Mark Scheme (Results)
Summer 2010

GCE

Core Mathematics C1 (6663)

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SOME GENERAL PRINCIPLES FOR C1 MARKING
(But the particular mark scheme always takes precedence)

Method marks

Usually we would overlook simple arithmetic errors or sign slips but the correct **processes** should be used. So dividing by a number instead of subtracting would be M0 but adding a number instead of subtracting would be treated as the correct process but a sign error.

Method mark for solving 3 term quadratic:

1. Factorisation

$(x^2+bx+c)=(x+p)(x+q),\text{ where}|pq|=|c|$, leading to *x* = ...

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

2. Formula

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

3. Completing the square

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

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 mistakes in the substitution of values (but refer to the mark scheme first… the application of this principle may vary).
Where the formula is not quoted, the method mark can be gained by implication from correct working with values, but will be lost if there is any mistake in the working.

Equation of a straight line

Apply the following conditions to the M mark for the equation of a line through (a,b):
If the *a* and *b* are the wrong way round the M mark can still be given if a correct formula is seen, (e.g. $y-y_1=m(x-x_1)$) otherwise M0.
If (*a*, *b*) is substituted into $y=mx+c$ to find *c*, the M mark is for attempting this and scored when *c* =… is reached.

Answers without working

The rubric says that these may gain no credit. Individual mark schemes will give details of what happens in particular cases. General policy is that if it could be done "in your head", detailed working would not be required. Most candidates do show working, but there are occasional awkward cases and if the mark scheme does not cover this, please contact your team leader for advice.

Misreads

A misread must be consistent for the whole question to be interpreted as such.
These are not common. In clear cases, please deduct the first 2 A (or B) marks which would have been lost by following the scheme. (Note that 2 marks is the maximum misread penalty, but that misreads which alter the nature or difficulty of the question cannot be treated so generously and it will usually be necessary here to follow the scheme as written).
Sometimes following the scheme as written is more generous to the candidate than applying the misread rule, so in this case use the scheme as written.
If in doubt, send the response to Review.

June 2010
Core Mathematics C1 6663
Mark Scheme

Question Number	Scheme	Marks
1.	$\left(\sqrt{75}-\sqrt{27}\right)=5\sqrt{3}-3\sqrt{3}$	M1
	$= 2\sqrt{3}$	A1
		2
	Notes	
	M1 for $5\sqrt{3}$ from $\sqrt{75}$ or $3\sqrt{3}$ from $\sqrt{27}$ seen anywhere A1 for $2\sqrt{3}$; allow $\sqrt{12}$ or (or $k=2, x=3$ / allow $k=1, x=12$) Some Common errors $\sqrt{75}-\sqrt{27}=\sqrt{48}$ leading to $4\sqrt{3}$ is M0A0 $25\sqrt{3}-9\sqrt{3}=16\sqrt{3}$ is M0A0	

Question Number	Scheme	Marks
2.	$\frac{8x^4}{4} + \frac{6x^{\frac{3}{2}}}{\frac{3}{2}} - 5x + c$	M1 A1
	$= 2x^4 + 4x^{\frac{3}{2}}, -5x + c$	A1 A1
		4
	Notes	
	M1 for some attempt to integrate a term in *x*: $x^n \to x^{n+1}$ 1st A1 for correct, possibly un-simplified x^4 or $x^{\frac{3}{2}}$ term. e.g. $\frac{8x^4}{4}$ or $\frac{6x^{\frac{3}{2}}}{\frac{3}{2}}$ 2nd A1 for both $2x^4$ and $4x^{\frac{3}{2}}$ terms correct and simplified on the same line N.B. some candidates write $4\sqrt{x^3}$ or $4x^{1\frac{1}{2}}$ which are, of course, fine for A1 3rd A1 for $-5x+c$. Accept $-5x^1+c$. The $+c$ must appear on the same line as the $-5x$ N.B. We do not need to see one line with a fully correct integral Ignore ISW (ignore incorrect subsequent working) if a correct answer is followed by an incorrect version. Condone poor use of notation e.g. $\int 2x^4 + 4x^{\frac{3}{2}} - 5x + c$ will score full marks.	

Question Number	Scheme	Marks
3. **(a)**	$3x-6<8-2x \rightarrow \; 5x<14$ (Accept $5x-14<0$ (o.e.))	M1
	$x<2.8$ or $\frac{14}{5}$ or $2\frac{4}{5}$ (condone $\le$)	A1 (2)
(b)	Critical values are $x=\frac{7}{2}$ and -1	B1
	Choosing "inside" $-1<x<\frac{7}{2}$	M1 A1 (3)
(c)	$-1<x<2.8$	B1ft (1)
	Accept any exact equivalents to -1, 2.8, 3.5	**6**

Notes

(a)

M1 for attempt to rearrange to $kx < m$ (o.e.) Either $k = 5$ or $m = 14$ should be correct
Allow $5x = 14$ or even $5x > 14$

(b)

B1 for both correct critical values. (May be implied by a correct inequality)
M1 ft their values and choose the "inside" region
A1 for fully correct inequality (Must be in part (b): do not give marks if only seen in (c))
Condone seeing $x < -1$ in working provided $-1 < x$ is in the final answer.

e.g. $x>-1,\; x<\frac{7}{2}$ <u>or</u> $x>-1$ "or" $x<\frac{7}{2}$ <u>or</u> $x>-1$ "blank space" $x<\frac{7}{2}$ score M1A0

BUT allow $x>-1$ and $x<\frac{7}{2}$ to score M1A1 (the "and" must be seen)

Also $\left(-1,\frac{7}{2}\right)$ will score M1A1

NB $x<-1, x<\frac{7}{2}$ is of course M0A0 and a number line even with "open" ends is M0A0

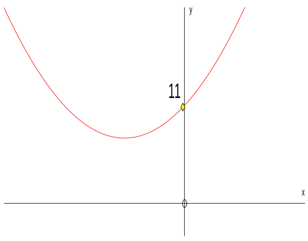
Allow 3.5 instead of $\frac{7}{2}$

(c)

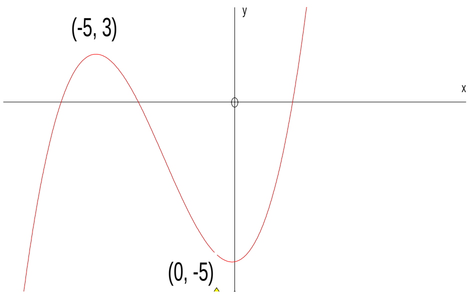
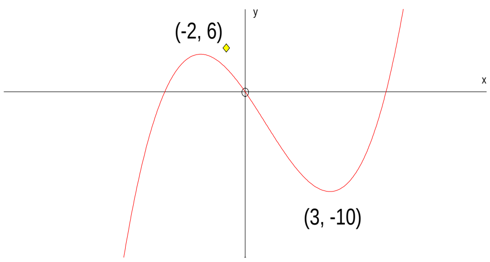
B1ft for $-1<x<2.8$ (ignoring their previous answers) <u>or</u> ft their answers to part (a) and part (b) provided both answers were regions and not single values.
Allow use of "and" between inequalities as in part (b)
If their set is empty allow a suitable description in words or the symbol $\varnothing$.

<u>Common error:</u> If (a) is correct and in (b) they simply leave their answer as $x<-1$, $x < 3.5$ then in (c) $x < -1$ would get B1ft as this is a correct follow through of these 3 inequalities.

Penalise use of $\le$ only on the A1 in part (b). [i.e. condone in part (a)]

Question Number	Scheme	Marks
4. **(a)**	$(x+3)^2+2$ or $p=3$ or $\frac{6}{2}$ $q=2$	B1 B1 (2)
(b)	 U shape with min in 2nd quad (Must be above *x*-axis and not on *y*=axis) U shape crossing *y*-axis at (0, 11) only (Condone (11,0) marked on *y*-axis)	B1 B1 (2)
(c)	$b^2-4ac=6^2-4\times 11$ $=\underline{-8}$	M1 A1 (2) **6**
	Notes	
(a)	Ignore an "= 0" so $(x+3)^2+2=0$ can score both marks	
(b)	The U shape can be interpreted fairly generously. Penalise an obvious V on 1st B1 only. The U needn't have equal "arms" as long as there is a clear min that "holds water" 1st B1 for U shape with minimum in 2nd quad. Curve need not cross the *y*-axis but minimum should NOT touch *x*-axis and should be left of (not on) *y*-axis 2nd B1 for U shaped curve crossing at (0, 11). Just 11 marked on *y*-axis is fine. The point must be marked on the sketch (do not allow from a table of values) Condone stopping at (0, 11)	
(c)	M1 for some correct substitution into b^2-4ac. This may be as part of the quadratic formula but must be in part (c) and must be only numbers (no *x* terms present). Substitution into $b^2<4ac$ or $b^2=4ac$ or $b^2>4ac$ is M0 A1 for -8 only. If they write $-8<0$ treat the <0 as ISW and award A1 If they write $-8\geq 0$ then score A0 A substitution in the quadratic formula leading to -8 inside the square root is A0. So substituting into $b^2-4ac<0$ leading to $-8<0$ can score M1A1. Only award marks for use of the discriminant in part (c)	

Question Number	Scheme	Marks
5.		
(a)	$a_2 = \left(\sqrt{4+3}\right) = \sqrt{7}$	B1
	$a_3 = \sqrt{\text{"their 7"}+3} = \sqrt{10}$	B1ft (2)
(b)	$a_4 = \sqrt{10+3}\left(=\sqrt{13}\right)$	M1
	$a_5 = \sqrt{13+3} = 4$ *	A1 cso (2)
		4
	<u>Notes</u>	
(a)	1st B1 for $\sqrt{7}$ only 2nd B1ft follow through their "7" in correct formula provided they have $\sqrt{n}$,where n is an integer.	
(b)	M1 for an attempt to find a_4. Should see $\sqrt{\text{"their"}(a_3)^2+3}$. Must see evidence for M1. $a_4 = \sqrt{13}$ provided this follows from their a_3 working or answer is sufficient A1cso for a correct solution (M1 explicit) must include the = 4. Ending at $\sqrt{16}$ only is A0 and ending with $\pm$ 4 is A0. Ignore any incorrect statements that are not used e.g. common difference = $\sqrt{3}$ <u>Listing</u>: A <u>full</u> list: $2\ \left(=\sqrt{4}\right),\ \sqrt{7},\ \sqrt{10},\ \sqrt{13},\ \sqrt{16}=4$ is fine for M1A1	
ALT	<u>Formula</u>: Some may state (or use) $a_n = \sqrt{3n+1}$ leading to $a_5 = \sqrt{3\times5+1} = 4$. This will get marks in (a) [if correct values are seen] and can score the M1 in (b) if $a_n = \sqrt{3n+1}$ or $a_4 = \sqrt{13}$ are seen.	
$\pm\sqrt{\ }$	If $\pm\sqrt{\ }$ appear any where ignore in part (a) and withhold the final A mark only	

Question Number	Scheme	Marks	
6.			
(a)			
	Horizontal translation of ± 3	M1	
	$(-5, 3)$ marked on sketch **or in text**	B1	
	$(0, -5)$ and min intentionally on y-axis Condone $(-5, 0)$ if correctly placed on negative y-axis	A1	(3)
(b)			
	Correct shape and intentionally through (0,0) between the max and min	B1	
	$(-2, 6)$ marked on graph **or in text**	B1	
	$(3, -10)$ marked on graph **or in text**	B1	(3)
(c)	$(a =)$ <u>5</u>	B1	(1)

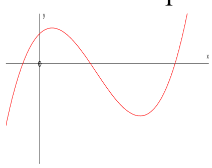
<u>Notes</u>

Turning points (not on axes) should have both co-ordinates given in form(x,y) .
Do not accept points marked on axes e.g. -5on x-axis and 3 on y-axis is not sufficient.
For repeated offenders apply this penalty **once only** at first offence and condone elsewhere.

In (a) and (b) no graphs means no marks.

In (a) and (b) the ends of the graphs do not need to cross the axes provided max and min are clear

(a)



M1 for a horizontal translation of ± 3 so accept [graph] i.e max in 1st quad <u>and</u> coordinates of $(1, 3)$ <u>or</u> $(6, -5)$ seen.
[Horizontal translation to the left should have a min <u>on</u> the y-axis]
If curve passes through (0,0) then M0 (and A0) but they could score the B1 mark.

A1 for minimum clearly on negative y-axis and at least -5 marked on y-axis.
Allow this mark if the minimum is very close and the point $(0, -5)$ clearly indicated

(b)

1st B1 Ignore coordinates for this mark
Coordinates or points on sketch override coordinates given in the text.
Condone (y, x) confusion for points on axes only. So $(-5,0)$ for $(0, -5)$ is OK if the point is marked correctly but (3,10) is B0 even if in 4th quadrant.

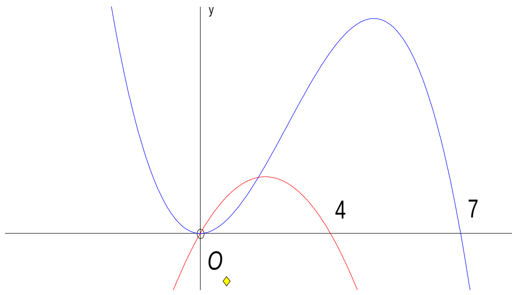
(c)

This may be at the bottom of a page or in the question...make sure you scroll up and down!

