Pearson
Edexcel

Mark Scheme (Results)

January 2019

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

Question Number	Scheme	Marks
1. (a)	Any one response in context from : Each person **turns up** independently/randomly of others oe Probability/proportion/percentage of not **turning up** remains constant (5%) oe	B1 (1)
(b)	$X \sim B(50, 0.05)$	
(i)	$[P(X = 0) =] 0.076944\ldots$ awrt **0.0769**	B1
(ii)	$P(X = 1) = 0.2794 - 0.0769 = 0.20248...$ awrt **0.202/0.203**	M1A1 (3)
(c)	Let T = total earnings for a journey	
	T | 880 | 940 | 1000 $P(T = t)$ | "0.0769" | "0.2025" | (1 – ("0.0769"+"0.2025"))=[0.7206]	M1
	$E(T) = 880 \times$ "0.0769" $+ 940 \times$ "0.2025" $+ 1000 \times (1 -$ ("0.0769+0.2025"))	dM1
	=£978.62 awrt (£) **979**	A1 (3)
	Alternative Let S = possible pay out	**Alternative**
	S | 60 | 120 $P(S = s)$ | "0.2025" | "0.0769"	M1
	$E(T) = 1000 - (120 \times$ "0.0769" $+ 60 \times$ "0.2025")	dM1
	=£978.62 awrt (£) **979**	A1 **[7 marks]**

	Notes
(a)	Must be in context containing the words in bold. Allow turning up rather than not turning up and vice versa.
(b)	
(ii)	M1 for correct use of tables or for correct use of formula $50(0.05)(0.95)^{49}$ Allow $P(X \leq 1) - P(X = 0)$ oe written of used
(c)	1st M1 for identifying the 3 possible total earnings 880, 940, 1000 oe 2nd dM1 for a correct ft expression for $E(T)$ eg 880 × 'their b(i)' + 940 × ' their b(ii)' + 1000 × (1 – ('their b(i) + their b(ii)) Alternative: 1st M1 for identifying the 2 possible pay outs 120 and 60 oe 2nd dM1 for a correct ft expression for $E(T)$ Eg 1000 – (120 × their b(i) + 60 × their b(ii)) Eg

Question Number	Scheme	Marks
2. (a)	$[X \sim \text{Po}(2)]$ $\text{P}(X < 5) = \text{P}(X \leq 4)$ $= 0.947346\ldots$ awrt **<u>0.947</u>**	M1 A1 (2)
(b)	$Y \sim \text{Po}(6)$ $e^{-6}\frac{6^n}{(n)!} = e^{-6}\frac{6^{n+1}}{(n+1)!} \rightarrow (n+1) = 6$ **or** $\text{P}(Y=4) = 0.13385\ldots$, $\text{P}(Y=5) = 0.16062\ldots$, $\text{P}(Y=6) = 0.16062\ldots$ **<u>$n = 5$</u>**	B1 M1 A1 (3)
(c)	$[D \sim \text{Po}(9)]$ $\text{P}(c \leq D \leq 12) = \text{P}(D \leq 12) - \text{P}(D \leq c-1)$ or $\text{P}(X \leq d) = 0.8758 - 0.8546 = 0.0212$ $0.8546 = 0.8758 - \text{P}(D \leq c-1)$ $\text{P}(D \leq c-1) = 0.0212$ $\quad$ $\text{P}(X \leq 3) = 0.0212$ $c - 1 = 3$ **<u>$c = 4$</u>** $\quad$ **<u>$c = 4$</u>**	M1 dM1 A1 (3)
(d)	$\text{P}(X = 2) = 0.27067\ldots$ $W \sim \text{B}(6,$ awrt $0.27067\ldots)$ $\text{P}(W = 4) = {}^6\text{C}_4(\text{“}0.27067\ldots\text{”})^4(1 - \text{“}0.27067\ldots\text{”})^2$ $= 0.0428\ldots$ awrt **<u>0.043</u>**	B1 B1ft M1 A1 (4) **[12 marks]**
	Notes	
(a)	M1 for writing or using $\text{P}(X \leq 4)$ If answer is incorrect this must be shown	
(b)	B1 for writing or using Po(6) M1 for a correct expressions for $\text{P}(Y = n)$ and $\text{P}(Y = n + 1)$ using their value of λ or for finding at least 2 of the given probabilities for Po(6) only correct to 3sf. A1 must be only one value of n given. If more than one value of n is given working must be shown to award the B1 and M1, 5 on its own gains B1M1A1	
(c)	1st M1 for the expression $\text{P}(D \leq 12) - \text{P}(D \leq c-1)$ oe Condone $\text{P}(D \leq 12) - \text{P}(D \leq c)$ allow any letters. 2nd dM1 for correct substitution of 0.8758 (awrt 0.876) and 0.8546 leading to $\text{P}(D \leq c-1)$ = a probability. Condone $\text{P}(D \leq c)$ = a probability allow any letters	
(d)	For an awrt 0.043 from correct working award full marks. 1st B1 for awrt 0.271 seen 2nd B1ft Follow through their $\text{P}(X = 2)$ but you must see either B(6, “0.27067…”) or working of the form $(\text{“}0.27067\ldots\text{”})^4(1 - \text{“}0.27067\ldots\text{”})^2$. Condone missing ${}^6\text{C}_4$ **NB** If $\text{P}(X = 2)$ is not stated and 0.271 is not seen do not ft. M1 ${}^6\text{C}_4\, p^4(1-p)^2$ or $\text{P}(W \leq 4) - \text{P}(W \leq 3)$ or $0.9932\ldots - 0.9504\ldots$ written	

