Level 3 Certificate
MATHEMATICAL STUDIES
1350/2C

Paper 2C Graphical techniques

Mark scheme

June 2019

Version: 1.0 Final

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Mark schemes are prepared by the Lead Assessment Writer 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 associates 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 associate understands and applies it in the same correct way. As preparation for standardisation each associate 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, associates encounter unusual answers which have not been raised they are required to refer these to the Lead Assessment Writer.

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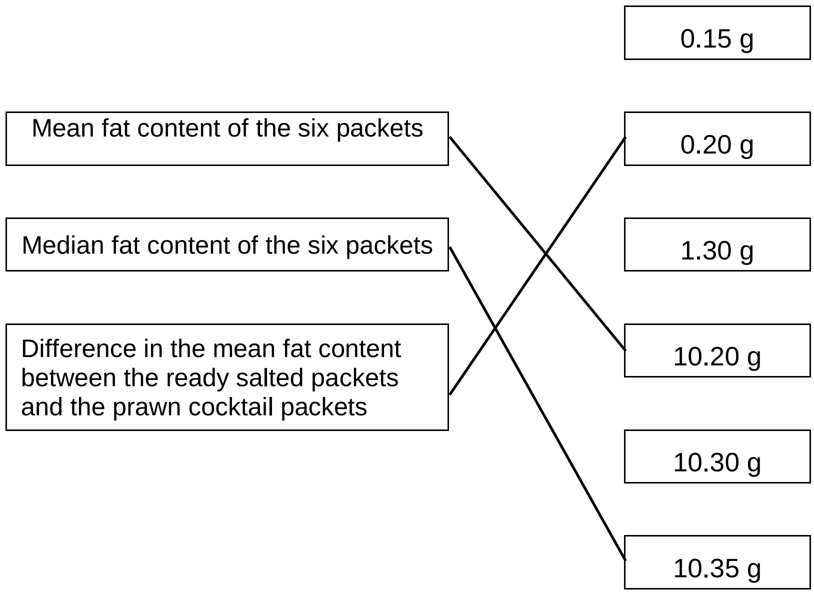
Further copies of this mark scheme are available from aqa.org.uk

<table>
<tr><th>Q</th><th>Answer</th><th>Mark</th><th>Comments</th></tr>
<tr><td rowspan="3">1 (a)</td><td>
</td><td>B3</td><td>B2 for two pairs correctly matched
B1 for one pair correctly matched</td></tr>
<tr><td colspan="3">Additional Guidance</td></tr>
<tr><td colspan="3">Two lines from one left hand box is choice</td></tr>
</table>

Q	Answer	Mark	Comments
1 (b)	No labels on the (horizontal) x axis Wrong units used (kg used instead of g) One of the bars is incorrect (brand C's ready salted) No title for the graph The scale labelled incorrectly as 9 instead of 0.009 etc. Has/should not have a broken axis or does not start at zero	E2	oe E1 for each valid error Condone improvements which imply errors e.g. add a title
	Additional Guidance		
	Ignore any incorrect additional suggestion		

Q	Answer	Mark	Comments
1 (c)	**Alternative method 1**		
	230 ÷ 10 or 2.3(0) ÷ 0.1(0)	M1	or indicates there are 23 lots of 10p Can be implied by 69 (not 69.1(2)) or their 69.1(2) ÷ 23 or their 69.1(2) ÷ (230 ÷ 10) or 3.(…)
	160 ÷ 25 × 10.8 or 69.1(2)	M1	Condone 9.6 instead of 10.8
	their 69.1(2) ÷ 23 or 3.(…) or 3 × 23 or 69 or their 69.1(2) ÷ 3	M1	
	3.(…) or 3.005(217…) or 3.01 **and** Yes or 69.1(2) **and** 69 **and** Yes or 23.04 **and** 23 **and** Yes	A1	Allow 3 with method
	Alternative method 2		
	230 ÷ 10 or 2.3(0) ÷ 0.1(0)	M1	or indicates there are 23 lots of 10p Can be implied by 6.95(…) or 6.96 or 7
	160 ÷ 23 or 6.95(…) or 6.96 or 7	M1	g per 10p 6.96 or 7 implies M2
	10.8 ÷ 25 × their 6.95(…) or 0.432 × their 6.95(…)	M1	Condone 9.6 instead of 10.8
	3.(…) or 3.005(217…) or 3.01 **and** Yes	A1	Allow 3 with method

