Mark Scheme (Results)

January 2018

Pearson Edexcel
International Advanced Subsidiary 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.

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
- o.e. – 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
- $\lfloor$ 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.

January 2018
WST02 STATISTICS 2
Mark Scheme

Question	Scheme	Marks
1.(a)	$1 - F(4) = 1 - \frac{1}{16}(4-1)^2 = \frac{7}{16}$	M1 A1 (2)
(b)	$[P(X > 3 \mid 2 < X < 4) =] \frac{F(4)-F(3)}{F(4)-F(2)} = \frac{\frac{9}{16}-\frac{4}{16}}{\frac{9}{16}-\frac{1}{16}} = \frac{5}{8}$	M1 dM1 A1 (3)
(c)	$f(x) = \frac{d}{dx}F(x) = \frac{1}{8}(x-1)$	M1
	$E(X) = \int_1^5 \frac{1}{8}x(x-1)dx$	dM1
	$E(X) = \left[\frac{1}{24}x^3 - \frac{1}{16}x^2\right]_1^5 = \left(\frac{5^3}{24} - \frac{5^2}{16}\right) - \left(\frac{1}{24} - \frac{1}{16}\right) = \frac{11}{3}$	dM1 A1 (4)
		Total 9

	Notes
(a)	M1 for writing or using 1 – F(4) A1 for $\frac{7}{16}$ oe (allow 0.4375 or 0.438)
(b)	1st M1 for writing or using F(4) – F(3) (may be implied by $\frac{5}{16}$ or 0.3125) 2nd dM1 (dep on 1st M1) for a ratio of probabilities with F(4) – F(2) written or used in the denominator (may be implied by $\frac{1}{2}$). Do not award 2nd M1 if numerator > denominator. A1 for $\frac{5}{8}$ or 0.625
(c)	1st M1 for differentiating F(x) to find f(x) (at least one $x^n \rightarrow x^{n-1}$) 2nd dM1 (dependent upon 1st M1) for multiplying 'xf(x)' and integrating (at least one $x^n \rightarrow x^{n+1}$) 3rd dM1 (dependent upon 2nd M1) for substitution in of correct limits. May be implied by $\frac{175}{48} - \left(-\frac{1}{48}\right)$ A1 for $\frac{11}{3}$ or awrt 3.67

Question	Scheme	Marks
2. (a)	$\frac{n^3}{(n+1)^3} = 0.729 \Rightarrow \frac{n}{n+1} = \sqrt[3]{0.729} \Rightarrow n = 9$	M1A1cso (2)
(b)	$P(T = 24) = 0.9^2(1-0.9)\times 3$ $P(T = 30) = 0.9(1-0.9)^2 \times 3$ $P(T = 36) = (1-0.9)^3$	M1 M1
	T | [18] | 24 | 30 | 36 $P(T = t)$ | [0.729] | 0.243 | 0.027 | 0.001	A1 A1 (4)
(c)	$P(R = 0) = P(T = 18) + P(T = 36) = 0.73$ $P(R = 6) = P(T = 24) + P(T = 30) = 0.27$	M1 A1 (2) **Total 8**

	Notes
(a)	M1 for a correct equation in n, $n+1$ and 0.729 A1 cso M1 must be scored and no errors seen Alternative (verification): M1 for $\frac{9^3}{(9+1)^3} = 0.729$ A1 cso for stating $n = 9$ from correct working
(b)	1st M1 for either $p^2(1-p)\times 3$ or $p(1-p)^2 \times 3$ 2nd M1 for $(1-p)^3$ or use of $1 - P(T \neq 36)$ 1st A1 for at least 1 correct probability 2nd A1 dependent on both M marks. Must have t values of 24, 30 and 36 associated with correct probabilities. (Need not be in a table).
(c)	M1 for correct calculation for either $P(R = 0)$ or $P(R = 6)$ A1 both probabilities correct and associated with correct r values and no other (non-zero) probabilities

