edexcel

Mark Scheme (Results)

January 2013

GCE Core Mathematics C2 (6664/01)

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General Marking Guidance

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

EDEXCEL GCE MATHEMATICS

General Instructions for Marking

1. The total number of marks for the paper is 75.

2. The Edexcel Mathematics mark schemes use the following types of marks:

- **M** marks: method marks are awarded for 'knowing a method and attempting to apply it', unless otherwise indicated.
- **A** marks: Accuracy marks can only be awarded if the relevant method (M) marks have been earned.
- **B** marks are unconditional accuracy marks (independent of M marks)
- Marks should not be subdivided.

3. Abbreviations

These are some of the traditional marking abbreviations that will appear in the mark schemes and can be used if you are using the annotation facility on ePEN.

- bod – benefit of doubt
- ft – follow through
- the symbol $\surd$ will be used for correct ft
- cao – correct answer only
- cso - correct solution only. There must be no errors in this part of the question to obtain this mark
- isw – ignore subsequent working
- awrt – answers which round to
- SC: special case
- oe – or equivalent (and appropriate)
- dep – dependent
- indep – independent
- dp decimal places
- sf significant figures
- $*$ The answer is printed on the paper
- ⎾ The second mark is dependent on gaining the first mark

4. All A marks are 'correct answer only' (cao.), unless shown, for example, as A1 ft to indicate that previous wrong working is to be followed through. After a misread however, the subsequent A marks affected are treated as A ft, but manifestly absurd answers should never be awarded A marks.

5. For misreading which does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, in that part of the question affected. If you are using the annotation facility on ePEN, indicate this action by 'MR' in the body of the script.

6. If a candidate makes more than one attempt at any question:

- If all but one attempt is crossed out, mark the attempt which is NOT crossed out.
- If either all attempts are crossed out or none are crossed out, mark all the attempts and score the highest single attempt.

7. Ignore wrong working or incorrect statements following a correct answer.

8. Marks for each question are scored by clicking in the marking grids that appear below each student response on ePEN. The maximum mark allocation for each question/part question(item) is set out in the marking grid and you should allocate a score of '0' or '1' for each mark, or "trait", as shown:

	0	1
aM		●
aA	●	
bM1		●
bA1	●	
bB	●	
bM2		●
bA2		●

9. Be careful when scoring a response that is either all correct or all incorrect. It is very easy to click down the '0' column when it was meant to be '1' and all correct.

January 2013
6664 Core Mathematics C2
Mark Scheme

Question Number	Scheme		Marks
1.	$(2-5x)^6$		
	$(2^6 =)\ 64$	Award this when first seen (not $64x^0$)	B1
	$+6\times(2)^5(-5x)+\frac{6\times5}{2}(2)^4(-5x)^2$	Attempt binomial expansion with correct structure for at least one of these terms. E.g. a term of the form: $\binom{6}{p}\times(2)^{6-p}(-5x)^p$ with p = 1 or p = 2 consistently. Condone sign errors. Condone missing brackets if later work implies correct structure and allow alternative forms for binomial coefficients e.g. ${}^6C_1$ or $\binom{6}{1}$ or even $\left(\frac{6}{1}\right)$	M1
	$-960x$	Do **not** allow $+-960x$	A1 (first)
	$(+)6000x^2$	Allow this to come from $(5x)^2$	A1 (Second)
	Ignore any extra terms and isw e.g. divides all terms by 2 The terms do not have to form a sum i.e. they can be listed with commas or given on separate lines.		
	<u>Special Case</u> - decreasing powers can score M1 with the conditions as above for the second and third terms.		
	$(2-5x)^6 = 64+\binom{6}{1}(2^5-5x)+\binom{6}{2}(2^4+(-5x)^2)$ **scores B1 only as the powers of 2 and (-5x) are being added not multiplied.**		
	Fully correct answer with no working can score full marks. If either the second or third term is correct, the M1 can be implied and the A1 scored for that term.		
			(4)
Way 2	$64(1\pm.....)$	64 **and** (1 ± ..... – Award when first seen.	B1
	$\left(1-\frac{5x}{2}\right)^6 = 1\ \underline{-6\times\frac{5x}{2}}+\underline{\frac{6\times5}{2}\left(-\frac{5x}{2}\right)^2}$	Correct structure for at least one of the underlined terms. E.g. a term of the form: $\binom{6}{p}\times(kx)^p$ with p = 1or p = 2 consistently and $k \neq \pm5$ Condone sign errors. Condoned missing brackets if later work implies correct structure but it must be an expansion of $(1-kx)^6$ where $k \neq \pm5$	M1
	$-960x$	Do **not** allow $+-960x$	A1
	$(+)6000x^2$	Allow this to come from $\left(\frac{5x}{2}\right)^2$	A1
			(4)

