second dose is given, the total amount of the antibiotic in the bloodstream is 7.5 mg.

(*c*) Show that $T = a \ln\left(b + \frac{b}{\mathrm{e}}\right)$, where a and b are integers to be determined.

(4)

(Total 8 marks)

TOTAL FOR PAPER: 75 MARKS

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<table>
<tr><th>Question</th><th colspan="2">Scheme</th><th>Marks</th></tr>
<tr><td>1(a)</td><td colspan="2">$\text{fg}(x)=\dfrac{28}{x-2}-1 \qquad \left(=\dfrac{30-x}{x-2}\right)$
Sets $\text{fg}(x)=x \Rightarrow \dfrac{28}{x-2}-1=x$
$\Rightarrow 28=(x+1)(x-2)$
$\Rightarrow x^2-x-30=0$
$\Rightarrow (x-6)(x+5)=0$
$\Rightarrow x=6,\ x=-5$</td><td>M1

M1

dM1 A1
(4)</td></tr>
<tr><td>(b)</td><td colspan="2">$a=6$</td><td>B1 ft
(1)
5 marks</td></tr>
<tr><td>Alt 1(a)</td><td colspan="2">$\text{fg}(x)=x \Rightarrow \text{g}(x)=\text{f}^{-1}(x)$
$\dfrac{4}{x-2}=\dfrac{x+1}{7}$
$\Rightarrow x^2-x-30=0$
$\Rightarrow (x-6)(x+5)=0$
$\Rightarrow x=6,\ x=-5$</td><td>M1

M1

dM1 A1
4 marks</td></tr>
<tr><td>S. Case</td><td>Uses $\text{gf}(x)$ instead $\text{fg}(x)$
$\dfrac{4}{7x-1-2}=x$
$\Rightarrow 7x^2-3x-4=0$
$\Rightarrow (7x+4)(x-1)=0$
$\Rightarrow x=-\dfrac{4}{7},\quad x=1$</td><td>Makes an error on $\text{fg}(x)$
Sets $\text{fg}(x)=x \Rightarrow \dfrac{7\times 4}{7\times(x-2)}-1=x$
$\Rightarrow x^2-x-6=0$
$\Rightarrow (x+2)(x-3)=0$
$\Rightarrow x=-2,\quad x=3$</td><td>M0

M1

dM1 A0
2 out of 4 marks</td></tr>
</table>

(a)

M1 Sets or implies that $\text{fg}(x)=\dfrac{28}{x-2}-1$ Eg accept $\text{fg}(x)=7\left(\dfrac{4}{x-2}\right)-1$ followed by $\text{fg}(x)=\dfrac{7\times 4}{x-2}-1$

Alternatively sets $\text{g}(x)=\text{f}^{-1}(x)$ where $\text{f}^{-1}(x)=\dfrac{x\pm 1}{7}$

Note that $\text{fg}(x)=7\left(\dfrac{4}{x-2}\right)-1=\dfrac{28}{7(x-2)}-1$ is M0

M1 Sets up a 3TQ (= 0) from an attempt at $\text{fg}(x)=x$ or $\text{g}(x)=\text{f}^{-1}(x)$

dM1 Method of solving 3TQ (= 0) to find at least one value for x. See "General Priciples for Core Mathematics" on page 3 for the award of the mark for solving quadratic equations
This is dependent upon the previous M. You may just see the answers following the 3TQ.

A1 Both $x=6$ and $x=-5$

(b)

B1ft For $a=6$ but you may follow through on the largest solution from part (a) provided more than one answer was found in (a). Accept 6, $a=6$ and even $x=6$
Do not award marks for part (a) for work in part (b).

Question	Scheme	Marks
2(a)	$y=\dfrac{4x}{(x^2+5)}\Rightarrow\left(\dfrac{\mathrm{d}y}{\mathrm{d}x}\right)=\dfrac{4(x^2+5)-4x\times 2x}{(x^2+5)^2}$	M1A1
	$\Rightarrow\left(\dfrac{\mathrm{d}y}{\mathrm{d}x}\right)=\dfrac{20-4x^2}{(x^2+5)^2}$	M1A1
		(4)
(b)	$\dfrac{20-4x^2}{(x^2+5)^2}<0\Rightarrow x^2>\dfrac{20}{4}$ Critical values of $\pm\sqrt{5}$	M1
	$x<-\sqrt{5},\ x>\sqrt{5}$ or equivalent	dM1A1
		(3)
		7 marks

(a)M1 Attempt to use the **quotient rule** $\dfrac{vu'-uv'}{v^2}$ with $u=4x$ and $v=x^2+5$. If the rule is quoted it must be correct. It may be implied by their $u=4x, u'=A,\ v=x^2+5, v'=Bx$ followed by their $\dfrac{vu'-uv'}{v^2}$

If the rule is neither quoted nor implied only accept expressions of the form

$\dfrac{A(x^2+5)-4x\times Bx}{(x^2+5)^2},\ A,B>0$ You may condone missing (invisible) brackets

Alternatively uses the **product rule** with $u(/v)=4x$ and $v(/u)=(x^2+5)^{-1}$. If the rule is quoted it must be correct. It may be implied by their $u=4x, u'=A,\ v=x^2+5, v'=Bx(x^2+5)^{-2}$ followed by their $vu'+uv'$. If the rule is neither quoted nor implied only accept expressions of the form $A(x^2+5)^{-1}\pm 4x\times Bx(x^2+5)^{-2}$

A1 $\mathrm{f}'(x)$ correct (unsimplified). For the product rule look for versions of $4(x^2+5)^{-1}-4x\times 2x(x^2+5)^{-2}$

M1 Simplifies to the form $\mathrm{f}'(x)=\dfrac{A+Bx^2}{(x^2+5)^2}$ oe. This is not dependent so could be scored from $\dfrac{v'u-u'v}{v^2}$

When the product rule has been used the A of $A(x^2+5)^{-1}$ must be adapted.

