



Mark Scheme (Results)

January 2024

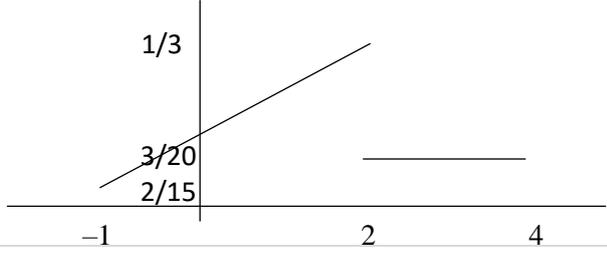
Pearson Edexcel International Advanced Level
in Statistics S2 (WST02) Paper 01

Question Number	Scheme		Marks
1 (a)	[Mean =] 2.95		B1
	[Variance =] $\frac{2091}{180} - ("2.95")^2$		M1
	= 2.914.... ($s^2 = 2.930...$)		awrt 2.91 (2.93) A1
			(3)
(b)	The mean is close to the variance		B1
			(1)
(c)	$W \sim \text{Po}(3)$		
(i)	[P(W ...3) =] $1 - P(W \leq 2) = 0.5768$		awrt 0.577 M1 A1
(ii)	[P(4 < W < 8) =] $P(W \leq 7) - P(W \leq 4)$ or $P(W=5) + P(W=6) + P(W=7)$		M1
	= 0.1728...		awrt 0.173 A1
			(4)
(d)	$X \sim N(21, 21)$		B1
[P(X < 19) =] $P\left(Z \leq \frac{18.5 - 21}{\sqrt{21}}\right) [= -0.5455...]$ or			M1M1A1
[P(X > 23) =] $P\left(Z \leq \frac{23.5 - 21}{\sqrt{21}}\right) [= 0.5455...]$			
= 0.2912 (calc 0.29268...)*			A1*cso
			(5)
(e)	$Y \sim B(13, "0.29")$		M1
[P(Y = 5) =] ${}^{13}C_5 ("0.29")^5 (1 - "0.29")^8 = 0.170465$ (calc 0.17317...)			awrt 0.17 M1 A1
			(3)
Notes			Total 16
(a)	B1	cao allow exact equivalents	
	M1	Ft their mean. Using $\frac{\sum fx^2}{180} - (\text{their mean})^2$ or $\frac{180}{179} \left(\frac{\sum fx^2}{180} - (\text{their mean})^2 \right)$	
	A1cso	Allow with a square root – may be implied by awrt 1.71 awrt 2.91 (2.93)	
(b)	B1	cao – Allow equivalent wording. Allow mean = variance. If no values/non compatible values calculated, then B0. Condone the use of ‘closed’ for ‘close’	
(c)(i)	M1	for $1 - P(W \leq 2)$ or $1 - 0.4232$	
	A1	awrt 0.577	
(ii)	M1	for $P(W \leq 7) - P(W \leq 4)$ or $P(W=5) + P(W=6) + P(W=7)$	
	A1	or 0.9881 – 0.8153 or 0.1008 + 0.0504 + 0.0216 awrt 0.173	
(d)	B1	for writing or using $N(21, 21)$. May be seen in a standardisation expression.	
	M1	for standardisation (\pm) using their mean and sd. Allow 17.5, 18, 18.5, 19, 19.5, 22.5, 23, 23.5, 24, 24.5	
	M1	for using 19 ± 0.5 or 23 ± 0.5	
	A1	for a fully correct standardisation expression Implied by awrt ± 0.546	
	A1*	awrt 0.291 or 0.293 from correct working seen	
(e)	M1	for writing or using $B(13, 0.29)$ ft their 0.29 (Must be 2 sf or better) or for $(p)^5(1-p)^8$	
	M1	ft their 0.29 (Must be 2 sf or better) . Condone B(0.29, 13)	
	M1	for ${}^{13}C_5 (p)^5 (1-p)^8$ oe with $0 < p < 1$ Allow 1287 for ${}^{13}C_5$	
	A1	awrt 0.17 (0.17168 from using 0.2912)	