Question	Scheme	Marks
3. (a)	$[f(d) =]\begin{cases}\frac{1}{5} & -2.5 \le d \le 2.5 \\ 0 & \text{otherwise}\end{cases}$	B1 B1 (2)
(b)	$\sqrt{\frac{(2.5-(-2.5))^2}{12}} = 1.4433...$ **awrt <u>1.44</u>**	M1 A1 (2)
(c)	0	B1 (1)
(d)	$\left[\frac{1-(-1)}{5}\right] = \frac{2}{5}$	B1 (1)
(e)	X~B(10, '0.4') $[P(X \ge 6) =]1 - P(X \le 5) = 1 - 0.8338 = 0.1662$ **awrt <u>0.166</u>**	M1 M1 A1 (3) **Total 9**
	Notes	
(a)	1st B1 for $\frac{1}{5}$ (ignore range for the 1st B1 mark) 2nd B1 fully correct distribution, including ranges. Condone use of other letters instead of d Allow < or $\le$	
(b)	M1 for a correct expression with square root A1 awrt 1.44 allow $\frac{5\sqrt{3}}{6}$ oe For integration allow complete correct expression to score M1 e.g. $\sqrt{\int_{-2.5}^{2.5} \frac{1}{5}x^2 dx}$	
(e)	1st M1 for writing or using binomial with 10 and 'their (d)' 2nd M1 for writing or using $1 - P(X \le 5)$ A1 awrt 0.166 Alternative (for 'their(d)' > 0.5) If using $Y \sim B(10, 1 - \text{'their (d)'})$ 1st M1 for writing or using binomial with 10 and 1 – 'their (d)' 2nd M1 for writing or using $P(Y \le 4)$	

Question	Scheme	Marks
4.(a)	$np = 4.2$ $np(1-p) = 3.57$	M1
	leading to $(1-p) = 0.85$	M1
	$p = 0.15$ $n = 28$	A1 A1
		(4)
(b)	$X \sim B(25, 0.35)$	
	$E(X) = 8.75$	B1
	$[P(X > 8.75) = P(X \geq 9) =]$	
	$1 - P(X \leq 8) = 1 - 0.4668 = 0.5332$ **awrt <u>0.533</u>**	M1 A1
		(3)
(c)	$H_0 : p = 0.1$ $H_1 : p < 0.1$	B1
	$Y \sim B(40, 0.1)$	
	$P(Y \leq 1) = 0.080473\ldots$	M1
	Do not reject H_0 / Not significant	dM1
	The <u>proportion</u> of customers buying more than 2 bags of sweets is <u>not less than 10%/not less than the shop's claim</u>	A1cso
	or	
	The <u>shop's claim</u> is not rejected	
		(4)
		Total 11

	Notes
(a)	1st M1 for correct expressions for mean and variance
	2nd M1 for attempting to solve simultaneously by eliminating n or p
	1st A1 for $p = 0.15$
	2nd A1 for $n = 28$
(b)	B1 for $E(X) = 8.75$ (may be implied by the M1)
	M1 for using $1 - P(X \leq 8)$ with binomial (25, 0.35) (allow ft for a correct probability statement consistent with their $E(X)$ with binomial (25, 0.35))
(c)	B1 both hypotheses correct (must use p or π)
	1st M1 for awrt 0.0805 **or** for stating critical region is $Y = 0$ from B(40, 0.1)
	2nd dM1 Dependent on previous M being awarded. A correct statement (do not allow if there are contradicting non-contextual statements). This mark may be implied by a correct contextual statement.
	A1cso A correct contextual statement. All previous marks must be awarded for this mark to be awarded. Must include proportion/number/percentage/probability (condone rate) oe <u>and</u> 10%/shop's claim **or** The shop's claim is not rejected. Allow The shop's claim is supported/accepted