Question Number	Scheme	Marks
3. (a)	$P(3 < X < 7) = F(7) - F(3)$ [= 0.7 – 0.2] **0.5**	M1 A1 (2)
(b)	$a = \frac{0.4-0}{4-2}$ $b = \frac{0}{6-4}$ $c = \frac{1-0.4}{8-6}$ **a = 0.2 b = 0 c = 0.3**	M1 A1 A1 (3)
(c)	$E(X) = \int_2^4 "0.2"x\,dx + \int_4^6 "0"x\,dx + \int_6^8 "0.3"x\,dx$ $E(X) = \left[\frac{0.2x^2}{2}\right]_2^4 + \left[\frac{0.3x^2}{2}\right]_6^8$ = **5.4** **Alternative** $E(X) = 3\times p + 7\times 2\times$"their c" or $3\times 2\times$"their a"$+ 7\times p$ where $0 < p < 1$ $= 3\times$"0.4"$+ 7\times$"0.6" = **5.4**	M1 A1ft A1 (3) **Alternative** M1 A1ft A1 **[8 marks]**
	Notes	
(a)	M1 for writing or using F(7) – F(3) Implied by answer 0.5	
(b)	M1 for attempt to find the gradient of at least 1 line segment (may be implied by either a or c correct) 1st A1 two values correct 2nd A1 all three values correct	
(c)	M1 for a correct expression for $\int xf(x)\,dx$ (ignore limits) using their a, b and c (Condone a, b and c as a function of x) and an attempt to integrate ($x^n \to x^{n+1}$). No need to see $\int_4^6 "0"x\,dx$ if $b = 0$ otherwise it must be present A1ft correct integration with correct limits (ft their constants a, b and c from part (b)) A1 5.4 oe **Alternative** M1 must have 3, 7 and one half correct ft their values for a/c. A1ft $3\times 2\times$"their a"$+ 7\times 2\times$"their c" A1 5.4 oe	

Question Number	Scheme	Marks
4. (a)	H_0: $p = 0.35$ H_1: $p > 0.35$	B1
	Probability route: $P(X \geq 11) = 1 - P(X \leq 10)$ [$= 1 - 0.9468$] $= 0.0532$ | CR route: $P(X \leq 11) = 0.9804$, $P(X \geq 12) = 0.0196$, CR: $X \geq 12$	M1 A1
	Do not Reject H_0 or not significant or 11 does not lie in the CR	dM1
	Hadi's belief is not supported or the proportion of customers paying by credit card is not greater than 35%.	A1cso
		(5)
(b)	$X \sim B(20, 0.35)$	
	[$E(X) =$] 7	B1
	S.D. $= \sqrt{20 \times 0.35 \times 0.65}$ [$= \sqrt{4.55} = 2.133\ldots$]	B1
	"7" + 2 × "2.133…" | 11 – "7" < 2 × 2.133… | $\frac{11-"7"}{\sqrt{"4.55"}}$ | 11 – 2 × "2.133…"	M1
	11 < 11.266 | 4 < 4.266 | 1.875 < 2 | 6.734 < 7	A1cso
		(4)
		[9 marks]