Question Number	Scheme		Marks
2 (a)	$[P(D < 108) =] P\left(Z < \frac{108 - 112.4}{\sigma}\right) = 0.05$		
	$\Rightarrow \frac{108 - 112.4}{\sigma} = -1.6449$		M1 M1
	$\sigma = 2.6749... \text{ days (calc 2.67501...)}$		awrt 2.67/2.68 A1
			(3)
(b)	$J \sim B(25, 0.05)$		
	$[P(J \dots 4) =] 1 - P(J \dots 3) = 1 - 0.9659$		M1
	$= 0.0341 \text{ (calc 0.034090...)}$		awrt 0.0341 A1
			(2)
(c)	$T \sim \text{Po}[200 \times "0.0341"] = 6.82 \text{ (calc 6.8181...)}$		M1
	$[P(T \dots 2) =] 1 - P(X \dots 1) = 1 - (e^{-"6.82"} + e^{-"6.82"} \times "6.82")$		M1
	$= 0.99146... \text{ calc (0.99144...)}$		awrt 0.991 dA1
			(3)
Notes			Total 8
(a) (i)	M1	for standardisation using 108(Condone 107.5), 112.4 and σ set equal to z where $1.5 < z < 2.5$	
	M1	for correct equation awrt -1.6449 (Allow awrt 1.6449 if compatible with their equation)	
	A1	awrt 2.67/2.68 NB M1 M0 A1 is possible	
(b)	M1	for $1 - P(J \dots 3)$ or $1 - 0.9659$	
	A1	awrt 0.0341	
(c)	M1	for writing or using correct Poisson model ft their part (b) May be implied by 0.00853(73)	
	M1	for writing or using $1 - (e^{-" \lambda " } + e^{-" \lambda " } \times " \lambda ")$ where $1 < \lambda < 200$ (may be implied by awrt 0.991) Allow $1 - P(X \dots 1)$ if Poisson distribution is stated or used	
	dA1	dep on both method marks being awarded awrt 0.991 (NB Binomial gives awrt 0.992 and if no working shown awrt 0.992 will gain M0M0A0) Allow 0.9915 if both M marks are awarded	

Question Number	Scheme		Marks
3 (a)	The vacuum tubes shatter independently		B1
	The probability of a vacuum tube shattering is constant		B1
			(2)
(b)	$C \sim B(15, 0.35)$ plus $[P(C \leq 9) =]0.0142$ or $[P(C \leq 10) =]0.0124$ or $[P(C \leq 9) =]0.9876$		M1
	Critical regions $[0,] C \leq 1$ or $10 \leq C [, 15]$		M1
	$[0,] C \leq 1$ and $10 \leq C [, 15]$ plus $P(C \leq 9) = 0.0142$ and $P(C \leq 10) = 0.0124$		A1
			(3)
(c)	0.0266		B1ft
			(1)
(d)	[4 is not in the CR therefore] there is no evidence to reject Rowan's belief		B1ft
			(1)
(e)	$F \sim B(40, 0.35)$		
	$H_0: p = 0.35$ and $H_1: p < 0.35$		B1
	$P(F \leq 8) = 0.0303$ or CR $F \leq 8$		M1A1
	Sufficient evidence to reject H_0 or significant or 8 lies in the Critical region		M1
	There is sufficient evidence to support that the proportion of type B vacuum tubes that shatter when exposed to alternating high and low temperatures is less than 35%		A1
			(5)
Notes			Total 12
(a)	B1	for one correct reason which must mention tube(s) and shatter/shattering or 2 correct reasons not in context	
	B1	for 2 correct reasons which must mention tube(s) and shatter/shattering at least once	
(b)	M1	for using the correct distribution to find awrt 0.0142 or awrt 0.0124 or awrt 0.988 Allow $B(15, 0.35)$ is written and one of awrt 0.014 or awrt 0.012 or awrt 0.99 is seen	
	M1	for lower CR or $C \leq 1$ oe e.g. $C < 2$ or upper CR $C \leq 10$ oe e.g. $C > 9$ Allow other notation and any letter(s) for CR Do not allow CR written as a probability statement	
	A1	for both CR correct with the relevant probabilities (3 sf and must be seen in part (b)). Do not allow CR written as a probability statement	
(c)	B1ft	for awrt 0.0266 or 2.66% or ft the sum of the probabilities in (b) for "their 2 critical regions" if seen. If no probabilities for their CR given then the answer must be 0.0266	
(d)	B1ft	for a correct statement consistent with their CR Must mention Rowan/his/her or a correct conclusion based on Rowan's belief with the words highlighted in bold e.g. no evidence to suggest that the proportion/probability/number/amount (allow 35% as proportion) of tubes that shatter has changed oe	
(e)	B1	for both hypotheses correct in terms of p or π	
	M1	for using or writing $P(F \leq 8)$ or awrt 0.0303	
	A1	for awrt 0.0303 or correct CR Allow $F \leq 8$ or $F < 9$ but not if part of a probability statement	
	M1	for a correct conclusion – need not be in context. ft their probability or CR. Ignore hypotheses. do not allow contradicting non contextual comments. May be implied by a correct contextual statement on its own	
	A1	for a correct conclusion – must be in context, with words highlighted in bold. ft their probability or CR only. Independent of hypotheses. Do not allow contradicting statements. Allow probability/number/amount/35% for proportion. Allow decreased for less than 35%	

