Mark Scheme (Results)

October 2018

Pearson Edexcel International Advanced 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.
- 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.

PEARSON 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)
   - d… or dep – dependent
   - indep – independent
   - dp decimal places
   - sf significant figures
   - * The answer is printed on the paper or ag- answer given
   - $\sqsubset$ or d… 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. If a candidate makes more than one attempt at any question:
    - If all but one attempt is crossed out, mark the attempt which is NOT crossed out.
    - If either all attempts are crossed out or none are crossed out, mark all the attempts and score the highest single attempt.

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

October 2018
WST02 STATISTICS 2
Mark Scheme

Question	Scheme	Marks
1.(a)	$X \sim \text{Po}(6)$ $\text{P}(X = 1)$ [$=6e^{-6} = 0.0174 - 0.0025$]$= 0.01487\ldots$ awrt **<u>0.0149</u>**	M1 A1 (2)
(b)	$\text{H}_0 : \lambda = 6$ (or 9) $\text{H}_1 : \lambda > 6$ (or 9) $Y \sim \text{Po}(9)$ $\text{P}(Y \geq 14) = 1 - \text{P}(Y \leq 13) = 1 - 0.9261 = 0.0739$ / $\text{P}(Y \geq 15) = 0.0415$, CR: $Y \geq 15$ Do not reject H_0 /Not significant/ 14 is not in the critical region There is not enough evidence to suggest that the rate of **calls** for reservations has increased.	B1 M1A1 dM1 A1cso (5) **Total 7**
	Notes	
(a)	1st M1 writing or using Po(6)	
(b)	1st B1 for both hypotheses correct with λ or μ 1st M1 for writing or using $1 - \text{P}(Y \leq 13)$ and Po(9) <u>or</u> writing or using $\text{P}(Y \geq 15)$ and Po (9) for a CR method 1st A1 for awrt 0.0739 / CR: $Y \geq 15$ / $Y > 14$ 2nd dM1 dependent on 1st M1 for correct statement (i.e. Do not reject H_0 /Not significant/14 is not in the critical region) (may be implied by a correct contextual statement). Do not allow contradictory statements. 2nd A1cso A correct contextual statement must include the word **calls** and the idea the rate has not increased. All previous marks must be awarded for this mark to be awarded. **SC:** $1 - \text{P}(Y \leq 14) = 0.0415$ so reject H_0 scores M0A0M1A0	

Question	Scheme	Marks
2.(a)	$X \sim B(12, 0.2)$	B1
	$P(X < 3) = P(X \leq 2) = 0.5583\ldots$ awrt **0.558**	M1A1 (3)
(b)(i)	[P(customer takes sugar) =] $0.8 \times 0.35 + 0.2 \times 0.6$ [= 0.4*]	B1cso (1)
(ii)	[$Y \sim$] $B(n, 0.4)$	B1 (1)
(c)(i)	$P(Y = 4)$ [$= {}^{10}C_4(0.4^4)(0.6^6) = 0.6331 - 0.3823$] $= 0.2508$ awrt **0.251**	B1 (1)
(ii)	$P(Y \leq 6 \mid Y \geq 3) = \dfrac{P(3 \leq Y \leq 6)}{P(Y \geq 3)}$	M1
	$\dfrac{P(Y \leq 6) - P(Y \leq 2)}{1 - P(Y \leq 2)} = \dfrac{0.9452 - 0.1673\ [= 0.7779]}{1 - 0.1673\ [= 0.8327]} = 0.934\ldots$ awrt **0.934**	M1A1 (3)
(d)	$C \sim B(150, 0.4) \rightarrow N(60, 36)$	M1
	$P(C \geq 75) = P\left(Z > \dfrac{74.5 - 60}{\sqrt{36}}\right)$ [$= P(Z > 2.416\ldots)$]	M1 M1
	$1 - 0.9922 = 0.0078$ awrt **0.0078**	A1 (4)
		Total 13