	Notes
(a)	B1 both hypotheses correct (may use p or π). Must have H_0 and H_1 1st M1 for writing or using $1 - P(X \leq 10)$ or if leading to a CR allow $P(X \leq 11)$ = awrt 0.980 (condone 0.98) or $P(X \geq 12)$ = awrt 0.0196 (may be implied by awrt 0.0532 or correct CR) A1 for 0.0532 or CR: $X \geq 12$ oe **NB** M1 A1 for $0.9468 < 0.95$ 2nd M1 Dependent on the 1st M1. For a correct statement i.e. not significant/accept H_0/Not in CR Follow through their probability/CR and their H_1 . Must have a Critical region not just a critical value Do not allow non-contextual conflicting statements. May be implied by a correct contextual statement on its own 2nd A1cso fully correct solution and correct contextual statement. Underlined words required and in a correct statement. eg Allow Hadi is wrong or Hadi's claim is not supported The (proportion/percentage/number/rate/probability) paying by credit card (is not greater/is 35%(0.35)/ remains the same) or there is insufficient evidence that the proportion of customers who pay by credit card has increased
(b)	1st B1 $E(X) = 7$ 2nd B1 for a correct expression for standard deviation M1 for using 'mean' + 2 × 'standard deviation' or 11- "their mean" < 2 × 'standard deviation' or $\frac{11-"\text{their } E(X)"}{"\text{Their sd}"}$ If $E(X)$ and sd not given then allow $5 < E(X) < 10$ and $0 < sd < 5$ A1cso for comparison with 11 or 4 or 2 allow awrt (11.3 or 4.27 or 1.88 or 6.43) oe and no errors seen

Question Number	Scheme	Marks
5. (a)(i)	$\frac{(b-2a)-a}{b-a}=\frac{1}{3}$ $3(b-3a)=(b-a)$ $b=4a$ $\mathrm{E}(X)=\frac{a+4a}{2}=\frac{5a}{2}$* or $\frac{b-(b-2a)}{b-a}=\frac{2}{3}$ $6a=2(b-a)$ $b=4a$ $\mathrm{E}(X)=\frac{a+4a}{2}=\frac{5a}{2}$* oe	M1 M1A1cso (3)
(ii)	**[**[P($X > b-4a$) = P($X > 0$) =] 1	B1 (1)
(b)(i)	$\frac{(c-3)^2}{12}=3c-9$ $c^2-42c+117=0 \rightarrow (c-3)(c-39)=0$ **$\underline{c = 39}$**	M1 M1 A1 (3)
(ii)	P($2Y-7<20-Y$) = P($Y<9$) $\frac{9-3}{'39'-3}=\frac{1}{6}$ **awrt 0.167**	M1 A1ft A1 (3)
(iii)	$\mathrm{E}(Y^2)$ = Var(Y) + [E(Y)]^2 = $(3('39')-9)+\left(\frac{'39'+3}{2}\right)^2$ $\mathrm{E}(Y^2)$ = **$\underline{549}$**	M1 A1ft A1 (3) **[13 marks]**
	Notes	
(a)(i)	1st M1 for a correct probability equation = $\frac{1}{3}$ (or a correct probability equation = $\frac{2}{3}$)in terms of a and b 2nd M1 for use of E(X) = $\frac{a+'4a'}{2}$ oe A1cso correct solution with no errors seen.	
(b)(i)	1st M1 for $\frac{(c-3)^2}{12}=3c-9$ 2nd M1 for rearranging correctly to form 3TQ = 0 and attempt to solve or $\frac{c-3}{12}=3$ oe For attempt at factorising it must give two of the terms when multiplied out For using the formula allow 1 slip if the correct formula is written down otherwise no errors For completing the square allow one sign error. A1 If more than one value is given and c = 39 is not clearly selected then A0. Allow [3,39]	
(ii)	M1 for rearranging to (or using) P($Y < 9$) 1st A1ft for a correct probability expression ft their '39'. If (i) is incorrect we must see a correct expression eg $\frac{9-3}{"39"-3}$ or $\frac{6}{"36"}$ to ft	
(iii)	M1 for writing or using $\mathrm{E}(Y^2)=\mathrm{Var}(Y)+[\mathrm{E}(Y)]^2$ (must be $\mathrm{E}(Y^2)=$) $\int_3^{'39'} \frac{1}{'39'-3} y^2 \mathrm{d}y$ with $y^2 \rightarrow y^3$ condone different letter. If c is incorrect, they must show where Var(Y) and E(Y) come from. A1ft correct (follow through) expression for $\mathrm{E}(Y^2)$ allow $\frac{1}{'39'-3}\left[\frac{y^3}{3}\right]_3^{'39'}$	