Q	Answer	Mark	Comments
1 (c) Cont.	**Alternative method 3**		
	160 ÷ 25 × 10.8 or 6 × 10.8 + 2 × 2.16 or 16 × 4.32 or 69.1(2)	M1	Condone 9.6 instead of 10.8 Using 10.8g in 25g so 2.16 in 5g or 4.32 in 10g
	10 ÷ 3 or 3.3(3…)	M1	
	their 3.3(3…) × their 69.1(2) or 230 ÷ their 69.1(2) or 3.327(….) or 3.328 or 230 ÷ their 3.3(3…) or 69.(0…)	M1	Must convert £2.30 to 230 Must convert £2.30 to 230
	[228, 230.4] **and** 230 **and** Yes or 3.327(….) or 3.328 **and** 3.3(3…) **and** Yes or 69.1(2) **and** 69.(0…) **and** Yes	A1	Must convert £2.30 to 230
	Additional Guidance		
	Award full marks in all alternative methods for final correct answer with no or some working. Alt 1 gives final answer 3.(…) or 3.005(217…) or 3.01 **and** Yes or 69.1(2) **and** 69 **and** Yes or 23.04 **and** 23 **and** Yes Alt 2 gives final answer 3.(…) or 3.005(217…) or 3.01 **and** Yes Alt 3 gives final answer [228, 230.4] **and** 230 **and** Yes or 3.327(….) or 3.328 **and** 3.3(3…) **and** Yes or 69.1(2) **and** 69.(0…) **and** Yes		
	Using 9.6 instead of 10.8 can score M3A0. The corresponding values are as follows; 69.1(2) → 61.4(4) 3.(…) → 2.67(…) 23.04 → 20.48 [228, 230.4] → [202.7, 205] 3.327(….) → 3.74(…)		

Q	Answer	Mark	Comments
2 (a)	**Main article** Give information about what the scores represent Keep information nearer the graph it refers to Show all data in a table format for ease of comparison Show data/values for years between 2006 and 2012 State what OECD is Write down the scores from previous PISA rather than saying gone up/down from previous **Graphs** Add a vertical axis Add overall average PISA/OECD scores to graph(s) Add a broken axis Correct the title of each graph so it says ‘score’ not ‘ranking’ Label or add units to the *x*/*y*/both axes Line up the scores precisely with the horizontal lines State what NI is Start the vertical scales at the same point Show the UK line in each graph for ease of comparison Use common vertical scales (i.e. 460 to 520) or increase height of vertical axis Use scales/grid line so can easily read the values for each year	E3	E1 for each valid improvement Ignore any additional but incorrect suggestions SC1 two errors identified but no suggestions for improvement SC2 three errors identified but no suggestions for improvement e.g. data is not shown in table format no details for years before 2006

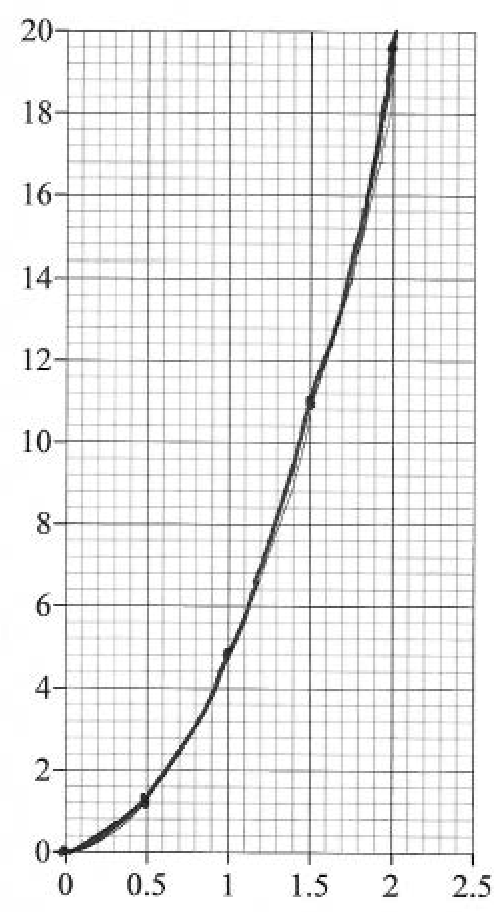
<table>
<tr><th>Q</th><th>Answer</th><th>Mark</th><th>Comments</th></tr>
<tr><td rowspan="3">2 (b)</td><td>makes one or more statements implying critical analysis
and
gives 3.24(…)% or 3.25% as final answer with all errors corrected or any correct method shown
or
makes two or more statements implying critical analysis
and
gives 3.24(…)% or 3.25% as final answer with no method shown