	Notes
(a)	B1 for writing or using B(10, 0.2) M1 for writing or using $P(X \leq 2)$
(b)(i)	B1cso for $0.8 \times 0.35 + 0.2 \times 0.6$ or equivalent Condone use of percentages here
(ii)	B1 $B(n, 0.4)$
(c)(ii)	1st M1 for a correct ratio expression [Do not allow $P(Y \leq 6 \cap Y \geq 3)$ on numerator] 2nd M1 for writing or using $\dfrac{P(Y \leq 6) - P(Y \leq 2)}{1 - P(Y \leq 2)}$
(d)	1st M1 for using a Normal approximation to binomial with $\mu = np$ and $\sigma^2 = np(1-p)$ 2nd M1 for standardising 74.5, 75, 75.5 with their mean and standard deviation 3rd M1 for use of continuity correction (75 ± 0.5) [Note actual probability is 0.00827…]

Question	Scheme	Marks
3.(a)		B1 (shape) B1 (domain)
	This is not a valid probability density function since f(x) < 0 for $x > 3$	B1 (3)
(b)	$[g(y) = k(12y - y^3)]$	
	$[g'(y)] = k(12 - 3y^2)$	M1
	$12 - 3y^2 = 0$	M1
	$y = 2$	A1 (3)
(c)	$\int k(12y - y^3)\mathrm{d}y = k\left[6y^2 - \frac{y^4}{4}\right]_1^3$	M1
	$k\left(6 \times 3^2 - \frac{3^4}{4} - 6 + \frac{1}{4}\right) = 1$	M1
	$k = \frac{1}{28}$	A1 (3)
(d)	$\int_1^m \frac{1}{28}(12y - y^3)\mathrm{d}y = \frac{1}{28}\left(6 \times m^2 - \frac{m^4}{4} - \left(6 \times 1^2 - \frac{1^4}{4}\right)\right) = 0.5$	M1
	$m^4 - 24m^2 + 79 = 0 \rightarrow m = 1.98437...$ awrt **<u>1.98</u>**	M1 A1 (3)
(e)	Median ≈ Mode, therefore there is no skew.	M1A1ft (2)
		Total 14

	Notes
(a)	1st B1 for correct shape (decreasing quadratic) for this mark ignore graph $x < 1$ and $x > 4$ must cross x axis 2nd B1 for correct domain (graph starting at $x = 1$ and finishing at $x = 4$) If $x = 3$ is labelled, then it must be correctly placed at the x–intercept 3rd B1 for Not a density function/Albert is incorrect **and** correct supporting reason Allow any reference to pdf cannot be negative.
(b)	1st M1 for expanding and attempting to differentiate (or using product rule to differentiate) 2nd M1 for equating to 0 and attempt to solve A1 for 2 only
(c)	1st M1 for attempt to integrate ($y^n \rightarrow y^{n+1}$) 2nd M1 for equating to 1 and use of correct limits
(d)	1st M1 for use of $\int_1^m g(y)\mathrm{d}y = 0.5$ 2nd M1 for arranging to a 3TQ = 0 and attempt to solve A1 awrt 1.98 only
(e)	M1 for a comparison of 1 <u>≤</u> 'their (b)' <u>≤</u> 3 with 1 < 'their (d)' <u>≤</u> 3 Note: mean = 1.9857… A1ft for no skew (allow [slight] negative skew). Correct statement following from their comparison Note: mean = 1.9857… comparisons based on the mean must use correct mean awrt 1.99