A1 CAO. Accept exact equivalents such as $(\mathrm{f}'(x))=\dfrac{4(5-x^2)}{(x^2+5)^2}$, $-\dfrac{4x^2-20}{(x^2+5)^2}$ or $\dfrac{-4(x^2-5)}{x^4+10x^2+25}$

Remember to isw after a correct answer

(b)

M1 Sets their numerator either $=0$, <0, $\leqslant 0$ >0, $\geqslant 0$ and proceeds to at least **one** value for x

For example $20-4x^2\geqslant 0\Rightarrow x\geqslant\sqrt{5}$ will be M1 dM0 A0.

It cannot be scored from a numerator such as 4 or indeed $20+4x^2$

dM1 Achieves **two** critical values for their numerator $=0$ and chooses the outside region

Look for $x<$ smaller root, $x>$ bigger root. Allow decimals for the roots.

Condone $x\leqslant -\sqrt{5}, x\geqslant\sqrt{5}$ and expressions like $-\sqrt{5}>x>\sqrt{5}$

If they have $4x^2-20<0$ following an incorrect derivative they should be choosing the inside region

A1 Allow $x<-\sqrt{5}, x>\sqrt{5}$ $x<-\sqrt{5}$ or $x>\sqrt{5}$ $\{x:-\infty<x<-\sqrt{5}\cup\sqrt{5}<x<\infty\}$ $|x|>\sqrt{5}$

Do not allow for the A1 $x<-\sqrt{5}$ and $x>\sqrt{5}$. $\sqrt{5}<x<-\sqrt{5}$ or $\{x:-\infty<x<-\sqrt{5}\cap\sqrt{5}<x<\infty\}$ but you may isw following a correct answer.

Question	Scheme	Marks
3.(a)	$R=\sqrt{5}$	B1
	$\tan\alpha=\frac{1}{2}\Rightarrow\alpha=26.57°$	M1A1
		(3)
(b)	$\frac{2}{2\cos\theta-\sin\theta-1}=15\Rightarrow\frac{2}{\sqrt{5}\cos(\theta+26.6°)-1}=15$	
	$\Rightarrow\cos(\theta+26.6°)=\frac{17}{15\sqrt{5}}=(awrt\ 0.507)$	M1A1
	$\theta+26.57°=59.54°$	
	$\Rightarrow\theta=awrt\ 33.0°$ or $awrt\ 273.9°$	A1
	$\theta+26.6°=360°-\text{their '}59.5°\text{'}$	dM1
	$\Rightarrow\theta=awrt\ 273.9°$ and $awrt\ 33.0°$	A1
		(5)
(c)	$\theta-\text{their }26.57°=\text{their }59.54°\Rightarrow\theta=...$	M1
	$\theta=\text{awrt }86.1°$	A1
		(2)
		(10 marks)

(a)

B1 $R=\sqrt{5}$. Condone $R=\pm\sqrt{5}$ Ignore decimals

M1 $\tan\alpha=\pm\frac{1}{2}$, $\tan\alpha=\pm\frac{2}{1}\Rightarrow\alpha=...$

If their value of R is used to find the value of α only accept $\cos\alpha=\pm\frac{2}{R}$ OR $\sin\alpha=\pm\frac{1}{R}\Rightarrow\alpha=...$

A1 $\alpha=\text{awrt }26.57°$

(b)

M1 Attempts to use part (a) $\Rightarrow\cos(\theta\pm\text{their }26.6°)=K$, $|K|\leqslant 1$

A1 $\cos(\theta\pm\text{their }26.6°)=\frac{17}{15\sqrt{5}}=(\text{awrt }0.507)$. Can be implied by $(\theta\pm\text{their }26.6°)=\text{awrt }59.5°/59.6°$

A1 One solution correct, $\theta=awrt\ 33.0°$ or $\theta=awrt\ 273.9°$ Do not accept 33 for 33.0.

dM1 Obtains a second solution in the range. It is dependent upon having scored the previous M.
Usually for $\theta\pm\text{their }26.6°=360°-\text{their }59.5°\Rightarrow\theta=...$

A1 Both solutions $\theta=awrt\ 33.0°$ and $awrt\ 273.9°$. Do not accept 33 for 33.0.
Extra solutions inside the range withhold this A1. Ignore solutions outside the range $0\leqslant\theta<360°$

(c)

M1 $\theta-\text{their }26.57°=\text{their }59.54°\Rightarrow\theta=...$
Alternatively $-\theta+\text{their }26.6°=-\text{their }59.5°\Rightarrow\theta=...$
If the candidate has an incorrect sign for α, for example they used $\cos(\theta-26.57°)$ in part (b) it would be scored for $\theta+\text{their }26.57°=\text{their }59.54°\Rightarrow\theta=...$

A1 awrt $86.1°$ ONLY. Allow both marks following a correct (a) and (b)
They can restart the question to achieve this result. Do not award if 86.1 was their smallest answer in (b). This occurs when they have $\cos(\theta-26.57°)$ instead of $\cos(\theta+26.57°)$ in (b)

Answers in radians: Withhold only one A mark, the first time a solution in radians appears
FYI (a) $\alpha=0.46$ (b) $\theta_1=\text{awrt }0.58$ and $\theta_2=\text{awrt }4.78$ (c) $\theta_3=\text{awrt }1.50$. Require 2 dp accuracy