statements of critical analysis
1. makes reference to the denominator,
e.g. should be ÷ 493 (not 509) oe
2. recognises that the % sign is placed incorrectly, e.g.
should multiply 0.0314 by 100(%)
or
should not put % sign after 0.0314 oe
or
allow ×100 seen</td><td>B3</td><td>B2 makes two statements implying critical analysis
and
gives no or incorrect final answer
or
B2 gives 3.24(…)% or 3.25% as final answer with all errors corrected or any correct method shown
and
makes no statement implying critical analysis
or
B2 makes one statement implying critical analysis
and
gives 3.24(…)% or 3.25% as final answer with no method shown
or
B1 makes one statement implying critical analysis
and
gives no or incorrect final answer
or
B1 gives 3.24(…)% or 3.25% as final answer with no working and no statement implying critical analysis</td></tr>
<tr><td colspan="3">Additional Guidance</td></tr>
<tr><td colspan="3">No critical analysis can score maximum B2</td></tr>
</table>

Q	Answer	Mark	Comments
2 (c) (i)	**Alternative method 1** (Simon)		
	493 **and** 478 seen or 493 – 478 (=15)	M1	
	15 **and** Yes	A1	
	Alternative method 2 (Simon)		
	[492, 495] **and** [476, 479] seen or [492, 495] – [476, 479] (= [13, 19])	M1	Two chosen numbers must be within the given range
	[13, 19] **and** Yes	A1	
	Alternative method 3 (Simon)		
	Wales is below 480 **and** all the others/England are above 490 **and** Yes	B2	B1 Wales is below 480 and all the others/England are above 490
	Additional Guidance		
	Right answer from wrong method scores M0 A0 e.g. 509 – 492 = 17 and Yes. 509 is outside [492, 495] and 492 is outside [476, 479]		

Q	Answer	Mark	Comments
2 (c) (ii)	**Alternative method 1** (Rukshana)		
	493 ÷ 506 (×100) or [0.97, 0.9744] or [97, 97.44] or 13 ÷ 506 (×100) or [0.0256, 0.03] or [2.56, 2.57]	M1	oe
	their [0.97, 0.9744] × 493 or 493 – their [0.0256, 0.03] × 493	M1	oe
	[0.97, 0.9744] × 493 = [478, 481] **and** Yes or 493 – [0.0256, 0.03] × 493 = [478, 481] **and** Yes	A1	
	Alternative method 2 (Rukshana)		
	[492, 495] ÷ [505, 508] (×100) or [0.968, 0.98] or [96.8, 98] or [10, 16] ÷ [505, 508] (×100) or [0.0196, 0.0317] or [1.96, 3.17]	M1	oe
	their [0.968, 0.98] × [492, 495] or [492, 495] – their [0.0196, 0.0317] × [492, 495]	M1	oe
	[0.968, 0.98] × [492, 495] = [476, 485) **and** Yes or [492, 495] – [0.0196, 0.0317] × [492, 495] = [485, 485.2] **and** No	A1	
	Additional Guidance		
	[476, 485) → 476 ≤ value < 485		

Q	Answer	Mark	Comments
3(a)	0, 1.225 or 1.23, 4.9, 19.6	B2	B1 One correct non-zero value

<table>
<tr><th>Q</th><th>Answer</th><th>Mark</th><th>Comments</th></tr>
<tr><td rowspan="2">3(b)</td><td rowspan="2">
</td><td>M1</td><td>Their values plotted correctly to within one square.
Condone (0, 0) not plotted.</td></tr>
<tr><td>A1</td><td>Correct graph through the correct points to within one square vertically.</td></tr>
</table>

