Mark Scheme (Results)

January 2020

Pearson Edexcel International A Level
in Statistics S2 (WST02) Paper 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 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)	$\mathrm{P}(H=6)=\dfrac{\mathrm{e}^{-4}4^6}{6!}$ or $\mathrm{P}(H\le 6)-\mathrm{P}(H\le 5)=0.8893-0.7851$		M1
	$=0.10419\ldots$ $=0.1042$	awrt **0.104**	A1
			(2)
(b)	$J\sim \mathrm{Po}(8)$		B1
	$\mathrm{P}(J\le 7)-\mathrm{P}(J\le 2)=0.4530-0.0138$		M1
	$=0.4392$	awrt **0.439**	A1
			(3)
(c)	$K\sim \mathrm{N}(28,28)$		M1
	$\mathrm{P}(K>30)\approx \mathrm{P}\left(Z>\dfrac{30.5-28}{\sqrt{28}}\right)$		M1M1A1
	$=\mathrm{P}(Z>0.4724...)$		
	$=1-0.6808$		
	$=0.3192$ (calc 0.3183)	awrt **0.319/0.318**	A1
			(5)
(d)(i)	The p(robability)/0.97 is not small oe		B1
			(1)
(ii)	$L\sim \mathrm{Po}(3)$		B1
	$\mathrm{P}(L\le 4)=0.8153$	awrt **0.815**	M1A1
			(3)
	Notes		**Total 14**
	Correct answers imply all marks in each part of this question.		

1(a)	**M1**	Allow any value for lambda $\dfrac{\mathrm{e}^{-\lambda}\lambda^6}{6!}$ or $\mathrm{P}(H\le 6)-\mathrm{P}(H\le 5)$
	A1	awrt 0.104
(b)	**B1**	Writing Po(8). This may be implied by a correct answer or sight of awrt 0.453 or awrt 0.0138 or awrt 0.0424 or awrt 0.313
	M1	$\mathrm{P}(J\le 7)-\mathrm{P}(J\le 2)$ oe or (awrt 0.453 – awrt 0.0138)
	A1	awrt 0.439
(c)	**M1**	Using normal approximation with mean = variance = 28 (May be seen in standardisation which takes priority) or writing N(28,28)
	M1	$\pm\left(\dfrac{30.5 \text{ or } 30 \text{ or } 29.5 \ - \ \text{their mean}}{\text{their sd}}\right)$ If they have not given a mean and a variance, they must be correct here.
	M1	Writing or using a continuity correction 30 ± 0.5
	A1	Correct standardisation with 30.5 or awrt 0.47
	A1	awrt 0.319/0.318
(d)(i)	**B1**	Probability is not small (too large). Allow mean ≠ variance. Do not allow e.g. '*np* too large/*np* > 10' on its own. Ignore extraneous non-contradictory comments.
(ii)	**B1**	Writing or using Po(3)
	M1	Writing or using $\mathrm{P}(L\le 4)$ oe
	A1	awrt 0.815

Question	Scheme	Marks
2(a)	$E \sim B(6, 0.35)$	B1
(i)	$P(E = 2) = P(E \le 2) - P(E \le 1)$ or $\left({}^6C_2\right)0.35^2(1-0.35)^4$	M1
	$= 0.6471 - 0.3191$	
	$= 0.328$ awrt **0.328**	A1
(ii)	$P(E \ge 4) = 1 - P(E \le 3)$ or $1 - 0.8826$	M1
	$= 0.1174$ awrt **0.117**	A1
		(5)
(b)	$H_0 : p = 0.35$ $H_1 : p > 0.35$	B1
	$L \sim B(50, 0.35)$ $P(L \ge 25) = 1 - P(L \le 24)$ $P(L \ge 24) = 0.0396$	M1
	$= 1 - 0.9793$ $P(L \ge 23) = 0.071$	
	$= 0.0207$ CR $L \ge 24$	A1
	Reject H_0 or Significant or 25 does lie in the critical region	dM1
	There is evidence to support Kiyoshi's **belief** oe <u>or</u> that the **proportion/number** oe of **large eggs** has increased after adding the supplement	A1cso
		(5)
(c)	Expected profit before supplement = $"0.1174" \times 1.20 + (1 - "0.1174") \times 0.60$	M1
	$= (£)0.67044$	
	$P(X \ge 4) = 0.2553$ awrt 0.255	B1
	Expected profit per box after supplement = $"0.2553" \times 1.20 + (1 - "0.2533") \times 0.60 - "0.67044"$	M1
	$= (£)0.08274$	A1
	OR Expected profit per box after supplement = $"0.2553" \times 1.20 + (1 - "0.2553") \times 0.60 - 0.10$	(M1)
	$= (£)0.65318$	(A1)
	Kiyoshi should not continue to add the supplement (as 0.0827 < 0.10 or 0.653 < 0.67[0])	A1cso
		(5)
		Total 15