Question	Scheme	Marks
5. (a)	$[X \sim \text{Po}(10)]$ $[\text{P}(X > 12) = 1 - \text{P}(X \leq 12) = 1 - 0.7916] = 0.2084$ **awrt <u>0.208</u>**	B1 (1)
(b)	$[\text{P}(X > k) \geq 2 \times$ '0.2084'$]$ $\text{P}(X \leq k) < 1 -$ '0.4168…' [=0.583…] $k =$ **<u>10</u>**	M1 A1cao (2)
(c)	$W \sim \text{Po}(5)$ $[\text{P}(W = 4)]^2 \left[= \left(\frac{\text{e}^{-5}5^4}{4!} \right)^2 = (0.4405 - 0.2650)^2 = \right] = 0.030788...$ **awrt <u>0.0308</u>**	B1 M1 A1 (3)
(d)	$\text{P}((X_1 \geq 10 \cap X_2 \geq 10) \mid (Y = 21)) = \dfrac{\frac{\text{e}^{-10}10^{10}}{10!} \times \frac{\text{e}^{-10}10^{11}}{11!} + \frac{\text{e}^{-10}10^{11}}{11!} \times \frac{\text{e}^{-10}10^{10}}{10!}}{\frac{\text{e}^{-20}20^{21}}{21!}}$ $= 0.336376…$ Use of tables: $\dfrac{2 \times (0.5830 - 0.4579)(0.6968 - 0.5830)}{\frac{\text{e}^{-20}20^{21}}{21!}} = 0.336537...$ **awrt <u>0.336/7</u>**	M1 M1 M1 A1 (4)
(e)	$L \sim \text{Po}(40) \approx \text{N}(40, 40)$ $\text{P}(L > 27) = \text{P}\left(Z > \dfrac{27.5 - 40}{\sqrt{40}} \right)$ $\text{P}(Z > -1.98) = 0.9761$ **<u>awrt 0.976</u>**	B1 B1 M1 M1 A1 (5) **Total 15**

	Notes
(b)	M1 for $\text{P}(X \leq k) < 1 - 2$'$p$' or $\text{P}(X < k + 1) < 1 - 2$'$p$' follow through their '$p$' < 0.5 (condone = or $\leq$ instead of $< 1 - 2$'p') A1 $k = 10$ implies the M mark
(c)	B1 for writing or using Po(5) M1 for $[\text{P}(W = 4)]^2$ or for either correct expression
(d)	1st M1 for use of Po(10) with $X = 10$ or $X = 11$ May be implied by $[\text{P}(X = 10) =]$ awrt 0.125 or $[\text{P}(X = 11) =]$ awrt 0.114 2nd M1 for correct expression for $2 \times \text{P}(X = 10) \times \text{P}(X = 11)$ from Po(10) May be implied by awrt 0.0284 or 0.0285 3rd M1 for a ratio of probabilities with correct denominator (awrt 0.0846) and num<denom A1 awrt 0.336 or awrt 0.337
(e)	1st B1 for Po(40) (may be implied by 2nd B1) 2nd B1 for writing or using normal distribution with mean and variance 40 (These values may be seen in the standardisation expression) 1st M1 attempting continuity correction (27 ± 0.5) 2nd M1 standardising using their mean and their standard deviation and 26.5/27/27.5 A1 awrt 0.976

Question	Scheme	Marks
6. (a)	$X \sim \text{B}(80,0.6) \approx \text{N}(48,19.2)$	M1 A1
	$\text{P}(X \geq n) < 0.05$ $\qquad$ $\text{P}(X \leq n-1) > 0.95$	
	$\text{P}\left(Z > \dfrac{(n-0.5)-48}{\sqrt{19.2}}\right) < 0.05$ $\qquad$ $\text{P}\left(Z < \dfrac{((n-1)+0.5)-48}{\sqrt{19.2}}\right) > 0.95$	M1
	$\dfrac{(n-0.5)-48}{\sqrt{19.2}} > 1.6449$	M1 B1
	$n > 55.7$ $\qquad$ $n = 56$	A1cao
		(6)
(b)	$[\text{H}_0 : \lambda = 9 \qquad \text{H}_1 : \lambda > 9]$	
	$[B \sim \text{Po}(9)]$	
	$\text{P}(B \leq 14) = 0.9585 / \text{P}(B \geq 15) = 0.0415 \ (< 0.05)$	M1
	$B \geq 15$	A1
		(2)
		Total 8

