Version 1.0

Free-Standing Mathematics Qualification
June 2013

Mathematics Advanced Level 6991

(Specification 6991)

Working with Algebraic and Graphical Techniques

Final

Mark Scheme

Mark schemes are prepared by the Principal Examiner and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation events which all examiners participate in and is the scheme which was used by them in this examination. The standardisation process ensures that the mark scheme covers the students' responses to questions and that every examiner understands and applies it in the same correct way. As preparation for standardisation each examiner analyses a number of students' scripts: alternative answers not already covered by the mark scheme are discussed and legislated for. If, after the standardisation process, examiners encounter unusual answers which have not been raised they are required to refer these to the Principal Examiner.

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Key to mark scheme abbreviations

M	mark is for method
m or dM	mark is dependent on one or more M marks and is for method
A	mark is dependent on M or m marks and is for accuracy
B	mark is independent of M or m marks and is for method and accuracy
E	mark is for explanation
√or ft or F	follow through from previous incorrect result
CAO	correct answer only
CSO	correct solution only
AWFW	anything which falls within
AWRT	anything which rounds to
ACF	any correct form
AG	answer given
SC	special case
OE	or equivalent
A2,1	2 or 1 (or 0) accuracy marks
–*x* EE	deduct *x* marks for each error
NMS	no method shown
PI	possibly implied
SCA	substantially correct approach
c	candidate
sf	significant figure(s)
dp	decimal place(s)

No Method Shown

Where the question specifically requires a particular method to be used, we must usually see evidence of use of this method for any marks to be awarded.

Where the answer can be reasonably obtained without showing working and it is very unlikely that the correct answer can be obtained by using an incorrect method, we must award **full marks**. However, the obvious penalty to candidates showing no working is that incorrect answers, however close, earn **no marks**.

Where a question asks the candidate to state or write down a result, no method need be shown for full marks.

Where the permitted calculator has functions which reasonably allow the solution of the question directly, the correct answer without working earns **full marks**, unless it is given to less than the degree of accuracy accepted in the mark scheme, when it gains **no marks**.

Otherwise we require evidence of a correct method for any marks to be awarded.

Question	Solution	Marks	Total	Comments
1(a)	$k = 12$	B1	1	
(b)	$0.01 \times 3 \times 9 = 0.27(\text{m})$	B1	1	27 cm B1 27 alone B0
(c)	$x = 6$ or half (their) k	B1		
	$y = 0.01 \times 6^2 = 0.36(\text{m})$	B1	2	
(d)(i)	$y = 0.01x(12 - x)$			or: q = half (their) k M1
	$= 0.12x - 0.01x^2$			p = max. height M1
	$= -0.01(x^2 - 12x)$	M1		
	$= -0.01\{(x-6)^2 - 36\}$	M1		completing the square leading to
	$= 0.36 - 0.01(x-6)^2$	A1A1	4	$p = 36$ and $q = 6$: M1 A1 M1 A0 Alternative solution: $0.01x(12-x) \equiv p - 0.01(x-q)^2$ $0.12x - 0.01x^2 \equiv p - 0.01x^2 + 0.02qx - 0.01q^2$ M1 $0.12 = 0.02q$ M1 $q = 6$ A1 $0 = p - 0.01q^2$ $p = 36 \times 0.01 = 0.36$ A1
(ii)	p is the greatest height	B1		or: p and q are the y and x coordinates of the maximum point B1B1; **but** if y and x are swapped or no order is implied, then B0B0
	q is the value of x where this occurs	B1	2	
(e)	$\text{B}(12,0);\text{C}(14,-0.24)$			
	$m = -\dfrac{0.24}{2}$	M1		for correctly using (their) coordinates to find m
	$= -0.12$	A1	2	(+)0.12 is B1B0
(f)	inverted quadratic shape	B1		
	correct for $x = 0, 10$ and 20	B1		
	completely correct	B1	3	± 2 mm
	Total		**15**	