Question	Scheme	Marks
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Number		
4 (a)		M1 A1 (2)
(b)	<p> $[P(G \leq 2)] = 1 - 2 \times \frac{3}{20} [= 0.7]$ or $\frac{1}{2} \times 3 \times \left(\frac{2}{15} + \frac{1}{3}\right)$ or $\frac{1}{15} \int_{-1}^2 (g+3) dg [= 0.7]$ or $\frac{1}{30} \times 2^2 + \frac{1}{5} \times 2 + \frac{1}{6} [= 0.7]$ or $\left[P\left(G \leq \frac{1}{2}\right)\right] = \frac{1}{2} \times 1.5 \times \left(\frac{2}{15} + \frac{3.5}{15}\right) [= 0.275]$ or $\frac{1}{15} \int_{-1}^{0.5} (g+3) dg [= 0.275]$ or $\frac{1}{30} \times 0.5^2 + \frac{1}{5} \times 0.5 + \frac{1}{6} [= 0.275]$ or $\left[P\left(\frac{1}{2} \leq G \leq 2\right)\right] = \frac{1}{2} \times 1.5 \times \left(\frac{7}{30} + \frac{1}{3}\right) [= 0.425]$ or $\frac{1}{15} \int_{0.5}^2 (g+3) dg [= 0.425]$ or $\frac{1}{30} \times (2^2 - 0.5^2) + \frac{1}{5} \times (2 - 0.5) [= 0.425]$ </p> <p> $[P(1 \leq 2G \leq 6 G \leq 2)] = \frac{P\left(\frac{1}{2} \leq G \leq 2\right)}{P(G \leq 2)} = \frac{0.425}{0.7}$ or $1 - \frac{0.275}{0.7}$ oe $= \frac{17}{28}$ or 0.607... awrt 0.607 </p>	M1 M1M1 A1 (4)
(c)	<p> $[E(H^2)] = 2.4 + 12^2 [= 146.4]$ </p> <p> $[E(G)] = \int_{-1}^2 \frac{1}{15}(g^2 + 3g) dg + \int_2^4 \frac{3}{20} g dg$ </p> <p> $[E(G)] = \left[\frac{1}{15}\left(\frac{1}{3}g^3 + \frac{3}{2}g^2\right)\right]_{-1}^2 + \left[\frac{3}{40}g^2\right]_2^4$ </p> <p> $= \frac{1}{15}\left(\frac{8}{3} + \frac{12}{2} + \frac{1}{3} - \frac{3}{2}\right) + \left(\frac{48}{40} - \frac{12}{40}\right) [= 1.4]$ </p> <p> $[E(2H^2 + 3G + 3)] = 2 \times "146.4" + 3 \times "1.4" + 3$ $= 300$ </p>	M1 M1 M1 dM1 M1 A1 (6) Total 12