Question	Scheme	Marks
4.(a)	(i) 21	B1
	(ii) $4e^{2x}-25=0 \Rightarrow e^{2x}=\frac{25}{4} \Rightarrow 2x=\ln\left(\frac{25}{4}\right) \Rightarrow x=\frac{1}{2}\ln\left(\frac{25}{4}\right), \Rightarrow x=\ln\left(\frac{5}{2}\right)$	M1A1, A1
	(iii) 25	B1
		(5)
(b)	$4e^{2x}-25=2x+43 \Rightarrow e^{2x}=\frac{1}{2}x+17$	M1
	$\Rightarrow 2x=\ln\left(\frac{1}{2}x+17\right) \Rightarrow x=\frac{1}{2}\ln\left(\frac{1}{2}x+17\right)$	A1*
		(2)
(c)	$x_1=\frac{1}{2}\ln\left(\frac{1}{2}\times 1.4+17\right)=awrt\, 1.44$	M1
	awrt $x_1=1.4368, x_2=1.4373$	A1
		(2)
(d)	Defines a suitable interval 1.4365 and 1.4375	M1
	...and substitutes into a suitable function Eg $4e^{2x}-2x-68$, obtains correct values with both a reason and conclusion	A1
		(2)
		(11 marks)

In part (a) accept points marked on the graph. If they appear on the graph and in the text, the text takes precedence. If they don't mark (a) as (i) (ii) and (iii) mark in the order given. If you feel unsure then please use the review system and your team leader will advise.

(a) (i)

B1 Sight of 21. Accept $(0, 21)$

Do not accept just $|4-25|$ or $(21, 0)$

(a) (ii)

M1 Sets $4e^{2x}-25=0$ and proceeds via $e^{2x}=\frac{25}{4}$ or $e^{x}=\frac{5}{2}$ to $x=..$

Alternatively sets $4e^{2x}-25=0$ and proceeds via $(2e^{x}-5)(2e^{x}+5)=0$ to $e^{x}=..$

A1 $\frac{1}{2}\ln\left(\frac{25}{4}\right)$ or awrt 0.92

A1 cao $\ln\left(\frac{5}{2}\right)$ or $\ln 5-\ln 2$. Accept $\left(\ln\left(\frac{5}{2}\right), 0\right)$

(a) (iii)

B1 $k=25$ Accept also 25 or $y=25$

Do not accept just $|-25|$ or $x=25$ or $y=\pm 25$

(b)

M1 Sets $4e^{2x}-25=2x+43$ and makes e^{2x} the subject. Look for $e^{2x}=\frac{1}{4}(2x+43+25)$ condoning sign slips.Condone $\left|4e^{2x}-25\right|=2x+43$ and makes $\left|e^{2x}\right|$ the subject. Condone for both marks a solution with $x=a/\alpha$

An acceptable alternative is to proceed to $2e^{2x}=x+34 \Rightarrow \ln 2+2x=\ln(x+34)$ using ln laws

A1* Proceeds correctly without errors to the correct solution. This is a given answer and the bracketing must be correct throughout. The solution must have come from $4e^{2x}-25=2x+43$ with the modulus having been taken correctly.

Allow $e^{2x}=\frac{1}{4}(2x+43+25)$ going to $x=\frac{1}{2}\ln\left(\frac{1}{2}x+17\right)$ without explanation

Allow $\frac{1}{2}\ln\left(\frac{1}{2}x+17\right)$ appearing as $\frac{1}{2}\log_e\left(\frac{1}{2}x+17\right)$ but not as $\frac{1}{2}\log\left(\frac{1}{2}x+17\right)$

....

If a candidate attempts the solution backwards they must proceed from $x=\frac{1}{2}\ln\left(\frac{1}{2}x+17\right) \Rightarrow e^{2x}=\frac{1}{2}x+17 \Rightarrow 4e^{2x}-25=2x+43$ for the M1

For the A1 it must be tied up with a minimal statement that this is $g(x)=2x+43$

....

(c)

M1 Subs 1.4 into the iterative formula in an attempt to find x_1

Score for $x_1=\frac{1}{2}\ln\left(\frac{1}{2}\times 1.4+17\right)$ $x_1=\frac{1}{2}\ln(17.7)$ or awrt 1.44

A1 awrt $x_1=1.4368$, $x_2=1.4373$ Subscripts are not important, mark in the order given please.

(d)

M1 For a suitable interval. Accept 1.4365 and 1.4375 (or any two values of a smaller range spanning the root=1.4373) Continued iteration is M0

A1 Substitutes both values into **a suitable function**, which must be defined or implied by their working calculates both values correctly to 1 sig fig (rounded or truncated)

Suitable functions could be $\pm\left(4e^{2x}-2x-68\right)$, $\pm\left(x-\frac{1}{2}\ln\left(\frac{1}{2}x+17\right)\right)$, $\pm\left(2x-\ln\left(\frac{1}{2}x+17\right)\right)$.

Using $4e^{2x}-2x-68$ f (1.4365) = -0.1, f (1.4375) = +0.02 or +0.03

Using $2e^{2x}-x-34$ f (1.4365) = -0.05/-0.06, f (1.4375) = +0.01

Using $x-\frac{1}{2}\ln\left(\frac{1}{2}x+17\right)$ f (1.4365) =-0.0007 or -0.0008, f (1.4375) =+ 0.0001 or +0.0002

Using $2x-\ln\left(\frac{1}{2}x+17\right)$ f (1.4365) = -0.001 or -0.002, f (1.4375) =+0.0003 or +0.0004

and states a reason (eg change of sign)
and a gives a minimal conclusion (eg root or tick)

It is valid to compare the two functions. Eg $g(1.4365)=45.7(6)<2\times 1.4365+43=45.8(73)$, $g(1.4375)=45.90>2\times 1.4375+43=45.8(75)$

but the conclusion should be $g(x)=2x+43$ in between, hence root .