Question Number	Scheme		Marks
2.			
(a)	$f(1) = a + b - 4 - 3 = 0$ **or** $a + b - 7 = 0$	Attempt f(±1)	M1
	$a + b = 7$ *	Must be f(1) and = **0** needs to be seen	A1
			(2)
(b)	$f(-2) = a(-2)^3 + b(-2)^2 - 4(-2) - 3 = 9$	Attempt f(±2) **and uses** f(±2) = 9	M1
	$-8a + 4b + 8 - 3 = 9$	Correct equation with exponents of (-2) removed	A1
	$(-8a + 4b = 4)$		
	Solves the **given equation from part (a)** and their equation in a and b from part (b) as far as a =... or b = ...		M1
	$a = 2$ **and** $b = 5$	**Both** correct	A1
	Attempts at trial and improvement in (b): Allow the first M1 if they try values for a and b where $a + b = 7$ and substitute their values into the cubic along with $x = \pm 2$ and sets = 9. For completion to $a = 2$ and $b = 5$ fully shown to be correct allow 4/4. For incomplete or incorrect solutions allow the first M1 only. **If in doubt consult your team leader.**		
			(4)
			[6]
	Long Division		
(a)	$(ax^3 + bx^2 - 4x - 3) \div (x - 1) = ax^2 + px + q$ where p and q are in terms of a or b or both and sets their remainder = 0 NB Quotient = $ax^2 + (a + b)x + (a + b - 4)$		M1
	a + b = 7 *		A1
			(2)
(b)	$(ax^3 + bx^2 - 4x - 3) \div (x + 2) = ax^2 + px + q$ where p and q are in terms of a or b or both and sets their remainder = 9 NB Quotient = $ax^2 + (b - 2a)x + (4a - 4 - 2b)$		M1
	4b – 8a + 5 = 9		A1
	Follow scheme for final 2 marks		

Question Number	Scheme		Marks
3.			
(a)	$120000\times(1.05)^3=138915*$	Or $120000\times1.05\times1.05\times1.05=138915$ Or 120000, 126000, 132000, 138915 Or a = 120000 and $a\times(1.05)^3=138915$	B1
			(1)
(b)	$120000\times(1.05)^{n-1}>200000$	Allow n or $n-1$ and ">", "<", or "=" etc.	M1
	$\log1.05^{n-1}>\log\left(\frac{5}{3}\right)$	Takes logs correctly Allow n or $n-1$ and ">", "<", or "=" etc.	M1
	$(n-1>)\frac{\log\left(\frac{5}{3}\right)}{\log1.05}$ or equivalent e.g $(n>)\frac{\log\left(\frac{7}{4}\right)}{\log1.05}$	Allow n or $n-1$ and ">", "<", or "=" etc. Allow $1.\dot{6}$ or awrt 1.67 for 5/3.	A1
	2024	M1: Identifies a calendar year using their value of n or n - 1 A1: 2024 only cso	M1A1
	2024 with no working = no marks		
	See appendix for alternative taking logs base 1.05 and mis-read as **total** profit		
			(5)
(c)	$\frac{a(1-r^n)}{1-r}=\frac{120000\left(1-1.05^{11}\right)}{1-1.05}$	M1: Correct sum formula with n = 10, 11 or 12 A1: Correct numerical expression with n = 11	M1 A1
	1704814	Cao (Allow 1704814.00)	A1
			(3)
			[9]
	Listing or trial/improvement in (b)		
	U_{10} = 186 159.39, U_{11} = 195 467.36, U_{12} = 205 240.72		
	Attempt to find at least the 10th or 11th or 12th terms correctly using a common ratio of 1.05 (all the terms need **not** be listed)		M1
	Forms the geometric progression correctly to reach a term > 200 000 (May be implied e.g. reaches 195 467.36 – Hence the next year)		M1
	Obtains an "11th" term of awrt 195 500 **and** a "12th" term of awrt 205 200		A1
	Uses their number of terms to identify a calendar year		M1
	2024		A1
	If you are not sure how to award the marks please consult your Team Leader		**(5)**