		Notes
(a)	M1	for correct shape $\left(g = \frac{3}{20} \text{ must be below } \frac{1}{3}\right)$ with the lines not joining at $x = 2$ and none below/touch the x -axis. Ignore any broken/dotted lines drawn
	A1	for fully correct graph with labels on the x axis
(b)	M1	For a correct method to find $P(G, 2)$ or $P\left(G, \frac{1}{2}\right)$ or $P\left(\frac{1}{2}, G, 2\right)$ May be implied by $0.7 / \frac{7}{10}$ or $0.425 = \frac{17}{40}$ or $0.275 / \frac{11}{40}$
	M1	for $\frac{p}{0.7}$ where $0 < p < 0.7$ or $\frac{0.425}{q}$ where $0.425 < q < 1$ or $1 - \frac{0.275}{r}$ where $0.275 < r < 1$ Allow un-simplified probabilities
	M1	For $\frac{P\left(\frac{1}{2}, G, 2\right)}{P(G, 2)}$ or a correct ratio of probabilities
	A1	$\frac{17}{28}$ oe or awrt 0.607
(c)	M1	for a correct method to find $E(H^2)$
	M1	for realising $\int xf(x)dx$ on both functions and adding together. Ignore limits
	M1	for attempting to integrate $(x^n \rightarrow x^{n+1})$ at least one part of $xf(x)$
	dM1	dep on previous M1 being awarded. For use of correct limits in one part of $xf(x)$ If working not shown, then this may be implied by 0.5 or 0.9 or 1.4. If integration is incorrect then working must be shown.
	M1	For using $2 \times$ "their $E(H^2)$ " + 3 "their $E(G) + 3$, provided $E(H^2)$ and $E(G)$ have been shown. NB You may have to check their answer if no working is shown for $2 \times$ "their $E(H^2)$ " + 3 "their $E(G) + 3$
	A1	Cao

Question Number	Scheme		Marks
5(a)	$\frac{(a+6)^2}{12} = 27$		M1
	$a = \sqrt{27 \times 12} - 6 \Rightarrow 12^*$ or $a^2 + 12a - 288 = 0 \Rightarrow a = 12^*$		A1*
			(2)
(b)(i)	$\frac{12-b}{18} = \frac{3}{5}$ or $\frac{b+6}{18} = \frac{2}{5}$		M1
	$b = 1.2$		A1
			(2)
(ii)	$P(-6 < W < "0.6") = \frac{"0.6" + 6}{18}$		M1
	$= \frac{11}{30}$ or 0.3666....		A1ft
			(2)
(c)	Let C be the point where the wood is cut and x is the distance AC		
	$\frac{x}{2}$ and $\left(\frac{160-x}{2}\right)$	$L+W = 80$ and $LW = 975$	M1
	$\frac{x}{2} \times \left(\frac{160-x}{2}\right) = 975 \Rightarrow x = 30$ or 130	$L(80-L) = 975 \Rightarrow L = 15$ or 65	M1
	$P("30" < x < "130") = \frac{"130" - "30"}{160} \left[= \frac{5}{8} \right]$ oe	$P("15" < x < "65") = \frac{"65" - "15"}{80} \left[= \frac{5}{8} \right]$ oe	dM1
	$= \frac{5}{8}$ oe		A1
			(4)
Notes			Total 10
(a)	M1	for setting up the correct equation. Do not allow verification	
	A1*	for an un-simplified expression for a leading to $a = 12$ or for a correct $3TQ = 0$ leading to $a = 12$ Condone any letter for a	
(b)(i)	M1	for setting up the correct equation	
	A1	Cao oe	
(ii)	M1	for a correct method. Do not ISW	
	A1ft	ft their value for b , provided the answer is between 0 and 1	
(c)	M1	For both expressions seen. Allow any letters e.g. $\frac{y}{2}$ for $\left(\frac{160-x}{2}\right)$ May be implied by a correct equation for the area	
	M1	for a correct equation for area in terms of any letter. Condone an inequality	
	dM1	dep on previous method mark awarded. For a fully correct method ft their x values provided add to 160 or 80 Do not ISW	
	A1	Cao	