Question Number	Scheme	Marks
7.	$\frac{3x^2+2}{x} = 3x + 2x^{-1}$	M1 A1
	$(y'=)\,24x^2, -2x^{-\frac{1}{2}}, +3-2x^{-2}$	M1 A1 A1A1
	$\left[24x^2 - 2x^{-\frac{1}{2}} + 3 - 2x^{-2}\right]$	
		6
	Notes	
	1st M1 for attempting to divide(one term correct) 1st A1 for both terms correct on the same line, accept $3x^1$ for $3x$ or $\frac{2}{x}$ for $2x^{-1}$ These first two marks may be implied by a correct differentiation at the end. 2nd M1 for an attempt to differentiate $x^n \to x^{n-1}$ for at least one term of their expression "Differentiating" $\frac{3x^2+2}{x}$ and getting $\frac{6x}{1}$ is M0 2nd A1 for $24x^2$ only 3rd A1 for $-2x^{-\frac{1}{2}}$ allow $\frac{-2}{\sqrt{x}}$. Must be simplified to this, not e.g. $\frac{-4}{2}x^{-\frac{1}{2}}$ 4th A1 for $3-2x^{-2}$ allow $\frac{-2}{x^2}$. Both terms needed. Condone $3+(-2)x^{-2}$ If "+c" is included then they lose this final mark They do not need one line with all terms correct for full marks. Award marks when first seen in this question and apply ISW. Condone a mixed line of some differentiation and some division e.g. $24x^2 - 4x^{\frac{1}{2}} + 3x + 2x^{-1}$ can score 1st M1A1 and 2nd M1A1	
Quotient /Product Rule	$\frac{x(6x)-(3x^2+2)\times 1}{x^2}$ or $6x(x^{-1})+(3x^2+2)(-x^{-2})$ $\frac{3x^2-2}{x^2}$ or $3-\frac{2}{x^2}$ (o.e.)	1st M1 for an attempt: $\frac{P-Q}{x^2}$ or $R+(-S)$ with one of P,Q or R,S correct. 1st A1 for a correct expression 4th A1 same rules as above

Question Number	Scheme	Marks
8.		
(a)	$m_{AB} = \dfrac{4-0}{7-2} \quad \left(=\dfrac{4}{5}\right)$	M1
	Equation of *AB* is: $y-0=\dfrac{4}{5}(x-2)$ or $y-4=\dfrac{4}{5}(x-7)$ (o.e.)	M1
	$\underline{4x - 5y - 8 = 0}$ (o.e.)	A1 (3)
(b)	$(AB =)\sqrt{(7-2)^2+(4-0)^2}$	M1
	$=\sqrt{41}$	A1 (2)
(c)	Using isos triangle with $AB = AC$ then $t = 2\times y_A = 2\times 4 = 8$	B1 (1)
(d)	Area of triangle = $\frac{1}{2}t\times(7-2)$	M1
	= $\underline{20}$	A1 (2)
		8
	Notes	
(a)	**Apply the usual rules for quoting formulae here.** For a correctly quoted formula with some correct substitution award M1 If no formula is quoted then a fully correct expression is needed for the M mark 1st M1 for attempt at gradient of *AB*. Some correct substitution in correct formula. 2nd M1 for an attempt at equation of *AB*. Follow through their gradient, not e.g. $-\dfrac{1}{m}$ Using $y = mx + c$ scores this mark when c is found. Use of $\dfrac{y-y_1}{y_2-y_1}=\dfrac{x-x_1}{x_2-x_1}$ scores 1st M1 for denominator, 2nd M1 for use of a correct point A1 requires integer form but allow $5y + 8 = 4x$ etc. Must have an "=" or A0	
(b)	M1 for an expression for *AB* or AB^2. Ignore what is "left" of the equals sign	
(c)	B1 for $t = 8$. May be implied by correct coordinates (2, 8) or the value appearing in (d)	
(d)	M1 for an expression for the area of the triangle, follow through their t ($\neq 0$) but must have the $(7-2)$ or 5 and the $\frac{1}{2}$.	
DET	e.g. $\begin{matrix} 2 & 7 & 2 & 2 \\ 0 & 4 & t & 0 \end{matrix}$ Area $=\frac{1}{2}\left[8+7t+0-(0+8+2t)\right]$ Must have the $\frac{1}{2}$ for M1	

Question Number	Scheme	Marks
9. **(a)**	$a+29d=40.75$ or $a=40.75-29d$ or $29d=40.75-a$	M1 A1 (2)
(b)	$(S_{30})=\frac{30}{2}(a+l)$ or $\frac{30}{2}(a+40.75)$ or $\frac{30}{2}(2a+(30-1)d)$ or $15(2a+29d)$	M1
	So $1005=15[a+40.75]$ *	A1 cso (2)
(c)	$67 = a + 40.75$ so <u>a = (£) 26.25 or 2625p or $26\frac{1}{4}$ NOT $\frac{105}{4}$</u>	M1 A1
	$29d = 40.75 - 26.25$	M1
	$= 14.5$ so <u>d = (£)0.50 or 0.5 or 50p</u> or $\frac{1}{2}$	A1 (4)
		8
	Notes	
(a)	M1 for attempt to use $a + (n - 1)d$ with n =30 to form an equation . So $a + (30 - 1)d$ = any number is OK A1 as written. Must see $29d$ not just $(30 - 1)d$. Ignore any floating £ signs e.g. $a+29d=$ £40.75 is OK for M1A1 These two marks must be scored in (a). Some may omit (a) but get correct equation in (c) [or (b)] but we do not give the marks retrospectively.	
	Parts (b) and (c) may run together	
(b)	M1 for an attempt to use an S_n formula with n =30 . **Must see one of the printed forms.** ($S_{30}=$ is not required) A1cso for forming an equation with 1005 and S_n and simplifying to printed answer. Condone £ signs e.g. 15[a+ £40.75]=1005 is OK for A1	
(c)	1st M1 for an attempt to simplify the given linear equation for a. Correct processes. Must get to $ka = \ldots$ or $k = a + m$ i.e. one step (division or subtraction) from $a = \ldots$ Commonly: $15a = 1005 - 611.25$ (= 393.75) 1st A1 For a = 26.25 or 2625p or $26\frac{1}{4}$ NOT $\frac{105}{4}$ or any other fraction 2nd M1 for correct attempt at a linear equation for d, follow through their a or equation in (a) Equation just has to be linear in d, they don't have to simplify to d =… 2nd A1 depends upon 2nd M1 and use of correct a. Do not penalise a second time if there were minor arithmetic errors in finding a provided a = 26.25 (o.e.) is used. Do not accept other fractions other than $\frac{1}{2}$ **If answer is in pence a "p" must be seen.**	
Sim Equ	Use this scheme: 1st M1A1 for a and 2nd M1A1 for d. Typically solving: $1005=30a + 435d$ and $40.75 = a + 29d$. If they find d first then follow through use of their d when finding a.	

Question Number	Scheme	Marks	
10. (a)			
	(i) $\cap$ shape (anywhere on diagram)	B1	
	Passing through or stopping at (0, 0) and (4,0) only(Needn't be $\cap$ shape)	B1	
	(ii) correct shape (-ve cubic) with a max and min drawn anywhere	B1	
	Minimum or maximum at (0,0)	B1	
	Passes through or stops at (7,0) but NOT touching.	B1	(5)
	(7, 0) should be to right of (4,0) or B0		
	Condone (0,4) or (0, 7) marked correctly on x-axis. Don't penalise poor overlap near origin.		
	Points must be marked on the sketch...not in the text		
(b)	$x(4-x)=x^2(7-x)$ $(0=)x[7x-x^2-(4-x)]$	M1	
	$(0=)x[7x-x^2-(4-x)]$ (o.e.)	B1ft	
	$0=x(x^2-8x+4)$ *	A1 cso	(3)
(c)	$(0=x^2-8x+4\Rightarrow)x=\dfrac{8\pm\sqrt{64-16}}{2}$ or $(x\pm4)^2-4^2+4(=0)$	M1	
	$(x-4)^2=12$	A1	
	$=\dfrac{8\pm4\sqrt{3}}{2}$ or $(x-4)=\pm2\sqrt{3}$	B1	
	$x=4\pm2\sqrt{3}$	A1	
	From sketch A is $x=4-2\sqrt{3}$	M1	
	So $y=(4-2\sqrt{3})(4-[4-2\sqrt{3}])$ (dependent on 1st M1)	M1	
	$\underline{=-12+8\sqrt{3}}$	A1	(7)
			15
	Notes		
(b)	M1 for forming a suitable equation B1 for a common factor of x taken out legitimately. Can treat this as an M mark. Can ft their cubic = 0 found from an attempt at solving their equations e.g. $x^3-8x^2-4x=x(\ldots$ A1cso no incorrect working seen. The "= 0" is required but condone missing from some lines of working. Cancelling the x scores B0A0.		
(c)	1st M1 for some use of the correct formula or attempt to complete the square 1st A1 for a fully correct expression: condone + instead of $\pm$ **or** for $(x-4)^2=12$ B1 for simplifying $\sqrt{48}=4\sqrt{3}$ or $\sqrt{12}=2\sqrt{3}$ .Can be scored independently of this expression 2nd A1 for correct solution of the form $p+q\sqrt{3}$: can be $\pm$ or + or − 2nd M1 for selecting their answer in the interval (0,4). If they have no value in (0,4) score M0 3rd M1 for attempting $y=\ldots$using their x in correct equation. An expression needed for M1A0 3rd A1 for correct answer. If 2 answers are given A0.		

Question Number	Scheme	Marks
11. (a)	$(y=)\frac{3x^2}{2}-\frac{5x^{\frac{1}{2}}}{\frac{1}{2}}-2x \quad (+c)$	M1A1A1
	$f(4)=5 \quad \Rightarrow 5=\frac{3}{2}\times 16-10\times 2-8+c$	M1
	$\underline{c=9}$	A1 (5)
	$\left[f(x)=\frac{3}{2}x^2-10x^{\frac{1}{2}}-2x+9 \right]$	
(b)	$m=3\times 4-\frac{5}{2}-2 \quad \left(=7.5 \text{ or } \frac{15}{2}\right)$	M1
	Equation is: $y-5=\frac{15}{2}(x-4)$	M1A1
	$\underline{2y-15x+50=0}$ o.e.	A1 (4) **(9marks)**
(a)	1st M1 for an attempt to integrate $x^n \to x^{n+1}$ 1st A1 for at least 2 correct terms in x (unsimplified) 2nd A1 for all 3 terms in x correct (condone missing $+c$ at this point). Needn't be simplified 2nd M1 for using the point (4, 5) to form a linear equation for c. Must use $x = 4$ and $y = 5$ and have no x term and the function must have "changed". 3rd A1 for $c = 9$. The final expression is not required.	
(b)	1st M1 for an attempt to evaluate $f'(4)$. Some correct use of $x = 4$ in $f'(x)$ but condone slips. They must therefore have at least 3×4 or $-\frac{5}{2}$ and clearly be using $f'(x)$ with $x = 4$. Award this mark wherever it is seen. 2nd M1 for using their value of m [or their $-\frac{1}{m}$] (provided it clearly comes from using $x = 4$ in $f'(x)$) to form an equation of the line through (4,5)). Allow this mark for an attempt at a normal or tangent. Their m must be numerical. Use of $y = mx + c$ scores this mark when c is found. 1st A1 for any correct expression for the equation of the line 2nd A1 for any correct equation with integer coefficients. An "=" is required. e.g. $2y = 15x - 50$ etc as long as the equation is correct and has integer coefficients.	
Normal	Attempt at normal can score both M marks in (b) but A0A0	

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Summer 2010

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SOME GENERAL PRINCIPLES FOR C2 MARKING
(But the particular mark scheme always takes precedence)

Method mark for solving 3 term quadratic:

1. Factorisation

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

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

2. Formula

Attempt to use 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 = ...

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 mistakes in the substitution of values (but refer to the mark scheme first… the application of this principle may vary).
Where the formula is not quoted, the method mark can be gained by implication from correct working with values, but will be lost if there is any mistake in the working.

Equation of a straight line
Apply the following conditions to the M mark for the equation of a line through (a,b):
If the *a* and *b* are the wrong way round the M mark can still be given if a correct formula is seen, (e.g. $y-y_1=m(x-x_1)$) otherwise M0.
If (*a*, *b*) is substituted into $y=mx+c$ to find *c*, the M mark is for attempting this.

Answers without working
The rubric says that these may gain no credit. Individual mark schemes will give details of what happens in particular cases. General policy is that if it could be done "in your head", detailed working would not be required. Most candidates do show working, but there are occasional awkward cases and if the mark scheme does not cover this, please contact your team leader for advice.

Misreads
A misread must be consistent for the whole question to be interpreted as such.
These are not common. In clear cases, please deduct the first 2 A (or B) marks which would have been lost by following the scheme. (Note that 2 marks is the maximum misread penalty, but that misreads which alter the nature or difficulty of the question cannot be treated so generously and it will usually be necessary here to follow the scheme as written).
Sometimes following the scheme as written is more generous to the candidate than applying the misread rule, so in this case use the scheme as written.
If in doubt, send the response to Review.

June 2010
Core Mathematics C2 6664
Mark Scheme

Question Number	Scheme	Marks
1.	(a) 2.35, 3.13, 4.01 (One or two correct B1 B0, all correct B1 B1) Important: If part (a) is blank, or if answers have been crossed out and no replacement answers are visible, please send to Review as 'out of clip'.	B1 B1 (2)
	(b) $\frac{1}{2}\times 0.2$ ...... (or equivalent numerical value) $k\{(1+5)+2(1.65+p+q+r)\}$, k constant, $k\neq 0$ (See notes below) = 2.828 (awrt 2.83, allowed even after minor slips in values) The fractional answer $\frac{707}{250}$ (or other fraction wrt 2.83) is also acceptable. Answers with no working score no marks.	B1 M1 A1 A1 (4) **6**
	(a) Answers must be given to 2 decimal places. No marks for answers given to only 1 decimal place. (b) The p, q and r below are positive numbers, none of which is equal to any of: 1, 5, 1.65, 0.2, 0.4, 0.6 or 0.8 M1 A1: $k\{(1+5)+2(1.65+p+q+r)\}$ M1 A0: $k\{(1+5)+2(1.65+p+q)\}$ or $k\{(1+5)+2(p+q+r)\}$ M0 A0: $k\{(1+5)+2(1.65+p+q+r+\textit{other value}(s))\}$ Note that if the only mistake is to omit a value from the second bracket, this is considered as a slip and the M mark is allowed. Bracketing mistake: i.e. $\frac{1}{2}\times 0.2(1+5)+2(1.65+2.35+3.13+4.01)$ instead of $\frac{1}{2}\times 0.2\{(1+5)+2(1.65+2.35+3.13+4.01)\}$, so that only the (1 + 5) is multiplied by 0.1 scores B1 M1 A0 A0 unless the final answer implies that the calculation has been done correctly (then full marks can be given). Alternative: Separate trapezia may be used, and this can be marked equivalently.	

Question Number	Scheme	Marks
2	(a) Attempting to find $f(3)$ or $f(-3)$	M1
	$f(3) = 3(3)^3 - 5(3)^2 - (58 \times 3) + 40 = 81 - 45 - 174 + 40 = -98$	A1 (2)
	(b) $\{3x^3 - 5x^2 - 58x + 40 = (x-5)\}\ (3x^2 + 10x - 8)$	M1 A1
	Attempt to factorise 3-term quadratic, or to use the quadratic formula (see general principles at beginning of scheme). This mark may be implied by the correct solutions to the quadratic.	M1
	$(3x-2)(x+4) = 0 \quad x = ...$ or $x = \dfrac{-10 \pm \sqrt{100+96}}{6}$	A1 ft
	$\frac{2}{3}$ (or exact equiv.), -4, 5 (Allow 'implicit' solns, e.g. f(5) = 0, etc.)	A1 (5)
	Completely correct solutions without working: full marks.	**7**

(a) Alternative (long division):

Divide by $(x-3)$ to get $(3x^2 + ax + b)$, $a \neq 0, b \neq 0$. [M1]

$(3x^2 + 4x - 46)$, and –98 seen. [A1]

(If continues to say 'remainder = 98', isw)

'Grid' method

3	3	–5	–58	40
	0	9	12	–138
	3	4	–46	–98

(b) 1st M requires use of $(x-5)$ to obtain $(3x^2 + ax + b)$, $a \neq 0, b \neq 0$.