Question Number	Scheme		Marks
4.			
	$\cos^{-1}(-0.4) = 113.58 \ (\alpha)$	Awrt 114	B1
	$3x-10=\alpha \Rightarrow x=\dfrac{\alpha+10}{3}$	Uses their α to find *x*. Allow $x=\dfrac{\alpha\pm10}{3}$ **not** $\dfrac{\alpha}{3}\pm10$	M1
	Note: If $x=\dfrac{\alpha\pm10}{3}$ is not clearly applied from their first angle it may be recovered if applied to their second or third angle.		
	$x = 41.2$	Awrt	A1
	$(3x-10=)360-\alpha \ (246.4....)$	$360-\alpha$ (can be implied by 246.4...)	M1
	x = 85.5	Awrt	A1
	$(3x-10=)360+\alpha \ (=473.57....)$	$360+\alpha$ (Can be implied by 473.57...)	M1
	x = 161.2	Awrt	A1
	Note 1: Do not penalise incorrect accuracy more than once and penalise it the first time it occurs. E.g if answers are only given to the nearest integer (41, 85, 161) only the first A mark that would otherwise be scored is lost.		
	Note 2: Ignore any answers outside the range. For extra answers in range in an otherwise **fully** correct solution lose final A1		
	Note 3: Lack of working means that it is sometimes not clear where their intermediate angles are coming from. In these cases, if the final answers are incorrect score M0.		
	Note 4: Candidates are unlikely to be working in radians deliberately but may have their calculator in radian mode (gives α = 1.98). In such cases the main scheme should be applied and the method marks are available. If you suspect that the candidate is working in radians correctly then please use the review mechanism and/or consult your team leader.		
Way 2	$\cos^{-1}(0.4) = 66.42 \ (\alpha)$		
	180 – 66.42 = 113.58	Awrt 114	B1
	$3x-10=113.58 \Rightarrow x=\dfrac{113.58+10}{3}$	Uses their 113.58 to find *x*	M1
	x = 41.2	Awrt	A1
	$3x-10=180+\alpha \ (246.4....)$	$180+\alpha$	M1
	to give x = 85.5		A1
	$3x-10=540-\alpha \ (473.57....)$	$540-\alpha$	M1
	to give x = 161.2		A1
	Special case - takes 0.4 as -0.4		
	$\cos^{-1}(0.4) = 66.42 \ (\alpha)$		B0
	$3x-10=66.4 \Rightarrow x=\dfrac{66.4\pm10}{3}$		M1
	x = 41.2		A0
	$3x-10=360-\alpha \ (293.6....)$		M1
	x = 101.2		A0
	$3x-10=360+\alpha \ (426.4....)$		M1
	x = 145.5		A0
			(3/7)

