



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

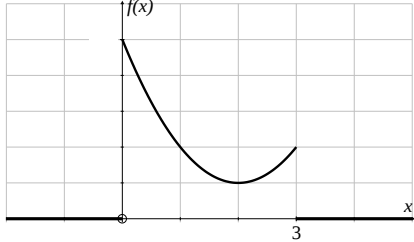
These are some of the traditional marking abbreviations that will appear in the mark schemes.

- bod – benefit of doubt
 - ft – follow through
 - the symbol $\checkmark$ 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
 - $\square$ 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. $X \sim \text{Po}(9.5)$ $P(X = 12) = \frac{e^{-9.5} \times (9.5)^{12}}{12!}$ $= 0.08444\dots$ awrt 0.0844	M1 A1
	(ii)	$P(X \leq 7)$ $= 0.26866\dots$ awrt 0.269	M1 A1 (4)
	(d)	Let R = number of bars with fewer than 8 hazelnuts. $R \sim B(3, 0.2687)$ $P(R = 1) = "0.2687" \times (1 - "0.2687")^2 \times 3$ $= 0.4312\dots$ awrt 0.431	B1 M1 A1 (3)
	(e)	$Y \sim \text{Po}(23.75)$ oe $\Rightarrow$ approximately $Y \sim N(23.75, 23.75)$ $P(Y \geq 30) = P\left(Z > \frac{29.5 - 23.75}{\sqrt{23.75}}\right) [= 1 - P(Z < 1.18)]$ $(= 1 - 0.8810) = 0.1190$ awrt 0.119	B1 M1 M1dM1 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 $P(X \leq 7)$ seen or implied by correct answer. Do Not allow $P(X < 8)$ for M1 unless correct answer	
	(d)	B1 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 M1 correct calculation of the form $3pq^2$ where $p + q = 1$. Working to be seen if (c)(ii) wrong	
	(e)	B1 for writing or using new mean of 23.75 oe Condone $N(23.75, 23.75^2)$ if used correctly in standardisation M1 for normal approx with changed mean = variance. May be seen in standardisation M1 for $\pm \left(\frac{28.5 / 29 / 29.5 / 30 / 30.5 - \text{their mean}}{\text{their sd}} \right)$ If they do not have not given a mean and variance they must be correct in here. (allow $1 \pm$ standardisation) M1d Dep on previous M being awarded. For attempt at continuity correction (condone 30.5 or 28.5)	

