



Mark Scheme (Results)

January 2022

Pearson Edexcel International A Level
In Statistics S3 (WST03) Paper 01

Question Number	Scheme		Marks
1 (a)	$\bar{x} = 11.42$		B1
	$s^2 = \frac{1310.464 - 10 \times 11.42^2}{9}$		M1
	$= 0.7$		A1
			(3)
(b)	z value for 95% CI is 1.96		B1
	'11.42' $\pm 1.96 \times \frac{0.8}{\sqrt{10}}$		M1
	(10.924..., 11.915...) awrt (10.92, 11.92)		A1 A1
			(4)
(c)	$Y \sim N("11.92", 0.8^2)$		M1
	$P(Y < 10.5) = P\left(Z < \frac{10.5 - "11.92"}{0.8}\right) [= P(Z < -1.775)]$		M1
	$= 0.03837...$ awrt 0.038		A1
			(3)
	Notes		Total 10
1(a)	B1	for 11.42 cao	
	M1	for use of $s^2 = \frac{\sum x^2 - n\bar{x}^2}{n-1}$	
	A1	for 0.7 cao	
(b)	B1	for writing or using 1.96 (or better from calculator 1.9599...)	
	M1	For use of $\bar{x} \pm z \text{ value} \times \frac{\sigma}{\sqrt{n}}$ ft their z value, $1 < z < 2$ and their 11.42	
	A1	for awrt 10.9 or awrt 11.9	
	A1	for awrt 10.92 and awrt 11.92	
(c)	M1	for identifying the normal distribution with the upper confidence interval value as mean and 0.8 as standard deviation (may be seen in standardisation)	
	M1	for standardising with 10.5, their mean (which must be in their confidence interval (including limits) from part (b)) and standard deviation = 0.8	
	A1	awrt 0.038 (tables = 0.0375)	

Question Number	Scheme		Marks
2(a)	$H_0 : \mu_{year7} = \mu_{year8} \quad H_1 : \mu_{year7} \neq \mu_{year8}$		B1
	$SE = \sqrt{\frac{38}{240} + \frac{42}{240}}$		M1
	$z = \frac{103 - 101}{SE}$		M1
	$= (\pm)3.464.... \quad \left(2\sqrt{3}\right)$ awrt $(\pm) 3.46$		A1
	$Z_{critical} = 2.5758$		B1
	In CR/Significant/Reject H_0		M1
	There is sufficient evidence to suggest that the regional education <u>officer</u> 's claim is not correct/ There is a difference between the <u>mean scores</u> of the two year groups.		A1
(b)	CLT allows us to use <u>sample means</u> (oe) being normally distributed		(7) B1
			(1)
	Notes		Total 8
(a)	B1	both hypotheses correct. Allow equivalent rearrangements. Must be in terms of μ If using e.g. $\mu_A = \mu_B$ A and B must be clearly identified with year groups	
	M1	for use of SE with 38 and 42 (may be implied by SE = awrt 0.577)	
	M1	for a correct standardisation expression using 103, 101 (in either order) and SE = awrt.0577 or ft their stated SE or if not stated (i.e. only seen in standardisation) only allow $\sqrt{\frac{38^2}{240} + \frac{42^2}{240}}$ or $\sqrt{\frac{\sqrt{38}}{240} + \frac{\sqrt{42}}{240}}$	
	A1	awrt 3.46 or awrt -3.46 allow p value of awrt 0.000266	
	B1	$ CV = 2.5758$ or better (seen)	
	M1	a correct statement linking their test statistic and their CV – need not be contextual but do not allow contradicting non contextual comments.	
	A1	do not allow a ft conclusion here. a correct contextual statement (dependent on 2 nd M1) which must be consistent with their test statistics and CV and which also must reject H_0 . It must mention the officer or mean scores.	
(b)	B1	a correct explanation which must mention sample means oe (population means are normally distributed is B0) ignore extraneous non-contradictory comments	