Notes

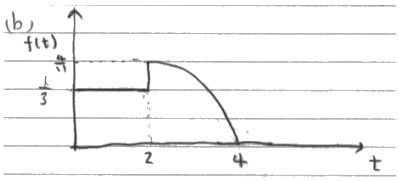
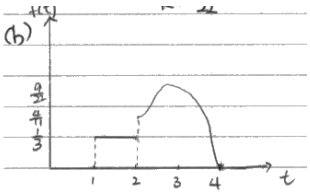
2(a)	**B1**	Using or writing B(6,0.35) in either part
(i)	**M1**	Using or writing $P(E \le 2) - P(E \le 1)$ oe or writing $\left({}^6C_2\right)0.35^2(1-0.35)^4$ oe
	A1	awrt 0.328
(ii)	**M1**	Either writing or using $P(E \ge 4)$ or $1 - P(E \le 3)$ or P(E = 4) + P(E = 5) + P(E = 6) oe
	A1	awrt 0.117 (Correct answers imply all previous marks in part (a))
(b)	**B1**	Both hypotheses correct with p or π
	M1	Writing or using $L \sim B(50, 0.35)$ **and** $1 - P(L \le 24)$ **or** writing P($L \ge 24$) = 0.0396 or P($L \ge 23$) = 0.071 **leading to a CR**. Condone use of normal approx $M \sim N(17.5,$ awrt 11.4) **and** 1 – P(M < 24.5) for the M1
	A1	awrt 0.0207 or $L \ge 24$ allow any letter
	dM1	dep on previous M being awarded for a correct statement (condone Accept H_1) ft their probability or CR Do not allow contradicting non-contextual comments.
	A1cso	All previous marks must be awarded. A correct statement in context. Need **bold words. NB** award M1A1 for a correct contextual statement on its own.
(c)	**Note:**	Some candidates may multiply by n or an integer so allow these multiples throughout.
	M1	$"\text{their (ii)} \times 1.20 + (1 - "\text{their(ii)}") \times 0.60$
Allow £ or pence in part (c)	**B1**	awrt 0.255
	M1	$"p" \times 1.20 + (1 - "p") \times 0.60 - "\text{their } 0.67044"$ or $"p" \times 1.20 + (1 - "p") \times 0.60 - 0.10$ oe where $p > 0.1174$ (do not allow $p = 0.45$ for this mark)
	A1	awrt (£)0.083 or awrt (£)0.65
	A1cso	Dep on all previous marks in (c). Correct conclusion with correct supporting figures.

Question Number	Scheme	Marks
3(a)	$\frac{3}{4}$	B1
		(1)
(b)	$\mathrm{E}(T)=\dfrac{50+2k}{2}[=25+k]$	B1
	$\mathrm{Var}(T)=\dfrac{(4k)^2}{12}\left[=\dfrac{4k^2}{3}\right]$	B1
	$\mathrm{E}\left(T^2\right)=\dfrac{4k^2}{3}+\left(25+k\right)^2$	M1
	$\dfrac{7k^2}{3}+625+50k=918.76$	
	$7k^2+150k-881.28=0$	dM1
	$k=\frac{-150\pm\sqrt{150^2+4\times7\times881.28}}{14}$	dM1
	$k=4.8$ oe only	A1
		(6)
(c)	$\mathrm{P}(T<25)=\frac{1}{4}$	B1
	B(50, 0.25)	
	$\mathrm{P}\left(X\geq20\right)=1-\mathrm{P}\left(X\leq19\right)$	M1
	$= 1 - 0.9861$	
	$= 0.0139$ awrt 0.0139	A1
		(3)
		Total 10