Question Number	Scheme	Marks
6. i.(a)	n is large and p is small	B1 (1)
(b)	$[X \sim \text{B}(3000, 0.0025) \rightarrow] \; Y \sim \text{Po}(7.5)$ $\text{P}(Y > 7) = 1 - \text{P}(Y \leq 7) = 1 - 0.5246 = 0.47536\ldots$ awrt **0.475**	B1 M1 A1 (3)
ii.(a)	A **list/database/register** of **all employees**	B1 (1)
(b)	The **probability** distribution of the **number of employees** that **cycle** to work [from all possible samples of 150]	B1 (1)
(c)	$D \sim \text{N}(60, 36)$ $\text{P}(C \leq \alpha) = \text{P}(Z \leq z) = 0.0668$ $\frac{\alpha - "60"}{"6"} = -1.5$ or $\frac{"60" - \alpha}{"6"} = 1.5$ **α = 51**	B1 M1 B1 A1cao (4)
(d)	$\text{P}(C \leq 51) = \text{P}(D \leq 51.5)$ $\text{P}\left(Z \leq \frac{"51" - "60" + 0.5}{"6"}\right)$ $= \text{P}(Z \leq -1.42) = 1 - 0.9222$ $= 0.0778/0.0782\ldots$ awrt **0.078**	M1 A1 (2) **[12 marks]**

	Notes
(a)	n is bigger then 10 and $p < 0.25$
i. (b)	B1 for writing or using Po(7.5) M1 for writing or using $1 - \text{P}(Y \leq 7)$ oe
ii (a)	B1 must be **all** employees
(b)	B1 Allow **number of employees** that **cycle** to work and their associated **probabilities**
(c)	1st B1 for Normal approximation with mean = 60 and variance = 36 / standard deviation = 6 M1 for standardising with no continuity correct and equating to z using their mean and sd (if not stated clearly they must be correct here), with $\lvert z \rvert > 1$ 2nd B1 for – 1.5 (or 1.5) Their sign must be compatible with their standardisation. Allow if used their 36 instead of their 6
(d)	M1 for standardising with use of continuity correction 'their 51' + 0.5 allow same mean and sd used in part(c) A1 awrt 0.078

