Mark Scheme (Results)

January 2022

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

Question Number	Scheme	Marks
1 (a)	$\overline{x} = 11.42$	B1
	$s^2 = \dfrac{1310.464 - 10 \times 11.42^2}{9}$	M1
	$= 0.7$	A1
		(3)
(b)	z value for 95% CI is 1.96	B1
	$'11.42' \pm 1.96 \times \dfrac{0.8}{\sqrt{10}}$	M1
	(10.924…, 11.915…) awrt (10.92, 11.92)	A1 A1
		(4)
(c)	$Y \sim N(\text{“}11.92\text{”}, 0.8^2)$	M1
	$P(Y < 10.5) = P\left(Z < \dfrac{10.5 - "11.92"}{0.8}\right) [= P(Z < -1.775]$	M1
	$= 0.03837\ldots$ awrt 0.038	A1
		(3)

	Notes		Total 10
1(a)	**B1**	for 11.42 cao	
	M1	for use of $s^2 = \dfrac{\sum x^2 - n\overline{x}^2}{n-1}$	
	A1	for 0.7 cao	
(b)	**B1**	for writing or using 1.96 (or better from calculator 1.9599…)	
	M1	For use of $\overline{x} \pm z$ value $\times \dfrac{\sigma}{\sqrt{n}}$ ft their z value, $1 < \lvert z \rvert < 2$ 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)	$H_0 : \mu_{year7} = \mu_{year8}$ $H_1 : \mu_{year7} \neq \mu_{year8}$	B1
	$SE = \sqrt{\frac{38}{240} + \frac{42}{240}}$	M1
	$z = \frac{103 - 101}{SE}$	M1
	$= (\pm)3.464....$ $\left(2\sqrt{3}\right)$ 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 officer's claim is not correct/ There is a difference between the mean scores of the two year groups.	A1
		(7)
(b)	CLT allows us to use sample means (oe) being normally distributed	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 2nd 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)	$\left[r = \frac{S_{xy}}{\sqrt{S_{xx}S_{yy}}} = \right] \frac{15.1608}{\sqrt{6.90181 \times 45.304}}$	M1
	$= 0.8573\ldots$ 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 positive correlation between MR and BMI	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 MR and DPA	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 |their CV| < 1 and |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 |their CV| < 1 and |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 H_1 : Subject enjoyed the most and group are not independent	B1
	Expected: Maths / Physics / Chemistry / Total Group *A*: 21.06 / 8.97 / 8.97 / (39) Group *B*: 32.94 / 14.03 / 14.03 / (61) Total: (54) / (23) / (23) / (100)	M1
	Observed / Expected / $\frac{(O-E)^2}{E}$ / $\frac{O^2}{E}$ 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…	dM1
	$\left[X^2 =\right]\sum\frac{(O-E)^2}{E}$ 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_o] There is not sufficient evidence to suggest that subject enjoyed and group 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 1st 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 2nd 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 3rd M1 and 3rd B1. A correct contextualised conclusion which is not rejecting H_o Must mention subject and group. Contradictory statements score A0 e.g. "significant, do not reject H_o" 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	
	$T \sim \text{N}(41+81+57, 5.2^2+4.2^2+6.6^2)$ [So $T \sim \text{N}(179, 88.24)$]	M1 A1
	$\text{P}(T>180) = \text{P}\left(Z > \frac{180-179}{\sqrt{88.24}}\right)$	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 $D = R - S - 20$	
	$Y \sim \text{N}(16, 70.6)$ or $D \sim \text{N}(-4, 70.6)$	B1
	$\text{P}(Y>20) = \text{P}\left(Z > \frac{20-16}{\sqrt{70.6}}\right)$ or $\text{P}(D>0) = \text{P}\left(Z > \frac{0-(-4)}{\sqrt{70.6}}\right)$	M1
	$=1-0.6844=0.3156$ (calculator gives 0.3170…) awrt 0.316/0.317	M1 A1
		(4)
(c)	$\text{P}(T>t)=0.95 \Rightarrow \text{P}\left(Z > \frac{t-179}{\sqrt{88.24}}\right)=0.95 \Rightarrow \frac{t-179}{\sqrt{88.24}} = -1.6449$	M1 B1
	$t = 163.548...$ awrt 164	A1
		(3)
(d)	Let X = the number of times greater than 3 hours in 6 attempts	
	$X \sim \text{B}(6, "0.456")$	B1ft
	$\text{P}(X \geqslant 1) = 1 - \text{P}(X=0) = 1 - "0.5438"^6$ $\text{P}(X \geqslant 1) = 1 - \text{P}(X=0) = 1 - "0.5438"^6$	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 $\text{N}(\pm 16, 70.6)$ or $\text{N}(\pm 4, 70.6)$ 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 $1 < \lvert z \rvert < 2$
	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 $\text{P}(X \geqslant 1) = 1 - \text{P}(X=0)$ [$=1-(1-\textit{their}(a))^6$] allow $\text{P}(X \geqslant 1) = \text{P}(X=1) + \text{P}(X=2) + ... + \text{P}(X=6)$
	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)	$\mathrm{P}(S<303.5)=\mathrm{P}\left(Z<\dfrac{303.5-310}{4}\right)$ or $\mathrm{P}(S>315.5)=\mathrm{P}\left(Z>\dfrac{315.5-310}{4}\right)$	M1
	$=0.05208$ or $0.084565\ldots$ 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
	$\left[X^2=\right]\sum\dfrac{(O-E)^2}{E}=\dfrac{(5-'5.2')^2}{'5.2'}+\dfrac{(4-'8.5')^2}{'8.5'}+9.71$	M1 M1
	$=12.10\ldots$ 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 $\dfrac{(5-'5.2')^2}{'5.2'}$ or $\dfrac{(4-'8.5')^2}{'8.5'}$
	M1	for a complete method to find $\sum\dfrac{(O-E)^2}{E}$ e.g. 9.71 + 2 additional terms this mark is independent of the 1st 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 2nd 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.