Notes

(a)	**B1**	0.75 oe
(b)	**B1**	$\mathrm{E}(T)=\dfrac{50+2k}{2}[=25+k]$ allow equivalent unsimplified expressions
	B1	$\mathrm{Var}(T)=\dfrac{(4k)^2}{12}\left[=\dfrac{4k^2}{3}\right]$ allow equivalent unsimplified expressions
	M1	Using Var(T) + [E(T)]^2 oe e.g. $"\frac{4k^2}{3}"=\mathrm{E}(T^2)-"(25+k)"^2$
	dM1	Dependent on previous M being awarded. Substituting E(T^2) = 918.76, multiplying out and combining like terms leading to a 3TQ = 0
	dM1	Dependent on previous M being awarded. A correct method for solving their quadratic – use of formula (allow one slip), completing the square, factorising.
	A1	Must have 4.8 oe on its own as answer (must reject k = –26.2 if seen) 4.8 on its own scores 6 out of 6.
	ALT	**For first 4 marks in (b)** $\int_{25-k}^{25+3k} t^2(\frac{1}{4k})\mathrm{d}t=\left[\dfrac{t^3}{12k}\right]_{25-k}^{25+3k}\rightarrow\dfrac{(25+3k)^3}{12k}-\dfrac{(25-k)^3}{12k}=918.76$ B2 for correct integral (ignore limits), M1 for attempt at integration $t^2\rightarrow t^3$, dM1 for use of limits and = 918.76, then follow main scheme
(c)	**B1**	0.25
	M1	Writing or using $1-\mathrm{P}\left(X\leq19\right)$
	A1	awrt 0.0139

Question Number	Scheme		Marks
4(a)	$\int_1^2 \frac{1}{3}\,\mathrm{d}t + \int_2^4 k(4t^2 - t^3)\,\mathrm{d}t = 1$		M1
	$\left[\frac{1}{3}t\right]_1^2 + \left[k\left(\frac{4t^3}{3} - \frac{t^4}{4}\right)\right]_2^4 = 1$		A1
	$\frac{1}{3} + k\left(\frac{64}{3} - \frac{20}{3}\right) = 1$ or $\frac{44}{3}k = \frac{2}{3}$ leading to $k = \frac{1}{22}$		A1cso
			(3)
(b)	[f(t)] [4/11] [1/3] 1 2 4 [t]		B1(shape) dB1 (labels)
			(2)
(c)	$\frac{\mathrm{d}f(t)}{\mathrm{d}t} = k\left(8t - 3t^2\right)$		B1
	$8t - 3t^2 = 0$		M1
	$t = \frac{8}{3}$ only	awrt 2.67	A1
			(3)
(d)	$\int_1^t \frac{1}{3}\,\mathrm{d}x = \left[\frac{x}{3}\right]_1^t$		M1
	$\mathrm{F}(2) + \int_2^t \frac{1}{22}\left(4x^2 - x^3\right)\mathrm{d}t = \frac{1}{3} + \left[\frac{4x^3}{66} - \frac{x^4}{88}\right]_2^t$ Or $\int \frac{1}{22}\left(4t^2 - t^3\right)\mathrm{d}t = \frac{2t^3}{33} - \frac{t^4}{88} + C$ and $\mathrm{F}(4) = 1$		M1
	$\mathrm{F}(t) = \begin{cases} 0 & t<1 \\ \frac{1}{3}t - \frac{1}{3} & 1 \le t < 2 \\ \frac{2t^3}{33} - \frac{t^4}{88} + \frac{1}{33} & 2 \le t \le 4 \\ 1 & \text{otherwise} \end{cases}$		A1 A1 A1
			(5)
(e)	$\mathrm{P}(T > 3) = 1 - \mathrm{F}(3)$		
	$= 1 - \left[\frac{4\times 3^3}{66} - \frac{3^4}{88} + \frac{1}{33}\right]$		M1
	$= \frac{67}{264}$ or 0.2537…	awrt 0.254	A1
			(2)
			Total 15