Question Number	Scheme		Marks
3 (a)	$\left[r = \frac{S_{xy}}{\sqrt{S_{xx}S_{yy}}} = \frac{15.1608}{\sqrt{6.90181 \times 45.304}} \right]$		M1
	= 0.8573... awrt 0.857		A1
			(2)
(b)	$H_0 : \rho = 0$, $H_1 : \rho > 0$		B1
	Critical value 5% = 0.5494		B1
	Significant evidence to suggest that there is a <u>positive correlation</u> between <u>MR</u> and <u>BMI</u>		B1
			(3)
(c)	MR and BMI measurements are normally (or bivariate normal) distributed		B1
			(1)
(d)	Ranks for MR: 9 10 6 7 8 4 5 1 2 3		B1
	$\sum d^2 = 1 + 9 + 9 + 1 + 4 + 1 + 16 + 9 + 9 + 1 [= 60]$		M1
	$r_s = 1 - \frac{6(60)}{10(99)}$		M1
	= 0.6363 awrt (\pm) 0.636		A1
			(4)
(e)	$[H_0 : \rho = 0$, $H_1 : \rho \neq 0]$		
	Critical value 0.6485		B1
	There is insufficient evidence of a correlation between <u>MR</u> and <u>DPA</u>		B1
			(2)
	Notes		Total 12
(a)	M1	for use of $\frac{S_{xy}}{\sqrt{S_{xx}S_{yy}}}$	
	A1	awrt 0.857	
(b)	B1	both hypotheses correct. Must be in terms of ρ . Must be attached to H_0 and H_1 Do not allow hypotheses in words on their own.	
	B1	critical value of 0.5494	
	B1	correct conclusion rejecting H_0 which must mention positive correlation, MR and BMI which must be consistent with their CV and their r , with $ \text{their CV} < 1$ and $ \text{their } r < 1$	
(c)	B1	correct assumption referring to MR and BMI needing to be normally distributed	
(d)	B1	attempt to rank MR (at least four correct) (may be implied by correct $\sum d^2$ or correct answer) allow reverse ranks for MR: 2 1 5 4 3 7 6 10 9 8	
	M1	for finding the difference between each of the ranks and evaluating $\sum d^2$ (implied by $\sum d^2 = 60$ or for reverse ranks $\sum d^2 = 270$)	
	M1	using $1 - \frac{6\sum d^2}{10(99)}$ with their $\sum d^2$	
	A1	awrt (\pm) 0.636	
(e)	B1	critical value of 0.6485 (or -0.6485 if $r_s < 0$)	
	B1	correct conclusion which is not rejecting H_0 , which must mention MR and DPA which must be consistent with their CV and their r_s , with $ \text{their CV} < 1$ and $ \text{their } r_s < 1$	

Question Number	Scheme						Marks	
4(a)	Non random sampling/description of non random sampling oe						B1	
	from (different groups of the) population until each quota has been met						B1	
							(2)	
(b)	H_0 : Subject enjoyed the most and group are independent						B1	
	H_1 : Subject enjoyed the most and group are not independent							
		Expected	Maths	Physics	Chemistry	Total	M1	
		Group A	21.06	8.97	8.97	(39)		
		Group B	32.94	14.03	14.03	(61)		
		Total	(54)	(23)	(23)	(100)		
		Observed	Expected		$\frac{(O - E)^2}{E}$	$\frac{O^2}{E}$	dM1	
		16	21.06		1.215745...	12.15575...		
		10	8.97		0.118272...	11.14827...		
		13	8.97		1.81058...	18.84058...		
		38	32.94		0.77728...	43.83728...		
		13	14.03		0.075617...	12.04562...		
		10	14.03		1.157584...	7.127584...		
		Totals		5.155...		105.155...		
		$[X^2 =] \sum \frac{(O - E)^2}{E}$ or $\sum \frac{O^2}{E} - 100$						dM1
		= 5.155... awrt 5.16 or awrt 5.15						A1
	$\nu = (3 - 1)(2 - 1) = 2$						B1	
	$\chi^2_2(0.05) = 5.991$						B1ft	
	[not in CR/not significant/Do not reject H_0] There is not sufficient evidence to suggest that <u>subject</u> enjoyed and <u>group</u> are not independent						A1	
							(8)	
(c)(i)	No change (as the test is still the same)						B1	
(ii)	No change (as $\nu = 2$ still)						B1	
(iii)	Test statistics would double (= 10.310...) (as all observed and expected values are doubled.)						B1	
(iv)	Conclusion is the opposite (There is sufficient evidence to suggest that subject enjoyed and group are not independent) as test statistic is now greater than the critical value (10.31 > 5.991)						B1	
							(4)	
	Notes						Total 14	
(a)	B1	for a correct statements referring to non-random sampling or a description of a non-random method for selecting participants e.g. choosing people as they leave the school . Do not allow labelling or numbering						
	B1	for a correct statement referring to selection from different groups until quota is filled						
(b)	B1	both hypotheses correct. Must mention “Subject” and “group” at least once. (may be written in terms of association)						
	M1	Some attempt at $\frac{(\text{Row Total}) \times (\text{Column Total})}{\text{Grand Total}}$ Can be implied by at least one correct E_i to 1 dp						
	dM1	dependent on 1 st M1 for at least 2 correct terms for $\frac{(O - E)^2}{E}$ or $\frac{O^2}{E}$ or correct expressions with their E_i Accept 2 sf accuracy						