Question Number		Scheme	Marks
3(a)		$\frac{a+b}{2} = 6 \quad \frac{1}{12}(b-a)^2 = 3$ $a+b=12 \text{ and } b-a = \pm 6 \text{ or } a^2 - 12a + 27 = 0 \text{ or } b^2 - 12b + 27 = 0$ $a = 3, b = 9$	B1 dM1 A1 (3)
(b)		$[P(Y > 6 + \sqrt{3}) =] \frac{"9" - (6 + \sqrt{3})}{"9" - "3"}$ $= \frac{3 - \sqrt{3}}{6} \text{ or } 0.211(32\dots)$	M1 A1 awrt 0.211 (2)
(c)		$[F(y) =] \begin{cases} 0 & y < 3 \\ \frac{y-3}{6} & 3 \leq y \leq 9 \\ 1 & y > 9 \end{cases}$	B1 B1 (2)
			Total 7
Notes			
(a)	B1 dM1 A1	for correct equations for both mean and variance. Implied by the dM1 dependent on B1. A correct pair of linear equations or a correct quadratic in 1var. 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 A1	$\frac{"their b" - (6 + \sqrt{3})}{"their b" - "their a"} \text{ or } 1 - \frac{(6 + \sqrt{3}) - "their a"}{"their b" - "their a"}$ Allow use of awrt 7.73 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. $\frac{3 - \sqrt{3}}{6} \text{ oe or awrt } 0.211$	
(c)		$[F(y) =] \begin{cases} 0 & y < "a" \\ \frac{y - "their a"}{"their b - a"} & "their a" \leq y \leq "their b" \\ 1 & y > "b" \end{cases}$ 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 2 nd line is correct all same letter used in the function and range or just the 1 st and 3 rd line correct with the same letter used for both ranges. Allow otherwise once NB Allow $<$ signs for $\leq$ and vice versa and $>$ for $\geq$ 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 $\lambda \neq 10$) Under $H_0: X \sim \text{Po}(2.5)$ Either: $P(X \geq 6) = 1 - P(X \leq 5)$ $= 1 - 0.9580$ $= 0.0420$ 4.2% > 2.5% so not significant, do not reject H_0 There is no evidence of a change in the rate of accidents, OR supermarket manager's claim is not rejected.	B1 M1 A1 dM1 A1 (5)
		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 $1 - P(X \leq 5)$ (can be implied) or a correct probability statement leading to a critical region . NB $P(X \geq 7) = 0.0142$ 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 $P(X \leq 5) = 0.9580$ on its own
	dM1	dependent on 1 st M1 for correct decision based on their probability/region and 2.5% (two tail test) or 5% (one tail test). If using $P(X \leq 5) = 0.9580$ 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)	$f(0) = 5k$ $k\{(a-2)^2 + 1\} < 5k$ condone $k\{(a-2)^2 + 1\} = 5k$ $(a-2)^2 < 4 \Rightarrow 0 < a < 4$	M1 A1 (2)
(b)(i)(ii)	 Shape for $0 < x < 3$ $(2, k)$ or labels 2 and k	B1 B1 (2)
(c)	$\int_0^3 f(x) dx = 1$ $k \left[\frac{x^3}{3} - 2x^2 + 5x \right]_0^3 = 1$ or $k \left[\frac{(x-2)^3}{3} + x \right]_0^3 = 1$ $k \left(\frac{27}{3} - 2 \times 9 + 15 \right) - 0k = 1$ or $k \left(\frac{1}{3} + 3 \right) - \frac{-8}{3}k = 1$ $6k = 1 \Rightarrow k = \frac{1}{6}^*$	M1A1 dM1 A1* (4)
(d)	$E(X) = \int_0^3 x \times \frac{1}{6} (x^2 - 4x + 5) dx$ $= \int_0^3 \frac{1}{6} (x^3 - 4x^2 + 5x) dx = \frac{1}{6} \left[\frac{x^4}{4} - \frac{4x^3}{3} + \frac{5x^2}{2} \right]_0^3$ $= \frac{1}{6} \left(\frac{81}{4} - \frac{108}{3} + \frac{45}{2} - 0 \right)$ or $\frac{9}{8}$ $\text{Var}(X) = 2.1 - \left(\frac{9}{8} \right)^2 = \frac{267}{320}$ $= \frac{267}{320}$ awrt 0.834	M1 dM1A1 dM1 dM1 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 $\frac{1}{6} \left[9 - 18 + 15 - \left(\frac{8}{3} - 8 + 10 \right) \right] = \frac{2}{9}^*$ or $1 - \frac{1}{6} \left[\left(\frac{8}{3} - 8 + 10 \right) \right] = \frac{2}{9}^*$	M1 A1* cso (2)
(f)	$P(1 < X < 2) = \frac{2}{9}$ or use of symmetry $P(X > 1) = \frac{4}{9}$ Therefore median < 1	$P(X < 1) = \left[\frac{1}{6} \left(\frac{x^3}{3} - 2x^2 + 5x \right) \right]_0^1$ $P(X < 1) = \frac{5}{9}$ M1 A1 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 $E(X) = \int x \times f(x)$ oe Ignore limits.
	dM1	Dependent on 1 st 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 2 nd M1 For correct use of limits, implied by a correct mean. Condone missing 0
	dM1	Dependent on 3 rd M1. For $2.1 - (\text{their mean})^2$ 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 $\leq$ 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 $\frac{1}{3}\int_0^1 x^2 - 4x + 5[dx]$ or $F(1)$ for $P(X < 1)$
	A1cso	stating median < 1 NB $\int_0^1 x^2 - 4x + 5[dx]$ 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)		$[8 \times 0.3 =] \quad 2.4$	B1 (1)
(c)		Let X = number of pots which crack $X \sim B(8, 0.3)$ $P(X = 2) = {}^8C_2 \times 0.3^2 \times 0.7^6$ $= 0.29647\dots$ awrt 0.296/0.297	M1 A1 (2)
(d)		$P(X \leq 5) = 0.9887$ $[k =] 6$	M1 A1 (2)
(e)		$H_0: p = 0.3 \quad H_1: p < 0.3$ Under H_0 , $Y \sim B(20, 0.3)$ $P(Y \leq 2) = 0.0355 \quad P(Y \leq 3) = 0.1071$ C.R. is $Y \leq 2$	B1 M1 A1cao (3)
(f)		3.55% or 0.0355	B1 (1)
			Total 11
		Notes	
(a)	B1 B1	for an assumption in a correct context. Must have words in bold for a second assumption need not be in context. Also ignore incorrect context NB 2 correct assumptions not in context gets B0B1	
(c)	M1 A1	for a correct expression ${}^8C_2 \times p^2 \times (1-p)^6$ oe where $0 < p < 1$ or $P(X \leq 2) - P(X \leq 1)$ oe for awrt 0.296/0.297	
(d)	M1 A1	For $P(X \leq 5) = 0.9887$ or $P(X \geq 6) = 0.0113$ or $P(X \leq k-1) = 0.9887$ (Implied by $[k =] 6$). Do not allow $P(X \geq k) = 0.0113$ Need to state 6 and not have it as part of a probability statement.	
(e)	B1 M1 A1	for both hypotheses correct (must be in terms of p or π) and attached to H_0 and H_1 correctly 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 Allow any letter, condone missing letter. Allow $Y < 3$ (A probability statement ie $P(X \leq 2)$ for final answer scores A0). Do not allow if there is an upper critical region given as well.	