Question	Scheme	Marks
Question	Scheme	Marks
4.(a)	P($D = -1$) [=P(1 blue and 2 red marbles selected)] = $3\times0.2\times0.8^2 = 0.384$*	M1A1cso (2)
(b)	d | -3 | $[-1]$ | 1 | 3 | 0.8^3 | $[3\times0.2\times0.8^2]$ | $3\times0.2^2\times0.8$ | 0.2^3 P($D = d$) | $0.512 = \frac{64}{125}$ | $[0.384 = \frac{48}{125}]$ | $0.096 = \frac{12}{125}$ | $0.008 = \frac{1}{125}$	B1 M1 A1 (3)
(c)	-3	B1 (1)
(d)	$X \sim B(12, 0.2)$ P($X \leq 4$) = 0.9274 P($X \geq 5$) = 0.0726 < 0.10 P($X \leq 3$) = 0.7946 P($X \geq 4$) = 0.2054 > 0.10 CR: $X \geq 5$	M1 A1 (2)
(e)	0.0726	B1ft (1)
		Total 9
	Notes	
(a)	M1 for identifying 1 blue and 2 red leading to $0.2\times(1-0.2)^2$ A1cso for a complete correct calculation $3\times0.2\times0.8^2$	
(b)	B1 for all correct d-values M1 for correct expression for at least 1 other probability A1 for a complete distribution	
(d)	1st M1 for using $X \sim B(12, 0.2)$ to find a relevant probability to determine a critical region [P($X \leq 3$) = 0.7946, P($X \geq 4$) = 0.2054, P($X \leq 4$) = 0.9274, P($X \geq 5$) = 0.0726] P($X \geq 5$) as final answer is M1A0	
(e)	B1ft for a significance level consistent with their CR from (d). Must come from a one-tailed test from $X \sim B(12, 0.2)$ so may see P($X \geq 6$) = 0.0194 or P($X \geq 7$) = 0.0039	

Question	Scheme	Marks
5.(a)	$f(x) = \frac{1}{100}(3ax^2 + 2bx + 15)$	M1 A1
	$E(X^2) = \int x^2 f(x) dx$	
	$\frac{1}{100}[\frac{3}{5}ax^5 + \frac{1}{2}bx^4 + 5x^3]_0^5 = 6.25$	M1
	$1875a + 312.5b + 625 = 625$	dM1
	$6a + b = 0$ *	A1cso
		(5)
(b)	$F(5) = 1$	
	$\frac{1}{100}(125a + 25b + 75) = 1$	M1
	Solving simultaneously $\begin{cases} 5a + b = 1 \\ 6a + b = 0 \end{cases}$	M1
	$\underline{a = -1}$ and $\underline{b = 6}$	A1 A1
		(4)
(c)	$[P(3 \leq X \leq 7) =] F(5) - F(3)$ or $1 - F(3)$	M1
	$1 - \frac{1}{100}(27a + 9b + 45)$	
	$\underline{0.28}$	A1
		(2)
		Total 11

	Notes
	Mark parts (a) and (b) together as may see use of F(5) = 1 in part (a)
(a)	1st M1 for use of $\frac{d}{dx}[F(x)]$ to find $f(x)$ $(x^n \to x^{n-1})$
	1st A1 for correct differentiation
	2nd M1 for attempt to integrate $\int x^2 f(x) dx$ (ignore limits) $(x^n \to x^{n+1})$
	Should see x^5 as the highest power of x here
	3rd dM1 for $\int x^2 f(x) dx = 6.25$ **and** substitution of $x = 5$ to obtain an equation in terms of a and b only (dependent upon 2nd M1)
	2nd A1cso for $6a + b = 0$ from correct working
(b)	1st M1 for use of $F(5) = 1$
	2nd M1 for solving simultaneously leading to $a = \ldots$
	1st A1 for $a = -1$
	2nd A1 for $b = 6$
(c)	M1 for $1 - F(3)$ or $\int_3^5 f(x) dx$ attempt to integrate with use of correct limits
	A1 0.28oe

Question	Scheme	Marks
6.(a)	$a = 4 \times(-0.5)$ and $b = 4 \times 0.5$	B1 (1)
(b)(i)	$\sqrt{\frac{(2-(-2))^2}{12}} = \frac{2\sqrt{3}}{3} = 1.1547...$ awrt **1.15**	M1 A1
(ii)	$[P(-\frac{2\sqrt{3}}{3} < W < \frac{2\sqrt{3}}{3}) =] \frac{\frac{2\sqrt{3}}{3} - (-\frac{2\sqrt{3}}{3})}{2-(-2)} = \frac{\sqrt{3}}{3} = 0.57735...$ awrt **0.577**	M1 A1 (4)
(c)	$P(W > 1.9) = \frac{2-1.9}{2-(-2)}$ [=0.025] $X \sim B(100, 0.025)$ $\rightarrow Po(2.5)$ $P(X \geq 5) = 1 - P(X \leq 4) = 1 - 0.8912 = 0.1088$ awrt **0.109**	M1 M1 M1 A1 (4)
		Total 9