(Working need not be seen… this could be done 'by inspection'.)

'Grid' method

3	3	–5	–58	40
	0	15	50	–40
	3	10	–8	0

$(3x^2 + 10x - 8)$ ⟵

2nd M for the attempt to factorise their 3-term quadratic, or to solve it using the quadratic formula.

Factorisation: $(3x^2 + ax + b) = (3x + c)(x + d)$, where $|cd| = |b|$.

A1ft: Correct factors for their 3-term quadratic followed by a solution (at least one value, which might be incorrect), or numerically correct expression from the quadratic formula for their 3-term quadratic.

Note therefore that if the quadratic is correctly factorised but no solutions are given, the last 2 marks will be lost.

Alternative (first 2 marks):

$(x-5)(3x^2 + ax + b) = 3x^3 + (a-15)x^2 + (b-5a)x - 5b = 0$,

then compare coefficients to find values of a and b. [M1]

$a = 10,\ b = -8$ [A1]

Alternative 1: (factor theorem)

M1: Finding that $f(-4) = 0$

A1: Stating that $(x+4)$ is a factor.

M1: Finding third factor $(x-5)(x+4)(3x \pm 2)$.

A1: Fully correct factors (no ft available here) followed by a solution, (which might be incorrect).

A1: All solutions correct.

Alternative 2: (direct factorisation)

M1: Factors $(x-5)(3x+p)(x+q)$ A1: $pq = -8$

M1: $(x-5)(3x \pm 2)(x \pm 4)$

Final A marks as in Alternative 1.

Throughout this scheme, allow $\left(x \pm \frac{2}{3}\right)$ as an alternative to $(3x \pm 2)$.

Question Number	Scheme	Marks
3	(a) $\left(\frac{dy}{dx}=\right)\ 2x-\frac{1}{2}kx^{-\frac{1}{2}}$ (Having an extra term, e.g. $+C$, is A0)	M1 A1 (2)
	(b) Substituting $x = 4$ into their $\frac{dy}{dx}$ and 'compare with zero' (The mark is allowed for : $<, >, =, \leq, \geq$) $8-\frac{k}{4}<0$ $k > 32$ (or $32 < k$) Correct inequality needed	M1 A1 (2) **4**
	(a) M: $x^2 \to cx$ or $k\sqrt{x} \to cx^{-\frac{1}{2}}$ (c constant, $c \neq 0$) (b) Substitution of $x = 4$ into y scores M0. However, $\frac{dy}{dx}$ is sometimes called y, and in this case the M mark can be given. $\frac{dy}{dx}=0$ may be 'implied' for M1, when, for example, a value of k or an inequality solution for k is found. Working must be seen to justify marks in (b), i.e. $k > 32$ alone is M0 A0.	

Question Number	Scheme	Marks
4	(a) $(1+ax)^7 = 1+7ax....$ or $1+7(ax)....$ (<u>Not</u> unsimplified versions)	B1
	$+\frac{7\times 6}{2}(ax)^2 + \frac{7\times 6\times 5}{6}(ax)^3$ Evidence from <u>one</u> of these terms is enough	M1
	$+21a^2x^2$ or $+21(ax)^2$ or $+21(a^2x^2)$	A1
	$+35a^3x^3$ or $+35(ax)^3$ or $+35(a^3x^3)$	A1 (4)
	(b) $21a^2 = 525$	M1
	$a = \pm 5$ (Both values are required) (The answer a = 5 with no working scores M1 A0)	A1 (2) **6**
	(a) The terms can be 'listed' rather than added. M1: Requires correct structure: a correct binomial coefficient in any form (perhaps from Pascal's triangle) with the correct power of x. Allow missing a's and wrong powers of a, e.g. $\frac{7\times 6}{2}ax^2$, $\frac{7\times 6\times 5}{3\times 2}x^3$ However, $21+a^2x^2+35+a^3x^3$ or similar is M0. $1+7ax+21+a^2x^2+35+a^3x^3 = 57+.....$ scores the B1 (isw). $\binom{7}{2}$ and $\binom{7}{3}$ or equivalent such as $^7C_2$ and $^7C_3$ are acceptable, but <u>not</u> $\left(\frac{7}{2}\right)$ or $\left(\frac{7}{3}\right)$ (unless subsequently corrected). 1st A1: Correct x^2 term. 2nd A1: Correct x^3 term (The binomial coefficients <u>must</u> be simplified). <u>Special case</u>: If $(ax)^2$ and $(ax)^3$ are seen within the working, but then lost… … A1 A0 can be given if $21ax^2$ and $35ax^3$ are <u>both</u> achieved. <u>a's omitted throughout</u>: Note that only the M mark is available in this case. (b) M: Equating their coefficent of x^2 to 525. An equation in a or a^2 alone is required for this M mark, but allow 'recovery' that shows <u>the required coefficient</u>, e.g. $21a^2x^2 = 525 \Rightarrow 21a^2 = 525$ is acceptable, but $21a^2x^2 = 525 \Rightarrow a^2 = 25$ is not acceptable. After $21ax^2$ in the answer for (a), allow 'recovery' of a^2 in (b) so that full marks are available for (b) (but not retrospectively for (a)).	

Question Number	Scheme	Marks
5	(a) $\tan\theta = \frac{2}{5}$ (or 0.4) (i.s.w. if a value of θ is subsequently found) Requires the correct value with no incorrect working seen.	B1 (1)
	(b) awrt 21.8 (α) (Also allow awrt 68.2, ft from $\tan\theta = \frac{5}{2}$ in (a), but no other ft) (This value must be seen in part (b). It may be implied by a correct solution, e.g. 10.9)	B1
	$180 + \alpha$ $(= 201.8)$, or $90 + (\alpha / 2)$ (if division by 2 has already occurred) (α found from $\tan 2x = ...$ or $\tan x = ...$ or $\sin 2x = \pm...$ or $\cos 2x = \pm...$)	M1
	$360 + \alpha$ $(= 381.8)$, or $180 + (\alpha / 2)$ (α found from $\tan 2x = ...$ or $\sin 2x = ...$ or $\cos 2x = ...$) OR $540 + \alpha$ $(= 561.8)$, or $270 + (\alpha / 2)$ (α found from $\tan 2x = ...$)	M1
	Dividing at least one of the angles by 2 (α found from $\tan 2x = ...$ or $\sin 2x = ...$ or $\cos 2x = ...$)	M1
	$x = 10.9,\ 100.9,\ 190.9,\ 280.9$ (Allow awrt)	A1 (5) **6**

(b) Extra solution(s) in range: Loses the final A mark.
Extra solutions outside range: Ignore (whether correct or not).
Common answers:
10.9 and 100.9 would score B1 M1 M0 M1 A0 (Ensure that these M marks are awarded)
10.9 and 190.9 would score B1 M0 M1 M1 A0 (Ensure that these M marks are awarded)
Alternatives:
(i) $2\cos 2x - 5\sin 2x = 0$ $\quad R\cos(2x + \lambda) = 0$ $\quad \lambda = 68.2 \Rightarrow 2x + 68.2 = 90$ B1
$2x + \lambda = 270$ M1
$2x + \lambda = 450$ or $2x + \lambda = 630$ M1
Subtracting λ and dividing by 2 (at least once) M1
(ii) $25\sin^2 2x = 4\cos^2 2x = 4(1 - \sin^2 2x)$
$29\sin^2 2x = 4$ $\quad 2x = 21.8$ B1
The M marks are scored as in the main scheme, but extra solutions will be likely, losing the A mark.
Using radians:
B1: Can be given for awrt 0.38 (β)
M1: For $\pi + \beta$ or $180 + \beta$
M1: For $2\pi + \beta$ or $3\pi + \beta$ (Must now be consistently radians)
M1: For dividing at least one of the angles by 2
A1: For this mark, the answers must be in degrees.
(Correct) answers only (or by graphical methods):
B and M marks can be awarded by implication, e.g.
10.9 scores B1 M0 M0 M1 A0
10.9, 100.9 scores B1 M1 M0 M1 A0
10.9, 100.9, 190.9, 280.9 scores full marks.
Using 11, etc. instead of 10.9 can still score the M marks by implication.

Question Number	Scheme	Marks
6	(a) $r\theta = 9\times 0.7 = 6.3$ (Also allow 6.30, or awrt 6.30)	M1 A1 (2)
	(b) $\frac{1}{2}r^2\theta = \frac{1}{2}\times 81\times 0.7 = 28.35$ (Also allow 28.3 or 28.4, or awrt 28.3 or 28.4) (Condone 28.35^2 written instead of $28.35\,\text{cm}^2$)	M1 A1 (2)
	(c) $\tan 0.7 = \frac{AC}{9}$	M1
	$AC = 7.58$ (Allow awrt) <u>NOT</u> 7.59 (see below)	A1 (2)
	(d) Area of triangle $AOC = \frac{1}{2}(9\times \text{their } AC)$ (or other complete method)	M1
	Area of R = "34.11" – "28.35" (triangle – sector) or (sector – triangle) (needs a <u>value</u> for each)	M1
	= 5.76 (Allow awrt)	A1 (3) **9**
	(a) M: Use of $r\theta$ (with θ in radians), or equivalent (could be working in degrees with a correct degrees formula). (b) M: Use of $\frac{1}{2}r^2\theta$ (with θ in radians), or equivalent (could be working in degrees with a correct degrees formula). (c) M: Other methods must be fully correct, e.g. $\frac{AC}{\sin 0.7} = \frac{9}{\sin\left(\frac{\pi}{2}-0.7\right)}$ $(\pi - 0.7)$ instead of $\left(\frac{\pi}{2}-0.7\right)$ here is <u>not</u> a fully correct method. <u>Premature approximation (e.g. taking angle *C* as 0.87 radians)</u>: This will often result in loss of A marks, e.g. AC = 7.59 in (c) is A0.	

Question Number	Scheme	Marks
7	(a) $2\log_3(x-5) = \log_3(x-5)^2$	B1
	$\log_3(x-5)^2 - \log_3(2x-13) = \log_3 \dfrac{(x-5)^2}{2x-13}$	M1
	$\log_3 3 = 1$ seen or used correctly	B1
	$\log_3\left(\dfrac{P}{Q}\right) = 1 \Rightarrow P = 3Q$ $\left\{\dfrac{(x-5)^2}{2x-13} = 3 \Rightarrow (x-5)^2 = 3(2x-13)\right\}$	M1
	$x^2 - 16x + 64 = 0$ (*)	A1 cso
		(5)
	(b) $(x-8)(x-8) = 0 \Rightarrow x = 8$ <u>Must</u> be seen in part (b). Or: Substitute $x = 8$ into original equation and verify. Having additional solution(s) such as $x = -8$ loses the A mark. $x = 8$ with no working scores both marks.	M1 A1 (2) **7**

(a) Marks may be awarded if equivalent work is seen in part (b).

1st M: $\log_3(x-5)^2 - \log_3(2x-13) = \dfrac{\log_3(x-5)^2}{\log_3(2x-13)}$ is M0

$2\log_3(x-5) - \log_3(2x-13) = 2\log\dfrac{x-5}{2x-13}$ is M0

2nd M: <u>After the first mistake above</u>, this mark is available only if there is 'recovery' to the required $\log_3\left(\dfrac{P}{Q}\right) = 1 \Rightarrow P = 3Q$. Even then the final mark (cso) is lost.

<u>'Cancelling logs'</u>, e.g. $\dfrac{\log_3(x-5)^2}{\log_3(2x-13)} = \dfrac{(x-5)^2}{2x-13}$ will also lose the 2nd M.

<u>A typical wrong solution</u>:

$$\log_3\frac{(x-5)^2}{2x-13} = 1 \Rightarrow \log_3\frac{(x-5)^2}{2x-13} = 3 \Rightarrow \frac{(x-5)^2}{2x-13} = 3 \Rightarrow (x-5)^2 = 3(2x-13)$$

(Wrong step here)

This, with no evidence elsewhere of $\log_3 3 = 1$, scores B1 M1 B0 M0 A0

However, $\log_3\dfrac{(x-5)^2}{2x-13} = 1 \Rightarrow \dfrac{(x-5)^2}{2x-13} = 3$ is correct and could lead to full marks.

(Here $\log_3 3 = 1$ is implied).

<u>No log methods shown</u>:

It is <u>not</u> acceptable to jump immediately to $\dfrac{(x-5)^2}{2x-13} = 3$. The only mark this scores is the 1st B1 (by generous implication).

(b) M1: Attempt to solve the <u>given</u> quadratic equation (usual rules), so the factors $(x-8)(x-8)$ with no solution is M0.

Question Number	Scheme	Marks
8	(a) $\frac{dy}{dx} = 3x^2 - 20x + k$ (Differentiation is required) At $x = 2$, $\frac{dy}{dx} = 0$, so $12 - 40 + k = 0$ $k = 28$ (*) <u>N.B. The '= 0' must be seen at some stage to score the final mark.</u> <u>Alternatively</u>: (using $k = 28$) $\frac{dy}{dx} = 3x^2 - 20x + 28$ (M1 A1) 'Assuming' $k = 28$ only scores the final cso mark if there is justification that $\frac{dy}{dx} = 0$ at $x = 2$ represents the <u>maximum</u> turning point.	M1 A1 A1 cso (3)
	(b) $\int (x^3 - 10x^2 + 28x)\,dx = \frac{x^4}{4} - \frac{10x^3}{3} + \frac{28x^2}{2}$ Allow $\frac{kx^2}{2}$ for $\frac{28x^2}{2}$ $\left[\frac{x^4}{4} - \frac{10x^3}{3} + 14x^2\right]_0^2 = \ldots$ $\left(= 4 - \frac{80}{3} + 56 = \frac{100}{3}\right)$ (With limits 0 to 2, substitute the limit 2 into a 'changed function') y-coordinate of $P = 8 - 40 + 56 = 24$ <u>Allow if seen in part (a)</u> (The B1 for 24 may be scored by implication from later working) Area of rectangle = $2 \times$ (their y-coordinate of P) Area of R = (their 48) $-$ $\left(\text{their } \frac{100}{3}\right)$ $= \frac{44}{3}$ $\left(14\frac{2}{3} \text{ or } 14.\dot{6}\right)$ If the subtraction is the 'wrong way round', the final A mark is lost.	M1 A1 M1 B1 M1 A1 (6) **9**
	(a) M: $x^n \to cx^{n-1}$ (c constant, $c \neq 0$) for one term, seen <u>in part (a)</u>. (b) 1st M: $x^n \to cx^{n+1}$ (c constant, $c \neq 0$) for one term. Integrating the <u>gradient function</u> loses this M mark. 2ndM: Requires use of limits 0 and 2, with 2 substituted into a 'changed function'. (It may, for example, have been differentiated). Final M: Subtract their values either way round. This mark is dependent on the use of calculus and a correct method attempt for the area of the rectangle. A1: Must be <u>exact</u>, not 14.67 or similar, but isw after seeing, say, $\frac{44}{3}$. <u>Alternative</u>: (effectively finding area of rectangle by integration) $\int \{24 - (x^3 - 10x^2 + 28x)\}\,dx = 24x - \left(\frac{x^4}{4} - \frac{10x^3}{3} + \frac{28x^2}{2}\right)$, etc. This can be marked equivalently, with the 1st A being for integrating the same 3 terms correctly. The 3rd M (for subtraction) will be scored at the same stage as the 2nd M. If the subtraction is the 'wrong way round', the final A mark is lost.	

