Mark Scheme (Results)

Summer 2019

Pearson Edexcel International A Level
in Statistics S2 (WST02/01)

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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.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

EDEXCEL IAL 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.

- 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
- $\underline{}$ 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.

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

Question Number	Scheme	Marks
1(a)	eg $4750\times\frac{80}{40000}$ o.e. $[=9.5]$*	B1*
		(1)
(b)	Two appropriate assumptions. e.g. **Hazelnuts** occur singly **or hazelnuts** occur randomly (independently) **or hazelnuts** are well mixed in **or mean** number of **hazelnuts** (per kg) is **constant or hazelnuts** occur at a constant **rate**	B1 B1
		(2)
(c)(i)	Let X = number of hazelnuts. $X \sim$ Po(9.5)	
	$P(X = 12) = \frac{e^{-9.5}\times(9.5)^{12}}{12!}$	M1
	$= 0.08444\ldots$ awrt 0.0844	A1
(ii)	$P(X \leqslant 7)$	M1
	$= 0.26866\ldots$ awrt 0.269	A1
		(4)
(d)	Let R = number of bars with fewer than 8 hazelnuts. $R \sim$ B(3, 0.2687)	B1
	$P(R = 1) = "0.2687"\times(1 - "0.2687")^2 \times 3$	M1
	$= 0.4312\ldots$ awrt 0.431	A1
		(3)
(e)	$Y \sim$ Po(23.75) oe	B1
	$\Rightarrow$ approximately $Y \sim$ N(23.75, 23.75)	M1
	$P(Y \geqslant 30) = P\left(Z > \frac{29.5 - 23.75}{\sqrt{23.75}}\right)$ $[= 1 - P(Z < 1.18)]$	M1dM1
	$(= 1 - 0.8810) = 0.1190$ awrt 0.119	A1
		(5)
		Total 15

		Notes
(a)	B1*	for equivalent working. Allow equation $\frac{x}{4750} = \frac{80}{40000}$ oe. **Answer is given**
(b)	B1 B1	for an assumption in a correct context. Allow equivalent wording with words in bold a second assumption need not be in context. Also ignore in correct context **NB** 2 correct assumptions not in context get **B0B1**
(c)(i)	M1	$\frac{e^{-\lambda}\times(\lambda)^{12}}{12!}$ or writing or using $P(X \leq 12) - P(X \leq 11)$
(ii)	M1	for $P(X \leqslant 7)$ seen or implied by correct answer. Do Not allow $P(X < 8)$ for M1 unless correct answer
(d)	B1 M1	writing B(3, "0.269") or B(3, 1 – "0.269") **or** seeing $("0.269")^n \times (1 - "0.269")^{3-n} \times {}^3C_n$ oe where $1 \leq n \leq 2$ (with their 0.269 or better) Implied by correct answer correct calculation of the form $3pq^2$ where $p + q = 1$. Working to be seen if (c)(ii)wrong
(e)	B1 M1 M1 M1d	for writing or using new mean of 23.75 oe Condone N(23.75, 23.75^2) if used correctly in standardisation for normal approx with changed mean = variance. May be seen in standardisation for $\pm\left(\frac{28.5 / 29 / 29.5 / 30 / 30.5 - \textit{their mean}}{\textit{their sd}}\right)$ If they do not have not given a mean and variance they must be correct in here. (allow 1 $\pm$ standardisation) Dep on previous M being awarded. For attempt at continuity correction (condone 30.5 or 28.5)

<table>
<tr><th>Question Number</th><th>Scheme</th><th>Marks</th></tr>
<tr><td>2(a)

(b)</td><td>$P(T=0) = P(0+0, \text{ or } -1+1)$
$= 0.4^2 + 2(0.2\times0.4) \quad = 0.32^*$