	dM1	dependent on 2 nd M1 for applying $\sum \frac{(O - E)^2}{E}$ or $\sum \frac{O^2}{E} - 100$
	A1	awrt 5.16
	SC	If no expected frequencies shown, then an answer of awrt 5.16 scores M0M0M1A1
	B1	$\nu = 2$ may be implied by a correct critical value of 5.991
	B1ft	5.991 allow ft from their stated degrees of freedom (may see 3.841, 7.815, 9.488, 11.070)
	A1	dependent on 3 rd M1 and 3 rd B1. A correct contextualised conclusion which is not rejecting H ₀ . Must mention subject and group. Contradictory statements score A0 e.g. “significant, do not reject H ₀ ” If no hypotheses or hypotheses wrong way round do not award.
(c)(i)	B1	a correct statement
(ii)	B1	a correct statement
(iii)	B1	a correct statement which must state that the test statistic doubles
(iv)	B1	a correct statement with correct reasoning

Qu. No.	Scheme		Marks
5 (a)	Let T = total time taken		
	$T \sim N(41 + 81 + 57, 5.2^2 + 4.2^2 + 6.6^2)$ [So $T \sim N(179, 88.24)$]		M1 A1
	$P(T > 180) = P\left(Z > \frac{180 - 179}{\sqrt{88.24}}\right)$		M1
	$= 1 - 0.5438 = 0.4562$ (calculator gives 0.4576...) awrt 0.456 to 0.458		M1 A1
			(5)
(b)	Let Y = difference between run and swim or Let $D = R - S - 20$		
	$Y \sim N(16, 70.6)$ or $D \sim N(-4, 70.6)$		B1
	$P(Y > 20) = P\left(Z > \frac{20 - 16}{\sqrt{70.6}}\right)$ or $P(D > 0) = P\left(Z > \frac{0 - (-4)}{\sqrt{70.6}}\right)$		M1
	$= 1 - 0.6844 = 0.3156$ (calculator gives 0.3170...) awrt 0.316/0.317		M1 A1
			(4)
(c)	$P(T > t) = 0.95 \Rightarrow P\left(Z > \frac{t - 179}{\sqrt{88.24}}\right) = 0.95 \Rightarrow \frac{t - 179}{\sqrt{88.24}} = -1.6449$		M1 B1
	$t = 163.548...$ awrt 164		A1
			(3)
(d)	Let X = the number of times greater than 3 hours in 6 attempts		
	$X \sim B(6, "0.456")$		B1ft
	$P(X \geq 1) = 1 - P(X = 0) = 1 - "0.5438"$ $P(X \geq 1) = 1 - P(X = 0) = 1 - "0.5438"$		M1
	$= 0.9741...$ (using the calculator value gives 0.9745...) awrt 0.974/0.975		A1
			(3)
(e)	eg The times for each event are not now likely to be independent		M1
	Jane is correct / calculation is not valid		A1 (2)
	Notes		Total 17
(a)	M1	for setting up a normal distribution with a mean $41 + 81 + 57 (= 179)$	
	A1	for a correct expression of variance implied by (variance =) 88.24 or for s.d. = awrt 9.39	
	M1	for standardising with 180, their mean and their standard deviation	
	M1	use of $1 - p$ with $0.5 < p < 1$	
	A1	awrt 0.456 to 0.458	
(b)	B1	For $N(\pm 16, 70.6)$ or $N(\pm 4, 70.6)$ May be seen in a calculation	
	M1	for standardisation with ± 20 or 0, their mean and their s.d.(their var must be > 0) must be compatible e.g. -20 with -16	
	M1	use of $1 - p$ with $0.5 < p < 1$	
	A1	awrt 0.316/0.317	
(c)	M1	for standardising using their mean and standard deviation = z value $1 < z < 2$	
	B1	for correct z value ± 1.6449 or better. Must have compatible sign with standardisation	
	A1	awrt 164	
(d)	B1ft	for writing or using $B(6, '0.4562')$ ft their answer to part (a) to 3sf	
	M1	use of $P(X \geq 1) = 1 - P(X = 0)$ [$= 1 - (1 - \text{their}(a))^6$] allow $P(X \geq 1) = P(X = 1) + P(X = 2) + \dots + P(X = 6)$	
	A1	awrt 0.974/0.975	
(e)	M1	Reference to the events no longer being independent (he might get tired after each event or events now follow consecutively)/ calculation does not include time between events	
	A1	Correct conclusion (Jane is correct) with corresponding reason	