Question Number	Scheme	Marks
7. (a)	$\int_{-3}^{0} c(x+3)\,\mathrm{d}x + \int_{0}^{3} \frac{5}{36}(3-x)\,\mathrm{d}x$ **or** area of triangle $= \frac{3\times 3c}{2} + \frac{3\times\frac{5}{36}(3)}{2}$	M1
	$c(-\frac{9}{2}+9)+\frac{5}{8}=1$ oe $\qquad \frac{3\times 3c}{2}+\frac{5}{8}=1$ oe	dM1
	$c=\frac{1}{12}$*	A1cso (3)
	Alternative	
	$\left[\int c(x+3)\right] = c\left(\frac{x^2}{2}+3x\right)+d$ and $\left[\int \frac{5}{36}(3-x)\right] = \frac{5}{36}\left(3x-\frac{x^2}{2}\right)+e$	M1
	Using F(– 3) = 0 and F(3) = 1 and $d = e$	dM1
	$c=\frac{1}{12}$*	A1 cso
(b)(i)	A correct sketch of f(x) with straight line positive gradient from $-3 \le x < 0$ and straight line negative gradient from $0 \le x \le 3$, LHS below RHS at y axis	B1
	Correct labels: –3 and 3 on x-axis and $\frac{1}{4}$ and $\frac{5}{12}$ oe on y-axis	B1
(ii)	**Highest point** [at f(0), so $X = 0$ is the mode] oe	B1 (3)
(c)	$\int_{-3}^{x} \frac{1}{12}(t+3)\,\mathrm{d}t$ or $\int \frac{1}{12}(x+3)\,\mathrm{d}x$ with + c and F(–3) = 0	M1
	$\int_{-3}^{0} \frac{1}{12}(t+3)\,\mathrm{d}t + \int_{0}^{x} \frac{5}{36}(3-t)\,\mathrm{d}t$ or $\int \frac{5}{36}(3-x)\,\mathrm{d}x$ with + d and F(3) = 1	
	$\mathrm{F}(x)=\begin{cases}0 & x<-3\\ \frac{1}{24}x^2+\frac{1}{4}x+\frac{3}{8} & -3\le x<0\\ \frac{5}{12}x-\frac{5}{72}x^2+\frac{3}{8} & 0\le x\le 3\\ 1 & x>3\end{cases}$ **or** $\mathrm{F}(x)=\begin{cases}0\\ \frac{1}{24}(x+3)^2\\ 1-\frac{5}{72}(3-x)^2\\ 1\end{cases}$	B1 A1 A1 (4)
(d)	$[\mathrm{P}(X>d \mid X>0) =] \ \frac{1-\mathrm{F}(d)}{1-\mathrm{F}(0)} = \frac{2}{5}$ oe	M1
	$1-\mathrm{F}(d) = \frac{2}{5}\times\frac{5}{8}[=\frac{1}{4}]$ oe	A1
	Using cdf **or** area of triangle	
	$1-\left("\frac{5}{12}d-\frac{5}{72}d^2+\frac{3}{8}"\right)="\frac{2}{5}\times\frac{5}{8}"$ **or** $\frac{(3-d)\frac{5}{36}(3-d)}{2}="\frac{2}{5}\times\frac{5}{8}"$ oe	dM1
	$d =$ awrt **1.10**	A1 (4)
		[14 marks]

Notes

(a) M1 for correct integrals added, including limits, or area of triangle. Condone missing dx
Do not accept c(0 + 3)=5/36(3 – 0)
dM1 for equating to 1 and attempting to solve
A1 cso for $c = \frac{1}{12}$ with no incorrect working seen

(b)(ii) B1: oe eg Maximum value. Condone highest probability

(c) M1 for attempting to integrate first line of pdf with correct limits **or** + c and F(–3) = 0
or for attempting to integrate second line of pdf with correct limits +F(0) **or** + d and F(3) = 1

(d)	NB Allow use of F(0) = $\frac{3}{8}$ instead of either F(-3) =0 or F(3) =1 B1 1st and 4th line correct. Allow one of range to be otherwise, $\leq$ instead of $<$ and $\geq$ instead of $>$ 1st A1 correct 2nd line with limits. Allow $<$ instead of $\leq$ and vice versa 2nd A1 correct 3rd line with limits. Allow $<$ instead of $\leq$ and vice versa 1st M1 for a correct probability expression, allow $\frac{\mathrm{P}(X > d)}{\mathrm{P}(X > 0)} = \frac{2}{5}$oe implied by A1. Do not allow $\mathrm{P}(X > d) \cap \mathrm{P}(X > 0)$ for $\mathrm{P}(X > d)$ 1st A1 for $1 - \mathrm{F}(d) = \frac{2}{5} \times \frac{5}{8}$ or $1 - \mathrm{P}(x < d) = \frac{2}{5} \times \frac{5}{8} [= \frac{1}{4}]$ or $\mathrm{F}(d) = \frac{3}{4}$ or $\mathrm{P}(x > d) = \frac{1}{4}$oe 2nd dM1 previous M1 awarded. For $1 - \mathrm{F}(d) =$ their $\mathrm{P}(X > d)$ for their cdf oe **and** attempting to solve leading to a value for *d*.

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