	Notes
(a)	1st M1 for writing or using a normal approximation 1st A1 correct mean and variance (may be implied by the standardisation expression) 2nd M1 for attempting a continuity correction ($n \pm 0.5$) or (($n-1$) $\pm$ 0.5) (allow $n-48.5$ or $n-47.5$ or $n-46.5$ as numerator in a standardisation attempt) 3rd M1 for standardising n or ($n \pm 0.5$) or ($n-1$) or (($n-1$) $\pm$ 0.5) with their mean and their standard deviation and comparing to z-value, $\lvert z \rvert > 1$ B1 for use of 1.6449 or better compatible with their standardisation A1 56 cao dependent upon all M marks (from correct working- can score A1 from z-value $1.64 \leq z \leq 1.65$) NB: Use of binomial score 0 out of 6
(b)	M1 for either $\text{P}(B \leq 14) = 0.9585$ or $\text{P}(B \geq 15) = 0.0415$ (may be implied by correct CR) A1 allow use of any letter but must be a CR not a probability statement

Question	Scheme	Marks
7. (a)	$\int_1^3 \frac{1}{16}x^2\,dx + \int_3^4 k(4-x)dx = 1$	M1
	$\left[\frac{x^3}{48}\right]_1^3 + \left[k(4x - \frac{x^2}{2})\right]_3^4 = 1$	
	$\left(\frac{27}{48} - \frac{1}{48}\right) + k((16-8) - (12 - \frac{9}{2})) = 1$	M1
	$k = \frac{11}{12}$ **	A1cso
		(3)
(b)	Correct shape for $1 \leq x < 3$	B1
	Correct shape for $3 \leq x \leq 4$	B1
		(2)
(c)	[X=] 3	B1
		(1)
(d)	$E(X^2) = \int_1^3 \frac{1}{16}x^4\,dx + \int_3^4 \frac{11}{12}(4x^2 - x^3)dx$	M1
	$E(X^2) = \left[\frac{1}{80}x^5\right]_1^3 + \left[\frac{11}{12}(\frac{4}{3}x^3 - \frac{1}{4}x^4)\right]_3^4$	dM1
	$\text{Var}(X) = \frac{5863}{720} - (\frac{25}{9})^2 = \frac{2767}{6480}, = 0.427...$ **awrt <u>0.427</u>**	M1, A1
		(4)
(e)(i)	$c = -1$	B1cao
(ii)	F(4)=1	
	$\frac{11}{12}(4(4) - \frac{1}{2}(4^2) + d) = 1$	M1
	$d = -\frac{76}{11}$	A1cao
		(3)
(f)	$\frac{11}{12}(4x - \frac{1}{2}x^2 - '\frac{76}{11}') = 0.75$	
	$11x^2 - 88x + 170 = 0$	M1
	$x = 3.26$ only	A1
		(2)
		Total 15

	Notes
(a)	1st M1 equating sum of two expressions for area to 1 (ignore limits)
	2nd M1 correct use of limits to obtain a linear equation in k
	A1 for $k = \frac{11}{12}$ with correct integration and no incorrect working seen
(b)	1st B1 for positive quadratic starting above x-axis with correct curvature
	2nd B1 for line with negative gradient which starts above the quadratic finishing on x-axis with labels 1, 3 and 4 on x-axis Ignore sketch outside of range $1 \leq x \leq 4$
(d)	1st M1 attempt to find $E(X^2)$ by multiplying f(x) by x^2 and attempt to integrate $x^n \rightarrow x^{n+1}$
	2nd dM1 (dep on 1st M1) for correct integration with correct limits (condone ft on their k)
	3rd M1 for use of Var(X) = $E(X^2)$ – $(\frac{25}{9})^2$
	A1 awrt 0.427
(e)(ii)	M1 use of F(4)=1 [or use of F(3) = '$\frac{13}{24}$'] (condone ft on their k)
	A1 $-\frac{76}{11}$ or exact equivalent (isw after $-\frac{76}{11}$ oe seen)
(f)	M1 for equating their third line to 0.75 (condone ft on their k)
	A1 for 3.26 only

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