Question Number	Scheme	Marks	
9	(a) $25\,000 \times 1.03 = 25750$ $\left\{25000 + 750 = 25750, \text{ or } 25000\dfrac{(1-0.03^2)}{1-0.03} = 25750\right\}$ (*)	B1	(1)
	(b) $r = 1.03$ Allow $\dfrac{103}{100}$ or $1\dfrac{3}{100}$ but no other alternatives	B1	(1)
	(c) $25000r^{N-1} > 40000$ (Either letter r or their r value) Allow ' = ' or '<'	M1	
	$r^M > 1.6 \Rightarrow \log r^M > \log 1.6$ Allow ' = ' or '<' (<u>See below</u>) OR (by change of base), $\log_{1.03} 1.6 < M \Rightarrow \dfrac{\log 1.6}{\log 1.03} < M$	M1	
	$(N-1)\log 1.03 > \log 1.6$ (Correct bracketing required) (*)	A1 cso	
	Accept work for part (c) seen in part (d)		(3)
	(d) Attempt to evaluate $\dfrac{\log 1.6}{\log 1.03} + 1$ {or $25000(1.03)^{15}$ <u>and</u> $25000(1.03)^{16}$ }	M1	
	$N = 17$ (<u>not</u> 16.9 and not e.g. $N \geq 17$) Allow '17th year'	A1	
	Accept work for part (d) seen in part (c)		(2)
	(e) Using formula $\dfrac{a(1-r^n)}{1-r}$ with values of a and r, and n = 9, 10 or 11	M1	
	$\dfrac{25000(1-1.03^{10})}{1-1.03}$	A1	
	287 000 (<u>must</u> be rounded to the nearest 1 000) Allow 287000.00	A1	(3) **10**

(c) 2nd M: Requires $\dfrac{40000}{25000}$ to be dealt with, and 'two' logs introduced.

With, say, N instead of $N-1$, this mark is still available.

<u>Jumping</u> straight from $1.03^{N-1} > 1.6$ to $(N-1)\log 1.03 > \log 1.6$ can score only M1 M0 A0.
(The intermediate step $\log 1.03^{N-1} > \log 1.6$ must be seen).

<u>Longer methods</u> require correct log work throughout for 2nd M, e.g.:

$$\log(25000r^{N-1}) > \log 40000 \Rightarrow \log 25000 + \log r^{N-1} > \log 40000 \Rightarrow$$
$$\log r^{N-1} > \log 40000 - \log 25000 \Rightarrow \log r^{N-1} > \log 1.6$$

(d) Correct answer with no working scores both marks.

Evaluating $\log\left(\dfrac{1.6}{1.03}\right) + 1$ does <u>not</u> score the M mark.

(e) M1 can also be scored by a "year by year" method, <u>with terms added</u>.
(Allow the M mark if there is evidence of adding 9, 10 or 11 terms).
1st A1 is scored if the 10 correct terms have been added (allow terms to be to the nearest 100).
To the nearest 100, these terms are:
25000, 25800, 26500, 27300, 28100, 29000, 29900, 30700, 31700, 32600

<u>No</u> working shown: Special case: 287 000 scores 1 mark, scored on ePEN as 1, 0, 0.
(Other answers with no working score no marks).

Question Number	Scheme	Marks
10	(a) $(10-2)^2+(7-1)^2$ or $\sqrt{(10-2)^2+(7-1)^2}$ $(x\pm 2)^2+(y\pm 1)^2=k$ (k a positive value) $(x-2)^2+(y-1)^2=100$ (Accept 10^2 for 100) (Answer only scores full marks)	M1 A1 M1 A1 (4)
	(b) (Gradient of radius =) $\frac{7-1}{10-2}=\frac{6}{8}$ (or equiv.) Must be seen in part (b) Gradient of tangent $=\frac{-4}{3}$ (Using perpendicular gradient method) $y-7=m(x-10)$ Eqn., in any form, of a line through (10, 7) with any numerical gradient (except 0 or ∞) $y-7=\frac{-4}{3}(x-10)$ or equiv (ft gradient of radius, dep. on both M marks) $\{3y=-4x+61\}$ (N.B. The A1 is only available as ft after B0) The unsimplified version scores the A mark (isw if necessary... subsequent mistakes in simplification are not penalised here. The equation must at some stage be exact, not, e.g. $y=-1.3x+20.3$	B1 M1 M1 A1ft (4)
	(c) $\sqrt{r^2-\left(\frac{r}{2}\right)^2}$ Condone sign slip if there is evidence of correct use of Pythag. $=\sqrt{10^2-5^2}$ or numerically exact equivalent $PQ\left(=2\sqrt{75}\right)=10\sqrt{3}$ Simplest surd form $10\sqrt{3}$ required for final mark	M1 A1 A1 (3) **11**
	(b) 2nd M: Using (10, 7) to find the equation, in any form, of a straight line through (10, 7), with any numerical gradient (except 0 or ∞). Alternative: 2nd M: Using (10, 7) and an m value in $y = mx + c$ to find a value of c. (b) Alternative for first 2 marks (differentiation): $2(x-2)+2(y-1)\frac{dy}{dx}=0$ or equiv. B1 Substitute $x = 10$ and $y = 7$ to find a value for $\frac{dy}{dx}$ M1 (This M mark can be awarded generously, even if the attempted 'differentiation' is not 'implicit'). (c) Alternatives: To score M1, must be a fully correct method to obtain $\frac{1}{2}PQ$ or PQ. 1st A1: For alternative methods that find PQ directly, this mark is for an exact numerically correct version of PQ.	

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Mark Scheme (Results)
Summer 2010

GCE

Core Mathematics C3 (6665)

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Summer 2010

Publications Code UA023702

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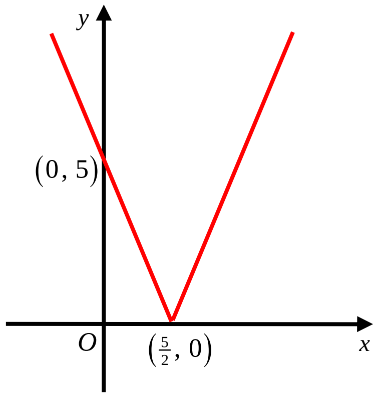
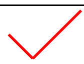
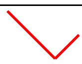
June 2010
6665 Core Mathematics C3
Mark Scheme

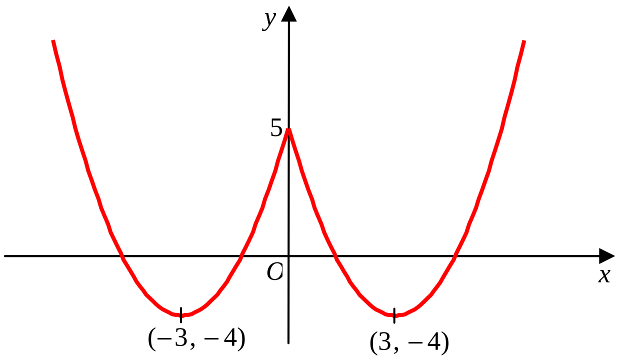
Question Number	Scheme	Marks
1. (a)	$\dfrac{2\sin\theta\cos\theta}{1+2\cos^2\theta-1}$	M1
	$\dfrac{\not{2}\sin\theta\not{\cos\theta}}{\not{2}\cos\theta\not{\cos\theta}} = \tan\theta$ (as required) **AG**	A1 **cso**
		(2)
(b)	$2\tan\theta = 1 \Rightarrow \tan\theta = \dfrac{1}{2}$	M1
	θ_1 = awrt 26.6°	A1
	θ_2 = awrt -153.4°	A1 $\sqrt{}$
		(3) **[5]**
	(a) M1: Uses **both** a correct identity for $\sin 2\theta$ **and** a correct identity for $\cos 2\theta$. Also allow a candidate writing $1+\cos 2\theta = 2\cos^2\theta$ on the denominator. Also note that angles **must be consistent** in when candidates apply these identities. A1: Correct proof. No errors seen. (b) 1st M1 for either $2\tan\theta = 1$ or $\tan\theta = \dfrac{1}{2}$, seen or implied. A1: awrt 26.6 A1 $\sqrt{}$: awrt -153.4° or $\theta_2 = -180^\circ + \theta_1$ **Special Case**: For candidate solving, $\tan\theta = k$, where $k \neq \frac{1}{2}$, to give θ_1 and $\theta_2 = -180^\circ + \theta_1$, then award M0A0B1 in part (b). **Special Case:** Note that those candidates who writes $\tan\theta = 1$, and gives ONLY two answers of 45° and -135° that are inside the range will be awarded SC M0A0B1.	

Question Number	Scheme	Marks
2.	At P, $y = \underline{3}$	B1
	$\frac{dy}{dx} = \underline{3(-2)(5-3x)^{-3}(-3)}$ $\left\{\text{or } \frac{18}{(5-3x)^3}\right\}$	M1<u>A1</u>
	$\frac{dy}{dx} = \frac{18}{(5-3(2))^3}$ $\{= -18\}$	M1
	$m(\mathbf{N}) = \frac{-1}{-18}$ or $\frac{1}{18}$	M1
	$\mathbf{N}$: $y - 3 = \frac{1}{18}(x-2)$	M1
	$\mathbf{N}$: $\underline{x - 18y + 52 = 0}$	A1
		[7]
	1st M1: $\pm k(5-3x)^{-3}$ can be implied. See appendix for application of the quotient rule. 2nd M1: Substituting $x = 2$ into an equation involving their $\frac{dy}{dx}$; 3rd M1: Uses $m(\mathbf{N}) = -\frac{1}{\text{their } m(\mathbf{T})}$. 4th M1: $y - y_1 = m(x-2)$ with 'their NORMAL gradient' or a "changed" tangent gradient and their y_1. Or uses a complete method to express the equation of the tangent in the form $y = mx + c$ with 'their NORMAL ("changed" **numerical**) gradient', their y_1 and $x = 2$. Note: To gain the final A1 mark all the previous 6 marks in this question need to be earned. Also there must be a completely correct solution given.	

Question Number	Scheme	Marks
3. (a)	$f(1.2) = 0.49166551...,\quad f(1.3) = -0.048719817...$ Sign change (and as $f(x)$ is continuous) therefore a root α is such that $\alpha \in [1.2, 1.3]$	M1A1 (2)
(b)	$4\text{cosec}x - 4x + 1 = 0 \Rightarrow 4x = 4\text{cosec}x + 1$	M1
	$\Rightarrow x = \text{cosec}x + \frac{1}{4} \Rightarrow \underline{x = \frac{1}{\sin x} + \frac{1}{4}}$	A1 *
		(2)
(c)	$x_1 = \frac{1}{\sin(1.25)} + \frac{1}{4}$	M1
	$x_1 = 1.303757858...,\quad x_2 = 1.286745793...$	A1
	$x_3 = 1.291744613...$	A1
		(3)
(d)	$f(1.2905) = 0.00044566695...,\quad f(1.2915) = -0.00475017278...$	M1
	Sign change (and as $f(x)$ is continuous) therefore a root α is such that $\alpha \in (1.2905, 1.2915) \Rightarrow \alpha = 1.291$ (3 dp)	A1
		(2) **[9]**
	(a) M1: Attempts to evaluate both $f(1.2)$ and $f(1.3)$ and evaluates at least one of them correctly to awrt (or truncated) 1 sf. A1: both values correct to awrt (or truncated) 1 sf, sign change and conclusion. (b) M1: Attempt to make $4x$ or x the subject of the equation. A1: Candidate must then rearrange the equation to give the required result. It must be clear that candidate has made their initial $f(x) = 0$. (c) M1: An attempt to substitute $x_0 = 1.25$ into the iterative formula Eg $= \frac{1}{\sin(1.25)} + \frac{1}{4}$. Can be implied by x_1 = awrt 1.3 or x_1 = awrt 46°. A1: Both x_1 = awrt 1.3038 and x_2 = awrt 1.2867 A1: x_3 = awrt 1.2917 (d) M1: Choose suitable interval for x, e.g. [1.2905, 1.2915] or tighter and at least one attempt to evaluate $f(x)$. A1: both values correct to awrt (or truncated) 1 sf, sign change and conclusion.	

Question Number	Scheme	Marks
4. (a)		M1A1 (2)
(b)	$\underline{x = 20}$ $2x - 5 = -(15 + x)\ ;\Rightarrow \underline{x = -\tfrac{10}{3}}$	B1 M1;A1 oe. (3)
(c)	$\text{fg}(2) = \text{f}(-3) = \lvert 2(-3) - 5\rvert ; = \lvert -11\rvert = 11$	M1;A1 (2)
(d)	$\text{g}(x) = x^2 - 4x + 1 = (x-2)^2 - 4 + 1 = (x-2)^2 - 3$. Hence $\text{g}_{\min} = -3$ Either $\text{g}_{\min} = -3$ or $\text{g}(x) \geqslant -3$ or $\text{g}(5) = 25 - 20 + 1 = 6$ $\underline{-3 \leqslant \text{g}(x) \leqslant 6}$ or $\underline{-3 \leqslant y \leqslant 6}$	M1 B1 A1 (3) **[10]**
	(a) M1: V or  or  graph with vertex on the x-axis. A1: $\left(\tfrac{5}{2}, \{0\}\right)$ and $\left(\{0\}, 5\right)$ seen and the graph appears in both the first and second quadrants. (b) M1: Either $2x - 5 = -(15 + x)$ or $-(2x - 5) = 15 + x$ (c) M1: ***Full method*** of inserting $\text{g}(2)$ into $\text{f}(x) = \lvert 2x - 5\rvert$ or for inserting $x = 2$ into $\lvert 2(x^2 - 4x + 1) - 5\rvert$. There must be evidence of the modulus being applied. (d) M1: **Full method** to establish the minimum of g. Eg: $(x \pm \alpha)^2 + \beta$ leading to $\text{g}_{\min} = \beta$. Or for candidate to differentiate the quadratic, set the result equal to zero, find x and insert this value of x back into $\text{f}(x)$ in order to find the minimum. B1: For either finding the correct minimum value of g (can be implied by $\text{g}(x) \geqslant -3$ or $\text{g}(x) > -3$) or for stating that $\text{g}(5) = 6$. A1: $\underline{-3 \leqslant \text{g}(x) \leqslant 6}$ or $\underline{-3 \leqslant y \leqslant 6}$ or $\underline{-3 \leqslant \text{g} \leqslant 6}$. **Note that:** $-3 \leqslant x \leqslant 6$ is A0. **Note that:** $-3 \leqslant \text{f}(x) \leqslant 6$ is A0. **Note that**: $-3 \geqslant \text{g}(x) \geqslant 6$ is A0. **Note that:** $\text{g}(x) \geqslant -3$ or $\text{g}(x) > -3$ or $x \geqslant -3$ or $x > -3$ with no working gains M1B1A0. **Note that for the final Accuracy Mark**: If a candidate writes down $-3 < \text{g}(x) < 6$ or $-3 < y < 6$, then award M1B1A0. If, however, a candidate writes down $\text{g}(x) \geqslant -3$, $\text{g}(x) \leqslant 6$, then award A0. If a candidate writes down $\text{g}(x) \geqslant -3$ or $\text{g}(x) \leqslant 6$, then award A0.	