Question Number	Scheme					Marks								
6(a)	8, 11, 14, 17, 20					M1								
	$[P(\text{even}) =]\frac{1}{5}$ and $[P(\text{odd}) =]\frac{4}{5}$					M1								
	$[P(X = 8) =]\left(\frac{4}{5}\right)^4$ or $[P(X = 20) =]\left(\frac{1}{5}\right)^4$					M1								
	$[P(X = 11) =]4 \times \left(\frac{1}{5}\right)\left(\frac{4}{5}\right)^3$ or $[P(X = 17) =]4 \times \left(\frac{4}{5}\right)\left(\frac{1}{5}\right)^3$					M1								
	$[P(X = 14) =]^4C_2 \times \left(\frac{1}{5}\right)^2 \left(\frac{4}{5}\right)^2$					M1								
		<table border="1"> <thead> <tr> <th>X</th> <th>8</th> <th>11</th> <th>14</th> <th>17</th> <th>20</th> </tr> </thead> <tbody> <tr> <td>P(X = x)</td> <td>$\frac{256}{625}$ (0.4096)</td> <td>$\frac{256}{625}$ (0.4096)</td> <td>$\frac{96}{625}$ (0.1536)</td> <td>$\frac{16}{625}$ (0.0256)</td> <td>$\frac{1}{625}$ (0.0016)</td> </tr> </tbody> </table>	X	8	11	14	17	20	P(X = x)	$\frac{256}{625}$ (0.4096)	$\frac{256}{625}$ (0.4096)	$\frac{96}{625}$ (0.1536)	$\frac{16}{625}$ (0.0256)	$\frac{1}{625}$ (0.0016)
X	8	11	14	17	20									
P(X = x)	$\frac{256}{625}$ (0.4096)	$\frac{256}{625}$ (0.4096)	$\frac{96}{625}$ (0.1536)	$\frac{16}{625}$ (0.0256)	$\frac{1}{625}$ (0.0016)									
(6)														
(b)	$1 - (1 - "0.1536")^n > 0.95$ or $("0.8464")^n < 0.05$					M1								
	$n > 17.96$ or $n > \frac{\log(0.05)}{\log("0.8464")}$ or $n > \log_{"0.8464"}(0.05)$					M1								
	$n = 18$					A1								
(3)														
Notes					Total 9									
(a)	M1	For at least 2 scores correct and no more than 3 incorrect												
	M1	for writing or using $\frac{4}{5}$ and $\frac{1}{5}$. May be implied by a correct probability												
	M1	for p^4 where $0 < p < 1$												
	M1	for $4 \times (1 - p) p^3$ where $0 < p < 1$												
	M1	for $6 \times (1 - p)^2 p^2$ where $0 < p < 1$ or probabilities that add to 1 (at least 2 but not more than 5)												
	A1	for all 5 probabilities correct and associated with the correct values. Need not be in a table but probabilities must be attached to the correct total												
(b)	M1	for using $1 - (1 - P(Y = 0))^n > 0.95$ allow = instead of $>/\geq$. condone $</\leq$ or allow for at least 2 trials for n between 10 and 20 ft their $P(X = 14)$												
	M1	for $n > \text{awrt } 17.96$ or $n > \frac{\log(0.05)}{\log("0.8464")}$ ft their 0.8464 or $n > \log_{"0.8464"}(0.05)$ ft their 0.8464 or for the two trials for $n = 17$ and 18 Allow = instead of $>/\geq$. condone $</\leq$ May be implied by a correct answer ft their 0.8464												
	A1	Cao (Do not allow any inequality for this mark)												