Similarly candidates can compare the functions x and $\frac{1}{2}\ln\left(\frac{1}{2}x+17\right)$

Question	Scheme	Marks
5 (i)	$y = e^{3x}\cos 4x \Rightarrow \left(\frac{dy}{dx}\right) = \cos 4x \times 3e^{3x} + e^{3x} \times -4\sin 4x$	M1A1
	Sets $\cos 4x \times 3e^{3x} + e^{3x} \times -4\sin 4x = 0 \Rightarrow 3\cos 4x - 4\sin 4x = 0$	M1
	$\Rightarrow x = \frac{1}{4}\arctan\frac{3}{4}$	M1
	$\Rightarrow x = \text{awrt } 0.9463$ 4dp	A1 **(5)**
(ii)	$x = \sin^2 2y \Rightarrow \frac{dx}{dy} = 2\sin 2y \times 2\cos 2y$	M1A1
	Uses $\sin 4y = 2\sin 2y\cos 2y$ in their expression	M1
	$\frac{dx}{dy} = 2\sin 4y \Rightarrow \frac{dy}{dx} = \frac{1}{2\sin 4y} = \frac{1}{2}\text{cosec}4y$	M1A1 **(5)** **(10 marks)**
(ii) Alt I	$x = \sin^2 2y \Rightarrow x = \frac{1}{2} - \frac{1}{2}\cos 4y$	2nd M1
	$\frac{dx}{dy} = 2\sin 4y$	1st M1 A1
	$\Rightarrow \frac{dy}{dx} = \frac{1}{2\sin 4y} = \frac{1}{2}\text{cosec}4y$	M1A1 **(5)**
(ii) Alt II	$x^{\frac{1}{2}} = \sin 2y \Rightarrow \frac{1}{2}x^{-\frac{1}{2}} = 2\cos 2y\frac{dy}{dx}$	M1A1
	Uses $x^{\frac{1}{2}} = \sin 2y$ AND $\sin 4y = 2\sin 2y\cos 2y$ in their expression	M1
	$\frac{dy}{dx} = \frac{1}{2\sin 4y} = \frac{1}{2}\text{cosec}4y$	M1A1 **(5)**
(ii) Alt III	$x^{\frac{1}{2}} = \sin 2y \Rightarrow 2y = \text{invsin}\, x^{\frac{1}{2}} \Rightarrow 2\frac{dy}{dx} = \frac{1}{\sqrt{1-x}} \times \frac{1}{2}x^{-\frac{1}{2}}$	M1A1
	Uses $x^{\frac{1}{2}} = \sin 2y$, $\sqrt{1-x} = \cos 2y$ and $\sin 4y = 2\sin 2y\cos 2y$ in their expression	M1
	$\Rightarrow \frac{dy}{dx} = \frac{1}{2\sin 4y} = \frac{1}{2}\text{cosec}4y$	M1A1 **(5)**

(i)

M1 Uses the product rule $uv' + vu'$ to achieve $\left(\frac{dy}{dx}\right) = Ae^{3x}\cos 4x \pm Be^{3x}\sin 4x \quad A, B \neq 0$

The product rule if stated must be correct

A1 Correct (unsimplified) $\frac{dy}{dx} = \cos 4x \times 3e^{3x} + e^{3x} \times -4\sin 4x$

M1 Sets/implies their $\frac{dy}{dx}=0$ factorises/cancels)by e^{3x} to form a trig equation in just $\sin 4x$ and $\cos 4x$

M1 Uses the identity $\frac{\sin 4x}{\cos 4x}\equiv\tan 4x$, moves from $\tan 4x = C, C\neq 0$ using correct order of operations to $x=...$ Accept $x=$ awrt 0.16 (radians) $x=$ awrt 9.22 (degrees) for this mark.

If a candidate elects to pursue a more difficult method using $R\cos(\theta+\alpha)$, for example, the minimum expectation will be that they get (1) the identity correct, and (2) the values of R and α correct to 2dp. So for the correct equation you would only accept $5\cos(4x+\text{awrt } 0.93)$ or $5\sin(4x-\text{awrt } 0.64)$ before using the correct order of operations to $x=...$

Similarly candidates who square $3\cos 4x-4\sin 4x=0$ then use a Pythagorean identity should proceed from either $\sin 4x=\frac{3}{5}$ or $\cos 4x=\frac{4}{5}$ before using the correct order of operations …

A1 $\Rightarrow x=$ awrt 0.9463.

Ignore any answers outside the domain. Withhold mark for additional answers inside the domain

(ii)

M1 Uses chain rule (or product rule) to achieve $\pm P\sin 2y\cos 2y$ as a derivative.

There is no need for lhs to be seen/ correct

If the product rule is used look for $\cancel{\frac{dx}{dy}}=\pm A\sin 2y\cos 2y\pm B\sin 2y\cos 2y$,

A1 Both lhs and rhs correct (unsimplified) . $\frac{dx}{dy}=2\sin 2y\times 2\cos 2y=(4\sin 2y\cos 2y)$ or

$1=2\sin 2y\times 2\cos 2y\frac{dy}{dx}$

M1 Uses $\sin 4y = 2\sin 2y\cos 2y$ in their expression.

You may just see a statement such as $4\sin 2y\cos 2y = 2\sin 4y$ which is fine.