Question Number	Scheme	Marks
5. (a)	Either $y = 2$ or $(0, 2)$	B1
		(1)
(b)	When $x = 2$, $y = (8 - 10 + 2)e^{-2} = 0e^{-2} = 0$	B1
	$(2x^2 - 5x + 2) = 0 \Rightarrow (x-2)(2x-1) = 0$	M1
	Either $x = 2$ (for possibly B1 above) or $\underline{x = \frac{1}{2}}$.	A1
		(3)
(c)	$\frac{dy}{dx} = (4x-5)e^{-x} - (2x^2 - 5x + 2)e^{-x}$	M1A1A1
		(3)
(d)	$(4x-5)e^{-x} - (2x^2 - 5x + 2)e^{-x} = 0$	M1
	$2x^2 - 9x + 7 = 0 \Rightarrow (2x - 7)(x - 1) = 0$	M1
	$x = \frac{7}{2}, 1$	A1
	When $x = \frac{7}{2}$, $y = 9e^{-\frac{7}{2}}$, when $x = 1$, $y = -e^{-1}$	ddM1A1
		(5)
		[12]
	(b) If the candidate believes that $e^{-x} = 0$ solves to $x = 0$ or gives an extra solution of $x = 0$, then withhold the final accuracy mark. (c) M1: (their u')e^{-x} + $(2x^2 - 5x + 2)$(their v') A1: Any one term correct. A1: Both terms correct. (d) 1st M1: For setting their $\frac{dy}{dx}$ found in part (c) equal to 0. 2nd M1: Factorise or eliminate out e^{-x} correctly and an attempt to factorise a 3-term quadratic or apply the formula to candidate's $ax^2 + bx + c$. See rules for solving a three term quadratic equation on page 1 of this Appendix. 3rd ddM1: An attempt to use at least one x-coordinate on $y = (2x^2 - 5x + 2)e^{-x}$. Note that this method mark is dependent on the award of the two previous method marks in this part. Some candidates write down corresponding y-coordinates without any working. It may be necessary on some occasions to use your calculator to check that at least one of the two y-coordinates found is correct to awrt 2 sf. Final A1: Both $\{x = 1\}$, $y = -e^{-1}$ and $\{x = \frac{7}{2}\}$, $y = 9e^{-\frac{7}{2}}$. **cao** Note that both exact values of y are required.	

Question Number	Scheme	Marks
6. (a) (i)	$(3, 4)$	B1 B1
(ii)	$(6, -8)$	B1 B1 (4)
(b)		B1 B1 B1 (3)
(c)	$\mathrm{f}(x) = (x-3)^2 - 4$ or $\mathrm{f}(x) = x^2 - 6x + 5$	M1A1 (2)
(d)	Either: The function f is a many-one {mapping}. Or: The function f is not a one-one {mapping}.	B1 (1) **[10]**
	(b) B1: Correct shape for $x \geqslant 0$, with the curve meeting the positive y-axis and the turning point is found below the x-axis. (providing candidate does not copy the whole of the original curve and adds nothing else to their sketch.). B1: Curve is symmetrical about the y-axis or correct shape of curve for $x < 0$. **Note:** The first two B1B1 can only be awarded if the curve has the correct shape, with a cusp on the positive y-axis and with both turning points located in the correct quadrants. Otherwise award B1B0. B1: Correct turning points of $(-3, -4)$ and $(3, -4)$. Also, $(\{0\}, 5)$ is marked where the graph cuts through the y-axis. Allow $(5, 0)$ rather than $(0, 5)$ if marked in the "correct" place on the y-axis. (c) M1: Either states $\mathrm{f}(x)$ in the form $(x \pm \alpha)^2 \pm \beta$; $\alpha, \beta \neq 0$ Or uses a complete method on $\mathrm{f}(x) = x^2 + ax + b$, with $\mathrm{f}(0) = 5$ and $\mathrm{f}(3) = -4$ to find both a and b. A1: Either $(x-3)^2 - 4$ or $x^2 - 6x + 5$ (d) B1: Or: The inverse is a one-many {mapping and not a function}. Or: Because $\mathrm{f}(0) = 5$ and also $\mathrm{f}(6) = 5$. Or: One y-coordinate has 2 corresponding x-coordinates {and therefore cannot have an inverse}.	

Question Number	Scheme	Marks
7. (a)	$R = \sqrt{6.25}$ or 2.5	B1
	$\tan\alpha = \frac{1.5}{2} = \frac{3}{4} \Rightarrow \alpha = \text{awrt } 0.6435$	M1A1 (3)
(b) (i)	Max Value $= 2.5$	B1$\sqrt{}$
(ii)	$\underline{\sin(\theta - 0.6435) = 1}$ or $\underline{\theta - \text{their }\alpha = \frac{\pi}{2}}$; $\Rightarrow \theta = \text{awrt } 2.21$	<u>M1</u>;A1 $\sqrt{}$ (3)
(c)	$H_{\text{Max}} = 8.5$ (m)	B1$\sqrt{}$
	$\underline{\sin\left(\frac{4\pi t}{25} - 0.6435\right) = 1}$ or $\underline{\frac{4\pi t}{25} = \text{ their (b) answer}}$; $\Rightarrow t = \text{awrt } 4.41$	M1;A1 (3)
(d)	$\Rightarrow 6 + 2.5\sin\left(\frac{4\pi t}{25} - 0.6435\right) = 7$; $\Rightarrow \sin\left(\frac{4\pi t}{25} - 0.6435\right) = \frac{1}{2.5} = 0.4$	M1;M1
	$\left\{\frac{4\pi t}{25} - 0.6435\right\} = \sin^{-1}(0.4)$ or awrt 0.41	A1
	Either $t = \text{awrt } 2.1$ or awrt 6.7	A1
	So, $\left\{\frac{4\pi t}{25} - 0.6435\right\} = \{\pi - 0.411517... \text{ or } 2.730076...^c\}$	ddM1
	Times $= \{14{:}06,\ 18{:}43\}$	A1 (6)
		[15]
	(a) B1: $R = 2.5$ or $R = \sqrt{6.25}$. For $R = \pm 2.5$, award B0. M1: $\tan\alpha = \pm\frac{1.5}{2}$ or $\tan\alpha = \pm\frac{2}{1.5}$ A1: $\alpha = \text{awrt } 0.6435$ (b) B1$\sqrt{}$: 2.5 or follow through the value of R in part (a). M1: For $\sin(\theta - \text{their }\alpha) = 1$ A1$\sqrt{}$: awrt 2.21 or $\frac{\pi}{2} + \text{their }\alpha$ rounding correctly to 3 sf. (c) B1$\sqrt{}$: 8.5 or $6 + \text{their } R$ found in part (a) as long as the answer is greater than 6. M1: $\sin\left(\frac{4\pi t}{25} \pm \text{their }\alpha\right) = 1$ or $\frac{4\pi t}{25} = \text{ their (b) answer}$ A1: For $\sin^{-1}(0.4)$ This can be implied by awrt 4.41 or awrt 4.40. (d) M1: $6 + (\text{their } R)\sin\left(\frac{4\pi t}{25} \pm \text{their }\alpha\right) = 7$, M1: $\sin\left(\frac{4\pi t}{25} \pm \text{their }\alpha\right) = \frac{1}{\text{their } R}$ A1: For $\sin^{-1}(0.4)$. This can be implied by awrt 0.41 or awrt 2.73 or other values for different α's. Note this mark can be implied by seeing 1.055. A1: Either $t = \text{awrt } 2.1$ or $t = \text{awrt } 6.7$ ddM1: either $\pi - \text{their PV}^c$. Note that this mark is dependent upon the two M marks. This mark will usually be awarded for seeing either 2.730… or 3.373… A1: Both $t = 14{:}06$ and $t = 18{:}43$ or both 126 (min) and 403 (min) or both 2 hr 6 min and 6 hr 43 min.	

Question Number	Scheme	Marks
8. (a)	$\dfrac{(x+5)(2x-1)}{(x+5)(x-3)} = \dfrac{(2x-1)}{(x-3)}$	M1 B1 A1 **aef**
		(3)
(b)	$\ln\left(\dfrac{2x^2+9x-5}{x^2+2x-15}\right)=1$	M1
	$\dfrac{2x^2+9x-5}{x^2+2x-15}=\mathrm{e}$	dM1
	$\dfrac{2x-1}{x-3}=\mathrm{e} \Rightarrow \quad 3\mathrm{e}-1 = x(\mathrm{e}-2)$	M1
	$\Rightarrow \quad x = \dfrac{3\mathrm{e}-1}{\mathrm{e}-2}$	A1 **aef cso**
		(4) **[7]**
	(a) M1: An attempt to factorise the numerator. B1: Correct factorisation of denominator to give $(x+5)(x-3)$. Can be seen anywhere. (b) M1: Uses a correct law of logarithms to combine at least two terms. This usually is achieved by the subtraction law of logarithms to give $\ln\left(\dfrac{2x^2+9x-5}{x^2+2x-15}\right)=1.$ The product law of logarithms can be used to achieve $\ln\left(2x^2+9x-5\right)=\ln\left(\mathrm{e}\left(x^2+2x-15\right)\right).$ The product and quotient law could also be used to achieve $\ln\left(\dfrac{2x^2+9x-5}{\mathrm{e}(x^2+2x-15)}\right)=0.$ dM1: Removing ln's correctly by the realisation that the anti-ln of 1 is e. Note that this mark is dependent on the previous method mark being awarded. M1: Collect x terms together and factorise. Note that this is not a dependent method mark. A1: $\dfrac{3\mathrm{e}-1}{\mathrm{e}-2}$ or $\dfrac{3\mathrm{e}^1-1}{\mathrm{e}^1-2}$ or $\dfrac{1-3\mathrm{e}}{2-\mathrm{e}}$. aef Note that the answer needs to be in terms of e. The decimal answer is 9.9610559… Note that the solution must be correct in order for you to award this final accuracy mark. **Note: See Appendix for an alternative method of long division.**	

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6666 Core Mathematics C4
Mark Scheme

Question Number	Scheme	Marks
1.	(a) $y\left(\frac{\pi}{6}\right) \approx 1.2247,\ y\left(\frac{\pi}{4}\right) = 1.1180$ accept awrt 4 d.p.	B1 B1 **(2)**
	(b)(i) $I \approx \left(\frac{\pi}{12}\right)\left(1.3229 + 2\times 1.2247 + 1\right)$ B1 for $\frac{\pi}{12}$	B1 M1
	≈ 1.249 cao	A1
	(ii) $I \approx \left(\frac{\pi}{24}\right)\left(1.3229 + 2\times\left(1.2973 + 1.2247 + 1.1180\right) + 1\right)$ B1 for $\frac{\pi}{24}$	B1 M1
	≈ 1.257 cao	A1 **(6)** **[8]**

Question Number	Scheme		Marks	
2.	$\frac{du}{dx} = -\sin x$		B1	
	$\int \sin x \, e^{\cos x + 1} dx = -\int e^u du$		M1 A1	
	$= -e^u$	ft sign error	A1ft	
	$= -e^{\cos x + 1}$			
	$\left[-e^{\cos x + 1}\right]_0^{\frac{\pi}{2}} = -e^1 - \left(-e^2\right)$	or equivalent with u	M1	
	$= e(e - 1)$ $*$	cso	A1	**(6)**
				[6]

Question Number	Scheme	Marks
3.	$\frac{\mathrm{d}}{\mathrm{d}x}\left(2^x\right) = \ln 2.2^x$	B1
	$\ln 2.2^x + 2y\frac{\mathrm{d}y}{\mathrm{d}x} = 2y + 2x\frac{\mathrm{d}y}{\mathrm{d}x}$	M1 A1= A1
	Substituting $(3, 2)$	
	$8\ln 2 + 4\frac{\mathrm{d}y}{\mathrm{d}x} = 4 + 6\frac{\mathrm{d}y}{\mathrm{d}x}$	M1
	$\frac{\mathrm{d}y}{\mathrm{d}x} = 4\ln 2 - 2$ Accept exact equivalents	M1 A1 **(7)**
		[7]

Question Number	Scheme	Marks
4.	(a) $\dfrac{\mathrm{d}x}{\mathrm{d}t} = 2\sin t\cos t,\ \dfrac{\mathrm{d}y}{\mathrm{d}t} = 2\sec^2 t$	B1 B1
	$\dfrac{\mathrm{d}y}{\mathrm{d}x} = \dfrac{\sec^2 t}{\sin t\cos t}\left(= \dfrac{1}{\sin t\cos^3 t}\right)$ or equivalent	M1 A1 **(4)**
	(b) At $t = \dfrac{\pi}{3},\ x = \dfrac{3}{4},\ y = 2\sqrt{3}$	B1
	$\dfrac{\mathrm{d}y}{\mathrm{d}x} = \dfrac{\sec^2 \frac{\pi}{3}}{\sin\frac{\pi}{3}\cos\frac{\pi}{3}} = \dfrac{16}{\sqrt{3}}$	M1 A1
	$y - 2\sqrt{3} = \dfrac{16}{\sqrt{3}}\left(x - \dfrac{3}{4}\right)$	M1
	$y = 0 \Rightarrow x = \dfrac{3}{8}$	M1 A1 **(6)**
		[10]