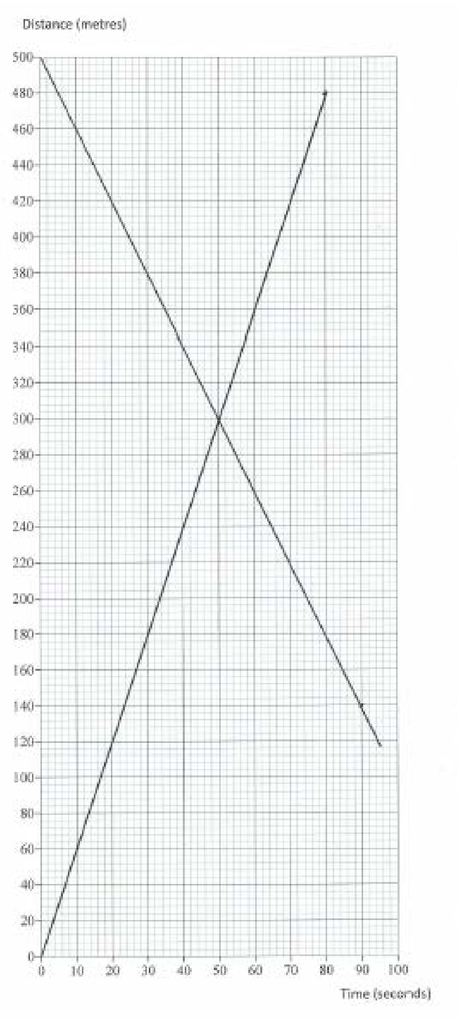
Q	Answer	Mark	Comments
3(c)	Draws a tangent at d = 15	M1	
	Finds the gradient of their line by dividing	M1	
	Obtains gradient in the range 15 to 19.5	A1	

Q	Answer	Mark	Comments
3(d)	Reads value from the graph or solves equation $15 = 4.9t^2$ or 1.75	M1	Reads value from the graph or solves equation
	15 ÷ their 1.75	M1	Uses their time in the range 1.6 to 1.9
	Obtains speed in the range 8 to 9.	A1	
Additional Guidance			
SC1 19.6 ÷ 2 = 9.8			
SC1 20 ÷ 2 = 10			

Q	Answer	Mark	Comments
4(a)	4	B1	

Q	Answer	Mark	Comments
4(b)	10	B1	

Q	Answer	Mark	Comments
4(c)	$10 = 4e^x$	M1	ft their 4
	$(x =)\ln 2.5$	M1	ft their 4
	$x = 0.916$	A1	Completely correct answer scores full marks
Additional Guidance			
SC1 $(4e)^x = 10$ giving $x = 0.965$			

Q	Answer	Mark	Comments
5(a)		M1	Straight line with a negative gradient
		M1	Passes through (0, 500)
		A1	Correct graph Ignore any incorrect extras.

Q	Answer	Mark	Comments
5(b)	Andrew travels 300 metres	B1	B1ft ft from their graph
	Emma travels 200 metres	B1	B1ft ft from their graph with negative gradient or 500 – Andrew's

Q	Answer	Mark	Comments
6(a)	Changes speed to metres/second $\left(\times \frac{1000}{60\times60}\right)$ (= $31.\dot{1}$)	M1	Seeing $\times \frac{1000}{60\times60}$ anywhere in their working
	Uses distance = their speed × time (= $31.\dot{1} \times 2$)	M1	Must have attempted to express speed in ms^{-1}
	62.2 or 62	A1	
Additional Guidance			
SC2 for answer of 56 but **only** if from the following method (oe): $2 \div 60 \div 60 = 0.000\dot{5}$ Then used $0.0005 \times 1000 \times 112 = 56$			

Q	Answer	Mark	Comments
6(b)(i)	The speed is zero or Traffic is not moving (at a standstill) or There is congestion	B1	