		Notes
4(a)	**M1**	Adding the two integrals together with correct limits and setting = 1 (may be done in stages) Allow $\frac{1}{3}$ instead of first integral
	A1	Correct integration (again allow $\frac{1}{3}$ instead of first integration)
	A1cso	Must have at least one line of working before the given answer and no errors
(b)	**B1**	Correct shape with correct curvature Horizontal line, then quadratic (increasing then decreasing as t increases) starting above horizontal line and finishing on horizontal axis. The sketch is not continuous. There should be no **solid** vertical lines.
	dB1	Fully correct with 1, 2 and 4 each labelled at appropriate place on horizontal axis (Ignore vertical labelling). e.g.  B0B0 (solid vertical line)  B1B1Condone curvature
(c)	**B1**	For $k\left(8t-3t^2\right)$
	M1	Putting their differential = 0 ignore missing k
	A1	Allow awrt 2.67 only
(d)	**M1**	For $\int_1^t \frac{1}{3}\mathrm{d}x$ with attempt to integrate. Must have correct limits. Or for integration with +C and use of F(1) = 0
	M1	For $\mathrm{F}(2)+\int_2^t \frac{1}{22}\left(4x^2-x^3\right)\mathrm{d}x$ and attempt to integrate or $\int \frac{1}{22}\left(4t^2-t^3\right)\mathrm{d}t=\frac{4t^3}{66}-\frac{t^4}{88}+C$ and using F(4) =1 or F(2) = $\frac{1}{3}$ – must attempt to integrate, have + C
	A1	For 2nd line of cdf oe (allow < instead of $\leq$ and vice versa ditto > and $\geq$) (allow any letter to be used for this A1 mark)
	A1	For 3rd line of cdf oe (allow < instead of $\leq$ and vice versa ditto > and $\geq$) (allow any letter to be used for this A1 mark)
	A1	All correct and in terms of t including F(t). Allow the otherwise to be for any of the parts but there must be only one. (allow < instead of $\leq$ and vice versa ditto > and $\geq$)
(e)	**M1**	Attempting to find 1 – F(3) with attempt to use 3rd line of their F(t) or $\int_3^4 k(4t^2-t^3)\mathrm{d}t$
	A1	$\frac{67}{264}$ oe or awrt 0.254

Question Number	Scheme	Marks
5(a)	$X \sim \text{Po}(4)$	M1
	$\text{P}(X = 0) = 0.0183$ $\quad$ $\text{P}(X \geq 8) = 0.0511$	
	$\text{P}(X \leq 1) = 0.0916$ $\quad$ $\text{P}(X \geq 9) = 0.0214$	
	CR $X = 0$ oe $\quad$ $X \geq 9$ oe	A1A1
		(3)
(b)	3.97%	B1
		(1)
(c)	6 is not in the critical region – the data collected are consistent with Chris's claim	B1ft
		(1)
(d)	$\lambda = \dfrac{2n}{9}$	B1
	$1 - \text{P}(Y = 0) > 0.9$	M1
	$1 - \text{e}^{-\frac{2n}{9}} > 0.9$	
	$\text{e}^{-\frac{2n}{9}} < 0.1$	
	$n = 10$ and $\text{e}^{-\frac{2n}{9}} = 0.1083...$ $\quad$ or $\quad -\dfrac{2n}{9} < \ln 0.1$	dM1
	$n = 11$ $\quad$ $\text{e}^{-\frac{2n}{9}} = 0.08677...$	
	Therefore $n = 11$	A1 cao
		(4)
(e)	$\text{H}_0 : \lambda = 10$ $\text{H}_1 : \lambda < 10$	B1
	[$W \sim \text{Po}(10)$ $\text{P}(W \leq 5) =$] 0.0671 or CR $W \leq 4$	B1
	Do not reject H_0 or insignificant or 5 does not lie in the critical region	M1
	There is no significant evidence that the **mean** number/**rate** of **whales** has decreased.	A1cso
		(4)
		Total 13

Notes

(a)	**M1**	Writing or using Po(4) (may be implied by one correct CR)
	A1	**Either tail** $X = 0$ (allow $X \leq 0$) **or** [$18 \geq$] $X \geq 9$ (allow $X > 8$) Allow any letters in place of X
	A1	**Both tails** $X = 0$ oe , [$18 \geq$] $X \geq 9$ oe Allow any letters in place of X
		SC: $\text{P}(X = 0)$ and $\text{P}(X \geq 9)$ as final answer to score M1A1A0.
(b)	**B1**	awrt 3.97% or awrt 0.0397
(c)	**B1ft**	Supports this claim **and** correct reason. Allow a correct f.t. statement and reason based on their CR
(d)	**B1**	writing or using $\frac{2n}{9}$
	M1	May be implied by $\text{P}(Y = 0) < 0.1$ (Allow = in place of <)
	dM1	Dep on previous M mark for solving $\text{e}^{-\lambda} < 0.1$. This may be implied by n = awrt 10.4
		Allow for a trial of any n value or $"-\frac{2n}{9}" < \ln 0.1$ (condone $\frac{2n}{9} = 2.5$) (Allow = in place of <)
	A1	11 cao (Do not allow $n \geq 11$)
(e)	**B1**	Both hypotheses with λ or μ (Allow $\text{H}_0 : \lambda = 2$ $\text{H}_1 : \lambda < 2$)
	B1	awrt 0.0671 or $W \leq 4$
	M1	Correct statement – ft their probability or CR Do not allow contradicting non-contextual comments
	A1cso	Fully correct solution with conclusion in context must have mean/rate with whales.
		NB award M1A1 for a correct contextual statement on its own provided previous marks scored