Question Number	Scheme	Marks
5.	(a) $A = 2$	B1
	$2x^2 + 5x - 10 = A(x-1)(x+2) + B(x+2) + C(x-1)$	
	$x \to 1$ $\quad -3 = 3B \Rightarrow B = -1$	M1 A1
	$x \to -2$ $\quad -12 = -3C \Rightarrow C = 4$	A1 **(4)**
	(b) $\dfrac{2x^2+5x-10}{(x-1)(x+2)} = 2 + (1-x)^{-1} + 2\left(1+\dfrac{x}{2}\right)^{-1}$	M1
	$(1-x)^{-1} = 1 + x + x^2 + \ ...$	B1
	$\left(1+\dfrac{x}{2}\right)^{-1} = 1 - \dfrac{x}{2} + \dfrac{x^2}{4} + \ ...$	B1
	$\dfrac{2x^2+5x-10}{(x-1)(x+2)} = (2+1+2) + (1-1)x + \left(1+\dfrac{1}{2}\right)x^2 + \ ...$	M1
	$= 5 + \ ...$ ft their $A - B + \frac{1}{2}C$	A1 ft
	$= \ ... + \dfrac{3}{2}x^2 + \ ...$ $0x$ stated or implied	A1 A1 **(7)**
		[11]

Question Number	Scheme		Marks	
6.	(a) $\mathrm{f}(\theta) = 4\cos^2\theta - 3\sin^2\theta$			
	$= 4\left(\frac{1}{2} + \frac{1}{2}\cos 2\theta\right) - 3\left(\frac{1}{2} - \frac{1}{2}\cos 2\theta\right)$		M1 M1	
	$= \frac{1}{2} + \frac{7}{2}\cos 2\theta \ \ast$	cso	A1	**(3)**
	(b) $\int \theta\cos 2\theta \,\mathrm{d}\theta = \frac{1}{2}\theta\sin 2\theta - \frac{1}{2}\int \sin 2\theta \,\mathrm{d}\theta$		M1 A1	
	$= \frac{1}{2}\theta\sin 2\theta + \frac{1}{4}\cos 2\theta$		A1	
	$\int \theta\,\mathrm{f}(\theta)\,\mathrm{d}\theta = \frac{1}{4}\theta^2 + \frac{7}{4}\theta\sin 2\theta + \frac{7}{8}\cos 2\theta$		M1 A1	
	$\left[\ \ldots\ \right]_0^{\frac{\pi}{2}} = \left[\frac{\pi^2}{16} + 0 - \frac{7}{8}\right] - \left[0 + 0 + \frac{7}{8}\right]$		M1	
	$= \frac{\pi^2}{16} - \frac{7}{4}$		A1	**(7)**
				[10]

Question Number	Scheme	Marks
7.	(a) **j** components $3+2\lambda=9 \Rightarrow \lambda=3$ $(\mu=1)$	M1 A1
	Leading to $C:(5,9,-1)$ accept vector forms	A1 **(3)**
	(b) Choosing correct directions or finding $\overrightarrow{AC}$ and $\overrightarrow{BC}$	M1
	$\begin{pmatrix}1\\2\\1\end{pmatrix}.\begin{pmatrix}5\\0\\2\end{pmatrix}=5+2=\sqrt{6}\sqrt{29}\cos\angle ACB$ use of scalar product	M1 A1
	$\angle ACB=57.95°$ awrt $57.95°$	A1 **(4)**
	(c) $A:(2,3,-4)$ $B:(-5,9,-5)$	
	$\overrightarrow{AC}=\begin{pmatrix}3\\6\\3\end{pmatrix}$, $\overrightarrow{BC}=\begin{pmatrix}10\\0\\4\end{pmatrix}$	
	$AC^2=3^2+6^2+3^2 \Rightarrow AC=3\sqrt{6}$	M1 A1
	$BC^2=10^2+4^2 \Rightarrow BC=2\sqrt{29}$	A1
	$\triangle ABC=\frac{1}{2}AC\times BC\sin\angle ACB$	
	$=\frac{1}{2}3\sqrt{6}\times2\sqrt{29}\sin\angle ACB\approx33.5$ $15\sqrt{5}$, awrt 34	M1 A1 **(5)**
		[12]
	Alternative method for (b) *and* (c)	
	(b) $A:(2,3,-4)$ $B:(-5,9,-5)$ $C:(5,9,-1)$	
	$AB^2=7^2+6^2+1^2=86$	
	$AC^2=3^2+6^2+3^2=54$	
	$BC^2=10^2+0^2+4^2=116$ Finding all three sides	M1
	$\cos\angle ACB=\frac{116+54-86}{2\sqrt{116}\sqrt{54}}$ $(=0.53066\ ...)$	M1 A1
	$\angle ACB=57.95°$ awrt $57.95°$	A1 **(4)**
	If this method is used some of the working may gain credit in part (c) and appropriate marks may be awarded if there is an attempt at part (c).	

Question Number	Scheme		Marks	
8.	(a) $\dfrac{dV}{dt} = 0.48\pi - 0.6\pi h$		M1 A1	
	$V = 9\pi h \quad \Rightarrow \dfrac{dV}{dt} = 9\pi \dfrac{dh}{dt}$		B1	
	$9\pi \dfrac{dh}{dt} = 0.48\pi - 0.6\pi h$		M1	
	Leading to $75\dfrac{dh}{dt} = 4 - 5h$ ∗	cso	A1	**(5)**
	(b) $\displaystyle\int \frac{75}{4-5h}\,dh = \int 1\,dt$	separating variables	M1	
	$-15\ln(4-5h) = t \quad (+C)$		M1 A1	
	$-15\ln(4-5h) = t + C$			
	When $t = 0,\ h = 0.2$			
	$-15\ln 3 = C$		M1	
	$t = 15\ln 3 - 15\ln(4-5h)$			
	When $h = 0.5$			
	$t = 15\ln 3 - 15\ln 1.5 = 15\ln\left(\dfrac{3}{1.5}\right) = 15\ln 2$	awrt 10.4	M1 A1	
	Alternative for last 3 *marks*			
	$t = \left[-15\ln(4-5h)\right]_{0.2}^{0.5}$			
	$= -15\ln 1.5 + 15\ln 3$		M1 M1	
	$= 15\ln\left(\dfrac{3}{1.5}\right) = 15\ln 2$	awrt 10.4	A1	**(6)**

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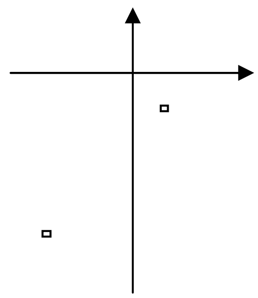
Further Pure Mathematics FP1 6667
Mark Scheme

Question Number	Scheme	Marks
1.	(a) $(2-3\text{i})(2-3\text{i}) = \ldots..$ **Expand and use** $\text{i}^2 = -1$, getting completely correct expansion of 3 or 4 terms	M1
	Reaches $-5-12\text{i}$ after completely correct work (must see 4 – 9) (*)	A1cso (2)
	(b) $\lvert z^2 \rvert = \sqrt{(-5)^2 + (-12)^2} = 13$ **or** $\lvert z^2 \rvert = \sqrt{5^2 + 12^2} = 13$	M1 A1 (2)
	Alternative methods for part (b) $\lvert z^2 \rvert = \lvert z \rvert^2 = 2^2 + (-3)^2 = 13$ Or: $\lvert z^2 \rvert = zz^* = 13$	M1 A1 (2)
	(c) $\tan\alpha = \frac{12}{5}$ (allow $-\frac{12}{5}$) or $\sin\alpha = \frac{12}{13}$ or $\cos\alpha = \frac{5}{13}$	M1
	$\arg(z^2) = -(\pi - 1.176...) = -1.97$ (or 4.32) allow awrt	A1 (2)
	Alternative method for part (c) $\alpha = 2 \times \arctan\left(-\frac{3}{2}\right)$ (allow $\frac{3}{2}$) **or** use $\frac{\pi}{2} + \arctan\frac{5}{12}$	M1
	so $\arg(z^2) = -(\pi - 1.176...) = -1.97$ (or 4.32) allow awrt	A1
	(d)  Both in correct quadrants. Approximate relative scale No labels needed Allow two diagrams if some indication of scale Allow points or arrows	B1 (1) **7 marks**
	Notes: (a) M1: for 4 – 9 – 12i or 4 – 9 – 6i – 6i or $4-3^2-12\text{i}$ but must have correct statement seen and see i^2 replaced by -1 maybe later A1: Printed answer. Must see 4 – 9 in working. Jump from 4 – 6i – 6i + 9i^2 to -5-12i is M0A0 (b) Method may be implied by correct answer. NB $\lvert z^2 \rvert = 169$ is M0 A0 (c) Allow $\arctan\frac{12}{5}$ for M1 or $\pm\frac{\pi}{2} \pm \arctan\frac{5}{12}$	

Question Number	Scheme	Marks
2.	(a) $\mathbf{M} = \begin{pmatrix} 4 & 3 \\ 6 & 2 \end{pmatrix}$ Determinant: $(8-18) = -10$	B1
	$\mathbf{M}^{-1} = \frac{1}{-10}\begin{pmatrix} 2 & -3 \\ -6 & 4 \end{pmatrix}$ $\left[= \begin{pmatrix} -0.2 & 0.3 \\ 0.6 & -0.4 \end{pmatrix} \right]$	M1 A1 (3)
	(b) Setting $\Delta = 0$ and using $2a^2 \pm 18 = 0$ to obtain $a = .$	M1
	$a = \pm 3$	A1 cao (2) **5 marks**
	Notes: (a) B1: must be -10 M1: for correct attempt at changing elements in major diagonal and changing signs in minor diagonal. Three or four of the numbers in the matrix should be correct – eg allow one slip A1: for any form of the correct answer, with correct determinant then isw. Special case: *a* not replaced is B0M1A0 (b) Two correct answers, $a = \pm 3$, with no working is M1A1 Just *a* = 3 is M1A0, and also one of these answers rejected is A0. Need 3 to be simplified (not $\sqrt{9}$).	

Question Number	Scheme	Marks
3.	(a) $\text{f}(1.4) = \ldots$ and $\text{f}(1.5) = \ldots$ Evaluate both	M1
	$\text{f}(1.4) = -0.256$ (or $-\frac{32}{125}$), $\text{f}(1.5) = 0.708\ldots$ (or $\frac{17}{24}$) **Change of sign, $\therefore$ root**	A1 (2)
	Alternative method: **Graphical method** could earn M1 if 1.4 and 1.5 are both indicated A1 then needs correct graph and conclusion, i.e. change of sign $\therefore$ root	
	(b) $\text{f}(1.45) = 0.221\ldots$ or 0.2 [$\therefore$ root is in [1.4, 1.45]]	M1
	$\text{f}(1.425) = -0.018\ldots$ or -0.019 or -0.02	M1
	$\therefore$ root is in [1.425, 1.45]	A1cso (3)
	(c) $\text{f}'(x) = 3x^2 + 7x^{-2}$	M1 A1
	$\text{f}'(1.45) = 9.636\ldots$ (Special case: $\text{f}'(x) = 3x^2 + 7x^{-2}$ +2 then $\text{f}'(1.45) = 11.636\ldots$)	A1ft
	$x_1 = 1.45 - \frac{\text{f}(1.45)}{\text{f}'(1.45)} = 1.45 - \frac{0.221\ldots}{9.636\ldots} = 1.427$	M1 A1cao (5) **10 marks**

Notes

(a) M1: Some attempt at two evaluations
A1: needs accuracy to 1 figure truncated or rounded and conclusion including **sign change** indicated (One figure accuracy sufficient)

(b) M1: See f(1.45) attempted and positive
M1: See f(1.425) attempted and negative
A1: is cso – any slips in numerical work are penalised here even if correct region found.
Answer may be written as $1.425 \le \alpha \le 1.45$ or $1.425 < \alpha < 1.45$ or (1.425, 1.45) must be correct way round. Between is sufficient.
There is no credit for linear interpolation. This is M0 M0 A0
Answer with no working is also M0M0A0

(c) M1: for attempt at differentiation (decrease in power) A1 is cao
Second A1may be implied by correct answer (do not need to see it)
ft is limited to special case given.
2nd M1: for attempt at Newton Raphson with their values for f(1.45) and $\text{f}'(1.45)$.
A1: is cao and needs to be correct to 3dp
Newton Raphson used more than once – isw.
Special case: $\text{f}'(x) = 3x^2 + 7x^{-2} + 2$ then $\text{f}'(1.45) = 11.636\ldots$) is M1 A0 A1ft M1 A0 This mark can also be given by implication from final answer of 1.43

Question Number	Scheme	Marks
4.	(a) $a=-2, \quad b=50$	B1, B1 (2)
	(b) -3 is a root	B1
	Solving 3-term quadratic $x=\dfrac{2\pm\sqrt{4-200}}{2}$ or $(x-1)^2-1+50=0$	M1
	$=1+7\text{i}, \quad$ 1-7i	A1, A1ft (4)
	(c) $(-3)+(1+7\text{i})+(1-7\text{i})=-1$	B1ft (1) **7 marks**
	Notes (a) Accept $x^2-2x+50$ as evidence of values of *a* and *b*. (b) B1: –3 must be seen in part (b) M1: for solving quadratic following usual conventions A1: for a correct root (simplified as here) and A1ft: for conjugate of first answer. Accept correct answers with no working here. If answers are written down as factors then isw. Must see roots for marks. (c) ft requires the sum of two non-real conjugate roots and a real root resulting in a real number. Answers including *x* are B0	

Question Number	Scheme	Marks
5.	(a) $y^2 = (10t)^2 = 100t^2$ and $20x = 20\times 5t^2 = 100t^2$	B1 (1)
	Alternative method: Compare with $y^2 = 4ax$ and identify a = 5 to give answer.	B1 (1)
	(b) Point A is (80, 40) (stated or seen on diagram). May be given in part (a) Focus is (5, 0) (stated or seen on diagram) or (a , 0) with a = 5 May be given in part (a). Gradient: $\dfrac{40-0}{80-5} = \dfrac{40}{75} \left(= \dfrac{8}{15}\right)$	B1 B1 M1 A1 (4) **5 marks**
	Notes: (a) Allow substitution of x to obtain $y = \pm 10t$ (or just 10t) or of y to obtain x (b) M1: requires use of gradient formula correctly, for their values of x and y. This mark may be implied by correct answer. Differentiation is M0 A0 A1: Accept 0.533 or awrt	

Question Number	Scheme	Marks
6.	(a) $\begin{pmatrix} 8 & 0 \\ 0 & 8 \end{pmatrix}$	B1 (1)
	(b) $\begin{pmatrix} 1 & 0 \\ 0 & -1 \end{pmatrix}$	B1 (1)
	(c) $\mathbf{T} = \begin{pmatrix} 1 & 0 \\ 0 & -1 \end{pmatrix}\begin{pmatrix} 8 & 0 \\ 0 & 8 \end{pmatrix} = \begin{pmatrix} 8 & 0 \\ 0 & -8 \end{pmatrix}$	M1 A1 (2)
	(d) $\mathbf{AB} = \begin{pmatrix} 6 & 1 \\ 4 & 2 \end{pmatrix}\begin{pmatrix} k & 1 \\ c & -6 \end{pmatrix} = \begin{pmatrix} 6k+c & 0 \\ 4k+2c & -8 \end{pmatrix}$	M1 A1 A1 (3)
	(e) "$6k + c = 8$" and "$4k + 2c = 0$" Form equations and solve simultaneously $k = 2$ and $c = -4$	M1 A1 (2) **9 marks**
	Alternative method for (e) **M1: AB = T ⇒ B = A^{-1}T =** and compare elements to find k and c. Then A1 as before.	
	<u>Notes</u> (c) M1: Accept multiplication of their matrices either way round (this can be implied by correct answer) A1: cao (d) M1: Correct matrix multiplication method implied by one or two correct terms in correct positions. A1: for three correct terms in correct positions 2nd A1: for all four terms correct and simplified (e) M1: follows their previous work but must give two equations from which k and c can be found and there must be attempt at solution getting to k = or c =. A1: is cao (but not cso - may follow error in position of $4k + 2c$ earlier).	