<table><tr><td>t</td><td>-2</td><td>-1</td><td>0</td><td>1</td><td>2</td></tr><tr><td>$P(T=t)$</td><td>$0.2^2 =$ 0.04</td><td>$2\times0.2\times0.4 =$ 0.16</td><td>(0.32)</td><td>$2\times0.4^2 =$ 0.32</td><td>$0.4^2 =$ 0.16</td></tr></table></td><td>M1
A1
(2)

B1
M1M1
A1
(4)</td></tr>
<tr><td></td><td></td><td>Total 6</td></tr>
<tr><td></td><td>Notes</td><td></td></tr>
<tr><td>(a)</td><td>M 1

A1</td><td>for identifying (0,0) and (–1,1) as the two cases that result in $T = 0$
May be implied by seeing 0.4^2 and 0.2×0.4 with no other calculations added.
Or identifying (–1, –1) and (1,1) and (–1,0) and (0,1) and subtracting from 1
May be implied by $1-0.2^2-3\times0.4^2-2\times0.2\times0.4$ with no other calculations subtracted
Do not allow 2×0.4^2
for complete calculation shown. Need to see $0.4^2 + 2(0.2\times0.4)$ or $0.16 + 2(0.08)$ leading to 0.32 oe</td></tr>
<tr><td>(b)</td><td>B1

1st M1

2nd M1

A1</td><td>for identifying the correct set of T values – extras must have a probability of 0
May be split eg -1 may appear twice

<table><tr><td>pairs</td><td>$-1,-1$</td><td>$-1,0$ or $0,-1$</td><td>$0,1$ or $1,0$</td><td>$1,1$</td></tr><tr><td>$P(T=t)$</td><td>$0.2^2 =$ 0.04</td><td>$2\times0.2\times0.4 =$ 0.16</td><td>$2\times0.4^2 =$ 0.32</td><td>$0.4^2 =$ 0.16</td></tr></table>
for at least two correct calculations or probs attached to the correct value of t (from the four listed) or at least two correct calculations or probs attached to the correct pair. See table. Must have <u>added</u> the calculations/probs for {(-1,0) and (0,-1)} and {(0,1) and (1,0)} if calculated separately

for all four calculations or probs attached to the correct value of t (from the four listed) or all four correct calculations or probs attached to the correct pair. See table

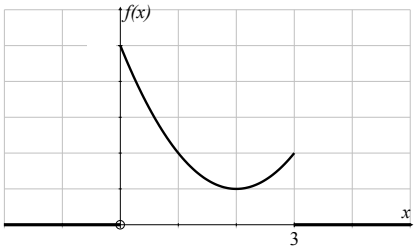
for full set of probabilities associated with respective T values. Allow equivalent fractions. Allow in any order. Condone missing labels</td></tr>
</table>

Question Number	Scheme	Marks
3(a)	$\frac{a+b}{2}=6$ $\quad \frac{1}{12}(b-a)^2=3$	B1
	$a+b=12$ and $b-a=\pm 6$ **or** $a^2-12a+27=0$ **or** $b^2-12b+27=0$	dM1
	$a=3,\ b=9$	A1
		(3)
(b)	$[\mathrm{P}(Y>6+\sqrt{3})=]\ \frac{"9"-\left(6+\sqrt{3}\right)}{"9"-"3"}$	M1
	$=\frac{3-\sqrt{3}}{6}$ or $0.211(32\ldots)$ awrt 0.211	A1
		(2)
(c)	$\left[\mathrm{F}(y)=\right]\begin{cases}0 & y<3\\ \frac{y-3}{6} & 3\leqslant y\leqslant 9\\ 1 & y>9\end{cases}$	B1 B1
		(2)
		Total 7