Question Number	Scheme		Marks	
7(a)	$f(x) = [k](a + 3bx^2 - 4x^3)$		M1	
	$[k](6bx - 12x^2) = 0$		M1	
	$9b - 27 = 0 \Rightarrow b = 3$ or $6 \times 3 \times 1.5 - 12 \times 1.5^2 = 0 \Rightarrow \therefore b = 3^*$		A1*	
			(3)	
(b)	$a + 3 - 1 - 4 = 0$ oe $[\Rightarrow a = 2]$		B1*	
			(1)	
(c)	$k(2 \times 2 + 3 \times 2^3 - 2^4 - 4) = 1 \quad \left[\Rightarrow k = \frac{1}{8} \right]$		M1	
	$F(x) = 0.5$	$F(x) = 4$	$F(x) = 0$	
	$F(1.4) = 0.3988\dots$ $F(1.5) = 0.5078\dots$	$F(1.4) = 3.1904\dots$ $F(1.5) = 4.0625\dots$	$F(1.4) = -0.8(096\dots)$ $F(1.5) = 0.06(25\dots)$	M1A1
	$0.399 < 0.5 < 0.508$ therefore, the median lies between 1.4 and 1.5	$3.1904 < 4 < 4.0625$ therefore, the median lies between 1.4 and 1.5	$-0.8(096) < 0 < 0.06(25)$ therefore, the median lies between 1.4 and 1.5	A1
	ALTERNATIVE M1A1A1 for F(x) = 0			
	$x_1 = 2.91\dots \quad x_2 = 1.49\dots \quad x_3 = -0.70\dots$ So $x = 1.49\dots$ as $1 \leq x \leq 2$			M1 A1
	$1.4 < 1.49\dots < 1.5$ [therefore, the median lies between 1.4 and 1.5]			dA1
			(4)	
Notes			Total 8	
(a)	M1	for attempting to differentiate $x^n \rightarrow x^{n-1}$ Condone missing k (May be implied by 2 nd M1)		
	M1	for correctly differentiating twice and equating to zero. Condone missing k		
	A1*	substituting $x = 1.5$ leading to a correct linear equation in b leading to $b = 3$		
(b)	B1*	for correctly using $F(1) = 0$ to form an equation in a (May be seen in part (a)) and substitution of $b = 3$		
(c)	M1	for using $F(2) = 1$ to form a correct equation in terms of k only. May be seen in any part of the question		
	M1	For a calculation of $F(1.4)$ or $F(1.5)$ correct to 2 sf (If $F(x) = 0$ used then allow 1 sf or better) (Allow $F(1.4) = \text{awrt } 3.190k$ or $F(1.5) = \text{awrt } 4.063k$)		
	A1	For a calculation of $F(1.4)$ and $F(1.5)$ correct to 2 sf (If $F(x) = 0$ used then allow 1 sf or better)		
	dA1	Dependent on previous A1. For a correct comparison and conclusion. Allow comparisons in words e.g. For $F(X) = 0$ a comment about a change in sign implies a comparison with 0		
	ALTERNATIVE			
	M1	For solving the given equation. May be implied by 2.91... or 1.49... or -0.70...		
	A1	For $x = 1.49\dots$ identified as being in the range specified by the CDF. May be implied by rejecting the other solutions		
	dA1	Dependent on previous A1. For a correct comparison and conclusion		

Examples of other acceptable comparisons for 0.5

$F(1.4) < 0.5 < F(1.5)$, Median lies between the range

$F(1.4) < F(\text{median}) < F(1.5)$, so median lies between 1.4 and 1.5

$F(1.4) < F(Q2) < F(1.5)$, therefore $Q2$ lies between 1.4 and 1.5

$F(1.4) < F(m) < F(1.5)$, $1.4 < m < 1.5$

$F(1.4) < 0.5$, $F(1.5) > 0.5$, so median of X lies between 1.4 and 1.5

Allow equivalent comparisons for 4 and 0