Question Number	Scheme		Marks
7.	(a) LHS = $f(k+1) = 2^{k+1} + 6^{k+1}$ $= 2(2^k) + 6(6^k)$ $= 6(2^k + 6^k) - 4(2^k) = 6f(k) - 4(2^k)$	OR RHS = $= 6f(k) - 4(2^k) = 6(2^k + 6^k) - 4(2^k)$ $= 2(2^k) + 6(6^k)$ $= 2^{k+1} + 6^{k+1} = f(k+1)$ (*)	M1 A1 A1 (3)
	OR $f(k+1) - 6f(k) = 2^{k+1} + 6^{k+1} - 6(2^k + 6^k)$		M1
	$= (2-6)(2^k) = -4.2^k$, and so $f(k+1) = 6f(k) - 4(2^k)$		A1, A1 (3)
	(b) n = 1: $f(1) = 2^1 + 6^1 = 8$, **which is divisible** by 8		B1
	Either Assume f(k) divisible by 8 and try to use f(k + 1) = 6f(k) - $4(2^k)$ Show $4(2^k) = 4 \times 2(2^{k-1}) = 8(2^{k-1})$ or $8(\frac{1}{2}2^k)$ Or valid statement Deduction that result is implied for $n = k + 1$ and so is true for positive integers by induction (may include n = 1 true here)	**Or** Assume f(k) divisible by 8 and try to use f (k + 1)– f (k) or f (k + 1) + f (k) including factorising $6^k = 2^k 3^k$ $= 2^3 2^{k-3}(1 + 5.3^k)$ or $= 2^3 2^{k-3}(3 + 7.3^k)$ o.e. Deduction that result is implied for $n = k + 1$ and so is true for positive integers by induction (must include explanation of why n = 2 is also true here)	M1 A1 A1cso (4) **7 marks**
	Notes (a) M1: for substitution into LHS (or RHS) or $f(k+1) - 6f(k)$ A1: for correct split of the two separate powers cao A1: for completion of proof with no error or ambiguity (needs (for example) to start with one side of equation and reach the other or show that each side separately is $2(2^k) + 6(6^k)$ and **conclude** LHS = RHS) (b) B1: for substitution of n = 1 and **stating** "true for n = 1" or "divisible by 8" or tick. (This statement may appear in the concluding statement of the proof) M1: Assume f(k) divisible by 8 and consider f(k + 1) = 6f(k) - $4(2^k)$ or equivalent expression that could lead to proof – not merely f (k+1) – f(k) unless deduce that 2 is a factor of 6 (see right hand scheme above). A1: Indicates each term divisible by 8 **OR** takes out factor 8 or 2^3 A1: Induction statement . Statement n = 1 here could contribute to B1 mark earlier. NB: $f(k+1) - f(k) = 2^{k+1} - 2^k + 6^{k+1} - 6^k = 2^k + 5.6^k$ **only** is M0 A0 A0 (b) **"Otherwise" methods** Could use: $f(k+1) = 2f(k) + 4(6^k)$ or $f(k+2) = 36f(k) - 32(6^k)$ or $f(k+2) = 4f(k) + 32(2^k)$ in a similar way to given expression and Left hand mark scheme is applied. Special Case: Otherwise Proof **not involving induction**: This can only be awarded the B1 for checking n = 1.		

Question Number	Scheme	Marks
8.	(a) $\frac{c}{3}$	B1 (1)
	(b) $y=\frac{c^2}{x} \Rightarrow \frac{dy}{dx}=-c^2x^{-2}$, **or** $y+x\frac{dy}{dx}=0 \Rightarrow \frac{dy}{dx}=-\frac{y}{x}$ **or** $\dot{x}=c,\ \dot{y}=-\frac{c}{t^2}$ so $\frac{dy}{dx}=-\frac{1}{t^2}$	B1
	and at A $\frac{dy}{dx}=-\frac{c^2}{(3c)^2}=-\frac{1}{9}$ so gradient of normal is 9	M1 A1
	Either $y-\frac{c}{3}=9(x-3c)$ **or** y=9x + k and use x=3c, y= $\frac{c}{3}$	M1
	$\Rightarrow$ $3y=27x-80c$ (*)	A1 (5)
	(c) $\frac{c^2}{x}=\frac{27x-80c}{3}$ $3c^2=27x^2-80cx$ $(x-3c)(27x+c)=0$ so $x=$ $x=-\frac{c}{27}$, $y=-27c$ $\frac{c^2}{y}=\frac{3y+80c}{27}$ $27c^2=3y^2+80cy$ $(y+27c)(3y-c)=0$ so $y=$ $x=-\frac{c}{27}$, $y=-27c$ $3\frac{c}{t}=27ct-80c$ $3c=27ct^2-80ct$ $(t-3)(27t+1)=0$ so $t=$ ($t=-\frac{1}{27}$ and so) $x=-\frac{c}{27}$, $y=-27c$	M1 A1 M1 A1 , A1 (5) **11 marks**
	Notes (b) B1: Any valid method of differentiation but must get to correct expression for $\frac{dy}{dx}$ M1 : Substitutes values and uses negative reciprocal (**needs to follow calculus**) A1: 9 cao (needs to follow calculus) M1: Finds equation of line through A with any gradient (other than 0 and ∞) A1: Correct work throughout – **obtaining printed answer**. (c) M1: Obtains equation in one variable (x, y or t) A1: Writes as correct three term quadratic (any equivalent form) M1: Attempts to solve three term quadratic to obtain x = or y = or t = A1: x coordinate, A1: y coordinate. (cao but allow recovery following slips)	

Question Number	Scheme	Marks
9.	(a) If $n=1$, $\sum_{r=1}^{n} r^2 = 1$ and $\frac{1}{6}n(n+1)(2n+1) = \frac{1}{6}\times 1\times 2\times 3 = 1$, so true for n = 1.	B1
	Assume result true for $n = k$	M1
	$\sum_{r=1}^{k+1} r^2 = \frac{1}{6}k(k+1)(2k+1)+(k+1)^2$	M1
	$=\frac{1}{6}(k+1)(2k^2+7k+6)$ or $=\frac{1}{6}(k+2)(2k^2+5k+3)$ or $=\frac{1}{6}(2k+3)(k^2+3k+2)$	A1
	$=\frac{1}{6}(k+1)(k+2)(2k+3)$ $=\frac{1}{6}(k+1)(\{k+1\}+1)(2\{k+1\}+1)$ or equivalent	dM1
	True for $n = k + 1$ if true for $n = k$, (and true for n = 1) so true by induction for all n.	A1cso (6)
	Alternative for (a) After first three marks B M M1 as earlier :	B1M1M1
	May state RHS $=\frac{1}{6}(k+1)(\{k+1\}+1)(2\{k+1\}+1)=\frac{1}{6}(k+1)(k+2)(2k+3)$ for third M1	dM1
	Expands to $\frac{1}{6}(k+1)(2k^2+7k+6)$ and show equal to $\sum_{r=1}^{k+1} r^2 = \frac{1}{6}k(k+1)(2k+1)+(k+1)^2$ for A1	A1
	So true for $n = k + 1$ if true for $n = k$, and true for n = 1, so true by induction for all n.	A1cso (6)
	(b) $\sum_{r=1}^{n}(r^2+5r+6) = \sum_{r=1}^{n} r^2 + 5\sum_{r=1}^{n} r +$ ($\sum_{r=1}^{n} 6$)	M1
	$\frac{1}{6}n(n+1)(2n+1)+\frac{5}{2}n(n+1),\quad +6n$	A1, B1
	$=\frac{1}{6}n[(n+1)(2n+1)+15(n+1)+36]$	M1
	$=\frac{1}{6}n[2n^2+18n+52]=\frac{1}{3}n(n^2+9n+26)$ or $a = 9$, $b = 26$	A1 (5)
	(c) $\sum_{r=n+1}^{2n}(r+2)(r+3) = \frac{1}{3}2n(4n^2+18n+26)-\frac{1}{3}n(n^2+9n+26)$	M1 A1ft
	$\frac{1}{3}n(8n^2+36n+52-n^2-9n-26)=\frac{1}{3}n(7n^2+27n+26)$ (*)	A1cso (3) **14 marks**
	Notes: (a) B1: Checks n = 1 on both sides and states true for n = 1 here or in conclusion M1: **Assumes true** for $n = k$ (should use one of these **two** words) M1: Adds (k+1)th term to sum of k terms A1: Correct work to support proof M1: Deduces $\frac{1}{6}n(n+1)(2n+1)$ with $n = k + 1$ A1: Makes induction statement. Statement true for n = 1 here could contribute to B1 mark earlier	

	Question 9 Notes continued: (b) M1: Expands and splits (but allow 6 rather than sigma 6 for this mark) A1: first two terms correct B1: for 6*n* M1: Take out factor *n*/6 or *n*/3 correctly – no errors factorising A1: for correct factorised cubic or for identifying *a* and *b* (c) M1: Try to use $\sum_{1}^{2n}(r+2)(r+3)-\sum_{1}^{n}(r+2)(r+3)$ with previous result used **at least once** A1ft Two correct expressions for their a and b values A1: Completely correct work to printed answer

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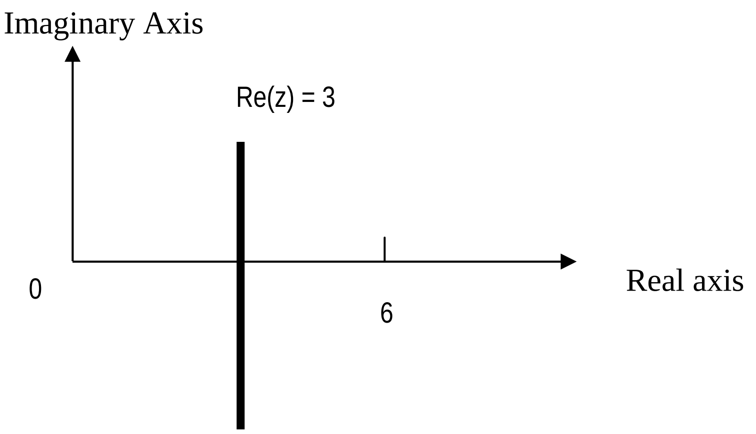
Question Number	Scheme	Marks
1(a)	$\frac{1}{3r-1}-\frac{1}{3r+2}$	M1 A1 (2)
(b)	$\sum_{r=1}^{n}\frac{3}{(3r-1)(3r+2)}=\frac{1}{2}-\frac{1}{5}+\frac{1}{5}-\frac{1}{8}+\frac{1}{8}-\frac{1}{11}+\ldots\frac{1}{3n-1}-\frac{1}{3n+2}$ $=\frac{1}{2}-\frac{1}{3n+2}=\frac{3n}{2(3n+2)}$ *	M1 A1ft A1 (3)
(c)	Sum = f(1000) – f(99) $\frac{3000}{6004}-\frac{297}{598}=0.00301$ or 3.01×10^{-3}	M1 A1 (2) **7**

Question Number	Scheme	Marks
2	$\mathrm{f}''(t) = -x - \cos x, \qquad \mathrm{f}''(0) = -1$	B1
	$\mathrm{f}'''(t) = (-1 + \sin x)\dfrac{\mathrm{d}x}{\mathrm{d}t}, \qquad \mathrm{f}'''(0) = -0.5$	M1A1
	$\mathrm{f}(t) = \mathrm{f}(0) + t\mathrm{f}'(0) + \dfrac{t^2}{2}\mathrm{f}''(0) + \dfrac{t^3}{3!}\mathrm{f}'''(0) + \ldots$ $= 0.5t - 0.5t^2 - \frac{1}{12}t^3 + \ldots$	M1 A1 **5**

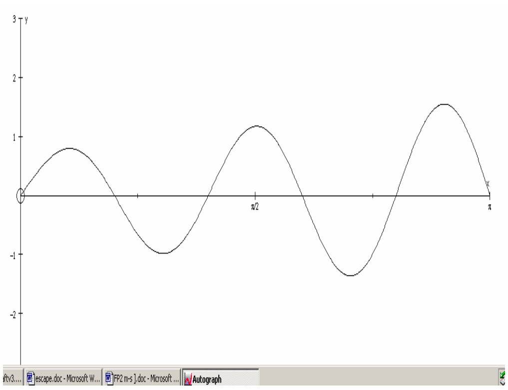
Question Number	Scheme	Marks
3(a)	$(x+4)(x+3)^2-2(x+3)=0$, $(x+3)(x^2+7x+10)=0$ so $(x+2)(x+3)(x+5)=0$ or alternative method including calculator	M1
	Finds critical values –2 and -5	A1 A1
	Establishes $x > -2$	A1ft
	Finds and uses critical value –3 to give $-5 < x < -3$	M1A1 (6)
(b)	$x > -2$	B1ft (1)
		7

Question Number	Scheme	Marks
4(a)	Modulus = 16 Argument = $\arctan(-\sqrt{3}) = \frac{2\pi}{3}$	B1 M1A1 (3)
(b)	$z^3 = 16^3(\cos(\frac{2\pi}{3}) + \mathrm{i}\sin(\frac{2\pi}{3}))^3 = 16^3(\cos 2\pi + \mathrm{i}\sin 2\pi)$ =4096 or 16^3	M1 A1 (2)
(c)	$w = 16^{\frac{1}{4}}(\cos(\frac{2\pi}{3}) + \mathrm{i}\sin(\frac{2\pi}{3}))^{\frac{1}{4}} = 2(\cos\left(\frac{\pi}{6}\right) + \mathrm{i}\sin\left(\frac{\pi}{6}\right))\ \left(= \sqrt{3} + \mathrm{i}\right)$ OR $-1+\sqrt{3}\mathrm{i}$ OR $-\sqrt{3}-\mathrm{i}$ OR $1-\sqrt{3}\mathrm{i}$	M1 A1ft M1A2(1,0) (5) **10**