	Notes
(a)	B1 for correct explanation that each error is [–0.5, 0.5] and these are multiplied by 4. It must be clear that W could be above or below the true value.
(b)(i)	M1 for use of correct formula with square root A1 awrt 1.15 (allow 1.155)
(ii)	M1 for a correct follow through ($2 \times \frac{1}{4} \times$ their (b)(i))
(c)	1st M1 for a correct expression for $P(W > 1.9)$ 2nd M1 for Binomial distribution $B(100, P(W > 1.9))$ 3rd M1 for Poisson approximation with mean $100 \times P(W > 1.9)$ **and** $1 - P(X \leq 4)$ Note: using binomial distribution gives 0.106…

Question	Scheme	Marks
7.(a)	$X \sim \text{Po}(1)$ and $\text{P}(X \geq n) < 0.05$ or $\text{P}(X < n) > 0.95$ $n = 4$	M1 A1 (2)
(b)	$Y \sim \text{Po}(0.5m)$ $\text{P}(Y = 0) < 0.05$ or $\text{e}^{-\frac{1}{2}m} < 0.05$ $0.5m = 3$ $m = 6$	M1 A1 (2)
(c)	$W \sim \text{Po}(0.5)$ $[\text{P}(W \geq 1)]^3 = (1 - \text{P}(W = 0))^3 = (1 - 0.6065)^3 = 0.06093\ldots$ awrt **0.0609**	M1M1A1 (3)
(d)	$S \sim \text{Po}(4)$ $\text{P}(S = 4) = 0.1953\ldots$ awrt **0.195**	M1 A1 (2)
(e)	$A \sim \text{Po}(1)$ $B \sim \text{Po}(2)$ P(sightings in last 2 months> sightings in first 2 months | 4 sightings in 4 months) = $\frac{\text{P}(A=1)\times\text{P}(A=3)+\text{P}(A=0)\times(A=4)}{\text{P}(B=4)} = \frac{\text{e}^{-1}\times\frac{\text{e}^{-1}}{3!}+\text{e}^{-1}\times\frac{\text{e}^{-1}}{4!}}{\frac{\text{e}^{-2}\times 2^4}{4!}} = \frac{5}{16}$	M1 M1 A1 (3)
		Total 12

	Notes
(a)	M1 for writing or using Po(1) **and** $\text{P}(X \geq n) < 0.05$ or $\text{P}(X < n) > 0.95$ or for Po(1) **and** $\text{P}(X \leq 2) = 0.9197$ or $\text{P}(X \leq 3) = 0.9810$ or $\text{P}(X > 2) = 0.0803$ or $\text{P}(X > 3) = 0.019$
(b)	M1 for $\text{P}(Y = 0) = 0.1353$ from Po(2) or $\text{P}(Y = 0) = 0.0821$ from Po(2.5) or $\text{P}(Y = 0) = 0.0498$ from Po(3)
(c)	1st M1 for $\text{P}(W \geq 1)$ and Po(0.5) 2nd M1 for $(1 - \text{P}(W = 0))^3$ (allow $W \sim \text{Po}(\lambda)$ $\lambda > 0$)
(d)	M1 for use of Po(4)
(e)	1st M1 for $\text{P}(A = 1) \times \text{P}(A = 3)$[=0.02255...] + $\text{P}(A = 0) \times \text{P}(A = 4)$[=0.0056...] from Po(1) 2nd M1 for conditional probability with $\text{P}(B = 4)$[= 0.0902…] on the denom from Po(2) (M0 if num>denom) A1 allow awrt 0.312/0.313