Candidates who write $\cancel{\frac{dx}{dy}}=A\sin 2x\cos 2x$ can score this for $\cancel{\frac{dx}{dy}}=\frac{A}{2}\sin 4x$

M1 Uses $\frac{dy}{dx}=1\Big/\frac{dx}{dy}$ **for their expression in *y***. Concentrate on the trig identity rather than the coefficient in awarding this. Eg $\frac{dx}{dy}=2\sin 4y\Rightarrow\frac{dy}{dx}=2\operatorname{cosec}4y$ is condoned for the M1

If $\frac{dx}{dy}=a+b$ do not allow $\frac{dy}{dx}=\frac{1}{a}+\frac{1}{b}$

A1 $\frac{dy}{dx}=\frac{1}{2}\operatorname{cosec}4y$ If a candidate then proceeds to write down incorrect values of p and q then do not withhold the mark.

NB: See the three alternatives which may be less common but mark in exactly the same way. If you are uncertain as how to mark these please consult your team leader.

In **Alt I** the second M is for writing $x=\sin^2 2y\Rightarrow x=\pm\frac{1}{2}\pm\frac{1}{2}\cos 4y$ from $\cos 4y=\pm 1\pm 2\sin^2 2y$

In **Alt II** the first M is for writing $x^{\frac{1}{2}}=\sin 2y$ and differentiating both sides to $Px^{-\frac{1}{2}}=Q\cos 2y\cancel{\frac{dy}{dx}}$ oe

In **Alt 111** the first M is for writing $2y=\text{invsin}\left(x^{0.5}\right)$ oe and differentiating to $M\cancel{\frac{dy}{dx}}=N\frac{1}{\sqrt{1-\left(x^{0.5}\right)^2}}\times x^{-0.5}$

Question	Scheme	Marks
6(a)	$x^2+x-6\overline{)x^4+x^3-3x^2+7x-6}$ with quotient x^2+3	
	$\underline{x^4+x^3-6x^2}$	
	$3x^2+7x-6$	M1 A1
	$\underline{3x^2+3x-18}$	
	$4x+12$	
	$\dfrac{x^4+x^3-3x^2+7x-6}{x^2+x-6} \equiv x^2+3+\dfrac{4(x+3)}{(x+3)(x-2)}$	M1
	$\equiv x^2+3+\dfrac{4}{(x-2)}$	A1
		(4)
(b)	$f'(x)=2x-\dfrac{4}{(x-2)^2}$	M1A1ft
	Subs $x=3$ into $f'(x=3)=2\times3-\dfrac{4}{(3-2)^2}=(2)$	M1
	Uses $m=-\dfrac{1}{f'(3)}=\left(-\dfrac{1}{2}\right)$ with $(3, f(3))=(3,16)$ to form eqn of normal	
	$y-16=-\dfrac{1}{2}(x-3)$ or equivalent cso	M1A1
		(5)
		(9 marks)

(a)

M1 Divides $x^4+x^3-3x^2+7x-6$ by x^2+x-6 to get a quadratic quotient and a linear or constant remainder. To award this look for a minimum of the following

$$\begin{array}{r} \boldsymbol{x^2(+..x)+A} \\ x^2+x-6\overline{)x^4+x^3-3x^2+7x-6} \\ \underline{\boldsymbol{x^4+x^3-6x^2}} \\ \overline{\qquad(\boldsymbol{Cx})+\boldsymbol{D}} \end{array}$$

If they divide by $(x+3)$ first they must then divide their by result by $(x-2)$ before they score this method mark. Look for a cubic quotient with a constant remainder followed by a quadratic quotient and a constant remainder

Note: FYI Dividing by $(x+3)$ gives x^3-2x^2+3x-2 and $\left(x^3-2x^2+3x-2\right)\div\left(x-2\right)=x^2+3$ with a remainder of 4.

Division by $(x-2)$ first is possible but difficult.....please send to review any you feel deserves credit.

A1 Quotient = x^2+3 and Remainder = $4x+12$

M1 Factorises x^2+x-6 and writes their expression in the appropriate form.

$$\left(\frac{x^4+x^3-3x^2+7x-6}{x^2+x-6}\right)\equiv \text{Their Quadratic Quotient}+\frac{\text{Their Linear Remainder}}{(x+3)(x-2)}$$

It is possible to do this part by partial fractions. To score M1 under this method the terms must be correct and it must be a full method to find both "numerators"

A1 $x^2+3+\frac{4}{(x-2)}$ or $A=3, B=4$ but don't penalise after a correct statement.

(b)

M1 $x^2+A+\frac{B}{x-2} \to 2x \pm \frac{B}{(x-2)^2}$

If they fail in part (a) to get a function in the form $x^2+A+\frac{B}{x-2}$ allow candidates to pick up this method mark for differentiating a function of the form $x^2+Px+Q+\frac{Rx+S}{x \pm T}$ using the quotient rule oe.

A1ft $x^2+A+\frac{B}{x-2} \to 2x - \frac{B}{(x-2)^2}$ oe. FT on their numerical A, B for for $x^2+A+\frac{B}{x-2}$ only

M1 Subs $x=3$ into their $f'(x)$ in an attempt to find a numerical gradient

M1 For the correct method of finding an equation of a normal. The gradient must be $-\frac{1}{\text{their } f'(3)}$ and the point must be $(3, f(3))$. Don't be overly concerned about how they found their f(3), ie accept x=3 y =.

Look for $y-f(3) = -\frac{1}{f'(3)}(x-3)$ or $\left(y-f(3)\right) \times -f'(3) = (x-3)$

If the form $y=mx+c$ is used they must proceed as far as c =

A1 cso $y-16=-\frac{1}{2}(x-3)$ oe such as $2y+x-35=0$ but remember to isw after a correct answer.

Alt (a) attempted by equating terms.