		Notes
(a)	B1	for correct equations for both mean and variance. Implied by the dM1
	dM1	dependent on B1. A correct pair of linear equations or a correct quadratic in 1var.
	A1	must state $a = 3$ and $b = 9$ or write [3, 9] not just write 3 and 9 . If two answers gained the incorrect one must be eliminated NB correct answer with no working gains 3/3
(b)	M1	$\frac{"their\ b"-\left(6+\sqrt{3}\right)}{"their\ b"-"their\ a"}$ or $1-\frac{\left(6+\sqrt{3}\right)-"their\ a"}{"their\ b"-"their\ a"}$ Allow use of awrt7.73 for $6+\sqrt{3}$ Only allow 7.7 if $6+\sqrt{3}$ is seen. If a and b are incorrect working must be shown to award this mark.
	A1	$\frac{3-\sqrt{3}}{6}$ oe or awrt 0.211
(c)		$\left[\mathrm{F}(y)=\right]\begin{cases}0 & y<"a"\\ \frac{y-"\text{their } a"}{"\text{their } b-a"} & "\text{their } a"\leqslant y\leqslant "\text{their } b"\\ 1 & y>"b"\end{cases}$ Award B1B1 if all 3 lines correct using the same letter (ft " their a and b")
		Award B1 B0 if all correct but a mixture of letters (ft " their a and b")
		Award B1B0 if just the 2nd line is correct all same letter used in the function and range **or** just the 1st and 3rd line correct with the same letter used for both ranges. Allow otherwise once NB Allow < signs for $\leqslant$ and vice versa and > for $\geqslant$ and Ignore F(y)

Question Number	Scheme	Marks
4(a)	Let X = number of traffic accidents (in 12 months) H_0: $\lambda = 2.5$ (or $\lambda = 10$) H_1: $\lambda \neq 2.5$ (or $\lambda \neq 10$)	B1
	Under H_0: $X \sim$ Po(2.5)	
	Either: $P(X \geqslant 6) = 1 - P(X \leqslant 5)$ $= 1 - 0.9580$ $= 0.0420$	Or: $[P(X \leqslant 0) = 0.0821]$ $P(X \geqslant 7) = 1 - 0.9585 = 0.0142$ C.R. is $[X < 0$ and$]$ $X \geqslant 7$	M1 A1
	$4.2\% > 2.5\%$	$6 < 7$
	so not significant, do not reject H_0	dM1
	There is no evidence of a change in the rate of **accidents**, OR supermarket **manager's** claim is not rejected.	A1
		(5)
(b)	Test is now one-tailed, or now have H_1: $\lambda > 2.5$ (or $\lambda > 10$)	B1
	$4.2\% < 5\%$ or $[P(X \geqslant 6) = 0.0420$ so$]$ C.R is $X \geqslant 6$.	
	so result is significant, reject H_0	M1ft
	There is evidence of an increase in the rate of **accidents**, OR **resident**'s claim is supported.	A1
		(3)
		Total 8

		Notes
(a)	B1	for both hypotheses correct. Must be in terms of λ (or μ) and connected to H_0 and H_1 correctly
	M1	for writing or using Poisson 2.5 and $1 - P(X \leqslant 5)$ (can be implied) or a correct probability statement **leading to a critical region**. NB $P(X \geqslant 7) = 0.0142$ with no CR gets M0
	A1	for correct probability or right hand critical region. Allow awrt 0.0420 Condone 0.042. **NB** Allow M1 A1 for statement $P(X \leqslant 5) = 0.9580$ on its own
	dM1	dependent on 1st M1 for correct decision based on their probability/region and 2.5% (two tail test) or 5% (one tail test). If using $P(X \leqslant 5) = 0.9580$ we must see $0.9580 < 0.975$(1-tail) or $0.9580 > 0.95$ (2-tail)
	A1	for correct conclusion in context. Words in bold needed. Must be change oe (not increase) Do Not award if one tail test or there are no hypotheses
(b)	B1	If no hypotheses or a 2-tail in (a) this is for recognising that the test is now one-tailed eg hypotheses (condone incorrect letters) New CR or using 5% to compare(must be seen) If 1- tail test in (a) then stating no change or only conclusion changes (must be stated. It is not implied by them repeating the test in (a)
	M1	for correct decision based on their probability/region compared to 5%. Allow ft from their 0.0420 / CR or allow correct value. Do not allow if there are any incorrect non contextual statements
	A1	for correct conclusion in context. Allow number instead of rate but must have increase oe not change, Words in bold needed. **NB** In (a) A correct contextual conclusion on its own gains M1A1 providing previous M1 awarded In (b) A correct contextual conclusion on its own gains M1A1