Question Number	Scheme		Marks
5.			
(a)	**Parts (i) and (ii) are likely to be solved together so mark as one part**		
(i)	The centre is at (10, 12)	B1: $x = 10$ B1: $y = 12$	B1 B1
(ii)	Uses $(x-10)^2+(y-12)^2 = -195+100+144 \Rightarrow r = ...$		M1
	Completes the square for both x and y in an attempt to find r. $(x \pm "10")^2 \pm a$ and $(y \pm "12")^2 \pm b$ and $+195 = 0, (a, b \neq 0)$ Allow slips in obtaining their r^2 but must find square root		
	$r = \sqrt{10^2+12^2-195}$	A correct numerical expression for r including the square root and can implied by a correct value for r	A1
	$r = 7$	Not $r = \pm 7$ unless -7 is rejected	A1
			(5)
(a) Way 2	Compares the given equation with $x^2+y^2+2gx+2fy+c=0$ to write down centre $(-g,-f)$ i.e. (10, 12)	B1: $x = 10$ B1: $y = 12$	B1B1
	Uses $r = \sqrt{(\pm"10")^2+(\pm"12")^2-c}$		M1
	$r = \sqrt{10^2+12^2-195}$	A correct numerical expression for r	A1
	$r = 7$		A1
			(5)
	Note that although the marks for the centre are B marks, they do need to come from correct work. E.g. $(x+10)^2, (y+12)^2$ **giving a centre of (10, 12) scores B0 B0 but could score the M1A1ftA1ft for the radius as a special case. Similarly** $(x+10)^2, (y-12)^2$ **giving a centre of (-10, 12) scores B0 B1,** $(x-10)^2, (y+12)^2$ **giving a centre of (10, -12) scores B1 B0 but both could score M1A1ftA1ft for the radius as a special case also.**		
(b)	$MN = \sqrt{(25-"10")^2+(32-"12")^2}$	Correct use of Pythagoras	M1
	$MN\left(=\sqrt{625}\right) = 25$		A1
			(2)
(c)	$NP = \sqrt{("25"^2-"7"^2)}$	$NP = \sqrt{(MN^2-r^2)}$	M1
	$NP = \sqrt{(25^2+7^2)}$ is M0 (Quite common)		
	$NP\left(=\sqrt{576}\right) = 24$		A1
			(2)
(c) Way 2	$\cos(NMP) = \frac{7}{"25"} \Rightarrow NP = "25"\sin(NMP)$	Correct strategy for finding NP	M1
	$NP = 24$		A1
			(2)
			[9]

Question Number	Scheme		Marks
6.			
(a)	$2\log(x+15)=\log(x+15)^2$		B1
	$\log(x+15)^2-\log x=\log\dfrac{(x+15)^2}{x}$	Correct use of $\log a-\log b=\log\dfrac{a}{b}$	M1
	$2\log(x+15)-\log x=6\Rightarrow\log\left(\dfrac{(x+15)^2}{x}\right)=6$ with no incorrect work scores B1 M1 together		
	$2\log_2(x+15)-\log_2 x=2\log_2\dfrac{(x+15)}{x}$ is M0		
	$2^6=64$ or $\log_2 64=6$	64 used in the correct context	B1
	$\log_2\dfrac{(x+15)^2}{x}=6\Rightarrow\dfrac{(x+15)^2}{x}=64$	Removes logs correctly	M1
	$2\log(x+15)-\log x=6\Rightarrow\log(x+15)^2-\log x=6\Rightarrow\dfrac{(x+15)^2}{x}=64$ Is acceptable for the first 4 marks		
	This method mark should only be awarded for the removal of logs in an appropriate way. Some examples are below, $\dfrac{\log(x+15)^2}{\log x}=6\Rightarrow\dfrac{(x+15)^2}{x}=6$ **M0** $\log\dfrac{(x+15)^2}{x}=6\Rightarrow\dfrac{(x+15)^2}{x}=6$ **M0** $\log\dfrac{(x+15)^2}{x}=6\Rightarrow\dfrac{(x+15)^2}{x}=\log_2 6$ **M0** $\log\dfrac{(x+15)^2}{x}=6\Rightarrow\dfrac{(x+15)^2}{x}=6^2$ **M0** $\log\left(\dfrac{(x+15)}{x}\right)^2=6\Rightarrow\left(\dfrac{(x+15)}{x}\right)^2=64$ **M1**		
	$\Rightarrow x^2+30x+225=64x$ *or* $x+30+225x^{-1}=64$	Must see expansion of $(x+15)^2$ to score the final mark.	
	$\therefore x^2-34x+225=0$ *	Correct completion to printed answer with no errors but allow recovery from 'invisible' brackets e.g. $x+15^2\rightarrow x^2+30x+225$	A1
			(5)
(b)	$(x-25)(x-9)=0\Rightarrow x=25$ or $x=9$	M1: Correct attempt to solve the **given** quadratic as far as x =... **It must be an attempt at solving the given quadratic but allow mis-copy e.g. 255 for 225** A1: Both 25 and 9	M1 A1
			(2)
			[7]
	See appendix for some alternative correct and incorrect methods for (a)		