Question Number	Scheme		Marks
6(a)	$\mathrm{E}(X^2)=\int_{-1}^{1}\frac{1}{8}\left(x^4+2x^3+x^2\right)\mathrm{d}x+\int_{1}^{\frac{11}{3}}\frac{1}{4}x^2\mathrm{d}x$		M1
	$=\left[\frac{1}{8}\left(\frac{x^5}{5}+\frac{2x^4}{4}+\frac{x^3}{3}\right)\right]_{-1}^{1}+\left[\frac{x^3}{12}\right]_{1}^{\frac{11}{3}}$		A1
	$=\frac{1684}{405}$		
	$\mathrm{Var}(X)=\text{"}\frac{1684}{405}\text{"}-\left(\frac{31}{18}\right)^2$		dM1
	$=\frac{1931}{1620}$ or 1.1919…	awrt **1.19**	A1
			(4)
(b)	$\mathrm{P}\left(X<-\frac{1}{2}\right)=\int_{-1}^{-0.5}\frac{1}{8}\left(x^2+2x+1\right)\mathrm{d}x$ **or** $1-\int_{-0.5}^{0.5}\frac{1}{8}\left(x^2+2x+1\right)\mathrm{d}x$ (gets M2)		M1
	$\mathrm{P}\left(X>\frac{1}{2}\right)=\frac{2}{3}+\int_{0.5}^{1}\frac{1}{8}\left(x^2+2x+1\right)\mathrm{d}x$		M1
	$\mathrm{P}\left(X<-\frac{1}{2}\right)=\left[\frac{x^3}{24}+\frac{x^2}{8}+\frac{x}{8}\right]_{-1}^{-0.5}$ **or** $\mathrm{P}\left(X>\frac{1}{2}\right)=\frac{2}{3}+\left[\frac{x^3}{24}+\frac{x^2}{8}+\frac{x}{8}\right]_{0.5}^{1}$ **or** $1-\left[\frac{x^3}{24}+\frac{x^2}{8}+\frac{x}{8}\right]_{-0.5}^{0.5}$		A1
	$=\frac{83}{96}$ or 0.8645…	awrt **0.865**	A1
			(4)
			Total 8

Notes

In parts (a) and (b) a correct answer does NOT imply all marks.

(a)

M1 For attempt at $\int x^2\mathrm{f}(x)\mathrm{d}x$ for both parts of f(x) added **and** attempt to integrate $x^n \to x^{n+1}$

A1 Correct algebraic integration (ignore limits). This mark cannot be implied.

dM1 dep on previous M1 for "an expression for their E(X^2)" – [E(X)]^2
Values must be substituted here

A1 awrt 1.19

(b)

	Main scheme method	Alternative method using F(x)
M1	$\int_{-1}^{-0.5}\frac{1}{8}\left(x^2+2x+1\right)\mathrm{d}x$ oe	$\int_{-1}^{x}\frac{1}{8}\left(t^2+2t+1\right)\mathrm{d}t$ or $\int\frac{1}{8}\left(x^2+2x+1\right)\mathrm{d}x$ with + C
M1	$\frac{2}{3}+\int_{0.5}^{1}\frac{1}{8}\left(x^2+2x+1\right)\mathrm{d}x$ oe	Use of F(–0.5) + (1 – F(0.5)) oe
NB	$1-\int_{-0.5}^{0.5}\frac{1}{8}\left(x^2+2x+1\right)\mathrm{d}x$ gets M2	**Note:** $\mathrm{F}(-0.5)=\frac{1}{192}$ and $\mathrm{F}(0.5)=\frac{9}{64}$
A1	One correct integration (may be implied by $\frac{1}{192}$, $\frac{9}{64}$ or $\frac{55}{64}$)	$\mathrm{F}(x)=\frac{1}{8}\left(\frac{x^3}{3}+x^2+x+\frac{1}{3}\right)$ (from $-1<x<1$)

A1 $\frac{83}{96}$ or awrt 0.865 must come from correct working and dependent on all previous marks.

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