Qu. No.	Scheme		Marks
6(a)	$P(S < 303.5) = P\left(Z < \frac{303.5 - 310}{4}\right)$ or $P(S > 315.5) = P\left(Z > \frac{315.5 - 310}{4}\right)$		M1
	$= 0.05208$ or $0.084565\dots$ awrt 0.052 or awrt 0.084/0.085		A1
	So $a = 5.2$ or $b = 8.5$ awrt 5.2 or awrt 8.4/8.5		A1
	e.g. $b = 100 - 10.6 - 16.3 - 19.6 - 18.4 - 13.6 - 7.8 - '5.2'$		M1
	Both $a = 5.2$ and $b = 8.5$ awrt 5.2/5.3 and awrt 8.4/8.5		A1
			(5)
(b)	H ₀ : The normal distribution N(310, 16) is a suitable model/The data are consistent with the model. H ₁ : The normal distribution N(310, 16) is not a suitable model/The data are not consistent with the model.		B1
	$\left[X^2 =\right] \sum \frac{(O - E)^2}{E} = \frac{(5 - '5.2')^2}{'5.2'} + \frac{(4 - '8.5')^2}{'8.5'} + 9.71$		M1 M1
	$= 12.10\dots$ awrt 12.0 to 12.1		A1
	$\nu = 7$		B1
	$\chi^2_7(0.05) = 14.067$		B1ft
	[not in the CR/not significant/Do not reject H ₀] There is not sufficient evidence to suggest that N[(310, 16)] is not a suitable model/The model is suitable/The data are consistent with the model		A1
			(7)
(c)	$\nu = 8 - 3 = 5$ / two parameters estimated so additional degrees of freedom subtracted		M1
	Therefore the critical value is reduced/now 11.070		A1
			(2)
Notes			Total 14
(a)	M1	for standardising with 303.5 or 315.5, 310 and 4	
	A1	awrt 0.052 or awrt 0.084/0.085	
	A1	either correct value	
	M1	a complete method to find the second missing value	
	A1	both correct values	
(b)	B1	both hypotheses correct. If mentioning normal, must mention N(310, 16) at least once.	
	M1	for either $\frac{(5 - '5.2')^2}{'5.2'}$ or $\frac{(4 - '8.5')^2}{'8.5'}$	
	M1	for a complete method to find $\sum \frac{(O - E)^2}{E}$ e.g. 9.71 + 2 additional terms this mark is independent of the 1 st M1	
	A1	allow awrt 12.0 to 12.1	
	B1	$\nu = 7$ This mark can be implied by a correct critical value of 14.067	
	B1ft	14.067 (may see 5.991, 7.815, 9.488, 11.070, 12.592)	
	A1	dependent on 2 nd M1 a correct conclusion which states that the model is suitable and must be consistent with their X^2 value and their χ^2 critical value. If no hypotheses or hypotheses wrong way round do not award.	
(c)	M1	a statement that implies 2 additional degrees of freedom are subtracted	
	A1	a correct conclusion from correct reasoning.	