Question Number	Scheme		Marks
7.			
(a)	$9^2 = 4^2 + 6^2 - 2\times4\times6\cos\alpha \Rightarrow \cos\alpha = ...$	Correct use of cosine rule leading to a value for cos α	M1
	$\cos\alpha = \dfrac{4^2+6^2-9^2}{2\times4\times6}\left(= -\dfrac{29}{48} = -0.604..\right)$		
	$\alpha = 2.22$ *	Cso (2.22 must be seen here)	A1
	(NB $\alpha = 2.219516005$)		**(2)**
(a) Way 2	$XY^2 = 4^2 + 6^2 - 2\times4\times6\cos 2.22 \Rightarrow XY^2 = ..$	Correct use of cosine rule leading to a value for XY^2	M1
	$XY^2 = 81.01....$		
	$XY = 9.00....$		A1
			(2)
(b)	$2\pi - 2.22 (= 4.06366.....)$	$2\pi - 2.22$ or awrt 4.06 or $2\pi - 2.2$ or awrt 4.08 (May be implied)	B1
	$\frac{1}{2}\times4^2\times"4.06"$	Correct method for major sector area. Allow $\pi - 2.22$ for the major sector angle.	M1
	32.5	Awrt 32.5	A1
	Finding the minor sector area here (17.8) is 0/3		**(3)**
(b) Way2	**Circle – Minor sector**		
	$\pi\times4^2$	Correct expression for circle area	B1
	$\pi\times4^2 - \dfrac{1}{2}\times4^2\times2.22 = 32.5$	Correct method for circle - minor sector area	M1
	$= 32.5$	Awrt 32.5	A1
			(3)
(c)	Area of triangle = $\frac{1}{2}\times4\times6\times\sin 2.22\left(=9.56\right)$	Correct expression for the area of triangle XYZ (allow 2.2 or awrt 2.22)	B1
	So area required = "9.56" + **"**32.5"	Their Triangle XYZ (**Not** triangle ZXW) + (part (b) answer or correct attempt at major sector)	M1
	= 42.1 cm^2 or 42.0 cm^2	Awrt 42.1 or 42.0 (Or <u>just</u> 42)	A1
			(3)
	Note: The **minor** sector area (17.76) + the triangle (9.56) = 27.32 which looks like the answer to (d) – beware!		
(d)	Arc length $= 4\times4.06\left(=16.24\right)$ Or $8\pi - 4\times2.22$	M1: $4\times\mathit{their}\left(2\pi - 2.22\right)$ Or circumference – minor arc A1: Correct ft expression	**M1A1ft**
	Perimeter = ZY + WY + Arc Length	9 + 2 + Any Arc	**M1**
	Perimeter = 27.2 or 27.3	Awrt 27.2 or awrt 27.3	**A1**
	Note the order of marks on Epen is M1M1A1A1 – the M's and A's must correspond so that the second mark on Epen is the second M1 on the scheme		
			(4)
	(Generally do not apply isw in this question and mark their final answer **unless a correct answer is subsequently rounded incorrectly**)		**[12]**
	In this question we will need to be careful with labelling as each part has clear demands and must be marked as labelled by the candidate.		