Alt (a)	$x^4+x^3-3x^2+7x-6 \equiv (x^2+A)(x^2+x-6)+B(x+3)$ Compare 2 terms (or substitute 2 values) AND solve simultaneously ie $x^2 \Rightarrow A-6=-3, \quad x \Rightarrow A+B=7, \quad \text{const} \Rightarrow -6A+3B=-6$ $A=3, B=4$	M1 M1 A1,A1

1st Mark M1 Scored for multiplying by (x^2+x-6) and cancelling/dividing to achieve $x^4+x^3-3x^2+7x-6 \equiv (x^2+A)(x^2+x-6)+B(x \pm 3)$

3rd Mark M1 Scored for comparing two terms (or for substituting two values) **AND** solving simultaneously to get values of ***A*** and ***B***.

2nd Mark A1 Either $A=3$ or $B=4$. One value may be correct by substitution of say $x=-3$

4th Mark A1 Both $A=3$ and $B=4$

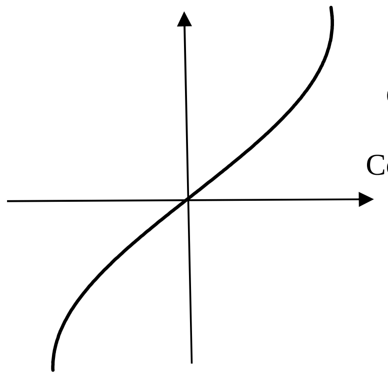
Alt (b) is attempted by the quotient (or product rule)

ALT (b) 1st 3 marks	$f'(x) = \frac{\left(x^2+x-6\right)\left(4x^3+3x^2-6x+7\right)-\left(x^4+x^3-3x^2+7x-6\right)(2x+1)}{\left(x^2+x-6\right)^2}$ Subs $x=3$ into	M1A1 M1

M1 Attempt to use the **quotient rule** $\frac{vu'-uv'}{v^2}$ with $u=x^4+x^3-3x^2+7x-6$ and $v=x^2+x-6$ and achieves an expression of the form $f'(x) = \frac{\left(x^2+x-6\right)\left(..x^3........\right)-\left(x^4+x^3-3x^2+7x-6\right)(..x..)}{\left(x^2+x-6\right)^2}$.

Use a similar approach to the product rule with $u=x^4+x^3-3x^2+7x-6$ and $v=\left(x^2+x-6\right)^{-1}$

Note that this can score full marks from a partially solved part (a) where $f(x) \equiv x^2+3+\frac{4x+12}{x^2+x-6}$

Question	Scheme	Marks
7(a)		
	Correct position **or** curvature	M1
	Correct position **and** curvature	A1
		(2)
(b)	$3\arcsin(x+1)+\pi=0 \Rightarrow \arcsin(x+1)=-\dfrac{\pi}{3}$	M1
	$\Rightarrow (x+1)=\sin\left(-\dfrac{\pi}{3}\right)$	
	$\Rightarrow x=-1-\dfrac{\sqrt{3}}{2}$	dM1A1
		(3)
		(5 marks)

(a) Ignore any scales that appear on the axes

M1 Accept for the method mark
Either one of the two sections with correct curvature passing through (0,0),
Or both sections condoning dubious curvature passing through (0,0) (but do not accept any negative gradients)
Or a curve with a different range or an "extended range"
See the next page for a useful guide for clarification of this mark.

A1 A curve only in quadrants one and three passing through the point (0,0) with a gradient that is always positive. The gradient should appear to be approx ∞ at each end. If you are unsure use review
If range and domain are given then ignore.

(b)

M1 Substitutes $g(x+1)=\arcsin(x+1)$ in $3g(x+1)+\pi=0$ and attempts to make $\arcsin(x+1)$ the subject
Accept $\arcsin(x+1)=\pm\dfrac{\pi}{3}$ or even $g(x+1)=\pm\dfrac{\pi}{3}$. Condone $\dfrac{\pi}{3}$ in decimal form awrt1.047

dM1 Proceeds by evaluating $\sin\left(\pm\dfrac{\pi}{3}\right)$ and making x the subject.
Accept for this mark $\Rightarrow x=\pm\dfrac{\sqrt{3}}{2}\pm1$. Accept decimal such as -1.866
Do not allow this mark if the candidate works in mixed modes (radians and degrees)
You may condone invisible brackets for both M's as long as the candidate is working correctly with the function

A1 $-1-\dfrac{\sqrt{3}}{2}$ oe with no other solutions. Remember to isw after a correct answer
Be careful with single fractions. $-\dfrac{2-\sqrt{3}}{2}$ and $\dfrac{-2+\sqrt{3}}{2}$ are incorrect but $-\dfrac{2+\sqrt{3}}{2}$ is correct

Note: It is possible for a candidate to change $\dfrac{\pi}{3}$ to $60°$ and work in degrees for all marks