Question Number	Scheme	Marks
5(a)	$1.5+\sin 3\theta = 2 \quad \rightarrow \quad \sin 3\theta = 0.5 \quad \therefore 3\theta = \frac{\pi}{6} \left(\text{or } \frac{5\pi}{6}\right),$	M1 A1,
	and $\therefore \theta = \frac{\pi}{18}$ or $\frac{5\pi}{18}$	A1 (3)
(b)	Area = $\frac{1}{2}\left[\int_{\frac{\pi}{18}}^{\frac{5\pi}{18}} (1.5+\sin 3\theta)^2 \, d\theta\right]$, $-\frac{1}{9}\pi \times 2^2$	M1, M1
	$= \frac{1}{2}\left[\int_{\frac{\pi}{18}}^{\frac{5\pi}{18}} (2.25+3\sin 3\theta+\frac{1}{2}(1-\cos 6\theta))d\theta\right] - \frac{1}{9}\pi \times 2^2$	M1
	$= \frac{1}{2}\left[(2.25\theta - \cos 3\theta + \frac{1}{2}(\theta - \frac{1}{6}\sin 6\theta))\right]_{\frac{\pi}{18}}^{\frac{5\pi}{18}} - \frac{1}{9}\pi \times 2^2$	M1 A1
	$= \frac{13\sqrt{3}}{24} - \frac{5\pi}{36}$	M1 A1 (7)
		10

Question Number	Scheme	Marks
6(a)		
	Vertical Straight line	B1
	Through 3 on real axis	B1
		(2)
(b)	These are points where line x = 3 meets the circle centre (3, 4) with radius 5.	M1
	The complex numbers are 3 + 9i and 3 – i.	A1 A1
		(3)
(c)	$\|z-6\|=\|z\|\Rightarrow\left\|\frac{30}{w}-6\right\|=\left\|\frac{30}{w}\right\|$	M1
	$\therefore\|30-6w\|=\|30\| \;\;\Rightarrow\;\; \therefore\|5-w\|=\|5\|$	M1 A1
	This is a circle with Cartesian equation $(u-5)^2+v^2=25$	M1 A1
		(5)
		10

Question Number	Scheme	Marks
7(a)	$\frac{dy}{dx}=\frac{dy}{dz}.\frac{dz}{dx}$ and $\frac{dy}{dz}=2z$ so $\frac{dy}{dx}=2z.\frac{dz}{dx}$	M1 M1 A1
	Substituting to get $2z.\frac{dz}{dx}-4z^2\tan x=2z$ and thus $\frac{dz}{dx}-2z\tan x=1$ *	M1 A1 (5)
(b)	$\text{I.F.}=e^{\int -2\tan x dx} = e^{2\ln\cos x} = \cos^2 x$	M1 A1
	$\therefore \frac{d}{dx}\left(z\cos^2 x\right)=\cos^2 x \;\therefore z\cos^2 x=\int \cos^2 x dx$	M1
	$\therefore z\cos^2 x = \int \frac{1}{2}(\cos 2x+1)\,dx=\frac{1}{4}\sin 2x+\frac{1}{2}x+c$	M1 A1
	$\therefore z=\frac{1}{2}\tan x+\frac{1}{2}x\sec^2 x+c\sec^2 x$	A1 (6)
(c)	$\therefore y=(\frac{1}{2}\tan x+\frac{1}{2}x\sec^2 x+c\sec^2 x)^2$	B1ft (1) **12**

Question Number	Scheme	Marks
8(a)	Differentiate twice and obtaining $\frac{\mathrm{d}y}{\mathrm{d}x} = \lambda \sin 5x + 5\lambda x \cos 5x$ and $\frac{\mathrm{d}^2 y}{\mathrm{d}x^2} = 10\lambda \cos 5x - 25\lambda x \sin 5x$	M1 A1
	Substitute to give $\lambda = \frac{3}{10}$	M1 A1 (4)
(b)	Complementary function is $y = A\cos 5x + B\sin 5x$ or $P\mathrm{e}^{5ix} + Q\mathrm{e}^{-5ix}$	M1 A1
	So general solution is $y = A\cos 5x + B\sin 5x + \frac{3}{10}x\sin 5x$ or in exponential form	A1ft (3)
(c)	y= 0 when x = 0 means A = 0	B1
	$\frac{\mathrm{d}y}{\mathrm{d}x} = 5B\cos 5x + \frac{3}{10}\sin 5x + \frac{3}{2}x\cos 5x$ and at x = 0 $\frac{\mathrm{d}y}{\mathrm{d}x} = 5$ and so 5 = 5A	M1 M1
	So B = 1	A1
	So $y = \sin 5x + \frac{3}{10}x\sin 5x$	A1 (5)
(d)	 "Sinusoidal" through O amplitude becoming larger Crosses x axis at $\frac{\pi}{5}, \frac{2\pi}{5}, \frac{3\pi}{5}, \frac{4\pi}{5}$	B1 B1 (2) **14**

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Question Number	Scheme	Marks
1.	$\pm\frac{a}{e}=8, \quad \pm ae=2$	B1, B1
	$\frac{a}{e}\times ae=a^2=16$	
	$a=4$	B1
	$b^2=a^2(1-e^2)=a^2-a^2e^2$	
	$\Rightarrow b^2=16-4=12$	M1
	$\Rightarrow b=\sqrt{12}=2\sqrt{3}$	A1 (5)
		5

Question Number	Scheme	Marks
2.	$x^2+4x+13=(x+2)^2+9$	B1
	$\int \frac{1}{(x+2)^2+9}dx=\frac{1}{3}\arctan\left(\frac{x+2}{3}\right)$	M1 A1
	$\left[\frac{1}{3}\arctan\left(\frac{x+2}{3}\right)\right]_{-2}^{1}=\frac{1}{3}\left(\arctan 1-\arctan 0\right)$	M1
	$=\frac{\pi}{12}$	A1 (5)
		5

Question Number	Scheme	Marks
3(a)	$rhs = 1 + 2\sinh^2 x = 1 + 2\left(\dfrac{e^x - e^{-x}}{2}\right)^2$	M1
	$= \dfrac{2 + e^{2x} - 2 + e^{-2x}}{2}$	M1
	$= \dfrac{e^{2x} + e^{-2x}}{2} = \cosh 2x = lhs$ *	A1 (3)
(b)	$1 + 2\sinh^2 x - 3\sinh x = 15$	
	$2\sinh^2 x - 3\sinh x - 14 = 0$	M1
	$(\sinh x + 2)(2\sinh x - 7) = 0$	M1
	$\sinh x = -2, \dfrac{7}{2}$	A1
	$x = \ln\left(-2 + \sqrt{(-2)^2 + 1)}\right) = \ln\left(-2 + \sqrt{5}\right)$	M1
	$x = \ln\left(\dfrac{7}{2} + \sqrt{\left(\dfrac{7}{2}\right)^2 + 1)}\right) = \ln\left(\dfrac{7 + \sqrt{53}}{2}\right)$	A1 (5)
		8

Question Number	Scheme	Marks
4(a)	$\int (a-x)^n \cos x\mathrm{d}x = (a-x)^n \sin x + \int n(a-x)^{n-1} \sin x\mathrm{d}x$	M1A1
	$\left[(a-x)^n \sin x\right]_0^a = 0$	A1
	$= -n(a-x)^{n-1}\cos x - \int n(n-1)(a-x)^{n-2}\cos x\mathrm{d}x$	dM1
	$\mathrm{I}_n = na^{n-1} - n(n-1)\mathrm{I}_{n-2}$ *	A1 (5)
(b)	$\mathrm{I}_2 = 2\left(\frac{\pi}{2}\right) - 2\int_0^{\frac{\pi}{2}} \cos x\mathrm{d}x$	M1 A1
	$= \pi - 2\left[\sin x\right]_0^{\frac{\pi}{2}} = \pi - 2$	A1 (3)
		8

Question Number	Scheme	Marks
5(a)	$\frac{dy}{dx} = 2\text{ar}\cosh(3x) \times \frac{3}{\sqrt{9x^2-1}}$	M1A1A1
	$\sqrt{9x^2-1}\,\frac{dy}{dx} = 6\text{ar}\cosh(3x)$	
	$(9x^2-1)\left(\frac{dy}{dx}\right)^2 = 36\left(\text{ar}\cosh(3x)\right)^2$	dM1
	$(9x^2-1)\left(\frac{dy}{dx}\right)^2 = 36y$ *	A1 (5)
(b)	$\left\{18x\left(\frac{dy}{dx}\right)^2 + (9x^2-1)\times 2\frac{dy}{dx}\times\frac{d^2y}{dx^2}\right\} = 36\frac{dy}{dx}$	M1 {A1} A1
	$(9x^2-1)\frac{d^2y}{dx^2} + 9x\frac{dy}{dx} = 18$ *	A1 (4)
		9

Question Number	Scheme	Marks
6(a)	$\begin{pmatrix}1 & 0 & 3\\0 & -2 & 1\\k & 0 & 1\end{pmatrix}\begin{pmatrix}6\\1\\6\end{pmatrix}=\lambda\begin{pmatrix}6\\1\\6\end{pmatrix}$	
	$\begin{pmatrix}24\\4\\6k+6\end{pmatrix}=\begin{pmatrix}6\lambda\\\lambda\\6\lambda\end{pmatrix}$	
	Uses the first or second row to obtain $\lambda=4$	M1A1 (2)
(b)	Uses the third row and their $\lambda=4$ to obtain $6k+6=24\Rightarrow k=3$ *	M1 A1 (2)
(c)	$\begin{vmatrix}1-\lambda & 0 & 3\\0 & -2-\lambda & 1\\3 & 0 & 1-\lambda\end{vmatrix}=0$	
	$\Rightarrow(1-\lambda)\left((-2-\lambda)(1-\lambda)-0\right)-0\left(0(1-\lambda)-3\right)+3\left(0-3(-2-\lambda)\right)=0$	M1 A1
	$\Rightarrow(1-\lambda)(-2-\lambda)(1-\lambda)+9(2+\lambda)=(2+\lambda)\left(9-(1-\lambda)^2\right)=0$	
	$\left(\lambda^3-12\lambda-16=0\right)$	
	$\Rightarrow(\lambda+2)\left(\lambda^2-2\lambda-8\right)=0$	
	$\Rightarrow(\lambda+2)(\lambda+2)(\lambda-4)=0$	M1
	$\lambda=-2,4$	A1 (4)
(d)	Parametric form of l_1 : $(t+2,-3t,4t-1)$	M1
	$\begin{pmatrix}1 & 0 & 3\\0 & -2 & 1\\3 & 0 & 1\end{pmatrix}\begin{pmatrix}t+2\\-3t\\4t-1\end{pmatrix}=\begin{pmatrix}13t-1\\10t-1\\7t+5\end{pmatrix}$	M1 A1
	Cartesian equations of l_2 : $\dfrac{x+1}{13}=\dfrac{y+1}{10}=\dfrac{z-5}{7}$	ddM1A1(5)
		13

Question Number	Scheme	Marks
7(a)	$\begin{vmatrix} \mathbf{i} & \mathbf{j} & \mathbf{k} \\ -4 & 1 & 0 \\ 6 & -2 & 1 \end{vmatrix} = \begin{pmatrix} 1 \\ 4 \\ 2 \end{pmatrix}$	M1 A2(1,0)
	$\begin{pmatrix} 1 \\ 4 \\ 2 \end{pmatrix} \bullet \begin{pmatrix} 3 \\ 0 \\ 1 \end{pmatrix} = 5$	
	$\mathbf{r} \bullet \begin{pmatrix} 1 \\ 4 \\ 2 \end{pmatrix} = 5$	M1A1 (5)
(b)	Equation of l is $\mathbf{r} = \begin{pmatrix} 6 \\ 13 \\ 5 \end{pmatrix} + t\begin{pmatrix} 1 \\ 4 \\ 2 \end{pmatrix}$	M1
	At intersection $\begin{pmatrix} 6+t \\ 13+4t \\ 5+2t \end{pmatrix} \bullet \begin{pmatrix} 1 \\ 4 \\ 2 \end{pmatrix} = 5$	M1
	$\Rightarrow 6+t+4(13+4t)+2(5+2t)=5 \Rightarrow t=-3$	M1
	N is $(3,1,-1)$ *	A1 (4)
(c)	$\overrightarrow{PN} \bullet \overrightarrow{PR} = (-3\mathbf{i}-12\mathbf{j}-6\mathbf{k}) \bullet (-5\mathbf{i}-13\mathbf{j}-3\mathbf{k}) = 189$	M1 A1ft
	$\sqrt{9+144+36}\sqrt{25+169+9}\cos NPR = 189$	A1
	$NX = NP\sin NPR = \sqrt{189}\sin NPR = 3.61$	M1A1 (5) **14**

Question Number	Scheme	Marks
8(a)	$\frac{dx}{dt}=4\sec t\tan t \quad \frac{dy}{dt}=2\sec^2 t$	B1 (both)
	$\frac{dy}{dx}=\frac{2\sec^2 t}{4\sec t\tan t} \quad \left(=\frac{1}{2\sin t}\right)$	M1
	$y-2\tan t=\frac{1}{2\sin t}\left(x-4\sec t\right)$	M1 A1
	$2y\sin t-\frac{4\sin^2 t}{\cos t}=x-\frac{4}{\cos t}$	
	$2y\sin t=x-\frac{4-4\sin^2 t}{\cos t}=x-4\cos t$ *	A1 (5)
(b)	Gradient of l_2 is $-2\sin t$	M1
	$y=-2x\sin t$ (2)	A1
	$2\left(-2x\sin t\right)\sin t=x-4\cos t\Rightarrow x=\frac{4\cos t}{1+4\sin^2 t}$ (1)	M1 A1
	$y=\frac{-8\sin t\cos t}{1+4\sin^2 t}$	M1 A1
	$\left(x^2+y^2\right)^2=\left(\frac{16\cos^2 t}{\left(1+4\sin^2 t\right)^2}+\frac{64\sin^2 t\cos^2 t}{\left(1+4\sin^2 t\right)^2}\right)^2$	
	$=\frac{256\cos^4 t}{\left(1+4\sin^2 t\right)^4}\left(1+4\sin^2 t\right)^2=\frac{256\cos^4 t}{\left(1+4\sin^2 t\right)^2}$	M1
	$16x^2-4y^2=\frac{256\cos^2 t}{\left(1+4\sin^2 t\right)^2}-\frac{256\sin^2 t\cos^2 t}{\left(1+4\sin^2 t\right)^2}=\frac{256\cos^4 t}{\left(1+4\sin^2 t\right)^2}$	A1 (8) **13**

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