Question Number	Scheme		Marks
8.	$y = 6 - 3x - \frac{4}{x^3}$		
(a)	$\frac{dy}{dx} = -3 + \frac{12}{x^4} or -3 + 12x^{-4}$	M1: $x^n \rightarrow x^{n-1}$ $(x^{1} \rightarrow x^{0}$ or $x^{-3} \rightarrow x^{-4}$ or $6 \rightarrow 0)$ A1: Correct derivative	M1 A1
	$\frac{dy}{dx} = 0 \Rightarrow -3 + \frac{12}{x^4} = 0 \Rightarrow x = ...$ **or** $\frac{dy}{dx} = -3 + \frac{12}{\sqrt{2}^4}$	$y' = 0$ and attempt to solve for x May be implied by $\frac{dy}{dx} = -3 + \frac{12}{x^4} = 0 \Rightarrow \frac{12}{x^4} = 3 \Rightarrow x = ...$ **or** Substitutes $x = \sqrt{2}$ into their y'	M1
	So $x^4 = 4$ and $x = \sqrt{2}$ **or** $\frac{dy}{dx} = -3 + \frac{12}{\left(\sqrt{2}\right)^4}$ or $-3 + 12\left(\sqrt{2}\right)^{-4} = 0$	Correct completion to printed answer with no errors by solving their $y' = 0$ or substituting $x = \sqrt{2}$ into their y'	A1
	For solving, allow e.g. $x^{-4} = \frac{1}{4} \Rightarrow x = \left(\frac{1}{4}\right)^{-\frac{1}{4}} = \sqrt{2}$ The minimum for verification is as in the scheme which could be implied by -3 + 3 = 0		
	Do not allow $x^4 = 4 \Rightarrow x = 1.41... = \sqrt{2}$ for the final A1		**(4)**
(b)	$x = -\sqrt{2}$	Awrt -1.41	B1
			(1)
(c)	$\frac{d^2y}{dx^2} = \frac{-48}{x^5}$ or $-48x^{-5}$	Follow through their first derivative from part (a)	B1ft
			(1)
(d)	An appreciation that either $y'' > 0 \Rightarrow$ a minimum or $y'' < 0 \Rightarrow$ a maximum	A generous mark that is independent of any previous work	B1
	Maximum at P as $y'' < 0$	Cso	B1
	Need a fully correct solution for this mark. y'' need not be evaluated but must be correct and there must be reference to P or to $\sqrt{2}$ and negative or < 0 and maximum. There must be no incorrect or contradictory statements (NB allow y'' = awrt-8 or -9)		
	Minimum at Q as $y'' > 0$	Cso	B1
	Need a fully correct solution for this mark. y'' need not be evaluated but must be correct **and part (b) must be correct** and there must be reference to P or to $-\sqrt{2}$ and positive or > 0 and minimum. There must be no incorrect or contradictory statements (NB allow y'' = awrt 8 or 9)		
			(3)
			[9]
	Other methods for identifying the nature of the turning points are acceptable. The first B1 is for finding values of y or dy/dx either side of $\sqrt{2}$ or their x at Q and the second and third B1's for fully correct solutions to identify the maximum/minimum.		