Question	Scheme	Marks
8 (a)	$2\cot 2x+\tan x \equiv \dfrac{2}{\tan 2x}+\tan x$	B1
	$\equiv \dfrac{(1-\tan^2 x)}{\tan x}+\dfrac{\tan^2 x}{\tan x}$	M1
	$\equiv \dfrac{1}{\tan x}$	M1
	$\equiv \cot x$	A1*
		(4)
(b)	$6\cot 2x+3\tan x=\text{cosec}^2 x-2 \Rightarrow 3\cot x=\text{cosec}^2 x-2$	
	$\Rightarrow 3\cot x=1+\cot^2 x-2$	M1
	$\Rightarrow 0=\cot^2 x-3\cot x-1$	A1
	$\Rightarrow \cot x=\dfrac{3\pm\sqrt{13}}{2}$	M1
	$\Rightarrow \tan x=\dfrac{2}{3\pm\sqrt{13}} \Rightarrow x=..$	M1
	$\Rightarrow x=0.294, -2.848, -1.277, 1.865$	A2,1,0
		(6)
		(10 marks)
8 (a)alt 1	$2\cot 2x+\tan x \equiv \dfrac{2\cos 2x}{\sin 2x}+\tan x$	B1
	$\equiv 2\dfrac{\cos^2 x-\sin^2 x}{2\sin x\cos x}+\dfrac{\sin x}{\cos x}$	M1
	$\equiv \dfrac{\cos^2 x-\sin^2 x}{\sin x\cos x}+\dfrac{\sin^2 x}{\sin x\cos x} \equiv \dfrac{\cos^2 x}{\sin x\cos x}$	M1
	$\equiv \dfrac{\cos x}{\sin x}$	
	$\equiv \cot x$	A1*
8 (a)alt 2	$2\cot 2x+\tan x \equiv 2\dfrac{(1-\tan^2 x)}{2\tan x}+\tan x$	B1M1
	$\equiv \dfrac{2}{2\tan x}-\dfrac{2\tan^2 x}{2\tan x}+\tan x$ or $\dfrac{(1-\tan^2 x)+\tan^2 x}{\tan x}$	
	$\equiv \dfrac{2}{2\tan x}=\cot x$	M1A1*
Alt (b)	$6\cot 2x+3\tan x=\text{cosec}^2 x-2 \Rightarrow \dfrac{3\cos x}{\sin x}=\dfrac{1}{\sin^2 x}-2$	
	$\left(\times\sin^2 x\right) \Rightarrow 3\sin x\cos x=1-2\sin^2 x$	M1
	$\Rightarrow \dfrac{3}{2}\sin 2x=\cos 2x$	M1A1
	$\Rightarrow \tan 2x=\dfrac{2}{3} \Rightarrow x=..$	M1
	$\Rightarrow x=0.294, -2.848, -1.277, 1.865$	A2,1,0
		(6)

(a)

B1 States or uses the identity $2\cot 2x = \dfrac{2}{\tan 2x}$ or alternatively $2\cot 2x = \dfrac{2\cos 2x}{\sin 2x}$

This may be implied by $2\cot 2x = \dfrac{1-\tan^2 x}{\tan x}$. Note $2\cot 2x = \dfrac{1}{2\tan 2x}$ is B0

M1 Uses the correct double angle identity $\tan 2x = \dfrac{2\tan x}{1-\tan^2 x}$

Alternatively uses $\sin 2x = 2\sin x\cos x$, $\cos 2x = \cos^2 x - \sin^2 x$ oe and $\tan x = \dfrac{\sin x}{\cos x}$

M1 Writes their two terms with a single common denominator and simplifies to a form $\dfrac{ab}{cd}$.

For this to be scored the expression must be in either sin x and cos x or just tan x.

In alternative 2 it is for splitting the complex fraction into parts and simplifying to a form $\dfrac{ab}{cd}$.

You are awarding this for a correct method to proceed to terms like $\dfrac{\cos^2 x}{\sin x\cos x}$, $\dfrac{2\cos^3 x}{2\sin x\cos^2 x}$, $\dfrac{2}{2\tan x}$

A1* cso. For proceeding to the correct answer. This is a given answer and all aspects must be correct including the consistent use of variables. If the candidate approaches from both sides there must be a conclusion for this mark to be awarded. Occasionally you may see a candidate attempting to prove $\cot x - \tan x \equiv 2\cot 2x$. This is fine but again there needs to be a conclusion for the A1*

If you are unsure of how some items should be marked then please use review

(b)

M1 For using part (a) and writing $6\cot 2x + 3\tan x$ as $k\cot x$, $k \neq 0$ in their equation (or equivalent)

WITH an attempt at using $\text{cosec}^2 x = \pm 1 \pm \cot^2 x$ to produce a quadratic equation in just $\cot x / \tan x$

A1 $\cot^2 x - 3\cot x - 1 = 0$ The = 0 may be implied by subsequent working

Alternatively accept $\tan^2 x + 3\tan x - 1 = 0$

M1 Solves a 3TQ=0 in $\cot x$ (or tan) using the formula or any suitable method for their quadratic to find at least one solution. Accept answers written down from a calculator. You may have to check these from an incorrect quadratic. FYI answers are $\cot x =$ awrt $3.30, \quad -0.30$

Be aware that $\cot x = \dfrac{3 \pm \sqrt{13}}{2} \Rightarrow \tan x = \dfrac{-3 \pm \sqrt{13}}{2}$

M1 For $\tan x = \dfrac{1}{\cot x}$ and using arctan producing at least one answer for x in degrees or radians.

You may have to check these with your calculator.

A1 Two of $x = 0.294, -2.848, -1.277, 1.865$ (awrt 3dp) in radians or degrees.

In degrees the answers you would accept are (awrt 2dp) $x = 16.8°, 106.8°, -73.2°, -163.2°$

A1 All four of $x = 0.294, -2.848, -1.277, 1.865$ (awrt 3 dp) with no extra solutions in the range $-\pi \leqslant x \leqslant \pi$

See main scheme for Alt to (b) using Double Angle formulae still entered M A M M A A in epen

1st M1 For using part (a) and writing $6\cot 2x + 3\tan x$ as $k\cot x$, $k \neq 0$ in their equation (or equivalent)

then using $\cot x = \dfrac{\cos x}{\sin x}$, $\text{cosec}^2 x = \dfrac{1}{\sin^2 x}$ and $\times \sin^2 x$ to form an equation sin and cos

1st A1 For $\dfrac{3}{2}\sin 2x = \cos 2x$ or equivalent. **Attached to the next M**

2nd M1 For using both correct double angle formula

3rd M1 For moving from $\tan 2x = C$ to x=..using the correct order of operations.