2(a)	3800	B1	1	
(b)	$3820 = 3800 \times e^{0.00012t}$			
	$1.005263 = e^{0.00012t}$	M1		
	$0.00012t = \ln(1.005263)$	M1		for taking logs correctly
	$= 5.249 \times 10^{-3}$			
	$t = \left(5.249 \times 10^{-3}\right) \div 0.00012$	M1		
	43.7 (days)	A1	4	or 44 (with or without working)
(c)	$3800 \times e^{365 \times 0.00012} = 3970.14$	M1		
	(Their) $3970.14 - 3800 = 170.14$			4.477 SC2
	$\frac{170.14}{3800} \times 100$	M1		4.5 with working M1M1A0
	$= 4.48\%$	A1	3	
(d)	increasing, curved the right way	B1		
	M-intercept = 3800	B1	2	ignore anything drawn for $t < 0$
	Total		**10**	
3(a)	0; 15 625; 125 000; 421 875; 10 00 000	B1	1	
(b)	4 points correct	B1		
	all correct	B1		
	line	B1	3	± 2 mm
(c)	evidence of measurements of "Δx and Δy"	M1		
	$a = 9 \times 10^{-7}$ to 1×10^{-6}	A1	2	if no working is shown: • negative *a* in the range $[-1 \times 10^{-6}, -9 \times 10^{-7}]$ is SC1 • *a* = 0.09 to 0.1 is SC1
(d)(i)	$0 = 1.8 - \left(9.5 \times 10^{-7}\right) t^3$	M1		negative *t* correctly deduced from negative *a* SC2
	$t^3 = \frac{1.8}{9.5 \times 10^{-7}}$			
	$= 1894\,736.8$	M1		
	$t = \sqrt[3]{1894\,736.8}$	M1		
	$= 123.7$ or 124	A1	3	ft from their answers to (c) if $a > 0$ and $t > 100$
(ii)	the comet would hit the earth	B1	1	or: the model is bad, etc must be consistent with answer to (d)(i)
	Total		**10**	

4(a)	$D = 10\log_{10}\dfrac{58}{0.12} = 10\log_{10} 483.3$	M1		need to see $10\log_{10} 483.3$
	$= 26.8(\text{dB})$	A1	2	allow 26.84 or –26.8(4)
(b)(i)	$D = 10\log_{10}\left(\dfrac{P_2}{P_1}\right)$			or $D = 10\log_{10}\left(\dfrac{P_2}{P_1}\right)$
	$0.1D = \log_{10}\left(\dfrac{P_2}{P_1}\right)$	B1		$10^D = \left(\dfrac{P_2}{P_1}\right)^{10}$ B1
	$10^{0.1D} = \dfrac{P_2}{P_1}$			$10^{0.1D} = \dfrac{P_2}{P_1}$
	$P_1\left(10^{0.1D}\right) = P_2$	B1	2	$P_1(10^{0.1D}) = P_2$ B1
				or $D = 10\log_{10}\left(\dfrac{P_2}{P_1}\right)$
				$D = 10\log_{10} P_2 - 10\log_{10} P_1$
				$\log_{10} P_2 = 0.1D + \log_{10} P_1$
				$= \log_{10}\left(10^{0.1D}\right) + \log_{10} P_1$ B1
				$= \log_{10}\left(10^{0.1D} P_1\right)$
				$P_2 = \left(10^{0.1D}\right) P_1$ B1
(ii)	$P_2 = 0.04 \times 10^{6.2}$	M1		
	$= 63395.7$ or $63\,400$	A1	2	
	Total		**6**	

Question	Solution	Marks	Total	Comments
5(a)	13.1; 12(.0); 10.5; 8.82	B2	2	1 or 2 errors B1
(b)	correct graph	B2 Ft from (a)	2	1 or 2 errors B1 no curve = 1 error
(c)	$13.0-12.6=0.4$	M1		dividing by 13 instead of 12.6 gives max M1M0A0
	$\frac{0.4}{12.6}\times 100$	M1		
	3.17%	A1	3	
(d)(i)	tangent drawn at $t=30$ gradient calculated eg	M1		
	$\frac{4.3}{77}=0.056$	A1	2	0.05 to 0.065
(ii)	million km^2 per day	B1	1	
(iii)	the sea ice was growing/increasing by 0.056 (million) km^2 per day	B1	1	oe
(e)	$6.4=8.6+5.1\sin\{0.986(t+20)\}^\circ$			
	$\sin\{0.986(t+20)\}^\circ=\frac{-2.2}{5.1}=-0.4314$	M1		
	$\sin^{-1}(-0.4314)=-25.55^\circ$	B1		[if from here $-25.55\div 0.986=-25.9$ $-25.9-20=-45.9$ M1 $-45.9+360=314$ (or similar) B0]
	$180+25.6=205.6$	M1		or $360-25.6=334.4$ M1
	$205\div 0.986-20=188\,\text{days}\,(\text{or } 188.5\,\text{days})$	B1	4	$334.4\div 0.986-20=319\,\text{days}$ B1
(f)	vertical stretch or stretch parallel to *y*-axis scale factor 5.1 translation	B1 B1 B1		−1 for a third transformation
	$\begin{pmatrix}0\\8.6\end{pmatrix}$	B1	4	vector required
	Total		**19**	
	TOTAL		**60**	