Question Number	Scheme		Marks
9.	$y = 27 - 2x - 9\sqrt{x} - \frac{16}{x^2}$		
(a)	6.272 , 3.634	Awrt in each case	B1, B1
	Special case 6.27 <u>and</u> 3.63 scores B1B0		
			(2)
(b)	$\frac{1}{2}\times\frac{1}{2}$ or $\frac{1}{4}$		B1
	$....\left\{(0+0)+2\left(5.866+"6.272"+5.210+"3.634"+1.856\right)\right\}$	Need {} or implied later for A1ft	M1A1ft
	(0 + 0) may be implied if omitted and follow through their f(2) and f(3) in an otherwise correct expression and allow one missing or mis-copied term in the 2(....) bracket for the **method** mark		
	$\frac{1}{2}\times 0.5(0+0)+2\left(5.866+"6.272"+5.210+"3.634"+1.856\right)$ **Unless followed by an answer that implies correct (missing) brackets, scores B1M1A0A0 (Usually implied by an answer of 45.676)**		
	$\frac{1}{2}\times 0.5\left\{(0+0)+2\left(5.866+"6.272"+5.210+"3.634"+1.856\right)\right\}$ $= \frac{1}{4}\times 45.676$		
	= 11.42	cao	A1
	Separate trapezia may be used : B1 for 0.25, M1 for $\frac{1}{2}h(a+b)$ used 5 or 6 times (and A1ft all correct)		
	NB $\frac{1}{2}\times 0.5\left\{(0+0)+2\left(0+5.866+"6.272"+5.210+"3.634"+1.856+0\right)\right\}$ **Scores B1M0A0A0**		
	Correct answer with no working scores 0/4		
			(4)
(c)	$\int y\,dx = 27x - x^2 - 6x^{\frac{3}{2}} + 16x^{-1}(+c)$	M1: $x^n \rightarrow x^{n+1}$ on any term A1: $27x - x^2$ A1: $-6x^{\frac{3}{2}}$ A1: $+16x^{-1}$	M1A1A1A1
	Accept any correct and possibly unsimplified versions for the terms and mark **in this order** on Epen		
	$\left(27(4)-(4)^2-6(4)^{\frac{3}{2}}+16(4)^{-1}\right)$ $-\left(27(1)-(1)^2-6(1)^{\frac{3}{2}}+16(1)^{-1}\right)$	**Attempt to subtract either way round using the limits 4 and 1. Dependent on the previous M1. May be implied by 48 – 36 but you may need to check both their values if the integration has errors.**	dM1
	= (48 – 36)		
	12	Cao (Penalise -12)	A1
			(6)
			[12]

Appendix

3(b) Way 2	$120000\times(1.05)^{n-1} > 200000$	Allow n or $n-1$ and ">", "<", or "=" etc.	M1
	$\log_{1.05} 1.05^{n-1} > \log_{1.05}\left(\frac{5}{3}\right)$	Takes logs correctly Allow n or $n-1$ and ">", "<", or "=" etc. This may be implied by $n-1 > \log_{1.05}\left(\frac{5}{3}\right)$ and effectively gets the next A1	M1
	e.g. $\log_{1.05}\left(120000\times(1.05)^{n-1}\right) = (n-1)\log_{1.05}\left(120000\times(1.05)\right)$ would be M0		
	$(n-1>)\log_{1.05}"\frac{5}{3}"$	Allow n or $n-1$ and ">", "<", or "=" etc.	A1
	2024	M1: Identifies a calendar year using their value of n or n - 1 A1: 2024 only cso	M1A1
			(5)

3(b) MR?	$\frac{120000\times(1-1.05^n)}{1-1.05} > 200000$		M0
	$1.05^n > \frac{13}{12}$		
	$\log 1.05^n > \log\left(\frac{13}{12}\right)$	Takes logs correctly	M1
	$n > \frac{\log\left(\frac{13}{12}\right)}{\log 1.05}$		A0
	2014	M1: Identifies a calendar year using their value of n or n - 1 A1: 2024 only	M1A0
	Trial & Improvement for this MR is 0/5		
			(2/5)

4. **Way 3**	**General Solution**		
	$\cos^{-1}(-0.4) = 113.58 \ (\alpha)$	Awrt 114	B1
	$3x-10 = 360n+113.58$	$360n+\alpha$	M1
	$3x-10 = 360n-113.58$	$360n-\alpha$	M1
	$3x-10 = \alpha \Rightarrow 3x = \alpha+10$		
	$x = \frac{360n+123.58}{3}$ or $\frac{360n-103.58}{3}$	$x = \frac{360n \pm 113.58 \pm 10}{3}$	M1
	$x = 41.2$	Awrt	A1
	$x = 85.5$	Awrt	A1
	$x = 161.2$	Awrt	A1
			(7)