Question Number	Scheme	Marks
5(a)	f(0) = $5k$	
	$k\left\{(a-2)^2+1\right\} < 5k$ condone $k\left\{(a-2)^2+1\right\} = 5k$	M1
	$(a-2)^2 < 4 \Rightarrow \quad 0 < a < 4$	A1
		(2)
(b)(i)(ii)		
	Shape for $0 < x < 3$	B1
	$(2, k)$ or labels 2 and k	B1
		(2)
(c)	$\int_0^3 f(x)\,dx = 1$	
	$k\left[\frac{x^3}{3} - 2x^2 + 5x\right]_0^3 = 1$ or $k\left[\frac{(x-2)^3}{3} + x\right]_0^3 = 1$	M1A1
	$k\left(\frac{27}{3} - 2\times 9 + 15\right) - 0k = 1$ or $k\left(\frac{1}{3} + 3\right) - \frac{-8}{3}k = 1$	dM1
	$6k = 1 \quad \Rightarrow \quad k = \frac{1}{6}$ *	A1*
		(4)
(d)	$E(X) = \int_0^3 x \times \frac{1}{6}(x^2 - 4x + 5)\,dx$	M1
	$= \int_0^3 \frac{1}{6}(x^3 - 4x^2 + 5x)\,dx = \frac{1}{6}\left[\frac{x^4}{4} - \frac{4x^3}{3} + \frac{5x^2}{2}\right]_0^3$	dM1A1
	$= \frac{1}{6}\left(\frac{81}{4} - \frac{108}{3} + \frac{45}{2} - 0\right)$ or $\frac{9}{8}$	dM1
	Var (X) $= 2.1 - \left(\frac{9}{8}\right)^2 = \frac{267}{320}$	dM1
	$= \frac{267}{320}$ awrt 0.834	dA1
		(6)
(e)	$\frac{1}{6}\left[\frac{x^3}{3} - 2x^2 + 5x\right]_2^3$ oe or $1 - \frac{1}{6}\left[\frac{x^3}{3} - 2x^2 + 5x\right]_0^2$ oe	M1
	$\frac{1}{6}\left[9 - 18 + 15 - \left(\frac{8}{3} - 8 + 10\right)\right] = \frac{2}{9}$ * or $1 - \frac{1}{6}\left[\left(\frac{8}{3} - 8 + 10\right)\right] = \frac{2}{9}$ *	A1* cso
		(2)
(f)	P $1 < X < 2 = \frac{2}{9}$ or use of symmetry | P$(X<1) = \left[\frac{1}{6}\left(\frac{x^3}{3} - 2x^2 + 5x\right)\right]_0^1$	M1
	P $X > 1 = \frac{4}{9}$ | P $X < 1 = \frac{5}{9}$	A1
	Therefore median < 1	A1cso
		(3)
		Total 19