<table>
<tr><th>Q</th><th colspan="2">Answer</th><th>Mark</th><th colspan="2">Comments</th></tr>
<tr><td rowspan="10">6(b)(ii)</td><td colspan="5">Alternative method 1</td></tr>
<tr><td colspan="2">Uses (15, 112) and (175, 0) in $\frac{112-0}{15-175}$ to find A</td><td>M1</td><td colspan="2">Accept $\frac{0-112}{175-15}$</td></tr>
<tr><td colspan="2">Uses their A in eqn to find B
112 = (their –0.7 × 15) + B</td><td>M1</td><td colspan="2">or 0 = (their –0.7 × 175) + B</td></tr>
<tr><td colspan="2">A = –0.7 or $\frac{-7}{10}$
and
B = 122.5 or $\frac{245}{2}$</td><td>A1</td><td colspan="2">accept B = 123 (3sf)</td></tr>
<tr><td colspan="5">Alternative method 2</td></tr>
<tr><td colspan="2">Writes two eqns
112 = 15A + B
0 = 175A + B
and solves simultaneously to eliminate one unknown</td><td rowspan="2">M1</td><td colspan="2"></td></tr>
<tr><td>112 = –160A</td><td>19 600 = 160B</td><td colspan="2">allow any multiple</td></tr>
<tr><td>Uses their A in eqn to find B
112 = (their –0.7 × 15) + B</td><td>Uses their B in eqn to find A
112 = 15A + their 122.5</td><td>M1</td><td>or
0 = (their – 0.7 × 175) + B</td><td>or
0 = 175A + their 122.5</td></tr>
<tr><td colspan="2">A = –0.7 or $\frac{-7}{10}$
and
B = 122.5 or $\frac{245}{2}$</td><td>A1</td><td colspan="2">Accept B = 123 (3sf)

Using (15, 112)
Accept A = –0.7$\dot{3}$ or $\frac{-11}{15}$
(from 123)

Using (175, 0)
Accept A = –0.703 from
– 0.7028571429 or $\frac{-123}{175}$
(from 123)</td></tr>
<tr><td colspan="5"></td></tr>
<tr><td colspan="6">Additional Guidance</td></tr>
<tr><td colspan="6">A = -0.64 or B = 112 generally gains 0 marks</td></tr>
</table>

Q	Answer	Mark	Comments
6(b)(iii)	A is the change in speed (in km/h) when the density increases by 1 vehicle per km or For every extra 1 **vehicle per kilometre** The speed **decreases** by – (their – 0.7) km/h	B1	Condone "decrease in speed…." Allow 'drops by' instead of 'decreases'.

Q	Answer	Mark	Comments
6(b)(iv)	Uses their A (must be negative) and their B and writes or uses $\boldsymbol{q}$ = their – 0.7$\boldsymbol{k}^2$ + their 122.5$\boldsymbol{k}$	M1	
	Substitutes $\boldsymbol{k}$ = 87.5 into their **quadratic**	M1	Uses half of 175, acknowledging symmetry of parabola. **Do not accept** using the linear model here. Condone k = 87 or 88
	$\boldsymbol{q}$ = 5 360 (3 sf)	A1ft	from 5 359.375 **if B = 123 used** Accept 5 400 from 5 403.125 if A = $-0.7\dot{3}$ or $\frac{-11}{15}$ Accept 5 150 from 5 $14\dot{7}$.916 If A = –0.703 or $\frac{-123}{175}$ Accept 5 380 from 5 381.25 FT their values for *A* (must be negative) and *B*

Q	Answer	Mark	Comments
6(b)(v)	**Alternative Method 1**		
	Uses their $\boldsymbol{v} = \mathrm{A}\boldsymbol{k} + \mathrm{B}$	M1	ft their A and B from part (b)(ii)
	(their –0.7 × 87.5) + their 122.5 = 61.25	A1ft	Condone k = 87 or 88 but no other values. ft their A and B from part (b)(ii) Accept 61.3 (3 sf) Accept 61.75 or 61.8 from 123 Accept $58.8\dot{3}$ if $-0.7\dot{3}$ used Accept 61.5 if $\frac{-123}{175}$ or 61.5 (from 61.4875) if –0.703 used
	Alternative Method 2		
	Uses linear proportion from graph ½ of 175 = 87.5 so ½ of their B	M1	ft their A and B from part (b)(ii)
	= 61.25	A1ft	ft their A and B from part (b)(ii) Accept 61.3 (3 sf) or 61.5 if 123 used

Q	Answer	Mark	Comments
7(a)	Positive	E1	
	It is an increasing function or The gradient is increasing or The gradient is positive	B1	oe

Q	Answer	Mark	Comments
7(b)	Uses (12, 524) or (0,260) and (12, 520)	B1	
	$524 = 262\mathrm{e}^{12Q}$ Or $520 = 260\mathrm{e}^{12Q}$	M1	Condone use of 520 and 262
	$2 = \mathrm{e}^{12Q}$ or $\frac{524}{262} = \mathrm{e}^{12Q}$	M1	This gains the first three marks B1M1M1
	$\ln 2 = 12Q$	M1	
	$Q = \frac{1}{12}\ln 2 (= 0.05776\ldots) = 0.06$	A1	Must be from correct method