4.	**Special Case 1**		
	$\cos(3x-10) = \cos(3x)-\cos(10)$		
	$\cos(3x) = -0.4+\cos(10)$		
	$\cos(3x) = 0.5848....$		
	$3x = 54.2 = \alpha$		
	$x = 18.1$		
	B0M0A0 so far		
	$3x = 360-\alpha$	$360-\alpha$	M1
	$x = 101.9$	Awrt	A0
	$3x = 360+\alpha$	$360+\alpha$	M1
	$x = 138.1$	Awrt	A0
			(2/7)

4.	**Special Case 2 – Quite common**		
	$\cos^{-1}(-0.4) = 113.58 \ (\alpha)$	Awrt 114	B1
	$3x-10 = \alpha \Rightarrow x = \frac{\alpha+10}{3}$	Uses their α to find *x*. Allow $x = \frac{\alpha \pm 10}{3}$ **not** $\frac{\alpha}{3} \pm 10$	M1
	$x = 41.2$	Awrt	A1
	$3x-10 = \alpha \Rightarrow 3x = \alpha+10$		
	$3x = 360-(\alpha+10)$		M0
	$x = 78.8$		A0
	$3x = 360+(\alpha+10)$		M1
	$x = 161.2$	Awrt	A1
			(5/7)

4.	Possible scenarios		
	Answers	**Marks**	
	41.2, 97.9	B1M1A1M0A0M0A0	
	41.2, 97.9, 142.7	B1M1A1M0A0M0A0	
	41.2, 85.5, 97.9	B1M1A1M1A1M0A0	
	41.2, 97.9, 161.2	B1M1A1M0A0M1A1	
	41.2, 85.5, 97.9, 142.7	B1M1A1M1A1M0A0	
	41.2, 85.5, 97.9, 161.2	B1M1A1M1A1M1A0	
	41.2, 85.5, 97.9, 142.7, 161.2	B1M1A1M1A1M1A0	

6 Way 2	$2\log(x+15)=\log(x+15)^2$		B1
	$\log(x+15)^2=6+\log x$		
	$2^6=64$ or $\log_2 64=6$	64 used in the correct context	B1
	$\log_2 64+\log_2 x=\log_2(64x)$	Correct use of $\log a+\log b=\log ab$	M1
	$(x+15)^2=64x$	Removes logs correctly	M1
	$\Rightarrow x^2+30x+225=64x$	Must see expansion of $(x+15)^2$ to score the final mark.	
	$\therefore x^2-34x+225=0$ *	Correct completion to printed answer	A1
			(5)

6 Way 3	$2\log(x+15)=\log(x+15)^2$		B1
	$2^6=64$ or $\log_2 64=6$	64 used in the correct context	B1
	$\log_2(x+15)^2-\log_2 x=\log_2 64$		
	$(x+15)^2=64x$	Correct use of $\log a+\log b=\log ab$ (implied) and removes logs correctly.	M1, M1
	$\Rightarrow x^2+30x+225=64x$	Must see expansion of $(x+15)^2$ to score the final mark.	
	$\therefore x^2-34x+225=0$ *	Correct completion to printed answer	A1
			(5)

6 Way 4	$2\log(x+15)=\log(x+15)^2$		*B1*
	$\log(x+15)^2-\log x=\dfrac{\log\left(x+15\right)^2}{\log x}$		*M0*
	$2^6=64$ *or* $\log_2 64=6$	*64 used in the correct context*	*B1*
	$\dfrac{\log_2\left(x+15\right)^2}{\log x}=6\Rightarrow\dfrac{(x+15)^2}{x}=64$		*M0*
	$\Rightarrow x^2+30x+225=64x$		
	$\therefore x^2-34x+225=0$ *		*A0*
			(2/5)

6 Way 5			
	$2\log(x+15)-\log x=2\log\left(\dfrac{x+15}{x}\right)$		M0
	$\log_2\dfrac{\left(x+15\right)^2}{x}=6$		B0 (first)
	$2^6=64$ or $\log_2 64=6$	64 used in the correct context	B1
	$\dfrac{(x+15)^2}{x}=64$		M1
	$\Rightarrow x^2+30x+225=64x$		
	$\therefore x^2-34x+225=0$ *	Incorrect solution	A0
			(2/5)

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