		Notes
(a)	M1	for forming appropriate (in)equality using f(0), or for using symmetry of pdf graph. Condone missing k
	A1	c.a.o. (must be strict inequalities) **NB** A correct answer seen is M1 A1
(b)(i)	B1	a curve in a U shape only between 0 and 3 with curve lower at 3 than at 0. Must be above x-axis and it must not go beyond 0 or 3 For <0 or >3 may have patios or nothing
(ii)	B1	Allow 1/6 instead of k
(c)	M1	Attempting to integrate f(x), at least 1 term correct.
	A1	fully correct integration (Ignore limits here)
	dM1	dep on previous M being given. For putting = 1 and for use of correct limits leading to an equation for k. Need to see some substitution before $6k$ Condone missing $0k$
	A1*	c.s.o.
(d)	M1	for realising need for $\mathrm{E}(X) = \int x \times \mathrm{f}(x)$ oe Ignore limits.
	dM1	Dependent on 1st M1 Attempting to integrate, at least 1 term correct. Condone missing k
	A1	fully correct Integration with k **or** $\frac{1}{6}$ (Ignore limits here)
	dM1	Dependent on 2nd M1 For correct use of limits, implied by a correct mean. Condone missing 0
	dM1	Dependent on 3rd M1. For 2.1 – (their mean)^2 implied by correct answer.
	A1	dependent on all previous marks being awarded. Accept awrt 0.834 **NB** A correct answer does not imply the method marks we need see integration
(e)	M1	One of the 4 statements in the main MS **or** correct cdf line of $\frac{1}{6}\left(\frac{x^3}{3} - 2x^2 + 5x\right)$ with 1 – F(2) or F(3) – F(2) seen. Allow with k or $\frac{1}{6}$ Allow equivalent probability statement using < or $\leqslant$ for F(2) and F(3). These are not implied by $1-\frac{7}{9}$
	A1	cso both 3 and 2 substituted separately and correctly eg minimum of $\frac{1}{6}\left[\frac{4}{3}\right]$ or $1-\frac{1}{6}\left(\frac{14}{3}\right)$ leading to $=\frac{2}{9}$*
(f)	M1	Allow $\frac{1}{6}\left(\frac{x^3}{3} - 2x^2 + 5x\right) = 0.5$ oe Implied by a correct probability statement or the correct median being given. Allow statements in terms of k. Reference to skew is M0
	A1	P $X > 1 = \frac{4}{9}$ (0.44 or better) or (0.55 or 0.56 or better) or median = 0.8458… (allow awrt 0.85) **NB** allow $\frac{1}{3}\int_0^1 x^2 - 4x + 5[\mathrm{d}x]$ or F(1) for P($X < 1$)
	A1cso	stating median < 1 **NB** $\int_0^1 x^2 - 4x + 5[\mathrm{d}x]$ or P $X \leq 1$ for P $X < 1$

Question Number	Scheme	Marks
6(a)	Any two from: • **Probability** that a **pot** will **crack** is constant (0.3) • **Pots crack** independently/randomly • **Batch size** / number of **pots fired** (n) is constant	B1B1 (2)
(b)	$[8 \times 0.3 =]$ 2.4	B1 (1)
(c)	Let X = number of pots which crack $X \sim$ B(8, 0.3) $P(X = 2) = {}^8C_2 \times 0.3^2 \times 0.7^6$ $= 0.29647\ldots$ awrt 0.296/0.297	 M1 A1 (2)
(d)	$P(X \leqslant 5) = 0.9887$ $[k =]$ 6	M1 A1 (2)
(e)	H_0: $p = 0.3$ H_1: $p < 0.3$ Under H_0, $Y \sim$ B(20, 0.3) $P(Y \leqslant 2) = 0.0355$ $P(Y \leqslant 3) = 0.1071$ C.R. is $Y \leqslant 2$	B1 M1 A1cao (3)
(f)	3.55% or 0.0355	B1 (1)
		Total 11

		Notes
(a)	B1	for an assumption in a correct context. Must have words in bold
	B1	for a second assumption need not be in context. Also ignore incorrect context **NB** 2 correct assumptions not in context gets **B0B1**
(c)	M1	for a correct expression ${}^8C_2 \times p^2 \times (1-p)^6$ oe where $0 < p < 1$ or $P(X \leqslant 2) - P(X \leqslant 1)$ oe
	A1	for awrt 0.296/0.297
(d)	M1	For $P(X \leqslant 5) = 0.9887$ or $P(X \geqslant 6) = 0.0113$ or $P(X \leqslant k-1) = 0.9887$ (Implied by $[k =]$ 6). Do not allow $P(X \geq k) = 0.0113$
	A1	Need to state 6 and not have it as part of a probability statement.
(e)	B1	for both hypotheses correct (must be in terms of p or π) and attached to H_0 and H_1 correctly
	M1	for writing the correct binomial or evidence of correct use of binomial e.g. 0.0355 or 0.1071 seen. Implied by a correct lower CR
	A1	Allow any letter, condone missing letter. Allow $Y < 3$ (A probability statement ie $P(X \leqslant 2)$ for final answer scores A0). Do not allow if there is an upper critical region given as well.