Question Number		Scheme	Marks
7(a)		$1 \leq x < 2:$ $\int \frac{3}{4}(x-1)dx = \frac{3x^2}{8} - \frac{3x}{4} [+c] \quad \left[\text{OR } \dots = \frac{3}{8}(x-1)^2 [+c] \right]$ $F(1) = 0 \quad \Rightarrow \quad c = \frac{3}{8} \quad [\text{OR } \dots [c = 0]]$ $2 \leq x \leq 4:$ $\int \frac{3}{32}x(x-4)^2 dx = \frac{3x^4}{128} - \frac{x^3}{4} + \frac{3x^2}{4} [+k]$ $F(4) = 1 \text{ or } F(2) = \frac{3}{8} \quad \Rightarrow \quad k = -1$ $F(x) = \begin{cases} 0 & x < 1 \\ \frac{3x^2}{8} - \frac{3x}{4} + \frac{3}{8} \text{ o.e. e.g. } \frac{3}{8}(x-1)^2 & 1 \leq x < 2 \\ \frac{3x^4}{128} - \frac{x^3}{4} + \frac{3x^2}{4} - 1 \text{ o.e. e.g. } \frac{(x-4)^3(3x+4)}{128} + 1 & 2 \leq x \leq 4 \\ 1 & x > 4 \end{cases}$	M1 dM1 M1 dM1 A1 A1 A1 (7)
(b)		$F(m) = 0.5$ $F(2.165) = 0.493\dots$ $F(2.175) = 0.5001\dots$ $\Rightarrow F(2.165) < 0.5 < F(2.175) \quad \therefore m = 2.17 \text{ (2 dp)}$	M1 A1 (2)
Notes			Total 9
(a)	M1	for attempted integration of 1 st part (at least one $x^n \rightarrow x^{n+1}$)	
	dM1	(dependent on 1 st 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 $\left[\frac{3}{32}(x^3 - 8x^2 + 16x) \right]$ (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 3 rd 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 $\int_2^m \frac{3}{32}x(x-4)^2 dx + \text{their } F(2)$. 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.	
(b)	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 $\leq$ for $<$ signs and vice versa and $\geq$ for $>$	
(b)	M1	For use of $F(m) = 0.5$ and using 2 appropriate bounds from $(2.165 \leq m \leq 2.175 : m \neq 2.17)$ into their 2 nd part of $F(x)$ for $2 \leq x \leq 4$ or “their line for $2 \leq x \leq 4$ ” – 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”	