Question	Scheme	Marks
9(a)	Subs $D=15$ and $t=4$ $\quad x=15\mathrm{e}^{-0.2\times4}=6.740\ (mg)$	M1A1
		(2)
(b)	$15\mathrm{e}^{-0.2\times7}+15\mathrm{e}^{-0.2\times2}=13.754(mg)$	M1A1*
		(2)
(c)	$15\mathrm{e}^{-0.2\times T}+15\mathrm{e}^{-0.2\times(T+5)}=7.5$	M1
	$15\mathrm{e}^{-0.2\times T}+15\mathrm{e}^{-0.2\times T}\mathrm{e}^{-1}=7.5$	
	$15\mathrm{e}^{-0.2\times T}(1+\mathrm{e}^{-1})=7.5\Rightarrow \mathrm{e}^{-0.2\times T}=\dfrac{7.5}{15(1+\mathrm{e}^{-1})}$	dM1
	$\mathrm{T}=-5\ln\left(\dfrac{7.5}{15\left(1+\mathrm{e}^{-1}\right)}\right)=5\ln\left(2+\dfrac{2}{\mathrm{e}}\right)$	A1, A1
		(4)
		(8 marks)

(a)

M1 Attempts to substitute both $D=15$ and $t=4$ in $x=D\mathrm{e}^{-0.2t}$

It can be implied by sight of $15\mathrm{e}^{-0.8}$, $15\mathrm{e}^{-0.2\times4}$ or awrt 6.7

Condone slips on the power. Eg you may see -0.02

A1 CAO 6.740 (mg) Note that 6.74 (mg) is A0

(b)

M1 Attempt to find the sum of two expressions with D =15 in both terms with t values of 2 and 7

Evidence would be $15\mathrm{e}^{-0.2\times7}+15\mathrm{e}^{-0.2\times2}$ or similar expressions such as $\left(15\mathrm{e}^{-1}+15\right)\mathrm{e}^{-0.2\times2}$

Award for the sight of the two numbers awrt **3.70** and awrt **10.05**, followed by their total awrt **13.75**

Alternatively finds the amount after 5 hours, $15\mathrm{e}^{-1}=$ awrt **5.52** adds the second dose = **15** to get a total of awrt **20.52** then multiplies this by $\mathrm{e}^{-0.4}$ to get awrt **13.75**.

Sight of 5.52+15=20.52 $\rightarrow$ 13.75 is fine.

A1* cso so both the expression $15\mathrm{e}^{-0.2\times7}+15\mathrm{e}^{-0.2\times2}$ and $13.754(mg)$ are required

Alternatively both the expression $\left(15\mathrm{e}^{-0.2\times5}+15\right)\times\mathrm{e}^{-0.2\times2}$ and $13.754(mg)$ are required.

Sight of just the numbers is not enough for the A1*

(c)

M1 Attempts to write down a correct equation involving T or t. Accept with or without correct bracketing

Eg. accept $15\mathrm{e}^{-0.2\times T}+15\mathrm{e}^{-0.2\times(T\pm5)}=7.5$ or similar equations $\left(15\mathrm{e}^{-1}+15\right)\mathrm{e}^{-0.2\times T}=7.5$

dM1 Attempts to solve their equation, dependent upon the previous mark, by proceeding to $\mathrm{e}^{-0.2\times T}=\ldots$

An attempt should involve an attempt at the index law $x^{m+n}=x^m\times x^n$ and taking out a factor of $\mathrm{e}^{-0.2\times T}$ Also score for candidates who make $\mathrm{e}^{+0.2\times T}$ the subject using the same criteria

A1 Any correct form of the answer, for example, $-5\ln\left(\dfrac{7.5}{15\left(1+\mathrm{e}^{-1}\right)}\right)$

A1 CSO $\mathrm{T}=5\ln\left(2+\dfrac{2}{\mathrm{e}}\right)$ Condone t appearing for T throughout this question.

Alt (c) using lns

(c)	$15e^{-0.2\times T} + 15e^{-0.2\times(T+5)} = 7.5$ $15e^{-0.2\times T} + 15e^{-0.2\times T}e^{-1} = 7.5$ $e^{-0.2\times T}(1+e^{-1}) = 0.5 \Rightarrow -0.2\times T + \ln(1+e^{-1}) = \ln 0.5$ $\Rightarrow T = \dfrac{\ln 0.5 - \ln(1+e^{-1})}{-0.2}, \Rightarrow T = 5\ln\left(2+\dfrac{2}{e}\right)$	M1 dM1 A1, A1 **(4)** **(8 marks)**

You may see numerical attempts at part (c).

Such an attempt can score a maximum of two marks.

This can be achieved either by

Method One

1st Mark (Method): $15e^{-0.2\times T} + \text{awrt } 5.52e^{-0.2\times T} = 7.5 \Rightarrow e^{-0.2\times T} = \text{awrt } 0.37$

2nd Mark (Accuracy): $T=-5\ln(\text{awrt } 0.37)$ or awrt 5.03 or $T=-5\ln\left(\dfrac{7.5}{\text{awrt } 20.52}\right)$

Method Two

1st Mark (Method): $13.754e^{-0.2\times T} = 7.5 \Rightarrow T = -5\ln\left(\dfrac{7.5}{13.754}\right)$ or equivalent such as 3.03

2nd Mark (Accuracy): 3.03+2=5.03 Allow $-5\ln\left(\dfrac{7.5}{13.754}\right)+2$

Method Three (by trial and improvement)

1st Mark (Method): $15e^{-0.2\times 5} + 15e^{-0.2\times 10} = 7.55$ or $15e^{-0.2\times 5.1} + 15e^{-0.2\times 10.1} = 7.40$ or any value between
2nd Mark (Accuracy): Answer T =5.03.