Question Number	Scheme	Marks
7(a)	$1 \leqslant x < 2$:	
	$\int \frac{3}{4}(x-1)\,dx = \frac{3x^2}{8} - \frac{3x}{4}\ [+c]$ $\left[\text{OR } \ldots = \frac{3}{8}(x-1)^2\ [+c]\right]$	M1
	$F(1) = 0 \quad \Rightarrow \quad c = \frac{3}{8}$ [OR …. $[c = 0]$	dM1
	$2 \leqslant x \leqslant 4$:	
	$\int \frac{3}{32}x(x-4)^2\,dx = \frac{3x^4}{128} - \frac{x^3}{4} + \frac{3x^2}{4}\ [+k]$	M1
	$F(4) = 1$ or $F(2) = \frac{3}{8} \quad \Rightarrow \quad k = -1$	dM1
	$F(x) = \begin{cases} 0 & x < 1 \\ \frac{3x^2}{8} - \frac{3x}{4} + \frac{3}{8} \text{ o.e. e.g. } \frac{3}{8}(x-1)^2 & 1 \leqslant x < 2 \\ \frac{3x^4}{128} - \frac{x^3}{4} + \frac{3x^2}{4} - 1 \text{ o.e. e.g. } \frac{(x-4)^3(3x+4)}{128} + 1 & 2 \leqslant x \leqslant 4 \\ 1 & x > 4 \end{cases}$	A1 A1 A1
		(7)
(b)	$F(m) = 0.5$ $F(2.165) = 0.493\ldots$ $F(2.175) = 0.5001\ldots$	M1
	$\Rightarrow$ $F(2.165) < 0.5 < F(2.175)$ $\quad \therefore m = 2.17$ (2 dp)	A1
		(2)

	Notes	**Total 9**
(a)		
M1	for attempted integration of 1st part (at least one $x^n \to x^{n+1}$)	
dM1	(dependent on 1st M1) for $\int \frac{3}{4}(x-1)\,dx$ and use of F(1) = 0	
	or for $\int_1^m \frac{3}{4}(x-1)\,dx$ with both limits substituted. Implied by correct function	
M1	simplifying 2nd part $\left[\frac{3}{32}\left(x^3 - 8x^2 + 16x\right)\right]$ (3 terms at least 2 correct) oe condone missing 3/32 and integrating (at least one correct) or 1st stage of integration by parts correct	
dM1	(dependent on 3rd M1) $\int \frac{3}{32}x(x-4)^2\,dx$ and using F(4) =1 or $F(2) = \frac{3}{8}$ (need to see subst of 4 or 2) or $\int_2^m \frac{3}{32}x(x-4)^2\,dx$ + their F(2). Do not allow it written as F(2) rather than a value. For both these F(2) may be incorrect but the substitution of 2 into cdf part 1 must be seen. Implied by correct function.	
A1	fully correct 1st part of F(x).	
A1	fully correct 2nd part of F(x)	
A1	(dependent on at least one M1) for F(x) defined for $x < 1$ and $x > 4$ allow "otherwise" for one NB Allow $\leqslant$ for < signs and vice versa and $\geqslant$ for >	
(b)		
M1	For use of F(m) = 0.5 and using 2 appropriate bounds from $(2.165 \leqslant m \leqslant 2.175 : m \neq 2.17)$ into their 2nd part of F(x) for $2 \leqslant x \leqslant 4$ or "their line for $2 \leqslant x \leqslant 4$" – 0.5 Or median = 2.17471… 4 dp or better	
A1	Appropriate reason for their method. eg F(2.165) < 0.5 < F(2.175) or change in sign leading to conclusion that $m = 2.17$ or if value of median found "therefore median = 2.17 to 2 dp"	

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